Scenario Studies for the Rural Environment

Selected and edited Proceedings of the Symposium
Scenario Studies for the Rural Environment,
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PREFACE

In 1989 a new research institute was established by a merger of (parts of) four institutes of the Netherlands Ministry of Agriculture, Nature Management and Fisheries covering the fields of:

- land inventory and land evaluation;
- soil and groundwater protection;
- quantitative and qualitative water management;
- toxic substances in the environment;
- landscape management and landscape development;
- land use planning and outdoor recreation.

An explicit purpose was to promote integration of sectors (functions of rural areas, e.g. agriculture, nature, outdoor recreation); policy fields (e.g. environmental policies, economic policy); and branches of science of different but interlinked research activities with respect to rural areas. Thus, the DLO Winand Staring Centre for Integrated Land, Soil and Water Research was created. Its first lustrum in 1994 offered a good occasion both to evaluate what was accomplished and to look ahead to the research tasks to come. An international scientific symposium was one of the means to this end.

The symposium was held in Wageningen, the Netherlands on 12-15 September 1994 under the title *Scenario Studies for the Rural Environment*. Around 340 participants from 27 countries participated in the gathering. Thank to a generous gesture for support for the Commission of the European Communities, Directorate-General for Science, Research and Development (DG XII), a number of participants from Eastern European countries could attend the symposium. Although endangered environmental quality and accelerating land-use dynamics are worldwide phenomena, the focus of the symposium was on Europe. The central objective was to further our understanding of the needs, aims and methodologies of future-oriented and decision-supporting research for the rural environment, and in particular the role scenario studies could play. Rural areas need to fulfil a large variety of functions and to accommodate many activities. Therefore, the scope of the symposium and by consequence of these proceedings needs to be rather broad. It covers the following themes:

- nature, variety and scope of scenario studies;
- regional soil and water management;
- nature development and landscape quality;
- rural planning and the future of regions.

These themes are reflected in the four parts of this book.

The contributions to this symposium - papers by invited speakers and a selection of submitted posters - have been reviewed by the Editorial Scientific Committee composed of Winand Staring Centre staff, in some cases assisted by colleagues. The final decision whether or not to follow the suggestions by this Committee was, however, left to the authors. They are acknowledged for their ready and apt replies.

Gratitude is expressed to session chairpersons and invited discussants for their role in the success of the symposium and for providing the editors with basic material for the introduction to this book: Prof. Dr K. Verhoeff (former Director of Science and Technology Department of the Netherlands Ministry of Agriculture, Nature Management and Fisheries), Prof. Dr L.O. Fresco, Prof. Dr. J. Bouma, Prof. Dr R.A. Feddes, Prof. Dr. R. Rabbinge and Prof. Dr. H.N. van Lier (all from the Wageningen Agricultural University), Prof. Dr I.S. Zonneveld (Emeritus Professor at the International Institute for Aerospace Survey and Earth Sciences, ITC, Enschede, Netherlands) and Prof. Dr H.A. Udo de Haes (Centre for Environmental Studies, Leiden, Netherlands).

I would like to express our thanks also to all sponsors of the symposium: the Commission of the European Communities, Directorate-General for Science, Research and Development (DG XII), Brussels; the Netherlands Minstry of Agriculture, Nature Management and Fisheries, The Hague; Digital Equipment b.v., Utrecht; Grontmij n.v., De Bilt; Grafisch Service Centrum Van Gils b.v., Wageningen; CCE Land Use Management, Eindhoven; QRay Agrimathica, Veenendaal; Winnemuller, Wageningen; Separations b.v., Hendrik Ido Ambacht; Hago Nederland b.v., Heerlen; Bedrijfslaboratorium voor Grond- en Gewas-onderzoek, Oosterbeek; Kniphorst International Booksellers, Wageningen; B.V. Automobielbedrijf Ackermann, Wageningen; Allround Uitzendburo, Wageningen; DHV AIB b.v., Amersfoort; GTR b.v., Geldermalsen; Hoek Loos, Dieren; International Agricultural Centre (IAC), Wageningen; Koenders Instruments b.v., Hilversum; LEICA b.v., Rijswijk; Logisterion Automatisering, Rotterdam; Van der Most, Heerde; Observator Instruments b.v., Ridderkerk; Permar, Ede; Photogravure De Schutter, Antwerpen; Profcolor-Fotovaklab, Veenendaal; Rapidocolor Nederland b.v., Eindhoven; Wageningen Agricultural University, Wageningen.

A special word of graditude goes to the Commission of the European Communities, Directorate-General for Science, Research and Development (DG XII) for their support for the publication of this proceedings.

I am confident that these proceedings offer interesting reading, also for those who did not attend this fascinating symposium. Future-oriented research in general and scenario studies in particular are fun to do, but it should be done properly, not least due to the interest of our common future rural environment.

Wageningen, July 1995
G.A. Oosterbaan
Director DLO Winand Staring Centre for Integrated Land, Soil and Water Research

Selected and edited proceedings of the International Symposium organized by the DLO Winand Staring Centre for Integrated Land, Soil and Water Research, Wageningen, The Netherlands, co-sponsored by the Commission of the European Communities, Directorate-General for Science, Research and Development, DG-XII, Brussels.

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A Scenario Builder's Inquisition
(a muse from a Symposium)

So, you are a scenario - builder -
are these buildings sand castles,
castles in the air,
prisons, pubs or parliaments?

No, I tell stories of the future.
So: are they lies, science fiction or fantasy?
Are they tragedy, comedy, thriller or farce?
Are they literature or pulp?

No: I paint pictures of reality.
So: are they abstract or impressionist,
in or out perspective?
Are they in colour or black and white?
Are they master-pieces, cartoons, caricatures or junk?

No, I make models of the world.
So, to what scale and of what parts?
Are they toys, exhibits, plans or prototypes?
Are they fashion models or pornographic?

Perhaps they make you blind.

D.R. Harvey
Wageningen, 13-09-1994

CONTENTS: 'Scenario Studies for the Rural Environment'

GENERAL INTRODUCTION

Background

Rural areas need to fulfil a large variety of functions and accommodate many activities such as agriculture, forestry, nature conservation, water resources development, outdoor recreation and many others. As a result, the quality of the rural environment as a whole is under pressure. These pressures are caused in particular by claims on space (e.g. urbanization and infrastructure), agricultural production and its environmental effects (e.g. eutrofication, man-induced drought, acidification and inherited pollution), and non-agricultural activities and their environmental effects (e.g. disturbance of nature areas by outdoor recreation functions).

Policymakers at different levels -European, national, regional- develop plans to meet demands for space and to meet environmental goals.

In Europe, the dominating position of agriculture is increasingly affected. The future of rural areas is no longer concerned exclusively with the future of agriculture. Nature, instead of being a burden for agriculture which would just be tolerated in the fringes as a marginal phenomenon, may well become an ally. The rehabilitation of nature is an appealing task and a challenge for both the present and next generations. The same holds true for recreational uses of rural landscapes.

These new notions are also expressed as political issues on the future of the rural environment, such as:

- enhancing ecological connectivity and nature development;
- sustainable exploitation of natural resources;
- reducing pollution and pollutants, in particular excessive nutrients;
- land use changes and EU policies, in particular those with regard to set-aside of agricultural land to reduce agricultural production surpluses;
- an extension of the EU with eastern European states.

The complexity of the problems, limited funds and the almost irreversible character of some interventions result in a compelling need to evaluate *ex ante* the effects of alternative solutions for the designation of land, for measures to develop infrastructure and for soil and water management.

Origin and meaning of scenario studies

Scenario originally has a meaning as 'an outline or synopsis of a play, a plot outline used by actors of the Commedia dell'arte, a screenplay or a shooting script' (Webster, 1976). Scenario as an instrument for problem identification and for assisting decision making, as it is used in this book, dates back some fifty years when nuclear physicists used computer simulations to tackle probabilities and uncertainties. In the early seventies, various companies and governmental organizations started using a scenario approach for their strategic decision-making and planning. One of the reasons was the advantage of scenarios and scenario studies over expert judgements and other planning approaches in

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that they necessitate a systematic, coherent approach to the issues under study, and elucidate future uncertainties (Schoonenboom, this issue; Veeneklaas and Van den Berg, this issue).

When dealing with choices regarding designation, layout and management of the resources of rural areas, policy makers encounter both complexity and uncertainty. In such situations scenario studies can be a powerful tool in assisting the decision making. The intended benefit of scenarios is that they stretch as well as focus people's thinking. Scenarios are likely to reduce overconfidence (in the sense of a too narrow scope of possibilities thus overestimating the power to predict) by making available to the mind futures not yet considered as well as by challenging those presumed likely (P.J.H. Schoemaker: 'Multiple scenario development: its conceptual and behavioral foundation'. In: *Strategic Management Journal*, vol. 14, 1993: 193-213).

In its complete form a scenario should comprise a description of the current situation, of a possible or desirable future state as well as of the series of events that could lead from the current state of affairs to this future state (Veeneklaas and Van den Berg, Schoonenboom, both this issue). Scenario studies should be lucid and transparant enough to be evaluated, especially with regard to assumptions made. Their usefulness and credibility depend on it. The requirement of a consistent and coherent approach is the key-issue in scenario studies.
Scenario studies cannot dispel uncertainties; they do not aim at predicting the future, but at best depict its boundaries.

Renewal and modernization of the rural environment is both a necessity and a challenge. Scenario studies are undertaken to help manage the complexity, to bound uncertainties and to create new visions. In our age of information overload, the ability to distinguish signal from noise is a critical skill. "But, incisive pattern recognition can only occur if the right mental maps exists in one's mind. Scenarios can develop, align and focus such maps" (Schoemaker, 1993).
There are many kinds of scenarios and scenario studies. Moreover, authors are inclined to use their own definitions of scenarios and of scenario studies. The editors of the book have not made an attempt to unify terminology and nomenclature.

Scope

This book *Scenario Studies for the Rural Environment* addresses the following topics:
- to define the needs for future-oriented and decision-supporting research;
- to review the state of the art of scenario studies for the rural environment;
- to analyse the problems of incorporating environmental quality into rural land use planning;
- to analyse the influence of scenario studies on the practice of policy making and physical planning for the rural environment;
- to disseminate knowledge on scenario studies concerning the rural environment.

The Book

The book comprises four parts, each divided into chapters. Each part starts with more theoretical considerations and finishes with concrete, actual cases. In between, numerous operational tools for scenario studies are reviewed.
The structure of the book in four parts reflects to a large extent the framework of the two-day international symposium in September 1994. Part I reflects largely the first day plenary session with contributions of a general, more or less theoretical character by invited speakers. Parts II - IV correspond to the workshops of the second conference day. These contributions are clustered thematically according to broad scientific fields. In these parts, the contributions consist of the papers of invited speakers and a selection of submitted poster contributions in the form of extended abstracts.

Part I, *'On nature, variety and scope of scenario studies'*, covers the needs, aims and methodologies of future-oriented and decision-supporting research for the rural environment. This Part deals with scenario studies as a tool for policy-making and with the components and elements needed for scenario studies.

Part II, *'Regional soil and water management'*, elaborates on the ability of scenario studies to enhance the management of soil, water and nutrients. It reflects also the experience gained so far in scenario studies with respect to environmental problems. Scenario studies in this Part are generally model-based. Adequate modelling of regional processes means understanding the relevant processes at different scale levels and availability of both historical and present data on the environment.

In Part III, *'Nature development and landscape quality'*, the use of scenario studies for nature development in rural areas is discussed in the context of landscape quality policies. Nature and landscape qualities of future rural environments are the result of developments in society and its internal dynamics. The requirements of scientific tools, models and data in the wide and dynamic field of landscape ecology are examined in this Part.

Part IV, *'Rural planning and the future of regions'*, discusses the tools and operational methods of scenario studies for planners. This necessitated a discussion of the changing views on rural planning. Ongoing as well as possible future land use changes are related to EU policies, in particular those concerning the set-aside of agricultural land. Some papers discuss the impact of development plans for specific regions. Two questions are central to this Part:

- What is the gap to be bridged between scenario studies and actual rural physical planning?
- What are the practical experiences in drawing up scenarios supportive to policy and regional development?

Highlights of the discussion

During the symposium the usefulness of scenario studies as an analytical tool or as decision support was discussed extensively. Among others, it led point by point to the following observations:

- Scenario studies of rural areas are not meant to merely identify problems of these areas. They should be used to explore possiblities and new perpectives.
- Scenario studies can be powerful instruments if extended from the indicative to the explorative, from desires and options to real perspectives, and from single, straight jacketing plans to alternative beckoning designs.
- Change of land use is not an autonomous process, but also the result of political, economic and societal objectives and ambitions. The impact of these on the rural environment and those that live there must however be elucidated, leading to an active rural policy. In this context, discussions should focus on the priorities of the various objectives: economic, environmental and social.
- The transition from on-going to future land use is often unclear; the required time steps or path ways are often missing.
- More attention is paid to the physical rather than social prospects of rural environments.
- The spectacular development of hardware and software, data bases, expert systems, models and GIS makes it technically possible for scenarios to be developed far more rapidly than is often assumed. This makes it even more imperative that attention is devoted to the matter of accuracy and reliability of results to safeguard scientific credibility.
- Generally, scenario studies require interaction with users and other vested interests, including consideration of socio-economic aspects. This has major implications for future work in soil science and hydrology: being receptive towards users' demands, achieving effective presentations of results and creating truly interactive processes. In future projects, provision should be made for such activities, which at present is usually not the case.
- Scenario studies in the field of nature conservation have clear advantages over simple expert reports and demonstrate the ample opportunities for ecological rehabilitation of landscapes and nature. In many of these scenario studies, much attention is given to the essential generation of visions and backcasting research. Probably, this situation is partly due to the 'backs to the wall'-effect: nature is endangered from all sides. The application of, for instance, validation and optimalization techniques would be expedient now.
- Scenario studies by or in collaboration with those affected have far more of an impact on rural planning and plan implementation than mere expert views. Scenarios can be very stimulating in this respect, creating a new sense of a common direction which paves the way for planning as a collective action for change. Scenario studies also play an important role on the platforms where 'top-down' and 'bottom-up' processes regarding land use planning meet.

J.F.Th. Schoute, F.R. Veeneklaas and L.M. van den Berg

PART I

On the nature, variety and scope of scenario studies

CHAPTER

Introduction to Part I

Scenario studies are a tool (e.g. for policy making or scientific analysis) but also need tools of their own. Chapters 1 and 2 deal with these two aspects respectively. The concluding chapter of this part is dedicated to scenarios in a policy environment, both in the Netherlands and in Europe.

In the first chapter Veeneklaas & Van den Berg introduce the matter by defining scenario studies and discussing their usefulness. They draw attention to the inherent tension that exists between the way the builders of scenarios and the users look upon this tool for future oriented analysis. This particular theme is picked up by Van de Klundert. In actual policy making, in the fields of physical planning, economics and environment, scenarios can have different meanings and uses. He concludes with some suggestions to improve the effectiveness of scenarios. Van de Klundert's paper is preceded by Schoonenboom's in which an overview and state of the art of scenario studies is presented. Comparing a number of recently published future studies, he concludes that, even in the case of scenarios with apparently similar characteristics, large differences in results can be observed. This has to do with the different purposes of the studies: crucially, whether the scenarios are designed to shed some light on the 'probable' or the 'possible'.

Chapter 2 presents - not exhaustively - some tools for scenario building. They originate from a large array of scientific branches. Van Walsum et al. represent the natural sciences. Taking a hydrological system with potentially conflicting interests of agriculture and nature as their point of departure, they discuss, among other things, the difference between the use of simulation models and optimization models in policy making. A case study for a region in the Netherlands serves as an example. Harvey & White follow an economic approach. They discuss the key economic relationships between land use and environment. In essence, this involves decomposing the several attributes of land use - ranging from the production of marketable biomass and provision of rural employment through landscape appearance, to wild life diversity, environmental quality and resource conservation. Their approach is illustrated with reference to spatial modelling work done in the United Kingdom. Tools from the social sciences are presented in the paper by Van der Ploeg. He stresses the large and growing differentiation within agriculture and argues that, when this is ignored, policy making in physical planning is bound to fail. Ashok Bhalotra brings in the elements of creativity and design in scenario studies. In his own words: 'Landscape architects should employ a method of design which is, due to associative thinking, a tool to create an awareness which is not yet submitted to the censorship of the ratio; thinking with the ingenuous child's imagination as its model, when fantasy is still free from restraining logic ...' A number of examples of innovative design, vividly illustrated, support his discourse.

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Chapter 3 presents three contributions of speakers who are (or recently have been) directly involved in policy making concerning the rural environment. Van der Lely was, until recently, a high ranking civil servant at the Netherlands Ministry of Agriculture, Nature Management and Fisheries; Meester is also employed by this Ministry. Scheele works at the Directorate General of Agriculture for the European Commission in Brussels. They all stress the drastic changes that are occurring in European agriculture, in rural areas and in policy. In facing this uncertain future, scenarios can be of help.

F.R. Veeneklaas

CHAPTER 1

Scenarios as a tool

1.1 Scenario building: Art, craft or just a fashionable whim?

F.R. Veeneklaas and L.M. van den Berg
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What scenarios are ...

In future-oriented studies, scenario building and analysis are becoming increasingly fashionable. This apparent increase in popularity is, however, somewhat misleading: many studies in trend analysis, comparisons of static equilibria, variant analysis and sensitivity analysis are presented nowadays as scenario studies. We prefer to use the term 'scenario' in the stricter sense: a scenario is a description of the current situation, of a possible or desirable future state as well as of the series of events that could lead from the current state of affairs to this future state.

Two theses can be derived from this definition. Firstly, failing to describe the current situation properly by not including both the possibilities for change and the inherent inertia can easily lead to unverifiable science fiction. Secondly, failing to depict a development pathway harbours the danger of constructing utopias. It is also important to note that a scenario study usually comprises more than one scenario. Even if the outcome of a scenario study is just a single scenario (for instance a weather forecast), various scenarios have been considered during the analysis phase.

This type of thinking (in terms of various alternatives) implies that there are different interpretations of a current situation and of alternative series of future events. It is this variety of processes and outcomes which is the object of scenario studies.

Scenario building implies the formulation of an internally consistent and coherent set of assumptions about the main relations between the phenomena under study, the determining factors and their expected future development. The use of assumptions implies that reality can never be completely known by anybody. These assumptions are sometimes based on scientific knowledge and theory, but may also be more subjective and normative. *INTERFUTURES* from the Organization of Economic Cooperation and Development (OECD, 1979) and *Scanning the Future* from the Netherlands Central Planning Bureau (CPB, 1992) are good examples of the former approach, even though they do contain some normative elements. *A Policy-Oriented Survey of the Future* from the Netherlands Scientific Council for Government Policy (WRR, 1983) exemplifies the latter approach. The requirement for consistency and coherence in the philosophy behind the scenarios distinguishes scenario studies from mere variant analyses, in which one or only a few parameters or assumptions are modified to show the impact of these modifications on future developments.

With this consistent set of assumptions a systematic but selective description of the current situation is made and the most important external factors are identified that determine the future course of the phenomena under study. A scenario study on the future of health care, for instance, will identify demographic development as an external factor. On the other hand, a scenario study on population policy could use developments in health

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care as prominent external factors. This makes clear that every scenario study must clearly define its system boundaries: on one side of the borderline you have the phenomena into which you want to gain insight; on the other there is the environment about which one has to make statements but which falls outside the primary domain of the study. That different scenarios, whether original or borrowed from others, are sometimes used to describe the environment, adds to the confusion regarding the nature of scenario studies.

In the analysis for scenario-building, the description of the combined impact of the internal scenario assumptions and external factors over time leads to different series of events and therefore to different future states. Models, whether mathematical or otherwise, can be employed, but the analysis can also be based on purely qualitative reasoning, giving the study more the character of a thinking experiment.

The above-mentioned elements can be found in all scenario studies, although the sequence may vary. In backcasting, for instance, one starts with desirable end-states and tries to reason back through the steps required to reach these end situations. Different approaches can be discerned too: bottom-up constructions starting from partial analysis of key elements and attuning these different aspects in a later phase; or top-down approaches starting from an all-encompassing concept and filling out the details subsequently.

... and what they are not

With respect to scenario studies, an ongoing and probably never-ending debate is about the predictive power of these studies. Most scenario builders will stress that their scenarios do not pretend to be predictions of any kind: they are explorations of the future. Generally speaking, scenarios present stylized constructions of possible future developments, sometimes quite deliberately in the form of stereotypes, archetypes, optimum or doomsday situations, or other extremes. They refer to 'what might happen, if...', not to 'what will happen'. Real life, now or at any time, is not and will never be so orderly, consistent and neat as even the most complex scenario. In fact, the present situation would be an impossibility in the mind of the scenario builder or in any error-free model. Thus, in theory the scenario builders have a point.

In practice, however, considerations of plausibility are bound to infiltrate even the most rigid mind of any scenario builder. In many places current ideas about probable and less probable developments creep in: in the selection of factors deemed relevant, in the choice of the system boundaries or in the assessment of the external factors. This can clearly be demonstrated by looking back to past scenario studies. They are very much the product of their own time. Some scenario builders may explicitly limit their analyses to processes they consider the most likely. The builders of projective scenarios spend considerable energy on distinguishing these from the less likely courses of events. In contrast with this type, the more adventurous scenario studies produce prospective scenarios: they scan wider ranges of possibilities.

There will probably always be tension between scenario studies and their use. It is normally the scenario builder who tries to make clear the conditional and non-predictive nature of the scenario outcomes. The user of scenario studies, e.g. the policy maker or politician, on the other hand, is generally more interested in the impact of his actions or in extending his control over future events and developments. He will therefore keep on posing the question of plausibility and probability, provoking often irritated reactions from the scenario builder, whose prime interest is consistency and coherence, not probability. Given this conflict, plausibility assessment constitutes an extremely challenging aspect of scenario studies. This brings us to the key question of the purpose and usefulness of scenario studies.

Are they useful?

In general, the value of policy-oriented scenario studies lies in:
- depicting conceivable future situations while at the same time elucidating the driving forces behind them;
- showing the consequences of available policy options in an ever-changing external environment.

Numerous examples of research into both these aspects of the scenario approach will be presented in this book. Hence, for researchers the scenario approach appears to be a useful tool, but what about the policy maker, who has to act under uncertain conditions?

Uncertainty itself, of course, rules every future development. This is not removed by employing scenarios, but it is reduced to uncertainty caused by developments beyond the realm of policy control or the scope for choice by the policy maker. Scenario studies may offer both new perspectives and insight into the effectiveness of available policy instruments. In this sense, the contribution of scenario studies to policy is well expressed in the subtitle of OECD's INTERFUTURES: Mastering the probable and managing the unpredictable.

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1.2 Overview and state of the art of scenario studies for the rural environment

I.J. Schoonenboom

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Abstract

Recently a number of studies have been produced on the future of the rural environment in The Netherlands, within the European context. Usually the scenario approach is applied, in every study resulting in a number of scenarios. Even in the case of scenarios with apparently the same characteristics, enormous differences in results appear. These differences can be explained by the aims of the studies. The crucial point is whether the scenarios are supposed to shed some light on the 'probable' or on the 'possible' futures.

Keywords: *Scenario studies, rural areas, Europe*

Studies and Politics

At least in The Netherlands, a striking contrast can be observed between a number of recently produced studies on the future of the rural environment and the political concern with this future.

To mention some of the most recent studies: there is the study 'Exploration of Rural Land Use' commissioned by the Netherlands National Council for Agricultural Research and the report 'Ground for Choices' from the Netherlands Scientific Council for Government Policy (NRLO, 1993 and WRR, 1992). The DLO Winand Staring Centre has issued its Rhine Basin Study a volume entitled 'Past, Present and Future of Land Use' (Veeneklaas et al., 1994). The Netherlands Agricultural Economic Institute recently published a report called 'Agriculture 2015' (LEI/IKC, 1994).

In these reports the future of agriculture is mainly highlighted. Environmental aspects of agriculture play also an important role in each of these studies and so does the future of nature conservation. A number of other studies have these aspects as their prime focus.

And then politics. In the recent Policy Agreement of the newly formed government in The Netherlands - a document of roughly 40 pages - only one sentence is devoted to this subject. I quote: "On the rural areas an active innovation policy will be executed in which agriculture, nature and tourism will develop and modernize together" (Regeerakkoord, 1994). That is all: a harmonious modernization. To the consolation of the Dutch part of the audience I may add that the attention paid to the future of agriculture is 100 % greater: two sentences. The word 'physical planning' is not even mentioned in this policy program for the next four years. So, obviously we must - to put it mildly - not be too optimistic

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about the political response to all the future-research presently being undertaken in this country.

In the area of physical planning, the use of scenarios is not a new phenomenon. On the contrary. In The Netherlands the origins of future-research in general has been especially located in the realms of the economy and of physical planning. The relationship between scenario building and physical planning is even more obvious. The present popularity of the scenario approach in The Netherlands is, next to international influence, in many respects due to the work of the National Physical Planning Agency.

The notion of alternative possibilities has always been present in the field of physical planning. More than the economy, the population density of the country required planning of the existing space vis-à-vis the different claims. Planning requires a design or a concept, an idea of the direction in which processes of allocation should be corrected. The inherently long term character of physical planning thus almost automatically leads to a search for alternatives. Not only in an explorative sense: 'where are we heading?', but also in a normative sense: what future images, designs or concepts are desirable or feasible?

This almost natural preference for the scenario approach in the field of physical planning has resulted in a rich history of alternative concepts, as well for the urban future as for the future of rural areas. But as far as the rural areas are concerned the range of these alternatives was rather narrow, at least when considered in retrospect.

In the seventies and the early eighties, in future research as well as in government policy in The Netherlands, the future of rural areas was more or less taken for granted, and so were their problems. Traditionally land development always got much attention, but for a long time mainly from a farm-economic perspective. Of course, agricultural developments were not considered to be without problems: the steadily diminishing employment, for instance, was considered as worrisome. Also, the environmental impact of agriculture gave reason to adapt practises and to tighten regulations. But the claims to land use by the different functions were more or less considered as given. Alternative concepts referred to different ways of linking or separating these functions.

This situation has changed drastically now. It has increasingly become clear that the future of rural areas is not any more that obvious, that agricultural prospects, because of market forces as well as environmental concerns, might change dramatically. The notion of possible overproduction was already incorporated in the proposals from 1968 of the then European Commissioner, Mansholt (Commission of the EC, 1968). But we had to wait until 1991 for the restructuring plans of the European Common Agricultural Policy, to see this translated into serious structural policy (Commission of the EC, 1991).

Although a general awareness exists of problems to be expected, one cannot say that there is consensus on their magnitude, nor that there is anything like a consensus about a new development concept. I think such concepts are urgently needed: an outlook dominated by problems and shrinking possibilities is very discouraging and might obscure the view to new possibilities. At the policy level some interesting initiatives have been taken, such as the National Nature Policy Plan (Min. LNV, 1990). But still a lot of work must be done to create promising perspectives. Scenarios can be of help in this endeavour.

Scenarios

Before going into the characteristics of some of the produced scenarios, I would first like to dwell briefly on the scenario approach itself: what are scenarios and what are they not?

Scenarios are supposed to have three elements: 1) a description of the present situation, 2) a number of alternative futures and 3) possible pathways connecting the present situation with these images of the future.

There are two categories: the so-called *projective* and *prospective* scenarios (Van Doorn & Van Vught, 1981). Their common characteristic is that they both aim to explore alternative courses of development. But the lines of reasoning differ between the two. In projective scenarios this line runs from the past, through the present to the future. Given present dynamics, how might things change in future? The line of reasoning in prospective scenarios, on the other hand, goes from designed future-images back to the present situation. Here the effort comes down to *backcasting*. Given future possibilities or desirable future situations, how could these be realized?

The scenario approach is different from forecasts or predictions in which the ambition is not to explore possible futures or the feasibility of desired futures, but rather to describe the most probable future, the future to be expected. The forecaster tries to make a best guess on what the future situation *will* be.

The difference in philosophy behind the forecasting and the scenario approach is important. If the development of a phenomenon is considered to be governed by a strong momentum or an important built-in inertness, one might more easily decide to apply a forecasting or prediction approach. But when there exists a great deal of uncertainty about the future course of events, or a general feeling of dissatisfaction with the present situation and tendencies, the scenario approach is more suitable.

Future-thinking in the short term can often be more of a forecasting nature. In this case factors that are related to the subject may safely be considered as remaining constant or of a known dynamic. But in thinking about long term developments one must reckon with the possibility of important changes in trends, even when they seem very vigorous now, as well as changes in behavioral relations which now appear stable. This explains why scenarios are often used when studying long term developments.

This description of both approaches is of an idealized nature; in practice the differences are not that great. In scenario exercises one can often see a base-line scenario in which present developments are extrapolated or projected. And in exercises with a predictive ambition, the existing uncertainty about important parameters is often translated in a set of *variants*, together constituting the 'plausible' range of possible outcomes. Very often this results in a 'high' and a 'low' scenario. This is now standing practice in many areas of future-research.

There is more overlap between the two approaches. One might say that statements on the probable future are in fact also 'what if' statements, as is explicitly the case in the scenario approach; results are essentially always conditional on the chosen assumptions. Although many users of future-research expect to hear unconditional statements, namely what the future will be, and researchers are sometimes too eager to give in to such a tempting role, in honest moments the forecaster must admit that this is really 'a mission impossible'. So, the methodological character of scenarios and predictions is much the same.

However, mixed as reality often may be, the underlying question in both approaches remains very different. Interest in the future to be expected, including its variance, is really something else than being interested in what could happen or should happen. In a predictive approach one is interested in the future as determined by historical regularities. In a scenario approach one is interested in the openness or the possibly surprising nature of the future, in deviations from trends.

From this short discussion it becomes clear that the choice of which approach to follow is not all that obvious. However, a judgement is required about the lasting character of present developments. Unfortunately, the dynamics in many fields are often poorly understood. Even in the case of demography, which is one of the best documented areas in future-research, researchers have frequently been surprised by important deviations from their expectations. Empirical reality has often overruled expectations in a very decisive manner.

We should be very much aware of a cultural bias in our thinking about the future. We have in mind all kinds of future expectations, formed by history and by the interaction of all kind of institutions. Because of these often implicit expectations we consider certain developments as so evident that we can hardly imagine any change in their dynamics. From our own research it appeared that, in future studies, thinking in terms of the continuity of present developments is almost commonplace. Reverses in trends are very hard to imagine, not only by the general public but also by experts in future-studies (WRR, 1989). But, as societies are not mechanistic entities, the possibility of dramatic changes can never be ignored. Such breaks in trends which seem to be evident occur very often. I think that, 30 or 40 years ago, nobody would have foreseen the shift in the growth of productivity in agriculture in the past few decades, or the spectacular growth in tourism.

Future-researchers of course know all these things. Not only is a lot of effort put into the refining of models used to approach the observed reality as closely as possible. With this kind of improvement one stays within the continuity paradigm. Another reaction is to pay more attention to alternative developments.

In the famous study of Ascher (1978) it was shown that the accuracy of forecasts or predictions does not depend so much on the level of sophistication of the model used, but on the assumptions about the context of the subject studied. So in predicting the future of Dutch agriculture, the model describing this agricultural system itself is not that important. What really matters is what is to be assumed concerning the development of the European Union, the diffusion of technology and so on.

Different approaches of recent studies

What strikes the observer about the studies I mentioned earlier, is that all of them appear to have learnt the lesson of Ascher. None of them aims at predicting the future. The obviously existing uncertainty is expressed in the use of scenarios based upon differing assumptions about some of the external conditions. The choice of these conditions differs between the studies. Sometimes differing demographic developments are chosen (Veeneklaas et al., 1994), or the presupposed dominance of an economic mechanism, be it market or co-ordination by state intervention (NRLO, 1993). In another study it is the difference in economic performance by the main powers in the world economy that makes for different scenarios (LEI, 1994), and finally, in one study, scenarios are based upon a presupposed difference in the goals of the European Common Agricultural Policy (WRR, 1992).

I think nobody can deny the relevance of all of these factors. The point is of course how these factors are to be used, and here the studies show an important and interesting difference. All of them try to outline the plausible scope for developments. Nevertheless an enormous variation can be observed in the results when it comes to agricultural employment to be expected, or the amount of land to be used for agriculture or for conservation of nature. I think what contributes most to this is that the majority of the studies mentioned can be characterized as projective scenarios, whereas the one with the most extreme outcomes - Ground for Choices - is more of a prospective nature. In the first category, the question is: what is the plausible scope for future agriculture given present tendencies, whilst, in the second, it is: what is the plausible scope given what may be possible in future?

Let me take as an example two studies with an enormous difference in results, even when it comes to scenarios with apparently the same characteristics. First of all the report, 'Ground for Choices', which explored the agricultural perspectives of the European Union (WRR, 1992). When no change occurs in our diet, in The Netherlands, a reduction of the area used for agriculture might be possible between at least 10 percent in a European scenario governed by free market mechanisms and almost a hundred percent in the case of a scenario with a high priority in Europe for nature development. In this latter scenario there is in The Netherlands no place for any land-based agriculture. Other areas in the Community are then much more suitable. In the study 'Exploration of Rural Land Use', having about the same time horizon of 25 years ahead, the range is much smaller and goes from a 7.5 percent reduction in the case of a free market scenario to at most a reduction of only 12.5 percent in the case of the so-called ecocentristic scenario (NRLO, 1993). When it comes to agricultural employment the differences between the two studies are equally striking.

The strongly diverging impact on the prospects for rural areas needs no further comment. I would also say: 'poor government, if it is confronted with such tremendously divergent information'.

I will not act here as a judge and tell you who is right or wrong, being very well aware of the many heated disputes between adherents of the two approaches. It is the basic assumptions of both studies that make for the difference and discussion should focus upon these.

As said before, 'Ground for Choices' has primarily the character of research into possibilities, deliberately ignoring inertness on national and European levels that may prevent realisation. 'Exploration of Rural Land Use' is more an attempt to stay closer to the notion of the probable future, thereby stressing the impact of now known economic mechanisms, comparative advantages of the Dutch agricultural system, etc. In 'Ground for Choices' no prediction was made, albeit that in discussions after publication many people took the results for a forecast. To put it differently: 'Exploration of Rural Land Use', by stressing the inertness of the system within a presupposed dynamic external environment, tries to explore 'the plausible' as an extension from 'the probable'. 'Ground for Choices' explores the upper limits of what in theory could be possible if the suitable land in the European Community is used to its maximum potential and argues from this theoretical possibility to the plausible.

The concept of 'plausibility' is crucial here. Although it is sometimes used as a weak form of probability it stems from a different source. Probability has everything to do with a methodological framework. Plausibility has, by itself, no scientific status, although it plays an important role in the formation of hypotheses, in changing parameters when during the work first results seem too odd. It refers to the realm of pre-scientific knowledge, to what we, with all our experiences, can imagine as quite possible. As such it comes close to what was earlier said about expectations and the existence of a widely held image of the future. We consider a future event as plausible when we have seen it before or elsewhere. So, when we mention a set of scenarios as together defining 'the plausible range of possibilities' we rest heavily on what history has taught us so far. That the future might take another course can easily escape our attention.

It has already been said that there is ample evidence of the surprising character of the future. For better or for worse, both in a utopian and a non-utopian direction. The re-appearance of civil wars in what we once thought to be a civilized Europe is a harsh illustration.

In my opinion long term thinking is pre-eminently an area of thinking to counteract the supposedly evident character of the future. Where the future image held by so many, by those in power or in the mass media, is often so non-surprising, exploration of the future must try to widen the perspective. Future-research should create countervailing ideas. The addressees of this type of information are seldom grateful for it. Nothing is easier than to stick to a generally accepted paradigm, by which priorities are nicely ordered and so on.

With these statements I do not condemn predictive approaches nor consider research into theoretical possibilities as the only true approach. A predictive approach may also act as an eye-opener, be it in the magnitude of a problem or in the finding of surprising combinations. Possibility research may underestimate resistance to change or overestimate the ability of governments to rush ahead of their constituency.

Both approaches should be developed to the full. But the real challenge is to reap the fruits of a clash between the two: namely to formulate questions that could not be asked before.

To me the surprising result from 'Ground for Choices' was first of all that an upper limit in productivity could be defined at the level of the European Union, but even more in showing that this limit is not a remote possibility but almost reached in some countries, such as Denmark and The Netherlands. For that reason - given the still enormous potential for growth elsewhere - the comparative advantages in this country once thought to be permanent may come increasingly under pressure. The much more moderate outcomes of the study 'Exploration of Rural Land Use' as compared to the ones of 'Ground for Choices' leads to many questions like: how remote is 'the possible' from 'the plausible' and which factors stand in between?

Relation to decisionmaking

Although differing in approach and results, the studies all agree upon the direction of the changes to be expected. The character may differ according to policy efforts and priorities, but rural areas in Europe will be confronted with less agricultural employment and cultivated area, and also with higher environmental requirements. Although the magnitude of the problems to be expected differs between the studies, all point to the necessity of developing new perspectives for land use and employment. As is often the case: threats can also be seen as challenges or opportunities. The scenarios in the different studies can also be seen as first attempts to develop new concepts, for instance by looking into possibilities for agrification, forestry, development of new nature areas, tourism and urbanisation.

However, the radicality of the options presented for consideration differs. 'Ground for Choices' goes a long way, suggesting the possibility even of a complete departure of land-based agriculture from The Netherlands. Of course, it is a theoretical possibility. But this is not the same as suggesting that it could never happen. The recognition of this option as a possibility forces us to make up our minds as to what we really consider desirable or worthwhile to preserve, possibly at a high cost. In this country, with one of the highest population densities in the world, there are many claims on land. Why frustrate these claims when eventually agricultural functions could also, or even better, be located elsewhere? Why are we not grateful that more land could become available for other purposes? This 'thinking-the-unthinkable' option compels us to become aware why such a development is so much more dramatic than for instance the earlier disappearance of the mining industry or the textile industry from this country. Next to the obvious socio-economic functions of agriculture, I think it has also much to do with how we cherish our landscapes and with how closely agriculture is related to what we appreciate in our public space.

Less extreme options, which according to our expectations are perhaps more plausible, of course also pose the question of the desirable make-up of the country. I think we must admit that especially when it comes to this physical make-up, it is much easier to decide on what to preserve than on what to create. 'New skylines' are something that we associate more easily with cities than with rural areas.

There is still an enormous gap between the dry statistics and figures in all the studies mentioned and integrated concepts for restructuring the rural areas which eventually must or may evolve. Not only are the options presented still in a rudimentary stage of elaboration, and there is hardly any integration of information on the prospects of agriculture, forestry, nature conservation, tourism and so on, but they also lack the proper shape for an evaluation. What we need beyond concepts-on-paper are designs of possibilities, especially because of the functions other than economic that different kinds of land use represent.

A beautiful example of what I mean is the exhibition, The New Netherlands, from 1987 (Stichting NNAO, 1987). It visualized what urban and rural parts of the country could look like in 2050 if certain scenarios were to be realized. In these designs information on different subjects had to be brought together.
By presenting in a visual way sharply opposing ideas, this exhibition was not only challenging the dominant opinion at the time that The Netherlands was to be considered as more or less complete. This presentation also offered a splendid opportunity for evaluation. By being literally able to look at possible futures, one could become more certain than before about the desirability or undesirability of certain ideas.

Of course a design as such also shows only part of a possible option, the dry numbers and figures are not less important when it comes to employment and so on. But especially when it comes to a subject so closely connected with our visual experience, the two belong together and complement each other. It is also a perfect means to create a greater involvement in the future of a more general public than politicians, planners and future-researchers.

All in all, to bridge the gap between the scenario information and planning, designs are an important tool.

Europe

In this presentation I cannot avoid making a final observation. As said before, all of the studies mentioned locate the perspectives of Dutch agriculture against the background of the European Union, albeit in different ways and with a different weight. But which Union?

Where all studies try to say something about Dutch agriculture in 2015 and ahead it is remarkable that so little attention is paid to the changing political panorama in Europe and its consequences for European and Dutch agriculture. Here actual developments run ahead of the expectations of most of the future-researchers. Of course it is difficult in future-studies, which usually last at least a couple of years, to avoid lagging behind the changing reality. It might also be true that we are influenced too much by stories about stagnation in further European integration. But we might thus easily overlook the fact that decisionmaking concerning new members is accelerating under strong German pressure.

According to present plans, agreed upon by European leaders in Helsinki and Korfu, it might be expected that between 2005 and 2010 the European Union will number 27 full members (present 12 plus EFTA plus Poland, Hungary, Czechia, Slowakia, Bulgaria, Rumania, Baltic States, Malta and Cyprus), perhaps even 29 (Slovenia and Kroatia). Of course, it is not at all clear what 'a full membership' will mean in the future, now that the French and the Germans have started to talk about a 'hard core' within the Union, and the British also opt for a variable speed.

But whatever model might evolve, it is hard to imagine that such a huge extension of the Union in an eastern direction would not have tremendous consequences for the agriculture of the present members.

I think the time has come now to take full account of this development, including its varying future possibilities. The widening of the Union not only creates new markets but also adds an enormous new agricultural potential to the Union. These countries comprise a lot of good agricultural land that at present is only modestly utilized. The potential for a rise in productivity seems tremendous, in arable farming as well as, for instance, in horticulture. If this potential were to be realized, important effects could be expected for agriculture not only in these countries themselves but also in the older members of the Union.

With this subject a whole new area for future-research is opening up, ranging from elementary fact-finding to scenarios of a projective and prospective nature.
Many questions arise, such as the speed and nature of the transition process in these countries, the role and impact of newly-built institutions, the comparative prospects of different instruments promoting this transition, land evaluation as a basis to assess the potentials, market developments, differing models of integration and so on. Here too there is ample room for different approaches which - as they are properly interpreted - may not only complement each other but also may result in an increase in our understanding of threats and opportunities for the next few decades.

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1.3 The future's future

Inherent tensions between research, policy and the citizen in the use of future oriented studies

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Abstract
In this paper some thoughts are advanced on the future of future-oriented research in general and the use of the scenario approach in particular. My observations are based on experience as a policy maker and, more recently, my experience at the Winand Staring Research Centre.
First, I will dwell briefly on the purpose of scenarios, as seen from different points of perspective and by different users. Then, a short historical excursion will be made reviewing the use of future-oriented studies in The Netherlands in the post-war period, for physical planning, economics and environmental policy. Finally, some conclusions will be drawn, and some recommendations formulated for scenario builders.
Keywords: *future studies, scenarios, planning, contingency*

The various purposes of scenarios

Scholars define scenarios as descriptions of the current situation, of a possible or desirable future and of the series of events that could lead from the current state of affairs to this future state (see contributions of Schoonenboom and Veeneklaas & Van den Berg in this book). Clear causal relations, either incorporated in formal models or by qualitative reasoning, should elucidate the main driving forces. Consistency and coherence in the philosophy behind the scenarios distinguishes scenario studies from simple prognoses in which only one or a few parameters or assumptions are modified.

A distinction is made between projective scenarios and prospective scenarios by designers, starting out from the desired situation, which is not automatically a possible one. By their nature these scenarios are normative. Backcasting to generate the required time-steps and measures to arrive at the desired future may be included, but not necessarily so.

Analytically, it might be attractive to elucidate driving forces and think consistently; in practical use, however, it might be a perilous way to proceed. Going for a drive for instance (with your car as driving force), there is little chance that a consistent strategy will result in the most useful, economical or safe use: consistently taking left turnings won't lead you anywhere, neither does consistently alternating between left and right.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 25–32.

Also, driving consistently at 100 km per hour on a highway is highly dangerous. All consistent scenarios tend to lead to extremes.

More comprehensive and integrated scenarios make the number of variables increase drastically. A large number of explicit choices is required, which easily leads to getting lost in a forest of possibilities and to arbitrary pathways ultimately decided upon. No wonder Schoonenboom (see preceding section) maintains that scenarios must be informative in that they place corner flags, delineating the range of possibilities. By asking ourselves the question which of the possibilities are plausible, we enter the realm of subjectivity.

Policy makers generally state that the aim of scenario building is to structure and stimulate a society-wide discussion so that governments, business and other organisations can make better strategic decisions. Schoonenboom suggests that scenarios should lead to a different perception of the current state of affairs and towards reorientation of our actions. The social function of scenarios in his view is broadening the perspective.

Here we have in a nutshell the crux of the discussion about scenarios.
Scientists put the emphasis on the exploration of possibilities via consistent, lucid steps.
Designers, on the other hand, make a leap towards a desired future.
Politicians and policy makers, are mostly interested in the use of scenarios and the accompanying society-wide discussion. For these groups, the scenarios' capacity to frighten or to seduce is an important attribute. Moreover, they are especially interested in the domain of plausibilities, boundaries of which are considered rather arbitrary by scientists.

Experience with scenarios

I will try to illustrate the history of thinking about the usefulness of future oriented studies by the experience of their use in Dutch planning. In The Netherlands forecasts and other future studies are mainly used in physical planning, in the field of economics and, in recent times, also in environmental policy.

Physical planning

In the '50s and '60s expectations on economic growth, technological progress and the consequences of both were optimistic, generally speaking. High expectations too existed concerning the predictive power of forecasts and scenarios and the ability of government to steer, manage and control developments. Both the effects of technology and the range of socio-economic variables, however, turned out to be hard to predict. Moreover, room to manoeuvre for government appeared to be limited.

When scenarios are looked upon as predictions, the resulting plans can act as blueprints. We see that in the sixties (extreme) scenarios led to far-reaching plans for housing, roads and electricity supply. With hindsight we can count ourselves lucky that many of these plans, e.g. those for road-construction in the mid-sixties, were never put into effect.

In the '70s and '80s, the reaction came: increasing uncertainty about technology, predictability and the role of government. The latter was gradually reduced from that of active intervention and control to one of adjustment and correction. Scenarios, originally supposed to reduce uncertainty, turned out to be unable to do so. At most they were helpful in defining and classifying different types of uncertainty. Furthermore, the concept of plausibility moved towards the centre stage.

Though more integrated scenarios with various alternatives were made, their usefulness was limited. Not a single interest group wanted to endorse the alternatives put forward by the government, or - more precisely - by its civil servents, because they were all the result of a more or less arbitrary package of choices. And among these alternatives the middle-of-the-road one became a bloodless compromise, not appealing to anyone.

In the eighties and especially in the nineties physical planning was made more explicit in order to promote public discussion. Scenarios were useful in that context. Reducing uncertainty gave way to issues of public and political choice. How can we agree about what we want? This had to do with the awareness that the government was less able to control developments in society than formerly assumed: government started to seduce, to invite comments. An illustration of this is the phenomenon of 'demonstration plans', whereby the government has set aside funds for the most promising solution, put foreward by professionals in cooperation with local interest groups. Their effectiveness sometimes turned out to be greater than official plans.

Economic scenarios

In recent decades macro-economic scenarios were popular among policy makers. The economic projections, however, turned out to be highly contingent: expectations, e.g. on economic growth, are very much products of their time. They alter considerably from period to period but within one period a broad consensus tends to exist.

With respect to economic future-oriented studies, an interesting phenomenon occurs. In The Netherlands, election programmes of the main political parties and the Government's Budget have over the last few years been submitted to the Central Planning Bureau for quantitative assessment. As a reaction, we see that the political parties formulate their programmes in such a way that they produce the best results from the model. Nevertheless, nobody seems happy with the results. In parliament, politicians declare that they should be guided more by their own judgement because the predictions never prove to be correct. The same politicians who wish to decimate the number of advisory councils and planning bodies are simultaneously asking for competing agencies to assess economic plans as they are unsatisfied with the results of the Central Planning Bureau.

In the economic scenarios we seem to carry on calculating until we get the result that suits us. In this context, scenarios obtain a legitimating function. What seems to be lacking are economic scenarios of a prospective kind. The ability to design these appears to be the prerogative of those who are critical of current social structures.

Environmental scenarios

Since the Limits-to-Growth study of the Club of Rome, there have been many environmental forecasts. Environmental scenarios tend to be of a pessimistic kind. This is, at least partly, inherent in the very technique of scenario building.

Doomsday scenarios often have (for a time) considerable influence on the political agenda. At the same time, however, it soon becomes apparent that it is difficult to translate environmental scenarios into concrete policy measures. From the point of view of the science of public administration it is explainable why the original enthusiasm runs dry. Genuine change only comes about when the problem and the solution appear at the same time on the political agenda (Figure 1). In terms of scenarios: we need not only corner flags but also a projective scenario for a possible and desirable future.

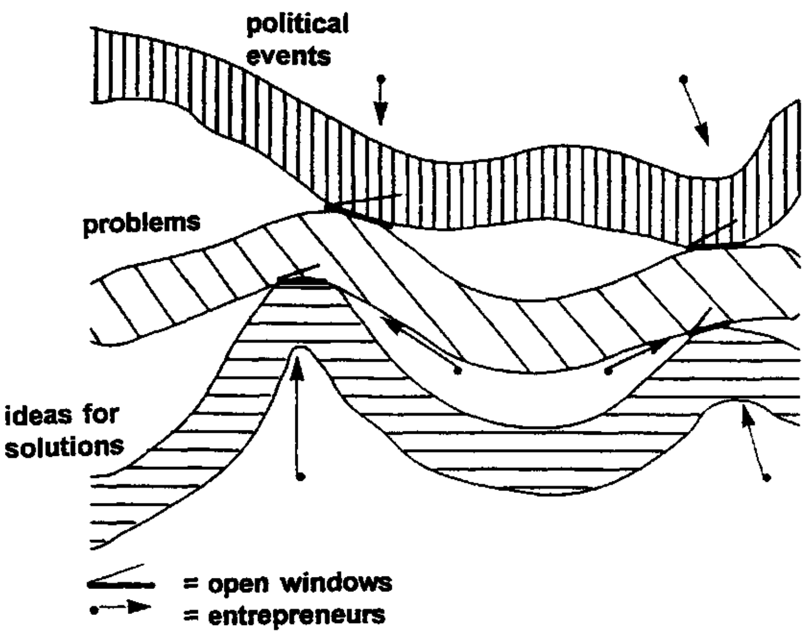

Fig. 1. Flow model by Kingdon (1984), showing that when political events, problems and ideas for solutions coincide, 'entrepeneurs' can act as 'policy windows' open.

Another reason for the limited impact of environmental scenarios is formulated in a recent report by the Netherlands Scientific Council for Government Policy (1994): "It is really no wonder that again and again we fail to satisfactorily meet the agreed aims of environmental policy. These aims are formulated exclusively on the basis of ecological advisability, but have to be achieved by sectors of society whose interests in the determination of the goals played no role whatsoever."
Even if the resilience of the environment could be determined in an objective, scientific way, it would still not be possible to deduce clear preconditions and unambiguous norms for human behaviour.

The philosopher Pirsig (1991) has developed an interesting way of thinking on this. He sees the definition of quality as an expression of a specific set of values, whereby he distinguishes four, static 'patterns of value', which he puts in a hierarchical order. Inorganic value patterns are at the lowest level, followed by biological value patterns, social value patterns, and - at the highest level - intellectual value patterns. A careful distinction should be made between the different levels. Each has its own specific qualities; weighing must however be done at the higher levels.
Above the static quality of these levels there is dynamic quality, which refers to the necessity of change. Dynamic relations between the levels are necessary but norms of a lower level can not simply be used as a dictate for higher levels.

Some conclusions on the nature of scenarios

The first conclusion is that scenarios are primarily contingent in the sense of being a product of their time. Assumptions vary considerably but they always start out from the continuity of the recent past. In particular the effects of new technologies appear to be extremely difficult to predict. Major social, cultural and political changes, like the collapse of the communist regimes, have hardly been foreseen.

A second conclusion may be that projective scenarios tend to be either arbitrary (in the case of comprehensive, integrated ones) or with a strong doomsday message (in the case of a rather narrow focus on e.g. environment).

A third conclusion is that prospective scenarios from governments are unlikely to receive much public support nowadays.

Improving the effectiveness of scenarios

Let us turn to the future of future oriented studies: what can we expect of the use of scenarios from an action-oriented, pragmatic perspective.

Of course we will continue to improve scenarios scientifically along different lines. All kinds of studies will be carried out to explore what is possible and what is desirable. Scientifically speaking there is a great challenge in relating the levels of Pirsig.

However, writing scenarios will in any caseanyway tell us more about our perception of the presentday world than about the future. Improving the power to predict is an illusion. In the natural sciences we know that small causes can have far-reaching consequences. In the social sciences we can hardly speak of a theory of human behaviour, certainly not in turbulent times. The predictive power of sociology and psychology is so low that it plays virtually no role in politics (Michael, 1985). Moreover, if we do not even agree on history, how could we agree on the future?
Nevertheless we must act, make choices. How can scenarios be of help? Philosophy and experiences in public administration might offer some guidance.

The contribution of philosophy

At first sight current philosophy does not look all that inspiring for scenario makers. The postmodernists, like Lyotard, paint a society without big ideals. This is in accordance with the most recent experience with scenarios. According to the postmodernists we are not on the way towards a new cultural phase but towards an intensification of existing middle-class culture with personal discretion and hedonistic consumerism as key elements. Fukuyama's view (*The End of History*, 1992) is the ultimate of contingency: everything remains the same. Liberal economies in autonomous countries.
The American philosopher Rorty is a more interesting figure for builders and users of scenarios. In his book *Contingency, irony and solidarity* (1989) he too maintains that all our ideas are contingent, products of random historical circumstances. But his conclusions are different. He sees philosophies more as means to reach certain goals than as a depiction of universal, essential principles. In his view fundamental insights cannot be considered to be the expression of a particular kind of knowledge but rather as stories in a particular vocabulary. If we recount the stories of philosophers, novelists, natural scientists and social scholars in each other's vocabulary, then we can communicate. But no-one can claim absolute truth; every tool must prove itself in practical use.

Via Rorty and Pirsig I come to experiences in the field of public administration which point roughly in the same direction.

Experiences in public administration

Hierarchical planning is becoming less successful and is increasingly replaced by a new concept of network planning. To make plans work, the parties involved in their execution must also be genuinely involved in drawing them up. Government is merely one player in the game. This form of network planning implies the acceptance of different definitions of reality. Rorty and many others have pointed out the importance of this. Definitions

of reality differ not only per professional group (see e.g. the contribution of Van der Ploeg in this book) but also per region.
Kingdon (1984) points out that problems, political agendas and solutions must be brought together to get things going (Figure 1). Divergence of perceptions and definitions of problems and solutions might constitute an even bigger problem.

Bringing the ideas of network planning, of Pirsig, of Rorty and of Kingdon together, I discern, from an action orientated perspective, an interesting field of use for scenarios at the regional level.

The future's future: a scenario

In the last few years I have been involved in the implementation of integrated plans for regions with very complex problems such as the Rotterdam harbour area and a district nearby Wageningen - the Gelderse Vallei.
What does this experience tells us about the use of scenarios in these policy making processes?

1. The citizens, organisations and politicians in these regions are often unaware of the significance of national scenarios for environmental and other policies regarding their region. And if they do know it, they don't feel it is their concern. Conclusion: scenarios should be translated to the regional level.

2. People have their own problem perception. In consequence, it is important to assist them in making their own projective scenarios to identify the problems they may encounter (see also Bryant's contribution in this book). Sometimes global projective scenarios by the government might be of help: if they are frightening enough it can motivate people to negotiate. My experience is that people only want to bargain if they know what they want (or want to avoid).

3. An overdose of plans from various policy areas and planning levels exists. The hierarchy and relative importance of such plans are seldom clear. The result is "plan fatigue". When, as a reaction to this, the government makes integrated plans, this is not particularly helpful (see above). Instead, the different parties should be assisted to articulate their own interests and wishes.

4. Parties tend to hide behind the alleged need of further research or endless calculations of alternatives. Under these circumstances, a neutral facilitator who focuses on the substantial arguments might be helpful.

5. Do not work with contrasting alternatives at the end of the planning process, as they may polarise the problem. Seek for packages that are satisfactory (though not perfect) to all participants. Let the solution emerge from the negotiations. After that, there is time for a design/prospective scenario.

6. Effective scenarios not only bring problems and solutions together but put them on the political agenda as well. For researchers: to be effective, make sure that you are in touch with policy makers and politicians.

Integrated plans, including those made for the long term, are extremely contingent. The added value is to be found primarily in agreement on a common point of departure and a jointly developed set of criteria for dealing with future developments.

I would like to conclude by paraphrasing Rorty:

We tell each other stories: no-one has a monopoly of the truth, so let's discuss.
We must be ironic: we must be conscious of the contingency of our convictions.
We must be solidary: we have to make the world a better place.

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CHAPTER 2

Tools for scenario building

2.1 Optimization of regional water management (quantity and quality) through scenario analysis

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Abstract
Uncontrolled socio-economic development of a region often leads to environmental degradation. In this paper we will focus on regions where the hydrological systems provide a high degree of spatial integration. In such regions local human actions have impacts on a wider scale, leading to conflicts of interests between e.g. agriculture and nature. It is the task of regional and national authorities to provide the control that is necessary for achieving a balanced and sustainable development. Scenario studies can provide useful information for taking the right decisions. The conventional method of decision-support is through evaluating scenarios with a simulation model. A more powerful method is to use an optimization model. In the latter case the role of the decision-maker(s) is essentially different: instead of being asked to specify the scenario, the decision-maker is asked to specify aspirations concerning the various interests. The model then supplies (if possible) the scenario for achieving that. By using an optimization model better use can be made of the possibilities that a region has, thus minimizing the conflicts of interest between for instance agriculture and nature. The methods are illustrated with case studies that involve both water quantity and quality. In the *Groote Peel* study the use of an optimization model increased the effectiveness of externally supplied water by 20%. We conclude that in principle an optimization model gives better decision support than what can be given with just simulation models. But it requires a greatly improved integration of modellers in the policy making process to actually reap those potential benefits. In the case of water quality problems, maximum benefits from using an optimization model are obtained if measures aimed at reducing the influx of contaminants are taken in conjunction with water *quantity* measures. In order to reap these benefits there must be a high degree of coordination between government agencies responsible for the different aspects of integrated water management.
Keywords: *integrated water management, scenario study, simulation, optimization*

Introduction

Intensive development of a region puts a heavy pressure on the natural environment. If left uncontrolled, this often leads to degradation of natural eco-systems; more often than not the various human activities also interact unintentionally. This is especially so in regions where the hydrological systems provide a medium through which interactions take place between activities at different locations within a region. This can lead to conflicts between various interests. Below we will shortly consider some of the most common causes of regional water-related conflicts in The Netherlands, which are schematically indicated in Fig. 1. Both water quantity and quality are involved.

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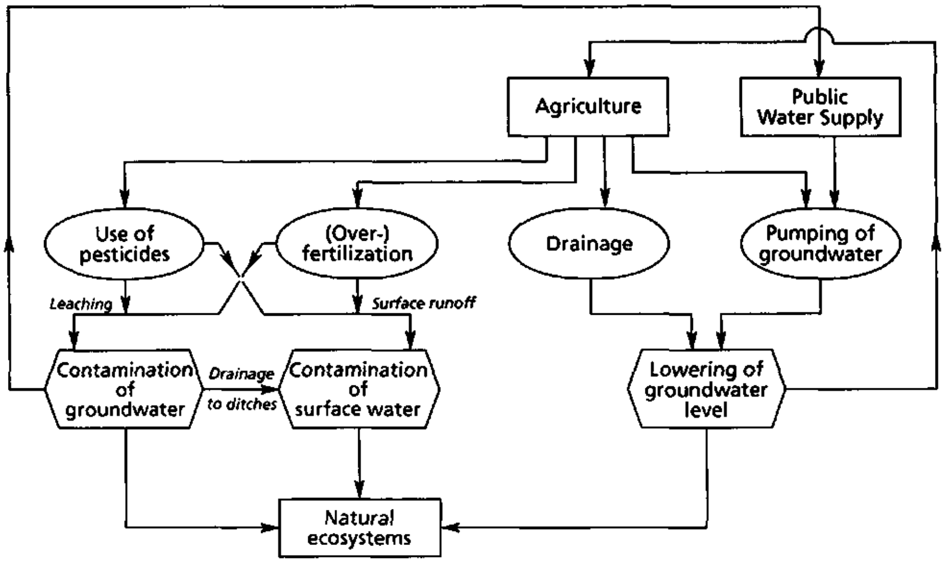

Fig. 1. Some interactions of agriculture, public water supply, and natural ecosystems through the regional hydrologic system.

Subsurface drainage systems serve to remove excess precipitation once the watertable has risen above a certain threshold. For agriculture this has the advantage that in spring the land can always be prepared in time for the new growing season. The crops themselves also germinate sooner if the land is well drained, because the soil has a lower heat capacity and a better aeration status. An unintended local effect is, however, that the soil can become more drought-sensitive, because at the start of the growing season the water content is lower. On a regional scale there can be impacts too, especially if the subsoil has a high permeability. This can lead to lowering of the watertable in areas where it is not desirable such as nature areas with a 'wet' ecology. The lowering of watertables in spring can be especially damaging to the floristic development.

In dry periods soil moisture of agricultural lands is often supplemented by sprinkler irrigation, either from surface water or from groundwater. The latter can cause an extra lowering of the watertable during the summer period, which can have a negative impact on a neighbouring nature area. Also the groundwater pumping for public water supply can cause conditions in nature areas to deteriorate. On the other hand, the supply of surface water for the purpose of infiltration in agricultural areas (to locally raise the watertable and thereby increase the capillary rise of moisture to the root zone) can have a beneficial effect on a neighbouring nature area. This is, however, often not the case if the nature area is at a relatively low position and has upward seepage. It can then happen that the seepage water becomes 'polluted' with the water that has been used for infiltration, even when this water seems to be clean. In that case the 'pollution' involves the substitution of calcium-rich groundwater by water that is low in calcium.

In regions of The Netherlands with a sandy subsoil there is a tradition of highly intensive livestock farming using imported foodstuffs and producing an excess of animal wastes. These wastes cannot be disposed of by fertilization at a level corresponding to the crop uptake of nutrients. As attempts to convert the animal wastes to a form in which they can be exported are far below target, over-fertilization is the inevitable consequence. Most soils in sandy regions have poor retention capacities for nutrients. Excess nitrate is therefore easily leached, increasing the nitrogen concentration of groundwater. Surface runoff is a second mechanism for the undesired dispersal of nutrients in the environment. In particular, the phosphorus load on surface water has been increased through this flowpath.

The cultivation of most crops involves the use of pesticides. In recent years the toxic side-effects have become of increasing concern. These effects can occur through leaching to groundwater, thus polluting the resources needed for drinking water supply, and through runoff and drainage to surface water.

Central governments and regional authorities realize that measures are needed for attaining a balanced and sustainable development of a region. The complexity of the relations between water users and water subsystems, as well as the large number of possible alternatives for restrictive and remedial measures, make it hard to design policies for the efficient control of quantity and quality of water. Scenario studies can provide information that is of use in this respect.

We will first give an outline of the methodology for providing the decision support we propose. This is followed by descriptions of case studies that we have been involved in. Finally, some conclusions are drawn and a research outlook is given. Since the use of optimization models plays a key role in the proposed methodology these models are somewhat elaborated upon. Another key issue concerns the possibilities which are offered by integrated water quantity and quality management. Relatively little attention will be given to the simulation models used in the case studies, because the focus of the paper is on methodological issues concerning the optimization of water management.

Methodology

Schematic representation of water-related activities

For a scenario study to be of any use it is usually not enough to take just water quantity and quality processes into account. That is because environmental degradation also has its roots in the socio-economic development of a region. Therefore we view a regional system as consisting of two major parts: the environmental subsystem (water-related aspects) and the socio-economic subsystem. With respect to the latter the distinction is made between socio-economic elements that have direct interactions with the environmental subsystem, such as farmers and drinking water supply companies, and socio-economic elements that try to regulate these interactions, such as national and regional authorities. This is represented in Figure 2 (where nature areas are considered to be water users). Each socio-economic element has its own goals and preferences. The Regional Authority (RA) is assumed to represent the goals and preferences of all socio-economic elements in the region.

Water quantity and water quality can be seen in an ever widening context. In a scenario study it is therefore essential to define the boundaries of the modelling. This is done by specifying which variables are considered to be exogenous (i.e. determined by decisions outside the system) and which ones are to be endogenous (i.e. determined inside the system). For instance, land use and the policies of the RA can be treated as fixed circumstances (exogenous), or as endogenous variables.

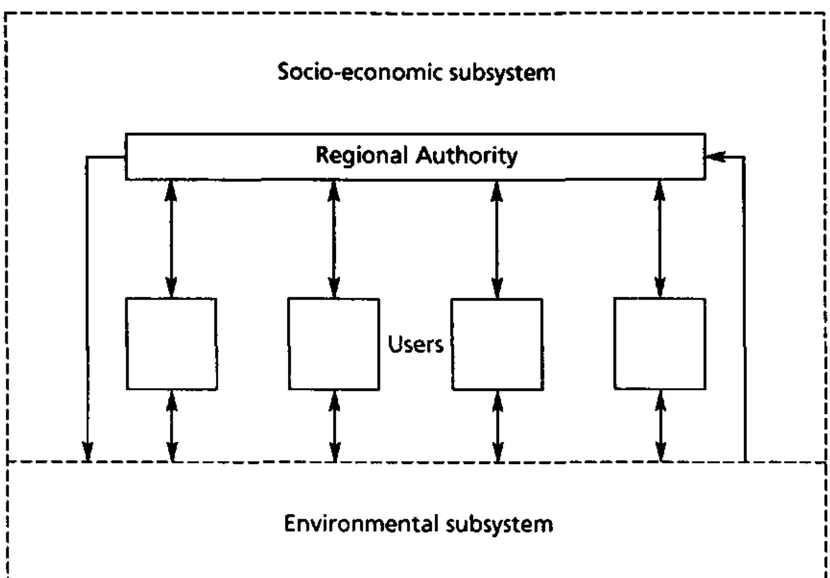

Fig. 2. Schematic representation of a regional system, as being composed of a socio-economic subsystem and an environmental subsystem.

A scenario for the water-related activities in a region defines a possible future state, in terms of exogenous and endogenous variables. The distinction between exogenous and endogenous in this paper is used at the level of the actual decision making problem that the RA is confronted with.

The endogenous variables can be further subdivided into control variables and state variables. The control variables are to a varying degree 'independent', thus allowing them to be chosen freely (to a certain extent). The state variables are invariably of the 'dependent' type, thus totally determined by exogenous and control variables. Some state variables are of special interest, because they give an indication of the 'well-being' of the regional system with respect to the interests of a group of water users. Such state variables are called 'indicators'; the total income from agriculture is an example.

Two-stage decision support system

In providing decision support it would be expedient to simultaneously consider the preferences and actions of both the users and the RA. Scenarios can then be produced that are efficient in achieving regional goals, and that are also acceptable to the users. This enhances the possibilities for implementation. It would however turn into a sort of defeatism if 'political realities' were to be respected right from the start of a scenario study. In order to explore the full potential of a region it can be an eye-opener to leave out this type of constraint in some of the scenarios. However, ultimately it makes no sense to formulate scenarios that can not be implemented due to lack of cooperation by for instance the farmers in a region. It is therefore essential to include a procedure that takes this aspect into account, so that the difference between assumed behaviour and predicted behaviour is kept within bounds.

Simultaneous consideration of the RA's preferences and those of the water users would require a formalized model for the behavioural responses to the implemented policies, and combining it with models of the processes in the water subsystem. Even if behavioural models were available, implementation into a single integrated model of the regional system would hardly be feasible, due to the complexities involved. For this reason we conceive the design of a desired future state of a region to consist of two separate stages with corresponding elements of the decision support system (Fig. 3; Orlovski et al. 1986):

- identification of the future possiblities of a region using a Scenario Generating System (SGS); at this stage simplified assumptions are made concerning the behaviour of the water users;
- analysis of the impact of potential water management measures using a Policy Analysis System (PAS); at this stage the actual behaviour of water users is simulated.

The Scenario Generating System can be used to generate scenarios that meet certain requirements with respect to indicators for the well-being of the different water users. The SGS generates a reference scenario that could be reached if all the water users would behave according to the simplified assumptions. In the first round of using the SGS one usually assumes that the water users behave completely according to the wishes of the RA, thus yielding the 'eye-opener' scenario mentioned above.

The Policy Analysis System can be used to analyse measures that influence the behaviour of the water users. If it turns out that the reference scenario identified by the SGS can not be reached, whatever policy the authority tries, it is apparently necessary to lower

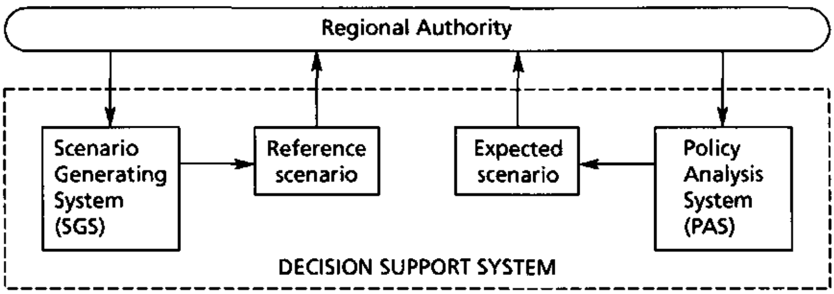

Fig. 3. Overview of a decision support system. For simplicity it is assumed that regional water management is in the hands of one (imaginary) Regional Authority. With the SGS (i.e. a formalized modelling system) future possibilities for a region can be identified. With the PAS (i.e. a non-formalized system) predictions can be made for the effects of potential water management measures. In using the decision support system the SGS and PAS can be used alternatively, starting with the SGS

the ambitions with respect to certain regional goals, and to use other simplified assumptions with respect to the water users. This leads to modified parameters of the SGS, or modified requirements, in order to ensure that more realistic scenarios are identified the next time a scenario search is made. So, the idea of the two-stage procedure is to switch between using the SGS and the PAS until convergence is achieved.

We do not have an operational model for predicting the behavioural responses of water users (see Vreke(1990) for an outline of a model for agriculture), so common sense is used for predicting reactions of water users to various measures. Even in this form the two-stage procedure (SGS/PAS) helps to clarify the decision support being offered to the regional decision makers, and is of use in structuring the interaction between the authorities and the system analysts involved in a study. Because a formal description of the Policy Analysis System is not available in the form of an operational model, in the rest of this paper attention will be focused on the Scenario Generating System.

Scenario generating system

Interaction with the decision makers
The conventional way of exploring the possibilities for a region is through making simulation runs for different scenarios that are specified by the RA (or an executive from it). In this method of decision support, values are given for the exogenous variables and for the control variables (Fig. 4a). The SGS then computes the rest of the scenario, i.e. values of 'ordinary' state variables and indicators.

This cycle can be repeated several times, in an attempt to find a scenario that satisfies the RA. Especially when the scenarios involve a spatial component, as is nearly always the case when considering regional water management, the number of possible alternatives can become very high. This also happens when water quantity measures are considered in conjunction with measures aimed at reducing the influx of contaminants. The conventional procedure for scenario analysis using trial and error then becomes very cumbersome and often not very effective. In such a case it becomes expedient to make use of an optimization model. The role of the RA then becomes essentially different: instead of being asked to specify the values of both exogenous and endogenous variables, the decision-maker is asked to specify aspirations concerning the various indicators (Fig. 4b). These aspirations can for instance be specified in terms of minimal achievement levels of indicators. The outcome of the model comprises in this case also the values of endogenous control variables, whereas these values are input data in the conventional method.

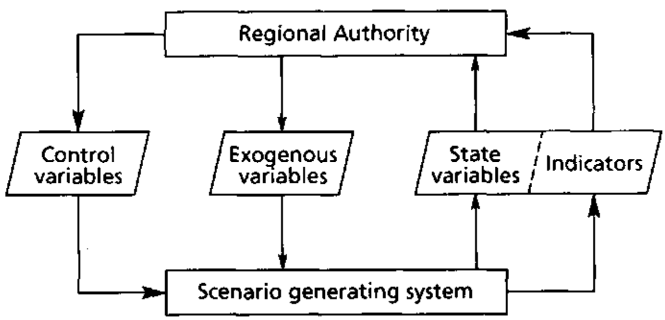

Fig. 4a. The conventional method for providing decision support in a scenario study. The Regional Authority specifies an alternative in terms of the exogenous variables and the control variables. The exogenous variables represent assumptions concerning the external circumstances, the values of control variables represent assumptions with respect to concrete actions taken by water users.

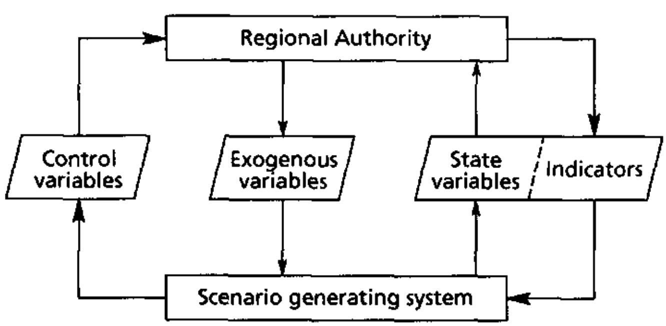

Fig. 4b. The optimization method for providing decision support in a scenario study. The authority specifies values of exogenous variables, and also aspirations with respect to the indicators. The Scenario Generating System then computes values of state variables and control variables.

A procedure for multi-objective decision-making can help the decision-makers in reaching a scenario that in their eyes forms a good compromise. The most simple is the so-called constraint method (e.g. Orlovski et al., 1986). In that method the RA specifies minimum levels for all but one of the indicators. The system then ascertains whether there is a scenario that meets these requirements; if so, it proceeds to optimize the value of the remaining indicator. Another method is Multiple Goal Programming (e.g. Veeneklaas, 1990): the RA is presented with minimum and maximum levels of each indicator, and is asked which of the minimum levels he dislikes most. He is also asked by how much he wants it to be improved. The SGS is then used for computing a new set of minimum and maximum values, taking the newly specified minimum-level into account, and so on.

Combining simulation and optimization
Most simulation models attempt to describe a system in great detail. They therefore usually contain complex transformations, through many steps. Such a model cannot be simply turned into an optimization model; for this their mathematical form is usually far too complex (see also Orlovski et al, 1986). This means that it becomes necessary to derive a simplified optimization model. Preferably it should consist of equations that are linear in the control variables, because this allows the use of Linear Programming (LP). Through special 'tricks' it is, however, possible to incorporate non-linear aspects in a linear model, e.g. through piece-wise linearization (Loucks et al., 1981). Another method involves the expansion of a term involving the product of two variables, and leaving out the non-linear part. For a certain class of problems (formal) non-linear programming can be used (e.g. Hillier and Liebermann, 1991). Here we will confine ourselves to Linear Programming because this is by far the most commonly used method.

Since there is usually more than one policy objective ('indicator'), a simplified model has to be formulated in such a manner that it can be used in conjunction with a method for multi-objective choice. The following form satisifies this requirement:

$$f = Cx$$
$$l \leq x \leq u$$
$$Ax \leq b$$

where: f - vector of objective functions
C - objective function matrix
x - vector of decision variables
l - vector of lower bounds
u - vector of upper bounds
A - constraint matrix
b - resources vector

The classification of variables given earlier relates to an LP-model in the following manner:

- exogenous variables can be found in different parts of the model, i.e. coefficients of C, lower and upper bounds, coefficients of A, and components of b;

- control variables are represented by decision variables;
- state variables that are not indicators are usually left out or eliminated by substitution (if they form a component of an objective function);
- indicators correspond to objective functions.

Such a model has to be effective only in searching for scenarios. For verification of promising scenarios simulation models are still needed. Thus the SGS involves the combined use of simulation and optimization models, as illustrated in Fig. 5. Not shown in the figure is the step that precedes the actual use of the SGS for decision support, namely the derivation of the simplified model. This can be done by simplifying the concepts, e.g. by completely linearizing the groundwater model. In that case the so-called

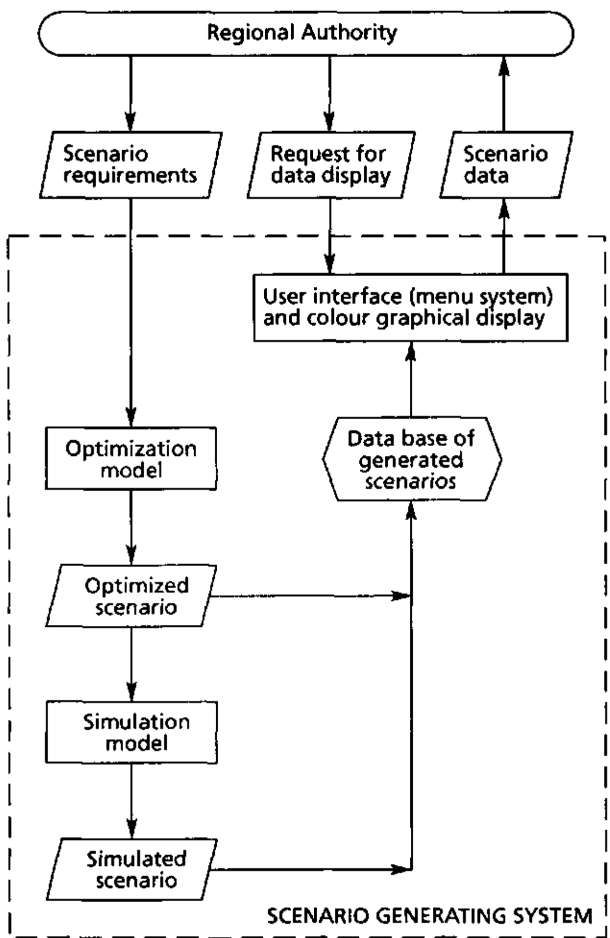

Fig. 5. Overview of the components of the Scenario Generating System and the way the Regional Authority can use them. An interactive system with colour graphics (Van Walsum, 1992a) can be used for visually analysing obtained results

embedding approach can be used (see e.g. Gorelick (1983) for an excellent overview of groundwater management models). Our experience has shown, however, that it is usually better to derive the simplified model through making computational experiments with the simulation model. Both types of approaches will be illustrated in examples of case studies given in the next section.

Case studies

In the following we will draw from our past experience with scenario studies, in order to illustrate a number of points made in the previous section. In Table 1 a few of these studies are listed and classified according to two criteria:
- type of models used in the study, i.e. simulation only, or also including optimization;
- type of processes decribed, in terms of 'water quantity' and 'water quality'.

The latter aspect requires some more explanation, namely the distinction between 'quantity + quality' and 'quantity x quality'. This distinction is made in order to differentiate between studies in which the water quantity conditions are calculated just once, for the current situation. Studies of the type 'quantity x quality' explicitly try to deal with the influence of water quantity on water quality processes.

Table 1. Classification of a few scenario studies. For an explanation of the '..', '+', 'x' and '?' signs the reader is referred to Section 3.

	quantity	quantity + quality	quantity x quality
simulation	..	..	Beerze & Reusel
simulation + optimization	Groote Peel	Zuidelijke Peel	?

In the table the categories 'simulation/quantity' and 'simulation/quantity+quality' have not been filled out because they concern relatively common types of studies that are of little interest in the present context.

The difference between 'quantity + quality' and 'quantity x quality' will be pointed out by making a comparison between the *Zuidelijke Peel* study (Drent, 1989) and the *Beerze & Reusel* study (Van der Bolt et al., 1995). The same two studies will be used for pointing out differences between 'simulation' and 'simulation+optimization'. As this paper is mainly focused on methodological issues concerning the use of models in scenario studies, only very limited attention will be paid to the actual models. The *Groote Peel* study (Van Walsum, 1992b and 1994a) will be used for demonstrating the technique of deriving a simplified model for optimization and combining simulation with optimization. Because it illustrates the focal point of this paper, the optimization model will be elaborated somewhat.

In Table 1 no example is given of 'simulation+optimization/quantity x quality'. The reason for this omission is that (for The Netherlands) we do not know any examples of such case studies. We will come back to that in our concluding remarks.

Zuidelijke Peel and Beerze & Reusel studies

The *Zuidelijke Peel* study is an example of study involving both simulation and optimization. The *Beerze & Reusel* study is an example of a 'conventional' scenario study involving only simulation. Both the *Zuidelijke Peel* study and the *Beerze & Reusel* study had the purpose of providing decision support with respect to the following control variables:

- cropping pattern;
- livestock breeding (pigs, calves, etc.);
- chemical fertilization (N and P);
- use of manure (amount, N- and P-contents, time of application);
- water management (surface water management, subsurface drainage, sprinkling).

State variables were for instance:

- groundwater levels;
- soil moisture contents;
- concentration of N- and P- in groundwater.

In the *Zuidelijke Peel* study the used indicators for the 'well-being' of the region were:

- total income (and employed labour) of agriculture;
- maximum concentration (in a spatial sense) of nitrogen in groundwater, as computed for the steady state;
- discharge of N and P into surface water;
- groundwater levels in nature areas.

In the *Beerze & Reusel* study the indicators concerned the nitrogen and phosphorus emissions into surface water and groundwater. In the course of the study it became clear how essential it is also to specify the scale for which the emission criteria should apply. Though the income from agriculture is naturally an important factor when taking decisions aimed at reducing emissions, it was not explicitly formulated as an indicator. That such a key indicator was not explicitly specified is typical of many scenario studies involving only simulation. When optimization is also used, full specification of key indicators is imperative at an early stage. Otherwise the optimization model simply cancels out all agriculture to achieve the water quality goals.

Examples of exogenous variables in the *Zuidelijke Peel* study were:

- market prices of products;
- cost of manure transport;
- labour requirements;
- boundary fluxes of groundwater.

In the *Beerze & Reusel* study income and labour were not explicitly quantified; thus the exogenous variables were limited to aspects directly related to water quantity and quality, like the boundary fluxes of groundwater.

Both the *Zuidelijke Peel* study and the *Beerze & Reusel* study employed the model SIMGRO (Querner & Van Bakel, 1989). SIMGRO is an integrated regional hydrologic model of groundwater, unsaturated soil moisture and surface water.

In the *Zuidelijke Peel* study the nitrate leaching was computed by multiplying manure applications by leaching factors. These leaching factors were obtained from experimental research (Lammers, 1983). The amount of leached nitrate was then multiplied by a so-called denitrification factor, to take the prevailing groundwater level into account: the higher the groundwater level the more denitrification takes place. This factor had also been obtained from experimental research (Steenvoorden, 1987). In the model computations, only the manure applications were varied. The influence of changes in water quantity conditions on the nitrate leaching was left out of consideration, thus illustrating the 'quantity + quality' approach.

In the *Beerze & Reusel* study the nitrate leaching was computed with the model ANIMO (Rijtema et al., in prep.), using results of hydrologic simulations with SIMGRO. ANIMO is an integrated model of nitrogen, phosphorus and carbon cycles in a soil column. This model was run for different levels of manure applications and different water quantity management scenarios. In Fig. 6 some results are shown to illustrate the influence of both the amount of manure (level of nitrogen input) and the groundwater level on the amount of leaching. The figure illustrates how highly sensitive the leaching is to the two mentioned factors. It even becomes zero for shallow watertables (less than 50 cm below soil surface). It however also shows that other factors must be at work as well (mainly the soil type), thus explaining the scatter along the regression curves. The results of SIMGRO-ANIMO demonstrate what opportunities are offered if water quantity and quality management are fully integrated, the 'quantity x quality' approach.

In the *Beerze & Reusel* study a number of scenarios were formulated by the Provincial Government that commissioned the research, which were then evaluated using SIMGRO and ANIMO. Thus, although the simulation modelling was more advanced than in the case of the *Zuidelijke Peel*, the modelling methodology was of the conventional type: though the set of control variables at the level of decision making includes for instance the cropping pattern, these variables were made exogenous in the actual modelling.

An inherent problem of scenario studies like *Beerze & Reusel* is that they require a system description on a scale that is hard to justify from a scientific viewpoint: a *regional* description that reflects 'state of the art' modelling is simply unattainable due to lack of financial means and manpower. Thus, one has to make do with a severely constrained budget for collecting data, and a model description that 'fits' into an affordable computer.

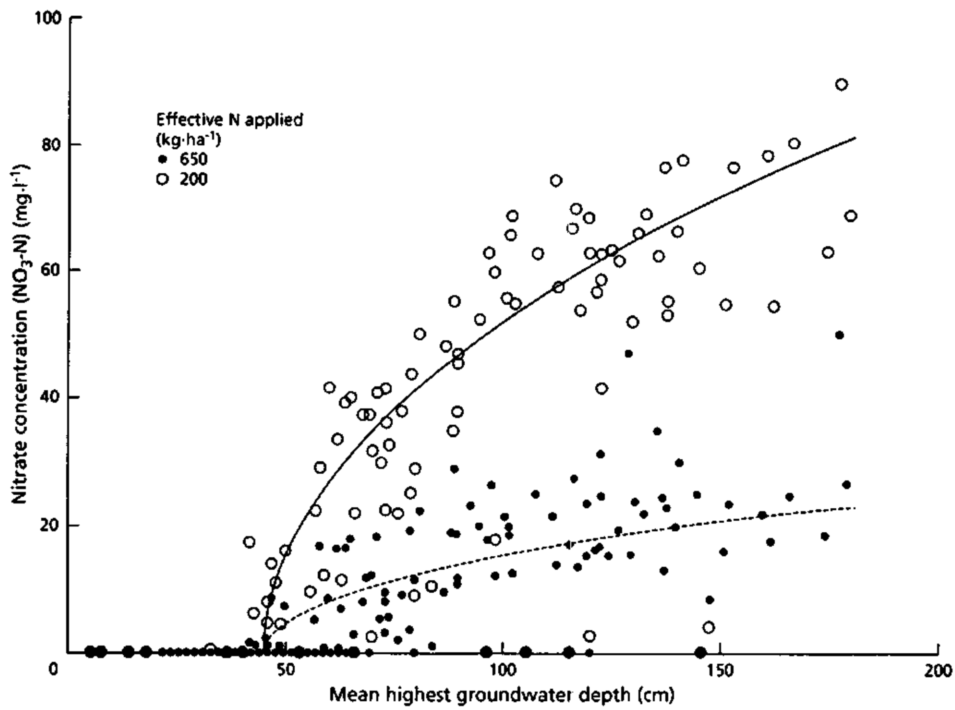

Fig. 6. Nitrate leaching computed with the model ANIMO for various locations in the Beerze & Reusel area. As can be seen both the level of nitrogen input and the groundwater level have a great influence on the nitrate leaching. They are, however, not the only factors involved, as can be seen from the scatter

When the involved processes are highly nonlinear this is an especially harsh constraint on studies involving water quality. Quite often most of the inaccuracy is caused by the water quantity model that is being used. Therefore water quality modelling will remain an important driving force for improving quantity modelling.

In the *Zuidelijke Peel* study simplified models were developed for both water quantity and quality, thus allowing the use of optimization techniques. In the water quality submodel, the leached nitrate was added to a 'mixing-cell model' (Fig. 7), which was implemented directly in the LP-formulation of the simplified model. This is an example of the 'embedding approach' to simplified modelling. The *Zuidelijke Peel* study had the character of developing a 'prototype', and did not involve a real decision-making situation. A number of scenarios were generated using the constraint method for multiple criteria analysis.

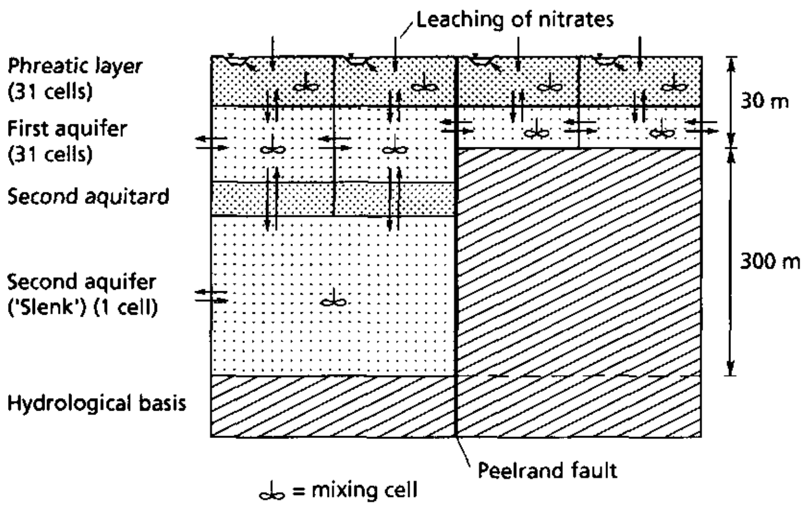

Fig. 7. Scheme of mixing cells used in the Zuidelijke Peel study. The water-flows between cells were kept constant in the scenario analyses, as were the water quantity factors that determine the leaching of nitrates, thus illustrating the type of scenario study 'quantity + quality'.

Groote Peel study

The *Groote Peel* is a so-called bog reserve that is considered to be of great natural value. Owing to the circumstance that it is slightly raised above the surrounding area, there is a permanent downward seepage from the bog. Efforts are being made to regenerate the bog, by for instance blocking the internal drainage as much as possible. Subsurface drainage in the surrounding area is seen as a threat to these efforts, because of the lowering of the groundwater level that is caused by it. This lowering is transmitted to the nature area by aquifers. Extraction of groundwater for sprinkling (and public water supply) is seen as a threat for just the same reason. Import of surface water from an external source to the area surrounding the *Groote Peel* is considered as a possible remedial measure. A more drastic option is to turn agricultural land just outside the bog reserve into a wet bufferzone by blocking the drainage system. This then requires buying the land from the farmers, and is a relatively expensive option. Developments in the region and the discussions about the future of the bog reserve resulted in a sharp conflict between farmers and nature conservationists. At that point the DLO Winand Staring Centre was asked to do a study that could aid the decison-making processes in the region.

Compared to the *Zuidelijke Peel* the *Groote Peel* study had a relatively narrow scope. For instance cropping pattern was endogenous in the other study and was in this case exogenous. Control variables were:

- surface water management, i.e. the levels and the distribution of the surface water supply;
- subsurface drainage;
- sprinkler irrigation, both from groundwater and surface water.

Examples of state variables were:
- the downward seepage from the bog;
- groundwater levels.

The choice of indicators turned out to be very problematic, because of the complex relationship between bog hydrology and bog ecology. In the end an indicator was found in terms of the 'potential bog area', using the downward seepage as the key intermediate variable.

It was especially this link between hydrology and ecology that gave rise to discussions with decision makers. It was an example of the frequent experiences we have had in scenario studies of the difference in perception between the modeller and the decision makers. Whereas the modeller tends to focus on the processes involved in the interventions and the regional links, the decision-makers and interest groups pay almost exclusive attention to the interface between the regional systems and the local interests, e.g. the chances for a certain type of vegetation to survive. Especially in the case of natural eco-systems it is necessary to bridge the gap between the scale of the regional modelling and the local site characteristics. An example of such a procedure is given in Van Walsum (1994b).

After having set up the SIMGRO model for the *Groote Peel* and surrounding area, a simplified model was derived from the mathematical form given by equation 1. The first step in deriving this model was to make a list of combined water management options, e.g. subsurface drainage in combination with surface water supply. This resulted in a list of 16 options, the first one being the 'zero' option, defining a reference scenario. The spatial discretization of the model involved 67 so-called subregions outside the bog-reserve (and 16 within). For each of the subregions (outside the bog) the 16 options could be chosen, implying that (in theory) there was a very high number of possible scenarios for the surrounding area.

The next step in deriving the simplified model was to make for each of the 15 'non-zero' options a 'spatial sensitivity analysis'. This was done subsequently by implementing each option in each of the 67 subregions. Thus in total 67 x 15 = 1005 simulation runs were made. Every run was compared with the 'zero'-option (the reference scenario), yielding coefficients of a so-called response matrix. This response matrix was then converted into the objective function matrix (through the down-scaling procedure described in Van Walsum, 1994b). An example of some of the results are graphically illustrated in Fig. 8. The way these results are presented illustrates the 'converse' way of thinking that is involved in constructing and using an optimization model: effects and causes are looked

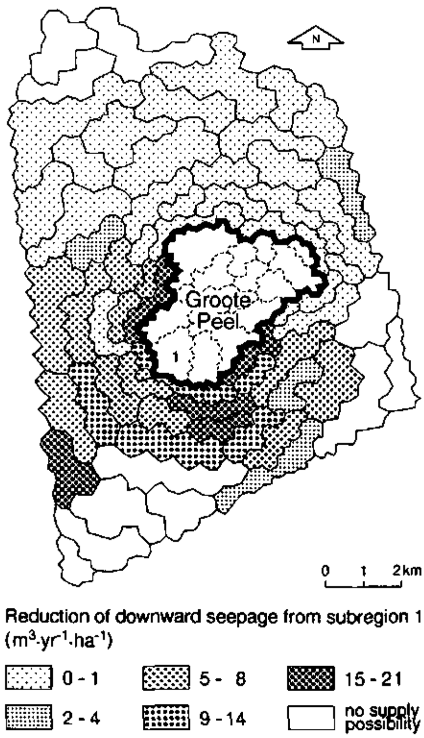

Fig. 8. Influence of surface water supply to the surrounding area on the downward seepage from subregion 1 of the Groote Peel, obtained by making a 'spatial sensitivity analysis' with SIMGRO. The influence has been normalized with respect to the area of agricultural land in a subregion, to avoid distortion.

at from the 'receiving' end, in this case the subregion 1 of the *Groote Peel*. The thematic map shows to what degree surface water supply in the agricultural area affects this one subregion. In mathematical terms, the thematic map involves a row of a response matrix.

Apart from the objective function matrix the simplified model required specification of constraints and lower and upper bounds of variables. For a full description the reader is referred to Van Walsum (1991) and Van Walsum (1994a).

The simplified model was used for generating a number of scenarios using the constraint method for dealing with multiple criteria. In Fig. 9 an example is given of a 'trade-off' curve that was generated in this manner, for a given total amount of extra surface water supply to the surrounding region ($0.5\ m^3.s^{-1}$). This total was thus an exogenous variable. The actual distribution within the region was computed endogenously, as part of the optimization process. An example of such a computed distribution is given in Fig. 10.

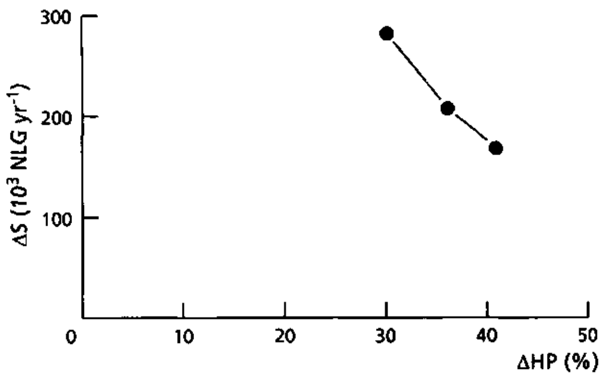

Fig. 9. Trade-off curve between the total change of income from agriculture (ΔS) and the change of the 'potential bog area' (ΔHP). The curve was computed for an exogenously fixed total amount of extra surface water supply.

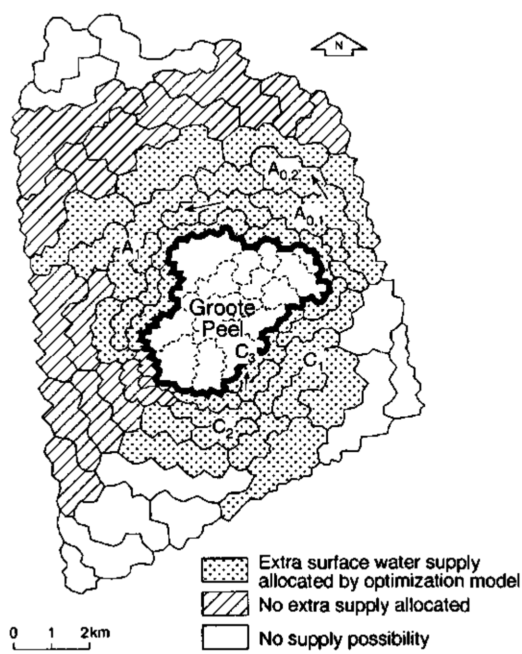

Fig. 10. Optimized distribution of surface water supply, obtained for 0.5 $m^3.s^{-1}$ extra surface water supply to the surrounding region.

An interesting feature is that the model did not allocate surface water supply to the South West of the *Groote Peel*. Apparently the model took into account that in that part of the region the supply of surface water has a relatively small effect, as can also be seen from Fig. 8. One would expect that the subregions near to subregion 1 of the *Groote Peel* have the most influence on the downward seepage from subregion 1, but that is not so because of the high groundwater levels; surface water supply for infiltration then does not have much effect. The optimization model takes this into account and distributes the surface water accordingly.

A comparison was made between scenarios that had been specified in the conventional manner (Fig. 4a) and scenarios that had been generated using the optimization model (Fig. 4b). It turned out that the ones obtained through optimization make about 20% better use of available surface water supply, thus yielding substantial gains in terms of indicator values. In the technical sense the study was therefore a success.

It was hard for the modeller to make clear to the decision makers what their role is in using the optimization model. The one moment they could not understand the need for an optimization model, the next they expected it to serve as a *deus ex machina* for them, producing a single 'optimal' scenario. It also seemed that the decision makers involved (or rather their executives with whom the modeller was in contact) showed unease about their role when optimization models are used, because it requires them to articulate their preferences with respect to certain indicators. For a politician, this is not necessarily opportune at the time of doing a study. For this reason the study was not done 'interactively': instead of being fully integrated in the policy making process, the study was done in an 'off-line' mode, with a number of scenarios being generated using the constraint method for multiple criteria analysis. It would have been better to have used a method like Multiple Goal Programming (Veeneklaas (1990)), but that does of course require cooperation from the side of the decision makers.

Also lacking was the availability of information relating to the Policy Analysis System, in the form of political constraints on the scenarios. The scenarios were generated assuming full cooperation of all 'actors' involved. In practice both farmers and nature conservationists have all kinds of considerations that have not been taken into account in the study. Considering that the decision-making about the *Groote Peel* has still not been concluded - after four years of political debate ! - one wonders how it will ever be possible to fit into such a process.

Concluding remarks

In the paper we first outlined a methodology for providing decision support in regions where water quantity and/or quality give rise to conflicts between various interest groups that each have their own goals. The methodology is a type of blueprint, as became clear from the given examples. None of these examples fully lived up to the ideal, i.e. fully integrated modelling of water quantity and quality, combined use of simulation and optimization, and simultaneous consideration of environmental processes and processes in the 'socio-economic' subsystem.

Partly, this shortcoming has a technical reason, namely the lack of adequate models (both simulation and optimization) for dealing with 'quantity x quality' processes at comparative levels of detail. The other side of it is, that decision makers have not yet got used to the different role they play when the decision support is provided using optimization models. In principle an optimization model provides better decision support than can be given with just a simulation model - the optimization model makes possible the identification of scenarios that make full use of the possibilities of a region, thus minimizing conflicts of interest between for instance agriculture and nature. But in order to reap the benefits of such models it requires good integration of the modeller in the policy making process, because it then becomes possible to identify step-by-step a scenario that matches the preferences of the policy makers. In the course of this process the policy makers have to concentrate on weighing the trade-offs between the various objectives (Fig. 4b) instead of explicitly formulating scenarios as in the conventional method (Fig. 4a).

In the case of water quality problems, maximum benefits from using an optimization model are obtained if measures aimed at reducing the influx of contaminants are taken in conjunction with water *quantity* measures. In order to reap these benefits there must be a high degree of coordination between government agencies responsible for the different aspects of integrated water management.

Although in the near future the required research effort should be directed towards broadening the scope of regional modelling, integration in the policy making process should also be worked on just as hard. For instance, the dynamics of land use patterns - which are usually treated as exogenous to the modelling - very much determine water quantity and quality; ideally they should therefore be treated as endogenous to the scenario study. There is the danger of 'over-stretch': does the system of models remain analytically tractable and are there enough data ? Secondly, there is the danger that it can lead to 'getting out of touch' with the decision-makers, thus frustrating attempts at becoming more integrated in the policy making process. For the latter to be achieved it also requires decision makers to get used to system analysts as 'live' partners, instead of just as authors of computer programs and reports.

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2.2 Regional economics approach: quantitative models in integrated scenario studies

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Abstract

The paper presents an overview of the key economic relationships between land use patterns and environmental consequences. In essence, this involves decomposing the several attributes of land use, ranging from the production of marketable biomass and provision of rural employment through landscape appearance, to wildlife diversity, environmental quality and resource conservation. The effects of land use on each attribute are generally a function of the intensity of land use: greater intensity leads to increased biomass production, and decreased wildlife diversity and environmental quality.

The paper then turns to the major problems associated with making this framework operational, either as a research or policy analysis tool. There are three major problems: i) the determination of the effects of social, market and policy changes on land management (defined as including both land cover and intensity of use decisions); ii) the specification of the technical or mechanistic relationships between land management and environmental/ecological consequences; iii) the valuation of attributes in order to derive either policy prescriptions or predict future land management patterns. The principal issue is the resolution of different spatial and temporal scales of the inter-relationships between land management change and the environment. The discussion is illustrated with reference to spatial modelling work being undertaken by the authors and others in the NERC/ESRC Land Use Programme (NELUP) and related projects.

Keywords: *Land Use, Rural Environment, Quantitative Modelling, Regional economics*

Introduction

The evolution of the CAP (and other agricultural and rural environmental policies) to date appears to be largely reactive and has been predominantly concerned with purely agricultural issues. There is little evidence of an agreed proactive strategy for the development of farm and environmental policy in the UK, or indeed elsewhere in the European Union. Changes in one policy, for instance product price support, are not designed and implemented in conjunction with changes in other policies, for instance those which directly concern the environment. Rather, failures of one policy generate pressures for changes in others. The resulting policy mix becomes progressively more complex with successive policies seeking to ameliorate unwanted side-effects of previous policies. In order to analyze possible policy improvements, however, it is necessary to abstract from the policy process and consider potential interactions and consequences of policy instruments and market conditions on current land use practices and patterns.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 55–73.

An analytical framework

Traill (1988) presents an economic perspective on the trade-offs and possible conflicts between various elements of the rural environment - Figure 1.

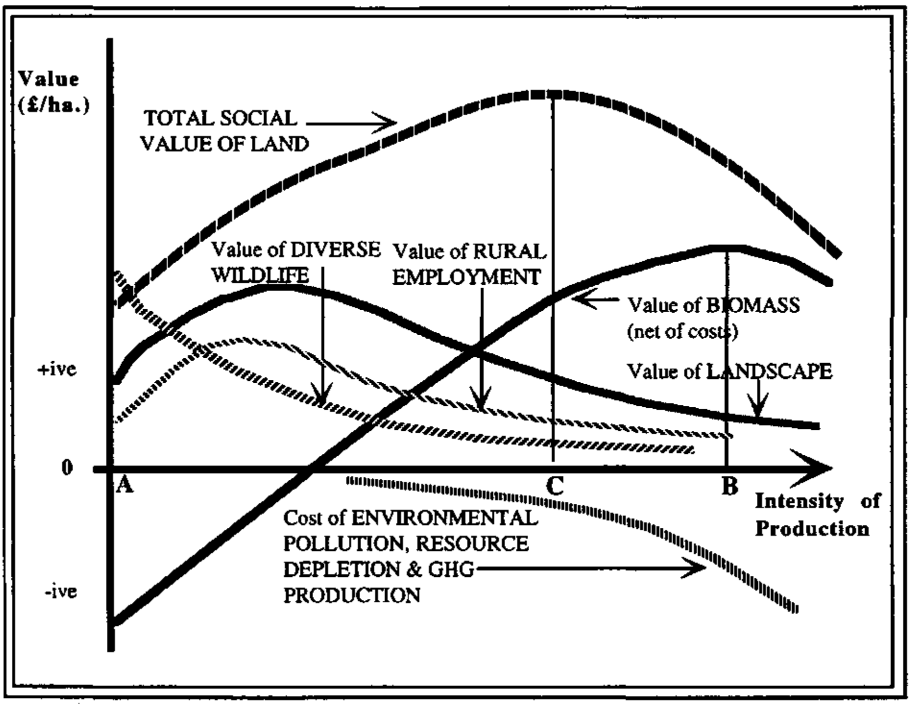

Fig. 1. Value of Land Using Activity as Intensity of Production Increases.

In this figure, intensity is measured as quantity of inputs per hectare. The net value of tangible goods from the land base (food, wood, fibre etc.) reaches a peak at point B - the profit maximising level of intensity. Since the 'biomass' curve reflects the net value of production, having subtracted all relevant actual and opportunity costs, the curve reflects net returns to land from agricultural (biomass) production, which in a competitive industry will be maximised through the individual pursuit of profit. The other curves represent hypothetical relationships between intensity and other intangible aspects of the rural environment, which have been christened CARE (Conservation, Amenity, and Rural Environment) goods (McInerney, 1986). In principle, separate curves could be added to represent contributions to reducing greenhouse gases and net costs of depleting non-renewable resources.

This representation of the rural environment emphasises three critical components of analysis of land use. First, it is necessary to understand the socio-economics of land use decisions and management practice, particularly from an economist's perspective, responses to market and policy conditions given peoples' motivations and circumstances. Second, the physical consequences of particular land use decisions and practices for the rural environment need to be identified. The combination of these two elements provide the definition of the several curves in Figure 1 in physical terms and the likely position on the horizontal axis chosen by land users. The third element concerns identification of the social valuations of the several goods and services provided through the interaction of land use and the rural environment.

Given that these three components can be identified, then it is possible to think of some socially optimal intensity of production at point C, as the maximum of the vertical sum of each of the component valuations, typically implying a reduction in intensity from present levels, at least in the majority of circumstances in which the social valuations of the intangible aspects of rural land use are not reflected to the land users, who thus have no incentive other than altruism to respect such values in their private decisions. Thus, although there is a reluctance to 'price' intangible aspects of the rural environment on the part of non-economists, this representation emphasises that all public and private land use decisions imply such a social valuation. In turn, this representation casts the debate and controversy over the rural environment as arguments about the behaviour of land users, the physical relationships between land use and the environment and the social values of the various outputs and consequences (goods and services in economic terms) from the rural environmental system. This paper is largely concerned with elaboration of attempts to deal with each of these three critical issues: Section 3 deals with the economic incentives and implications for land use, within an overview of modelling systems; Section 4 with the technical relationships between land use and ecological character; Section 5 with valuation issues.

As a preliminary comment, it can be noted that: a) present support for agricultural production has shifted point B upwards and to the right (see below); b) the valuations will vary between different regions and locations depending on their underlying circumstances and conditions - which makes the spatial representation of this framework a critical feature of the analysis; c) different policy options and market conditions encourage different production techniques which will shift these curves. A general conclusion of this representation is that (under most European conditions) point A (complete abandonment of rural land) will not be a socially optimal land use strategy, even if it where to produce the optimum level of bio-diversity. This remark is simply a corollary of the fact that bio-diversity is not the only attribute of land use or the natural environment which is valued by society.

Although the original brief for this paper included consideration of qualitative models in integrated scenario studies, the emphasis of this paper is on quantitative modelling systems. The justification for this is as follows. First, a companion paper (van der Ploeg) will deal with the socio-political aspects of behaviour patterns and decisions affecting land use. Second, within scenario studies, qualitative 'models' require at least an implicit systematic framework relating the several aspects of land use/environmental relationships. Specification of such a systematic framework (model) raises questions of the dimension and scale of the contributing factors and leads naturally to considerations of quantifying the relationships and contributing variables. However, it has to be admitted that the explicit quantification of these relationships on the basis of frequently inadequate or incomplete data and understanding, carries a severe risk of implying spurious accuracy or unwarranted realism. A strong *caveat* thus applies to the remainder of this paper: the explicit quantification of models systems should be treated as illustrative rather than an exact replication of the real world of peoples' behaviour interacting with our natural environment. In that sense, the quantitative models discussed in this paper are 'coloured' versions of qualitative models.

Economic Incentives and Land Use Patterns

Economic theory strongly suggests that support of the farm sector through product price intervention, either through border protection and domestic intervention (the 'old' CAP system) or through deficiency payments, results in increased land prices. The logic is simply that improved farm returns encourage more people to use more land more intensively. Given that total land is more or less fixed in supply (aside from improvements which can be made to the productive quality of land), increased demand for the productive services of land simply drives up the rents which land commands, and thus increases its price. Incidentally, the same logic applies to any input or resource whose supply to agriculture is limited. Thus, returns to suppliers of farm inputs, labour and capital are also likely to benefit from farm support policies to a greater or lesser extent, depending on the extent to which greater demand for these factors and inputs by the farm sector tends to increase their price. The economic logic of this result is that the higher are prices of farm products the more commercially viable are intensive and high cost production practices. Thus a greater value of output is produced per hectare and the more each hectare can earn in agriculture, so increasing rents and land values. This pushes the net value of biomass curve (Figure 1) upwards and to the right, according to recent estimates by as much as 50% on average (see, for example, Harvey, 1990)

A more detailed examination of the effects of market and policy conditions on land use practices requires a more mechanistic approach. Examples of this approach are currently being employed by the Centre for Agricultural Strategy (CAS), Reading University and under the Natural Environment Research Council (NERC) / Economic and Social Research Council (ESRC) Land Use Programme (NELUP) at Newcastle University. In both cases, the agricultural sector is being modelled as a single farm, in the CAS case, for the whole of England and Wales and, in the NELUP case, for a river basin (in the first instance, the Tyne).

As the first such model (at least in the UK), the CAS model pictures the agricultural system of England and Wales as if it were a single farm, employing a variety of different production activities to produce the various agricultural outputs using the range of different inputs (chemicals, fertilisers etc.) and resources (labour and capital) and different land types, as reflected in the Institute of Terrestrial Ecology's Land Classification System (LCS). Superimposed on this picture are the opportunities for using existing agricultural resources (land, labour and capital) for non-agricultural purposes: recreation and forestry. This information is incorporated in a Land Use Allocation model (LUAM), which allocates land types to different activities subject to specific constraints. The constraints are of three basic types:

(i) constraints on the availability of land, labour and capital, and/or the ability to shift these resources between different uses;
(ii) constraints on the total amount of production and input use which can be produced or used by the agricultural system, reflecting the demands for the products and the supplies of the inputs;
(iii) "policy" constraints which restrict production activities or land utilisation patterns in certain areas to conform to environmental objectives.

Within these constraints, land utilisation is modelled according to the net economic margins which can be earned by the various activities (including the forestry and recreational activities). These margins are generated from the requirements for inputs and resources of the various activities, the costs of these inputs and resources, and the returns which the activities produce from the sale of products. "Public goods", which have no market, can be reflected through specific constraints requiring the "production" of these goods in the form of specific land uses or practices, regardless of the economic returns which are generated. Alternatively, given that appropriate social valuations of these goods are available, they can be included through incorporation of their social values in the objective function.

As a starting point, the model is calibrated to a base situation, in terms of land use, output and input levels and resource use. This ensures that the model is consistent with existing data and allows the relationships between land use and intensity of production (input use per hectare) to be associated with the environmental and ecological characteristics of the land base as defined through the ITE Land Classification System (LCS). These relationships can then be used to project changes in environmental characteristics associated with changes in land use and use-practice. The model can be validated by re-calibrating the model to previous data, and then projecting the changes from the previous situation to the current base, using changes in market and policy conditions between the two dates. These projections can then be compared with the actual changes which took place. The choice of base years depends on the years for which accurate survey data is available within the ITE LCS.

The model is constructed on the basis of 15 land classes, representing the mix of land types in England and Wales. Within each land class, four major land types/uses are identified - arable, temporary grass or leys, permanent grass, and rough grazings. For each land class, a range of possible activities is specified, including 26 agricultural activities (14 crop and 5 livestock), each with 3 different levels of intensity, 4 categories of forestry enterprises, and (potentially) 3 non-agricultural activities (caravan sites, farmhouse bed and breakfast, self-catering accommodation), which compete with agricultural activities for labour and capital, and which depend to some extent on the "public good" aspects of land use. The intensity levels for the agricultural activities reflect the possibilities of using more or less inputs (especially chemicals and fertilisers) to produce more or less output per hectare, with corresponding differences in their environmental implications. Each of these activities, and intensity levels, has associated with it specific requirements for inputs and resources and specific output levels. Except for land and labour, these are specified in terms of their monetary equivalents, implying particular physical volumes and prices per unit of output or input.

Figure 2 illustrates the various components of the model framework. Although the limitations of the two dimensional representation force a particular pattern on this figure, the essential elements are:

a) The ecological and environmental data expressed through the Institute of Terrestrial Ecology's Land Classification System (LCS), and the Land Use Allocation Model (LUAM) which models land use and use-practice and is capable of simulation for different circumstances and conditions. These two components form the central part of the Figure. As is shown, they are linked through the land use and use-practices (intensities), which are described through the Land Classification System and modelled through the Land Use Allocation Model. The ecological characteristics associated with particular land uses and practices are determined through the LCS according to the relationships established in the base year (1990 in the current version of the model).
b) The top line of the Figure shows the MAFF Departmental Net Income Calculation (DNIC) and June Agricultural Census data (for the agricultural component of the model structure) which provide the foundation for the production model. The DNIC is essentially the agricultural sector's GDP calculation and provides estimates of national inputs, outputs and resource use in value terms, and has European counterparts in the value-added estimates published by the Statistical Office, European Commission. The June Census provides data from all farms of areas of land use and livestock numbers, which are used to calibrate the LUAM. The Farm Business Survey (FBS) data from the MAFF, again for the agricultural sector of the model, matched by available data comparable to these agricultural data for the other activities, are used to estimate or construct the production relationships represented in the LUAM. In the case of the FBS data, these are used to estimate input/output relationships for each enterprise within each land class. As a result, these relationships reflect the average practice of the farms in the FBS sample within each land class, and to that extent are as accurate a reflection of present practice as can be obtained from existing information. These data are also used to calibrate the LUAM to base data at the national (DNIC and Census data) level and at the ground level (the LCS proportions of land in different uses).
c) The left and right wings of the Figure show the major environmental and market/policy inputs and outputs. As is reflected in the *policy endogenous* and *policy exogenous* arrows, the model framework can be run in two directions. Either the effects of alterations in market and policy conditions can be input, in which case the land use and use-practice effects imply changes in the natural habitat. Or particular characteristics required for the natural environment can be specified as inputs, in which case the implications for agricultural and other rural activity returns are determined by the model, which in comparison with the base situation, define the penalties and incentives necessary to achieve the particular environment specified.
d) In either case, the model produces estimates of incomes and returns to rural resources (land, labour and capital) and associated use of labour and capital which can then be incorporated into regional economic and social analysis, as illustrated at the bottom of the Figure. Since the model is constructed on the basis of the 15 land classes, which are in turn defined on a kilometre grid square basis, the results can be aggregated to any desired regional specification. However, the resolution of the model structure is such that the degree of approximation will increase as the level of aggregation is reduced. While results could be presented in fine detail at the parish level, for instance, the degree of approximation at this level of disaggregation would be severe and the results would be of limited value. Nevertheless, the structure of the model on a grid square basis does allow the projections and characteristics of the

model to be compared directly with survey and other information and evidence, providing only that the grid reference or geographical location of this information is available.

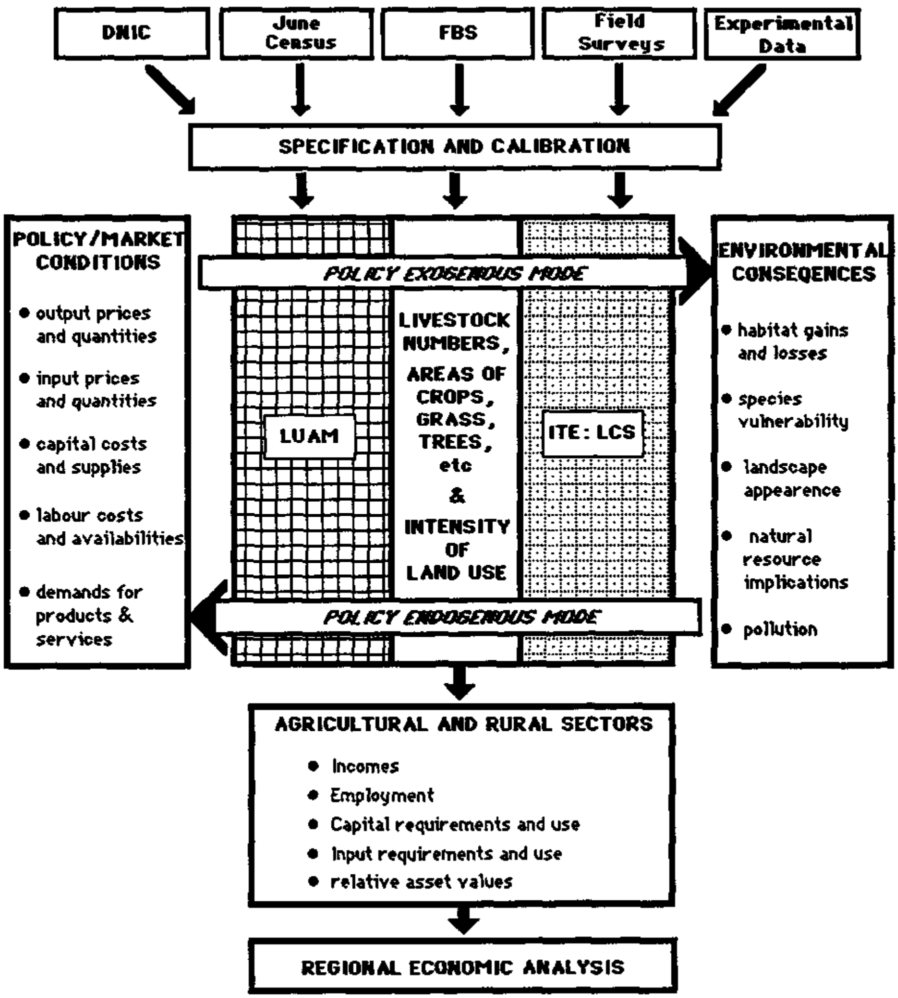

Fig. 2. Land Use Allocation Model Framework.

The calibration results provide a direct correspondence between observed ecological and environmental features (as contained in the LCS) in terms of species counts, field boundary types and characteristics etc., and the land uses and use practices associated with these features. This correspondence provides the basis for predicting changes in environmental features following changes in the behaviour of the agricultural and other land using activities (see below). Further details of the CAS model specification can be found in Harvey *et al.*, 1992.

Preliminary results using this model to examine the effects of the MacSharry reforms of the CAP indicate a substantial reduction in cereal intensity in response to the considerable reduction in market prices for cereals, and reflected in the reduction in costs associated with cereal production. A similar logic applies to the oilseeds areas and production. Although dairy quotas are imposed in the model, this does not prevent adjustments between intensity (yields) and cow numbers. With the exception of East Anglia and the Midlands, cow numbers are reduced, implying an increase in intensity of dairy production (as measured in yield per animal, an implication which is confirmed by the changes in intensity). Beef LSUs increase in all regions, while sheep LSUs decline in the south, midlands and East Anglia compared with the base case, but increase elsewhere. Intensity of beef and sheep production both tend to decline (that is become less intensive, in contrast to dairy production). With the exception of East Anglia and the east midlands, there is some evidence of a replacement of dairy cows with beef cows in these results, whereas in the south and midlands (except the south west), beef tend to replace sheep, with sheep production tending to move "back up the hill".

Overall, there is a strong tendency for beef to expand at the expense of cereal areas, supplemented by sheep in the remoter and more upland regions (south west, north west, north and especially Wales) and by dairy cattle in the lowlands (east Anglia and the midlands). Thus, a picture emerges which involves the replacement of cereals areas with grass and for land use to become more extensive. The exception (dairy production) to extensification typically reflects the use of cheaper grains rather than an intensification of grassland production.

Smaller-scale regional modelling

The LUAM model provides a tool for agro-environmental policy analysis at the national level, but the relatively small number of land classes included may not make it suitable for regional policy analysis. This issue is addressed by the NERC/ESRC Land Use Programme (NELUP) which considers the linkages between agriculture, ecology and hydrology at the level of a relatively small river catchment (250,000 ha). The catchments currently being studied are the Tyne in North East England and the Cam in South East England. While the economic components of NELUP and LUAM are similar in concept, there are important differences in their construction, and NELUP is of broader scope (though of reduced scale) in that the programme links explicit models of the both the hydrology and the ecology of the region through a GIS, which in turn is utilised to provide a 'decision support system' for use by planners and policy makers. The key problems with interdisciplinary modelling concern issues of spatial resolution, data definition and data availability.

The issue of spatial resolution concerns the units of spatial measurement employed; while a hydrology model may use as its basic unit a $1km^2$ grid square, the economic model may only be able to operate at a relatively coarse land class level, ecological models may require data at the level of $25m^2$. Immediately a problem of model incompatibility arises where the predictions of one model are not a suitable input into the others. The NELUP programme has been especially concerned with this problem, though no generic, universally applicable systems for its solution have yet been found. Explicit and specific aggregation and dis-aggregation procedures have been developed to reconcile the different model scales of the sub-systems of the NELUP model.

The problem of data definition is equally acute. A model of the agricultural system describes land cover using a number of broad categories. For instance 'wheat', 'intensive grassland' and 'extensive grassland'. Associated with these cover types is some measure of their productivity and associated management practices. Ecologists focus their attention on less productive agricultural cover types and sub-divide them into vegetation classes. A problem arises of how one definition of cover 'maps' onto another. Aspects of this problem are dealt with in more detail in the next section of this paper.

The final problem is that of data availability. Agricultural data in the UK has traditionally been collected to measure the level of food production and farm income. The recent focus upon environmental issues concerning agriculture has led to a need for a greater understanding of the spatial distribution of agricultural activity, this immediately raises issues concerning the quality of data by which the current state of the system is measured. Agricultural and forestry land use can be sub-divided into land cover and land management. From agricultural census data we know the total areas of crops and numbers of livestock, but it is not possible to locate their spatial distribution with any precision. From business survey data we know the costs and revenues derived from cropping and livestock production, but this is not related to particular types of land. Satellite data gives an indication of the spatial distribution of agricultural activity, but it is not always capable of distinguishing between arable crops and there is no means of locating livestock.

The approach used in NELUP is to build up data sets of the spatial distribution of agricultural activity on the basis of known spatial data. This approach is only necessary because as yet we do not have a comprehensive data set on the spatial distribution of agricultural activity. The first step is to establish a land classification based on soil, climate and elevation data using GIS. Each land class should be reasonable homogeneous in terms of agricultural practice and ecological vegetation type. The MLURI Land Class System (Bibby, *et al.*, 1991) was chosen for the NELUP work (in contrast to the LCS used in the CAS model) as it subdivided the marginal agricultural areas in the Tyne more distinctly and appropriately. The next step in the NELUP work is to use a procedure of areal interpolation which takes the agricultural census data and distributes it to the land classes - see Moxey and Allanson (1994) for a discussion of the statistical procedures involved. This procedure is much more refined than that used in the LUAM model, in which the proportionate distributions of agricultural land cover types by land class, revealed through the LCS, are simply applied to the 'known' agricultural census total areas of such cover types for the country as a whole. For the NELUP work, however, not only are the total census areas of land covers not known for the river basin (since the administrative boundaries do not coincide with the geographic/hydrological boundaries) but also the distributions of land covers between the MLURI land classes are not known, since the latter classification has not yet been associated with ecological field surveys.

The production processes employed for crops on each land class are determined by EPIC, a biophysical simulation model. This allows production functions to be determined for each crop on each land class, which define the options available to producers. The most important variable input is nitrogen as this is the limiting factor in determining the yield of crops and grassland. As input data, EPIC only requires an accurate description of the weather and the soil characteristics, but produces cover type output levels and input uses in physical terms applicable to the hydrological and ecological components of the system, in contrast to the LUAM system which relies entirely on physical approximations of current practice as estimated from the FBS management data. The latter can only loosely be connected with specific land classes, and thus the association of agricultural practices with specific land classes in the LUAM is somewhat 'fuzzy'. The use of the EPIC models in the NELUP model allows for much closer approximation of physical production relationships with land class characteristics, and also allows for the identification of changes in physical relationships as the intensity of production changes, which proves difficult with production functions estimated on the basis of farm management (FBS) data. However, as with the LUAM, measures of other costs associated with agricultural production in the NELUP model are derived from business survey data which estimates the cost of an input per pound of output, see Moxey and Tiffin (1994) for a fuller account of the methods used to derive input-output coefficients.

The constructed data sets on crop areas, yields and input-output coefficients are used, in a similar way to LUAM to construct a regional LP model. The model can then be used to explore regional issues concerning the generation of non-point pollution from agriculture and the efficient provision of environmentally sensitive areas. For instance, the pattern of nitrate emission within the Tyne catchment is notable for its spatial variability due to different agricultural practices and soil types. The implication of this is that a undifferentiated policy, such as a catchment-wide quota, to reduce the level of nitrate emissions would place unnecessary cost on some producers. The land class structure in the model enables an analysis of alternative policies: nitrogen emission quota; a targeted nitrogen input quota; an undifferentiated nitrogen quota. The emission quota represented the least-cost solution, but is not applicable owing to the problems of identifying the sources of a non-point pollutant. The targeted input quota gave a reduction in the cost to producers for a given level of abatement relative to the undifferentiated quota. This application illustrates how the use of land classes allows alternative management policies to be explored which have a spatial dimension, see Moxey and White (1994).

As a further example, heather moorland and extensive hay meadows are viewed as desirable ecosystems in the Tyne catchment. In other regions, Environmentally Sensitive Area (ESA) schemes are in place to protect and extend these ecosystem. The NELUP model has been used to simulate the development of an ESA in the Tyne catchment. A number of issues emerged. First the introduction of a hay meadow ESA may increase the intensity of land use outside the designated area. Second, payments to producers had to increase to reflect the progressive reduction in productivity as grassland intensity was reduced. The constraints placed upon producers were defined from the ecological model component of the system, which indicates the management regime required to establish hay meadows and heather moorland. In the case of heather moorland this requires a reduction in the level of sheep stocking. Hay meadows can only be established if the nitrogen input is reduced to zero and they are cut after the plants have produced seed. This study [Moxey *et al* (1994)] illustrates how an economic model can be linked with an ecology model by defining a set of management restrictions for specific land classes.

Technical relationships between land use & environmental consequences

There are essentially two approaches which can be used to identify the relationships between land use and environmental/ecological consequences:

i) a statistical/associative approach which 'simply' determines the apparent associations of land use practices and patterns with ecological features and conditions;
ii) a mechanistic approach, which requires detailed knowledge and understanding of the processes of ecological change and the determinants of ecological patterns. Given this knowledge, the actual (hypothetical) processes themselves can be modelled and the resulting models then used to predict land use/ecological associations both for validation and projection purposes.

To date, insufficient headway has been made with the mechanistic approach for it to be practical in models for large areas of countryside, so present modelling efforts have been largely concentrated on the associative approach. However, work underway in the NELUP programme is beginning to incorporate more mechanistic process-based model representations of environmental change.

As an example of the associative approach, LUAM uses the calibration run for establishing the correspondence between the intensity and type of land use and the environmental characteristics contained in the LCS, as illustrated in Figure 3 which concentrates on grassland types and use. The total areas of temporary grass, permanent grass and rough grazings derived from the agricultural census for England and Wales are allocated to each land class according to the proportions of total grass areas in each land class falling in particular species groups (herbage groups, of which there are nine, though this number will be expanded for some land classes to more accurately represent the diversity of ground cover and the special characteristics of this cover) from the Land Classification System (LCS) base survey. This is illustrated in the upper half of Figure 3. The identification of herbage groups which correspond to temporary grass, permanent grass and rough grazings allows for the establishment of consistency between the LCS definitions based on species dominance, and the census definition which refers to the time elapsed since sowing, while preserving the integrity of the census totals.

The calibration run of LUAM produces the base DNIC output levels with the census-recorded livestock numbers and DNIC input and resource use on these land areas, using the production activities as specified above, which include the range of different intensities as evidenced by the FBS data. The ratios in which the different intensity activities can enter the model solution are restricted in this run to conform to the estimated average yields and stocking rates (i.e. to enter the model on a 1:1 basis). The actual distribution of livestock activities and intensities which the model produces under these restrictions is identified in the matrix in the lower half of Figure 3.

The proportions of each grass type falling within each herbage group in the base year are known from the LCS. The results of the LUAM provide estimates of the proportions of each grass type which are used by each of the livestock activities, by livestock type and intensity level, again for the base year. Each of these activities has associated with it a particular level of input, especially fertiliser, use per hectare. These proportions can then be associated with the proportions of the same areas of grassland types in each herbage group in the LCS. The principle behind the assessment of environmental impacts is that the intensity of agricultural production can be related to the species composition and thus to habitat characteristics on the ground, as recorded in the LCS.

Thus the LUAM provides estimates of the total areas of land use within each land class, by enterprise and intensity, while the LCS includes information on a sample square and field basis for each herbage group. The problem is to reconcile these two different forms of information in such a way as to allow the larger and wider results from the LUAM to be interpreted at the ground level, which is necessary for the ecological consequences.

The LCS has already been analyzed independently of the construction of the LUAM to identify the probable current use of land, especially grassland, according to both the type and intensity of use.

This analysis can be used as a basis for the allocation of the LUAM land uses to the LCS herbage groups at the field level. However, it is not possible to ensure the consistency between the June census data, the DNIC data and the FBS data in this analysis of the LCS. To integrate the "ground level" (kilometre grid square) analysis of the LCS with the spatial and intensity allocation of enterprises achieved through the calibration run of the LUAM, the following procedure will be employed. For each land class, the calibration run of the LUAM produces the land use by enterprise and intensity which ensures the consistency of the census, DNIC and FBS data at the land class (and national) level. These land uses can be formally matched (or mapped) to the herbage group distribution as defined through the LCS on the basis of the probabilities of herbage groups being used by particular enterprises at particular intensities as established through the analysis of the LCS sample.

The NELUP model uses a more formal definition of the association between cover types and ecological characteristics, necessitated in part through the lack of specific spatially-defined ecological data for river basin areas (Moxey *et al*, 1994). Until recently, quantitative modelling of dependencies between natural plant and animal communities with physiographic characteristics, as modified by managerial practices, has not always been possible due to the absence of suitable data at the appropriate scale. However, opportunities for modelling have improved significantly with the development of the National Vegetation Classification (Rodwell, 1991, 1992).

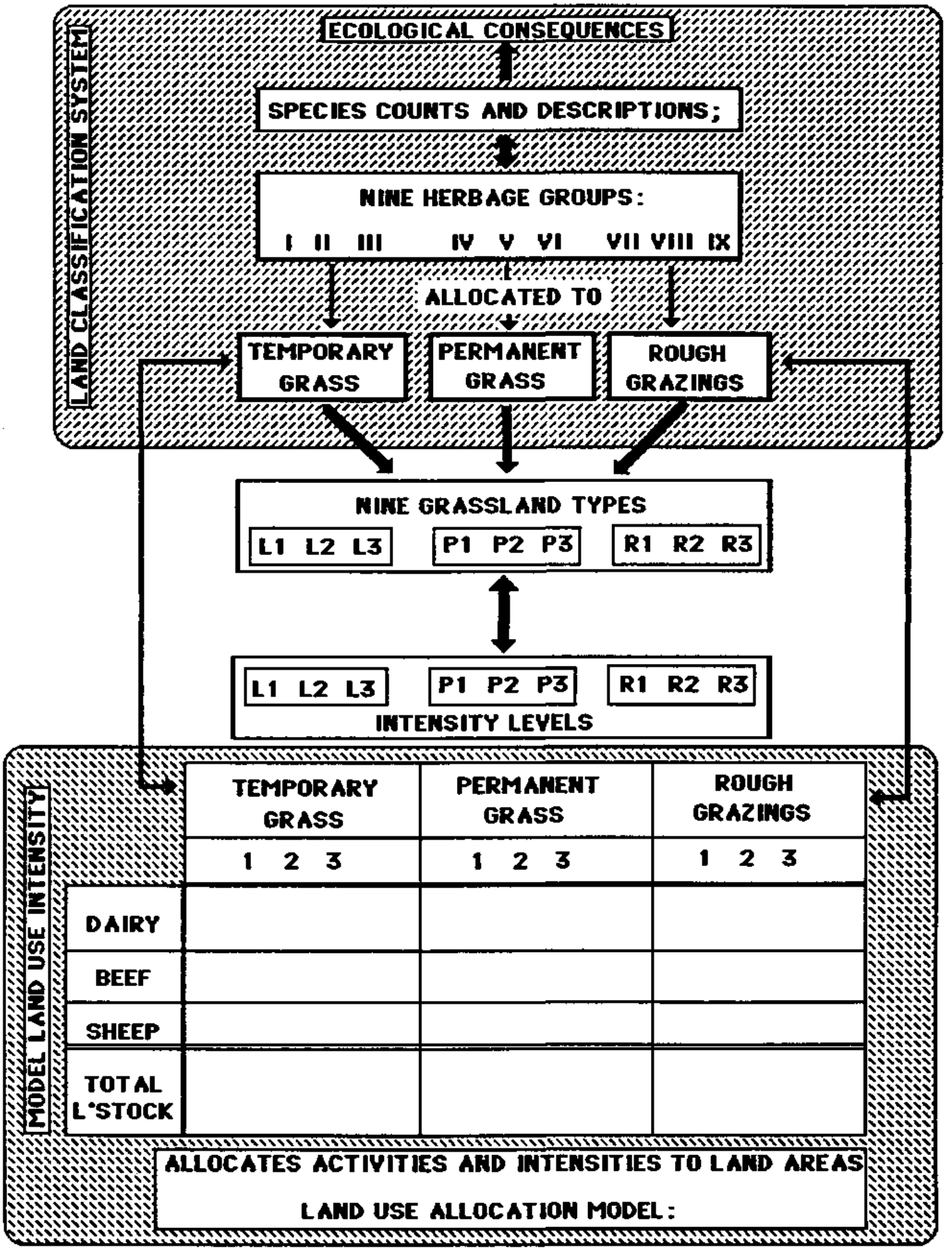

Fig. 3. Links between the Land Use Allocation Model and the Land Classification System

The National Vegetation Classification (NVC) provides a systematic and comprehensive phytosociological treatment of British vegetation based on accepted ecological field survey and data analysis methods. It consists of collection and collation of species data from some 35,000 quadrat samples, used to classify British vegetation into over 400 discrete plant communities. In many cases, a variety of environmental and management factors are also recorded, allowing dependencies between vegetation and site conditions to be identified. The NVC thus characterises the effects of both environmental conditions and management on semi-natural vegetation. However, it is not (unlike the LCS used in the LUAM system) associated with a specific land classification, though the NVC provides data on the environmental factors which determine the presence of the plant communities. These factors include soil type, altitude and climatic tolerances. Other information is provided on typical management practices such as grazing, cutting and fertiliser practices. The combinations of these variables form a multi-dimensional environment/management space in which all possible plant communities can be positioned. Separation of communities in this space represents their different environmental and management requirements.

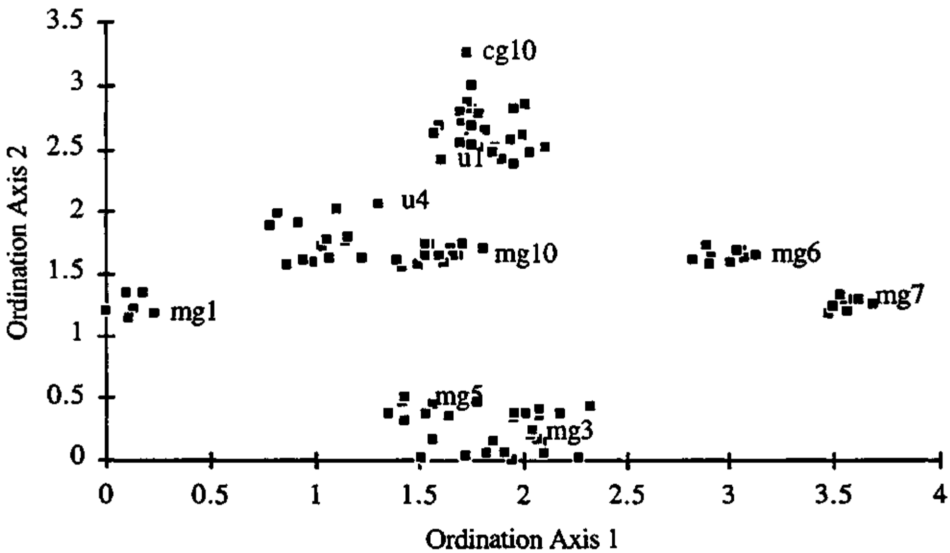

Fig. 4. Simplified Ordination Diagram for Selected NVC Communities

This complex multi-dimensional space can be simplified by ordinating the environmental and management data for all communities, as illustrated in Figure 4. This reduces the environmental/management dimensionality to a few axes which summarise the major variations in environment/management that occur across communities. Individual communities have scores on each of these axes. Equivalent scores can be calculated for the environmental and management variables.

Following Digby and Kempton (1987) and Jongman *et al* (1987), these ordination scores can be calculated using Correspondence Analysis. This approach (outlined in Moxey *et al*, 1994) allows the mapping of environmental and management variables (known from the land classification and the economic model system) to be directly related to the probable plant communities to be found in these conditions. In essence, the Euclidean distance of a new land parcel to each community in the ordination space represents a measure of how close the new land parcel is to the environment/management conditions in which individual plant communities are found. This distance can therefore be used as an inverse measure of the suitability of the environment and management conditions for a particular community. Thus ecological modelling systems based on the NVC can be used to predict the occurrence of plant species under specified, or changing, management scenarios. This model is comparatively static, like the LUAM approach, in that it predicts the steady state vegetation which emerges after a given management regime has been maintained for a sufficiently long period: the length of the transitional period to a new steady-state vegetation community will vary from community to community. It is also, again like the LUAM approach, associative rather than mechanistic, though more recent work under NELUP has made progress in developing mechanistic models for high profile species (badgers).

Valuation issues

While some people object to very idea of valuing intrinsically non-marketable or non-saleable attributes of the countryside or natural environment, the activities of individual land managers and operators, and also of policy makers and land use planners involves making choices between various land uses. These choices inevitably involve giving up one set of options and their associated consequences in favour of another set. Making these choices, whether on a personal basis or on behalf of society, involves making an implicit and relative valuation of each of the options. By making these valuations explicit, we are simply making the elements of the choice more amenable to analysis and discussion.

Valuing non market benefits of agricultural production and management practices therefore becomes extremely important, as does appropriate reflection of these values to the land using (primarily agricultural but also forestry and recreational) activities. Pearce and Turner 1990, outline several different approaches which can be employed to determine values of non-market environmental goods,. They identify "total economic value" as comprising: "use value" plus "option value" plus "existence value".

Use value is the value derived from a good or service by virtue of its use, and the value is approximated by the consumers' surplus area beneath the appropriate demand curve.

Option value is the willingness to pay for the option (opportunity) to use the good (service) in the future, which includes the value of being able to pass the good onto future generations (otherwise known as a bequest value).

Existence value is the intrinsic value which is independent of human beings altogether, unrelated to any actual or potential use. Pearce and Turner also discuss the three main features of environmental assets which make their valuation more difficult:

- irreversibility - that change in environmental assets cannot be (easily or cheaply) undone, if at all;
- uncertainty, especially about the future but also about substitutability between assets, goods and services;
- uniqueness, an extreme form of non-substitutability.

The elements of the three principal methods of valuing environmental benefits are as follows, see e.g. Pearce and Turner (1990) or Young and Allen (1986).

i. *Hedonic Price Approach.*
Different locations (typically of houses) are associated with different values, which can at least in principle be associated with different environmental attributes. Thus, if we can identify property value differentials due to environmental differences, we then can infer the differential value people are willing to pay for an environmental improvement. Given appropriate cross-sectional data it is possible to estimate the relationships between property values and the potential determining values through an equation such as:

Property price = F[property variables; neighbourhood variables; accessibility variables; environmental variables]

If this sort of equation can be estimated, then it is possible to estimate how much of the property price differential is associated with environmental differences, and thus to estimate how variations in the environment are valued, see for example Garrod and Willis (1992).

ii. *Travel Cost Approach.*
This approach is based on the value of time and other resources spent enjoying various (remove brackets) environmental features. Thus, using data on visits to specific sites including the types (social class) of people, distance travelled and time spent in the park or whatever, we can relate visits and durations to distance, cost and time, as well as to broad underlying characteristics of the visitors (income and wealth). It is then possible to construct a demand curve for the particular site, where the number of visits declines with the distance (cost) of making the visit, which then provides an estimate of the willingness to pay for the site, see e.g. Willis, Garrod and Dobbs (1991). In order to relate site values to environmental attributes, it is then necessary to decompose the total valuations of different sites to their several attributes. To date, little progress has been made on this aspect of the problem.

iii. *Contingent Valuation Method (CVM).*
This approach "simply" involves asking people how much they would be willing to pay for particular environmental improvements or features. This is often the only way of getting a handle on the value of environmental goods or assets, and is the only way of getting estimates of "option" or "existence" values - since by definition, these are not revealed in market transactions (house purchase - hedonic approach - or travel expenditures). The basic approach involves eliciting valuations or 'bids' which are close to those which would be revealed if an actual market existed. The hypothetical market (the questioner, questionnaire and respondent) must be as close as possible to an actual market, see for an example, Willis and Garrod (1992). Various possible biases are inherent in this approach, of which the most important can be identified as follows:

a) Strategic bias: which relates to the possible incentive to "free ride", where respondents assume that others would pay and there is no need for them to reveal their own willingness to pay;

b) Design bias: which in turn can be categorised into three sub-groups of problems: (i) Starting point: under which the choices which are given to respondents about the range of prices to chose from can influence the responses; (ii) Vehicle: the hypothesised method of payment (the payment vehicle) can also influence the responses about how much people are willing to pay; (iii) Informational bias: the information which respondents to such surveys already have (or are supplied by the questioner) about the issue in question can also have important influences on the levels and ranges of responses;

c) Hypothetical bias: which raises the important question of whether responses to hypothetical questions on how much people are willing to pay are likely to be reflected in reality, when people are actually required or asked to pay money for non-market goods;

d) Operational bias: which is (in some senses) the obverse of the hypothetical bias, and refers to the problem of whether hypothetical bids in abstract or conceptual markets (as explained in the willingness to pay questionnaires) are consistent with existing actual behaviour and markets.

In view of these biases, it is not surprising that the results of CVM research often provide rather different valuations of non-market goods and services than the previous two approaches which are based explicitly on observed behaviour in actual market conditions. However, since the CVM approach includes elements which, by definition, cannot be revealed in actual market behaviour to any great extent (especially by those not currently involved in market-based decisions), some divergence in results is to be expected. In this area, particularly, the problems of determining appropriate values for non-market goods and services present serious and presently unresolvable problems.

Discussion and Conclusions

Much of the basic modelling work of environmental/land use interactions in the UK has been conducted at the national (CAS) or river basin (NELUP) scale. However, it has long been recognised that, especially in lowland areas, much of the interesting and sensitive environmental interaction happens at the local (farm) level and is strongly dependent on particular farm practices. At the national and river basin scales it has only been possible to model environmental and ecological relationships on a probabilistic or associative basis rather than a mechanistic, deterministic or process basis. However, ecologists and environmental scientists are now able to model significant parts of the ecosystem as mechanisms or processes (eg. Hodgson and Grime, 1990; plant strategy models). Furthermore, conclusions beginning to emerge from Oglethorpe et al. (1995) strongly suggest that spatial relationships are critical, and that the mechanisms of dispersal and maintenance of populations in 'patchy' environments is crucial to understanding the spatial articulation of ecological change.

Development of these modelling systems requires more detailed projections of land use change at the farm and farm-cluster level. Preliminary development of this analysis being carried out at Newcastle [the Farm Level Land Use Environmental Relationships project (FLEUR), under the Joint Agriculture and Environment Programme - under the joint control of the three major Research Councils in the UK involved in these problems] begins with application of the associative relationships at the farm level, requiring the spatial definition of farm level results using GIS procedures already developed under NELUP.

However, scientific advance involves the development of specific mechanistic models, eventually leading to process models, of environmental change consequent on land use and management practice change. There are three major challenges in this work: a) the development of the modelling frameworks (which are expected to parallel and interact with the FLEUR farm models rather than being directly incorporated within the existing Linear Programming structure applied to the farm models); b) the calibration and validation of these model systems, eventually requiring substantial ecological data collection, though initially requiring integration and interpolation of existing data sets with known survey material; c) integration of farm/field level models with larger area models, since at the farm level the ecological focus will necessarily be limited to plant and invertebrate populations, with bird/mammal effects limited to habitat changes.

It is expected that the next phase of the FLEUR programme will be able to make substantial progress in areas (a) and (b), though progress under (c) would depend on the modelling of several adjacent farms and would thus be more limited, since the availability of necessary farm data for groups of contiguous farms is not currently easily available. Nevertheless, simulation experiments on representative or archetypal data could be developed as a preliminary stage of this work.

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2.3 The tragedy of spatial planning

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Abstract

In this contribution I intend to discuss some of the problems confronting spatial planning in The Netherlands. I will argue that these problems, despite their richly chequered and often somewhat chaotic appearance, have the same root.

First, there is the problem of the growing differentiation within agriculture. The tools and instruments used in spatial planning for analysis, design and implementation are unable to capture this process. The differentiation is not only socio-economic in character, it is closely related to the production and reproduction of 'green space'. Second, and at a very critical level, a fallacy is systematically introduced in the assumptions guiding the practice of spatial planning. Instead of departing from and returning to green space as a man-made constellation - that is to view green space as a property moulded and continuously transformed by agricultural activity - spatial planning makes increasing use of abstract spatial units. This involves the supposition that the intrinsic qualities of these units can be maintained without the socio-economic activities that produced them.

This discussion is followed by an examination of the alternatives flourishing in the Dutch countryside and here I try to make explicit the design principles embedded in these farmer-managed activities. These are principles which, I believe, could revitalize the institutionalized practices of spatial planning considerably. Scenario studies are to be built on the same design-principles as encountered in farmers' activities. Only thus can scenario-studies become an integral part of the required revitalization.

Keywords: *spatial planning, socio-economic approach, scenarios, agriculture, farming styles*

Some conceptual reflections

Agricultural land use is a concept strategic to the development of adequate models for spatial planning in the countryside and to the practice of spatial management. In this paper I argue that there is no single general set of spatial parameters that can be attributed to the sector as a whole. The practice of farming is characterized by a range of different farming styles. Each of these styles is grounded in a particular strategy and contains and defines a specific 'modelling' of green space: what is a relevant spatial organization for one farming style may well be completely irrelevant for another. The notion of 'land use' has, therefore, to be 'deconstructed'. What we need is a concept of land use that reflects the differentiated and dynamic nature of farming as a socio-economic activity. There is no general model that reflects the internal technical, productive, economic and spatial interrelations contained in the practice of farming. In each farming style these aspects are distinctively constructed. Consequently, it can be argued that spatial planning practices, built upon the implicit notion hidden within such a general model, produce their own contradictions and problems precisely because they neglect the differentiated nature of land.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 75–90.

The full range of land use practices should not be seen as remnants of the past or as obstacles to spatial planning. In fact this heterogeneity often involves a quite impressive range of under-utilized responses which can, perhaps, be used to help solve the dilemmas of agrarian and spatial politics (Van der Ploeg, 1993).

On differentiated development processes

Figure 1 represents the empirical distribution of dairy farms along the dimensions of scale and intensity. The figure shows the degree of variability present in 1969. At the time, this was considered to be of minor relevance. It was thought that the processes of modernization would lead to an increase in uniformity. This is illustrated by the arrow in the figure.

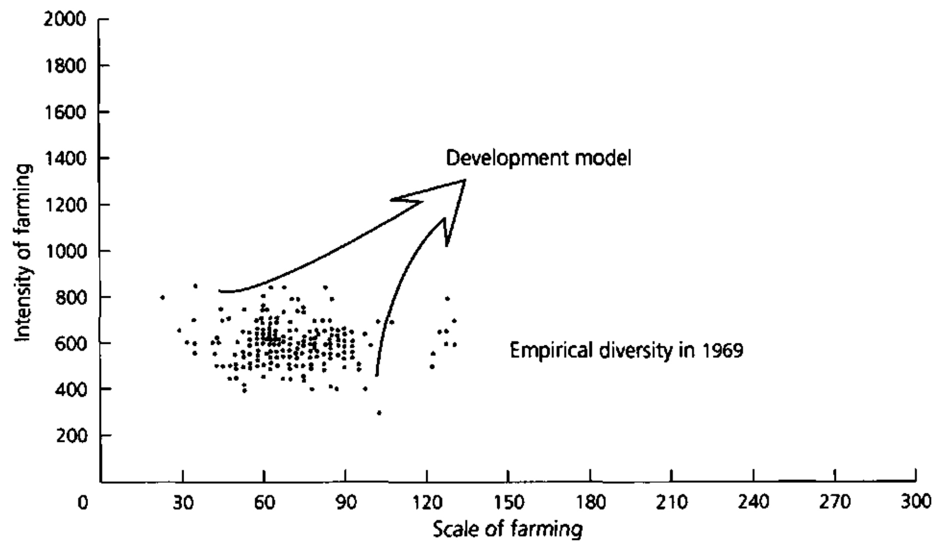


Fig. 1. Empirical diversity of scale and intensity of farming, 1969.

Thirteen years later, in 1982, the actual situation was very different from what had been expected. When data for 1969 and 1982 are compared it becomes clear that there was no apparent reduction of variability (see Figure 2); on the contrary it appears to have increased considerably. This period is, in fact, characterized by **differentiated** development trends. Farm development is not a unilinear or uniform process but a highly differentiated and multi-dimensional phenomenon: the differential development processes do not only express themselves in terms of differences in scale and intensity. Many other dimensions are involved as well. The differentiated nature of agrarian development processes reflects the various sets of possibilities and limitations encountered at farm level. Following their own specific strategy, the actors provide the driving force for specific farm structures and determine how these structures will develop over time.

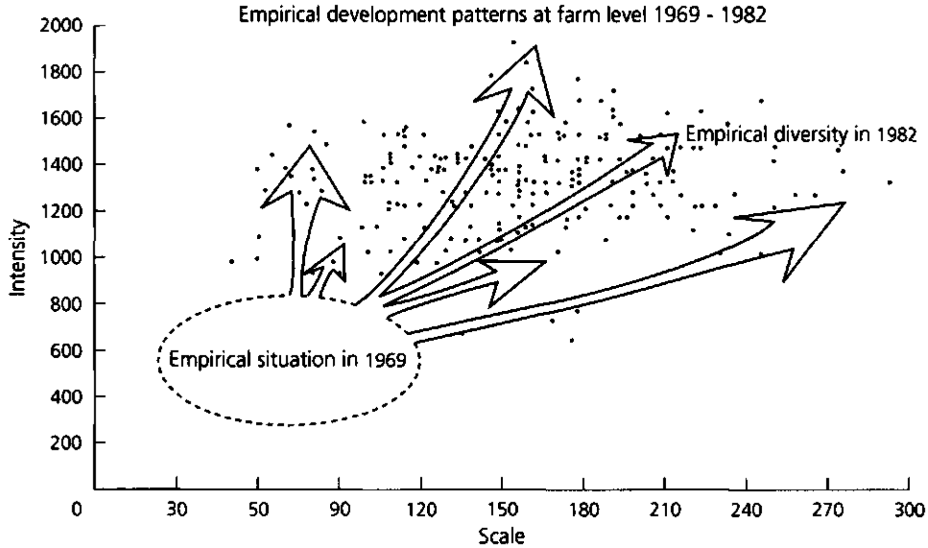


Fig. 2. Empirical development patterns at farm level 1969-1982

If we extend our time-horizon to the 1990s, we see that the overall pattern becomes even more complicated. In addition to differentiated trends towards intensification and enlargement of scale, there also emerge clear tendencies towards both decreases in scale and to extensification. These trends reflect a differentiated response towards the increasingly uniform - if not 'globalizing' - context in which farming as a socio-economic practice is embedded.

On farming styles

Differential development processes result in different farming systems. In the research tradition of Wageningen Agricultural University (WAU) these systems are known as farming styles. This is to stress the close interrelationship between the strategy of individual farmers and the specific farming practice created by their strategic activity. Second, we use the term farming style to emphasize the fact that probably the best and only way of getting to know and understand the particular dynamics, structure and rationale of a specific practice is through knowledge and experience of and insight into the goal-oriented actions of the actors involved.

In general terms a farming style can be defined as a particular unity and coherence made up of the following elements:

a) a set of strategic notions, values and insights that are shared by a particular group of farmers as to the way farming **ought** to be organized;
b) a specific structuring of farming practice that corresponds to the strategic notions or cultural repertoire used by these farmers;

c) a specific set of interlinkages between the farm enterprise on the one hand, and the surrounding markets, market-agencies, government policy and technology development on the other: these interrelations are structured in such a way that the specific farming practice can be reproduced over time. For an elaboration on this topic, see: Van der Ploeg (1990; 1992), Saccomandi (1991).

More specifically we can refer to the range of **empirical** farming styles that have been explored in recent Dutch research. Figure 3, using scale and intensity as major dimensions, provides a 'summary'. Using the folk concepts employed by Dutch farmers themselves, we indicate the different farming styles and relate them to the dimensions of scale and intensity.

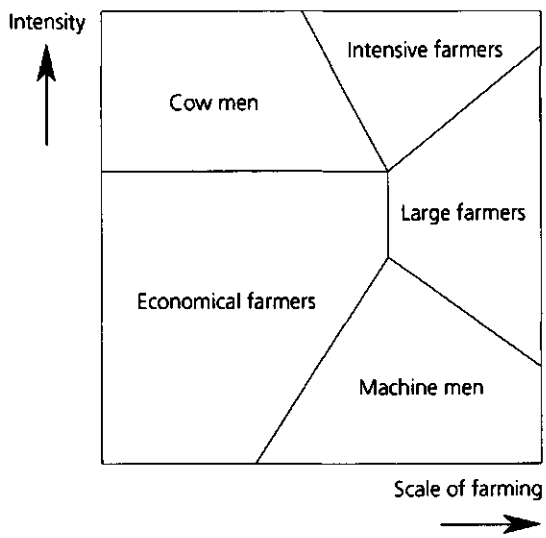


Fig. 3. Farming styles in Dutch dairy farming

Economical farmers are those who apply a strategy that aims to contain external, monetary costs, whilst striving for high levels of internal efficiency. These farmers target what they refer to as a step-by-step growth process. The balance between own and borrowed capital is carefully controlled and machinery is bought second-hand and carefully maintained on the farm itself. At the same time they keep down the amount of industrial feed and chemical fertilizer used following complementarity rather than substitution. As far as labour is concerned, the quantity and quality of labour is considered decisive for successful farming.

Intensive farmers stand in sharp contrast to their economical colleagues. Milk yields per cow, cattle density per hectare, fertilization levels, use of bought feed and fodder and also the number of animals per unit of labour force are not only much higher than those found on 'economical' farms but they are quite often higher than in any other of the farming styles considered here. Highly integrated into and dependent upon the several input markets, and having internalized the dominant technological model to a considerable degree, intensive farmers represent the most complete rupture with the past. This is also reflected in the comments heard amongst farmers themselves. Intensive farmers are described as the ones who, in the last few decades, have most conscientiously applied the message of formal agrarian policy. Central to their approach is the mobilization of market resources converting these into high output levels using the dominant technological model. A relatively low input/output efficiency is, however, the price that has to be paid for following this strategy. The gross margin is low, hence scale is a vital component in income generation and ongoing expansion becomes a built-in necessity in this farming style.

Machine-men have another way of arranging their farming activities and linking themselves to the external world. Central to their strategy is the principle of "producing as much as possible using the lowest labour input possible". Here the 'machine' becomes a metaphor that links low labour input to high production. Mechanization, particularly the mechanization of field work, is a critical factor. The intensification of animal production and the extra care this requires is considered counterproductive. For machine-men, the concept of work does not include "time wasted looking after cows".

Cow-men would disagree. For them, the cow is not only their main concern but the focal point of all farming activity. The treatment and care of animals is highly individualized and meadow use and grassland management in general depend on the feeding requirements of the herd. Cattle selection is considered to be the highly privileged domain of the farmers themselves and not a job to be delegated to external institutions. Observing the herd is certainly not seen as a waste of time, and the success of the cow-men's strategy in farming economic terms is demonstrated by the fact that the gross and net margin per cow is higher here than in any other farming style. Even though intensive farmers can claim a higher milk yield, cow-men distinguish themselves by their higher margins. In this way a specific strategy materializes into a particular practice which contains technical and economic interrelations which will confirm and reproduce this strategy.

A strategy to be found amongst **large farmers** in general, and one which contrast with those discussed above, is a strategy based on the need for ongoing expansion. A particular farming practice is only relevant if it creates the pre-conditions for expansion. Future prospects are considered a limited good, a telling indication of the degree to which the dominant discourse has been internalized. Only the largest farms are thought to have any perspective. The image of the large farmer evokes envy, admiration and criticism amongst Dutch farmers. To some extent, the evaluation of their specific practice is at the heart of a popular classification struggle.

Taken together, the styles described above form a richly chequered whole, in which specific sets of needs, interests and prospects lead to particular farming styles. To this could be added any regional variations. Economical farmers maintain a relatively high level of employment on their farms. This is felt to be important and is ensured by their particular strategy which gives a specific structure to the farm enterprise and the way it develops over time. In contrast, machine-men want to cut back on labour. This 'bottom-up pressure' is then translated into a strategic approach, materializing later in a particular farm enterprise structure.

These illustrations could be extended further. The central point, however, is clear. Farmers' strategies are not peripheral to the structure and dynamics of farming: they are central to it.

Many of today's modelling exercises appear **hybrids** when they are compared to the actual diversity of the empirical models that emerge from the very many different styles of farming current in The Netherlands. General models are constructed either on the bases of normative assumptions or on averaged data. In both cases the real 'systems' or farming practices as constructed by the farmers themselves are misrepresented. I will illustrate this point with two examples:

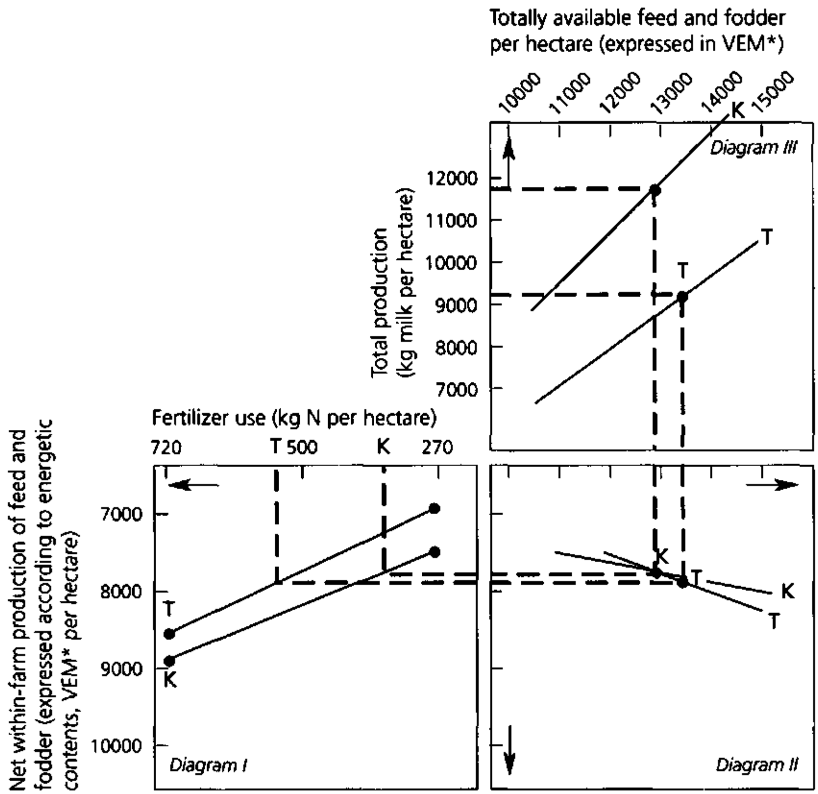
Let us first focus on the issue of input/output efficiency - a topic that can only be discussed here very briefly but which is evidently relevant to spatial planning. Figure 4 is constructed as a three-diagram representation of dairy production. Diagram I represents the interrelations between the use of nitrogen fertilizer and the production of feed and fodder within the farm enterprise and is operationalized according to energy value. Diagram II refers to the interrelation between feed and fodder as produced on the farm and feed and fodder as acquired on the market. Together this gives the total supply of feed and fodder per hectare. Diagram III links this total supply to total animal production per hectare.

In current modelling exercises, the interrelationships that are significant in each diagram are derived from what are seen as 'fundamental laws', ultimately supported by findings from experimental situations, or from empirical studies that identify the 'most efficient' solution. In the former, empirical diversity is understood in terms of deviation from the 'optimum'. In the latter, some hierarchy is assumed, which normally implies the introduction of 'vanguard farming' and 'backward farming' as decisive categories.

Departing from the concept of farming styles as productive constellations strategically constructed by and through the goal-oriented action of the actors concerned we are confronted by quite a different image. The strategic action of the cow-men, for example, results in an empirical model that differs substantially and significantly from the "model" or that entity of technical interrelations which together make up the dairy farming process as developed by the machine-men, for example. This is illustrated by the differential position of the (statistical) interrelations in the diagrams that make up Figure 4: **In their (differentiated) practices different groups of farmers create contrasting models.**

The relevance of such a finding can hardly be underestimated. To realize the same animal production per hectare machine-men need 31 percent more nutrients (N) than cow-men. This is not the most marked difference. Research on farming styles indicated time and again that the most 'polluting' styles represent levels of N-losses per hectare some 60% above that of the relatively 'clean' styles. It nevertheless shows that the environmental problem associated with intensive livestock systems would be quite different if the approach of certain styles was more generalized. Figure 4 also shows that realising a particular volume of production using the style of the machine-men makes far greater 'claims' on the green space available than when the style of the 'cow-men' is adopted.

More important, at least from a theoretical point of view, is the fact that the relatively low input/output efficiency of the machine-men cannot be conceptualized in terms of 'bad farming' or 'lack of knowledge'. Machine-men are generally well aware of the differences illustrated in Figure 4. They argue that their specific strategy - realizing as high an output



*VEM is a Dutch abbreviation for 'feed unit lactation'; I VEM is approximately II.5 kJ Metabolical energy.

Fig. 4. Three diagrams representing partial I/O relations in Dutch dairy farming; distinguished for 2 farming styles (K = cow-men; T = machine-men)

as possible with as low a labour input - is entirely rational and, therefore, legitimate. Cow-men, on the other hand, strive for the highest possible margins per cow. Within such a strategy a high input/output efficiency is both a decisive vehicle and a crucial outcome. By extending the three-diagram structure and adding a fourth, this can be underpinned statistically. Because of their particular modelling of the technical interrelations of the 'system', machine-men achieve better GVP/LU ratios (Gross Value of Production per Labour Unit), whilst cow-men achieve better values for the marginal return for each cow. Final income per labour unit may be the same in both situations: the way such an income is realized, however, can differ sharply. To neglect these empirical differences will mean that 'general models' will only be gross over-simplifications of farming as it is practised.

In a second example, derived from a study carried out in Friesland, a calculation was made of the quantitative aspects of different farming styles in terms of land use. It was again evident that there is no single, unilinear relationship between production and land use. As illustrated in Table 1, the amount of land needed to realize the provincial milk-quota, for example, can vary from 117,000 to 154,000 hectares. The number of farms and the total nitrogen-emission can also be expected to vary depending on which farming style is dominant. These facts emphasise the importance of the following conclusion: contemporary agriculture is more malleable than is often assumed.

Table 1. Differential impact on total land use of different farming styles

	required acreage (in ha)	number of cows	labour units	number of farms	total N-emission
intensive farmers	117,000	213,000	4,754	2,515	51.1
cow-men	132,000	216,000	4,114	2,154	43.6
economical farmers	144,000	232,000	5,065	3,107	59.0
large farmers	145,000	246,000	4,377	2,200	51.3
machine men	154,000	240,000	4,255	2,880	61.6

On the differentiated use of 'green space'

Each of the farming styles discussed here defines and contains a specific 'spatial impact'. The working methods of 'large farmers', for instance, presumes a continuous, frequently abrupt reorganization of a particular space that often borders on 'rebuilding'. This is due to several interrelations. First, there is ongoing expansion, which implies the frequent acquisition of additional pieces of land and thus spatial re-arrangement. Second, the continuous application of the most recent technological models requires a physical space stripped of those characteristics that might hinder the type of intensification and scale-enlargement suggested by these models. The 'casco-model' developed by our colleagues in WAU expresses the optimal space as required for this pattern extremely well: it consists only of boundaries, the rest has literally been 'stripped' away. Third, the scale of operations, evidenced, for example, in the machinery used requires very large plots, whilst the level of intensity implies a range of conditions at the spatial level that increasingly goes beyond the farm itself and involves such factors as the water-level in the subsoil and its relationship to carrying capacity; accessibility; distance to specific 'natural values' and the availability of water for irrigation.

Although these spatial requirements are often regarded as being 'universal' as far as modern farming is concerned, in comparative analysis they emerge as highly specific and 'local'. The style of economical farming provides an example. Here the ongoing 'rebuilding' of the natural environment, for instance, is often seen as being 'too expensive' and perhaps counterproductive. Generally speaking, the style of economical farmers is more in line with historically produced spatial patterns than that of the large farmers, for example, and is built upon the use of the non-commoditized local ecology. Therefore, in the economical style, the 'art' of using available natural resources is highly developed. The 'stripping' - so highly valued by large farmers - is seen as irrational, particularly because it ignores and makes superfluous any knowledge of local ecosystems.

The argument presented above can be illustrated by many examples. Here I have chosen one. In the sandy soils of eastern Friesland, known as the 'Friesian Woodlands', nineteenth century farmers worked their lands into a beautiful, small-scale landscape characterized by hedges and avenues of trees. In those days, these elements were multifunctional and highly useful components of local farming styles. Today under the influence of the 'large farmers', who have been responsible for the disappearance of many of these characteristic elements, a process of dismantling is taking place. For the economical farmers, however, these hedges and trees offer shade for farm animals, a habitat for useful predators and increase the quality of the environment in which farm families live and work. Because their farming-style is relatively small-scale and extensive, there is no urgent need to 'open up' these small parcels of land, nor any need to get maximum grassland-production out of the fields.

We can conclude that it is precisely those elements considered by large farmers to be major obstacles to development, which economical farmers view most positively.

The other styles of farming we have mentioned here could, of course, also be discussed in these terms and an interesting aspect of such a discussion are the different 'levels' involved. For cow-men, for example, the 'micro-level' (their fields) are of strategic importance. Grassland improvement, high fertilization levels, and standardized and highly productive grassland varieties, are decisive. Their major concern is the production of an energy-rich fodder capable of ensuring high milk-yields. Thus, any suggestion that grassland composition be altered to include more varieties of grass, flowers or herbs is likely to meet with considerable derision.

The farm at the meso-level and the landscape at the macro-level, however, are also seen somewhat differently by cow-men. Hedges, trees, bushes, and **pingos** (small lakes dating back to the glacial times), far from being a hinderance are essential components of the small-scale field lay-out allowing cow-men to easily adjust their grassland management to the needs of their herds.

In contrast, the machine-men, with a style that involves large-scale operations, often find the meso- and macro-level particularly troublesome. From their point of view the lay-out of the farm and the spatial structure of the area in general should contain as few 'obstacles' as possible. At the micro-level of the field, however, machine-men are able to tolerate a diverse collection of grass and plant varieties, take account of bird species with habitats on their land and are prepared to ensure that fertilizer is not spread too close to the boundaries of their fields so long as this can all be integrated into highly mechanized farming. 'Machine-men' are often the ones who receive contracts for mowing hundreds of hectares of grass in nature reserves.

The fallacy of the wrong level

Since farming is a highly differentiated socio-economic practice, the use and therefore the reproduction and transformation of 'green space' is also a highly differentiated phenomenon. Farming practices affect spatial structures in various ways: some farming styles give rise to the drastic transformation of spatial structures, others reproduce or even enrich these historically produced patterns. What has been demonstrated at the European or interregional level (Meeus et al., 1988), applies to the intra-regional level as well. It should also be noted that the interrelation between farming and land use on the one hand, and landscape and spatial structure on the other is not unilinear: what is relevant at one level, for example the 'fields', often forms a contrast with another level, for example, the level of the farm enterprise or the area as a whole. Finally it must be emphasized that what may appear to be particularly interesting or promising in one style, might be seen as completely counterproductive and irrational in another.

Particular landscapes - including the natural values embedded in them - are often understood and represented in isolation from the particular farming practices that produce and reproduce them. Specific natural and landscape-values are perceived as **the intrinsic** qualities of a certain geographical area. That is, these specific qualities are **disconnected** from the practices and actors that produced and reproduced them. That is how the current **fallacy of the wrong level** was born and sustained as it ravaged its way through spatial planning practices in The Netherlands. The fallacy of the wrong level might be understood as the **institutionalized disconnection** of farming on the one hand and spatial planning on the other.

It often happens that a certain area develops in a way that is particularly beautiful and it becomes evident that many values there are worth preserving. Consequently, it can be argued that this piece of countryside should be converted into a nature reserve and agriculture, seen as a menace, should be eliminated from the area altogether or at least be subordinated to the principles of landscape preservation.

If we assume that the area in question contains a differentiated agriculture (see Figure 5), characterized by different farming styles, it may be possible for some of these, particularly the economical farmers and, to a lesser degree, the cow-men and machine-men, to make a fruitful **combination** and **integration** of farming with the preservation of nature and landscape. For other farming styles, however, **separation** may be the only valid option: this would be the case for the large farmers with 'optimal farming' in one part and 'reserves' for nature and landscape in the other (see Figure 5).

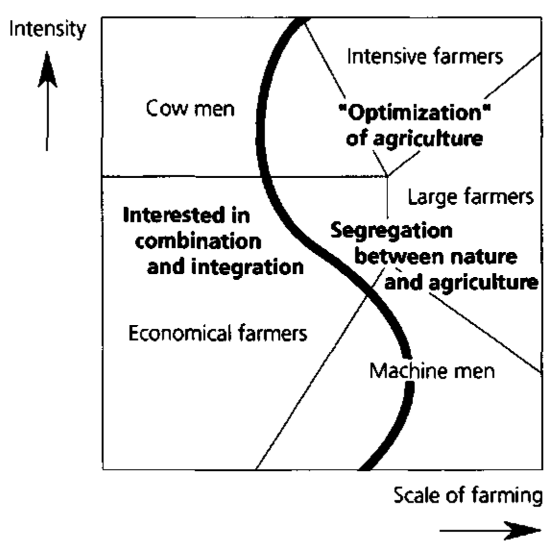


Fig. 5. Farming styles in Dutch dairy farming: integration or segregation of nature?

The fallacy of the wrong level arises from the basic mistake of taking **area** as the most relevant unit for analysis, planning and implementation. This is illustrated in Figure 6.

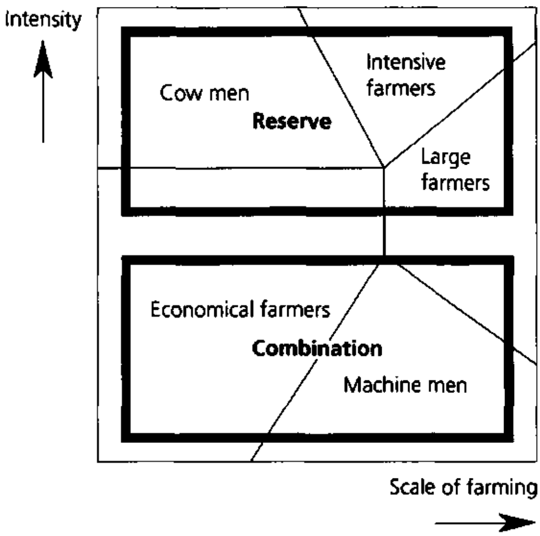


Fig. 6. The fallacy of the wrong level: area instead of farming practice

One area is designated 'reserve' whilst the other is assigned to become an area where the 'integration' of farming and the preservation of nature and landscape can take place. The juxtaposition of these two levels - the geographical and farming practices - will inevitably create a range of new problems and contradictions (see Figure 7). Proposals for 'integration' will probably satisfy some farmers whilst others will find it impossible to integrate the preservation of nature and landscape into their particular style. The same is true in the case of the 'reserve': whilst the total elimination of farming will probably be unnecessary in some reserves this may well be resisted by those farmers who want to get the highest expropriation payments possible so they can continue farming somewhere else.

Although Figure 7 may appear to be simplistic, I believe it gives us an insight into the drama that surrounds spatial planning not only in the Dutch countryside but in many other areas of Europe as well. Spatial planning generates its own counter-forces and opposition. Put more bluntly, it generates an overall, generalized opposition where many different reasonings, interests and prospects coincide. If, however, the level of analysis, planning and implementation was shifted from **area to the farmers and their farming practices** then a very different dynamic would be revealed.

Those of us who are familiar with farming systems in the Third World, are all aware of the 'tragedy of the commons'. Paraphrasing that notion slightly and applying it to the Dutch context we arrive at the 'tragedy of spatial planning'. In the rural areas today, there is considerable interest in the challenges associated with the new forms of spatial planning

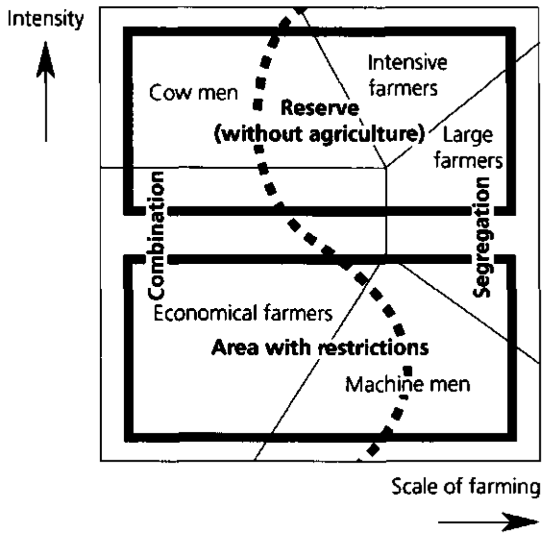


Fig. 7. Juxtaposition of the two levels

which include agrarian nature conservation, the agrarian preservation of particular landscapes, and agro-tourism. As has already been emphasized, these interests are highly diversified. This is not a problem in itself. However, because current spatial planning arrangements organized by state agencies presume a uniform 'package' for specific areas, the diversified nature of these interests immediately becomes a major hindrance to any practical step forward. This is precisely how the **tragedy** of spatial planning develops.

Towards local self regulation: the lesson of farmers' initiatives

Extensive research was carried out into farming styles in the area known as the Friesian Woodlands (De Bruin and Van der Ploeg, 1992). This study not only documented the differentiation in farming practices. It also focused on the differentiated use of 'green space'. A particularly interesting research method was used. Contrasting images relating to different 'levels' (fields, farm and landscape) were shown to farmers in a pair-wise presentation. Respondents were asked to choose which of two situations would be most acceptable to them. After applying factor analysis to the results there emerged a preferred image of how green space should be organized. As can be seen in Figure 8, two central dimensions were distinguished. The first relates to micro and meso conditions, the second concerned macro aspects. Again it was clear that the preferred image of green space was highly differentiated (see Figure 8). Despite the considerable variety in interests and prospects, the Friesland Woodlands turn out to be one of the most inspiring areas in The Netherlands as far as innovation in land use and spatial planning is concerned. The clue to this success lay in local self-regulation. Farmers in the Friesian Woodlands have created several new farmers' associations hoping to achieve a farmers' controlled management of nature, landscape and environment (detailed information is to be found in Hees et al., 1994 and in Renting et al., 1994). These associations offer a major alternative to the tragedies produced by current planning approaches.

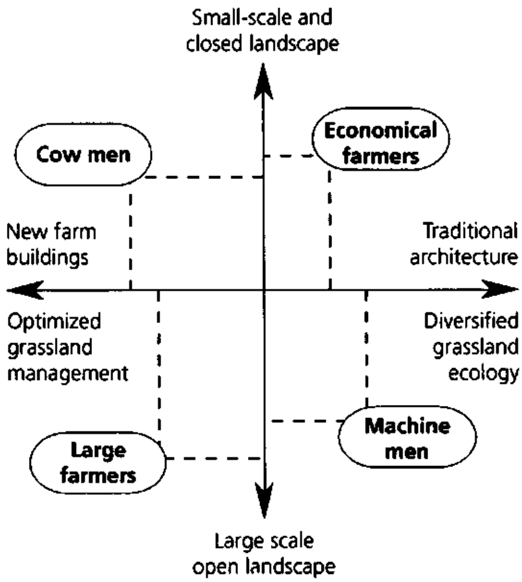


Fig. 8. The differentiated social definitions of required green space

The main design principles used in the Friesian Woodlands research are as follows:

1) In contrast to current practices, a first and very important innovation is the mutual repositioning of goals and means. Whilst state policy increasingly prescribes specific means, these farmers' associations claim autonomy to select, elaborate and implement the means which seem most appropriate for the assessed goals. There was an exchange as it were, in which the farmers' association accepts the general goals as defined by politics and parliament and ensures that these goals will be realized. In order to do so, however, they claim the necessary room for manoeuvre, which implies, amongst other things, that the required means will be selected and developed by the farmers themselves. One particularly interesting consequence of this approach is that many practical innovations have been developed. These offer promising, cost-effective and efficient alternatives to the methods used up to now which were developed in institutionalized research stations.

2) Internally, these farmers' associations combine and apply the notions of **diversity, exchangeability and flexibility** in a consistent way. The diversity of these associations is not only recognized, it is used as one of the main ways of realizing coherent plans. Individual interests and prospects are aggregated. Asking each member what he or she could contribute to the accepted goal has produced a richly chequered whole.

Proposing specific solutions can be very beneficial for individual farmers. In making their own contribution and by being a member of the association they contribute to the overall plan. This carries the implication that they are exempted from following the means prescribed by central government. An important illustration in this respect is the so-called 'ecological norm': this 'norm' implies that no expansion whatsoever is possible when there are natural objects in the neighbourhood which are susceptible to acid rain. In areas densely covered with shrubs and trees, this prohibition implies that 'agriculture becomes completely blocked', as farmers say. The associations referred to above proposed to the authorities that they would commit themselves to the maintenance of tree cover on condition that the ban on expansion would be lifted. This was accepted and, as it turns out, the deal works quite well in practise.

Exchangeability is another strategic feature. Due to the very diversity of conditions, some farms are able to do much more than others. They create - at least temporarily - a 'buffer' that allows other farmers to adapt their way of farming. This allows an exchange of possibilities and constraints, at least as long as the general goals at the level of the association as a whole are honoured. Again, for individual farmers, this is a considerable advantage. Let me illustrate this with a simple example: in current spatial planning approaches, prohibition dominates. In order to protect hedges and avenues of trees, for example, it is forbidden to damage or cut them down. However, on some farms, for example, making a gap in a hedge through which cattle and machinery can be driven would allow quicker movement from one plot to another and might be a rational solution especially if it creates more 'free' time which could then be spent on maintaining the remaining hedges. Exchangeability implies that if one farmer is prepared to plant more hedges the other farmer, who needs to make a gap, will be allowed to do so. In these arrangements compensation can be money-wise or in kind.

3) The example cited above makes clear that the emergence of a **collective** of farmers - leading perhaps to a regionally interdependent and dynamic approach - allows several new perspectives and solutions to emerge. Exchanges between farmers become possible and the same applies to a exchangeability between sub-zones. Protection of birds, for example, will be especially relevant in the wet zones near the lakes (the former 'hay-lands'). Instead of compelling all farmers whatever their specific conditions, interests and prospects to comply with these measures, a more dynamic approach emerges: in wet zones certain solutions pertain; in the higher, dry zones there are others. The interdependence of the two is evidently crucial (see also Figure 9) and the same applies to the distribution of costs and benefits. It is only with diversity, flexibility and exchangeability as design-principles applied by and within a collective of farmers that such approaches can be consolidated.

4) The last design-principle to be discussed here is the emergence of **social control**. It is in the interest of all farmers that each member of the association complies with the internal arrangements that have been developed. 'Free-riders' could jeopardize the success of the association as a whole and therefore the interests of all its members. Social control is, therefore, institutionalized in these associations although the term is not used as such. When compared to the bureaucratic control associated with current spatial planning, one cannot but conclude that this type of social control is more effective, cheaper and more socially 'acceptable'.

Re-grounding scenario approaches

The example of the Friesian associations was quickly followed in several other parts of The Netherlands and there are now about 50 of these associations throughout the country. The political moment is especially interesting. The Minister of Agriculture has granted an experimental status to some of these associations in order to explore further their scope and impact.

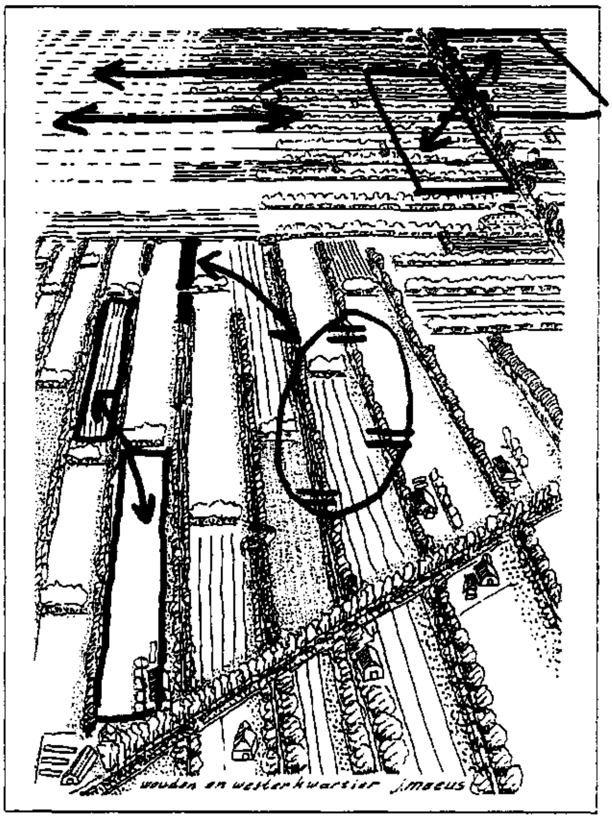


Fig. 9. Schematic overview of 'exchange' forms

The growing support for farmers' management of nature and landscape is the result of a specific use of scenario-studies. It is through such studies that the potential impact and therefore the benefits derived have been made transparant and accessible to a larger public. Crucial to the scenario-studies was that they were grounded meticulously in the dynamics described here. Then, two typical 'scenario' assumptions were introduced. The first was that the interesting possibilities deriving from specific farming styles would be supported and eventually strengthened at national and regional levels through specific policy adaptations. The second assumption was that none of this would be realized. Consequently, the impact in terms of employment, income, spatial patterns (as well as the costs, the B/C ratio, the effectiveness, etc.) of a renewed policy could be assessed and introduced into public and political debates. From this I derive one main conclusion. That is that the central issue of scenario-studies is not to be found in the domain of technicalities. It is instead located in the question of "grounding": What are the perspectives, prospects and interests that are made visible? What are the potential processes that are highlighted? On whose experiences and possibilities are scenarios grounded? It is only when links such as those indicated are established that scenario studies will achieve their full potential.

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2.4 From scenario to plan

The role of landscape design in integrated scenario studies

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Abstract

Designers translate complicated calculations on what would happen if this or that was done into shapes and colours that people can understand as being part of their imagined future lives. They also show the technical specialists how their ideas would affect other aspects of the environment and what needs to be done to offset unwanted side-effects: designs act as mirrors for analysts and policy makers.

Many scenario studies contain a spatial component: they relate the evolution of a landscape. In such cases architects and landscape architects are well equipped to show this impact in a clear and convincing way, or to show different design solutions for the same spatial problem.

What are the tools normally or exclusively used by these designers? Certainly not just pencils, brushes and paint, but at least also a verbal tool kit. And there is 'computer-aided design' as well, which is a relatively new tool to show the evolution of a landscape under various sets of assumptions and constructed trends.

In three examples the use of this diverse set of architectural tools for the development of integrated scenarios will be demonstrated: housing and glasshouse horticulture truly integrated in a symbiotic way ("City Fruitful"); bridging the existing/the familiar and the new/the unexpected in a contemporary equivalent of the old estate-cum-stately home ("the Bridge"); and the transformation of the man-made island of Neeltje Jans, part of the Netherlands Delta works, into a dynamic environment where nature and culture meet.

Keywords: *Design, architecture, landscape architecture, integration*

Introduction

Architects and landscape architects should employ a method of design which is, due to associative thinking, a tool to create an awareness which is not yet submitted to the censorship of the ratio, thinking with the ingenuous child's imagination as its model, when the fantasy is still free from a restraining logic, but accessible to the change resulting from the confrontation with the commonplace; the ratio of the associations brings abstraction closer to reality.

The 'associative' approach moreover helps to bring together tangible and intangible dimensions. In spite of the fact that their stories are secretive, their rules are absurd and chaotic, this method is in a state to create a new order whereby the cultural life can be infused into the dead matter.

Many scenario studies contain a spatial component: they relate to the evolution of a landscape. In such cases architects and landscape architects are well equipped to show this impact in a clear and convincing way, or to show different design solutions for the same spatial problem. Is this type of design more than a mere visualisation of the

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 91–97.

scenarios? If so, what is the additional value? "Integration" is perhaps the magical word, but how does an architect do it? Isn't he selective in what he picks up from the predominantly technical scenario-studies? What are the tools normally or exclusively used by these designers? Certainly not just pencils, brushes and paint, but at least also a verbal tool kit: "the narrative". And there is "computer-aided design" as well, which is a relatively new tool to show the evolution of a landscape under various sets of assumptions and constructed trends.

In the following examples the use of this diverse set of architectural tools for the development of integrated scenarios will be demonstrated: 1) "City Fruitful", a metamorphosis of the agrarian land into a symbiosis of housing and green houses within the concept of a sustainable development, 2) turning an agricultural area into the estate of the 21st century, a contemporary equivalent of the old estate-cum-stately home, integrating "perma-culture" afforestation, recreation and nature, 3) sculpting the artificial island of Neeltje Jans built to construct the flood barrier Oosterschelde into a nature reserve with recreational and educational values.

City Fruitful

For everyone the city is a reality, for us it is also an ideal. Reality is modelled after the ideal, but it is also possible for reality to model the ideal. The discussion about the city balances between dream and action, will and habit, utopian desires and material constraints. A group of people "of different feathers" (urban planners, architects, market gardeners and economists) took up the challenge to build an ideal city based on four fields of force: Energy, Ecology, Economy and Emotions.

A symbiotic concept was born: a combination of housing and glasshouse cultivation, two functions which had been strictly separated before. The symbiosis of housing and cultivation opened up a whole new environment, in which both living, working and recreation and the production and consumption of food were combined in one part of the city (Plate 1a and 1b).

To see how realistic this concept was, it has been worked out in as much detail as possible. We found the perfect site in Dordrecht, a site between city and landscape. When Kuiper Compagnons, who had been asked earlier to draw up a master plan for the city of Dordrecht, applied the idea of the city as an archipelago to this site, the concept was already halfway.

In City Fruitful about 1700 houses have been combined with approximately 24 hectares of glasshouse and 5 hectares of open air cultivation. The built surface covers about 56 hectares. The dwellings are located on, under, between and next to commercial glasshouses, in which vegetables and fruit are grown in a clean and environmentally-friendly manner. The project is based on as many closed water, energy and waste cycles as possible and on communal transport systems for dwellings and glasshouses. Besides, the City Fruitful inhabitants are involved in the food production processes themselves; it is a true green culture.

Over the years Dutch glasshouse cultivation has developed into an "industry" which puts a heavy burden on the environment and must be kept far from the residential areas. These past few years, however, many technological innovations have been taking place in market gardening, opening up the way to clean and healthy cultivation methods. Among these innovations: ecological crop protection, bottomless cultivation, storage of drainage water, recycling of nutrients and raw materials, computer-controlled climate management techniques, energy screens and the like. Cultivation may take place in a closed circuit without harmful emissions into soil, water or air.

From the point of view of space and energy, this symbiosis has many advantages. Traditional mono-functional areas of residence and glasshouse cultivation take up about 1.5 times more space, and energy demands are considerably higher there.

On the whole, the city is out of bounds for cars; inhabitants and visitors can leave their cars in a large, glass parking space, offering a view of plant and glasshouse world. The main access road intersects the city. At a right angle to this main road one finds three side-roads and a fine-meshed network of roads and paths, some of which take one right through glasshouses and winter gardens. They are there to make transport on foot, by bike or by public transport attractive. This is one of the starting points of the project.

The City Fruitful design has a number of elements: the market as the centre of exchange of knowledge, goods and culture, the Parking Glasshouse, the Glass Pavilion - the centre of information and knowledge, the Giant Hedge with its vertical multi-layer glasshouse and fruit gardens to the sides - a green wall in summer and a clear band of light in winter, the Reed Lake with its rush fields for natural purification, and combined cultivation/residential areas with titillating names like Double Bottom, Sun Gardens, Glass Field, Crystal Gardens, City Wall and Rolling Field.

Three of these areas are characterized by a solid symbiosis of residence and glasshouse cultivation. Thus in the Double Bottom a close carpet of patio dwellings is crowned by a second ground level: a glass-covered layer with glasshouses and paths for reaching the homes. The Sun Gardens are glass-covered zones for multi-layer cultivation. Here courtyards with ponds have been left free, while in the Glass Field the houses have been lifted to leave space for crop cultivation and a winter garden.

The solid symbiosis of residence and cultivation in Double Bottom, Sun Gardens and Glass Field is alternated with zones which are much more open: wood- and orchard-like strips, a fruit garden, the Crystal Gardens with their glass-envelope dwellings - these free objects in their parklike surroundings - and Translucent Mountain, a four-plane pyramid, two sides of which surround a winter garden and the other two hide a number of terraced flats. In this design it is essential for each house to border both on the exterior and glasshouse environment. In controlling the quality of the air in the living quarters, all sorts of precision control techniques from glasshouse cultivation are being used, such as linking the quality of the air to the system of opening and closing airing windows and sun shields.

A strip-shaped plot, the Rolling Field, has been projected right across the other zones. The Rolling Field is a chain of dwellings, with a slightly rolling roof of hills and valleys and with gardens on top of the houses.

Contributions of the initiators were many and varied: philosophies about city and culture, fascination for constructions of glass, experiments with climate-control equipment and new horticultural techniques, visual creativity, construction ingenuity and emotional impact. We created the ideal of a most exciting synthesis of the artificial and the natural, which had to materialize in recycling systems and energy circuits. As urban planners, architects, glasshouse market gardeners, technicians and economists, we have combined plain common sense with enthusiasm and imagination. It has become a quest to make separate functions, which have always been kept apart, such as living, working, recreation, producing and consuming, prosper together and, from this hybrid, breed attractive, healthy and clean surroundings. The wager was - make it a fruitful, a fruit bearing environment. For us its creation has been a source of tremendous pleasure, which we hope will catch on.

The estate of the 21st century

A new estate in the Dutch province of Overijssel, situated in the Twente countryside, between the towns of Almelo and Borne. On the estate, where everyday life will take its normal course, it will be possible to experience the interaction of nature and culture in works of landscape design and art. In many respects this new estate may be a link or transition between units which are now separated: between the Almelo and Twickel estates; between present and future; between the existing/the familiar and the new/the unexpected; between what has grown little by little and what has been designed as a work of art; between wearing out nature and offering it some new space. This is why this estate of the twenty-first century will be named "the Bridge" (Plate 1c and 1d).

The system of brooks and water routes in and around the area may be restructured to separate comparatively clean and comparatively polluted water, in line with the ideas of the Regge and Dinkel River Board. Nature development may have its roots in the New System of Brooks.

The presence of a rubbish dump in the area is inevitable; a hill, 25 metres in height. The inclusion of this element in the estate-concept must be seen as a recognition of the need for transition, present here as well; the transition between the spendthrift of our consumer society on one hand and the essential economy of resources and energy on the other. While the hill grows and grows, all we can do is lower our eyes and be ashamed. Hence the name of the hill: the Hill of Shame.

The estate must be of the twenty-first century. Contrary to the 'traditional' estates there will be no imposing manor in the centre and ownership of the estate will not be a one-man or one-woman business only. For that reason the first step in estate foundation will be demarcation of the edges of the area intended for nature development. The area, 16 hectares in size, will be marked by eight poles on the borderline. With their periscope optics they will also serve as watchtowers, allowing anyone interested a glimpse 'from above' of the estate formation process. These will be the Picket Watchmen. The image of the area will be largely determined by its edges, the zones bordering on this demarcation line. On each of the four sides there will be a specific landscape-art visualization of the 'Bridge' notion, governed by four themes: Ethics, Aestheticism, Romanticism and Logic.

The new brook system will be the most important exponent of nature in the making. In addition, 60 to 100 hectares of new forest will be planted. These are the key elements of Landscape Transformation.

For the middle of the square estate-area, a water element has been planned, called the 'Pond of Reflection'. At some distance, on the edge of a swamp forest area, there is an elevated garden - the 'Garden of Present and Future'. A series of forest plots along the main access road of the area will be given a thematic structure, evoking specific moods and emotions. The rubbish dump has the visual potential of affecting the way people handle their resources and waste matter.
In various parts of the estate the visual arts will be clearly present, expressing the hidden feelings for and expectations from nature and giving the area a special dimension as the Place of Modern Myths.

The estate area is inhabited by people as well, who depend on the land for their living. The plan allows for highly qualified agriculture of an environmentally safe nature. Of course forestry and nature development will occupy agricultural fields. But these will only be obtained if the farmers give their permission. This means that estate formation requires a gradual process of inhabitants and users of the area evolving from Fellow-Sufferers into Fellow-Participants.

The new estate will play a major role as an outlet for the urban population of Twente. The visitor, looking for entertainment, will not find a whole range of 'facilities' in the area but will be confronted with a special harmony of culture and nature, allowing him to be immersed in the mental re-creation, culminating in the awareness that the formative power of nature may blossom in full when culture offers the space to do so: Cherishing Nature is an Act of Culture.

The twenty-first century "Bridge" estate is a gift of Het Overijssels Landschap to the inhabitants of Overijssel, a gift which does not look back but ahead, into the twenty-first century. A gift which is not ready yet. A gift which has to be given flesh and bones with the help of the people in the area.
In the process the idea might be altered in many ways, but enthusiasm and creativity will have to be its pillars.

Neeltje Jans

The former sandbar in the Oosterschelde, called Neeltje Jans, acquired additional and very special significance, when it was 'kidnapped' to serve as an artificial island for the construction of the Oosterschelde flood barrier. In the middle of the sea with its infinite horizons, Neeltje Jans now watches over the Oosterschelde nature, proudly presenting the technology which allows nature conservation to be an act of culture. Right from the start people have come to watch the impressiveness and ingenuity of the flood barrier. Nature, developing on the island, increasingly becomes a focus of attention too.

Delta Expo Foundation takes care of the facilities for visitors and informs them about the island. Their information mainly concerns the Delta works. Delta Expo would like to expand its function, to be able to serve a new kind of visitor. The first step in this new addition to the information set-up will be the construction of a water pavilion, with adjoining water playground, offering a large audience information about integrated water management. It will be the initial impetus to the further development of Neeltje Jans as an island where nature and culture can be enjoyed in close harmony. The intentions represented in the Masterplan state that Neeltje Jans must be a 'working-island for sustainable development', which addresses a visitor's intellect and emotions and which turns the island into a 'place of modern myths'.

Any further development of Neeltje Jans must first and foremost be based on natural development. And this is precisely why the masterplan suggests covering as much of the island as possible with a landscape of dunes, which will never stop developing (Plate 2a). In this natural environment the constructed elements and public facilities will be located. They will be made subject to the landscape: their location will be in and beneath the dunes. Buildings will present themselves as incisions in the surface of the earth. To create a zoning between areas of lively activity and areas of tranquillity and to create a sheltered environment, the constructed facilities will be gathered round an open circle, thus creating an 'inner-dune-edge'. From this circle three lines intersect the island. Each of these lines has its own physical shape and specific programme.

The Line of Knowledge and Know-how connects the Oosterschelde barrier and the extensive landscape of dunes allowing visitors to experience the interrelationship of technology and study of nature. Elements which might be bordering this line include a fishing-information centre, a visitors centre for the Oosterschelde National Park, a Temple of Nature and a Stay in the New Age, the latter being a modest conference centre, a test-case for the latest developments of a sustainable way of building and living.

The Line of Thinking and Dreaming might be set up as a series of art projects, which (in one way or another) relate to the dynamic natural landscape of dunes and specific situations on the island. In the Inner-dune-edge, an art exhibition centre might serve as a pillar to support the line.

On the island the Line of Wind and Water is the bridge between the North Sea and the Oosterschelde. On the North-Sea side, the theme is 'wind'. This theme might be visualized in a wind playground and a wind pavilion.
On the Oosterschelde side, the theme is 'water'. This will be the location of the future water playground and water pavilion. The centre of the wind-water-axis will be an existing tunnel under the road. It is the perfect site for the visual expression of the mythical associations of the wind and water theme. A rough draft reveals the architectural concept of the water pavilion (Plate 2b). This draft shows a building in two parts: one underground section, part of the newly created landscape of dunes, and another section rising from the Oosterschelde, its shape and materials reminding one of a drop of water.

Step by step Neeltje Jans will be given its shape, a process leaving plenty of room for the unexpected initiative. Within the visual-spatial context described above the masterplan also offers a programme base for adding new elements to the island, the accompanying catering facilities and the essential logistics (clearly emphasizing the option of the island as a forbidden territory for cars).

Conclusions

In the context of studying different options for the future of our urban and rural environment, not only a range of technical trends and solutions to perceive problems needs to be taken into consideration, but also assumptions on how societies respond to the new problems that are generated by their solutions. It is on this meeting ground between technical options and societal perceptions that designers play an important role. They translate complicated calculations on what would happen if this or that were done into shapes and colours that people can understand as being part of their imagined future lives. They also show the technical specialists how their ideas would affect other aspects of the environment and what needs to be done to offset unwanted side-effects: designs act as mirrors for analysts and policy makers.

CHAPTER 3

Scenarios and rural policy

3.1 Rural areas in perspective. A policy view

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Abstract

In this opening address three issues are discussed: (a) developments in rural areas with emphasis on The Netherlands and the competition for space in present and future land uses, (b) the role of science and knowledge transfer for the Netherlands Ministry of Agriculture, Nature Management and Fisheries in the policy process, and (c) the significance of scenario studies to the Ministry as powerful instruments to help to make choices regarding long-term strategies.

Keywords: *policy, rural areas, scenario studies, future land use, environmental protection, area-specific, science and knowledge transfer*

Introduction

The decision in the late 1980s to integrate four research institutions engaged in soil survey, land and water management, ecotoxicology and landscape planning was the right one. The aim was to improve the conditions for integrated land, soil and water research and this has been achieved.

The title of the symposium reflects the coherence of these different aspects in rural areas and their options for the future, with special emphasis on the help scenario studies may offer.

I shall discuss three points. The first deals with developments in rural areas and a recent policy statement on these by the Netherlands' government. The second is concerned with the role of science. And the third, with the significance of scenario studies for the Ministry of Agriculture, Nature Management and Fisheries.

Developments in rural areas

Rural land use in The Netherlands is undergoing drastic changes. Changes are occurring in rural areas not only in The Netherlands but also in large parts of Europe. Agriculture in particular is going through a phase of adjustment. There are three reasons for this.

- Firstly, stricter requirements for environmental protection as well as technological developments necessitate adjustments at the level of the farm.
- Secondly, changes in EU agricultural policy and international free trade are causing the agricultural sector to take more account of market forces and consumer wishes.

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- Thirdly, uses other than agriculture, such as nature, out-door recreation, and urbanization, are gaining importance in rural areas.

All these uses make demands for more and more land. They are competing for space, at the expense of agriculture. Since the processes of change all have their own dynamics, it is hard to predict the outcome.

The Netherlands, which is small and densely populated (about 500 inhabitants per square kilometre), has some beautiful, very characteristic rural landscapes with high cultural and historical values. It also has all sorts of transitional areas, ranging from areas where human intervention is relatively limited to areas where the influence of man is dominant, from comparatively natural ecosystems via nature-culture landscapes and agricultural production areas to peri-urban and urban areas.

The Dutch and the millions of people visiting our country set great store by this wide variety within a land area of some 3 million hectares. But where there is competition for space, adequate policies are imperative to guarantee both economic activity and culture and nature conservation.

Recently, the government published a 'Structure Plan for the Rural Areas in The Netherlands', a solid mid-term plan for the countryside (Ministerie van Landbouw, Natuurbeheer en Visserij en Ministerie van Volksgezondheid, Ruimtelijke Ordening en Milieu, 1992). The Structure Plan is based on reports laying down long-term goals for agriculture, nature, forestry and landscape, outdoor recreation and the environment. Under the Structure Plan the area of nature in The Netherlands will expand by 150,000 ha in the years ahead. 50,000 ha will consist of areas where the development of nature and landscape values has top priority. The Plan also provides for the layout of large open spaces of 7,500 ha for outdoor recreation in the vicinity of towns and cities in the western Netherlands. Moreover, the existing area under forest will be expanded by 75,000 ha.

It is a challenge to realize and maintain a sustainable, high-quality countryside via a rebalancing of land-use priorities.

This presents both opportunities and threats for the different land uses. There is a great need for clear pictures of potential developments. I shall come back later to the role of scenario studies. Firstly, the present course of developments will be outlined.

The traditional dominance of agriculture is waning. The sector is making an effort to satisfy the requirements of both the market and the environment. Despite national policies - the Nature Policy Plan - which aim to combine agricultural and nature purposes, nature and landscapes are under pressure (Ministerie van Landbouw, Natuurbeheer en Visserij, 1990). Agri-environmental management is still in its infancy, even though the agricultural sector is increasingly willing to play a part in managing rural environments.

The western Netherlands has an acute shortage of space. The 'green heart', the central area of open space between Amsterdam, The Hague, Rotterdam and Utrecht, is under attack. Elsewhere, particularly in arable areas in the north, agricultural land is set aside and afforested. The extent to which agricultural land will be used for other purposes in the future is uncertain. In some parts of The Netherlands the quality of life is affected by unemployment, an ageing population and declining facilities. It should be noted, however, that in view of the short distances in The Netherlands these problems are much less pressing than in southern and central Europe. New administrative relations develop as a result of the devolution of government powers to provinces, the creation of urban provinces and the tendency to place steering responsibilities at the level of regions and target groups.

The recent policy statement issued by the Dutch government explicitly urges the renovation of the rural areas (Regeerakkoord (Policy Agreement), 1994). Policies are initiated to further strengthen the integrated development of sustainable agriculture, nature, outdoor recreation and tourism. The political issue of rural innovation is not entirely new. Several activities are already under way. In the years to come the emphasis will be on the following:

* the restructuring of existing uses and the development of new uses (as a new socio-economic impulse, for example);
* the changing relationship between urban areas and the countryside;
* the varied uses of water;
* the redevelopment of the countryside to absorb these developments;
* a new approach to planning and implementation.

This policy will be realized in close co-operation with the Ministry of Housing, Spatial Planning and the Environment (VROM) and against the background of developments elsewhere in Europe.

The role of science and knowledge transfer

Given the rapid changes in the rural areas I have mentioned, it goes without saying that science and knowledge transfer play a major role. A role which is much needed in the different stages of the policy process and on behalf of the various aspects involved: agriculture, nature and recreation. I would like to add here that I am convinced that the Agricultural Research Department (DLO) and Wageningen Agricultural University as 'the Wageningen Centre of Knowledge', both nationally and internationally, occupy a prominent place where the rural areas are concerned.

In 1993 the Ministry of Agriculture, Nature Management and Fisheries (LNV) published a policy document on its intentions for the development of its research, development and education policies for the years ahead (Ministerie van Landbouw, Natuurbeheer en Visserij, 1993). It was found that the creation of these policies and the establishment of priorities between sectors, between issues and between instruments require a strategic approach. Such an approach will consist of enquiries, scenario studies, analyses of strengths and weaknesses and policy assessments. These elements can be applied at various levels in the process and will ensure the most efficient use of available resources. The key issue in research, development and education policies is: how can we produce the facts and develop the insights required and how can we encourage the transfer and utilization of this information?

I shall illustrate my point. Suppose that the Netherlands Ministry of Agriculture starts working on a new covenant for the rural areas in the years ahead. This covenant is to contain statements on expectations and obligations of the major public bodies. It provides for sustainable ecological, public and economic support for further agreements between producers and consumers in the rural area. How can the basic requirements for change and development be met?

I shall now proceed to the knowledge which is desired for the policy-development and administration of the rural areas. From the brief sketch of problems I have given you before, a number of actual issues can be derived that are in dire need of proper analysis in order to help tackle them. Some of these issues are:

- ecotoxicology, in particular the behaviour of substances that have accumulated in soil and groundwater related to changes in land use;
- the requirements of nature in valuable man-made landscapes;
- the developments in agriculture and land use in a European context;
- developments in water use and water management;
- anticipated recreational behaviour related to the future of urban landscapes;
- solutions for complex administrative decision-making.

From the policy and administration viewpoint three angles can be distinguished.

1. The effect of the policy laid down in the Structure Plan for the Rural Areas of The Netherlands and the place of the Dutch rural areas in a European context. It is necessary to widen our horizon to another level because of economic interests, the wise use of natural resources and the desired increase of biodiversity.
2. The area-specific approach, which presents the opportunity to differentiate and to react more adequately to regional differences in potential, uses and interests.
3. The support of the work of the Government Service for Land and Water Use. It presents us with a challenge to consider nature and landscape development and recreational land use as well as the situation concerning agricultural production.

The significance of scenario studies to the Ministry

A scenario is a description of the current situation and of a possible or desirable future state. It is also a description of the series of events that could lead from the current state of affairs to this future state. Besides, a scenario study usually comprises more than one

scenario. This thinking in terms of various alternatives implies different interpretations of a current situation and of alternative series of future events. It is this variety of processes and outcomes which is the object of scenario studies. Scenario building implies the formulation of an internally consistent and coherent set of arguments about the main relations between the phenomena under study, the determining factors and their expected future development. With this consistent set of assumptions a systematic and selective description of the current situation is made and system boundaries are clearly defined. These are important conditions for a scenario study.
If we look at what scenarios really stand for, it is stated that they present stylized constructions of possible future developments, sometimes quite deliberately in the form of stereotypes, optimum or doomsday situations, or other extremes. They refer to 'what might happen if', and not to 'what will happen' (Schoonenboom, this volume; Veeneklaas and Van den Berg, this volume).

This quotation underlines the point that scenario studies are very useful to policy-makers. In general, the value of policy-oriented scenarios lies in the fact that they depict conceivable future situations while at the same time elucidating the driving forces behind them. And they show the consequences of available policy options in an ever-changing external environment. In other words, they can be powerful instruments to help us make our choices.

The Netherlands Ministry of Agriculture, Nature Management and Fisheries considers scenario studies important. This is because innovative insights are required into different long-term options for various activities and for several instruments. Scenario studies can prepare us for possible developments. Moreover, they provide us with an opportunity to inventory side-effects which may or may not be desired. Scenario studies can be carried out on a national, a regional or even a supranational scale.

Formulating a series of assumptions necessary for a scenario study requires knowledge of processes and adequate data sets. Both are readily available at the Agricultural Research Department (DLO) and can also be easily obtained elsewhere if necessary. This gives us good prerequisites for the area-specific weighing of pros and cons of enhancing agricultural production and recreation, ecological development, landscape quality and reduction of environmental pollution.

Policy and administration carry the responsibility for making choices and taking decisions. In rural areas, with their many claims, conflicting interests and rapid changes, scenario studies may be able to support the process of choice considerably. Now that there is less money available, scenario studies will lead to even clearer choices. The extensive programme content for this volume shows that researchers worldwide are committed to this subject. This shows great promise for the use of scenario studies and for the results.

Concluding remarks

In the first five years of its existence the DLO Winand Staring Centre has proved itself not to shy away from complex issues. Via process-based research its staff members seek to solve these problems, and they generally succeed. In the coming years this strategy will without doubt be continued. Their thorough, comprehensive approach, which involves a wide variety of disciplines, appears to be in great demand.

I trust that the Centre will also commit itself to new issues. I have indicated some of them and, in its own well-wrought strategy for 1994 to 1997, the institution is already responding to recent developments in the rural areas. Apart from thorough studies, policy-makers and administrators urgently need quick and short-term studies of urgent policy issues, covering between a few months and one year. The main thing is to strike the right balance between the long and the short run. Scenario studies focus on the long-term strategy.

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3.2 Changing factors in land use in the rural environment

Information gaps and implications for scenario studies

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Abstract
Land use in rural areas has faced tremendous changes in determining factors during the last few decades. In many regions, the economic and demographic situation becomes increasingly independent of the agricultural sector. The current EU policy can be described as one where market mechanisms are reinforced to ensure balanced economic development, while political action is focusing on those social and environmental problems which cannot be solved by market forces. Thereby, political programmes become more target-group oriented and site-specific. Both the actual problems and related political solutions constitute new information requirements which can only be met by following interdisciplinary approaches in compiling information systems. In addition, the scientific concepts of decision-supporting research must also reflect the social, the physical and especially the spatial dimension of policy issues in order to ensure provision of operational results.
Keywords: *rural development, environment, land use policy, agricultural policy, site-specific factors, information systems*

Introduction

Land use in rural areas has faced tremendous changes in determining factors during the last few decades, changes which will most probably continue in the near future. Major factors were shifts in the economic and socio-economic environment, the demographic development, changing priorities concerning the social functions of rural areas and, finally, the adjustment of political responses.

The new situation for political decision-making can be described as one where, on the one hand, the role of market mechanisms has been reinforced while, on the other hand, the shortcomings of market-guided outcomes and the incapability of market-forces to solve social and environmental problems are corrected by specific social and environmental policies.

It is evident that a shift from a more global, sector-oriented policy to problem-specific and site-specific solutions constitutes a new challenge for decision-supporting research in the fields of rural development, land use, agriculture, the environment and related policies.
The focus will be on general changes in factors determining land use and related information requirements. Finally some conclusions will be drawn on the implications for decision-supporting research and underlying scientific concepts.

'The following text reflects the opinion of the author and does not necessarily correspond in all parts the European Commission's viewpoint'.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 107–116.

Shifting emphasis from agriculture towards other rural functions

The most important form of land use in rural areas was traditionally agricultural production. During the last few decades, agriculture has lost its determining role in the rural economy. In the European Union, the proportion of the active population employed by agriculture is on average for all Member States less than 7%; the contribution of agriculture to the local value added has declined to less than 3%. Only in the most peripheral regions, is agriculture still a central sector because alternative income sources are not sufficiently available (Commission of the European Communities, 1991a).

Not only do the general figures on employment and value added give evidence of agriculture's declining importance for the viability of rural areas. Also, the agricultural sector itself has changed. In many areas of the European Union, off-farm employment has become a very important source of income. For instance, in Germany about 50 % of all farmers receive more than half of their income from off-farm sources (Bundesministerium für Ernährung, Landwirtschaft und Forsten, 1994).

The decreasing significance of agriculture for the local economy is also due to the fact that up-stream and down-stream industries (e.g. input retailers, food processing branches) which were traditionally linked to local farming, become more and more independent from the local context of agricultural production (Schäkel, 1993).

Finally, it has to be taken into account that the demographic development of rural areas is no longer closely related to the fate of agriculture. This is already evident from agriculture's decreasing share in the local economy. Besides this, re-migration to rural areas has become visible, especially in those areas which are located within commuting distance to urban centers (European Commission, 1994a). Only in peripheral areas, is the demographic development still closely connected to the economic situation of the agricultural sector.

Although agriculture has lost its decisive role for the rural economy and the demographic situation, it is still a significant factor, especially as regards land use and related policies. However, the role of agriculture and the public perception of it have changed character (Isermeyer and Scheele, 1994). While in former times the focus was on agricultural production and the agricultural sector's role as an employer, now agriculture's relationship with a great variety of social functions related to land use has become the center of public concerns. In this context, it must be born in mind that rural areas still provide the basis for the production of foodstuffs and renewable resources (bio-fuel, fiber, other raw material). Still, agriculture and forestry cover about 80 % of the EU's surface, having thereby significant impacts on the visual features of landscapes and environmental quality.

The highly productive agricultural sector is increasingly conflicting with other alternatives in land use. Of central importance is the function of rural areas to serve as a society's "bio-filter", ensuring the provision of clean water, fresh air and maintenance of biodiversity. Other competing functions are the use of the rural environment for recreation, tourism and the maintenance of cultural assets and the countryside.

The conflicts between agriculture and the above-mentioned functions of land use are, on the one hand, due to intensification in agricultural production. On the other hand, society has put a higher priority on the conservation of natural assets and environmental quality since the countryside has been re-discovered as an environment having the potential to provide a high standard of living. This leads to increasing demands for a clean environment and well-kept landscapes, combined with demands for housing, recreation and tourism.

Policy consequences of shifting emphasis in land use

The previously described changes in the factors determining land use in rural areas are widely reflected in changes in related policy areas. Political adjustment is mainly a reaction to the requirements resulting from economic and demographic developments. In addition, the impulse is coming from insights that in some cases it was the past policy itself which led to unwanted outcomes. The latter aspect is relevant especially for environmental problems caused by intensive agricultural land use.

As regards the pure economic function of agricultural land use, a new orientation of the European agricultural policy has emerged which emphasizes the importance of market mechanisms as a major force of balanced economic development. Besides this, it was the General Agreement on Trade and Tariffs (GATT) which required reduction of price support and improvement of the links between the European agricultural markets and the world markets. Evidently, under these conditions, the establishment of a competitive agricultural sector remains the central target of agricultural policy (Commission of the European Community, 1991b).

The reform of the Common Agricultural Policy (CAP) is based on price reduction while income policy is, at the same time, shifting from price support to the provision of direct income payments (Commission of the European Communities, 1993a). Those payments are intentionally de-coupled from agricultural production, since this is the most appropriate way to bring down agricultural surpluses and to reduce distortions in international trade. As an accompanying measure which supports the improvement of agricultural structures, an early-retirement-scheme was established.

In addition to price reduction, an obligatory set-aside scheme shall contribute to the reduction of agricultural surpluses. The farmers are obliged to fallow 12% of agricultural land in case of rotational set-aside and 17% in case of permanent set-aside. Since small farmers are exempted from this rule, the percentage of the actual set-aside area is much smaller. For example, only 9% of the land used for cereal production was set aside in 1993 (European Commission, 1994a). The set-aside scheme is combined with the idea of stimulating innovations in the field of renewable resources: Farmers are allowed to grow non-food products on set-aside land. Since those plots of land can be used at almost zero opportunity costs, competitiveness of renewable resources is thereby improved. However, until now only 6% of total set-aside land is used for the production of non-food products (European Commission, 1994b).

Changing economic significance of agriculture in rural development is also reflected in the reform of the Structural Funds aiming at environmentally sound amelioration of the economic conditions and the infrastructure in rural areas (Commission of the European Communities, 1993b). Initiatives taken to support rural labour markets correspond with the needs of farmers for whom off-farm employment has gained importance during the last few decades.

Besides following the aim of contributing to the economic and socio-economic development of rural areas, both the CAP reform and the reform of the Structural Funds are closely interlinked with environmental protection purposes. The environmental dimension of underlying programmes is partly due to side-effects and partly based on specific environmental programmes.

The major environmentally beneficial side-effect of the CAP reform results from the fact that reduction of agricultural prices makes the use of chemical-synthetic fertilizers and plant protection products less profitable. Reduced consumption of chemical-synthetic fertilizers and plant protection products can be regarded as a result of the restrictive price policy of the last few years. Since 1988, consumption of Nitrogen fertilizers has been reduced in some Member States by about a quarter; for Phosphorus fertilizers the reduction is even more than a third (European Commission, 1994c). During the last five years, consumption of crop protection products was reduced by about 15% (Brouwer *et al.*, 1994).

An element of the CAP reform, directly aiming at environmental goals, is the agri-environmental Council Regulation (EEC) 2078/92. The measures, established under this regulation, shall in the first instance improve the environmental soundness of agricultural production and ensure the maintenance of the cultivated landscape. Further objectives are to combine the reduction of agricultural surpluses with beneficial effects on the environment and to improve the farmer's incomes by granting them an appropriate reward for the provision of environmental services. The agri-environmental measures comprise the promotion of extensive methods of agricultural production including organic farming, upkeep of the cultivated landscape, conservation of biotopes like hedgerows or scattered orchards, 20 years set-aside for environmental purposes, keeping of breeds of local species endangered by extinction and measures to improve the training of farmers with regard to farming or forestry practices compatible with the environment.

Another measure, accompanying the CAP reform, having positive effects on the environment, is the afforestation scheme under Council Regulation (EEC) 2080/92. Financial aid is given for afforestation, upkeep of afforested land and investments for the improvement of forests, especially with respect to protection against forest fires.

As regards the positive environmental effects of the structural funds, a general orientation is given by the Framework Regulation (EEC) 2081/93 which stipulates that the European Agricultural Guidance and Guarantee (EAGGF) Guidance Section can intervene to "safeguard the environment and to preserve the countryside". In Council Regulation (EEC) 2085/93 it is stated that, within Objective 1 and 5b areas, measures may be funded for the "protection of the environment, maintenance of the countryside and restoration of landscapes". Examples are measures for the protection against erosion and against destruction of woodland by forest fires, actions to protect rare or endangered species, restoration of habitats and improved management of wilderness areas. In addition, support will be provided for demonstration and pilot projects for environmental and countryside management.

The new orientation of both the CAP and the structural funds corresponds perfectly with recent changes in the general institutional environment of the European Union. Article 130r of the Maastricht Treaty of the European Union (European Union, 1993) stipulates that "environmental policy requirements must be integrated into the definition and the implementation of other Community policies". The integration requirement was also underlined in the 5th Action Programme of the European Union "Towards Sustainability" (Commission of the European Communities, 1993c); it will be a central issue for future policies on land use planning and rural development.

In addition to the above-mentioned integrated approaches, there are a number of specific environmental policies by which environmental constraints for land use are directly established. Examples of this kind of direct intervention are the Drinking Water Directive 80/778/EEC, the Nitrate Directive 91/676/EEC, the Directive on Bird Protection 79/409/EEC and the Habitat Directive 92/43/EEC.

Information requirements: from general to specific

The previously described changes in factors of land use constitute a new situation for political decision-making and the administrational implementation of political programmes. There is a clear shift from general and sector-oriented approaches to specialized policies aiming at the solution of site-specific and target-group related problems.

A major approach of former policies was global intervention in economic processes and markets. As regards the CAP, this approach was materialized in the agricultural price support policy, aiming at higher farm income and certainty of food supply. Even programmes financed from the structural funds were not very specific in following the general goal of improved agricultural structures and farm competitiveness.

In contrast, the current situation can be characterized as one where global steering of the economy is left more and more to the market while policy is focusing on those specific problems which cannot be solved by market forces. As mentioned above, those problems include imbalances in local production structures, regionally differentiated income problems, site-specific decline of environmental quality, and planning requirements resulting from demands for housing, recreation and tourism.

While global steering tools like agricultural price support were pointing at the agricultural sector as a whole, having only a limited capability to influence local impacts, the new policy issues have, by their very nature, a clearly defined spatial dimension. Direct income payments are adjustable to regionally deviating conditions; promotion of environmental soundness in agricultural production must reflect the local situation; improvement in environmental quality, maintenance of cultivated landscapes and land use planning are site-specific.

As a major challenge resulting from site-specific and target-group-oriented policies, diagnosis and impact assessment, being a precondition of policy making, are confronted with new information requirements. While existing general or sector economic figures show how the market mechanism can efficiently link economic actors and locations to the single network of the market economy, they provide only limited assistance for the solution of environmental and social problems which cannot be solved by relying on market mechanisms.

Site-specific and target-group oriented policies require that the definition of operational targets reflect local conditions and spatially differentiated needs. Scenario studies, prognosis and policy assessment must be based on the analysis of key indicators like structural characteristics, environmental quality and the demand for social functions of land use, going into the technical details of site-specific conditions and providing insights into the spatial pattern of problems and possible solutions.

Implications for the interdisciplinary establishment of information systems

It is evident that scientific concepts and tools underlying decision-supporting research must be adjusted to the new information requirements. A major conclusion from the aforementioned considerations is that land use has, on the one hand, a more general, economic context while, on the other hand, the impact on social and environmental functions has in most cases a local context and requires target-group oriented and site-specific solutions.

In addition, it has to be taken into account that the social functions of land use and environmental quality are normally defined in physical terms while analysis of the efficiency of competing solutions refers to economic or monetary concepts. This collusion of physical and economic aspects in land use planning implies that related scientific analysis must be based on interdisciplinary approaches. The most difficult task to work out is the creation of operational interfaces between natural and social sciences and to establish both a problem-oriented and workable set of indicators.

An appropriate information tool must provide answers, for instance, to questions how far a specific environmental restriction of using crop protection products contributes physically to the environmental goal of protecting a certain water body. At the same time, it must support assessment of the comparative efficiency of potential measures. This task requires the estimation of effects, observable on single farms, at the sectorial level or, by affecting local and European-wide markets, at the level of upstream and downstream industries. The data set must comprise a mixture of economic and physical figures which can be aggregated and disaggregated in a coherent way.

An example for an appropriate information tool is the so-called Pressure-State-Response model (PSR) (OECD, 1991). The PSR model serves both analytical and administrational purposes. The pressure index provides information on spatially differentiated effects of certain activities on the environment. The state index mirrors those pressures by informing on the resulting state of the environment. The response index finally reflects the intensity of responding political interventions, taken to release the pressure on the environment.

The single indices can be presented in a spatially differentiated way by Geographical Informations Systems (GIS); they can be aggregated to more general indicators (e.g effects of agriculture on bio-diversity) and they can be combined with global figures on economic or structural developments (Adriaanse, 1993). Such a reduction in complexity is necessary, because political decision-making depends on easily understandable, aggregated information. However, consistent disaggregation must be possible in turn, since administrational implementation of specific programmes refers back to the local level and to site-specific problems. Coherence between the disaggregated and the aggregated level is indispensable, because monitoring and assessment of political programmes normally refer to the highly aggregated level in order to provide the political sphere with both clear and simple information.

The PSR approach delivers both coherence between different levels of aggregation and a combination of economic and physical data. The analytical requirements resulting for interdisciplinary work can, in contrast to purely physical or purely economic data systems, be reflected at the very beginning of data collection and processing. An additional advantage of the PSR is based on the fact that data gaps can be filled by proxy-variables.

For instance, the intensity of water pollution by nitrate from manure can be narrowed by figures reporting the livestock-density.

New concepts for the economic assessment of policy strategies

Changing factors in land use and related policies imply the necessity of an interdisciplinary approach not only for the establishment of information systems. They also have implications for the economic assessment of land use policies. This must be born in mind, because finally it is the chosen political strategy which determines the scope and the direction of scenario studies.

While approaches which refer only to physical data can hardly provide information on the comparative efficiency of a certain instrument, economic analysis most often fails to give operational answers because the spatial and physical dimensions of the social functions of land use are disregarded. The shortcomings are due to the fact that both underlying concepts and conceptualization of targets refer only to economic parameters.

In particular, the common categorization of environmental policy strategies into (a) voluntary agreements, (b) regulatory measures, (c) economic incentives and (d) transferable discharge permits, provides little help for the final choice of an efficient political strategy. The major shortcoming of this categorization is that it fails to clarify the characteristics of different strategies, relevant for comparative analysis. The instruments are only defined by the way they affect economic parameters like, for instance, the social costs of environmentally harmful production, abatement costs and their relation to quantities of products and pollutants. However, it is obvious that the efficiency of achieving defined environmental targets very much depends on other parameters influencing the precision of a certain strategy and instrument-specific administration costs. Therefore, it is the set of parameters described below, by which a complete definition of the distinctive characteristics of a certain measure can be given, which must be looked at in the comparative analysis of policy strategies (Scheele, Isermeyer and Schmitt, 1993 and Scheele, 1993a).

- One of the most decisive parameters relevant for the choice of a political strategy is **the spatial dimension** of both the polluting activity and the environmental target.

For instance, it must be decided whether a measure for water protection should be applied only to the most sensitive areas or to the total surface.

- Moreover, the **technological context** of pollution control must be taken into account. It must be clarified whether easily controllable parameters like the livestock density provide sufficient environmental incidence or whether a measure must refer to direct and, in most cases, more expensive measurement of pollutants.

- Furthermore, a decision must be taken on the choice of **the addressees** of a certain policy. Addressing a measure to the small number of producers of a harmful input implies low administration costs and high deviation from site-specific targets while in the case of referring to the large number of input users (farmers), both administration costs and precision will be high. Therefore, the decision is a trade-off between social costs due to missing precision and administration costs.

- Finally, a choice has to be made concerning the desired **distributional effects**. In the case of taxation, the burden of costs is imposed on polluters while assignment of discharge permit or definition of limit values result in cost sharing between the polluters and the public. Accordingly, a decision must be taken on the wanted social outcomes which will have high relevance for the negotiations on acceptable solutions (Scheele, 1993b).

Regarding the significance of the parameters described above, it becomes clear that the dominating debate on best strategies, being normally a struggle between interventionists and those who favour economic approaches, does not reflect the problem sufficiently. The basic idea of economic incentives like taxes is to leave scope for individual choice. That is, the polluter can reduce pollution, saving thereby non-compliance costs (taxes); or he can continue pollution, which is appropriate if the returns from polluting activities cover the non-compliance costs. While flexibility for the single actors normally leads to efficient results, efficiency is in some cases only achievable with more restrictive approaches. This becomes clear by referring to the spatial parameter. If site-specific conditions require abatement of pollution at specific locations, economic instruments will be highly inefficient, because they fail to enforce site-specific abatement. In contrast, regulative approaches allow for precise interventions, reflecting the requirements of specific locations.

Decision-making on political strategies is finally a choice on the spatial impact of a measure, of its technological context, of the addressee and the distributional effects. Therefore, rather than pressing political strategies into inappropriate categories which fail to clarify the characteristics of different solutions, impact assessment and related scenario studies must be based on decomposition of political strategies into the above mentioned parameters.

The decomposition approach corresponds perfectly with the previously described changes in the factors in land use, implying a reflection of the spatial and physical dimension; the decomposition approach can make use of interdisciplinary information systems and provides a workable analytical framework for scenario studies, impact assessment and prognosis.

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3.3 Possible economic scenarios in the CAP and their impact on land use in Europe

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Abstract
Increasing international conflicts and the necessity to curb budgetary expenditure caused a fundamental change in the Common Agricultural Policy of the European Union. This paper describes some possible scenarios for future developments. The most likely development is a continuation and extension of the system of direct income support per hectare or per animal as introduced in the reform of 1992. Another possible development is a system of decoupled income policy. The impact on land use is uncertain. A trend towards a gradual reduction in agricultural land use is perhaps most likely.
Keywords: *European Union, Common Agricultural Policy, Land use, scenario studies*

Policy developments in the past

During the past decade the Common Agricultural Policy (CAP) of the European Union (EU) was fundamentally changed. The immediate cause was the accumulation of surpluses in the land-using sectors leading to soaring budgets and international conflicts generated by the Common Agricultural Policy. The underlying cause was the imbalance between supply and demand considering the price levels desired. Technical progress made production rise by about 2 to 3% a year, whereas internal demand grew by a mere 0.5 to 1%. As a result, Europe became more self-sufficient and the Union gradually turned from a net importer into a net exporter of agricultural products.

The Common Agricultural Policy as it developed in the early 1960s was tailored to the net import status at the time. It was assumed that import protection could be used as the main instrument of market protection and that intervention measures and export subsidies would be supplementary only. The policy was to be financed largely by import levies. As the Union became more self-sufficient, intervention and export subsidies became the pillars of the policy. Budgets consequently went up and up and the policy came under increasing international pressure.

Initially, attempts were made to solve the problems by altering price relationships. In the early 1970s, for instance, the price relationship between milk and beef was changed, and ten years later that between cereals, oilseeds and protein crops. As soon as a product became in surplus, price relationships were changed in favour of a product the EU was a net-importer of. As a result, farmers changed their cropping plans and the EU became rapidly self-sufficient in these products, too.

Particularly after 1980, when the Union had become self-sufficient in cereals and beef and threatened to become self-sufficient in oilseeds and protein crops, the pressures to reform the Common Agricultural Policy increased.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 117–123.

The first fundamental change in the Common Agricultural Policy was the introduction of the super-levy on milk in 1984. Price guarantees were restricted to a maximum delivery quota per farm. In 1988 the stabilizer arrangements followed in an effort to curb Community spending on agriculture by automatic price cuts once production or intervention limits were breached. Finally, from 1992 price support for oilseeds and, from 1993, that for cereals and protein crops were (largely) replaced with direct income aid per hectare. Regarding beef, price support was partly replaced with income aid per animal, a scheme which has been used in the sheepmeat sector since the start of market regulation. In all cases, support was restricted to a historical base area or number of animals, and area aid was granted only if a specified percentage of the land was set aside. Of the major products tied to the land in the Union, price support was still applied only to milk and sugar, although production ceilings were set for both.

Whereas the introduction of the super-levy in 1984 and the stabilizer mechanisms in 1988 were prompted by the need to curb budgetary costs, the reforms of 1992 resulted from international pressure. The GATT Uruguay Round forced the Union to choose a policy of restrictions on import protection, amount and type of internal support and subsidized export. Although the reforms were also motivated by considerations of income redistribution and environmental protection in Europe, international pressure was the mainspring.

Land use in the past

Table 1 shows the developments in land use in the European Union in the period mentioned (NRLO, 1994). There are remarkably few changes. The total area of agricultural land declined by 0.2% a year on average and by 0.3% a year between 1960 and 1989. There were shifts between regions and between crops, but increasing self-sufficiency did not result in accelerated hiving-off of agricultural land.

Table 1. Total agricultural area in the EU-9 (x 1000 ha)

	1950	1960	1970	1980	1989
B	1799	1716	1599	1447	1363
DK	3167	3129	3006	2905	2785
D-11	14234	14222	13578	12248	11885
F	33312	34407	33127	31843	30690
IRL	4688	4717	4803	5706	5697
I	19537	19940	19324	17879	17215
L	144	141	135	130	126
NL	2344	2323	2205	2027	2019
UK	19524	19374	19414	18920	18563
EU-9	98749	100112	97385	93089	91124

Source: NRLO 1993, p.6

Changes between crops are shown in Table 2. The information available does not show whether some regions lag behind others in productivity. However, as the areas examined are aggregated at a level which is rather high, there may have been shifts within regions due to which certain agricultural areas have become marginal.

Table 2. Agricultural area under various crops in the EU-9 (x 1000 ha)

	Arable land (green fodder and fodderbeet excluded)		Cereals (rice excluded)		Root crops (fodderbeet excluded)		Grassland (green fodder and fodderbeet included)		Permanent crops	
	1950	1989	1950	1989	1950	1989	1950	1989	1950	1989
B	785	535	533	350	164	154	962	791	51	16
DK	1843	2115	1277	1573	447	103	1306	659	18	11
D-11	6635	6001	4840	4639	1459	589	7092	5671	147	184
F	13272	13205	8724	9419	1953	629	18144	16209	1896	1224
IRL	708	462	448	345	249	70	3976	5233	5	2
I	9219	6501	6517	4354	480	412	8004	7299	2314	3325
L	65	38	53	34	8	1	77	87	2	1
NL	889	656	495	203	246	289	1372	1310	82	37
UK	4678	5204	3350	3874	888	462	14702	13249	144	59
EU-9	38218	31193	25672	24791	5893	2836	55872	51748	4659	4963

Source: NRLO 1993, p.7

Possible future policy developments and their impact on land use

The question arises of what developments can be expected and what influence they may have on agricultural land use.

Return to price support unlikely

One line of thought is a return to the previous Common Agricultural Policy based on high price support. A reason for this could be that the system of direct income support involves a great deal of paperwork or becomes much too costly. As things are, the odds are against this.

First of all, the arrangements made under GATT do not allow it. The Union would run into serious international trouble if it were not to keep to the agreements.

Secondly, the situation in Europe does not allow a return either. Since the Berlin Wall has come down, it is no longer possible to seal off the eastern Union border, which is a condition for high-level price protection.

Thirdly, this border is likely to extend further eastward within a few years. Application of a system of high price protection to Poland, the Czech Republic, Slovakia, Hungary and other candidates for accession will have enormous consequences for supply and demand, thus aggravating the problems of the traditional policy. The option to control production at a high price level via quota systems, as is still the case in the Union for milk and sugar, is hardly feasible for other products as there is no bottleneck in the production chain.

And a final reason why it is unlikely that the old system will be reintroduced is that the application of the new system has as yet not caused too much difficulty.

Should the Union decide to return to the old system of price support, it will be necessary to provide support at a much lower level, i.e. on the basis of a price stabilization policy at the level of world market prices. This is in line with the reform package of 1992 for cereals and beef. In a recent study Nallet and Van Stolk (1994) plead for a similar line in support of agriculture in central and eastern Europe. If, for budgetary or administrative reasons, the direct income support scheme introduced in the MacSharry reform should fail, the Union could fall back on this low-level price support.

First scenario: extension of direct income support

However, as yet it seems more likely that in the years ahead, with price stabilization at a low level, variations in direct income support schemes will be maintained. A first option is to extend the existing scheme to other products. Already there is a tendency to bring a number of minor crops under the system in addition to cereals, oilseeds and protein crops. It is also a moot point whether in the long run the system of high prices in combination with quotas can be maintained for milk and sugar if other products receive low price support and direct income payments. The support scheme then might be extended to all land-using productions.

Under the present scheme the amount and sometimes the type of support differ per product. Premiums per hectare for oilseeds, for example, are higher than for cereals and in the livestock sector, too, the amounts differ per livestock unit and per hectare. These differences complicate the administrative implementation of the scheme and also distort supply. At present there is no political will to eliminate the differences in type and amount of support since this redistributes subsidies between sectors and member states. However, this could change in the long run. As yet the aid will be adjusted on an ad hoc basis should distortions be too drastic.

A second option under the current system is to make the supports subject to conditions other than just growing a specific crop. Such conditions are already in place, for example, the set-aside contribution for arable products and the stocking densities in the livestock sector. Besides, the member states may attach conditions regarding nature, the environment and landscape to income aid in the animal sector. This so-called cross-compliance option has been thoroughly studied recently, both regarding its technical feasibility and the political and public support (Baldock et al. 1993, CLM 1994). There seems to be little political support for this option. Income support is seen as compensation for reduced prices, whereas impulses on behalf of nature, the environment or landscape should come from accompanying measures. Nevertheless, this attitude might change in years to come, particularly if the costs of the current policy come under new pressures.

The first and most plausible scenario then is to plod along with the existing policy. In this way the designations of the areas remain fixed, for, to receive a premium, farmers must grow cereals, oilseeds or protein crops, or have a specified area devoted to grass and other fodder crops to satisfy the livestock density standard for beef premiums. In addition, there is the formal requirement to connect milk quota and land. The so-called base areas for supported arable crops have been laid down (more than 40 million hectare in the EU-12); the same goes for the livestock sector, although somewhat less strictly.

If these areas are given a different designation the farmers will lose their support. Therefore this is only likely to happen in those areas where non-agricultural demand for land has sufficient purchasing power to offset the loss of income.

If production continues to increase, the set-aside condition for a certain base area may be tightened to compensate for the extra surplus that will be produced. That is to say, perhaps 20-25% set aside instead of the present percentage. The pressure to combine the area set-aside regionally and to give it other designations on a semi-permanent basis might be increased. But in this scenario it is more likely that increased surpluses will increase pressure to lower cereal prices further and raise area aids at the same time. The attachment of land to supported products will then increase as well.

Second scenario: decoupled income support

A second scenario is the decoupling of income support from specific (agricultural) production. This system should be applied with (stabilized) prices at the international level. There are various reasons why this scenario is not wholly inconceivable. Firstly, there are the distortions mentioned before in the levels of support for the different products. After some experimenting, the insight might gain ground that one level of support per hectare, independent of the product grown on it and possibly even independent of whether or not the land is used for agriculture, is more acceptable than making several adjustments to support levels per separate product. Making all land eligible for support has the advantage that it does not distort the land market and, in fact, will make total supply less rigid.

A second reason is the pressure to renationalize income support. Renationalization has its merits, in particular to fulfil specific regional wishes, mainly in the 'founding' member states, which are becoming net payers in the Union. Renationalization of income support could also be the condition required for the possible extension of the Union to include central and eastern European countries (see e.g. CEC, 1994). Income support for agriculture in those countries identical to that in the present European Union and financed by the Community will boost production enormously. They will also lead to very high costs, to be paid mainly by the present member states. To have the Community financed income support in the richer, older member states on the grounds that they had to decrease prices in the past and to do nothing in the poorer accessing member states cannot be upheld politically. National funding then becomes attractive, the more so since member states could set the conditions for support themselves in the context of specific European prerequisites.

Such a scenario with general area aids, independent of agricultural output and funded nationally, might have far-reaching consequences for land use and land-use planning. For, distortion in the land market in favour of agriculture will disappear as a result of the decoupling of support to actual agricultural production, and in the case of renationalization extra pressure can be put on furthering other than strictly agricultural land use.

Demand for land from the agricultural sector

Especially in a scenario with decoupled income support, demand for land from the agricultural sector will strongly depend on such factors as international price levels and the international competitive position of European agriculture.

Calculations based on the various international models concerning possible economic effects of the GATT agreement warrant the expectation that, generally speaking, international price levels will rise (Tims, 1994). The world market price for cereals and oilseeds will rise slightly, that of milk and sugar fairly strongly, and beef will be in between. Whether the rise will result from actual shifts in supply and demand or from the elimination of the downward pressure on prices by abolishing export subsidies is not clear. Several models assume that various offerers will reduce their supply considerably. Self-sufficiency ratios in the European Union, for example, will drop drastically. Since the drop will be largely due to a reduction of supply, it must result in reduced agricultural land use in the Union. These model calculations are opposed by other studies, which show at least that large parts of the Union are well able to compete with other areas of the world (a.o. Stanton et al., 1986, for cereals, Isermeyer, 1988, for dairy products). 'Spontaneous' hiving-off of land by agriculture is less likely then. This calculation assumes that the land values that are supposed to be endogenous will also reduce considerably.

Just to add to the uncertainty of possible scenarios, I shall mention two other studies, which were both carried out in The Netherlands. In a report to the government the Netherlands Scientific Council for Government Policy (1992) has calculated that with the 'best technical means', present production in the EU needs only 20 to 60% of the existing area. So there is enormous potential for production increases. Should this potential be realized, the prospect of depopulation of large parts of the European countryside is looming large. The rural physical planners would have a great deal of work, first of all to enable the application of the 'best technical means' and secondly to monitor spontaneous hiving-off. In another study, the Scientific Council (1994) says that only 30% or less of the world area needs to be used for agricultural designations in order to produce sufficient food for a rapidly increasing world population, again starting from the 'best technical means' and sustainable production. In the EU-12, only 80 million ha would be needed of the present 130 million ha of agricultural land.

These calculations are contrasted with studies among which a report by the Centre for World Food Studies, the Central Planning Bureau and the Agricultural Economics Research Institute (e.g. Folmer et al., 1995), which take account of a strong increase in world demand for food of animal origin (in particular from Asia), which might contribute to the EU becoming an even larger exporter than now. International price levels in these circumstances would be sufficiently high for the EU to be competitive.

Conclusion

The above illustrates that, regarding Europe, there is no unequivocal scenario for possible economic developments in agriculture. A trend towards a gradual reduction in agricultural land use is perhaps most likely. Spontaneous additional hiving-off of large areas is not anticipated, perhaps with the exception of several millions of hectares brought under set-aside in the present regime. If this regime is abandoned for a generalized system of direct income support, the set-aside obligation will no longer apply; at the same time price distortion in favour of agricultural land use will be removed and non-agricultural demand may rise slightly. However, a more favourable international trading situation, environmental requirements for production, and a not-too-big non-agricultural demand with purchasing power as a percentage of the total European land area, on the other hand, could tip the land balance in favour of agriculture.

Large-scale changes in land use then are not so relevant to rural physical planning. Cereals are grown where they have always grown, grassland will remain grassland. Of course there will be marginal shifts to other crops (maize and sunflowers instead of traditional cereals, a limited area of luxury products, perhaps a bit more forestry). More dominant than changes in land use are adjustments to prerequisites related to changing production techniques. In the past the dominant factor was the enormous rise in prices of labour relative to machines, energy and chemical fertilizers. As a result, agriculture and land development came to be strongly based on labour-saving techniques. In the future it is possible that scarcity as regards the environment, nature and landscape will become more dominant in the development of agricultural land, but this scarcity will have to be 'priced' more adequately first. This is no easy task in a period of cut-backs and reduced government involvement.

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PART II

Regional soil and water management

CHAPTER

Introduction to Part II

In part I of this book, scenario studies were treated from a theoretical point of view, focusing also on methodology and their usefulness in policy making. Part II deals with scenario studies carried out to enhance the possibilities of managing soil, water and nutrients. Many research fields supply expertise to meet soil, water and nutrient management problems in the form of simulation models, which, therefore, inevitably become tools for carrying out scenario studies. In consequence, most chapters in part II are related to specific aspects of the application of models in the context of scenario studies.

Any model should be checked for its assumptions before being applied to a real world situation (conceptual validation). Chapter 4 deals with the different possible approaches to the simulation of water and nutrient flow in soils. The paper discusses the usefulness of these modelling approaches for both field studies and scenario studies. The accuracy of a model, i.e. its ability to describe reality as far as it can be measured, is one aspect of its usefulness. Deterministic models, if not accompanied by uncertainty analysis, are not reliable tools for scenario studies. Apart from accuracy, there is the question of portability. Models that perform well in specific field situations may or may not be portable to other situations. This aspect is of paramount importance when evaluating its suitability for use in scenario studies.

One assumption that is implicit in model application is that the scale at which the process is modelled can be transferred easily to a field or a region. Different methods exist to transfer from one spatial scale to another. One method is to maintain the detail of process description and simply increase the number of calculations to cover a larger area. Another method generalizes the process description and, often as a consequence, uses larger timesteps in modelling the behaviour of a larger system. In this case, it is clear that the spatial and temporal scales at which studies are performed are related. The issue of scale is closely associated with the uncertainty of model outcomes. A detailed grid resolution will probably have a smaller unresolved variability at the within-grid scale then a less detailed grid, which bears consequences for the uncertainty at grid cell level. Though the quantification of uncertainty is becoming quite fashionable, the model user should not stop there. Minimizing the uncertainty is the next step. Chapter 5 is dedicated to these issues of scale and the associated uncertainty of model outcomes. Cases at the local, regional and continental scales are presented with respect to hydrology and soil acidification.

Models are never really finished because scientific opinions change. For environmental policy however, operational tools are needed to support decision making and planning. These decision support instruments may have to fulfill two functions: that of short term planning and that of strategic planning. The first function asks for an instrument that can be applied by local or lower authorities, the second function is also required by higher (regional) authorities. However, from the cases presented in Chapter 6, it appears that

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decision support tools are often not operated by policy makers or planners. The scientist is still an essential interface if only to translate a policy to a sequence of quantifyable activities. Socio-economic actors are still treated as exogenous variables in decision support tools, which focus mainly on physical processes, though, in one case, the effects of local versus national policies are compared. Cases presented in Chapter 6 cover the fields of regional water management for irrigation, drainage and N-leaching as well as ammonia-emission. Most tools presented are meant for strategic planning rather than short term planning.

Another aspect of an operational tool might be that it enables a user-friendly graphical model execution as well as examination of results. The rapidly developing field of embedding models in a GIS-environment is a good illustration of this aspect. Both spatially and temporally varying data can be included in a GIS, which enables the user to monitor as well as model the behaviour of a system. Examples of regional water quantity and quality management are reported in Chapter 7.

Besides the development of models and devising user-friendly interfaces, data collection and subsequent model parametrization are important to achieve realistic scenario. Chapter 8 considers these matters. Data collection should not be a blind action, but should be preceded by an analysis of the data or information needed and their availability. Two studies of an analysis of data requirements for regional planning purposes are included in this Chapter. The topic of data collection is related to aspects of spatial variability, model uncertainty analysis and the magnitude of the so-called "data crisis". Data sampling can be done efficiently by first analyzing which parameters the models used are sensitive to, and subsequently focusing the sampling effort on those parameters which really matter. Existing data may be used to estimate values of less easy to measure data (using pedotransfer functions of some kind), but can also be used to refine spatial patterns of simulation results when the two are correlated. Another topic considered in Chapter 8 is the parametrization of models by a combination of calibration with a sensivity analysis. Research fields covered in Chapter 8 are soil quality and water quality and quantity at several scales.

Research which aims at increasing knowledge of the behaviour of the plant-soil-water-nutrient system may be in the form of scenario studies, but may also have a more limited scope like process identification, model building, etc. These studies, however limited, are extremely useful because they will eventually provide essential knowledge about "the horizons of possibilities" in future scenario studies. An example of this is a comparative study of integrated versus conventional farming systems. As mentioned before, the role of socio-economic actors and factors is seldom included in the studies presented. This gap must be filled in order to make results understandable and usable by policy makers. Case studies on land degradation, nutrient management and integrated water and nutrient management are reported on in Chapter 9.

P.A. Finke

CHAPTER 4

Modelling concepts

4.1 Changing modelling concepts and their relation to scenario studies

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Abstract

Increased stress on the environment induced by intensive industrial, municipal and agricultural landuse requires new strategies to protect the natural resources for our food and drinking water. This demand raises new questions about soil management including possibilities to prevent further contamination of soil, atmosphere and groundwater systems. Soil water flow and solute transport models can provide a tool to analyse and develop alternative management strategies, if they adequately address these new questions. Several modelling concepts are reviewed including deterministic capacity-type, Darcy-type, and multiple-continuum approaches as well as stochastic methods ranging from Monte Carlo and perturbation methods to travel time distribution models. They are discussed with respect to their usefulness for natural field soils and their applicability in scenario studies.

Keywords: *modelling, soil water flow, solute transport, deterministic and stochastic methods, multiple continuum transport, agro-ecosystem, scenario study*

Introduction

During the last four decades expansion and intensivation of agricultural land use has lead to a strong increase in crop production. This most often was achieved at the cost of an increased stress on the environment. Pesticides and fertilizers especially contaminate soil and groundwater systems, which are the most valuable natural resources for human food and drinking water production. Gaseous losses lead to atmospheric pollution. Also soil erosion, acidification, salinisation or pollution from municipal and industrial disposal sites endanger the subsurface environment. Soils and groundwaters are the result of geologic and hydrologic processes, acting for decades and even centuries. Their degradation therefore poses severe problems to this generation and future ones. Therefore proper soil management strategies to protect the subsurface environment have to be developed based on a more fundamental and multidisciplinary research for a better understanding of the dynamics and interaction of physical, chemical and biological processes in soil and groundwater systems. Simulation models are able to integrate the available knowledge on these different interacting processes. They can be used in scenario studies to formulate and evaluate alternative methods for a sustainable agricultural management and thus support the decision making process in rural land use planning.

This paper gives some examples to illustrate implications of changing flow and transport modelling concepts in scenario studies. These concepts include deterministic process-based

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descriptions ranging from simple capacity-type and Darcy-type to micro-structure and multiple-porosity transport models, which consider effects of preferential flow. Also stochastic approaches as given by transfer function models, Monte-Carlo methods and stochastic perturbation methods are mentioned. For each model simplifying assumptions, resulting limitations in its applicability to field studies and problems of model parameter estimation are briefly discussed.

Adequacy of the modelling concept

The choice of the modelling concept is a crucial point in developing models for scenario studies. It defines the conditions for the applicability of the model including the model assumptions and the set of input parameters needed to relate the model to what is conceived as real situation or reality under the model assumptions. Because of this necessarily restricted model view of reality, it is of fundamental importance that the modelling concept adequately addresses or fits the real situation behind the questions and problems for which it is used.

For example a rule- or knowledge-based expert system for fertilizer application recommendations (Armoni et al. 1988, Evans et al. 1990), which is based on a hierarchy of if-then statements, may be taken as a simple model. Its model assumptions are given by the description of the different field situations taken into account, which may comprise an indication of weather conditions, classification of soils and descriptions of crops. By choosing the appropriate situation (model input) the model could provide the farmer with knowledge about the best fertilizer to use on his fields including the quantity, product type, method and schedule of application. These recommendations might be adequate to obtain the best return on the fertilizer investment, but they can be inadequate for a sustainable agricultural management if they do not address the protection of the environment.

The theoretical question to formulate a quantitative law of water flow in unsaturated soils on a macroscopic scale, i.e. a scale much larger than the size of individual pores, led to the soil hydrodynamic concept expressed by Richards (1931) as eq. (1) in Appendix 1. The aim was to describe water flow in unsaturated soils by using principles of classical physics, the law of continuity for mass balances and the law of mass transfer to define mass fluxes. For soil water flow the mass transfer law can be expressed by an equation which generalizes Darcy's law for saturated porous media to the unsaturated case (eq. 3 in Appendix 1). The transfer coefficient $K(h)$, a function of the soil water pressure h, and related to it the retention curve $\theta(h)$ have to be estimated or measured for each volume under consideration, assuming the validity of Darcy's equation. Complemented by numerical methods for solving the Richards equation, this concept defines a deterministic or mechanistic transport model for variably saturated water flow in soils. Input parameters are the soil hydraulic functions $\theta(h)$ and $K(h)$, the upper and the lower boundary conditions and the initial distribution of the volumetric water content θ or the soil water pressure h. The validity assumption for the Darcy equation limits the model applicability to studies of uniform homogeneous soils or layered soils with uniform homogeneous layers and to carefully selected field soils which approximate to these conditions (Towner 1989). Nevertheless the model provided and will continue to provide a corner-stone for analysing and understanding the soil water flow process. The experimental efforts to confirm and to consolidate the concept of Darcy flow clarified the limitations and restrictions of regarding the soil as a continuum in order to describe transport processes. In this sense the model has been proven to be adequate in answering the question how classical physical descriptions of mass transfer can be applied to soil water transport (Towner 1989). But, because of heterogeneity it seems to be inadequate for applications to most field situations.

A similar example is given by transport models for pesticide leaching based on equations 1 and 2 in Appendix 1. They were used to predict fate and distribution of surface-applied pesticides in agricultural soils. Due to the extremely high spatial and temporal variability of chemical and biological reactions there exists much evidence that these models are inadequate to accurately describe pesticide transfer processes in most natural field soils. Moreover, recognizing that the usual yearly input of pesticides in farming operations amounts to solute concentrations about 10,000-fold the limit concentration value allowed in drinking water, modelling of pesticide transport and degradation processes might not be appropriate to predict when pesticide loads above this limit occur at the groundwater level. However, for laboratory column or lysimeter studies on pesticide volatilization and degradation, these models may provide a helpful tool to analyse the interrelationship between soil properties and physical, chemical and biological transport and transformation processes of pesticides.

Water flow and solute transport models for scenario studies

One of the major aspects in modelling rural environment scenarios is the simulation of agronomic ecosystems including the evaluation for crop production and environmental risks. These ecosystems are highly complex and heterogeneous. Their quantitative description relating system inputs as precipitation and fertilizers to outputs such as crop yield or nitrates has to combine the soil, plant and climate system in a hierarchy of time and spatial scales ranging from the microscale involving soil microbial activity to the landscape scale involving spatial variability of soils and crop systems (Fig. 1). The difficulty of modelling therefore is to deal with this complexity and heterogeneity at the levels and scales which are appropriate to the specific field sites and also adequate to address the problem of interest with sufficient quantitative accuracy (for instance to predict nitrate leaching or N_2O-emissions). Since each simulation model deserves uncertainty analyses and intensive testing by experiments, the hierarchy of scales and the complexity levels, which the scenario model incorporates should correspond to an experimental setup ranging from laboratory to field site experiments. The uncertainty of key results from scenario simulations could then be evaluated at different scales by considering the input ranges for which the model has been tested. Complexity and heterogeneity can be addressed by combining deterministic descriptions of the different relevant processes and by including processes caused by effects of heterogeneity. For instance denitrification

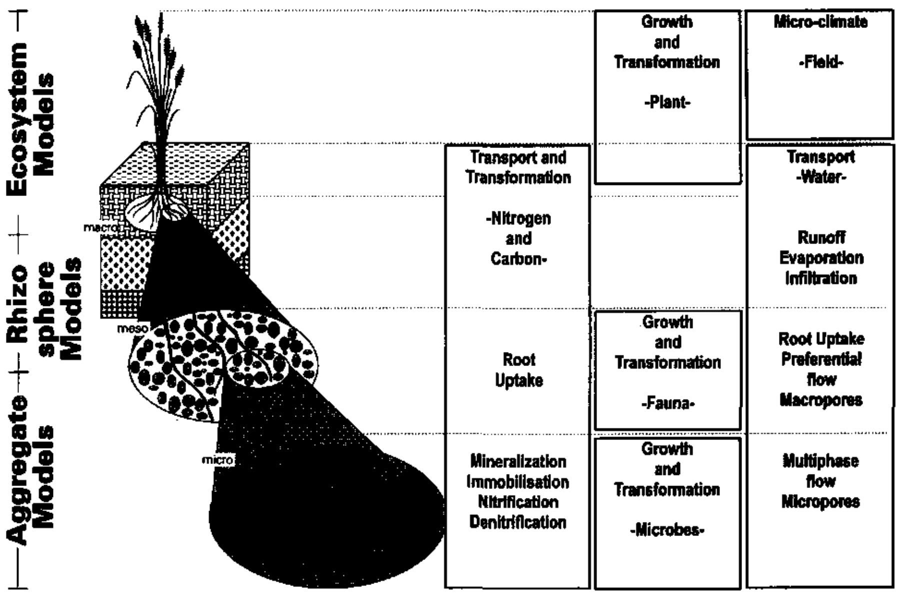

Fig. 1. Hierarchy of different scales adressed by agro-ecosystem models

may be described by considering microbial growth and nitrate transport including macropore flow, and plant water uptake may be adressed by considering water flow and root development including spatial variability of crop growth. Another way to take system complexity and heterogeneity into account is the use of stochastic models which assume a certain knowledge about the uncertainty of model parameters.

In the following, examples of process-based soil water and solute transport models and consequences of their use in agro-ecosystem simulations will be discussed. Afterwards examples of stochastic approaches will be given.

Capacity- versus darcy-type transport models

Many models which describe transport and cycling of nitrogen in agro-ecosystems use capacity type approaches to simulate transport of water and solutes (Engel et al. 1993). Capacity models have the advantage that they are mathematically very simple and their requirements for input data are modest (Appendix 2.). They usually need precipitation and evaporation data and values for soil porosity and water contents at field capacity and permanent wilting point. The soil parameter inputs are capacity factors, which usually are easier to measure or to estimate and less spatially variable than rate parameters. Despite these advantages, which make capacity models useful for crop management purposes and applicable for scenario studies, they tend to underestimate water fluxes and variation in leaching (Addiscott and Wagenet 1985). Moreover, capacity models cannot cope with capillary rise, which often characterizes water flow in soils with shallow groundwater tables.

Also Darcy-type models (Appendix 1.) as discussed above are subject to many simplifying assumptions involved in the premise of the validity of Darcy's law for variably-saturated conditions. For example, it is assumed that the effects of the air phase movement, of soil temperature, of very high or very low flow velocities, of matrix and fluid compressibilities are small and can be neglected. Usually a unique relationship between soil water head and water content is presumed without addressing hysteresis, which occurs in most field soils. Furthermore application of the model is often hampered by the extreme heterogeneity of field soils and by the difficulty to scale up the measured hydraulic and solute transport parameters from the laboratory to the field scale. Severe over- or under-estimations of water and solute fluxes may result from ignoring these limitations. Related to these difficulties is the question how to measure fluxes of water and solutes in field soils. Because of the enormous variability of the subsurface environment measurement probes can be bypassed by water and solute flow and in most cases it is not possible to control a larger soil volume or the entire vadose zone between soil surface and groundwater table to get complete mass balances. Therefore models are mainly tested against measured water contents and solute concentrations and not against measured fluxes. Hence, although models based on Darcy's law are theoretically well founded, it is not clear if they predict soil water flow and solute transport more accurately than the conceptually simpler capacity-type models.

Multiple-continuum models for structured soils

Mathematical homogenization provides a tool to derive macroscopic models from microscopic processes including the derivation of Darcy's law from pore scale Stokes flow (Allaire 1992, Hornung 1992). Many of these derived macroscopic models are well known in the soil science, petroleum and chemical engineering literature as dual-porosity, two-region, multiple-continuum, or first order nonequilibrium transport models for structured porous media (Coats and Smith 1964, van Genuchten and Wierenga 1976, Rasmuson and Neretnieks 1980, van Genuchten et al. 1984, Brusseau and Rao 1990, Gerke and van Genuchten 1993, Toride et al. 1993). For soils which contain macroporous regions such as earthworm burrows, root holes, cracks or inter-aggregate pore spaces these models are mainly used to describe preferential solute transport, the accelerated movement of dissolved chemicals, most often fertilizers or pesticides. Multiple-continuum models were also applied to seemingly homogeneous soils (Steenhuis et al. 1990), for instance sandy soils, to account for preferential flow, which occurs (Glass et al. 1991, Ritsema et al. 1993) due to unstable wetting front formation leading to fingered flow. Geometry-based bi-continuum models can be useful to simulate chemical reaction and microbial transformation processes in soil aggregates (Augustin et al. 1995). But they are difficult to apply since input parameter requirements for soil microbial activity are high and structured field soils often contain a mixture of aggregates of different sizes and shapes. If only transport phenomena are addressed, several of the more complicated geometry-based models can be equivalently described by the first order rate nonequilibrium model (van Genuchten and Dalton 1986). While this model has been successfully used in laboratory soil column studies (Nielsen et al. 1986) its applicability for field studies is not yet established. However, it was shown by Vanclooster et al. (1992), that the model included as submodel in an agro-ecosystem nitrogen transport model offers a flexible tool for solute transport description at the field scale. For scenario studies multiple-continuum models might therefore be applicable to simulate nonequilibrium solute transport including preferential flow, if the corresponding soil properties can be characterized for the appropriate regional scales.

Stochastic methods

With recognition of the problems caused by the overwhelming spatial variability of soils and the related uncertainty of measurements, an increasing number of stochastic transport models evolved in the last two decades (Dagan 1989, Jury and Roth 1990). In most of these models certain parameters are treated as stochastic processes, i.e. sets of random variables with values which are calculated by realization of given probability distributions. Furthermore, simplifying properties of the stochastic processes are often assumed: the ergodic hypothesis which states that ensemble averages can be approximated by spatial averages and the hypothesis of stationarity or statistical homogeneity, which assumes that the probability distributions of the random variables are independent of their position in the field.

For Monte Carlo simulations, parameters of the flow and transport equations are taken as random variables by assuming ergodicity and stationarity or weak stationarity, a more easily treated mathematical formulation of the stationarity hypotheses (Andersson and Shapiro 1983). From the joint probability distributions parameter values are generated and repeatedly used as input data to solve the model equations until a sufficiently large number of output data is available for statistical analysis. Using Monte Carlo simulation the importance of variability in pore-water velocities rather than in local dispersion to produce spatially variable solute fluxes can be shown (Amoozegard-Fard et al. 1982).

Another tool of stochastic analysis is the perturbation method. In this approach a random variable is expressed by the sum of its expectation value plus perturbation, which represents the actual deviation from the expectation value. For unsaturated water flow the perturbation approach was used to treat parameters of a specific unsaturated conductivity function as random variables (Yeh et al. 1985, Mantoglou and Gelhar 1987). By substituting the perturbed variables into 3D-Richards equation, considering the output variable itself as perturbed, and using spectral representations of the perturbation terms, the effective conductivity tensor of the considered soil volume, which occurs in the resulting mean Richards equation could be evaluated in terms of the underlying soil variability. It was concluded that the local heterogeneity of the hydraulic conductivity may cause anisotropy of the effective conductivity leading to increased horizontal flow and that large scale hysteresis of the retention could occur without assuming local hysteresis (Montaglou and Gelhar 1987). The first observation is in contrast to results obtained by Tietje and Richter (1992) using Monte Carlo simulations, which show an increased vertical effective conductivity due to local heterogeneity. In subsurface hydrology the method of perturbation was initially used by Gelhar et al. (1979) and Gelhar and Axness (1983) to show that there exists a macro-dispersion coefficient, whose value is asymptotically approached for large times or distances of solute displacement in aquifers.

Whereas the examples for the two stochastic approaches mentioned above treat parameters of mechanistic models based on local mass balances as stochastic processes, an alternative stochastic approach introduced by Jury (1982) with the transfer function model uses a nonlocal mass balance considering the transport volume as a whole. A probability distribution $f_L(t)$ of solute travel times from the soil surface to some reference depth L is estimated by sampling soil solution at depth L at various field locations. In many field experiments this travel time distribution proves to be lognormally distributed. The solute outflow concentration can be given by a convolution integral of $f_L(t)$ and the flux concentration entering the inflow boundary (Jury et al. 1986). The transfer function model was successfully applied to field scale expriments (Jury et al. 1982, Jury et al. 1990) and might be developed to a useful stochastically based management model for solute transport, since the generalized travel time concept allows to incorporate physical, chemical and biological processes that occur in the considered transport volume (Jury and Roth 1990, Sardin et al. 1991, van Genuchten 1994). At the regional scale however, the strong input data demand, i.e. that travel time distributions have to be known for each field site and lack of information on the portability of known travel time distributions to other fields seem to hamper the application of transfer function models in scenario studies.

Conclusions

The paper gives a brief overview of some modelling approaches currently available to simulate soil water and solute transport for scenario studies of agroecosystems. With the change from research issues most often dedicated to agricultural production to issues of ecosystem research and environmental protection, soil water and solute transport related questions about plant nutrition changed towards quantification of pollutant fluxes. New modelling concepts were developed to address preferential flow and to deal with the enormous heterogeneity of natural field soils. Many of them were successfully tested in laboratory soil column experiments, but the huge difficulties in measuring water and solute fluxes in the field at the appropriate scales make it almost impossible to evaluate the abilities of the various models simulating the field situation. New measurement techniques as well as improved sampling strategies are available to tackle this challenging problem. In each case however, the approach to evaluate the quality of the models has to be adapted to the question which has to be answered. There will be no approach which holds for all problems. Scaling problems for both the models including their parameters and the data sets used for evaluation have to be tackled and overcome. Good quality data sets have to be used to evaluate models on an international basis, more than this was done in the past. Process based and stochastic approaches combined in highly modular structured modelling systems also could help to get refined and more realistic models, useful for solving our environmental and agricultural problems.

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Appendix 1

One-dimensional variably-saturated water flow and solute transport model based on Richards equation

$$C(h)\frac{\partial h}{\partial t} = \frac{\partial}{\partial z}[K(h)\frac{\partial h}{\partial z} - K(h)] + S \tag{1}$$

and the convection-dispersion equation

$$\frac{\partial(\theta c)}{\partial t} = \frac{\partial}{\partial z}(\theta D\frac{\partial c}{\partial z} - qc) + \phi \tag{2}$$

where C is the slope of the soil water retention curve $\theta(h)$, θ is the volumetric water content, h is the soil water pressure head, t is time, z is depth positive downwards, K is the hydraulic conductivity, c is the solute concentration in the liquid phase, D is the dispersion coefficient, and q is the volumetric water flux given by Darcy's law

$$q = -K(h)\frac{\partial h}{\partial z} + K(h) \tag{3}$$

S and ϕ are sources or sinks, where S accounts mainly for root water uptake and ϕ includes sorption, nutrient uptake, or several chemical and biological reactions and transformations.

Appendix 2

Capacity-type soil water model
The soil is divided into n horizontal layers considered as water reservoirs situated above each other. Each reservoir can accommodate a minimum water storage

$$S_i^{min} = \theta_i^{pwp} d_i \tag{4}$$

and a maximum water storage

$$S_i^{max} = [\theta_i^{fc} + 0.5(\epsilon_i - \theta_i^{fc})]d_i, \tag{5}$$

where θ_i^{pwp} is the water content at the permanent wilting point and θ_i^{fc} at the field capacity, ϵ_i is the soil porosity and d_i the layer thickness for each layer $1 \leq i \leq n$. Initially at time t each layer i contains a storage S_i^t. Assuming that the precipitation P, the runoff R and the evaporation E are given by a constant value during the timestep Δt, the flow into the first upper layer is given by

$$Q_0 = P - R - E \tag{6}$$

The storage S_i^*, which would be found in the i-th layer at the new time $t + \Delta t$, if this layer were closed at the bottom is recursively defined

$$S_i^* = S_i^t + Q_{i-1}\Delta t \quad for \quad 1 \leq i \leq n, \tag{7}$$

where the flow Q_i to the i-th layer is

$$Q_i = \begin{cases} 0 & \text{for } S_i^* \leq S_i^{max} \\ [(S_i^* - S_i^{max})(\epsilon_i - \theta_i^{fc})/\epsilon_i]/\Delta t & \text{for } S_i^* > S_i^{max} \end{cases} \tag{8}$$

Finally the new storage $S_i^{t+\Delta t}$ and the new water content $\theta_i^{t+\Delta t} = S_i^{t+\Delta t}/d_i$ can be calculated for each layer $1 \leq i \leq n$ by

$$S_i^{t+\Delta t} = \begin{cases} S_i^* & \text{for } S_i^* \leq S_i^{max} \\ S_i^* - Q_i\Delta t & \text{for } S_i^* > S_i^{max} \end{cases} \tag{9}$$

CHAPTER 5

Models and scale aspect

5.1 Capabilities and limitations of regional hydrological models

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Abstract

Hydrological modelling requirements for scenario studies are discussed and it is noted that physically based distributed models have an appropriate structure for predicting the hydrological regimes associated with various land use change scenarios. The capabilities and limitations of current physically-based models are discussed: uncertainties in predictions derive primarily from unresolved sub-grid scale heterogeneity and from inadequate data bases for parameter identification. A rigorous validation framework for assessing predictions of land use change effects is described which can account for various sources of prediction uncertainty.

A case study of land use planning in the Tyne basin, UK is described in outline in which predictions of land use patterns generated by an agro-economic model have been used to generate predictions of flow and water quality using the physically based modelling system SHETRAN.

Keywords: *hydrological model, land use change, heterogeneity, uncertainty, validation*

Introduction

A key issue for policy-makers concerned with the rural environment at the present time is how to balance agricultural productivity, and the economic benefits that it generates, with the preservation of environmental quality. The inheritance of an era characterized by the pursuit of higher and higher levels of agricultural productivity is all too obvious: the pollution of surface and groundwaters from agrochemicals, and the reduction in ecological bio-diversity are evidence that such production levels cannot be sustained into the future. Moreover, subsidizing over-productivity is no longer acceptable to society, and policy-makers are now seeking new approaches to the management of the rural environment. This has generated a requirement for modelling tools which can be used to explore and evaluate alternative management strategies through scenario analysis, and through which the conflicts which have traditionally arisen at the land use/water resources interface can be explored and hopefully resolved.

The rural landscape of a region is characterized by a mosaic of land cover which reflects climate, topography and soil as well as the land management practices associated with agricultural production in the region. The land cover and land management practices will in turn exercise strong influences on the flow, sediment and solute regimes of river basins within the region. To analyze scenarios of alternative land cover and land management practices, henceforth referred to collectively as land use, hydrological models are required which can generate reliable predictions of the associated flow, sediment and solute regimes of river basins.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 143–156.

Before proceeding further, it is appropriate to consider how such scenarios might be constructed and analysed. It is assumed that a region can be broken down into one or more large river basins, and that the river basin forms the natural unit for policy analysis. A scenario is then defined by the following:

(i) the uncontrollable driving variables of precipitation and potential evapotranspiration;
(ii) the controllable land use patterns;
(iii) the river basin response variables which provide the basis for discriminating between the impacts of alternative land use patterns.

Hydrological Modelling Requirements

Modelling issues

As already discussed, land use changes can alter the flow, sediment and solute regimes of river basins to a degree that is environmentally unacceptable. Examples of the changes which may occur are the following:

(i) changes to the water balance of a catchment;
(ii) changes to the dynamics of the flow regime;
(iii) changes to the erosion and sediment transport regimes;
(iv) changes to the solute/water quality regime.

There are numerous other land use change impacts which might be cited but those listed above are of major concern.

A crucial requirement for any model employed for translating land use change scenarios into corresponding predictions of basin response is that the model should be able to predict the impacts of such changes on the flow, sediment and solute regimes. Predicting the effects of change has long been one of the most challenging areas of hydrological modelling research. Lacking the perfect model which can replicate the behaviour of the real world exactly, a model has to be chosen on the basis of its 'fitness for purpose': in the case of predictions associated with land use changes, the information in the predictions must be used to discriminate between the alternative scenarios on the basis of impact measures.

Physically-based distributed models have a structure which is consistent with predicting the hydrological regimes of river basins under alternative land use scenarios. Their distributed structure can accommodate any prescribed pattern of land use, while their physical basis allows changes to be made to their parameters which reflect the physical changes associated with different vegetation types. Moreover, they provide a space-time description of the flow regime (depths, velocities) to which descriptions of sediment and solute transport can be linked. A well known example of such a modelling system is the

Système Hydrologique Européen (SHE: Abbott et al 1986 a, b) which has been extended to include sediment and solute transport (SHETRAN: Ewen, 1990, 1995).

While physically-based models have in principle an appropriate structure for predicting the hydrological regimes associated with various land use change scenarios, translation of principle into practice is by no means straightforward. Firstly, the available equations describing the component processes may not be descriptive of the flow processes in nature: for example, macropore flow in soils is at variance with flow descriptions based on Richard's equation. Secondly, the need to discretize the basin and the process equations onto a finite difference grid for solution purposes brings with it various unwelcome problems. With present generation workstations, grid sizes in the range 500 - 1000m are necessary to achieve the desired storage and run times for basin areas of several hundred square kilometres, which means that parameter values derived from point, or locally averaged measurements are not consistent with the 'effective' parameter values associated with the model grid scale. Thirdly, there is the problem of model identification/-parameterization: how are the effective parameters to be determined from data bases which were never designed to support the parameterization of physically based distributed models of large river basins? These problems have been the subject of vigorous debate in the literature where the capabilities of physically-based models have been questioned (e.g. Beven, 1989, Grayson et al, 1992).

Two issues can be raised in relation to the above problems:
(a) what scientific research should be undertaken to address them?
(b) how can the present predictive capabilities of physically-based models be assessed?

Research challenges

Issue (a) impinges on the debate which has been ongoing in the literature for several years concerning the need for hydrology to establish itself as a science in its own right where fundamental long-term research programmes are conducted linking process research and intensive data collection programmes in the field with hypothesis testing and model development. Current attitudes and expectations in hydrological modelling are still influenced by the culture of the 1970s when success was judged by a good fit to a basin outflow discharge hydrograph and where such results could be obtained for a modest investment of effort, and with relatively little understanding of the physical processes generating runoff in the basin. Modelling in this era was also characterized by lateral diversification: many models were developed using a wide variety of empirical concepts and analytical techniques in contrast to a more focused evolutionary process in which a generation of models evolves progressively by achieving better representations of the physical phenomena, as has been observed in other fields.

While the need for a more fundamental approach to hydrological modelling has been recognised, expectations of what can be achieved, and on what time scale, can be unrealistic. It is easy to criticize the current generation of physically-based models, and to argue in favour of developing relatively simple models which are also based on sound physical concepts, and built on the foundations provided by new hydrologic laws. However, while much effort has been expended in the pursuit of such laws, none have been identified, but several models have emerged which are physically attractive in some respects, and founded on the a priori hypothesis that runoff production is primarily controlled by topography. TOPMODEL (Beven and Kirkby, 1979; Beven et al., 1984), TOPOG (O'Loughlin, 1986) and THALES (Grayson et al, 1992) are examples of the current generation of such models. While few would dispute that topography influences runoff production, the widespread availability of Digital Terrain Models (DTMs) and the ease with which one of these models can be coded and fitted to a catchment also have much to do with their widespread use today. However, efforts to reconcile the water table predicted by TOPMODEL with real world observations of groundwater level have not met with much success (Iorgulescu and Jordan, 1994) as the former is an artifact of the model (Franchini et al, 1995). Yet, when one of these models does not perform well in practice, the whole concept of physically-based modelling is called into question (Grayson et al, 1992), even though the model may incorporate questionable simplifying assumptions, particularly in dealing with heterogeneities, and may not be classified as a physically-based model (Smith et al, 1994).

Natural heterogeneities, and how to model them, arguably provide the most important current challenge in hydrological research. Physically-based distributed models attempt to represent these heterogeneities using effective parameters at the grid scale but neglect sub-grid scale variability. While simulation studies conducted with heterogeneous hillslopes have called into question the existence of an effective parameter under some conditions (Binley et al, 1989), no credible alternative has emerged, and the concept continues to find widespread use in groundwater modelling and other fields. Moreover, the heterogeneity in soil physical properties exerts a very important influence on runoff production, and yet this is represented in a highly simplified and homogeneous manner in topographically-based models of runoff production such as TOPMODEL. In a critical commentary by Smith et al (1994) on Grayson et al (1992), it is argued that parsimonious physically-based models, based on new laws where a representative elementary area can be quite large and where the parameters can somehow be measured, may not be achievable, and that effort should be concentrated on developing methods for dealing with heterogeneity using the available physical laws, as is demonstrably the case in the field of groundwater modelling. That is not to say that models based on simplified concepts such as TOPMODEL do not have a valid predictive role in hydrology; when suitably calibrated, they can provide good parsimonious representations of the contributing area dynamics within a catchment, and of discharge at the basin outlet. However, they should not be regarded as substitutes for fully distributed physically based models, which still appear to offer the only realistic path to predicting the effects of land use changes.

Model identifiability and prediction uncertainty

The issue of model identifiability is frequently cited as a major problem in the application of physically-based distributed models, where it is argued that the large number of parameters involved cannot be estimated from the available measurements. Viewed from a systems theory perspective, this may be considered to be correct, but only if the parameters are estimated through the formal mathematical solution of an inverse problem involving no other information than the available measurements. However, with physically-based modelling, this is not the case; a large amount of a priori information is used in parameterizing (assigning values to the parameters) a physically-based model such as SHETRAN for a particular catchment. This a priori information is a function of the available prior knowledge of the values of physically-based parameters for different vegetation types, soil types etc, of the informal information available on catchment response, and of the base of prior knowledge and experience which the modeller brings to the parameterization process. This greatly reduces the space for physically realistic and consistent parameter values, and can be likened to a Bayesian approach to parameter estimation in which the a priori information on the parameters (represented by the prior distribution) is combined with the measurement information (represented by the likelihood function) to derive the parameter estimates (represented by the a posteriori distribution). An application of this approach to the inverse problem in groundwater hydrology is demonstrated by Ferraresi et al (1995).

Nonetheless, questions of uniqueness can still remain: for example, can alternative but physically acceptable parameterizations, consistent with the available information, still give rise to the same set of measurements? This possibility can be greatly reduced by increasing the effective degrees of freedom through expanding the dimensionality of the measurement space. For example, if only the outflow measurements are used, then the possibility of non-unique parameterizations becomes more likely. However, if multiple measurements are available on soil physical properties, moisture contents and tensions in the unsaturated zone, groundwater levels etc., and internally consistent parameterizations of the component processes in a physically-based model can be obtained, then this further enhances the prospects of a unique and physically realistic parameterization of a catchment. While such measurements are frequently available for research catchments, they will not generally be available for large basins which may be the focus of scenario studies related to land use change. In such cases, uncertainties will arise due to the limited hydrological networks and data bases which have been designed to support decision-making in more traditional management problems e.g. water resources assessment, flood forecasting etc. Moreover, uncertainties will also result from the use of effective parameters at the grid scale and the unresolved sub-grid heterogeneity. How then can the ability of physically based models to predict land use change effects be assessed, given the current state of the art with process representation, the treatment of heterogeneity and the possibility of non-unique parameterizations in the presence of an insufficient data base (question (b) above). This is a key issue, since it is incumbent on the modelling community to demonstrate that predictions can be generated by physically-based models (and indeed by any other models thought to be appropriate to the problem) that can be useful in decision-making. It is recognised that there are unresolved scientific issues associated with physically-based models, but this does not mean that current generation models cannot generate useful information for decision-making, provided that the uncertainty in the predictions is explicitly recognised and quantified.

An extensive literature exists on quantifying uncertainty in hydrological predictions: popular techniques which have been widely applied are first order uncertainty analysis (e.g. Tung and Mays, 1981; Chow et al., 1988) and Kalman filtering (e.g. Chiu, 1978; Wood and Szollosi-Nagy, 1980). However, the application of such techniques to physically based models presents intractable analytical and computational problems. Recently, Beven and Binley (1992) have developed a Generalized Likelihood Uncertainty Estimation (GLUE) procedure which is based on a Monte Carlo simulation approach to analysing the relationship between model/parameter uncertainty and prediction uncertainty. The GLUE procedure can be applied to physically-based distributed models and is sufficiently flexible to account for a priori information on model parameters and boundary conditions through prior distributions, and to assess the worth of additional data in reducing prediction uncertainty. Beven and Binley (1992) have demonstrated the application of GLUE to a physically-based distributed model of a small upland catchment; however, GLUE is computationally intensive and parallel processing facilities were required in this case. While GLUE is a new and creative approach to model calibration and predictive uncertainty, it is still a research tool with a number of difficulties to be resolved before its use can be recommended (Clarke, 1994).

A practical approach to assessing the predictive capabilities of physically-based models, which focuses on model validation for predicting climate or land use changes, is outlined in the following section. The approach can encapsulate those sources of uncertainty in model predictions which are deemed to be important for a particular problem, and can also accommodate the a priori knowledge and skills of the modeller.

Validation of models for predicting land use change impacts

The issue of whether useful predictions can be generated by physically-based models hinges on the method to be used for model validation. However, the problem with predicting the effects of land use (and climate) changes is that data on the changed system are not (and cannot be) available for comparison with the model predictions. Thus, a validation framework is required which allows predictive capability to be assessed under such conditions.

Ewen and Parkin (1995) have reviewed various validation tests and noted that all of them involve model calibration. They argue that a framework in which the model is not calibrated should provide a more powerful test of a model's ability to predict change. They then propose a validation framework in which the predictions are generated for a catchment where measurements on the response of the catchment are available but are not provided to the modeller and are not used in parameterizing the model. Such measurements are subsequently compared with the model predictions in a validation test conducted independently of the process of generating the predictions. Such an approach mimics realistically the conditions under which predictions of the effects of land use changes are generated, and constitutes a 'blind test' of predictive capability for the model and modeller. Moreover, this approach shifts the focus away from the unresolved scientific issues associated with physically based models, and seeks to establish objectively their predictive ability, whatever their limitations.

Given the uncertainty in parameterizing the model under the conditions of a 'blind test', it is unrealistic that a single prediction of a catchment response variable be generated as in a simple validation test when, for example, the measured value is compared with a single predicted value at time t. Rather, bounds are predicted for each of the response variables within which a stated percentage of the observed measurements are predicted to lie. For example, in predicting the output discharge hydrograph, bounds would be generated within which the observed hydrograph would be predicted to lie for α% of the time. These bounds are created by first defining upper and lower bounds for uncertain model parameters, based on all the available information and a priori knowledge, and then generating an ensemble of simulations of each variable for appropriate combinations of the parameter bounds. The upper and lower bounds of these simulations reflect the uncertainties in the prediction, whatever their source, and represent the confidence of the modeller in his/her model predictions. Narrow bands with a high percentage success represent high predictive ability; wider bands reflect less confidence. The steps involved in a blind validation test are as follows:

1. Define the application
2. Collect physical property data
3. Run preliminary simulations
4. Define the features to be predicted
5. Collect meteorological and catchment response data (this is done by someone independent of the modeller)
6. Run simulations
7. Set bounds for each feature
8. Compare the predicted bounds with the measured data, and assess the success of the test, for each feature
9. Record the results of the validation test

An example of how the predictions of different response variables might be assessed is shown in Figure 1.

In association with the use of such a validation framework, Ewen and Parkin (1995) propose the documentation of a performance record for a model, to be used in demonstrating 'fitness for purpose' to those interested in using predictions from the model as a basis for decision-making. Such a record must contain evidence that the tests have been conducted by independent assessors who can vouch for the authenticity of the performance record. Only through the use of such a validation framework can the true capability of any model used in predicting the impacts of land use (and climate) changes be demonstrated.

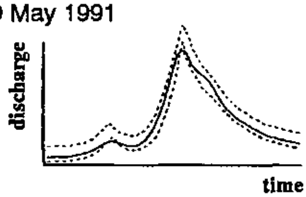
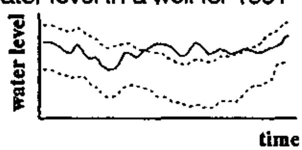
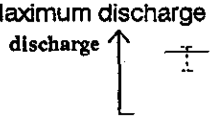
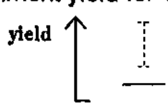
SPECIFIED FEATURE —— measured values ----- predicted bounds	RESULT	COMMENTS
Hydrograph for storm 19 May 1991  	successful	>95% within bounds; narrow confidence interval
Water level in a well for 1991  	unsuccessful	<95% within bounds; wide confidence interval
Maximum discharge for 1991  	successful	
Catchment yield for 1991  	unsuccessful	yield over-predicted

Fig. 1. Predicted bounds and measured values for various hydrological response variables.

Hydrological Modelling for Land Use Planning: A Case Study

The NERC/ESRC[1] land use programme (NELUP)

Scenarios of future land-use cannot be prescribed reliably without reference to the policies and economic forces which govern the uses made by farmers of the rural landscape;

[1] The acronvms NERC and ESRC refer to UK Natural Environment Research Council and the Economic Science Research Councils, respectively, who have funded NELUP.

otherwise, scenario studies assume the role of hypothetical 'what-if' type studies. Moreover, the impacts of changes in land use will transcend the hydrological regimes of river basins and affect terrestrial and in-stream ecology. The NERC/ESRC Land Use Programme (NELUP) at the University of Newcastle has been constructed to embrace the economic, hydrological and ecological aspects of land use planning, and the linkages which exist between them. This has been achieved by linking agro-economic, hydrological and ecological models within the framework of a Decision Support System (DSS) which has been structured to facilitate land use scenario studies. The structure of the DSS is depicted in Figure 2. Policy signals are fed into the agro-economic model, which generates information on the likely changes in land use, agricultural practices etc. This information is fed through a GIS to the hydrological and ecological models, which in turn generate predictions of impacts in space and time. Information on adverse impacts can be fed back to the agro-economic model, and constraints on agricultural policy imposed to ensure compliance, for example, with river water quality objectives.

The full scope of NELUP methodology and of the results obtained from a first case study of the Tyne basin in North East England is conveyed in a forthcoming special issue of the Journal of Environmental Planning and Management (O'Callaghan, 1995). Only a brief summary of the hydrological modelling undertaken as part of NELUP is provided here.

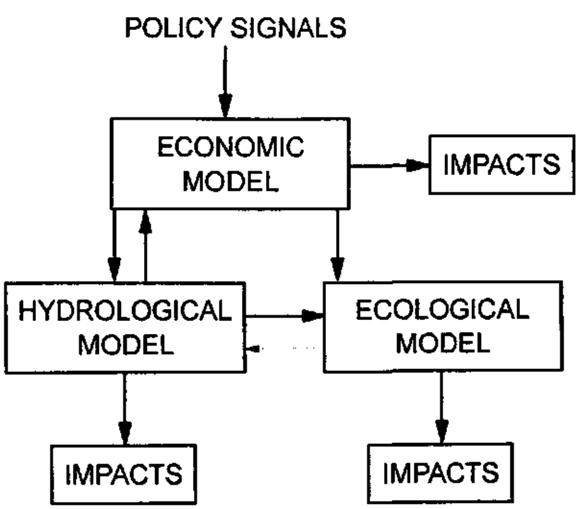


Fig. 2. Schematic of NELUP Land Use Programme.

The River Tyne basin

The River Tyne drains an area of some 3000 km^2 in the North East of England, and flows into the North Sea east of the city of Newcastle upon Tyne. The maximum altitude in the upper part of the basin is close to 900m; annual rainfall ranges from 1450mm in the upper basin to some 850mm in the lowlands.

The hydrological response of the Tyne basin is dominated by surface runoff, which accounts for about 80% of the total annual runoff, which in turn can be a similar percentage of total annual rainfall in the upper basin. A map showing the sub-catchments of the Tyne above the tidal boundary (area 2110km^2) is presented in Adams (this conference proceedings).

Peaty soils are found in the upland areas, with thin boulder clay deposits in the lowland Tyne and the upland valleys. The geology is predominantly carboniferous, ranging from coal measures in the eastern part of the catchment, to carboniferous limestone in the upland western areas. The depth to the impermeable bed is typically 1 metre and rarely in excess of 5m, except near streams, so there is little groundwater storage.

Land use in the Tyne basin

In the lowland area of the Tyne, the land use is mainly arable and grazing. Much of the north-west part of the catchment is extensively forested, while the remainder of the upper catchment (roughly 40%) consists of rough grazing and open moorland, with little arable activity due to the poor quality of the soils and the high rainfall.

In a typical upland sub-catchment (the East Allen) permanent pasture predominates, although there is a small percentage of ley pasture. The management of permanent pasture typically involves the application of four fertilizer applications totalling about 120kgN/h, in March, April, May and June. The fields are grazed for ten days a month for six months from March through to August. The stocking rate throughout the Tyne is about 2.5 units per hectare, with about 90% of plant matter returned to the soil in the form of animal waste. Fertilization of the ley pasture involves three applications of about 50kg N/h in late March, 100 kgN/h in mid April and 30kg N/h in late May. The ley pasture is also grazed but for a shorter duration. The total mass of fertilizer applied to the catchment in a year is of the order of 440 tonnes.

In a typical lowland sub-catchment (Derwent), the agricultural land cover is much more varied than for an upland sub-catchment. The major land use in the sub-catchment is grassland, with 36% of land covered by permanent pasture, 32% by rough grazing and 10% by ley pasture. Approximately 18% of the catchment is covered by cereal crops (winter barley, spring barley and wheat) and 3% of the land use is oil seed rape. The cereal crops are heavily fertilized in March and April. In addition, approximately 60 kgN/h is produced as dead plant matter when the cereal crops are harvested in mid September.

This causes a slow release of nitrogen into surface and soil water as dead roots and stubble decay. Oil seed rape has the highest single fertilizer application, with 225kgN/h applied to the crop in mid March. The total annual application of nitrogen in the sub-catchment is typically of the order of 1150 tonnes.

Hydrological modelling

The physically-based hydrological flow and modelling system SHETRAN (Ewen: 1990, 1995) was adopted for use in predicting the hydrological impacts of land use changes within NELUP. However, while the basic SHETRAN flow and solute transport modelling was available at the start of the study, a major investment of effort was required to facilitate its application to a basin on the scale of the Tyne. While substantial modelling extensions had to be undertaken to enable SHETRAN to generate predictions of nitrate in surface and groundwaters throughout the basin, much of the effort was expended in building an executive code (SHE-SHELL, Adams, these proceedings) which would facilitate the use of SHETRAN in scenario studies of land use within NELUP, and in developing algorithms for generating input data and parameter fields for SHETRAN from the available data bases. In modelling basins such as the Tyne with SHETRAN, the quantity and quality of the available data inevitably constrain the quality of the predictions generated by the model, since the data bases have never been designed to support physically-based modelling. Therefore, every effort was made to design algorithms which could exploit the available data fully. The algorithms generated input data and parameter values for SHETRAN on a $1km^2$ grid under the following headings.

(a) Climate: hourly values of precipitation were derived by combining point data from autographic and daily raingauges with altitude information from a digital elevation model (DEM).
(b) Topography/Water Courses: catchment boundaries and $1\ km^2$ grid square elevations were derived from a 50m DEM. The channel network was derived from 1:250,000 digitized stream network. Channel geometries were derived from catchment/geomorphological characteristics using empirical equations.
(c) Vegetation: the Landsat classification of remotely-sensed data was used to classify vegetation hydrologically and assign vegetation types and evapotranspiration parameters to $1km^2$ grid squares.
(d) Soils: a digital map of soil associations was used in conjunction with land use and topographical information to derive a digital map of soil series. Hydraulic parameter data defined for each series were then assigned to each $1\ km^2$ grid square on the basis of dominance.
(e) Geology: using digitized maps of solid and drift geologies, saturated horizontal conductivities and effective depths were derived by applying a vertical profile groundwater model to selected pathways defined using slope and aspect data.
(f) Agrochemicals: agrochemical inputs to SHETRAN were provided by outputs from the NELUP agro-economic model. A single cell nitrogen model was used to calculate the initial concentration profile in the soil.

Model calibration and validation

In applying SHETRAN to the sub-catchments of the Tyne basin, the approach taken was to carry out a limited calibration on one sub-catchment (Featherstone), and to use the results of this to assign parameter values to all the other sub-catchments in the basin. This represents a 'proxy-catchment' validation test in the terminology of Klemes (1986) which constitutes a reasonable test of SHETRAN's predictive ability in this case, although not as rigorous a test as that described in Section 3 above (the latter validation framework was not available at this time).

An hourly discharge record for the period 1985-89 was available for the Featherstone sub-catchment; similar records at 6 other sites in the basin were available for the validation test. The data for 1985 were used in the calibration exercise for Featherstone. Firstly, the simulated annual water balance was checked against the observed balance, and there were found to be an underestimation of total runoff, and an overestimation of evapotranspiration. The a priori assigned aerodynamic resistance values in the Penman-Monteith equation were re-interpreted and modified within the bounds of physical reason. The resulting annual interception loss was found to be similar to that quoted by Calder (1992) for grassland and forestry. Global changes were also made to the canopy resistances to compensate for the adjustments to the aerodynamic resistances. The resulting water balance and discharge hydrographs were found, on the basis of graphical comparisons and the coefficient of determination R^2, to agree reasonably well with the observed values for 1985, ($R^2 = 0.70$) and for the validation period 1986-89. However, in the spirit of preserving physical realism, the pursuit of a better fit through curve fitting was not pursued.

Given the variation in land-use throughout the Tyne basin, the evapotranspiration parameterization could be accepted as reasonable if the validation test with the other sub-catchments generated results of comparable quality to the Featherstone sub-catchment. This was found to be the case, and so the model was accepted as the basis for land use scenario studies.

Nitrate simulations were also generated by SHETRAN, and compared with the very limited spot-sample data available at a number of points in the basin. Reasonable agreement was obtained, but insufficient data were available to make an assessment of the model's predictive ability in this regard, particularly during periods of high river concentrations associated with surface water leaching. For details of the validation results, see Adams et al (1995).

Use of SHETRAN in land use scenario studies

To facilitate the use of SHETRAN in scenario studies within the Decision Support System (DSS), an executive code, SHE-SHELL, has been developed which is described in a companion paper by Adams (these proceedings). The user of the DSS can select a rural land use policy change and then set up a SHETRAN hydrological simulation to examine in detail the consequences of the policy change for water quantity and quality. SHE-SHELL will then process the details of the land cover changes and run the SHETRAN simulations off-line for later analysis. By structuring the simulations for a cascade of sub-catchments, SHE-SHELL identifies those sub-catchments undergoing change, and re-simulates these only, thus keeping computational requirements for large basin simulations manageable.

Conclusions

At the present time, physically-based distributed models appear to offer the only realistic option for assessing the hydrological impacts of land use changes. However, a number of unresolved difficulties associated with the use of physically based models have been the subject of considerable debate in the literature, and the usefulness of predictions generated by such models has been questioned. This has led not to a sustained and concentrated effort to resolve such difficulties, but to diversification into a search for more parsimonious physically based distributed models founded on newly established hydrological laws. However, this search may not prove fruitful, and it is argued that effort should continue to be devoted to how spatial heterogeneity can be satisfactorily represented in physically based distributed models. The developing programme of international climate change studies provides an excellent opportunity to carry out field experiments which will hopefully lead to real progress in dealing with heterogeneity.

However, reliable predictions of the impacts of land use changes are needed now to support decision-making. To enable the current predictive ability of physically based models to be assessed in this regard, a validation framework is advocated which provides a means of assessing predictive performance by employing 'blind' validation tests. The performance of models in such tests should be documented and made available for assessment by decision-makers.

A case study of land use planning in the Tyne basin, UK, has been used to illustrate what can be achieved with current modelling technology. To allow realistic land-use scenarios to be generated, an economic model must be used to convert policy signals into predictions of agricultural activities, which can then be translated into predictions of the altered flow and solute regimes. For large river basins such as the Tyne, the use of a physically based modelling system such as SHETRAN requires substantial effort in assembling the necessary data and converting these into SHETRAN inputs and parameter values. Algorithms to facilitate this process have been developed as part of the Tyne case study. Although the data available for such basins have not been designed to support physically-based modelling, the results of the Tyne case study suggest that acceptable results can be obtained which are consistent with the results of process experiments.

Finally the interdisciplinary nature of land use studies needs to be emphasized in any agenda for future research. Achieving consistent linkages between economic, hydrological and ecological models is necessary to ensure that the problem of land use planning is tackled in its entirety rather than in parts.

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5.2 Regional simulations as a basis for the assessment of national nutrient emissions at various input scenarios in Denmark

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Abstract

Several regional studies of N transformations and transport have been carried out in Denmark and are discussed briefly, with emphasis on data sources, problems encountered and conclusions reached. On this basis, limitations to regional modelling, strong and weak points of the approach and future potentialities are highlighted. The Danish experience regarding regional N-modelling is that it is possible to conduct reliable simulations of N-emissions from soils, where the process descriptions are valid and the models are properly validated. However, there is still need for model improvements.

Keywords: *Danish regional N modelling, unsaturated zone, saturated zone, management aspects*

Introduction

During the last decade problems regarding increased nutrient emissions have become more and more obvious. In a number of countries, the stage has now been reached, where political decisions regarding control of such emissions have been taken or are in the process of being taken, and there is an urgent need to be able to predict the effects of the suggested measures of pollution control. It is therefore very relevant to look into which tools are available for prediction, how reliable they are, and what are their limitations. The paper will specifically deal with the Danish experience with respect to modelling of nitrogen flows.

Modelling studies of regional and national nutrient-emissions from soils

Modelling of solute transport for regional and national purposes may be conducted in three fundamentally different ways:

I Empirical regression models (e.g. Simmelsgaard, 1981) may be used for estimation of leaching from a number of field conditions, which together represent the nation or region (e.g. Skop, 1993).

II One-dimensional deterministic models of the unsaturated zone may be used for simulation of a number of conditions, which together represent the nation or region. This method may be used to predict losses to groundwater or leaching below a given depth, provided the model is able to handle the relevant process descriptions and lower boundary conditions. Usually, this method does not include geochemical processes in the lower part of the unsaturated zone or in the saturated zone.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 157–167.

III a three-dimensional, fully deterministic, physically based model may be used to predict leaching to and movement in groundwater as well as transport to streams and lakes within selected catchments. This method contains the possibility of incorporating geochemical reactions, effects of denitrification in wetland areas along streams and other aspects which require inclusion of groundwater or surface water movements.

While method I is applicable only for field conditions similar to the ones the empirical relations were developed for, methods II and III allow for prediction of changes in emission due to changes in management practices. Both methods (I), II and III provide information concerning effects of dosages and cropping practices on leaching to groundwater. Effects of artificial drainage or buffer zones along streams as well as long term effects on groundwater, streams and lakes can only be evaluated using three dimensional models, or in some cases, quasi-three-dimensional.

The Danish experience

In Denmark, all three types of studies have been carried out for nitrogen/nitrates, method II and III using the Nitrogen simulation model 'DAISY' (Hansen et al. 1990, 1991), or DAISY coupled to the three-dimensional model MIKE SHE. DAISY is a one-dimensional, physically based root zone model, which simulates crop production, soil water dynamics and nitrogen dynamics (mineralization, nitrification, denitrification, nitrogen uptake by plants and nitrogen leaching) under various agricultural management practices. A few studies are described briefly in the following, with emphasis on data sources, problems encountered, and conclusions reached.

Regional and national studies by one-d. Deterministic models

A study of leaching in Vejle county (Stougaard et al., 1992, Jensen et al., 1992) and a national study (Nielsen et al., 1992) were carried out using DAISY. In the Vejle study DAISY was calibrated against measured yields, and nitrogen leaching was calculated for 46 points. Predicted yields (Fig. 1) and nitrogen concentrations in soil moisture were compared to observed values, with good results.

The nationwide study divided Denmark into five regions on the basis of climate, crop distribution, fertilization practises and administrative boundaries. Curves were generated from the DAISY simulations, showing leaching, yield, plant uptake, changes of humus content etc. as functions of four levels of applied fertilizer for each region. Secondly, information regarding the actual fertilization practice in the regions was coupled to the simulated curves for leaching, plant uptake, etc. Water and nitrogen balances were calculated on a regional basis. For each region the DAISY-simulations were conducted using combinations of 2 soil types, 25 cropping patterns, 4 fertilization levels and 8 periods, reaching a total of 1600 simulations. Simulated and measured yields and N-amounts were compared. Each of the simulations was given a spatial coverage corresponding to the actual soil maps in combination with statistics regarding cropping patterns and fertilization practice, and the total leaching for each region and nationally was estimated. The model was not calibrated prior to the simulation conducted in this study.

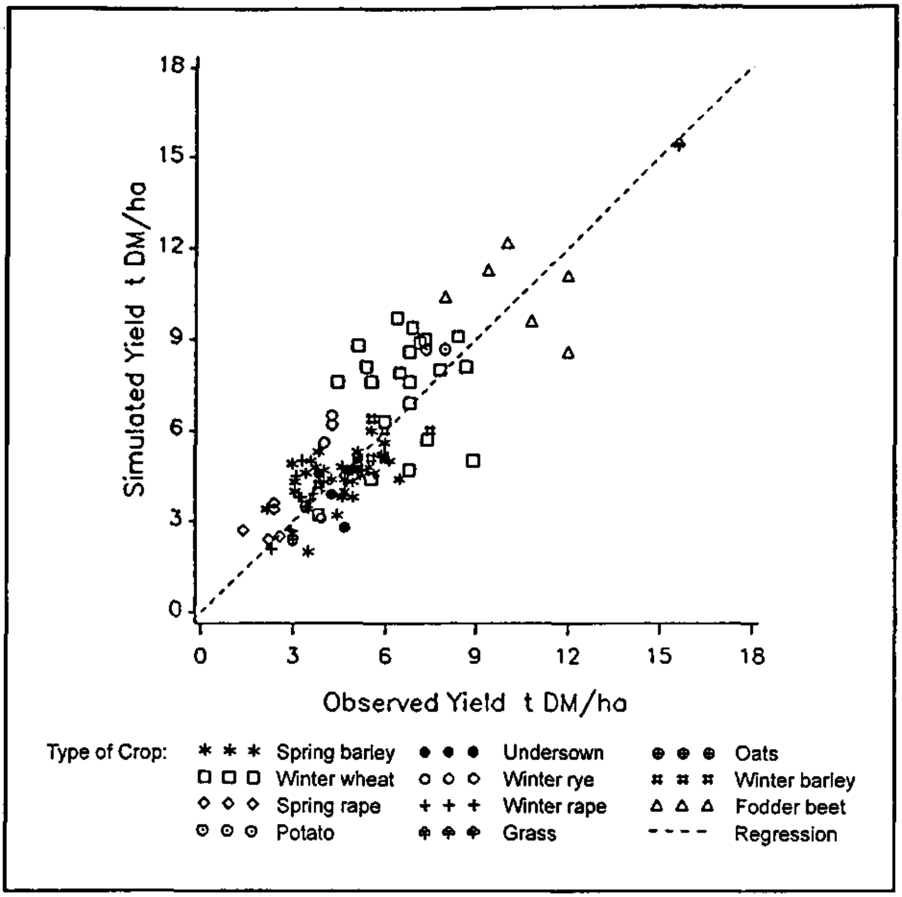

Fig. 1. The relation between observed and simulated dry matter yields in Vejle County. From Stougaard et al. (1992).

Data

Both studies used soil information from the Danish National Land Data Base System at the Dept. of Land Data, Danish Institute of Plant and Soil Science. The land data base contains soil physical and chemical data together with maps showing texture of top and subsoil, wetlands, landforms and slopes. In Vejle, this was supplemented with data from the Square Grid for Nitrate Investigations, which is a nationwide monitoring system. The Square Grid (7x7 km) was established in 1986 and contains 820 intersections with soil profile descriptions and analyses of physical and chemical properties. Inorganic nitrogen levels are established at four depths down to 1 metre on 50 x 50 m testplots at each intersection four times per year by the Danish Agricultural Advisory Centre (DAAC).

Weather data stem from the Meteorological Institute of Denmark and the Dept. of Agricultural Meteorology, Danish Institute of Plant and Soil Science. Data concerning irrigation stem from the Counties of Denmark.

Crop cover information stems from agricultural statistics (Danmarks Statistik, 1983-89). Farm management information is collected every year by DAAC for the Grid Square. Other sources are a study of 925 farms (Frederiksen, 1990), reviews of agricultural experiments (Bennetzen, 1984-86, Skriver, 1987-90), the 'Square Grid for Nitrate Investigation' interviews and interviews carried out in six special monitoring areas established by the Counties of Denmark, the National Environmental Research Agency and the National Agency of Environmental Protection.

Limitations
Both studies found that, for some crops, more effort needs to be put into the development and calibration of crop modules. Particularly for grass, the simulated 'harvested N-content' may be underestimated. Crops such as winter rape, maize, pea, and clover grass could not be included in the national calculations due to a lack of crop modules.

Estimation of nutrient contents in organic fertilizers may be difficult. Dry deposition of N takes place particularly during the periods of application of manure, but is simulated as a constant application. Not all data types were available in an adequately distributed manner for the national study, and it was necessary to extrapolate from investigations of single fields to larger regions. E.g. it was difficult to find analyses of the total N-content of soils, which makes the calculations of N-turnover unreliable. Furthermore, the absence of a description of the macropore flow process was considered a problem and so was the lack of knowledge concerning hydraulic conductivity of the simulated soils.

Conclusions
The Vejle study finds careful validation crucial, and states that a properly validated deterministic simulation model will be an effective tool both for improvement of the yearly fertilizer forecasts and as a prognostic tool for evaluation of scenarios.

The national study did not specifically include validation. The study concludes that DAISY is not able at present (1990) to produce realistic balances for N on a national level. This relates to a large extent to the simulated 'harvested' N-amount being too large and a large simulated decrease in organic N in the soil. The last problem may be related to the lack of knowledge concerning total N-content in the soil. Furthermore, only two soil types were considered with no described variation of the groundwater table. However, for some crops the correspondence with measured data was very good. The inability of the model to take into account N-fixation has not led to the use of other estimates for this in the national assessment.

While the conclusion is correct in the sense that the model is not able to describe all crops, and some data are difficult to obtain, DAISY produced good results for the crops which cover the majority of Denmark. Some of the problems mentioned could have been adjusted through a calibration/validation phase.

Three-dimensional catchment studies

Three-dimensional studies (Storm et al. 1990, Styczen and Storm, 1993 a, b) were conducted for a catchment in Jutland (522 km^2) and on Sealand (178 km^2). For Karup in Jutland, a period of 20 years was simulated, and different scenarios with respect to timing of fertilizer application, extent of autumn sown crops, and distribution of animal manure, were carried out. A less extensive study was conducted for Langvad on Sealand, with different soils and cropping patterns. Recently, a study of an area on Fuen (Denmark) has been conducted. Fig. 2 shows the coupling of the two models DAISY and MIKE SHE (DHI, 1993). MIKE SHE is a fully distributed hydrological modelling system containing process descriptions which covers the entire hydrological cycle, describing water flow at the soil surface, in the unsaturated zone and in the saturated zone. Furthermore it is possible to include solute transport in the simulations.

Data

Data concerning weather (Danish Meteorological Institute), topography (1:50.000 maps), soils (Dept. of Land Data, Danish Inst. of Plant and Soil Science, together with local profile descriptions), hydrogeology (ZEUS-database at Geological Survey of Denmark), and stream flow (Danish Land Development Service) were acquired. Land use and management information came from agricultural statistics and interviews with local agricultural consultants.

Simulations

Only the study from Karup will be described. First, DAISY was run for six research plots in the catchment, with good results. Calculations were done for the whole catchment, and, on a slightly smaller grid, for a subcatchment (Rabis brook), where measurements were carried out by other research groups. Although statistical information was used, the simulation results corresponded well with the levels of nitrate measured in Rabis brook. Both temporal and spatial variability of the results were studied. Selection of scenarios was carried out to assess the expected impacts of the implementation of the Danish Water Action Plan on nitrate leaching. The aim of the Danish Water Action Plan with regard to nitrate, was a 50 % reduction in nitrate leaching compared to the 80-84-level. This aim should be accomplished through regulation of management practices. The most important measures were a minimum soil coverage of 65 % during the autumn and a more optimal use of manure such as spring application and better distribution. Scenario simulations were conducted taking the points from the Action Plan to a greater extent than actually implemented in the plan.

Results/Conclusions

The calculated nitrate load to water bodies was compared with the goals given in the Danish Water Action Plan. It became obvious that a 50 % reduction in nitrate leaching is not realistic for the study areas, particularly the loamy soils. In western Jutland, the number of cattle has decreased, causing a decrease in use of manure and in leaching. On loamy soils, the level of leaching is already lower due to fewer animals and use of mineral fertilizer.

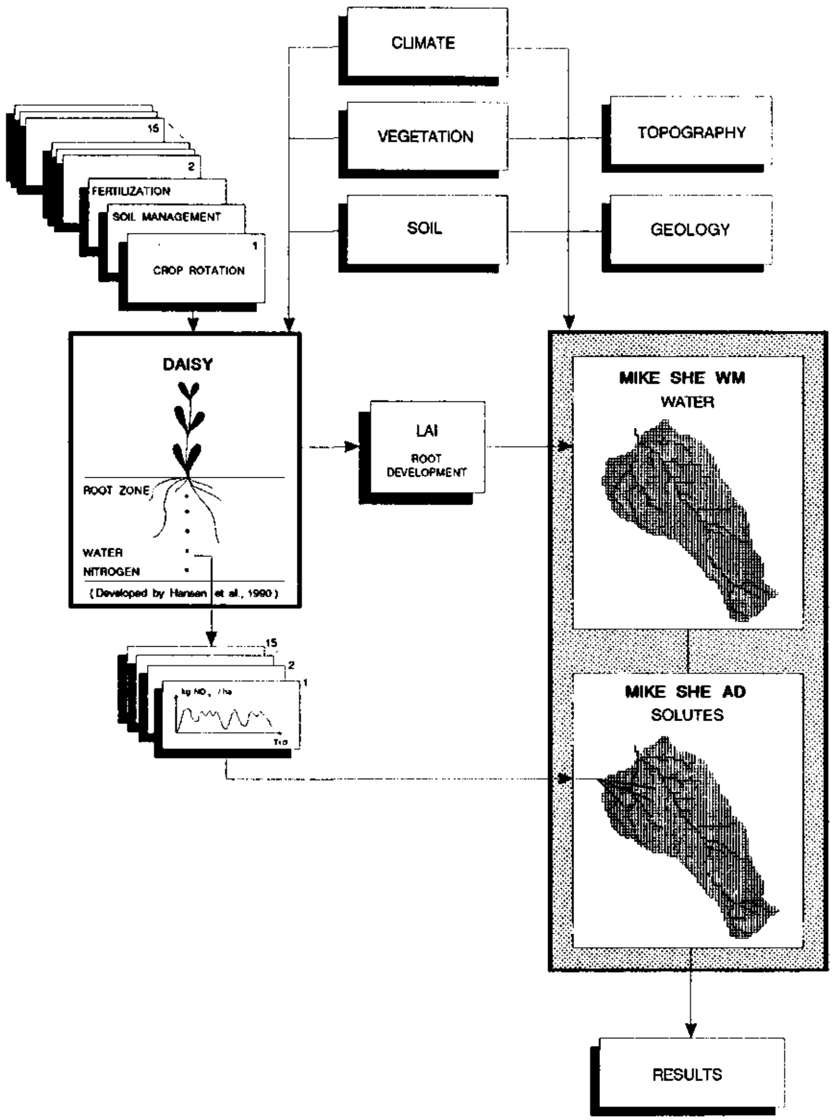

Fig. 2. Overview of the data need for and the coupling of MIKE SHE and DAISY. From Storm et al. (1990). The time step used during this study was 1 day, but it could be hourly if needed. There was no flow of information from MIKE SHE to DAISY. This was not necessary in the present study, as the UZ descriptions are nearly identical, the water flow of the two models were calibrated against each other, and the groundwater was relatively deep compared to the root zone.

Apart from information concerning leaching from the root zone, such studies may assist in clarifying distribution patterns, and changes over time with respect to the concentration of nitrate in the groundwater. Furthermore, it is possible to produce a description of the catchment response in relation to different treatments. Examples of the three types of information are given in Plate 2c, Fig. 3 and 4.

Other scenario studies

Styczen (1991) describes leaching as a function of different management practices, for four major crops. Hansen and Svendsen (1994) describes optimization of the N-balance for crop systems of pig farms on two soil types. They show how modelling may be used to simultaneously optimize production and minimize leaching.

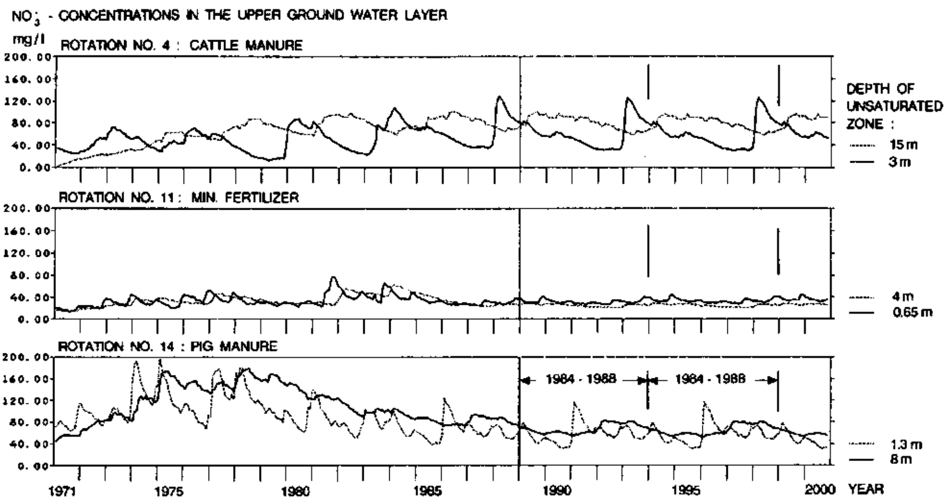

Fig. 3. Variation in time of the nitrate concentration in the upper groundwater under three selected crop sequences. For each crop sequence the concentration of two points with different thickness of the unsaturated zone are given. From Storm et al. (1990). The illustrations shows the large impact on nitrate concentrations in the groundwater arising from use of animal manure compared to the situation with application of mineral fertilizer only.

Policy implications of conducted studies

The national and three-dimensional studies were funded by the National Agency of Environmental Protection, together with other research, aimed at analysing the situation (1990) and assessing the impact of legislative changes which took place in 1984.

Both estimates led to the conclusion that approximately 210.000 t N is leached from agricultural areas of Denmark. Results of the three-dimensional study, a scenario-study (Styczen, 1991), and statistical information led to the estimate that the legislation had resulted in a decrease in N-leaching of 20 %. The reduction of 50 % compared to the 1980-84-level, which was the aim of the Water Action Plan, is not likely to be reached.

The different studies also pinpointed where the most serious problems with leaching were found (Miljøstyrelsen, 1990).

Thus, the models have been used as a tool for monitoring the implementation of environmental policy. It is possible also to use model results as a tool for developing an environmental policy for fertilizer management on a regional and national scale. The recently released report by Hansen and Svendsen (1994) clearly shows that modelling may also be used to support implementation of a national policy.

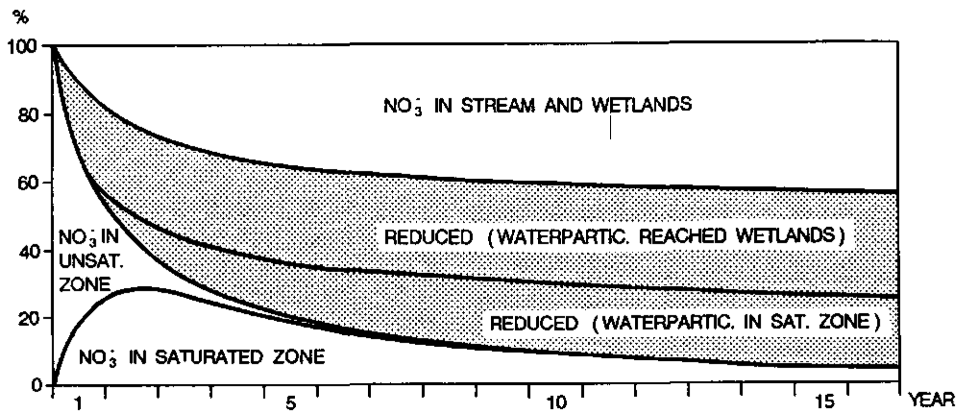

Fig. 4. Relative distribution of nitrate in time after a single nitrate application uniformly distributed over the agricultural area of the Karup stream catchment. From Storm et al. (1990). The illustration shows the response time of the system to changes in the amount of nitrate not used by the crops. After 15 years, approximately 46 % of the surplus amount of nitrate will have reached the streams, another 46 % has been reduced in the aquifer and the remaining 8 % will still be in the groundwater. The short response time of the nitrate transport to the streams in this study, is due to shallow groundwater in large parts of the area.

Limitations experienced during the course of the studies

Limitations to regional modelling may be related to deficiencies in the process descriptions or lack of data. Under Danish conditions, modelling has proven to be a strong tool on the sandy soils of Jutland, while more problems concerning solute transport are encountered on moraine soils where macropores may play an important role. Macropore flow is not yet included in DAISY, and there is still a lack of knowledge of important parameters connected to macropore flow in Danish soils.

DAISY modules for N-fixating crops such as pea and clover as well as a few other important crops are still missing.

With respect to general data, data bases are extensive. The problems experienced are generally related to the estimation of hydraulic conductivity and N-content in soil and organic manures. An important point of uncertainty is the division of the organic matter into pools. Errors in pools and transformation of organic matter may influence the simulations considerably for several years. The initial condition used with respect to these pools is therefore of utmost importance for the simulation results.

To reduce the amount of uncertainty influencing modelling of the N-balance, a targeted research programme concentrating on estimating specific parameters would be necessary.

Weak and strong points in the use of regional simulation models

The experience of the modeller is an underestimated issue when evaluating the quality of simulations. In three-dimensional modelling it is the experience that few scientists have the required knowledge in all of the relevant fields (agriculture, nitrogen chemistry, soil science, soil physics, hydrogeology, geochemistry, hydrology) and team work is therefore essential for good results.

Furthermore, the need for effective parameters is a difficult issue. Regional models require "effective" parameters, that is, parameters which represent a certain subarea equal to the resolution of the model, which may not be directly measurable in point measurements. The model output also represents a spatial average. The difference sometimes found between point measurements and parameter values or simulated values is a scientific problem and rather confusing for non-modellers.

Large models may seem opaque to non-modellers and policy makers. Furthermore, they force their users to quantify problems and solutions. But rather than to define what should be done, scientists may prefer to define what else should be studied. In Denmark, relatively few scientists and institutions, maybe for educational reasons, have been willing to use models as a management tool, particularly with respect to agricultural pollution. There is a need for strengthening modelling abilities, increasing acceptance of good models as being the best tools available for quantification of our integrated knowledge and encouraging scientists to dare to use them for management-related purposes.

Three of the strongest points of modelling are the ability to integrate knowledge from several fields, to incorporate a large amount of information, and to simulate effects of alternative management practices. Regional modelling is an efficient way of integrating knowledge from several disciplines and providing a quantitative estimate of water flow and solute transport. It brings together people who may otherwise not be forced to integrate their knowledge in a quantitative manner.

Validation on detailed data sets, preferably from a subcatchment of the area to be modelled is vital to the credibility of a model. If used nationally, validation requirements increase due to the variety of crops, soils, and types of manure involved. In the National Study mentioned earlier, the model was used outside its validated range.

In spite of the limitations to advanced modelling, the empirical methods are no alternative, as their predictive capacity is small. Modelling is the most promising way to improve environmental management, not only with respect to N, but also P, pesticides, point source pollution, irrigation, and optimization of land use changes. The potential in combining monitoring and modelling has hardly been explored. There is still ground to cover with respect to the development of management systems and knowledge of particular parameters, but with respect to N, there are no technical reasons hindering development of management support systems over the next 5-10 years, allowing farmers to optimize fertilizer use taking into account both yields and leaching risk, and policy makers to evaluate the effects of suggested legislation.

Conclusion

The Danish experience with regard to regional N-modelling is that it is possible to conduct regional simulations of N-emissions from soils, where the process descriptions are valid. Model results have been used as a tool for monitoring implementation of environmental policy, and the ever increasing capabilities of models indicate that models can be used both as a tool for developing an environmental policy for fertilizer management on a regional and national scale and to support its implementation.

There is still room for improvement in the models. For the Danish model DAISY, there is a need for development of more crop modules and for incorporation of preferential flow. Both are under way. A vast amount of data is available for modelling, but is situated in different institutions. Integrated modelling requires team work, both between individuals and institutions. The few data types which are missing in Denmark could be collected rather quickly in a targeted research programme.

The DAISY/MIKE SHE modelling system has recently been applied to a catchment in Slovakia also. The experience from this study suggests that other countries possess the necessary data for calibration/validation of deterministic models describing water and Nitrogen movements. This data only needs to be localized and made available.

The use of three-dimensional modelling allows estimation of the effects of drainage and wetland areas on denitrification, as well as a description of denitrification in groundwater due to differences in redox conditions. These facilities are of great importance for impact assessments, analyses of different management strategies or if the N-load to rivers from seepage water and drainage water is evaluated. As overland flow is not an important source in Denmark, this issue is not yet included in DAISY.

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5.3 Scenario studies on soil acidification at different spatial scales

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Abstract
Three dynamic soil acidification models have been developed for application at a local scale, a national scale and a continental (European) scale, i.e NUCSAM, RESAM and SMART. NUCSAM was specifically developed to gain insight into the effect of acidic deposition and nutrient cycling on a local scale and to aid further research (research aim), whereas the major objective of SMART was to assist decision makers in evaluating environmental policies in Europe (management aim). RESAM serves both aims but on a different scale (smaller compared to SMART and larger compared to NUCSAM). This paper gives an overview of various model studies including: (i) model validation on a local and a national scale and (ii) scenario studies, which evaluate effects of different deposition scenarios for SO_x, NO_x and NH_x on soils on a local, national and continental scale. Results showed (i) a reasonable-to-good agreement between measured and simulated soil solution chemistry both at a local and regional scale and (ii) an improvement in the future acidification status of Dutch forest soils at given emission-deposition reductions, whereas the reverse was predicted for European forest soils. The uncertainties in model predictions and the use of the models in acidification abatement policies is addressed and the various strong and weak points of the models are evaluated. Furthermore, the limitations and possibilities of using the models in other scenario studies, such as changes in land use, hydrology and heavy metal deposition, are discussed.
Keywords: *Acid deposition, soil acidification, models, validation, scenario analyses*

Introduction

Acid atmospheric deposition first became recognized as a problem in the early seventies when acidification of lakes and streams in Scandinavia and Northeastern America led to a decline in fish species (Likens and Bormann, 1974). Ulrich et al. (1979) were among the first to draw attention to acidification of forest soils caused by acid deposition and its potentially harmful effects on forest ecosystems. Evidence exists that the vitality of forest ecosystems in Europe is seriously endangered by changes in soil chemistry in the rootzone. Examples are a decrease in pH and base saturation, an increase in toxic Al and the unbalanced availability of base cation nutrients (Ca, Mg, K) due to excessive Al and NH_4 (Roelofs et al., 1985; Roberts et al., 1989). Although acidification of soils, such as decalcification and podzolization, is a natural process in coarse textured (sandy) soils in areas with a precipitation excess, it is the present rate of soil acidification which is alarming. Current enhanced soil acidification due to elevated atmospheric deposition of SO_x, NO_x and NH_x has been proven by input-output budgets. (e.g. Van Dobben et al., 1992). Recently enhanced soil acidification in Central and Northern Europe has also been proven by resampling forest soils at intervals of several decades (e.g. Hallbäcken and Tamm, 1986; Billet et al., 1988; Butzke,1988). These studies showed that soil pH and base saturation have decreased strongly within the rootzone of most forest soils in the past 20 to 30 years.

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At present various dynamic simulation models exist to predict the acidification of surface waters. Examples are the Integrated Lake Watershed Acidification Study (ILWAS) model, developed for the application on single catchments (Chen et al., 1983) and the Model for the Acidification of Groundwater in Catchments (MAGIC) developed for regional catchment applications (Cosby et al., 1985). At the Winand Staring Centre, different soil acidification models have been developed for use on different scales, i.e. NUCSAM (Nutrient Cycling and Soil Acidification Model; Groenenberg et al., 1994), RESAM (Regional Soil Acidification Model; De Vries et al., 1995) and SMART (Simulation Model for Acidification's Regional Trends; De Vries et al., 1989). The models RESAM and SMART were specifically developed to evaluate long-term soil responses to deposition scenarios on a regional (national to continental) scale, respectively. Consequently, RESAM and SMART do not include seasonal dynamics. The temporal resolution of the models is one year, and the hydrologic description in these models is very simple. Simulation of the interannual variability is, however, included in NUCSAM, which is specifically developed for application (and validation) on a local scale.

RESAM and SMART are part of integrated acidification simulation models that give a quantitative description of the linkages between emissions, deposition and environmental impacts such as soil acidification and effects on terrestrial and aquatic ecosystems. These integrated models are DAS (Dutch Acidification Simulation model) for application in The Netherlands (Olsthoorn et al., 1990) and RAINS (Regional Acidification Information and Simulation model) for application in Europe (Alcamo et al., 1990).

The major objective of this paper is to give a review of modelling studies with NUCSAM, RESAM and SMART about the impact of deposition scenarios for SO_x, NO_x and NH_x on soils at various regional scales. Furthermore, various studies on model validation and uncertainties in model predictions are reviewed. Finally the strong and weak points of the models are evaluated and their possible use in predicting the mobilization of heavy metals after environmental (e.g. land use) changes is discussed (chemical time bombs).

The models NUSCAM, RESAM and SMART

Two major groups of soil acidification models are those based on an empirical approach and those based on mechanistic descriptions of processes. A disadvantage of relatively simple empirical models is that they lack a theoretical basis for establishing confidence in the predictions. Consequently, the models NUCSAM, RESAM and SMART described here are all characterized by a process-oriented deterministic approach. The stochastic character of input data can, however, be included in all models by a Monte Carlo approach, given a specified range of input data (e.g. Kros et al., 1993). A disadvantage of relatively complex mechanistic models is, however, that input data for their application on a regional scale is generally incomplete. So, even if the model structure is correct (or at least adequately representing current knowledge), the uncertainty in the output of complex models may still be large because of the uncertainty of input data, (Hornberger et al., 1986). There is thus a trade off between detail and reliability of information obtained and regional applicability. Consequently the desired degree of spatial resolution in model output is a factor of crucial importance when selecting the level of detail in both the model formulation and its input data. A larger application scale justifies the development of a simpler model, as illustrated in Table 1.

Table 1. Characteristics of the dynamic soil acidification models used at the Winand Staring Centre

Name	Complexity	Soil layering	Time step	Application scale
NUCSAM	Complex	multi-layer	one day	Site
RESAM	Intermediate	multi-layer	one year	The Netherlands
SMART	Simple	one-layer	one year	Europe

The models SMART and RESAM, designed for regional predictions, are more simplified than the site scale model NUCSAM to minimize input requirements. The simplifications consist of: (i) the reduction of temporal resolution, i.e. using an annual time resolution, thus neglecting interannual variability of both model inputs and processes, (ii) the reduction in spatial resolution, by using a smaller number of soil compartments and (iii) the use of less detailed process formulations. To apply a model on a regional scale, the various processes occurring in the soils have either been limited to a few key soil processes, or represented by simple conceptualizations (process aggregation). The degree of process aggregation in the models increases (complexity decreases) when the availability of data decreases, which occurs with an increase in the geographic area of application.

The major reason for developing NUCSAM was to be able to validate the model on intensively (mostly biweekly) monitored sites during a relatively short-time period. Validation of dynamic models which do not include interannual variability, i.e. RESAM and SMART, is problematic, since long-term time series of soil chemistry date are generally lacking. However, long-term simulations with SMART and RESAM can be compared to those made with the validated NUCSAM model, that serves as a standard. In this way an indirect model output validation can be accomplished for the regional models RESAM and SMART.

The major reason for differentiating between the multi-layer RESAM model and the one-layer SMART model was the trade-off between the level of detail in model outputs and the availability of model inputs. RESAM gives insight into the spatial (vertical) variation in soil (solution) chemistry within the rootzone. Since the hydrologic description in the one-layer model SMART is simplified to the use of an annual precipitation excess draining from the rootzone, this model only predicts soil solution chemistry at the bottom of the rootzone. Important acidification indicators such as the Al concentration and Al/Ca ratio, however, increase with depth due to Al mobilization, transpiration and Ca uptake. Since most fine roots, responsible for nutrient uptake, occur in the upper soil layer (0-30 cm soil depth), it is important to obtain reliable estimates for this layer by including water uptake with depth and nutrient cycling (foliar uptake, foliar exudation, litterfall, mineralization and nutrient uptake) within the rootzone. However, inclusion of these processes in the model requires additional data on nutrient cycling. These data are readily available for The Netherlands but not for Europe. Consequently, RESAM, developed for application in The Netherlands, includes such processes whereas SMART, developed for application on a European scale, does not.

Process descriptions

NUCSAM, RESAM and SMART are all based on the principle of ionic charge balance and on a simplified solute transport description. In all models, it is assumed that: (i) a soil layer is a homogeneous compartment of constant density and (ii) the element input mixes completely in a soil layer. Furthermore, N-fixation, SO_4 reduction and SO_4 precipitation are not included and the various process descriptions for biological and geochemical interactions are simplified to minimize input data. Going from NUCSAM to SMART the degree of process aggregation increases by (i) a simpler hydrologial description, (in RESAM and SMART the annual water flux percolating through a soil layer is constant and equals the infiltration minus the transpiration, whereas NUCSAM contains a separate hydrological model), (ii) ignoring several processes (e.g. nutrient cycling), (iii) simpler descriptions of processes (e.g. equilibrium equations instead of rate limited reactions) and (iv) ignoring elements (e.g. organic anions, RCOO) or lumping elements (e.g. sum of base cations, BC, instead of Ca, Mg, K and Na separately). This is summarized in Table 2.

Biological processes are all described by rate-limited reactions. In most cases first-order reactions are used. Notable exceptions are the canopy interactions in NUCSAM and RESAM that are described by linear relationships with atmospheric deposition (cf Table 2). In SMART, all geochemical reactions are described by equilibrium equations, except for silicate weathering which is described by a zero-order reaction (Table 2). In NUCSAM and RESAM, the geochemical reactions are either described by equilibrium equations (dissociation of CO_2, cation exchange and SO_4 adsorption) or first-order reactions (protonation of organic anions and weathering of carbonates, silicates and secondary Al compounds). So, unlike SMART, NUCSAM and RESAM account for the effect of mineral depletion on the weathering rate.

Table 2. Processes and process formulations included in NUCSAM, RESAM and SMART

Processes	NUCSAM	RESAM	SMART
Hydrological processes:			
Water flow	Hydrological submodel	Variable flow with depth	Precipitation excess
Biological processes:			
Foliar uptake	Proportional to total deposition	Proportional to total deposition	-
Foliar exudation	Proportional to H and NH_4 deposition	Proportional to H and NH_4 deposition	-
Litterfall	First-order reaction	First-order reaction	-
Root decay	First-order reaction	First-order reaction	-
Mineralization/ immobilization	First-order reaction[1]	First-order reaction	Proportional to net N input
Growth uptake	- Constant growth - Logistic growth	- Constant growth - Logistic growth	Constant growth
Maintenance uptake	Forcing function[2]	Forcing function[2]	-
Nitrification	First-order reaction [1]	First-order reaction	Proportional to net NH_4 input
Denitrification	First-order reaction[1]	First-order reaction	Proportional to net NO_3 input
Geochemical processes:			
CO_2 dissociation	Equilibrium equation	Equilibrium equation	Equilibrium equation
RCOO protonation	First-order reaction	First-order reaction	-
Carbonate weathering	First-order reaction	First-order reaction	Equilibrium equation
Silicate weathering	First-order reaction[3]	First-order reaction[3]	Zero-order reaction
Al hydroxide weathering	- First-order reaction - Elovich equation	- First-order reaction - Elovich equation	Equilibrium equation
Cation exchange	Gaines Thomas equations[4]	Gaines Thomas equations[4]	Gaines Thomas equations[4]
Sulphate adsorption	Langmuir equation	Langmuir equation	Langmuir equation
Phosphate adsorption	Langmuir equation	-	-
Complexation reactions	Equilibrium equations	-	-

[1] In NUCSAM, these processes are also described as a funtion of temperature

[2] In RESAM and NUCSAM the maintenance uptake equals the sum of litterfall, root decay and foliar exudation minus foliar uptake.

[3] In RESAM and NUCSAM there is also the option to include a dependence of pH on the weathering rate.

[4] In SMART cation exchange is limited to H, Al and the sum of base cation (BC) whereas in RESAM and NUCSAM it includes H, Al, NH_4, Ca, Mg, K and Na

Validation and application of the models at various scales

Studies on a local scale

Methodology
The model NUCSAM was specifically developed for application and validation on a site scale. The major idea was to compare model predictions of the validated NUCSAM model with those of RESAM, to have confidence in the long-term predictions with the latter model in various scenario studies. Uncertainty caused by neglecting the seasonal variability in long-term predictions was therefore investigated by a comparison of long-term simulations (1990-2090) with NUCSAM and RESAM, using data from an intensively monitored spruce site at Solling, Germany (Kros et al., 1995a). NUCSAM and RESAM were also validated on that site by comparing simulated concentrations and leaching fluxes with measured values during the period 1973-1989. The SMART model was also validated on the Solling site, even though SMART (and RESAM) was not developed for application at such a scale. The major aim was to study the influence of model simplifications, especially with respect to process formulation and the reduction of temporal and spatial resolution, on the simulation of soil solution concentrations. A direct comparison of simulated data of SMART and RESAM with measured data was not possible, since both models simulate flux-weighted annual average concentrations, that can not be measured. Consequently, we compared monthly measured concentrations (which were assumed to equal the monthly average concentrations) with simulated values, that were derived by linear interpolation between annual values. In NUCSAM, monthly values were calculated by averaging the simulated daily concentrations.

To give more objective information concerning the performance of the models two statistical measures were calculated: the Normalized Mean Absolute Error (NMAE) and the Coefficient of Residual Mass (CRM) (Table 3). NMAE quantifies the average deviation between model predictions and measurements. CRM gives an indication of the tendency of the model to underestimate (positive value) or overestimate (negative value) the measured data. NMAE and CRM for the three models were calculated using monthly concentrations for model results and measurements.

We used two atmospheric deposition scenarios for the period 1990-2090, i.e.: (i) *business as usual* (BU): deposition at the Solling site in 1990 was kept unchanged for the period 1990-2090 and (ii) *improved environment* (IE): a linear 75% reduction was performed on the 1990 deposition values of SO_x, NO_x, and NH_x between 1990 and 2000, and after that the deposition values remained constant. For all other constituents the values of 1990 were kept constant, except for H, which is calculated from the charge balance. The total deposition fluxes for 1990 were 1470 $mol_c\ ha^{-1}\ yr^{-1}$ for NH_4, 1410 $mol_c\ ha^{-1}\ yr^{-1}$ for NO_3 and 3640 $mol_c\ ha^{-1}\ yr^{-1}$ for SO_4.

Table 3. Statistical measures for evaluation of model results

Measure	Symbol	Formulation	Optimum
Normalized Mean Absolute Error	NMAE	$\frac{\sum_{i=1}^{n} (P_i - O_i)}{N \cdot \bar{O}}$	0
Coefficient of Residual Mass	CRM	$\frac{\sum_{i=1}^{N} O_i - \sum_{i=1}^{N} P_i}{\sum_{i=1}^{N} O_i}$	0

P_i is the modelled value, O_i is the observed value, $\bar{O}$ is the mean of the observed values and N the number of observations

Model validation

Simulated and measured concentrations in the topsoil (10 cm) and subsoil (90 cm) for SO_4, NO_3 and Al are shown in Figure 1. All models were able to reasonably simulate the measured concentrations during the historical period. Differences between the multi-layer models, NUCSAM and RESAM, were rather small. Somewhat larger differences did occur between the concentrations simulated by SMART and those simulated by the multi-layer models.

The influence of vertical resolution is most clearly shown by the SO_4 concentrations. SO_4 concentrations are mainly governed by deposition and adsorption, which is described in all models in practically the same way. The trends in SO_4 concentrations, as simulated by NUCSAM and RESAM, were generally in good agreement with measured data. SMART, however, slightly overestimated SO_4 concentrations at 90 cm depth during the period 1972-1978 in which a strong rise in SO_4 concentrations took place at this depth (Fig. 1). This overestimation is caused by a larger dispersion of the SO_4 front in a one-layer system compared to a multi-layer system. For all models, the performance for SO_4 in the topsoil was comparable. NMAE values were somewhat higher for NUCSAM compared to the other models (Table 4), since the simulated variation within the year was larger than the measured variation.

The influence of the chosen temporal resolution on model performance can be seen most clearly for the simulated concentrations of NO_3 in the topsoil, which are strongly influenced by seasonal processes, such as nutrient cycling and mineralization. NO_3 concentrations in the topsoil simulated with NUCSAM were in close agreement with the measurements, whereas RESAM could not accurately simulate the seasonal peaks in NO_3 concentrations. SMART overestimated NO_3 concentrations (Fig. 1) in the subsoil (negative CRM) during the entire period, whereas concentrations in the topsoil were underestimated (positive CRM), due to the neglect of mineralization in the topsoil (cf Table 4).

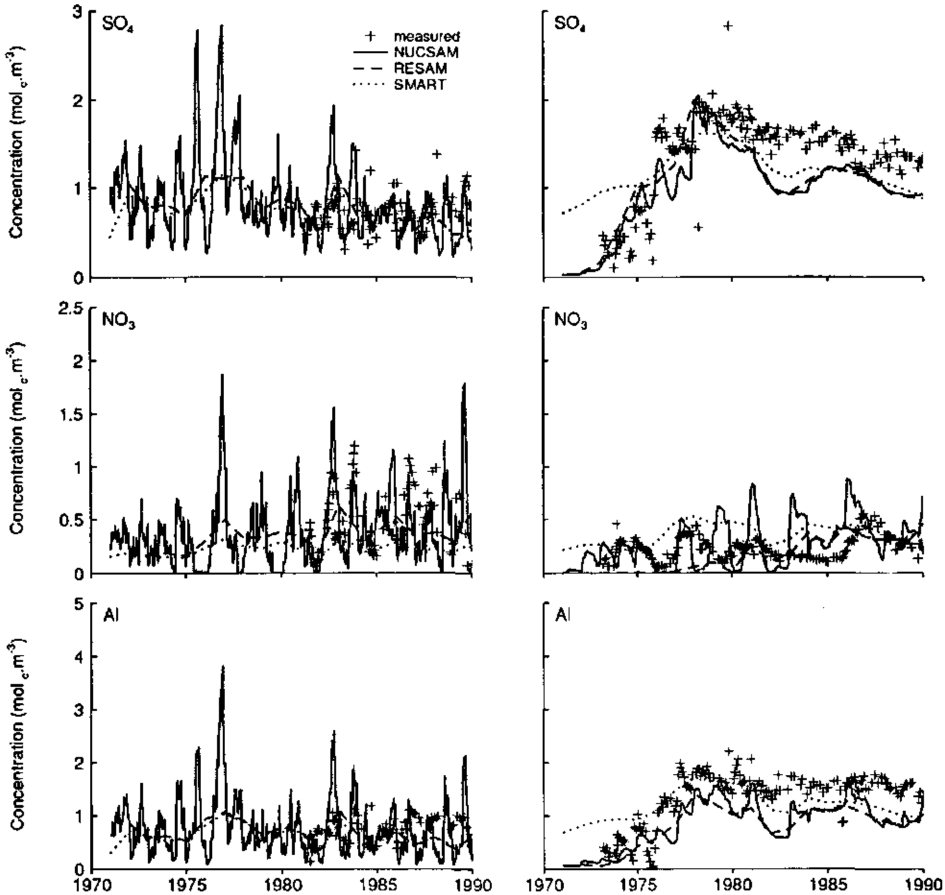

Fig. 1. Observed and simulated concentrations with NUCSAM, RESAM and SMART of SO_4, NO_3 and Al at Speuld at 10 cm depth (left) and 90 cm depth (right).

Results for the simulation of Al (main cation) were comparable with those for the main anion SO_4. (cf Table 4). The way in which Al concentrations were calculated (cf Table 2) appeared to have hardly any influence on the results for the chosen period. When applying the models for long-term predictions, however, deviations between the concentrations predicted by NUCSAM/RESAM and SMART may occur, particularly in the topsoil (cf Van der Salm et al 1994).

Table 4. Normalized Mean Absolute Error (NMAE) and Coefficient of Residual MASS (CRM) for simulated SO_4, NO_4 and Al concentrations with NUCSAM, RESAM, and SMART at Speuld

Component	Depth	NMAE			CRM		
		SMART	RESAM	NUCSAM	SMART	RESAM	NUCSAM
SO_4	10	0.23	0.25	0.37	0.10	0.05	-0.01
	90	0.26	0.24	0.25	0.06	0.12	0.18
NO_3	10	0.56	0.50	0.62	0.48	0.10	-0.04
	90	0.84	0.63	0.67	-0.79	0.36	-0.25
Al	10	0.32	0.33	0.52	0.20	0.13	0.02
	90	0.24	0.37	0.33	0.01	0.34	0.30

Model predictions

Flux-weighted annual average solute concentrations simulated by NUCSAM and RESAM for the Improved Environment (IE) scenario are given in Figure 2. The agreement between observed flux-weighted annual average concentrations and those simulated by RESAM and NUCSAM was generally good for all presented constituents (Fig. 2; see also Fig. 1). The most remarkable difference between the two model results was that the NUCSAM outputs were fickle, while the RESAM outputs were strongly consistent. This is, of course, inherent to the character of the models; daily time step versus annual averages.

Comparison of the long-term results of the models shows that trends in solute concentrations were very similar. This was also the case for the Business as Usual (BU) scenario (not shown). For most model outputs the NUCSAM result was oscillating around the RESAM result. The Al/Ca ratio in the subsoil predicted by RESAM, however, was lower than that predicted by NUCSAM from 2000 onwards. The maximum deviation occurred during the period of deposition reductions, between 2000 and 2010. This deviation was mainly caused by a quicker response of the adsorption complex in the RESAM model to a change in deposition, resulting in a shorter time-delay. However, during the periods with constant deposition, when a new steady-state between deposition and the adsorption complex was reached, the correspondence in Al/Ca ratios improved (cf Kros et al., 1994a).

Regarding the effect of time variability, this study showed that time resolution has only a rather small effect on the uncertainty in long-term (> 100 year) soil acidification. On a smaller time scale (10-50 years), during strong changes in deposition, the effect is more significant, especially when the Al/Ca ratio is considered. However, when seasonal or episodic values of concentrations or ratios are of importance, it is essential to use a short (daily) time step.

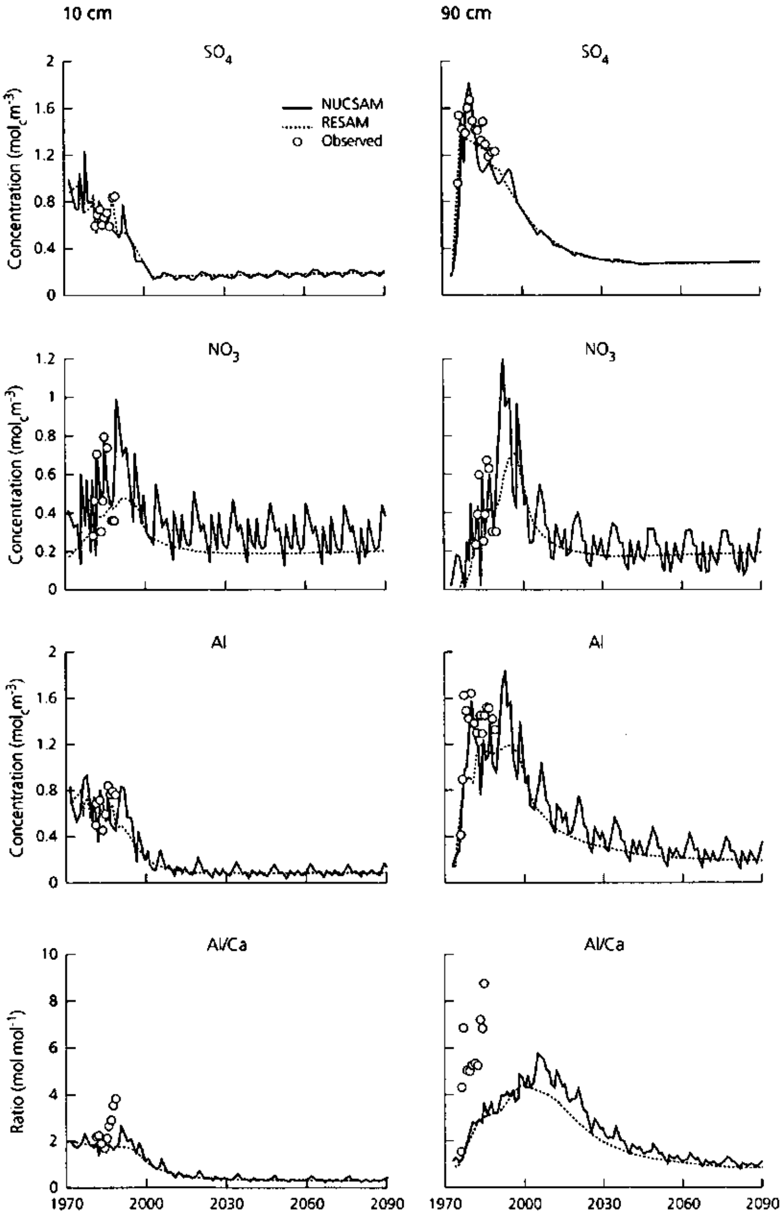

Fig. 2. Flux-weighted annual average concentrations simulated with NUCSAM *and with* RESAM *of* SO_4*,* NO_3*, Al and Al/Ca ratio at Speuld at 10 cm depth (left) and 90 cm depth (right), for the period 1970-2090 under the Improved Environment scenario. The observed flux-weighted annual average concentrations between 1970 and 1990 are also given.*

Studies on a national scale

Methodology

The long-term impact of atmospheric deposition on Dutch forest soils was evaluated with the RESAM model. Three emission-deposition scenarios for SO_x, NO_x and NH_x for the period 1960-2050 were generated based on: (i) historical emission data (1960-1990), (ii) expected emissions in the near future (1990-2000) and (iii) deposition targets (2000-2050) since no emission policy has been developed for the period after 2000. For this period three scenarios were used (the scenarios were identical up to 2000) based on deposition targets that were formulated for the years 2010 and 2050 (Table 5).

Table 5. Average values used for the potential acid deposition in 2010 and 2050 for three scenarios. Official deposition targets are underlined.

Receptor	Potential acid deposition (mol_c ha^{-1} yr^{-1})[1]					
	scenario 1		*scenario 2*		*scenario 3*	
	2010	2050	2010	2050	2010	2050
The Netherlands	<u>2240</u>[2]	<u>2240</u>	<u>1400</u>[3]	1230	1230	<u>700</u>[4]
Forest in The Netherlands[5]	2550	2550	1600	<u>1400</u>	<u>1400</u>	800

[1] Potential acid deposition in The Netherlands is defined as the sum of SO_x, NO_x and NH_x deposition minus seasalt corrected bulk deposition of base cations

[2] The official target was 2400 mol_c ha^{-1} yr^{-1} (cf De Vries, 1993) but on the basis of the measures described in NEPP+ a somewhat lower value was calculated.

[3] A critical acid load related to root damage caused by Al toxity (cf De Vries, 1993).

[4] A critical acid load that prevents nearly all possible negative effects including groundwater pollution (cf De Vries, 1993).

[5] Increased deposition on forests, due to filtering of gaseous air pollutants, was accounted for by multyplying the average dry deposition by empirically derived correction factors, (Erisman, 1991).

Twenty deposition areas with relatively uniform deposition values were identified. In order to limit both data acquisition and computation time, the calculations within each area were restricted to seven tree species and 14 representative profiles of acid sandy soils of major importance, which comprised nearly 65% of the total Dutch forest area. The various data, such as (i) water fluxes in soil layers, (ii) weathering, growth and turnover rates, (iii) element contents in tree compartments, litter, primary minerals, hydroxides and on the adsorption complex and (iv) rate and equilibrium constants for modelled soil processes, i.e. nitrification, denitrification, protonation, base cation weathering, Al dissolution and cation exchange, were derived from literature surveys, field research, laboratory experiments and model calibration (cf De Vries et al., 1994a).

To gain insight into the reliability of the predictions of the model RESAM on a national scale, a comparison was made between the results of 550 model simulations on the soil solid phase and soil solution chemistry in 1990 with measurements in 150 forest stands during the period March to May in the same year. The tree species and soil types included in the field survey were similar to those included in the simulations. However, one should be aware of the following differences: (i) The distribution of tree species differed between the field survey and the simulation runs, (ii) RESAM predicted water flux-weighted annual average concentrations, whereas the field data were single measurements in early spring and (iii) RESAM predictions for the topsoil were an average of two soil layers with a total depth varying between 20 and 30 cm, whereas the topsoil in the field data set referred to a layer of 0 to 30 cm. For the subsoil, RESAM predictions related to the bottom of the rooting zone, varying between 50 and 80 cm, whereas the field data referred to a layer of 60-100 cm.

Model validation

A comparison of median values of important soil solution parameters is given in Table 6. The pH, Al concentration, molar Al/Ca ratio and molar NH_4/K ratio in the topsoil (top 20 to 30 cm) are important indicators of forest stress, whereas pH, Al and NO_3 concentration in the subsoil are important indicators of potential groundwater pollution. The SO_4 concentration has been added to acquire an insight into the relative contributions of S and N in soil acidification.

Table 6. Median values of soil solution parameters measured in the field and simulated by RESAM.

Parameter	Unit	Topsoil		Subsoil	
		measured	simulated	measured	simulated
pH	(-)	3.6	3.7	3.9	3.8
Al	(mol_c m^{-3})	0.7	0.5	0.6	1.2
Al/Ca	(-)	1.3	1.7	-	-
NH_4/K	(-)	1.7	2.8	-	-
NO_3	(mol_c m^{-3})	-	-	0.5	0.7
SO_4	(mol_c m^{-3})	-	-	1.1	1.2

The agreement between model results and field data was good (difference < 10%) for the pH and the SO_4 concentration, reasonable (difference between 10-30%) for the Al/Ca ratio, the NO_3 concentration and the Al concentration in the topsoil and poor (difference > 30%) for the NH_4/K ratio and the Al concentration in the subsoil. Comparison between model results and field data for the tracers Na and Cl in both topsoil and subsoil showed that the model results are always (slightly) lower, especially in the topsoil (De Vries et al., 1994a). This partly explains the underestimation of Al concentrations in the topsoil. The overestimation of Al in the subsoil can partly be explained by an overestimation of the NO_3 and SO_4 concentration, which influences Al mobilization. The remaining difference is most probably due to the long-term effect of liming (Ca) and fertilization (mainly K) and/or a higher base cation input from the atmosphere, which will cause an increase in base cation concentration and a decrease in Al concentration. This also explains the overestimation of the molar Al/Ca ratio and molar NH_4/K ratio by RESAM. More detailed information on the regional validation of RESAM is given in De Vries et al. (1994a).

Model predictions

As an example of model predictions, trends in the forested area exceeding critical values for the Al concentration and Al/Ca ratio in the topsoil are given in Figure 3. Between 1990 and 2000 there is no difference in trends for the three scenarios because the deposition values are similar. In this period the estimated average deposition in The Netherlands drops from approximately 4700 to 2500 mol_c ha^{-1} yr^{-1}. In response to this deposition reduction there is a considerable decrease in the Al concentration and Al/Ca ratio in the topsoil. The area exceeding a critical Al concentration and Al/Ca ratio of 0.2 mol_c m^{-3} and 1.0 mol mol^{-1}, respectively, is approximately 75% and 60% in 1990, whereas the percentage of forest soils exceeding both values is approximately 40% in the year 2000. A deposition reduction according to scenario 2 was enough to avoid exceedances in Al concentration or Al/Ca ratio in forest topsoils in the year 2050. The average deposition level at this time is close to 1400 mol_c ha^{-1} yr^{-1} which is the average critical load derived for the effects of aluminium on forests (De Vries, 1993). For scenario 1 the area exceeding a critical Al concentration and Al/Ca ratio remained approximately 30% and 10% respectively, in the year 2050 (Fig. 3).

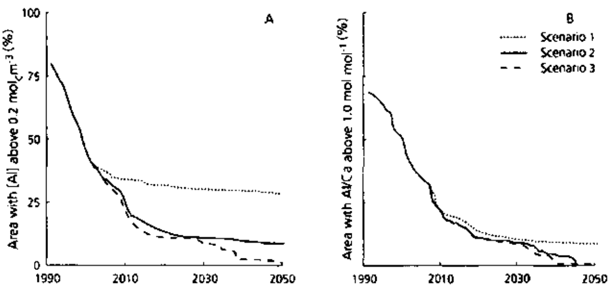

Fig. 3. The percentage of Dutch forest soils exceeding a critical Al concentration of 0.2 mol_c m^{-3} (A) and a critical molar Al/Ca ratio of 1.0 in the topsoil (B) in response to three scenarios.

The predicted response of "N related parameters", such as the molar NH_4/K ratio and NO_3 concentration, to a deposition reduction was small compared to the "Al related parameters". This was mainly due to N mobilization from litter, which in turn was caused by a decrease in the N content of leaves in response to decreased N deposition. This caused a time lag between the reduction in N deposition and the predicted concentrations of NH_4 and NO_3 (cf De Vries et al., 1994a).

Studies on a European scale

Methodology

The SMART model was used to evaluate the long-term impact of three emission - deposition scenarios on European forest soils, i.e: (i) the "Official Energy Pathways" scenario (OEP), based on governments' projections for future energy use, (ii) the "Current Reduction Plans" scenario (CRP) which takes into account likely reductions of emission due to proposed abatement measures, and (iii) the "Maximum Feasible Reductions" scenario (MFR), which assesses the impacts of a radical, but technologically feasible, decrease in emissions (mostly SO_2). The resulting total emissions for Europe in the period 1960-2050 for SO_2, NO_x and NH_3 are shown in Figure 4.

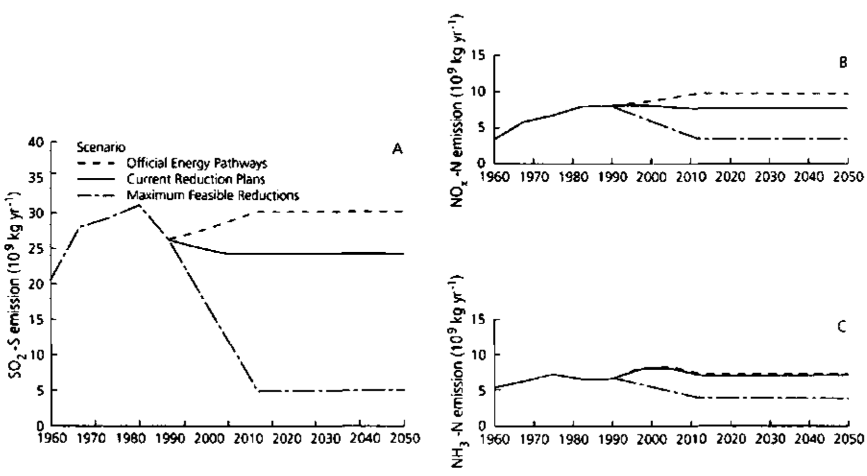

Fig. 4. Trends in total emissions of SO_2, NO_x, and NH_3 in Europe for three scenarios, i.e. Official Energy Pathways (OEP), Current Reduction Plans (CRP) and Maximum Feasible Reductions (MFR).

Deposition areas were defined by a grid net of 1.0° longitude versus 0.5° latitude. Within each gridcell calculations were made for all major combinations of tree species and soil types. A distinction was made between coniferous and deciduous trees to account for differences in dry deposition, transpiration and growth uptake. The spatial variability of the soil was taken into account by distinguishing 80 different soil types according to the FAO-UNESCO Soil Map of the World (FAO, 1981) on the basis of the dominant soil unit, texture class and slope class (De Vries *et al*., 1994c). Input data for SMART include system inputs and soil data. System inputs (and outputs), i.e. deposition, precipitation, evapotranspiration and growth uptake, were derived as a function of location (gridcell) and of forest type. Soil data were derived as a function of soil type irrespective of the location. Most soil data were related to readily available soil (and land) characteristics, using so-called transfer functions. Examples are the derivation of physical and chemical soil properties, such as the bulk density (ρ), volumetric moisture content (θ) and cation exchange capacity (CEC) from the (clay) and organic carbon content, (cf Table 7). Detailed information on the transfer functions used is given in De Vries et al. (1994c).

Model predictions

As an example of model predictions, impacts of the different scenarios on the Al concentration and Al/BC ratio are illustrated in Figure 5. Predictions of the forested area exceeding a critical Al concentration (0.2 $mol_c\ m^{-3}$) after 1985 showed a steady increase for the OEP scenario, a small reduction between 1985 and 2000 followed by a slight increase for the CRP scenario and a marked decrease, especially between 1985 and 2000, for the MFR scenario (Fig. 5A). The response of the Al/BC ratio was similar except for the CRP scenario. Unlike Al, the area exceeding a critical Al/BC ratio (1.0 mol mol^{-1}) increased after 1985 for this scenario (Fig. 5B). Apparently, the decrease in BC

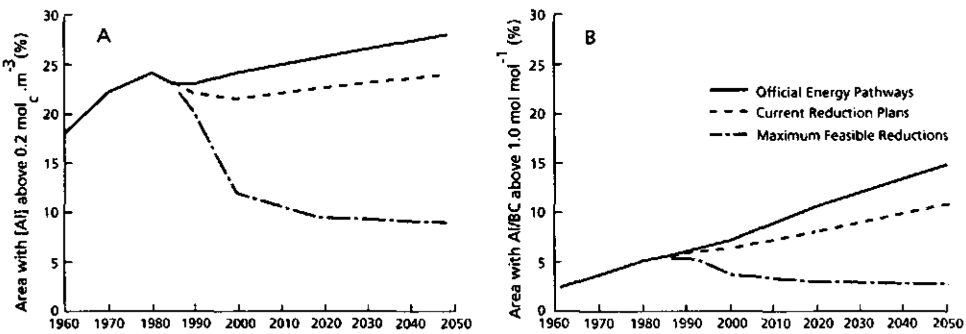

Fig. 5. Temporal development of the forested area in Europe (%) with Al concentrations above 0.2 mol$_c$ m^{-3} (A) and molar Al/BC ratios above 1.0 (B) in response to three scenarios.

concentration, induced by a decrease in base saturation change in response to ongoing acid deposition, compensated the decrease in Al concentration. The concentrations in 2050 were not yet at steady-state with respect to the deposition level at that time. Even when using the OEP scenario, with higher total S and N emissions in 2050 compared to 1985 (cf Fig. 4), the predicted areas with an Al concentration and Al/BC ratio exceeding critical values in 2050 were 'only' about 28% and 14%, respectively. Calculations with a steady-state version of the model SMART showed that these areas would increase up to 43% and 30% respectively at constant 1985 atmospheric deposition (De Vries et al., 1994b).

As with RESAM, the predicted response of "N related parameters", i.e. the C/N ratio and the NO_3 concentration, was different from the "Al related parameters". The predicted forested area with a C/N ratio or a NO_3 concentration above presumed critical values increased continuously after 1985, even for the maximum feasible reductions (MFR) scenario. The problem of N accumulation thus appeared to be more persistent on a European scale, than that of soil acidification (cf De Vries et alb, 1994c).

Table 7. Transfer functions between soil properties and soil characteristics (after De Vries et al., 1994d)[1)]

Soil property	Transfer function	Condition
ρ[2)] (kg m^{-3})	1000 / (0.625 + 0.05 · carbon + 0.0015 · clay)	carbon ≤ 5%
	725 - 337 · log carbon	carbon ≥ 15%
θ[3)] (m^3 m^{-3})	0.04 + 0.0077 · clay	clay ≤ 30%
	0.27	clay ≥ 30%
CEC[4)] (mmol$_c$ kg^{-1})	5 · clay + 27.25 · carbon	

[1)] Clay stands for clay content in % and carbon for organic carbon content in %
[2)] For 5% < carbon < 15%, ρ is interpolated linearly
[3)] Refers to the situation at field capacity
[4)] Refers to a value measured at pH 6.5

Discussion and conclusions

Evaluation of model predictions

Important aspects of model evaluation are validation of model results on measured data and assessment of the uncertainty in model results due to uncertainties in model structure and model inputs. According to Janssen et al. (1990), model validation can be divided into: (i) a conceptual validation (are the various model assumptions and concepts justified?), (ii) an operational validation (is the model suitable for the purpose aimed at, and does it produce plausible results?) and (iii) a model output validation (is there a good agreement between model predictions and measured data?). Even though SMART and RESAM were validated by comparing simulations with historical observations of changes in soil solution chemistry between 1974 and 1989 in a continuously monitored spruce site in Solling, Germany, the time period of the data set was too short for a rigorous validation of the model outputs. Consequenly, the question about the accuracy of the long-term soil responses estimated by the SMART and RESAM model cannot be answered satisfactorily. However, the reasonable-to-good agreement between measured and simulated (i) changes in soil solution chemistry on a site scale and (ii) frequency distributions of ion concentrations on a regional scale imply that SMART and RESAM produce plausible results.

Even though model predictions are plausible, the uncertainty can be large due to the uncertainty and spatial variability in input data, especially for large scale predictions. This can be derived from a study in which the uncertainty in the response of the model RESAM to a given deposition scenario has been evaluated in relation to the uncertainty (including spatial variability) of data (Kros et al., 1993). The main aim was to find out which additional data would most improve the reliability of predictions, to guide data derivation for a regional application of RESAM. The uncertainty analysis was performed by using Monte Carlo simulation techniques in combination with regression analysis. The uncertainty in model outputs was quantified by giving frequency distributions of input data instead of deterministic values. The resulting frequency distributions of the model outputs were analysed by regression analyses to evaluate the contribution of the uncertainty of various parameters to the model uncertainty. This uncertainty analysis has been restricted to a Leptic podzol with Douglas fir, subject to a reducing deposition scenario between 1987 and 2010.

Overall results showed that the uncertainty contribution of the various parameters depended upon the considered output variable, soil compartment and time. However, in most cases the uncertainty in the deposition of SO_2, NO_x and NH_3 and parameters determining the nitrogen and aluminium dynamics played the most important role (Kros et al., 1993). A simple sensitivity analysis performed earlier (De Vries and Kros, 1989) also showed that changes in the Al chemistry in the topsoil are strongly influenced by the parameters regulating nitrification and Al dissolution, because these processes mainly regulate H production and consumption, respectively. The relative unimportance of CEC and base saturation, is due to the low values (and the small range) for the base saturation of Dutch forest soils. On a European scale, these variables are likely to be more important. An important outcome of the study was, however, that average input data, used in a regional application in order to limit the number of simulations, produce adequate average model outputs for a specific soil vegetation combination.

Limitations of the models

The major possibilities and limitations of the three models are summarized in Table 8. The model limitations are related to their aim. NUCSAM was developed to reproduce soil (solution) chemistry on a site scale during a limited time period, whereas RESAM and SMART were developed to predict long-term impacts of acid deposition on the soil on a regional scale. Consequently, unlike NUCSAM, peaks in soil solution chemistry cannot be reproduced by RESAM and SMART. The annual time step of these models also hampers their validation, since long-term soil chemistry data are generally lacking. Unlike RESAM and SMART, however, NUCSAM can not (hardly) be used to evaluate acidification policies on a regional scale because of the immense data needs. Large-scale application of RESAM is already a huge task in this respect (cf. Table 8). Another drawback of NUCSAM is the complexity of the model, which makes it difficult for other modellers to use NUCSAM. In this respect, SMART is by far the easiest model to apply (cf. Table 8). A final aspect, regarding model limitations, is the possibility to use the models in other scenario studies. Examples are studies on the effects of changes in hydrology (e.g lowering of groundwater tables) and in land use (e.g reforestation of former agricultural lands) on the soil (solution) chemistry. Since NUCSAM contains a separate hydrological submodel, changes in hydrology can easily be included. Changes in land use, affecting the nutrient cycle, can also be included relatively easily in NUCSAM and in RESAM but not in the original SMART model, which excludes nutrient cyling. In principle, all models can, however, be revised so that other scenario studies are possible. For example, nutrient cycling has recently been included in SMART, together with the possibility of including seepage flow, to enable the calculation of nitrogen availability and pH in all major vegetation/soil combinations in The Netherlands (Kros et al ., 1995b). Another possibility is the coupling of these soil acidification models with models on heavy metal behaviour, including pH dependent adsorption processes. The effort that is required to adapt the models for use in other scenario studies will, however, differ as indicated in Table 8.

Table 8. Possibilities and limitations of the models NUCSAM, RESAM and SMART

Model	Possibilities for			
	Site scale validation	large scale application	use by other modellers	use in other scenario studies
NUCSAM	Good	Limited	Limited	Reasonable
RESAM	Limited	Reasonable	Reasonable	Limited
SMART	Limited	Good	Good	Limited

Use of the models to predict chemical time bombs

Chemical time bombs have been defined as a 'chain of events resulting in the delayed and sudden occurrence of harmful effects caused by the mobilization of chemicals stored in soils in response to alterations in certain environmental conditions' (after Stigliani et al., 1991). Such a situation may, for example, occur with respect to heavy metals after afforestation of former agricultural land. Due to the EC agricultural policy, arable land is currently being transformed into forest. Apart from atmospheric input, most arable soils received considerable additional metal loads originating from long-term agricultural management practices; e.g the application of animal manure and/or fertiliser. Consequently, total Cd, Zn and Cu contents of arable soils at the time of forestation are significantly higher compared to mature "natural" forest soils. Solution concentrations in arable soils are usually low due to liming, causing a near neutral soil pH, and low organic ligand contents. The conversion of arable land to forest, however, will lead to major changes in the chemical, physical and biological properties of the soil, which increase the mobility of the stored metals. Termination of liming results in a drop of the soil pH from the actual near neutral value (5.5-6.5) to an acid value (3.5-4.5). Furthermore, the maturation of the forest enhances the development of an organic layer which leads to higher concentrations of Dissolved Organic Carbon (DOC) and organic ligands in the soil solution.

A recent study by Römkens and de Vries (1995) showed that a relatively simple combined soil acidification-Cd mobility model gives comparable predictions of changes in pH and Cd concentrations such as those measured in afforested stands of different ages. However, in order to predict metal mobilisation more accurately, it will be necessary to further develop the integration of knowledge concerning soil acidification, organic matter dynamics and metal behaviour in the soil. Especially, the processes of acidification combined with the organic matter dynamics (development of an O_h layer, increase in DOC content, Al-organic matter interactions) need further attention in order to assess the future consequences of afforestation. With respect to land use changes in general, it can be concluded that there is still a lack of information concerning the dynamics of soil chemical processes within a time-frame of 10 to 100 years.

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5.4 Runoff, nitrogen loss and scale aspects on agricultural land in Southern Norway

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Abstract
JORDFORSK is carrying out a programme to collect information and obtain knowledge about the dynamics of nutrient runoff from agricultural land. The programme consists of measurements that are recorded at different scales. Included are measurements of water and nutrient transport in the plant-root system and measurement of nutrient runoff from catchments. On the basis of this measurement programme's results the total runoff and nutrient budget for the whole watershed is to be established.
Keywords: *runoff, nutrient loss, scaling of measurements, agricultural land*

Introduction

Runoff of nutrients from catchments often presents a serious threat to the quality of open water courses, lakes and coastal seas. Various measures have been initiated aiming to reduce nutrient runoff . An important incentive to this work, in Norway, has been "the North Sea Plan" where several western European countries agreed to reduce by 50% the runoff of nutrients from agricultural land by 1995. In Norway, two major programmes were initiated; one by the Ministry for Agriculture, called the "Environmental monitoring programme for agricultural land"; the second "Nitrogen from the mountains to the fjords", funded by the Norwegian Research Council.

Measurements carried out at different scales have given different results for nutrient runoff per unit area. JORDFORSK is carrying out investigations at the micro (25 m^2) and small catchment (10 - 700 ha) scale at various sites in Norway to get a better insight into this phenomenon.

Micro plots

Some results will now be presented from micro plots situated in Romerike, 100km N.E. of Oslo. Four 25 m^2 micro plots were established within small catchments. The soil type in these micro plots is a silt loam, with approximately 4% organic matter in the plough layer. The silt loam extends to a depth of approximately 90 -100 cm below soil surface. This is underlain with post glacial silty clay loam. Two of the plots were sown with wheat as a summer crop, whilst the other two were left fallow. A full description of the field experiment and plot characteristics is given by Deelstra, J. and Kolijn, J., (1994).

Nitrogen uptake by plants and the vertical transport of water and nitrogen in the unsaturated zone are studied during the growing season at the micro plot scale. Data collected

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on soil and plant parameters are used for calibration of models that are used to describe the transport of moisture and nitrogen within the soil/plant system.

Water flow in the soil and uptake by the plants can be described by the differential equation

$$\frac{\partial\theta}{\partial t} = - \frac{\partial q}{\partial z} + S \quad (3)$$

in which the water uptake by the plants is represented by the sink term (S). An important input in the model is the development of the root system over time and on the basis of a field experiment, carried out in 1992, it has been possible to measure the root development of the wheat crop through simultaneous measurements of the soil moisture suction at different depths under both crop and fallow conditions. The deduction of the root development over time is based on the principle of a decrease in the matric potential due to moisture uptake by plants when their root system reaches a certain depth. By plotting matric potentials for the cropped and fallow fields, water uptake by the plants (and therefore root development) can be visualised and estimated. This can be seen clearly from Figures 1 to 2 which represent matric potentials measured at respectively 20 and 40 cm below soil surface in cropped and fallow fields.

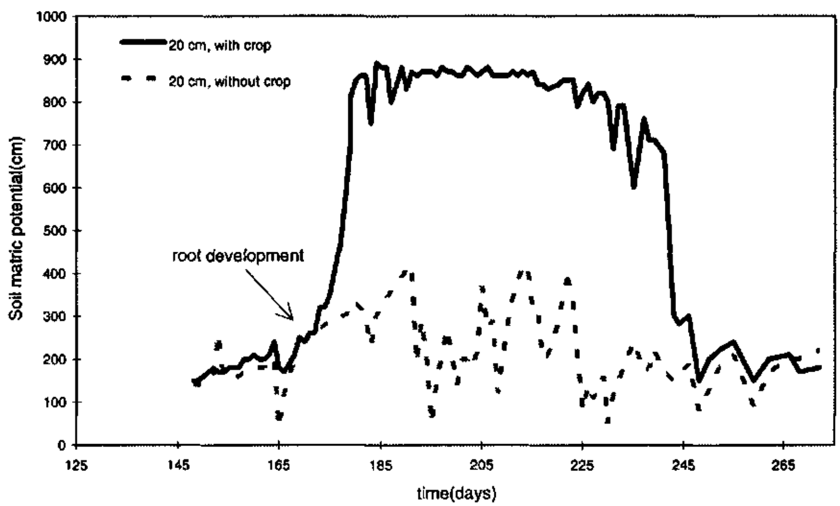

Fig. 1. Soil matric potential at 20 cm below soil surface

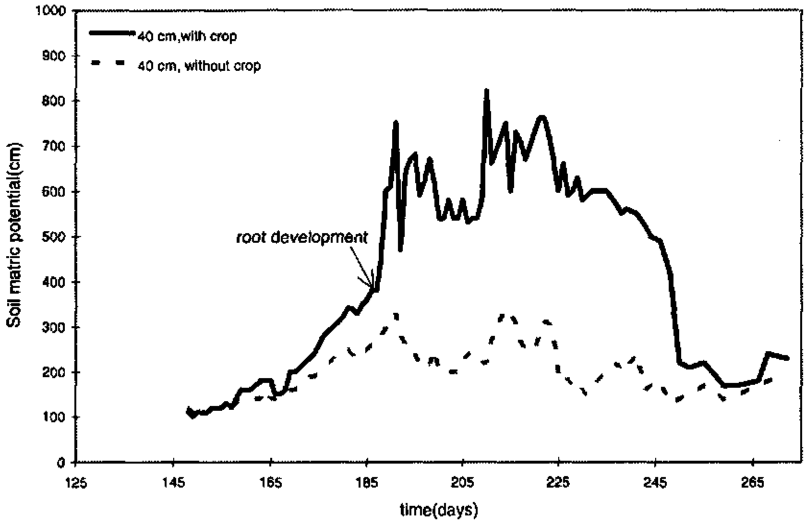

Fig. 2. Soil matric potential at 40 cm below soil surface

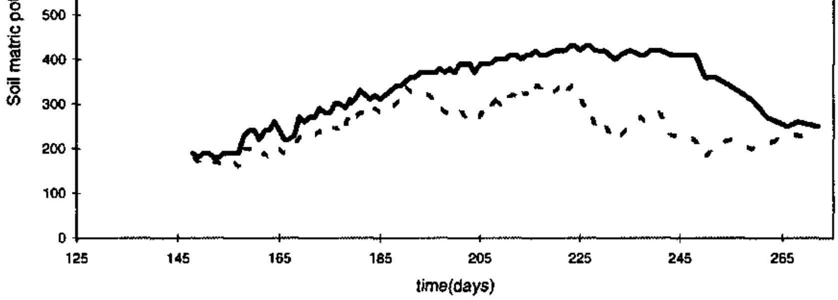

Fig. 3. Soil matric potential at 60 cm below soil surface

Readings at 60 cm below soil surface in Figure 3 do not show the same sharp decrease in matric potential, indicative that the root zone does not extend to this depth. One can notice a slight decrease in matric potential in the cropped field compared to the fallow field at this depth. This can be attributed to upward moisture transport into the root zone.

The precipitation during the growing season varied, with 29 mm in May and 19 mm in June, 62% and 31% respectively of the average precipitation. 70mm of precipitation fell in July (average) whilst 90mm was recorded in August, (18% over the expected average value).

The conditions during the 1992 growing season were "typical" of early summer drought. However, this did not lead to any negative effects on the crop yield for this particular soil type. On the contrary, yields recorded were above normal (pers. comm. Farmer).

The conclusion of the micro plot experiments was that, for the 1992 season, the root development of a wheat crop on the Romerike micro plots did not extend beyond a depth of 40 - 50 cm below soil surface. Normal "default" values for modelling the rooting depth of a wheat crop are usually estimated at 80 - 100 cm below soil surface.

Small catchments

Measurements as described above are carried out at the small catchment scale. Here, the total runoff is also measured. A number of different sized catchments with different land uses are monitored continuously. The catchments vary in size from 10 - 700 ha. The catchment topographies are undulating with slopes up to 15 - 20%. The predominant landuse is arable land with wheat, barley or oat as the main crops.
Runoff from the catchments is measured automatically, using a discharge measuring structure with known head-discharge relationship. Water sampling is datalogger controlled so that composite water samples are extracted. A detailed description of the measuring system is given by Deelstra, J. (1994). The water samples are collected every two to three weeks and analysed for nutrients and dissolved solids. Composite sampling was chosen because of it's greater accuracy in relation to point water sampling systems when calculating nutrient runoffs. Composite samples give an average concentration over the sampling period. Single samples on the other hand, represent an instantaneous concentration which can vary greatly over short periods, especially for small catchments with a large percentage of agricultural land. Large variations were measured in nitrogen runoff per unit area when comparing these two sampling techniques during a one-year period in five small catchments (Deelstra et. al., 1994). A summary of these results is presented in Table 1.

Table 1. Relative deviation in calculated nitrogen transport for the different sampling strategies relative to the composite sample results.

	1-week % deviation	2-weeks % deviation	4-weeks % deviation
Strategy 1	-39 < > -14	-51 < > +13	-73 < > +57
Strategy 2	-24 < > -1	-27 < > +20	-46 < > +52

Throughout the investigation, point samples were taken weekly. From this data, nitrogen transport was calculated based on sampling intervals of 1, 2 and 4 weeks.

In strategy 1, nitrogen loss is calculated based on the discharge and concentration recorded at the moment of sampling. Strategy 2 is equal to 1, except that calculations are based on continually recorded discharge data.
One can see that sampling techniques based on single samples lead to larger deviations compared to the composite sampling technique. It is also clear that an increase in sampling interval from 1 to 4 weeks has a very negative effect on the accuracy of calculated nitrogen transport.

Total watershed

Data on land use and farming practices are collected for the total watershed and compared to the land-use pattern and soil types in the small catchments. The objective is to establish the nitrogen balance for the whole watershed by scaling up the results obtained from the smaller measurement scales. Then, the effect of different land use and tillage measures on the total loss of nitrogen is to be simulated and the most effective measures to reduce nitrogen losses will be assessed. Much work is still to be done but results are expected by the end of 1995.

Conclusions

So far, the project has mainly dealt with the operation and maintenance of the monitoring stations, data collection and routine reporting. Some interesting results have, however, already been obtained. Micro plot results indicate that root system development of a wheat crop does not go more than 50 cm below the soil surface. This value is quite different from 80 - 100 cm below soil surface which is generally accepted as the rooting depth for wheat. Additional research is being carried out to confirm this, and results will be presented during 1995.

Different discharge measurements and sampling routines have also been shown to have a large effect on the calculated nitrogen transport out of the catchments. The conclusion was that a reliable figure for nitrogen loss should be based on a measuring system with continual recording of discharge together with composite water sampling.

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5.5 The soil and water management in the middle basin of the Biebrza River, Poland

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Abstract
The wetland of the Biebrza Valley is one of the largest peat soil deposits in Poland. The ecological conditions in the Biebrza Valley Middle Basin were disturbed by the construction of several canals. The water management project contains a few possible variants to improve the ecological conditions in the areas along the canals and to maintain the agricultural use in the other parts of the Basin. The evaluation of the planned activities has been carried out using several simulation models in combination with an optimization model of the river network.
Keywords: *wetland management, simulation model, optimization*

Introduction

The aim of the paper is to present an analysis of the hydrological system of the Biebrza River Valley with particular reference to the partly drained and transformed peatlands in part of the valley, the so called Biebrza Valley Middle Basin.

The wetland of the Biebrza Valley is one of the largest peat soil deposits in Poland and contains more than 110,000 ha of hydrophilous sites, most of them undisturbed. Referring to the morphological features, the Biebrza Valley can be divided into the following separate parts: the Upper Basin, Middle Basin and Lower Basin. A detailed description of the valley morphology has been done by Okruszko (1990). The hydrological conditions of the Middle Basin (40,000 ha of hydrogenic sites) were changed in 19th century by the construction of several canals. The plan of the canal network in the Middle Biebrza Basin is shown in Figure 1. Vegetation cover and peat soils underwent transformations along canals towards the formation of xerophilous sites. Structural changes of peat and mineralization of their organic matter occurred, causing mobilization of mineral nitrogen compounds.

The recovery of wetter conditions, which are close to those characterizing natural peatlands, can be created by different water management actions. Before any of them will be undertaken, the following questions should be answered:

- what is the goal in quantitative terms ?
- what is the impact of an action on the surrounding areas ?

In order to answer these questions studies within the area were conducted by several working groups i.e. hydrologists, ecologists, soils scientists and hydro-technicians (Okruszko H. et al., 1992). During their work, the methodological question arose how such a large and differentiated area could be modelled with the limited data availability? The applied materials and methods consist of three major items, namely: hydrological measures, different scale models, sets of criteria.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 195–200.

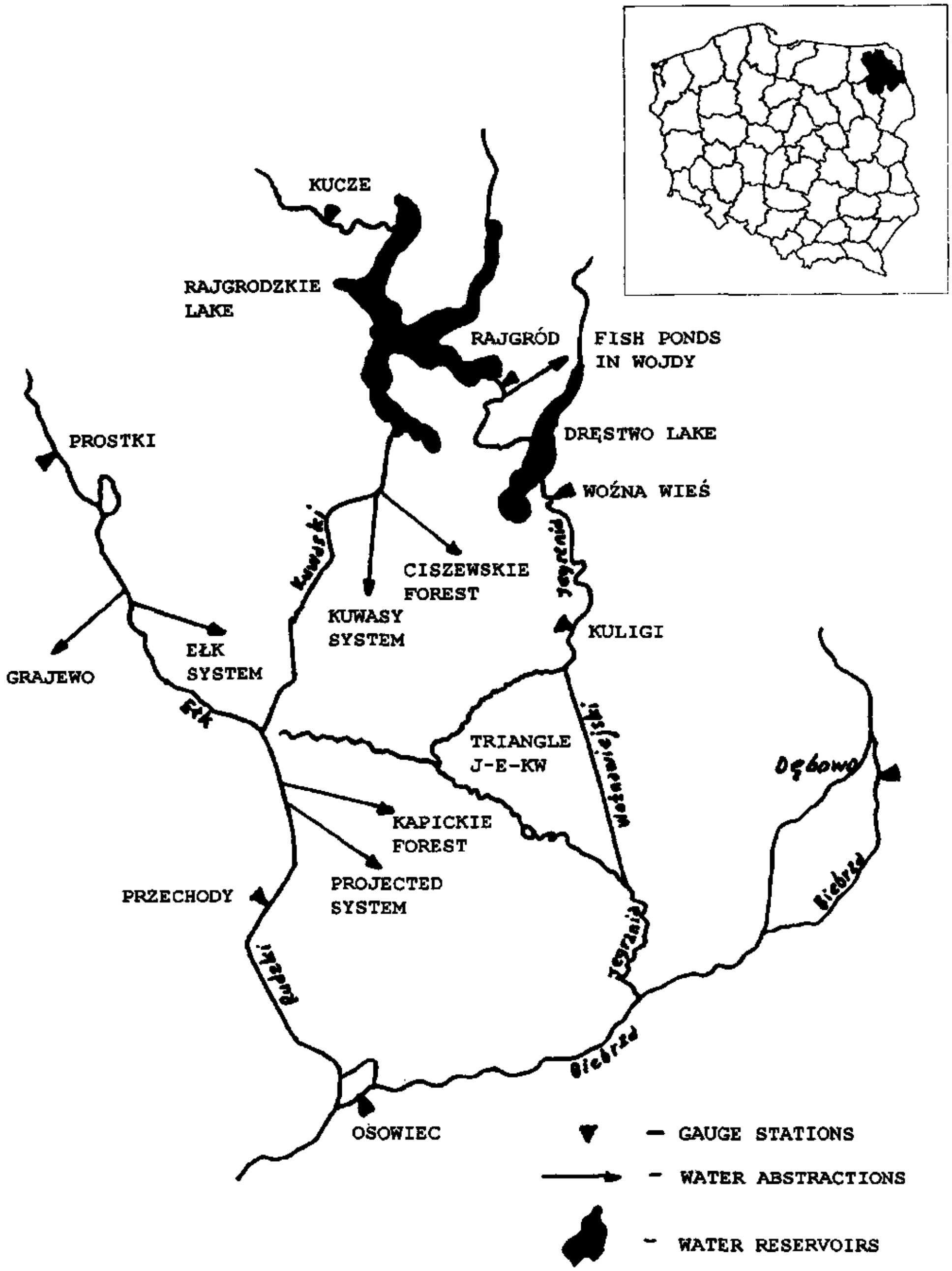

Fig. 1. The elements of the Middle Basin of Biebrza River

Materials and methods

Hydrological measures

In the area along the major drainage canals, several variants were examined and compared with the existing situation in order to restore the hydrological conditions. As the excessive drainage of the soils was caused by the so called Woznawiejski Canal, the first variant was to dam it and to increase the water level. The limited exchange of water between the canal and surrounding area might be an obstacle for the recovery of soil moisture conditions.

In the second variant, partial artificial floods were considered. They could be created using water from the water reservoir of 20 million cubic meters, located upstream on the Jegrznia river and by damming the Woznawiejski Canal.

As the water sources of the Jegrznia are limited, the use of an old bed of the Elk river with limited flow rates was considered as a next variant. It was accompanied by smaller floods and damming of the Woznawiejski Canal.

In the last, fourth variant, full restoration of the old Elk river was considered and damming of the Woznawiejski Canal. It leads to reduced flows in the Rudzki Canal, which should be dammed then as well.

A numerical model of the considered area should be constructed in order to assess the impact of measures.

Models

As a tool to solve the water management problems of wetlands restoration, a set of numerical models was constructed. The scale of the models was different, starting from the soil profile scale and ending on the basin scale (40,000 ha) optimization model. The following models were used:

SWACROP model (Wesseling et al. 1989) was applied to simulate the water regime in typical soil profiles. The soils with natural wetland plant communities and meadows with different levels of production were considered.

"River Triangle" model: for an area of 4000 ha, called "Triangle", a model was constructed to simulate the water cycle in the area bordered by the Woznawiejski Canal and the Jegrznia river. The models of groundwater movement, overland and subsurface flow and open channel flow were integrated. A model constructed in this way allows for an analysis of impacts of hydraulic structures on the flow of water in the Woznawiejski Canal and on the groundwater regime in the surrounding areas. This model was too complicated to be incorporated in the optimization model. A simplified version in the form of a regression model was constructed to be run on line during the optimization. The results of the optimization were again checked using the complex model of "River Triangle".

Drainage - irrigation scheme model: the model was constructed to simulate the effects of the existing drainage - irrigation systems, their water demands during the subsurface irrigation and water outflow during the rest of the vegetation season. The desired groundwater levels for typical soil profiles were obtained using the SWACROP model.

Based on SWACROP simulations it was possible to formulate a rather simple water balance model which was run on line during the optimization.

Optimization model: the model was constructed using the network programming. The structure of this model consists of arcs and nodes which represent the structure of the modelled river network and water users (Figure 2). In some nodes the simulation models, which can be run on line, were located. The optimization problem was solved using the "out-of-kilter" algorithm (Loucks et al., 1981). A system simulation was conducted for the variants consisting of a combination of measures to reach a goal, characterized by water control structures and different water demands. During the simulation, optimization runs of 25 years of historical data on water flows, precipitation and evapotranspiration were used.

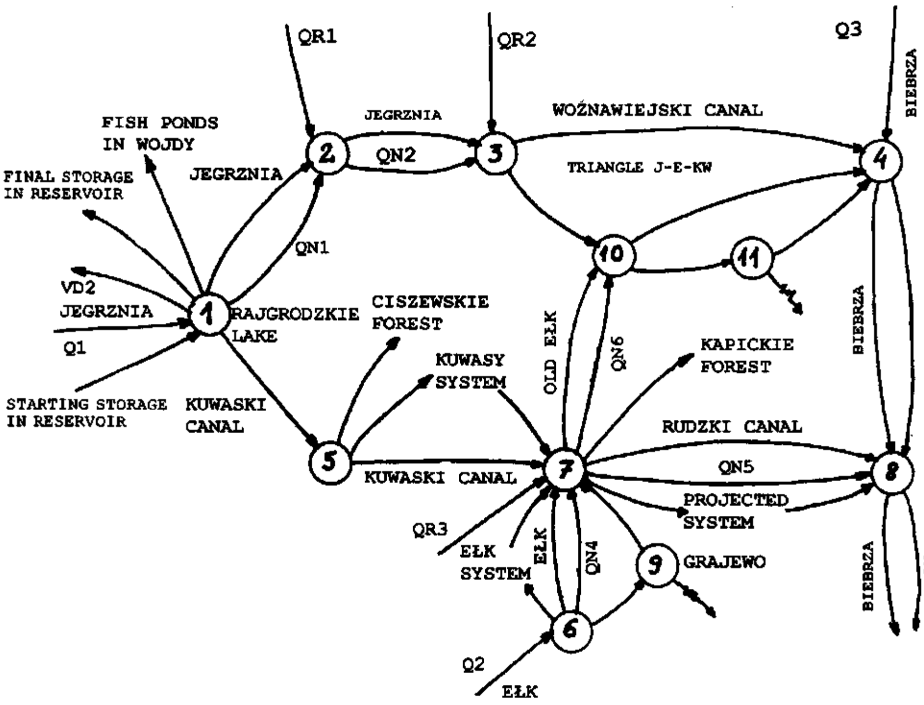

Fig. 2. The structure of the optimization model
QN stands for biological minimum flow; QR stands for increment of river flow

The optimization model was used for the selection of the best variant, which afterwards was checked with the "River Triangle" model and the SWACROP model. Of course, the choice of the best variant strongly depends on the criteria used.

Evaluation criteria

Four variants were analyzed using the models described above. The variants were compared using the optimization model and criteria for the most important system elements: rivers, drainage - irrigation systems, swamp forests, point users (city, carp ponds etc.). The performance of these elements was characterized by different criteria. The main types of criteria were:

- for the "Triangle" area, the guarantee of meeting demands for minimal flows in surrounding rivers and/or the guarantee of creating floods during 25 years;
- for the rivers, the guarantee of exceeding the biological minimum flow during 25 years;
- for drainage-irrigation systems, the guarantee of "proper" system performance during 25 years, the system fails if in a given year, in two successive ten day periods, soil moisture storage is below a specified minimum;
- for the swamp forest, the guarantee of meeting at least half the average precipitation deficit of the year;
- for the point users, the guarantee of meeting demands during 25 years.

The guarantee equal to one ("1") meant that in each of the 25 years the system element performed correctly e.g. demands were always met. The aforementioned five types of criteria used for different water users form in total 17 criteria, which were used for the variants evaluation. Variants which gained the greater number of "1" digits were classified as better ones.

Simulation - optimization analysis

After the validation of the models, the analysis was performed in three steps: simulation, optimization and again simulation.

During the first simulation phase the SWACROP model and the "River Triangle" model were used. As a result the optimum soil water regime at different locations and mandatory flows in particular river cross-sections were obtained. During this phase the simplified version of "River Triangle" - a regression model - was constructed. The data from selected years were used.

During the optimization phase the optimization model together with on line simulation models were used. The optimal (according to 17 criteria) variant was chosen as well as water reservoir releases and average ten day river flows in the whole river network. The 25 years' data records were used.

During the second, simulation phase again the "River Triangle" model and then the SWACROP model were used to check the best variant for water flows obtained from the optimization model and 25 years of historical meteorological data.

Results and conclusions

As a result of the analysis, it was found that the fourth variant (full restoration of the old Elk river and damming of the Woznawiejski Canal) is the optimal one. Because this variant is the most complicated (and expensive) one, the realization steps were also proposed. The second variant was proposed as an intermediate step between the existing situation and the final solution (fourth variant). Major conclusions from the study are:

1. The optimization model for water management proves to be a useful tool for designing the water policy in the investigated area.
2. The different scale simulation models are essential in such large areas; more accurate models are applicable for particular sites of interest or planned actions.
3. The most accurate model should be used for the analyses of soil water management for profiles chosen as being representative of the sites.
4. The analysis in three steps was useful in order to overcome difficulties in the combination of models of different scale and accuracy.

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CHAPTER 6

Operational decision support tools

6.1 The use of the SIWARE model package in water management scenario studies, Egypt

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Abstract

The SIWARE model package, which stands for SImulation of Water management in the Arab Republic of Egypt, has been developed as a decision support system for the Irrigation, Planning, and Research Sectors within the Ministry of Public Works and Water Resources.

Several scenarios have been simulated for the Nile Delta. In the Eastern Delta it appeared that reducing the allocation duties for the rice crop, rather than substituting the area with maize, is a better alternative to conserve water. Simulations for the Middle Delta showed that the total water supply could be safely reduced by some 10 to 15%, in combination with the introduction of spatial varied crop water duties. Finally, it has been indicated that for the Western Delta additional desert reclamation up to some 70,000 ha is economically viable with the present water resources and higher return flows of drainage water. A further extension, however, is not recommended without making more water available.

Keywords: *SIWARE, Water management, Water conservation, Re-use of drainage water*

Introduction

In arid and semi-arid regions, agricultural crop production is largely dependent on limited river based water resources. In Egypt more than 95% of the irrigation water supply is provided by the river Nile. Since the potential agricultural area appears to be abundant, only the available amounts of irrigation water determine the size of the irrigated area. Good water management practices are essential under these circumstances.

The Ministry of Public Works and Water Resources (MPWWR) of Egypt is the authority responsible for the distribution of the Nile water resources over the country. Allocated amounts should arrive timely and appropriately at the designated locations to meet farmers', domestic, and industrial demands.

Important issues currently at the attention of the MPWWR are (1) how to meet the increasing demand for water and food production due to a rapid population growth and (2) what measures should be taken for drought control?

One of the fundamental limitations in the planning of alternative irrigation water management policies lies in the uncertainty of changes in quantity and salinity of re-used drainage water for irrigation as a result of changes in water management and/or cropping patterns.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 203–208.

The proper procedure for predicting changes in such complex situations is to formulate all relevant physical and functional relationships and combine them in a simulation model. As a consequence the regional simulation model **SIWARE** (SImulation of Water management in the Arabic Republic of Egypt) has been developed within the framework of the 'Re-use of Drainage Water Project' (Abdel Gawad et al, 1991).

The **SIWARE** model package includes four physically based sub-models, each with a specific function in the regional water management simulation (Fig. 1). The four sub-models can be characterized as follows:

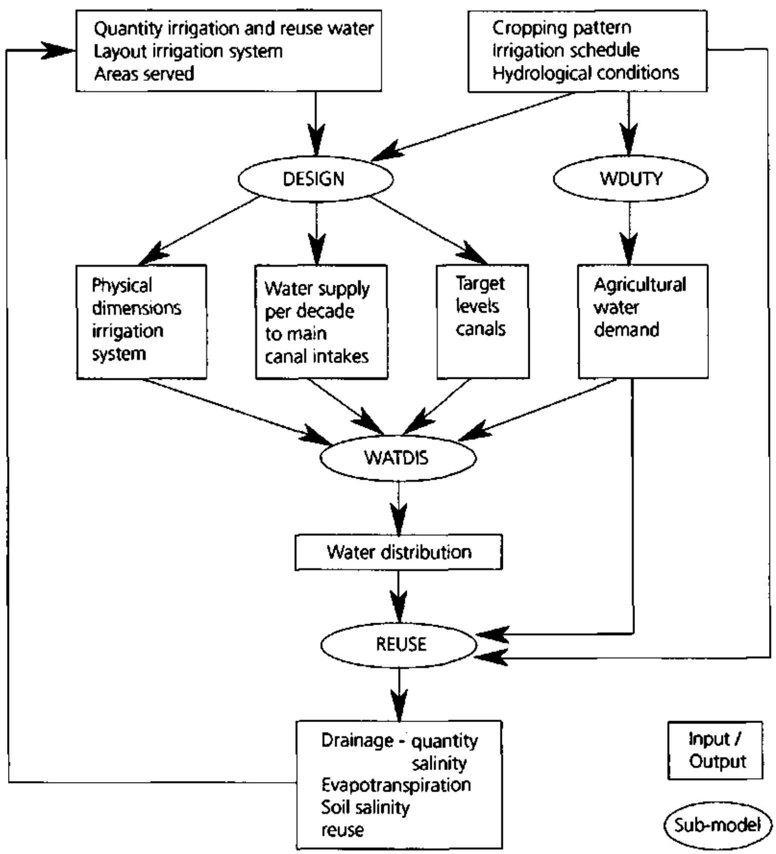

Fig. 1. Schematization of the SIWARE model, its sub-models, and in- and output

WDUTY:
A sub-model developed for the determination of the local crop water requirements (i.e. on the scale of a **SIWARE** calculation unit with an average area of around 6,500 ha). These requirements are also referred to as farmers' demand, and include such factors as local climate, hydrological conditions, initial soil moisture conditions, leaching requirements, irrigation practices, etc. The output is generated on a daily basis for 10 days.

DESIGN:
The **DESIGN** sub-model has mainly been implemented for synthesizing the irrigation canal and control structure dimensions based on the design values applied by the Ministry of Public Works and Water Resources (MPWWR). Although the lay-outs of the irrigation systems are available, canals and control structures dimensions are generally not complete and often subject to change as well. **DESIGN** furthermore provides the ability to compute the water allocation to the main command canal intakes (i.e. from the river Nile) and the target water levels at control structures.

WATDIS:
The WATDIS sub-model is designed for calculating the irrigation water distribution within the canal system. It effectively computes the amount of irrigation water lifted by the farmers from the lowest order irrigation canals (distributary canals), as well as the spillway losses and conveyance losses from the same canals. Moreover, **WATDIS** also provides the quantities spilled from the command canals at the tail-ends. Typical sink and source terms, such as municipal and industrial abstraction and drainage water recycling pump stations, are included in the calculations. The output is generated on a daily basis for 10 days, although the actual timestep may vary between 1 and 3 hours as to account for a sufficiently accurate representation of the farmers' behaviour with respect to irrigation practices.

RE-USE:
The **RE-USE** sub-model contains two levels. The first one is regional and keeps track of the following aspects:
1) organization of in- and output for the on-farm water management modules;
2) distribution of the irrigation water supplied to the calculation units among the different field crops;
3) simulation of crop succession after crop harvesting, i.e. at the onset of the next growing season;
4) simulation of the unofficial re-use of drainage water, i.e. local use by farmers;
5) simulation of the irrigation water salinity after mixing with drainage water by re-use pump stations;
6) simulation sequence of the calculation units in relation to changes in the salinity of the irrigation water due to official and/or unofficial re-use of drainage water;
7) calculation of time lags in the drainage canal system;
8) preparation of the presentation output.

The second level as covered by the **RE-USE** sub-model is the local one on calculation unit scale. The calculation unit is characterized as the basic agronomic element with constant parameter values. The relevant processes are simulated by the various on-farm water management modules simulating the following components in the water and salt balance cycle for each cropped field:
1) irrigation and field water losses (on-farm losses);
2) actual evapotranspiration;
3) leaching of salts from the crop root zone;

4) movements of salts in the soil;
5) leakage (percolation) to and seepage from the groundwater aquifer;
6) fast sub-surface drainage through soil cracks;
7) sub-surface drainage to open or underground drainage systems.

The DESIGN and WATDIS modules have been calibrated and validated using measurements from the MPWWR at some major control structures in the irrigation canal system for various years. The two other modules have subsequently been exposed to similar procedures using measurements in the major drains.

Potential of the SIWARE model package

RE-USE of drainage water and SIWARE

Re-use of drainage water occurs in Egypt on two different levels, namely: (1) through pump stations recycling water into the irrigation command canals (regional re-use) and (2) through stationary or movable pumps which directly deliver drainage water to the fields (local re-use).

Decisions for regional re-use are taken and implemented by the irrigation authorities. Once the stations are in operation, the expected quantities of drainage water are considered as irrigation water and consequently subtracted from the water allocation for the area.

A number of simulations carried out for the Western Nile Delta indicated that only when the total recycling of drainage water is substantially raised, the additional reclamation of some 70,000 ha of desert lands is economically viable with the present water budget for the area. The first stage of a planned expansion of the re-use (Umum project, phase I) is deemed sufficient with some 450 million m^3 additional water (50% more in total). A second phase, adding approximately 550 million m^3 of water, albeit with a higher salinity, would further contribute to the crop yields. On the other hand, simulations for a reclamation of 150,000 ha desert lands indicated such a measure as unprofitable, even for both re-use expansion phases, due to significant evapotranspiration losses in the old lands.

When farmers face water shortages from the irrigation canals, they will turn to the drains in the vicinity of their farm plots. Unlike the regional re-use, no data are available on the local re-use. Because only a limited number of farmers have access to the drainage canals and not all drainage water can be withdrawn, a fraction of the actual flow has been defined to be determined through model calibration. Contrary to the regional re-use of drainage water, the local re-use cannot be included in water management policies despite its profound impact on crop transpiration and soil salinity.

Cropping patterns and SIWARE

Generally, cropping patterns are not static over the years and may show significant changes. The acreage of cash crops, such as vegetables, may differ widely from year to year. Clover types (animal fodder) tend to increase gradually in Egypt, mostly because of wheat, which in turn is controlled by world market prices. The acreage of a major local crop like rice is strongly determined by water availability due to its high consumption. Egyptian Authorities, when faced with water shortages, as was the case in 1988, tend to reduce the area by defining rice belts in the Nile Delta with fixed maximum percentages.

The effects of various measures, be it under control of the Irrigation Authorities or as dictated by market prices, can be evaluated with the assistance of the SIWARE. A set of scenarios for the Eastern Delta showed that reducing the allocation duty for the rice crop, rather than substituting the area by maize, is a better measure to conserve water. Savings of some 8% were achieved in 1988 (with 1987 as a reference) using the alternatives of (a) substituting 30% of the total rice area by maize, or (b) cutting down the rice duty from 2,100 mm to 1,750 mm. The latter alternative clearly showed its superiority, both in crop yield and crop returns. Realized savings could either be used to counteract drought conditions or to supply new reclamation areas with irrigation water.

Reductions in the total water supply and SIWARE

Alleviation of drought conditions in the river Nile basin is nowadays secured by lake Nasser reservoir in the south of Egypt. However, despite the lake's enormous storage capacity, the water-level may drop below a critical value (closely approached during 1988), which in turn will force a shutdown of the electricity generators upon which the south of Egypt depends for its power supply. A further drop may even endanger irrigation water releases.

Simulations for the Middle Delta showed that the total water supply could be safely reduced by some 10 to 15%, that is in combination with the introduction of spatial varied crop water duties instead of the constant values used by the MPWWR for the Nile Delta. In the former case no production losses occurred whilst the preserved amounts could again be profitably used in the reclamation areas.

Conclusions

The SIWARE model package has proven to be a useful tool in decision support for the Egyptian Ministry of Public Works and Water Resources. Although simulating a complex agricultural system on a very large scale (Nile Delta), it provides useful and sufficiently accurate answers to support both short and long term planning.

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6.2 The integration of a physically based hydrological model within a decision support system to modelling the hydrological impacts of land use change

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Abstract

A powerful physically based hydrological modelling system, SHETRAN, has been integrated within a Decision Support System (DSS), to examine the effects of policy changes on rural land use. A shell program, SHESHELL has been developed to provide an interface between the DSS user and the modelling system. SHESHELL divides the river basin into sub-basins on which SHETRAN simulations are carried out. The results permit the user to identify areas where pollution problems, a water shortage, or excess water may occur. A trial application of the software has been completed for the River Tyne in North East England.

Keywords: *hydrological models, decision support system, physically based models, river basins, land use change*

Introduction

In catchment scale rural land use planning, a powerful modelling system is needed to investigate, in detail, the effects of the land use changes, generated by future economic policy changes on the water flows and water quality within a catchment.

The application of large scale physically based hydrological models to large river basins has historically been limited by both computer capabilities and the problems of storing large volumes of model input and output data.

Under the NERC/ESRC Land Use Programme (NELUP), being carried out at the University of Newcastle Upon Tyne, UK, a set of models has been developed to investigate the effects of rural land use change (O' Callaghan, 1992). Central to the research programme is the Decision Support System (DSS), which links a user interface, economics, ecological and hydrological models to a large database containing the catchment characteristics (Watson and Wadsworth, 1994). The economics model generates land use change information which is passed to the other two models to allow the impacts of the changes to be assessed by the user.

The hydrology model in the system is SHETRAN, which is a development of the SHE (Système Hydrologique Européen) modelling system, (Abbott et al., 1986 a,b). The original system has been substantially revised and extended to include a contaminant transport component (Ewen, 1990), and a sediment transport component (Purnama, 1990 a,b).

To link SHETRAN to the DSS, a "shell" program , SHESHELL, has been developed to allow hydrological modelling to be performed as part of the DSS. Following a decision by the user to run the hydrological model for a given problem, all SHESHELL operations, data management, simulation control and the processing of results, are handled automatically.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 209–214.

In order to test each operation in SHESHELL the Decision Support System has been applied to the Tyne catchment in North East England.

Methodology

SHESHELL has been developed to automatically perform four major tasks within the hydrology component of NELUP. The first is to link the SHETRAN modelling system to the DSS, effectively providing the interface to the user of the system. The second task is to create the data sets to run the specified SHETRAN simulations from the raw data held in the data base. The third task is to identify the sub-catchments to be simulated within the basin according to the physical locations of the land-use changes and then to link the sub-catchment simulations together. Finally, SHESHELL manages the results associated with each simulation and processes the large amounts of model output for use by the DSS user.

Figure 1 shows how SHESHELL integrates with the DSS and the databases.

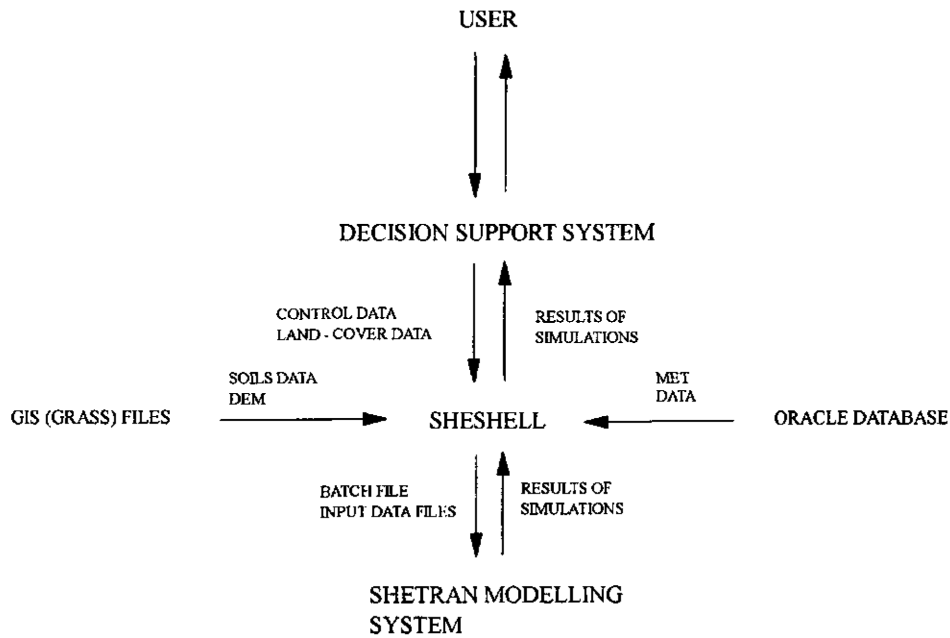

Fig. 1. Structure of SHESHELL

Data transformation

SHETRAN is a physically based hydrological modelling system which uses finite difference solutions to the equations of water flow. It is divided into several flow components, each requiring large quantities of physical parameters, which are stored in several data files.

To integrate SHETRAN within the DSS, input data files for each simulation are created from the raw data sets. These include, for example, algorithms to determine soil and geological parameters (Lunn et al., 1992) that are representative of the sub-catchment being modelled. Initially, the data transformation algorithms were developed as independent modules, and tested with SHETRAN. Simulations of the Rede sub-catchment were performed and analysed using the files created with the algorithms (Dunn et al., 1992). Each of the algorithms was subsequently incorporated into SHESHELL.

Linkages between sub - catchments

To perform hydrological simulations on a large river basin, the catchment is divided into a set of sub-catchments, and a model is prepared for each. The sub-catchment models are coupled together at their boundaries by surface and subsurface transfers of both water and contaminants. It is assumed that these transfers act one way only, so that the outflows from an upstream sub-catchment are unaffected by the hydrology of the downstream sub-catchment. The inputs to the downstream sub-catchment are provided by the outputs from the upstream sub - catchments, which allows simulations to be coupled together. The order of simulations proceeds from the sub-catchment furthest upstream, down the chain of subcatchments until the basin outlet is reached.

Processing land use changes

A set of hydrological simulations are first performed under the existing conditions in the catchment to obtain a set of results, against which the hydrological impacts of land use changes were compared, for the entire catchment. In practice, the hydrological impacts of most rural land use change scenarios will not affect the entire basin. SHESHELL is capable of distinguishing between sub-catchments affected either directly or indirectly by hydrologically significant changes in land use, and those sub-catchments that are unaffected. This eliminates the need to resimulate all the sub-catchments in the river basin, thereby reducing computational expense and data storage. Hydrologically significant changes are identified by the aggregation of twenty-five land cover types, represented in the data base by eight groups, e.g grassland. Each group possesses similar hydrological properties, e.g. canopy height and rooting depth. The physical parameters of each group are written to SHETRAN input files by SHESHELL, prior to each simulation.

In the present DSS, the user of the system can investigate the effects of the land use change on water quality by observing the concentrations of nitrates in the surface water and groundwater. To run these contaminant simulations, data from the DSS on the agricultural use of each area are required. These data include the areas of each crop type on each individual grid square in the catchment, and the dates and the amounts of the fertiliser applications. These data are supplied by the economics model and allow the nitrate applications and plant nitrogen uptake to be estimated. SHESHELL transforms the data and creates input files for each SHETRAN simulation.

Processing of SHETRAN model outputs

The user of the DSS can view the physical characteristics of the catchment in its existing state (the base conditions) and the results of the hydrological simulations performed under these conditions. The user can select either a default set of variables relating to the water balance or choose from a list of alternative SHETRAN water flow and quality variables. SHESHELL processes the set of requested variables, passes the information to SHETRAN, and after the simulation, processes the results for display on the DSS as time series or flow duration curves for output along the stream network in the catchment and as grid maps of the monthly or seasonal average values of the distributed variables.

Implementation of SHESHELL on the Tyne Catchment

Catchment characteristics

The catchment of the River Tyne, chosen for the development and testing of the NELUP software is located in the North East of England and covers some 3000 square kilometres. The modelled hydrological catchment chosen is smaller, since the tidal and urban reaches of the river are not modelled, and comprises the area upstream of Bywell gauging station, and the catchment of the River Derwent, (Figure 2). The two catchments have been divided into fourteen sub-catchments varying in size from 60 to 400 square kilometres.

Verification of SHESHELL

The downstream locations of each sub-catchment have been based on the sites of the flow gauging stations in the catchment. At most of these stations, historical records are available; these records have been used both to validate SHETRAN (Adams et. al., 1995), and to allow the verification of SHESHELL. The selected period for the simulations is January 1st 1985 to December 31st 1989. A full simulation over this period has been carried out, and SHESHELL has been successfully used both to link the results from each sub-catchment simulations together and to process the results for the DSS.
In the Tyne catchment model all fluxes between sub-catchments are transferred as channel flow. This assumes that each sub-catchment has a watertight subsurface boundary, with the groundwater divide coinciding with the surface water divide. In the Tyne catchment, where runoff is dominated by surface water flow, the simulation results and catchment simulated mass balances, in comparison with the historical data, have indicated that this assumption is valid.

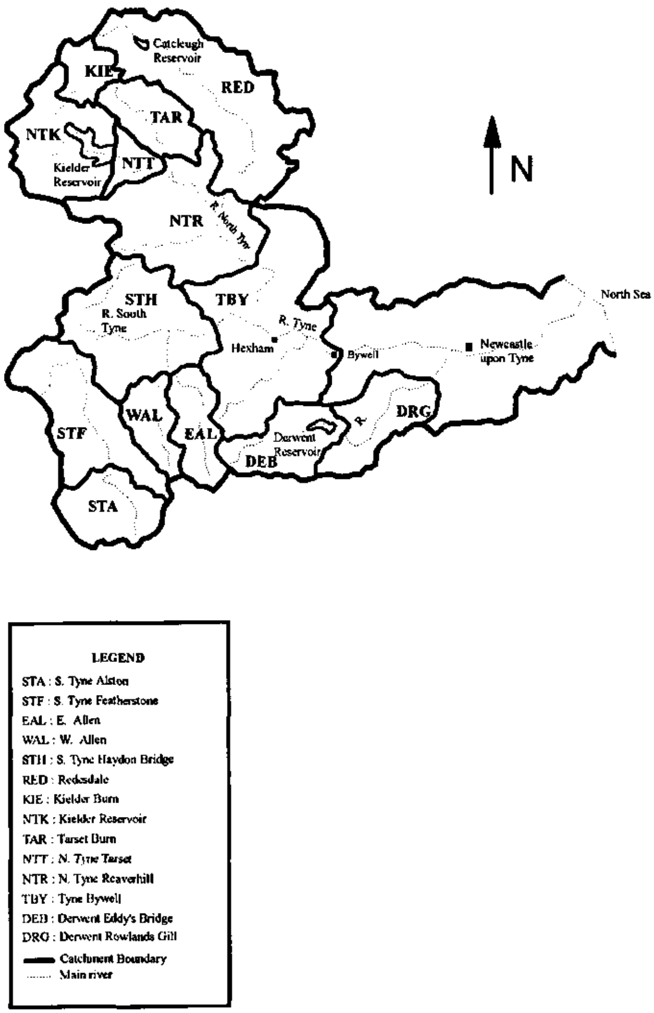

Fig. 2. The Tyne Basin and its Subcatchments.

Conclusions

The SHESHELL software has been developed to link a complex set of physically based catchment scale hydrological models with a Decision Support System (DSS). The methodology has been developed and tested on the Tyne catchment, and the system is fully operational. The user of the DSS can select a rural land use policy change and select a SHETRAN hydrological simulation to examine in detail the hydrological consequences of the policy change on water quality and quantity. SHESHELL will then process the details of the changes in vegetation, and run the SHETRAN simulations off line, processing the results for display to the user at a later date.

SHESHELL is a powerful software package for managing and linking SHETRAN simulations of several independent sub-catchments, created where the study catchment of interest is too large for a single model simulation. SHESHELL could be applied to the modelling of other large catchments where a physically based modelling study is required. Under a continuation of the Land Use Programme the system will shortly be applied to the River Cam catchment in South East England.

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6.3 A water management system for rural areas

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Abstract

A water management system has been developed, which aims at the development of sustainable agriculture and ecologically sound waters in rural areas. In those areas water resources are scarce and thus require protection and rational use. The Notec Regional Water Management System (NRWMS) is the pilot project in Poland. The system is divided into 12 subregions, in which research, implementation and promotion activities were conducted. The system principles of water management are under implementation in two large subregions: Old Notec subregion and Gasawka subregion. The latter one is presented in the paper as the example of implementation of regional water distribution and management methods. The water management system algorithm can be used to analyse alternatives for water management in the future.

Keywords: *water management, rural areas*

Introduction

For many years efforts have been made to define system activities aimed at a balanced development of farmland in regions where water is a resource available at a minimum level and thus requires protection and a rational use (Kemmers, 1986; Walsum and Drent, 1987; Lany *et al.*, 1993; Ayers and Patrick, 1993). Systematic studies and implementation work were carried out in the Upper Notec river catchment with an area of 4000 km^2 by the Institute for Land Reclamation and Grassland Farming. It was assumed that, to accomplish the objective of balanced rural areas development, a comprehensive and systemic approach is necessary for the regional water management.

In the course of the research and implementation activities, the Notec River Water Management System (NRWMS) was defined and developed (Kaca, 1993; Kaca and Labedzki, 1993). For organisational reasons a spatial division of the region was made into twelve subregions, being subcatchments. System principles of water management are under implementation in two large subregions.

The base for a rational management of water resources in the river catchment is provided by the water distribution manual for the subregion. The manual describes methods and a computer software package concerning operational flow planning, user/consumer water demand calculations and water distribution control. The implementation of the water distribution planning and management methods is illustrated by the example of the Gasawka river, a subcatchment with an area of 590 km^2.

The Gasawka subcatchment is also a supersystem for subirrigation systems and other water users and consumers. In order to ensure efficient management of water resources of the NRWMS, a three-level control hierarchy was established:

1. the top level for the coordination of water distribution between the water management subregions,
2. the subregional water distribution control level,
3. the user/consumer water management level (water management in a secondary subirrigated unit, fish ponds, etc.).

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The Gasawka subregion, as a subcatchment with no water inputs from other subregions, is an autonomous subregion and therefore a subregion where the coordination effect of the top level on water management is small and can be ignored. This observation has a significant impact on the adopted water planning and distribution algorithm in the subregion.

Description of water needs in the Gasawka subregion

The principal consumers and users of water in the Gasawka subregion are:
- fish ponds,
- a sugar plant,
- grasslands in two subirrigated objects,
- water biocenosis of the Gasawka river and its tributaries,
- angling, tourism and recreation.

Grasslands provided with technical facilities for the management of water (subirrigation systems), covering an area of 442 ha, are a major water consumer in the subregion. The water in the river also performs a biological function for fish habitats. An essential criterium for the biological function is the flow rate. A particularly inviolable flow is the sanitary flow directed from the Gasawka river to the town of Szubin.

The conducted analysis indicates a need for a rational and planned use of the water resources of the Gasawka river catchment and resources accumulated in water reservoirs. Failure to manage the water resources of the catchment may lead to considerable water deficits both in the biologically necessary flows and business water intakes. In a year characterised by a severe hydrological and atmospheric drought only full reservoirs (5.4 million m^3 of water) can provide water for the needs of all water users and consumers.

Technical subregional water distribution system

The water accumulation, transport, distribution and intake system in the subregion consists of two storage reservoirs, the Gasawka river with check structures, reservoir water intake and user water intake structures. The system is outlined in Fig.1.

The watertable in the check structures is maintained constant upstream which facilitates water intake from the user intake structures. Via reservoir intake structures water is carried to the Gasawka river. Subirrigation water intake structures are used to take water to feeders carrying water to secondary subirrigated units.

Most intake structures were calibrated and on this basis nomograms were prepared to determine water flow rate. Each reservoir intake and business water user intakes are provided with water level gauges upstream and downstream and a gate opening indicator. Water distribution in the subregion (second level control) is the responsibility of a specialised unit of the Provincial Board of Land Reclamation and Water Systems.

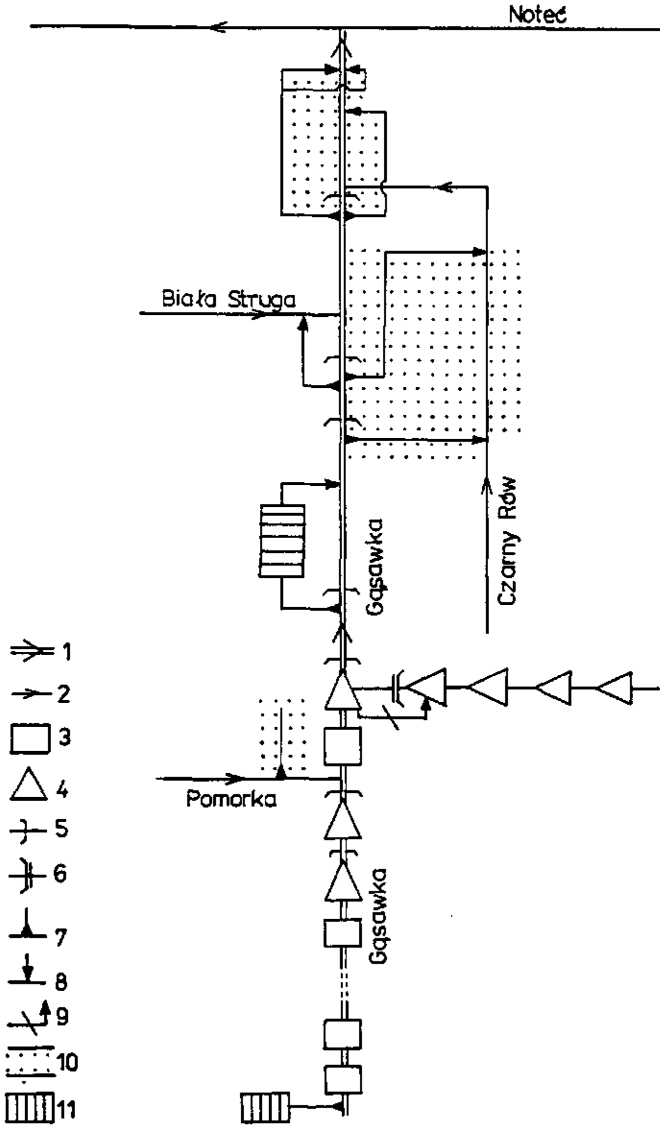

Fig. 1. The Gasawka Water Management Subsystem
1=Gasawka river, 2=stream, 3=lake, 4=reservoir, 5=weir, 6=dam with weir, 7=water intake, 8=water outlet, 9=pumping over water, 10=subirrigation system, 11=fish pond

Water distribution algorithm

According to the algorithm, operation planning of water flows and operation control settings for distribution structures in the subregion takes place periodically at 7-day intervals and with a 10-day planning horizon (decade planning).

The proper planning is preceded by gathering of information on the water flow and management conditions in the catchment for the previous 7 days. This information includes:
- water levels (volume) in the subregion's storage reservoirs,
- flow rates and other water stream characteristics for the reservoir intake structures, distribution structures and water user/consumer intake structures as well as for the typical balance sections of the river and water distribution channels,
- meteorological characteristics such as: daily precipitation and other data used to calculate evapotranspiration e.g. according to the Penman formula and crop coefficients,
- ground water and ditch water levels in subirrigation objects, applied as starting conditions to mathematical simulation models for subirrigation.

Next, using the gathered data and field reports, input and forecast data are prepared in the flow and control planning algorithm. These are:
- precipitation values expected in the planning decade, evapotranspiration of grasslands and specific runoff rates in the catchment,
- grassland area characteristics in units scheduled for subirrigation in the coming decade (area scheduled for irrigation, soil type and use type, required mean ground water levels, drainage standards and ditch water levels in the planning period),
- user/consumer flow requirement values outside the irrigated units scheduled for the coming decade,
- available river flow values for the subregion's reservoir intakes in the planned decade based on a regularly updated annual management strategy for reservoirs.

Characteristics of units scheduled for irrigation come from irrigation requirement reports submitted by water associations and from entities other than water associations. A water distributing entity evaluates correctness of information provided by checking e.g. ground water levels and ditch water levels by means of gauges installed in the water/drainage system.

The information gathered is used to calculate the upper measuring and control range of water flow for each intake structure and flow requirement for each subirrigated unit. The calculated results of flow requirement, expected values of runoff in the catchment and available flow values determined for reservoir intakes are used to prepare a water balance and thus also to determine the flow deficit for the unit intakes and for intakes of other water users. These values are calculated using a water supply priority plan.
A difficult problem that has not yet been solved is the assessment of economic, environmental and social losses within the system. Such estimates based on calculated water deficits in the system and reservoir water management prospects till the end of the season may provide a basis for a decision to change the volume of available water flow at reservoir intakes.

The water distribution algorithm, being used for a real time rational management of water resources in the catchment, can also be used for scenario studies and variant analysis. By performing simulations for various input data (e.g. long dry periods, a higher level of the minimum flow rate for a ecological function, the increased area of irrigated grasslands) different scenarios for water distribution can be generated.

Conclusions

Research and practical experience gained in the course of work in the Upper Notec River Management System show that:

- Pursuing objectives connected with water management can only be successful when personnel responsible for water management in a catchment and on the user and consumer premises are provided with adequate legal, organisational and technical solutions.
- Legal regulations should create favourable conditions for implementation of systemic principles of water management in river catchments, where water is the principal limitation to economic and ecologic development of the region.
- Fluvial valleys should be provided with efficient technical facilities for the accumulation, transport and distribution of water, while users and consumers of water should be provided with water- efficient management systems.
- Water management facilities should be in good repair and operated by organisations established for the purpose.
- Real time water distribution can be performed on the basis of the algorithm and organisation used in the Upper Notec region. The water management system algorithm can also be used to analyse alternatives for water management in the future.

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6.4 GIS-supported model for the assessment of the supra-regional nitrate pollution of groundwater in Germany

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Abstract

A comprehensive model describing the flow of nitrate in the soil and in the groundwater of Germany has been formed by a combination of submodels relating to nitrogen balance, ground-water recharge, groundwater flow and nitrate degradation. The entire model input data and model results are presented with the help of a geographical information system (GIS) in the form of coloured grid charts. This makes it possible to analyse the effect relationships responsible for the potential nitrate pollution of a certain area in Germany. The results of one submodel, illustrated in the grid chart 'Potential nitrate concentration in recharged groundwater', are discussed as an example.

Keywords: *nitrate pollution, GIS, model, groundwater, grid charts, systems analysis, soil*

Introduction

An essential basis for deriving political measures to solve the nitrate problem over a large area is a comprehensive comparative review of the potential nitrate pollution of the groundwater throughout the whole country. For this purpose it is neccessary to note the crucial factors influencing the hazard potential of an area. This includes

a) a regionally differentiated determination of potential nitrate output from the soil as a function of the agricultural and pedological site conditions
b) a regionally differentiated determination of residence times and degradation of nitrate in groundwater as a function of the hydrogeological conditions.

For the whole area of Germany such a study is being performed in a cooperative research project implemented on behalf of the Federal Ministry for Research and Technology (BMFT). This article focuses on presenting the basic GIS-supported model approach, and its field of application as a tool for the supraregional analysis of the nitrate problem.

Model structure and data bases

To achieve these tasks, a model describing the flow of nitrate within a reasonable spatial and temporal resolution had to be developed. Suitable subroutines for supraregional models have to fulfil two main requirements: (I) their input data must be available for the whole area in approximately the same quality and (II) the degree of accuracy of the model results must correspond to the generalized situation in the different natural regions. The latter has been validated by variability and sensitivity analysis (Kunkel, 1994). A detailled discussion of this investigation is out of the scope of this paper. Fig. 1 shows the flow chart of subroutines for the supraregional modelling of the nitrate pollution of groundwater in Germany.

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The input data for the model are based on mean values for each grid cell. This includes statistical information as well as hydrologic measurement series over a great many years, soil properties of importance for the environment and hydrogeological parameters. Kunkel (1994) was able to show that mean values of input data are sufficient to describe the mean of the model results at least in first approximation. The most important submodels used in the BMFT research project originate from:

- Liebscher & Keller (1979), U.S. Soil Conservation Service (1972), and water balance equation - Calculation of percolation water level.
- Bach (1987) - Calculation of N-Balances (Nitrogen Surpluses)
- Böttcher et al. (1989) - Calculation of denitrification rates in the aquifer
- Wendland (1992) - Calculation of residence times of groundwater in the aquifer.

The hydrological, pedological and hydrogeological model parameters needed to run the modules were digitalized from generalized thematic maps (scale 1:500 000 to 1:2 million). The area-differentiated nitrogen surpluses were calculated from agricultural statistics at the level of the local government unit.

The model is constructed in such a way that the results of one submodel provide important input data for the following submodel (see Fig. 1). For example the 'Potential nitrate concentration in recharged groundwater' was the result of the submodels "Hydrology" (percolation water level) and "N-Balance" (Nitrogen Surpluses). The 'Potential nitrate concentration in recharged groundwater' likewise represents important input data for the subroutine 'Denitrification in the aquifer'.

Information Value of Model Data Presented by GIS

The input data and model results for the large-area modelling of the nitrate flux in Germany are presented by grid charts. These grid charts divide the area of Germany into 39709 square grid cells, each grid representing a geographic unit area of 3 km x 3 km. The geographical reference of the grid charts is the Gauß-Krüger coordinate system relative to longitude 9° E and latitude 51° N. The most important reason suggesting the use of grid-based data for the model calculations is the fact that only because of the standardized geographic unit areas (9 km^2 grids) can spatial information be combined following mathematical formulas in a convenient way.

The input data of the model represent generalized geo-parameters and agricultural parameters. Therefore, the calculated potential nitrate concentrations in the ground-water based on these generalized parameters are not to be interpreted as actual nitrate concentrations for a certain point at a certain time. The model was not constructed for such local applications. On the contrary, the model permits a comparative analysis of the hazard potentials from nitrate for larger natural regions. In this way, for example, the chart 'Potential nitrate concentration in recharged groundwater' (Plate 3) shows the expected hazard potential from nitrate inputs into the groundwater for one region compared to the hazard potential throughout Germany.

All submodel parameters and results have been published as charts (31 in total) in an atlas (Wendland et al. 1993). This comprehensive illustration of the whole model in the "Nitrate Atlas" makes it possible to reconstruct the effect relationships which determine

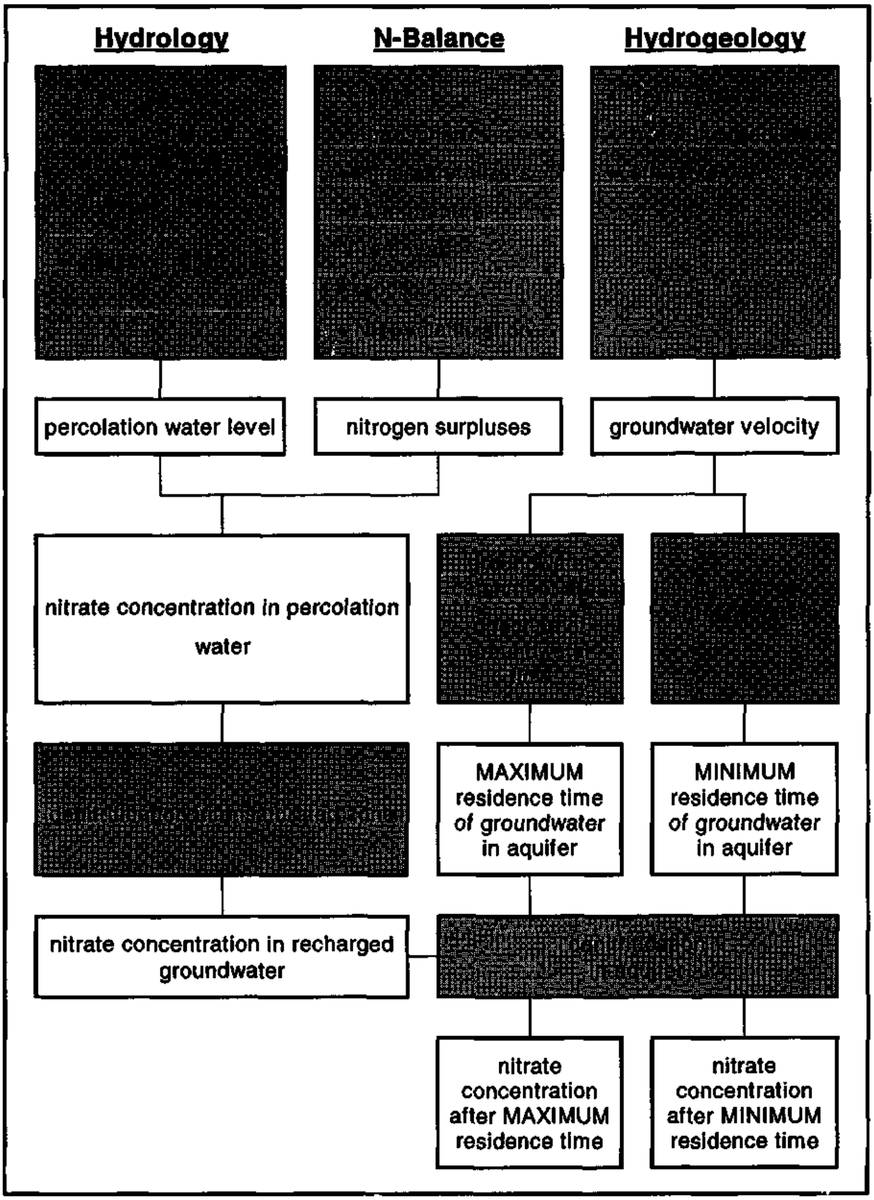

Fig. 1. Flow chart of modules. Shaded elements show the input parameters of the model. White elements indicate model results.

the potential nitrate pollution of an area. In the next section the chart 'Potential nitrate concentration in recharged groundwater' is discussed as an example of this kind of hazard potential analysis. This makes it necessary to refer to other GIS-presented charts published in the 'Nitrate Atlas' which cannot be shown in this article.

Example of the interpretation of a model result visualized by GIS

The chart 'Potential nitrate concentration in recharged groundwater' (see Plate 3) as the result of the identical submodel shows a considerable hazard potential (> 50 mg nitrate /l) almost area-wide in the eastern states of Germany. The reason for this, in addition to the nitrogen surpluses from agriculture (chart 27 in the 'Nitrate Atlas'), is above all the low percolation water level (chart 6 of the 'Nitrate Atlas') in these areas. In the western states of Germany the percolation water level is higher because of a higher precipitation level. For this reason the dilution of the nitrate in the soil water is higher, causing a lower potential nitrate concentration in the percolation water. Nevertheless, an important hazard potential in the western states can be expected in all regions with intensive farming, e.g. fertile plains where mineral fertilizers are used, (chart 24 of the 'Nitrate Atlas') and regions with intensive animal husbandry (chart 25 of the 'Nitrate Atlas').

If the chart showing the potential nitrate concentration in recharged groundwater is compared to the charts showing the soil properties of importance for the environment, such as soil type (chart 7 of the 'Nitrate Atlas'), soil quality (chart 8 of the 'Nitrate Atlas') or field capacity (chart 9 of the 'Nitrate Atlas') it becomes apparent that the distribution of the dominant soils coincides with the potential nitrate pollution load. Low potential nitrate concentrations in recharged groundwater are generally bound to less fertile soils of mountain areas in the highlands and in the Alps, where no intensive farming is possible. The less fertile sandy soils of the north German lowlands are an exception to this rule. In these areas of intensive indoor stock keeping the resulting huge quantities of farm manure are dumped on the sandy soils in the surrounding area. Because of their high risk of nitrate washout there is a severe hazard potential.

A comparison with chart 14 'Groundwater bearing formations' shows that the majority of groundwater occurrences of significance for the drinking water supply in Germany are found in regions of intensive agriculture and potentially high nitrate concentrations in recharged groundwater. The highest hazard potential exists for aquifers whose upper layers have only a low storage capacity for water and nitrate (chart 10 of the 'Nitrate Atlas'). Accordingly these aquifers are most endangered with respect to nitrate pollution.

Conclusion

The chart 'Potential nitrate concentration in recharged groundwater' illustrates the great responsibility borne by the agricultural use of soils for the nitrate pollution of groundwater. It can be concluded that effective political measures to solve the nitrate problem can only be drawn up if the type of agricultural production is adapted regionally to the natural site conditions of the region (water regime, soil, hydrogeology). There is still an urgent need for an integrated management concept, both regionally on the part of water utilities and water boards and supraregionally on the part of the legislature within the framework of EU policy. The GIS-supported model approach outlined above can be a useful tool to support these important efforts.

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6.5 Estimation of regional nitrogen leaching in the North-Eastern Germany area for different land use scenarios

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Abstract

Nitrogen losses by leaching were estimated for about 10,000 km^2 in North-eastern Germany using a simple simulation model. A classification was made for climate, soil, groundwater level, crops, yield and fertilizer level. Combination of these classes yielded 10,032 cases for simulation. The results were used to calculate nitrogen leaching for each community of the region in 1989, 1992 and a scenario based on the agricultural reforms of the EU. Compared to 1989, nitrogen pollution in 1992 is reduced by 26% due to a sharp decrease in animal production. After the agricultural reforms of the EU a considerable area falls out of production and nitrate pollution decreases further.

Keywords: *Nitrogen leaching, land use scenarios, simulation, macro scale*

Introduction

The new economic conditions following the reunification of Germany in 1990 led to drastic changes in the structure of agricultural production in the area of the former GDR. Furthermore the reform of agriculture in the European Union is supposed to induce further changes affecting the socio-economic as well as the ecological situation of the rural environment. Within a study (Bork et al., 1995) scenarios were developed to estimate the changes in land use under various economic boundary conditions for the North-eastern young moraine area. Also consequences of changing land use on some ecological parameters were studied.

In the present study a simple simulation model is used to estimate nitrate leaching in relation to different land uses for an area of about 10,000 km^2. Calculations were done to describe the situations in 1989 and 1992, before and after unification, and for scenarios describing the effects of the agricultural reforms within the European Union. Changes of land use for the latter case are the result of economical scenario calculations done by Kächele and Dabbert (1995).

Materials and methods

Simulation of nitrogen dynamics follows a relatively simple approach according to Kersebaum and Richter (1991). Results of simulation are further used by a second model "GEMBIL-N" to calculate area weighted means for nitrogen losses of the different land use distributions within the regarded communities. Nitrogen leaching is defined here as the amount of nitrogen translocated deeper than 130 cm which is assumed to be the limit of rooting depth. For lack of an appropriate approach to simulate forestry, we used, in this first attempt, static values for groundwater recharge and nitrogen leaching, based on literature and lysimeter studies under corresponding climate conditions.

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Data base

Nitrogen leaching is mainly determined by site specific factors like climate, soil and groundwater level as well as by the form and intensity of land use. Basic data were available at a municipal level containing percentages of soil texture classes, groundwater influenced soils and distribution of 10 different forms of cultivation. For each cover crop, potential yields were estimated from specific information on soil quality and climate within a community. The area under investigation is formed from 546 communities, but only 509 provided sufficient data for the calculation.
A data base of the former governmental farms, containing their specific level of mineral nitrogen fertilization, was used to estimate the nitrogen balance for each crop within a community for the situation in 1989. For 1992 and the scenarios, fertilizer levels were assumed based on the experience of the present situation in local practice. Additionally nitrogen input by manure was calculated from the number of different animals within an area. If data were not available at a municipal level they were derived by disaggregation of district information.
The whole area is divided into 4 weather regions. A fourteen-year time series from representative weather stations was used to generate daily mean weather for the simulation.

Simulation model

The model used here is a modified version of the model described by Kersebaum and Richter (1991). The model is divided into submodels for water balance, nitrogen mineralization, denitrification, nitrate transport and N uptake by plants. Details are given by Kersebaum and Richter (1991) and Kersebaum et al. (1995).
Data required by the model are: daily weather data, soil texture class, groundwater level, land use information, yield potential and nitrogen fertilization. Detailed information on dates of fertilization were not available on this scale. Therefore classes for the level of total N fertilization were distinguished for each crop underlayed with typical scenarios for the fertilizer distribution.
Corresponding to the municipal data base a distinction was made for 6 soil texture classes with typical organic matter contents (according to Körschens (1980). Two groundwater levels were defined (140 cm and 350 cm) and 10 crops were considered, each with 6 classes of yield and up to 7 classes of fertilization. Together with the four climate zones the free combination of all these cases gives 10,032 different model scenarios which were simulated over a period of 3-4 years. Results of each year are stored in a six-dimensional matrix for the further use of the model "GEMBIL-N".

Data transformation and calculation of area weighted means

Within a community the areas of the crops were distributed to the existing soil types based on their specific requirements. The total amount of nitrogen in manure is calculated from the animal production in the specified community. A hierarchy was defined to distribute the nitrogen in manure to the crops up to a plant specific limit. The fertilizer level was classified according to the sum of mineral fertilizer and the mineral equivalent of nitrogen in manure given to the specific crop.
The model GEMBIL-N identifies the existing combinations of soil and crop data and their area percentage and selects the corresponding results of the simulation model to calculate

an area weighted mean for the community. A special algorithm considers also the effects of the classified management on the nitrogen leaching of previous and later standard crops.

Scenarios

Based on the situation in 1989, which is well documented due to the centralism of the former socialist government, and on actual information from the official statistics and agricultural administration, the situation in 1992 after unification is evaluated. From this situation scenarios were calculated by an economical model (Kächele and Dabbert, 1995) to evaluate changes of land use due to the agricultural reform of the EU, assuming different economic flexibilities in agricultural production. The so-called scenario II, assuming low flexibility for the farmers should provide as an example. Within each scenario, alternatives were developed on how to use fields taken out of production for the future. Two main objectives were defined: a) fields should preferentially be used for afforestation or b) the fields should remain as open spaces which was assumed to have the same effect as longterm set-aside (pasture without cultivation and fertilization).

Results

The situation of 1989 is characterized by an intensive land use even on poor sites and high local concentrations of animal production. The map in Fig. 1 reflects the overlayed effect of climate, soil and intensity of land use. The nitrogen losses were calculated for agricultural land as well as forest and natural areas excluding settlement areas, gardens, roads and water plains. Nevertheless the plotted losses refer to the whole area of a community. Low values were estimated mainly in the lowlands of the river Oder with soils of high water holding capacity and a low annual precipitation of less than 480 mm and in regions where the present percentage of forest is very high (e.g. the biosphere reservation "Schorfheide-Chorin"). Higher nitrogen leaching was estimated in the northern part where the precipitation is higher (about 600 mm per year). Dark areas often indicate locations with a high concentration of animal production. The mean nitrogen surplus for the agricultural land is calculated to be 128 kg N/ha, the average nitrogen leaching for the total area is estimated as 33 kg N/ha.

After unification animal production declined drastically (over 50% less). The nitrogen surplus on agricultural land decreased to 69 kg N/ha and nitrogen leaching was estimated to be about 26% less (24 kg N/ha) than in 1989.

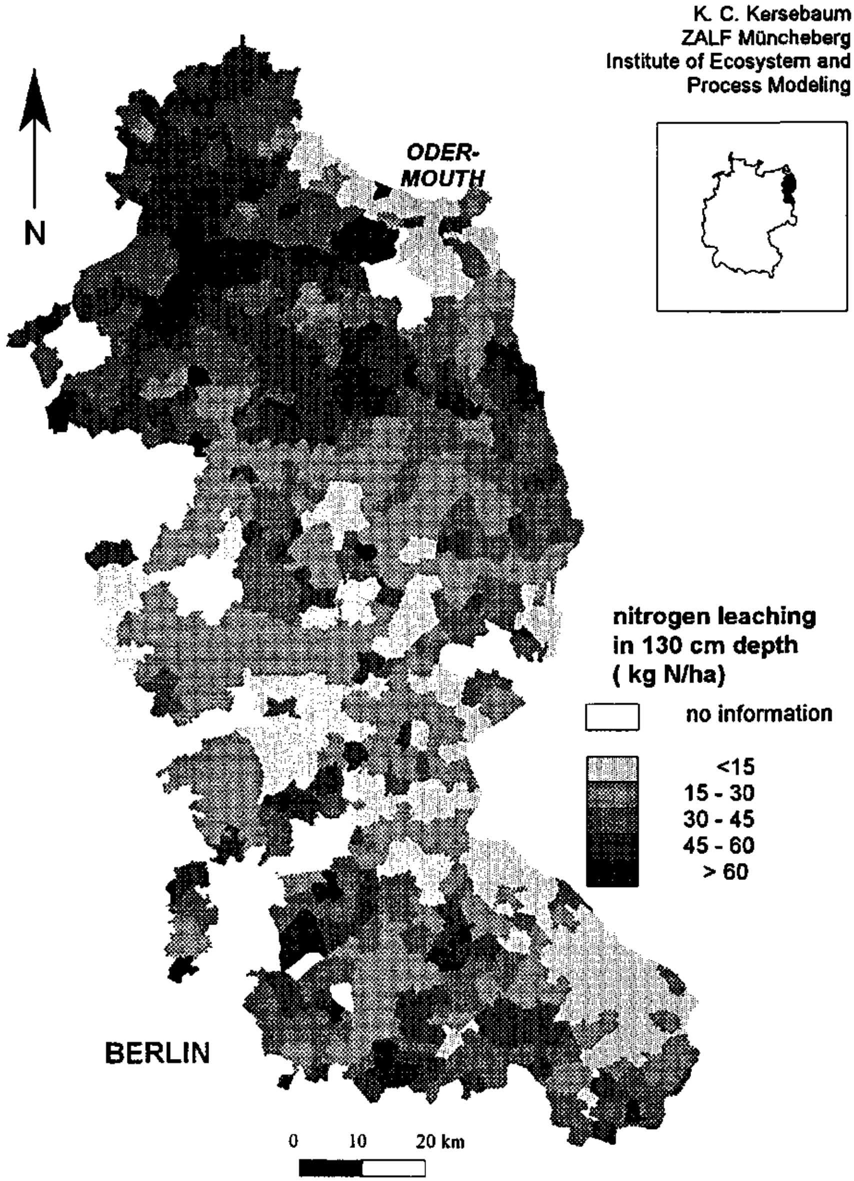

Fig. 1. Map of mean annual nitrogen leaching (referring to the municipal area) of communities in North-eastern Germany calculated for 1989.

Fig. 2 shows the effect on nitrogen leaching for the scenario IIa where about 32 % of the agricultural land is estimated to fall out of production. On average, losses (18 kg N/ha) are reduced by 26% in relation to the leaching of 1992 with a clear local trend. While in the northern part (Mecklenburg-Vorpommern) mainly pasture falls out of production, in the southern area of Brandenburg arable land is also given up. Therefore leaching in Brandenburg is reduced much more (37%) than in Mecklenburg-Vorpommern (16%). Because animal production is estimated to remain nearly constant at the 1992 level, the nitrogen balance for the remaining agricultural land increases again.

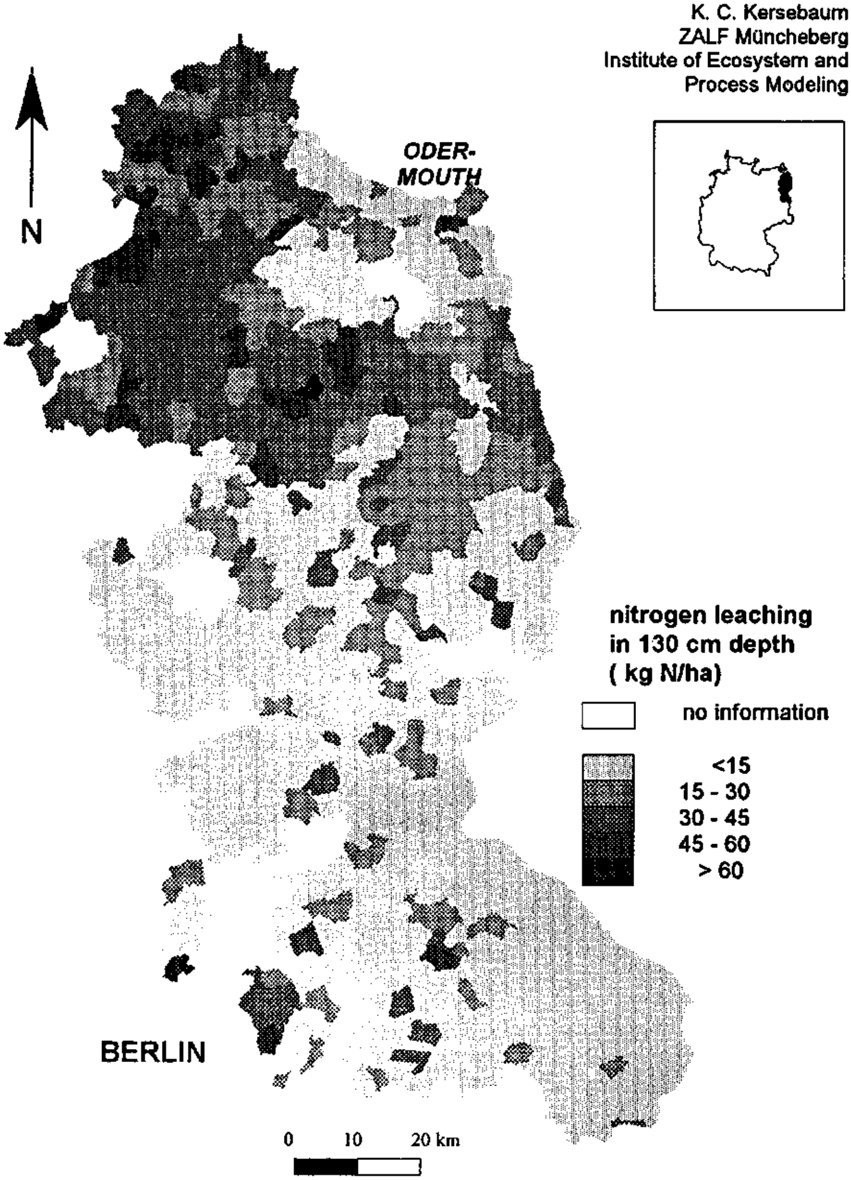

Fig. 2. Map of mean annual nitrogen leaching (referring to the municipal area) of communities in North-eastern Germany calculated for scenario IIa

Discussion

Compared to the nitrogen balances, the reaction of estimated nitrogen leaching on changes of land use seems very small, which is mainly a buffer effect of the organic pool in the soil. The amounts of calculated losses are relatively small, but regarding the low water surplus of 100 mm per year the concentration of drainage water is calculated to be at about 150 mg nitrate per liter in 1989. Because further reduction during the travel time versus the groundwater is not considered, the amounts presented can only be an assessment of the potential risk.

Conclusions

Regarding the results one has to keep in mind the uncertainty of data available on this scale and also deficiencies in the understanding of the processes of the nitrogen dynamic which may cause errors in the simulation. Two main deficiencies became evident during this study. One is the lack of appropriate approaches and data bases for forestry areas. Furthermore there is a need to investigate the losses by denitrification especially on peat soils which are an important element in this region. Although there is still a considerable need for further investigation the method described provides a useful tool to assess site specific effects of changing land use on a larger scale.

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6.6 The Gelderland ammonia information system for policy analysis, The Netherlands

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Abstract
The province of Gelderland has developed a GIS-based ammonia information system to investigate effects of national and provincial policies on ammonia emission and deposition. For provincial policies, effects on government budgets are calculated too. National policies consist of regulations on farm buildings, storage facilities and spreading of manure. The contents of provincial policies are still under discussion. In this paper, it is assumed that one item of provincial policies is a quicker rate of introduction of low-emission farm buildings and possibly of persuasion of farmers to move from certain areas.

Ammonia emission in Gelderland in 1980 is estimated at 39 million kilogrammes. It is calculated that, in comparison to 1980, national policies will result in a reduction in emission of 60-70% in the year 2000 and 70-80% in 2010. The effects of the assumed additional provincial policies are relatively small in comparison to the effects of national policies. In the year 2000 an additional reduction in emission of 0.5-0.7 million kg could be achieved at an estimated budget cost of 30-52 million HFl.

It is concluded that provincial policies should not aim at a quicker or further reduction of regional emission or deposition than national policies do. However, it is possible that provincial policies on a local level have obvious positive effects on individual natural elements.
Keywords: *ammonia, GIS, policy analysis*

Problem statement

The Dutch government has set out a national policy to decrease ammonia emission. Livestock farmers are obliged to inject manure while spreading it and to cover storage facilities. In the next 20 years, farm buildings must be converted into low-emission buildings (Tweede Kamer, 1993). Even though national policies aim at a reduction in the emission for 1980 of 50-70% in the year 2000 and 80-90% in 2010, in the long run, total deposition in concentration areas may still be too high. Therefore, provinces in these areas aim at further or quicker reductions in emission in areas of high natural value. This might be achieved by a better distribution of intensive livestock farming over the province or country and by extra use of technical measures to reduce emission.
Budget costs of these policies have to be taken into account.
In national policies, costs of technical adaptations are mainly paid for by farmers and partly by the state in the form of tax facilities for environmental investments. Provincial policies are probably paid for mainly by the national government. Given the scarcity of financial means to support provincial policies, a provincial debate arose on the question of whether it is preferable to select a few regions in which provincial policies are concentrated or more regions in which provincial policies are distributed. This paper shows the effects of national and provincial policies on emission and deposition in the province of Gelderland. Policies are investigated with an ammonia information system.

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The Ammonia Information System

The Ammonia Information System combines policy knowledge and a technical-economic ammonia model. The system uses a partial linkage of the ammonia model and a GIS. The input data of the ammonia model consist of three types: agricultural data, data on national and provincial policies and geographical information layers to determine areas where the defined policies are effective. During **preprocessing**, areas of (combined) geographical layers can be selected to assign a certain policy. All input data are transformed to a single standard grid that can be read by the model. The **ammonia model** calculates emission and deposition and related budget costs of the proposed scenario on a grid base (2*2 km). In **postprocessing**, the GIS offers the possibility to aggregate the individual grid values or to compare two scenarios.

Description of the data

Effects of national policies are calculated for the years 1991, 2000 and 2010. The year 1991 is chosen instead of 1980 because detailed information on livestock is available for 1991 only and in 1991 no emission policy was yet effective. Data on national policies have been described by Van Egmond et al. (1994). To summarize, national policies consist of: obligatory injection of manure during spreading before 1995, coverage of storage facilities and introduction of low-emission farm-buildings over a period of 20 years. Effects of provincial policies are calculated for the year 2000. These (yet) hypothetical provincial policies are introduced in limited areas in addition to national policies. It is assumed that provincial policies effect the number of animals and the number of low-emission buildings in the assigned grids.

Table 1. Assumed budget costs of provincial policies (in Hfl per animal head)

Financial input	No policy	High	Low
costs per head(HFl)			
cattle	-	262.50	75.00
pigs	-	21.25	5.00
sows	-	106.25	25.00
poultry	-	0.72	0.18

The first provincial scenario, called HEAVY, has a high financial input per grid; the second (LIGHT), is one with low financial input. High financial input is assumed to cause an additional increase of 35% in the number of low emission buildings in comparison to national policies. Moreover, 5% of the number of pigs and poultry farms are persuaded to leave the province. Costs of this persuasion are assumed to be 1.5 times as high as those of low-emission buildings. Low financial input causes an increase of 10% in low-emission buildings; no farmers are leaving the province. The (one time) costs of these measures are given in Table 1.

Two geographic information layers are combined, to select the areas in which provincial policies could be applied: areas with high, medium and low quality of natural elements and areas with soil types which are highly vulnerable for acidification. The HEAVY scenario is used in a limited number of areas with high quality of natural elements and high vulnerability of the soil (Plate 4a). The LIGHT scenario is used in a larger area with high and medium quality of natural elements and high soil vulnerability.

Results

National policies

Table 2 summarizes total emission and deposition in Gelderland in 1991, 2000 and 2010. Emission in 1980 has been estimated at 39 million kg. Compared to that year, reduction is 60-70% in 2000 and 70-80% in 2010. This means that national goals of reduction in emissions are likely to be achieved in 2000. In 2010 this is almost the case. The acreage with a deposition under 1000 mol/ha increases from 280 thousand hectares in 1991 to 486 in 2000 and 507 in 2010. The acreage with deposition above 1500 mol/ha decreases from 139 thousand hectares in 1991 to 0 hectares in 2010. In comparison with 1991 the average reduction in deposition is 740 mol/ha in 2000 and 878 mol/ha in 2010. Plate 4b shows that emission is relatively high in the midwestern part of the province and in the east. This pattern is unchanged in future scenarios. It is caused by the high density of livestock in these regions.

Table 2. Emission and deposition in Gelderland in 1991, 2000 and 2010 with national policies

	1991	2000	2010
emission (mln kg)	31.5	13.0 (14.8)[1]	9.5 (11.6)[1]
deposition (mln mol)[2]	649	268	196
average deposition mol/ha	1258	519	380

[1] emission values assuming no change in the number of animals

[2] about one third of emission is deposited within the province; the rest is exported. Import of ammonia is not taken into account.

Provincial policies

In the HEAVY-scenario, the acreage under 1000 mol per hectare hardly increases. In the LIGHT-policy this increase is limited. This means that the average deposition in the policy areas is hardly reduced in comparison to reduction by national policies (Table 3).

Table 3. Effects of the HEAVY and LIGHT provincial scenarios on emission, deposition and budget costs

	No policy	HEAVY	LIGHT
Emission (mln kg)	13.0	12.5	12.3
Deposition (mln mol)	268	257	253
Deposition reduction(mol/ha)	0	77	65
budget costs (mln HFl)	0	30	52

Conclusions and discussion

National policies have a great effect on emission and deposition of ammonia. The impact of hypothetical provincial policies compared to national policies is low in terms of the total reduction in emission. Budget costs of this reduction amount to about 30-52 million Hfl. Hence, it should not be expected that the provincial policies will result in a general reduction in emission levels in these areas. However, on a local scale the proposed provincial policies might be effective on a few farms with high emission levels near natural elements. This conclusion is supported by Overmars (1992). In order to achieve effective local results from provincial policies, it is considered necessary to establish a set of criteria on deposition levels in relation to the sensitivity of natural elements. Information on the vulnerability of individual natural areas is necessary to implement these policies.

In scenario studies, many assumptions have to be made. Most of them are based on national research. The budget costs and effects of proposed provincial policies are most uncertain. However, the authors feel that this assumption has not been a conservative one: 70% low-emission buildings and 5% of farmers leaving the province, seems to be quite optimistic. This means that the effects of the proposed provincial policies may be overestimated. This would strengthen the conclusion of this paper on the limited impact of provincial policies.

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CHAPTER 7

Models and GIS

7.1 Integration of a data base, hydrological models and a geographic information system to assist in regional water management

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Abstract
In an alluvial basin with an area of about 1000 km^2 agricultural, domestic and industrial water requirements are covered by groundwater pumping. Due to the overexploitation of the aquifer which is hydraulically linked with the Danube, the groundwater table has become remarkably lower within the last twenty years. To overcome water shortage and to improve environmental conditions several water management alternatives have been elaborated. All the plans are related to improved groundwater management strategies.

The objective of this paper is to describe an integrated model assisting governmental water authorities in water and environmental decision making. For this purpose water management scenarios can be easily interactively generated and subsequently analysed in its hydrological consequences. The scenarios include alternative sites for hydropower schemes and alternative measures for artificial groundwater recharge. The model consists of several components such as a relational data base, analytical tools, a two dimensional finite difference groundwater model and functional units from a geographical information system. These tools are integrated by a user friendly interface. The data base is designed to handle time series, spatial data, tables and texts. The analytical tools refer to time series analysis, spatial statistical analysis and facilities for overlays.
Keywords: *regional water management, decision support systems, geographic information systems, groundwater modelling*

Introduction

In an Austrian alluvial basin which is named Marchfeld and which has an area of about 1 000 km^2 all the regional water requirements are covered by groundwater. The increasing demand has led in the last twenty years to a remarkable decrease in the groundwater table. The alluvial basin is bordered by the Danube and the river March which both interact with the groundwater system. To overcome the water shortage an irrigation channel has been built to cover agricultural water requirements. Additionally it is planned to artificially recharge the groundwater to re-establish former hydrological conditions to serve other water uses for domestic, industrial and environmental purposes. The water management problems of this region are described in detail by EM (1986, 1990) and Nachtnebel et al. (1991).

The principal decision to build an irrigation channel was mainly a political decision and was taken already at the beginning of the eighties. Nevertheless it was based on wide

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ranging development plans emphasizing agricultural and environmental objectives. From the viewpoint of national economy the project was not undisputed.

Due to various water related projects such as hydropower schemes, plans to establish a national park to preserve the extended riverine forests along the Danube and several recharge schemes, the technical experts from the water law authority asked for a flexible and integrated computer based system providing all the regional information and modelling tools. This tool should assist in the assessment of plan impacts and in the analysis of the interference among the various water projects from independent companies.

The objective of this paper is to describe the integrated model consisting of the following main components (Fig. 1):

* a relational data base (RDB);
* analytical tools;
* a model base for groundwater and soil water;
* functional units from a geographical information system (GIS) to support visualization.

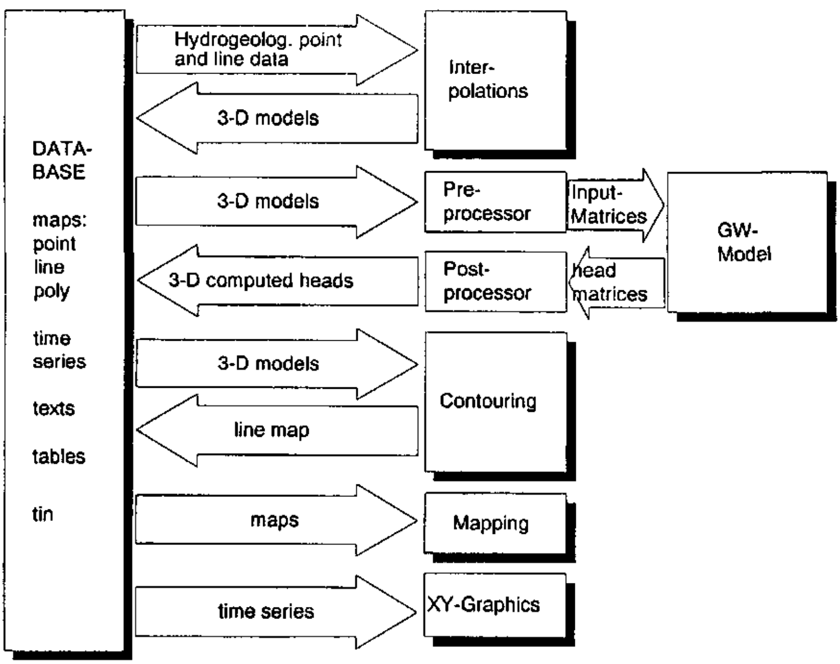

Fig. 1. Main components and functions of the integrated system.

These tools are integrated by a user friendly interface and should assist in the set-up of different groundwater models exhibiting a different network geometry, and in the evaluation of model scenarios. In general, the integrated model can be seen as a decision support system supplying the expert with physically based information for the evaluation of water management alternatives. The specific hydrological requirements are identified and compared using the capabilities of commercially available software.

In the process of simulation and analysis, large data sets exhibiting quite distinct structures have to be manipulated. Because of the time consuming procedure for grid design and model set-up, often only a single geometric structure is developed to describe the groundwater. Similarly, major efforts are required to evaluate the temporal and spatial patterns of output from model scenarios. An easily accessible data base, an interactive tool to administrate and manipulate spatial data, and utilities for the visualization of model results according to human perception would substantially reduce the effort to set-up alternative grids and management schemes. GIS provide some of these tools but the user comfort and the performance of GIS routines is highly varied among the commercially available software products.

The experiences from several case studies (Fuerst et al., 1987; Nachtnebel et al., 1991; Nachtnebel et al., 1992, Nachtnebel, 1994), in which different GIS (ARC/INFO and GRASS) were applied, are summarized and user requirements are identified that should be covered by GIS.

Design of the Data Base

The data base was designed to handle

* time series of hydrological observations;
* spatial information;
* generally structured tables;
* texts.

Hydrological data are mainly available as time series of groundwater observations taken more or less regularly at many sites. Rainfall data are available as regular time series while soil moisture measurements are scarce and quite irregularly taken.

Spatial data refer to points like the locations of observations wells, to arcs describing the river network, to areas representing soil types or soil thickness and subspaces defined by separating three-dimensional boundaries. A typical example is the 3-D characterization of the hydraulic permeability of an aquifer. It is worth noting that groundwater modelling would be facilitated by the systems ability to handle both raster and vectorized data. The former would be useful for the various matrices related data and the latter to characterize rivers acting as boundaries.

Tables are important for modelling relationships among hydrological variables. Simple tables describe stage discharge relationships and large matrices are used in two dimensional groundwater models to represent the spatial pattern of permeability or storage coefficient. Other tables might be required to describe the interaction between surface and groundwater systems by a stage-infiltration relationship valid within a certain section of a river.

Texts constitute important information which should be easily accessible during the modelling process. First, reports and documents referencing the region or describing projects are important. Secondly, a description of the various tools is required for online help and, thirdly, the actual work within a scenario session needs careful documentation, too.

Comparing these requirements with GIS capabilities it can be concluded that the internal database of some GIS is primarily designed to handle spatial information, either in vectorized form or in a grid based structure. There is a deficiency in the various GIS with respect to the handling of other than two-dimensional spatial data sets. This implies that the support of 3D volumetric (solid) modelling (Raper, 1989; Flynn, 1990) should be improved and that at least time series data should be integrated into the GIS data base. In the long-term perspective, the most attractive approach would be in the combination of an object oriented data base with a GIS.

Due to a lack of commercially available products another approach is in the combination of a GIS with an external Relational Data Base (RDB) (Nachtnebel et al., 1991) supported by an interface that also handles predefined standard queries. A standard window system (OSF Motif) has been applied to generate a user friendly interface which provides a data display and which assists in defining specific queries. To give an example, a typical modelling requirement is to select groundwater table data for a specific day. This task includes also procedures for selecting the closest date of measurement and for the temporal interpolation between measurements.

The data are grouped into objects (Fig. 2) each composed of a block of general information describing the characteristics of the data set and the data block itself. The first block contains information about the stations, including, amongst other information, its name, the agency responsible for monitoring, period of operation, coordinates, measurement variable and its unit. It has to be considered that, because of the lack of standardization of GIS databases, the information cannot be fully communicated between an external database and the internal GIS database. Additionally, it would be quite useful to provide facilities for managing large bit maps.

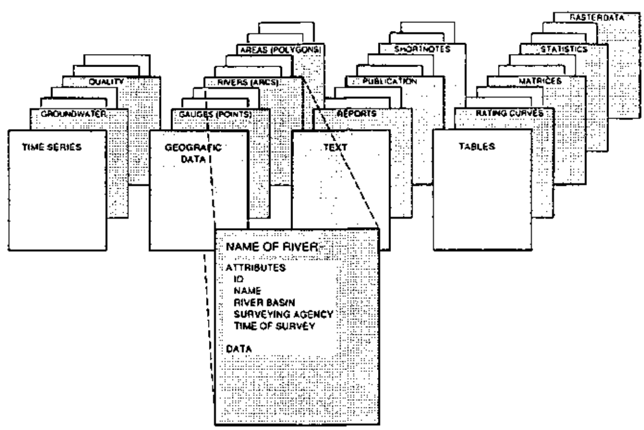

Fig. 2. Objects in the database.

Analytical Tools

The set-up of the network geometry and the design of the model is quite time consuming when manually carried out but it can be drastically simplified when a set of functions is provided. These functions should assist in

* deriving a generalized structure from the real world system;
* analysing spatial fields and generating fields with similar characteristics;
* spatio-temporal interpolation.

The definition of the boundaries is dependent on the observation network and the hydrological conditions. A user selectable background map including the relevant hydrological information (Fig. 3) is useful to select the boundaries, which often follow the course of a major surface water body. The supporting function should map the river onto the grid in such a way that the river course is represented by a series of the nearest node points. For this case a Dirichlet type boundary is associated with the water table of the river which should be directly accessible as an object in the data base. The data base may contain some surface water profiles or time series from measurements taken at a few gauging stations. First, it is necessary to interpolate the water table from the gauging station within the longitudinal river profile including typical water tables. Subsequently, the data have to be transferred to the respective node points.

In many case studies two dimensional models are applied, either finite difference models with a uniform rectangular grid or finite element structures exhibiting more flexibility in the grid design. Raster based systems facilitate finite difference approaches and subsequent GIS operations can be quickly performed. The disadvantage is that the grid extends uniformly over the whole region and that the minimum resolution has to be defined in the initial design phase. To avoid extremely large matrices, subregions which require a more detailed spatial resolution can be represented by local grid refinement. This methodology is only partially supported by vector based systems and many GIS provide only grid generating functions which relate to triangular or rectangular grids.

Also, when 3-D models with several distinct layers in the aquifer are considered a smooth and nonlinear gridding (Smith and Wessel, 1990) might be more appropriate to represent the physical system. In general, from a modelling viewpoint the locations of groundwater observation wells should coincide as good as possible with the centres of the grid cells. From some applications it can be concluded that the GIS gridding algorithms do not fully satisfy hydrological requirements. Triangularization techniques should be able to reflect discontinuities of the surface such as break lines or rivers. This line should be approximated by a polygon which is composed by the vertices of the final triangular grid.

After having designed the model geometry each grid cell requires a set of hydrogeological parameters such as

* bottom layer of the aquifer;
* permeability values;
* storage coefficient;
* recharge rates;
* observed groundwater tables acting as initial conditions.

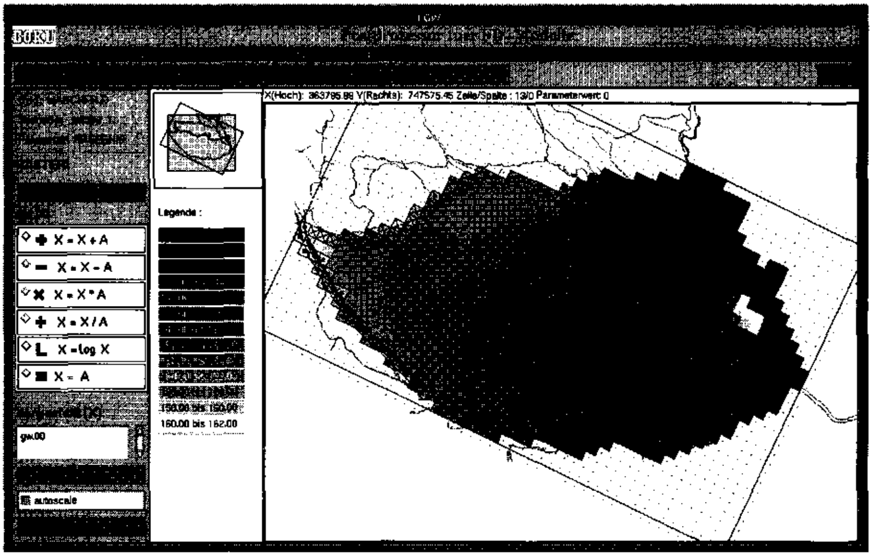

Fig. 3. Grid of a groundwater model with the surface water system in the background (the user interface is labelled in German).

In comparison to the number of grid cells all these parameters are obtained from only a few measurement locations. The point information has to be interpolated for each node and has to be averaged over the volume of the grid cell. To achieve this task some more advanced interpolation algorithms such as kriging, or universal kriging are required (Deutsch and Journel, 1992). These tools are integrated only in a few GIS, however recent attempts are made to include them in updated GIS versions. Therefore, it was necessary to combine such routines with the GIS. The interface was designed in the same layout to provide the same environment for the user. It is beyond the scope of this paper to explain the applied interpolation technique and to give some numerical results from scenarios but an example is selected to demonstrate how model uncertainties can be easily handled. Several model alternatives were generated utilizing spatial analytical techniques. Based on the semi-variogram for the logarithm of the given permeability values (Fig. 4) numerous sets of permeability fields are generated by conditional simulation (Brooker, 1985).

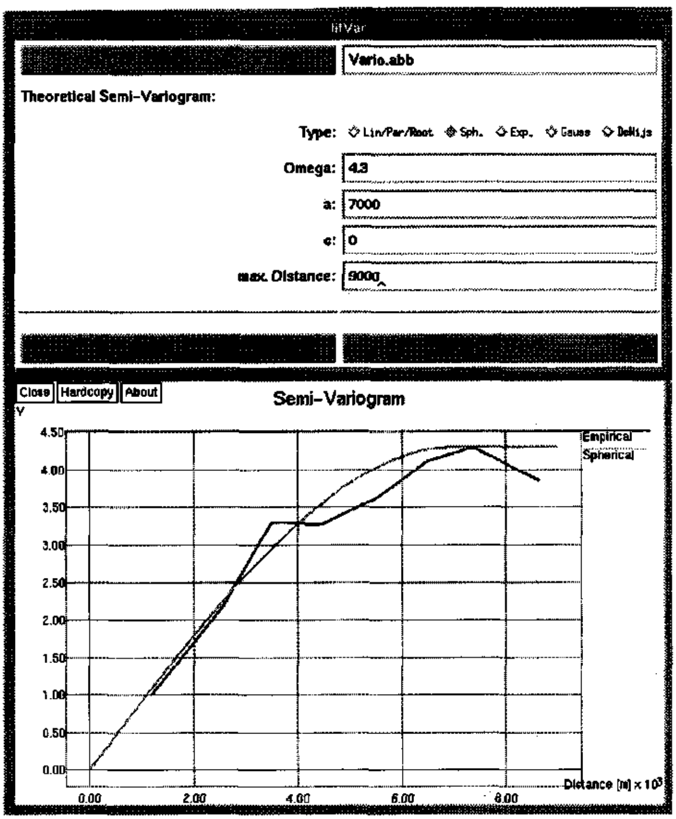

Fig. 4. Interface to the kriging routines - Fitting a theoretical semi-variogram to the empirical semi-variogram.

Each simulated field yields at the pumping test sites the observed value while in between a random field is generated which has the same spatial properties as the observed data. The spatial variability of a hundred simulations is given in Fig. 5. Obviously, the variability of the permeability values increases with the distance from a pumping test site. The variability in the output, the groundwater table, is given in Fig. 6 and is dependent not only on the input but also on the boundaries. In general, the greatest variability is found in the vicinity of flow dependent nodes, such as Neuman type boundaries or pumping sites. The simple access of the user to select appropriate colour codes for numeric intervals provides easily perceivable information about the uncertainties in the hydrological data.

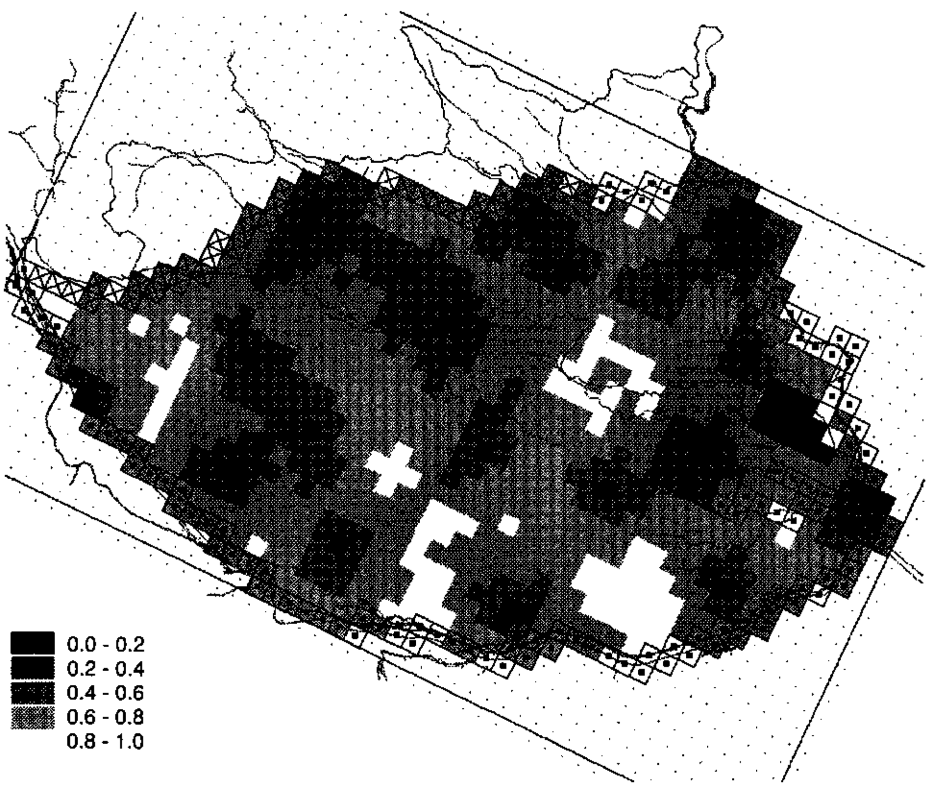

Fig. 5. Spatial variability of the simulated permeability field
Standard deviation of the logarithm of the simulated permeability values

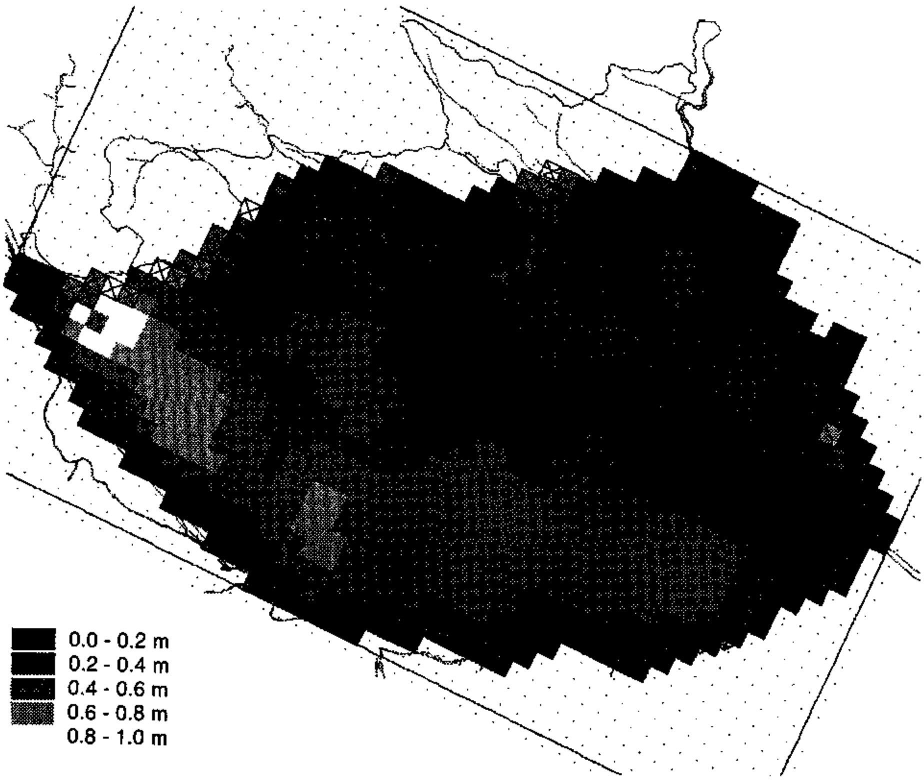

Fig. 6 *Spatial variability of the corresponding groundwater heads*
Standard deviation of the simulated piezometric heads

The Model base

In general, any groundwater model can be incorporated into the system. The tools described in the previous chapter should be adjusted to the model geometry. In the case study of this paper, only 2D groundwater models (Mc Donald and Harbough, 1984; Voss, 1984) were applied. These types of models utilize either a finite difference or a finite element approach. For the unsteady case the time dependent boundary conditions including also pumping and recharge figures have to be provided by the system in the respective format type.

A one-dimensional vertical model for the unsaturated zone (Nachtnebel and Holzmann, 1993) is also included in the model base to obtain estimates for the natural groundwater recharge for a given grid element. The required data are derived from a digitized soil map, a map for the thickness of the soil layer and some soil parameters stored in generally structured tables in the data base.

A raster type geometry of the groundwater models is recommended because it facilitates the mapping of digitized data on to the grid of the model.

In this type of integrated tool, consisting of a data base, a groundwater model and some other utilities, the model can be seen as a two (or three)-dimensional interpolation routine which is based on Darcy's Law and on the continuity equation. In consequence this approach will lead to a GIS which includes as a user supplied function a groundwater model (Fürst, 1990).

Visualization and Display of Simulation Results

The capabilities of GIS and some advanced graphical routines are quite powerful to display simulation results. After having carried out a model run all the relevant information is available in a set of identically structured tables of which several refer to different time steps. In the postprocessing phase these matrices are combined and displayed in different ways according to user requirements. This will be demonstrated by an example.

The groundwater table is observed at only a few locations while the model yields head data for every grid cell. Several techniques can be applied to compare observed and computed head values. Frequently, for unsteady groundwater problems time series are compared for observation points which should be interactively identifiable by the modeller (Fig. 7). To display the spatial pattern of the groundwater table the observations have to be interpolated over the grid nodes and either contour lines or a colour coded grid pattern can be displayed to compare, for instance, observed and simulated data. Contour lines, which can be generated by GIS routines, display the information about the groundwater system in a comprehensive way so that the modeller can compare two different groundwater tables simultaneously within the project area. Further, conclusions with respect to the flow directions can be drawn. The difference in head values can also be displayed in a colour coded grid pattern assisting in the identification of grid cells where the model describes the system unsatisfactorily. Many of these operations are supported by a GIS.

A gradually varying palette with many colours and a linear assignment of colours to values is well suited for displaying topography and geologic layers, whereas a palette of two colour families, say red and green, can intuitively signal sensitive areas where e.g. constraints are violated or high pollution loads are observed.

To assist the modeller in the perception of the geographical context the simultaneous display of several maps would be quite helpful. A transparent overlay of hydrological information over a scanned geographical map acting as background information could improve readability and acceptance of model results substantially. The overlay of a transparent colour coded grid map of deviations between model and observations will assist in both the identification of unsatisfactorily calibrated grid cells and also in their geographical allocation.

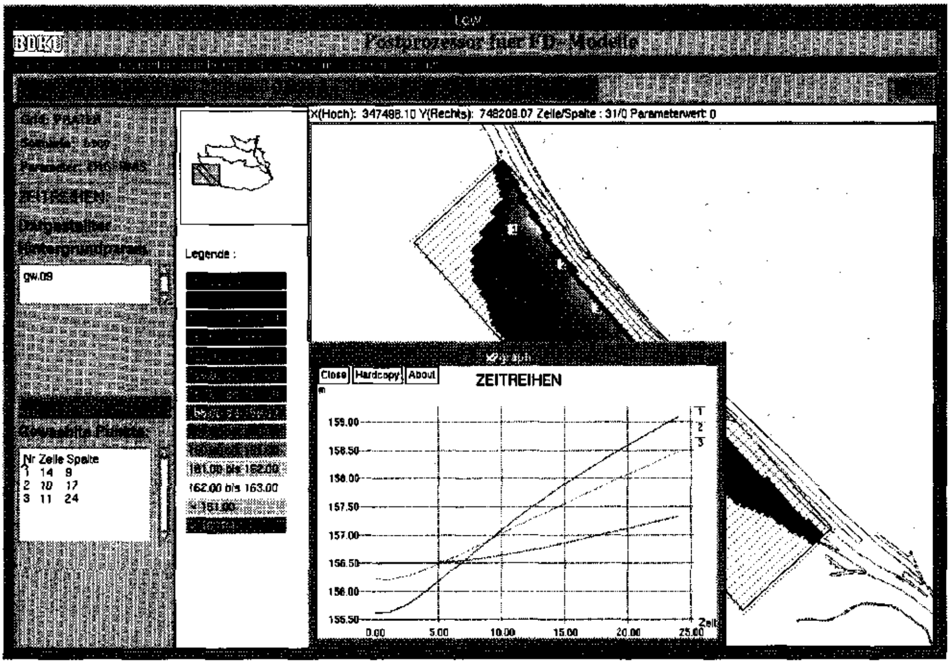

Fig. 7. Displaying two time series corresponding to two sites in a background map.

It should also be mentioned in this context that the definition of colour families and the joint manipulation of foreground and background colours would facilitate hydrological modelling and analysis. Some PC based systems already provide such tools while more sophisticated GIS which are based on workstations and on UNIX operating systems exhibit some deficiencies in this respect.

Arithmetic and Boolean operations on maps are implemented in several GIS. Vector based systems have to perform complex geometric calculations to obtain the transmissivity from the saturated thickness, which in turn is the combination of the groundwater table and the bottom layer, and from the permeability coverage. Raster based systems are preferable in this case.

Direct colour based mathematical operations might assist in the analysis of simulation results. As an example, two hydrological variables, each represented by its coloured spatial pattern, have to be combined to yield new information about the system. First, the numerical range of each variable is expressed by a colour array and then these two arrays have to be mapped onto a colour matrix. Obviously, the combination process which is described by the matrix is problem dependent. Boolean operations or tools for a user definable combination based on colour families (Burger and Gillies, 1989) should improve the analysis of the system.

Another GIS facility is in the display and analysis of cross sections. The user defines interactively in a map the trace of a cross section together with the hydrological variables to be displayed. In Fig. 8 the bottom layer, the groundwater table and the soil layers are displayed together with the background map.

From the hydrological viewpoint there is a need for the generation of grid lines orthogonal to head contours. At least for steady state situations, where stream lines are identical to the flow paths, this feature could eliminate the need for a particle tracking model. Some digital terrain models and related GIS routines provide such functions for obtaining gradients of 3-D surfaces. Applied to a groundwater surface and combined with maps of hydraulic transmissivity, a vector field can be generated which will represent flow velocity and specific discharge at the grid points in a groundwater model.

Although all the functions described do not really provide new information, they facilitate the handling of large data sets and their readability. Also, they support the expert in understanding model results and the systems behaviour. When the system has been designed to be really user friendly, it stimulates the expert to investigate a broader set of management alternatives because of the simplicity in the set-up.

Discussion and Conclusions

It was demonstrated in this paper that a GIS can help substantially in groundwater modelling. In principle, there are two different approaches to utilize GIS functions. In the first approach a groundwater model can be integrated into a GIS like any other macro-language based function. This implies that the user has to be trained to handle the entire GIS and which also means that a substantial unutilized overhead has to be accepted (Fuerst et al., 1987).

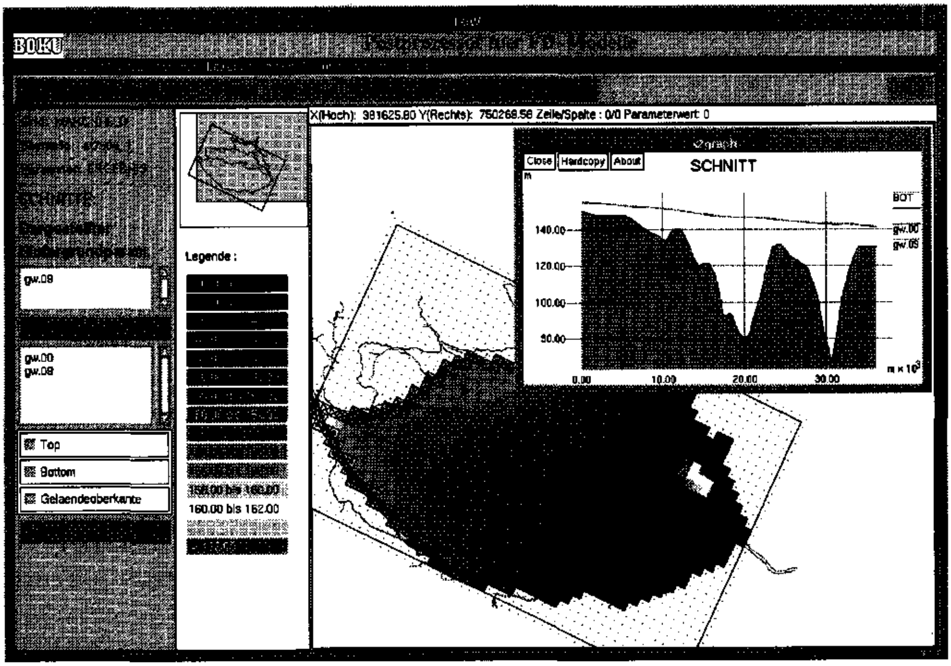

Fig. 8. Displaying hydrological variables in a cross section shown in the background map.

In the second approach specific GIS routines are selected and tailored to satisfy the data structures required by the groundwater model. Especially in the second case this requires that the GIS has to communicate with a couple of other software tools. Therefore, a GIS that should be efficiently applicable in groundwater modelling needs to be "open" at several levels:

* on the data level: GIS data structures should be well documented and easily accessible from external programs in both directions. The full information should be communicated.
* on the functional level: GIS routines should be modular, so that individual routines can be selected for groundwater modelling purposes.
* on the user interface level: To maintain a consistent user interface for all the modules of a "groundwater modelling workbench", the GIS should either provide a user interface development facility like a macro language that can also integrate external programs or it should be accessible through externally developed user interfaces.
* interdisciplinary openness: Within an interdisciplinary project all the data and modelling results should be easily accessible and understandable for other working groups, so that the GIS can become a communication platform which stimulates collaboration (Hary and Nachtnebel, 1989; Fedra, 1991).

The disadvantages or deficiencies of GIS with respect to hydrological requirements are seen in the following:

* GIS packages are not fully adequate for some aspects of groundwater modelling;
* several GIS lack full 3-D and solid modelling capabilities;
* GIS cannot efficiently handle time dependencies of spatial phenomena;
* GIS exhibit a lack in standardization. This implies that the exchange of data among different systems is difficult;
* lack of openness. GIS cannot be easily integrated into a user defined interface or cannot be easily combined with other components, like an RDB, visualization packages or geostatistics.

The experiences with the application of GIS in several groundwater modelling projects are beneficial with respect to:

* spatial data management;
* pre-processing and model set-up;
* GIS mapping facilities provide comprehensive and flexible visualization instruments;
* due to the visualization of complex data sets the understanding of processes is improved;
* due to the assistance in the model set-up more management alternatives can be explored;
* GIS can combine spatial information from different disciplines and can become a communication platform for interdisciplinary projects.

Acknowledgements

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7.2 Reducing nutrient loadings to marine waters

Building up an integrated assessment model

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Abstract
At the National Environmental Research Institute (NERI), Department of Policy Analysis, an interdisciplinary project group is building up a GIS-based integrated assessment model with the specific purpose of enabling cost-effectiveness analysis of different measures aiming at reduced nutrient loadings to marine waters. The analysis compares the (steady state-) changes in selected quantitative ecological goal variables (e.g. the average oxygen concentrations in the marine waters) with the costs to society of achieving these changes. The measures to be compared are not only different measures within one sector (e.g. structural and technological changes in agriculture) or across sectors (e.g. measures directed to agriculture or sewage plants) but also between regions, since specific regional or local natural conditions play an important role in the transformation of nutrients in the ecosystems. Thus the model will operate with 48 drainage basins.
Keywords: *Eutrophication, Integrated assessment, Cost Effectiveness Analysis*

Introduction

The environmental quality of the marine waters of Denmark has been of major political concern since the middle of the 1980's, when widespread fish death due to eutrophication was reported. However, an action plan for the aquatic environment did not yield the results intended by the plan regarding nitrogen: a 50% reduction of loadings to fjords and marine waters. Besides this, the external conditions for Danish agricultural production are changing rapidly these years due to the reorientation of the European agricultural policy; thus Danish agriculture might undergo structural changes which will in effect alter the loadings with nutrients from agriculture. It is therefore of interest to evaluate the environmental impacts and the economic costs to society of different structural or technological changes within sectors and activities in society responsible for nutrient pollution of the marine environment.

Several economic activities in society are responsible for loadings of nutrients to the environment. Important anthropogenic sources are: Agriculture, waste water treatment plants, power plants, transport and "imports" from foreign countries (either via transboundary airpollution or by seacurrents). However, agriculture is the major national polluter with nitrogen, accounting for about 80% of the national loadings to the marine waters. Hence, agricultural production and its economic and environmental implications are a central issue in the project.

The aim of the project is, on the one hand, to quantify the relationship between land-use and technology applied across sectors in various geographical regions (48 drainage basins) and the environmental quality of the Danish marine waters and fjords and, on the other

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hand, to calculate the costs to society and effects on the quality of the waters of various changes in these patterns. The results will be used for the formulation of a national policy strategy on reduced eutrophication of marine waters. For a more extensive presentation of the project, see Paaby *et al.* (1994).

Model-simulations of scenarios

In order to be able to estimate socioeconomic costs connected to the improvement of the environmental quality of either fjords or marine waters, an integrated nationwide assessment model is constructed. This model should facilitate comparisons between the economic flows and the flows of nutrients and their environmental effects in different pre-defined (by the model-simulator) steady states. The definitions of such steady states are called "scenarios" whereas the various elements of the scenarios (e.g. changes in landuse, number of animals, utilization of manure, waste water treatment) are called "measures".

The basic framework of the model

The basic framework of the assessment model is shown in Figure 1. The starting point of the model is the definition of a *scenario* which determines the structure and technology of the most important anthropogenic sources of nutrients, i.e. agriculture, waste water treatment, NO_x-emissions from power plants and traffic and "imports" of airborne or sea current of nitrogen compounds. Whereas the first two domestic sources in the model are handled as controllable, i.e. sources, being the subject of "measures" as defined above, the latter two main sources, NO_x-emissions and imports, are treated as exogenous to the model and beyond the control of the model simulator. This means that all measures will be directed towards reductions of nutrient losses from rural non-point sources or from waste water treatment plants. However, it will be possible to calculate the effects on the ecological goal-variables of changes in these exogenous sources (i.e. alternative scenarios of transboundary airpollution), and thus to compare the ecological effects of changes in loadings from these sources with changes in loadings from domestic, controllable sources. But the costs of changing loadings from these sources can not be calculated in the model. The analysis and the model simulations will be based on a geographical split of the land-area into 48 drainage basins to coastal waters or fjords, and the (inner) marine areas Kattegat, the Belts and the Baltic. The economic and environmental flows from rural areas (agricultural production and the loss of nutrients from rural areas) will be calculated for each municipality and aggregated to the 48 drainage basins. The primary aim of this is to take into account the variations in ecological conditions between regions.

The ecological sub-models

The environmental side of the model includes the following submodels: Leaching of nitrogen from rootzone; NH_x-emissions from livestock; loss of phosphorus from rural land; outlets of nutrients from municipal waste water treatment plants; retention of nitrogen in drainage basins; retention of nitrogen in fjords; depositions of NH_x-N; the effects of loadings in fjords; and the effects in open marine areas.

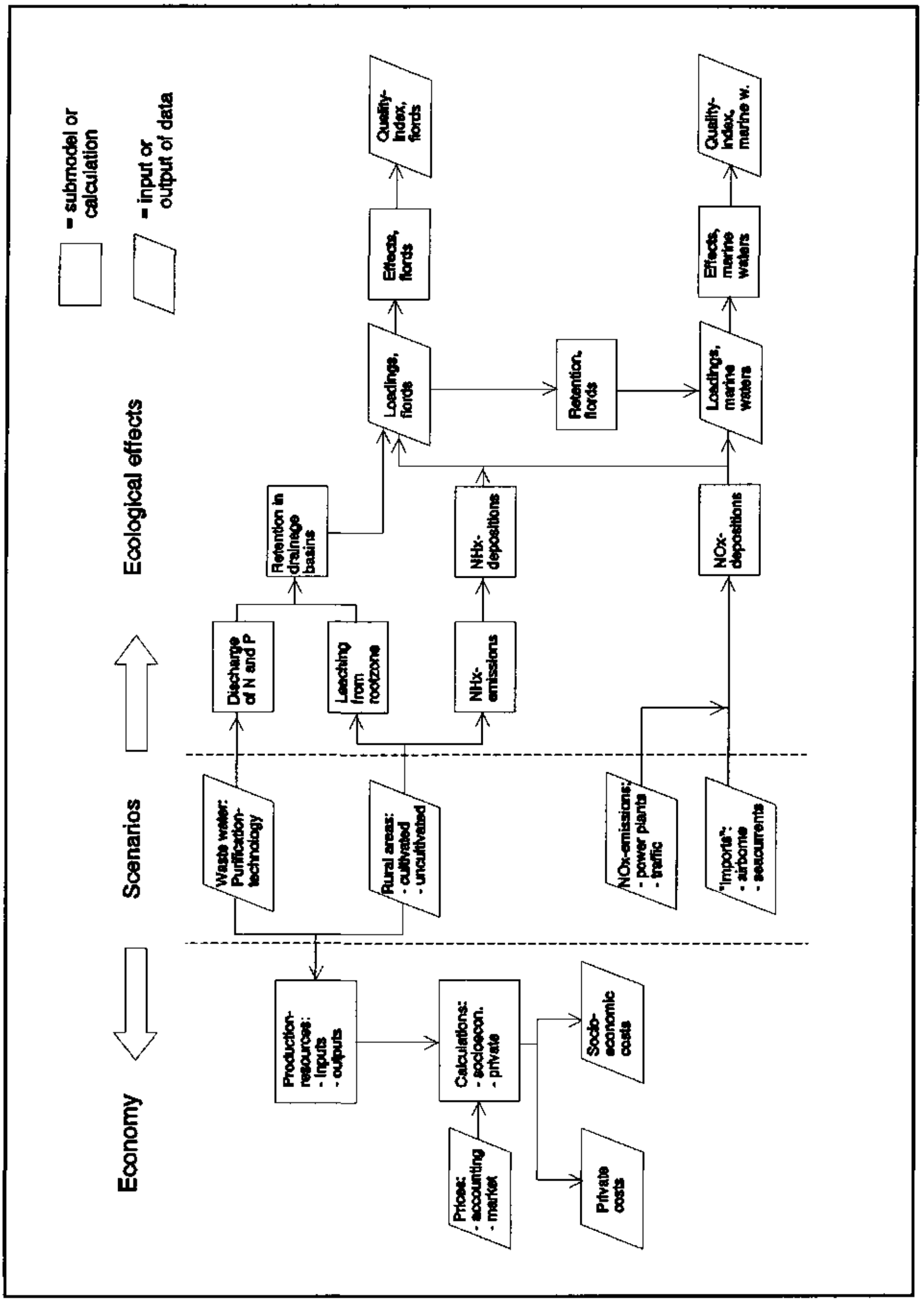

Fig. 1. Basic framework of the assessment model

Nitrogen leaching from the root zone is calculated by means of simple empirical exponential equations, which have been found adequate to explain the results of leaching experiments in Denmark (Simmelsgaard, 1991). The equations calculate the leaching of nitrogen as a function of soil type, crop type and the level of applied fertilizers. Calculations show an average N-leaching around 77 kg N ha^{-1}, but leaching differs greatly between farm types. Thus, average N-leaching from cattle-farms is 83 kg N ha^{-1}, for pig-farms 115 kg N ha^{-1} and for plant farms 53 kg N ha^{-1}.

Emission of ammonia is calculated by means of emission factors assigned to each livestock unit (LU) or cropland area:

* Cattle	27,7 kg N*LU^{-1}
* Pigs	41,6 kg N*LU^{-1}
* Other animals	64,5 kg N*LU^{-1}
* Commercial fertilizer and crops	1,0 kg N*ha^{-1}

Loss of phosphorus from agricultural land is calculated as a fixed coefficient per ha of agricultural land (0,3 kg P ha^{-1}).

Discharges of nitrogen (N) and phosphorus (P) with *municipal waste water* is calculated as a function of the amount of waste water and the purifying technology. In the model it is possible to choose between 6 different technologies, each of which determines the outlet concentrations of N and P.

Estimations of the *retention of nitrogen* in drainage basins are carried out by mass-balance principles and based on monitoring data. The origin of the data is a nationwide monitoring program (see Kronvang *et al.*, 1993). The retention rate in each drainage basin is calculated as the relative difference between the calculated leaching of nitrogen and the average agriculture related loading. The agricultural contribution to nitrogen loading is calculated as total nonpoint riverine loading subtracting loading from natural areas, atmospheric deposition on lake surfaces and loading from scattered dwellings. The retention rates of the drainage basins varies between 9% and 79%.

The retention in fjords will be calculated by estimated relationships between inflowing nutrient concentration and the nutrient concentration at fixed sampling sites. These relationships will be based on estimation of monthly water and nutrient loading for approx. 20 fjords in the period 1989-93 and corresponding measurements of chloride and nutrient concentrations at 80 fixed sampling sites in the fjords.

Simple empirical relationships between nutrient concentration in fjords and water quality indicators (e.g. chlorophyll a, Secchi disc transparency and depth penetration of macrophytes) will be used to estimate the *effects in fjords*.

The effects in marine waters is depicted by the oxygen concentrations in the bottom layers of the marine areas. The model used to simulate the oxygen conditions is developed by Hansen *et al.* (1993). It consists of a dynamic numerical model which includes the major hydrodynamic processes as well as the nitrogen cycle and the link to oxygen conditions. The model is based on the MIKE12 modelling system (Flint *et al.*, 1992).

The economic calculations

The model calculates the costs to society of moving from one steady state (a base scenario) to another specified scenario. The cost of changed land use and fertilizer application is calculated as the change in the rent of land, whereas the cost of upgrading waste water purification is calculated as the changed purification costs.

The rent of land is calculated as a function of livestock, soil type, crop-types, the input of nitrogen in commercial fertilizer as well as manure on crop fields, the utilization of manure and the prices of inputs and outputs.

Preliminary results

Preliminary calculations show that a considerable over-fertilization seems to take place on livestock-farms, i.e. a fertilization beyond the economic optimal levels. This means that there is room for reduced fertilization with low or even negative costs (benefits) to society. The strong variation in retention rates between drainage basins also means a difference in the cost-efficiency of measures between regions, i.e. it pays to take account of the natural retention capacity. This could serve as an argument for a geographically stratified set aside scheme. And finally further investments in waste water purification would only reduce nitrogen loadings of the marine waters slightly and be very costly.

Discussion and conclusions

The Cost Effectiveness Approach followed in the project - evaluating the effects of various cross-sectional and geographically specified *scenarios* - has a number of advantages and disadvantages:

- Large numbers and types of scenarios can be evaluated, and the specification of these (i.e. the specification of measures) can be chosen freely by the user. This is a useful feature in the actual land-use discussions following the EU agricultural reform including the set aside schemes.
- Calculations of the effects of scenarios clarifies an area of possible outcomes of environmental effects and connected costs to society.
- The natural scientifically based geographical split in the analysis makes it possible to take account of the geographical variations in ecological processes and responses and their significance for the problem under study, i.e. the quality of fjords and marine waters
- A sufficient number of scenario-calculations makes it possible to establish approximate cost functions of the relations between (minimal) costs and goals. By extending the assessment model with mathematical optimization routines it would be possible to construct the "true" (in a mathematical sense) cost-functions.
- A final optimization through the construction of one cost-function to society necessitates a weighting of the quality-indices of the various fjords and marine waters under consideration.

- Answering the questions of how to *implement* desirable states (scenarios), i.e. which policy instruments to use, necessitates behaviourial descriptions which, at the moment, are not included in the model. However, calculations of the private costs in the model might give an indication of the necessary economic incentives to economic agents to be established by the use of economic instruments.

The approach used in the model-description of the economic and ecological effects of the various scenarios can generally be described as simplistic modelling of complex relations. This means a limitation on the sort of questions one can answer with the model. Thus it is not possible to answer very specific and detailed questions, e.g. about the effects of climatic variations. However, this is not the aim of the project either.

Another limitation in the model is that only simulated steady states are compared, i.e. dynamic aspects (time and costs of reaching desirable steady states) are not considered.

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CHAPTER 8

Model parametrization and data needs

8.1 Spatial and temporal variability and the data crisis in scenario studies

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Abstract
The data crisis in scenario studies embodies topics such as (i) the relevance of existing data for current and forthcoming models; (ii) deciding on the use of existing soil data or sampling new data; (iii) the sensivity of models to several sources of uncertainty in model inputs and consequences for data sampling; (iv) pragmatic approaches to the data crisis; and (v) the presentation of uncertain model results. In all these topics, the magnitude of the data crisis with respect to any parameter is a function of the spatial and temporal variability of this parameter, and of the sensivity the simulation model shows to this variability. The five topics are addressed using case studies and literature reviews for illustrative purposes. Conclusions drawn with respect to the above topics, are: (i) soil data have merely an identification function when used with conceptual models, but have an estimation function too with implemented models; (ii) existing soil data may not be representing soil bodies unbiasedly, in which case probability sampling in combination with simulation modelling is a proposed method to select representative data based on soil behaviour; (iii) an uncertainty analysis of a model is a useful method to obtain sampling priorities; (iv) Pragmatic solutions to the data crisis exist in the field of exogenous model inputs, model initialisation and obtaining values for process parameters; (v) the presentation of results of scenario studies in terms of probabilities enables the incorporation of the effects of several sources of uncertainty and hence is a powerful method to be further developed.
Keywords: *Data crisis, simulation modelling, uncertainty, spatial variability, temporal variability*

Introduction

Simulation models are valuable tools in prospective research in general, and are indispensable for scenario studies. When scenarios are to be evaluated for which no empirical data exist relating doses to effects, regression-models cannot be applied and process-based dynamic models seem to be an appropriate alternative. Unfortunately, the use of these models brings on a need for values of process-parameters, which may not be available. This recognition has led to statements like "data crisis". We believe, however, that there does not exist a data crisis as such. Our data bases are full of data. The problem may exist for appropriate data but there are ways to meet this demand for data, for instance by using pedotransfer functions (PTF) to estimate difficult-to-measure parameters from easy-to-measure soil characteristics.

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The magnitude in which the data crisis manifests itself with respect to any parameter, is a function of how sensitive the applied simulation model reacts to the uncertainty of this parameter. Uncertainty of model outputs is a function of how well the processes are estimated by the model, how well the input parameters are measured or estimated, and how strongly the parameter values vary in space or in time. Few texts exist that elaborate on how the magnitude of the data crisis relates to specific model-parameter combinations, and what are possible consequences for sampling. This paper outlines the relation between the data crisis, models and several sources of uncertainty. The following topics are addressed:

(i) the role of existing soil data for the current generation of water balance simulation models and for models built on new concepts such as fingered flow and bypass flow;
(ii) deciding on the use of existing soil data or new data collection;
(iii) uncertainties involved in the use of PTF;
(iv) pragmatic solutions to the data crisis in scenario studies;
(v) options to present the combined effects of temporal (e.g. climatic) and spatial variability on a response variable.

These items will be addressed using case studies from The Netherlands and the Philippines, which were variant studies. The text will focus on data demands for models describing processes in the topsoil.

The role of existing soil data for current and next generation models

Soil data play an important role in the application of models. Two main applications of soil data are distinguished:

(i) *Identification*: the use of soil survey data to obtain functional units with respect to soil behaviour in a vertical and lateral sense. Examples are the use of soil survey data (profile descriptions) to group soil layers with comparable behaviour into "functional layers" (Wösten *et al.*, 1985) and the use of soil maps to obtain spatial patterns of soil behaviour on a regional scale (Breeuwsma *et al.*, 1986; Bregt and Beemster, 1989). Another example is the use of soil maps to select areas where a problem does or does not occur (Van Lanen *et al.*, 1992).
(ii) *Estimation*: the use of soil characteristics to estimate process parameters. A well-known example is the development of class-PTF and continuous PTF to estimate the parameters describing the relations between soil water pressure head, hydraulic conductivity and volumetric water content (Hutson, 1983; Wösten and Van Genuchten, 1988; Vereecken et al, 1989), of which Tietje and Tapkenhinrichs (1993) give an overview. Documented examples exist also for PTF that estimate chemical parameters for models. Examples for PTF to estimate the denitrification rate constant and the Cation Exchange Capacity are given in Breeuwsma *et al.* (1986, 1991). Examples related to mineral weathering are given in De Vries *et al.*, 1994.

Which of the two application types is most frequently used, depends in our opinion on the complexity and the degree of implementation of the model. As an example we will consider the case of water flow models.

Preferential flow models

The current generation of (deterministic) simulation models concerning water flow in the unsaturated zone is based on the Richards' equation and, in case of solute transport, on the convection-dispersion equation. Both assume the soil as a vertical sequence of homogeneous isotropic porous media. The data needs associated with this type of model were and are still being met by actually sampling the necessary data on site or by developing and using PTF. The dependence of soil physical characteristics on texture, bulk density and organic matter content is common knowledge and is used to develop PTF.

Developments within the current models are partly concentrated on technical aspects (numerical schemes, analytical solutions) and partly on the formulation of soil chemical processes (e.g. Boekhold *et al.*, 1992; Johnsson *et al.*, 1987) and associated data needs. With respect to the current generation of models, soil data are used both for identification and estimation. The type of soil data needed is known, and methods to obtain those data are or have been implemented.

Some major changes on modelling water flow in the unsaturated zone can be foreseen for the future. These are related to the proven invalidity in field situations of the assumption of homogeneous Darcy type flow. We will elaborate on the data needs for forthcoming models on preferential flow.

Preferential flow is here defined as non-uniform vertical displacement of water. Practical importance of preferential flow is associated with the higher risk of water and solute losses from the topsoil when compared to homogeneous infiltration. It is for this reason, that some modelling efforts have been made to quantitatively describe preferential flow. Models, both conceptual and implemented, exist. We will distinguish between macropore-flow (preferential flow through continuous macropores) and fingered flow (preferential flow through the soil matrix) because of the marked role of soil structure and the more advanced development of computermodels in the first case. The role of soil data in some pedon-scale models is summarized in Table 1.

A number of simulation models are now operational to describe the process of macropore flow. Bronswijk (1988) describes a model for swelling and shrinking clay soils and uses shrinkage characteristics to obtain a dynamic distribution of solid- and macropore domains as a function of the water content of a soil volume. Booltink *et al.* (1993) describe a model that can be used in any structured soil that does neither shrink nor swell. Input needed is (a.o.) a fractal interpretation of staining patterns at several depth intervals.
No fully operational deterministic models for preferential flow through the soil matrix (fingered flow) exist as yet, though some attempts have been made (Steenhuis *et al.* 1990). We will therefore treat the existing knowledge on the occurrence of fingered flow as fragments of conceptual models. The soil characteristics that are recognized to play a role

Table 1. Causes of and soil parameters related to preferential flow

Flow process	Physical cause	Indicative soil properties	Model type*	Model parameters	Reference
macropore flow	swelling/ shrinkage	swelling clay	i	Shrinkage characteristics	Bronswijk 1988
	structure formation	structured (top-)soils	i	Fractal dimension of staining patterns	Booltink *et al.*, 1993
fingered flow	non-homogeneous infiltration-	- microrelief - vegetation pattern	c	- -	Bronswijk *et al.*, 1990
		- water repellency (micro-morphology, drop tests)		- -	Bisdom *et al.*, 1993 Dekker and Ritsema (in press)
	unstable wetting fronts	- hydraulic conductivity increases with depth (surface crusts, textural gradient)	c	-	Raats, 1973 Ritsema and Dekker, 1994
		- water repellent surface layer	c	-	Hendrickx *et al.*, 1993

* : c=conceptual, i=implemented.

in the occurrence of fingered flow (indicative soil properties in Table 1), will most probably become input parameters in an implemented model (Table 1), or will be used as "early warning parameters" to signal the occurrence of preferential flow. The role of soil data on a parameter level is not yet clear.

In summary, in implemented models on preferential flow, soil data are used for both identification and estimation. In models that are still in a conceptual phase, soil data are mainly used for identification. New data needs concern the quantification of soil structure and its dynamics, and probably also factors like water repellency, microrelief and (susceptibility to formation of) crusts.

Deciding on the use of existing soil data or new data collection

Representativeness of soil data

Often, soil data are used for purposes different from the one they were collected for. An implication of this is that soil data bases often contain detailed information on parameters which may not be used as input to simulation models, whereas the needed data are missing. Another implication may be that sampled profiles, which were considered to be representative in a pedo-genetic sense, are not at all representative in the sense of practical soil behaviour. Both implications may or may not have consequences in the usefulness of existing soil data. We will address the matter of representativeness using a case study from The Netherlands.

Case study:

Comparison of two approaches to characterize soil mapping unit behaviour (Finke et al., 1994b)

The study focused on a soil mapping unit (SMU) as it occurs in the northeastern part of The Netherlands on the 1:50,000 soil map (Fig. 1). The SMU is defined as a sandy, siliceous, mesic Typic Haplaquod with a mean highest water-table (MHW) shallower than 40 cm and a mean lowest water-table (MLW) deeper than 120 cm. The behaviour of the SMU was established by using simulation models to calculate five functional properties of individual soil profiles located in the SMU. The data sets analyzed in this study consisted of: (i) the RP-data set: three Representative soil Profile descriptions for the SMU in three map sheets; (ii) the STS-data set: 24 soil profile descriptions obtained following a Stratified Two-Stage random sampling design (Cochran, 1977), where the three map sheets served as sampling strata.

Five soil properties were simulated for each soil profile using a connected water flow and solute transport model. A period of 18 months was simulated between October 1, 1979 and April 1, 1981, because the year 1980 is considered a representative year in terms of its precipitation surplus. The five properties were:

(i) The number of days with a good workability of the soil, assessed by the number of days between March 15 and May 15 where the pressure head at 5 cm depth is -70 mBar or dryer;
(ii) The number of days with sufficient aeration, assessed by the number of days in the same period with an air-filled porosity at 5 cm depth of at least 0.1 $m^3.m^{-3}$;
(iii) The elapsed time to 10% breakthrough of an inert tracer (Chloride);
(iv) The % breakthrough after 1 year of an adsorbing, inert contaminant (cadmium);
(v) The % breakthrough after 1 year of an adsorbing, degrading herbicide (Isoproturon).

Properties (iii) to (v) apply to a plane at 40 cm depth, below which solutes are considered lost for plant uptake.

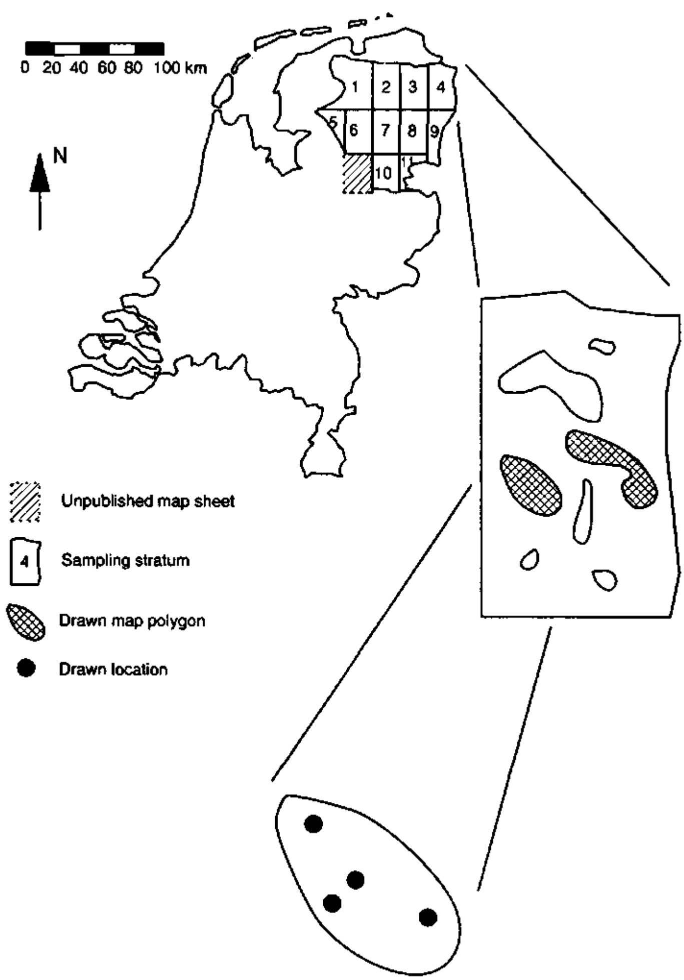


Fig. 1. Stratified two-stage sampling procedure in Typic Haplaquods in The Netherlands. In each sampling stratum two map polygons are drawn with replacement. In each drawn polygon, four sampling locations are drawn randomly.

Two options of characterizing SMU behaviour were compared: first, by using the available representative profiles; second, by using a number of profiles located in the SMU according to the statistical sampling design described above.

Basic soil data available were profile descriptions consisting of general characteristics such as rootable depth, MHW and MLW, and further, for each soil horizon, its depths and the characteristics: clay%, (clay+silt)% (CS), organic matter% (OM), pH_{KCl} and the median of the sand fraction (M_{50}).

It was investigated whether the representative profiles yielded accurate estimates of mean values for each property. A one-sample t-test on the difference of RP-values and STSvalues was made, adjusted for the used sampling design. Results showed, that the representative profiles yielded biased estimates of SMU-behaviour for four out of five simulated soil properties (Table 2). The bias was not only significant, but in case of the properties *cadmium breakthrough, Isoproturon breakthrough* and *days with sufficient aeration,* also highly relevant. This result presents important information for users of soil survey information in scenario studies, because when a distinct bias occurs already on a time scale of 18 months, little reliability of scenario studies can be expected over longer time periods.

To obtain reliable SMU-scale estimates of soil behaviour, it was proposed to select soil profiles using a probabilistic approach. Seven profiles sufficed to describe the 5%, 50% and 95% probability points in the SMU for all five calculated soil properties (Table 2). This approach gives good opportunities to make risk assessments in addition to the estimation of average behaviour in SMU, which may be important when the evaluation of scenarios is based on risks rather than on average values.

Table 2. Results of the test that RP data set yields good estimates of the stratum mean. The profile numbers corresponding to characteristic points of the cumulative frequency distribution of model output are presented. df is degrees of freedom, s.e.m. is standard error of mean values. From: Finke et al., 1994a.

Variable	Unit	Deviation from RP-values		t-value	Significance (%, df=21)	Profile number at % cumulative probability		
		mean	s.e.m.			5%	50%	95%
Workability	day	2	1.10	1.96	>85	114	103	64
Aeration	day	19	4.73	4.00	>95	114	103	64
Chloride breakthrough	day	-3	0.60	5.1	>97.5	64	103	114
Cadmium breakthrough	-	1.26	0.09	14.00	>99.5	86	107	113
Isoproturon breakthrough	-	1.44	0.45	3.20	>95	108	107	113

In this case study, both representative profiles and profiles sampled according to a statistical design were available. The question when to stop using available data (representative profiles) and start collecting new data could therefore be answered only *ad posteriori*. The results of the case therefore do not give a full answer to this question. When a decision on the continuation of sampling is to be made, sequential sampling methods can be applied during the sampling itself (Stein *et al.*, 1989).

When soil sampling aims at collecting representative soil data, an approach could be followed consisting of the following steps:

a. Perform a reconnaissance survey and simulate a standard scenario using the sampled data;

b. Use the simulated values of the target variable and sequential sampling statistics to decide if a good estimate of the average behaviour (for the spatial body considered) can be made;
c. If so, select a profile from the distribution obtained in b that is closest to the median, and take that profile as most representative.
d. If not so take a limited number of new samples and continue with b.

The conclusions of this case study with respect to scenario studies can be summarized as follows:
- When scenario studies are to be performed for spatial bodies, e.g. SMU's, attention must be given to the selection of representative soil profiles showing "average" behaviour;
- The effect of spatial variability (within SMU's) can be included in scenario studies when a few soil profiles representing characteristic points in the probability distribution of soil behaviour are included in the analyses.

Uncertainties involved in the use of pedotransfer functions

When continuous PTF are used, spatial variation of basic soil data is directly translated to variation of hydraulic functions and, subsequently, to variation of model outcomes. Additional to the effect of spatial variation of basic soil data on PTF's the estimation error of the PTF has an effect on variation of model outcomes. This effect may have consequences for data sampling.

Case study:

Effects of uncertainty in major input variables on simulated functional soil behaviour (Finke et al., 1994b)

This study aimed at quantifying the effect of variation of several model input variables on model outcomes. The role of soil variability was compared to that of PTF uncertainty, and evaluated for parameters of both a physical and chemical nature. Additionally, the spatial variation in water-table depth is considered. This case study was based on 88 profile descriptions, sampled in a stratified two-stage scheme in the SMU described in the previous section. The five properties mentioned earlier were used to evaluate physical and chemical soil behaviour.

The PTF's used (Finke *et al.*, 1994b) were constructed with multiple non-linear regression techniques from OM%, bulk density, (clay+silt)%, median of the sand fraction and the factor top- or subsoil to Van Genuchten parameters. A detailed description is given in Wösten *et al.* (1994). Along with these PTF's an error-covariance matrix was obtained during the regression. The PTF-error distribution was sampled, as was soil variability. For each combination of PTF-error and spatial sample, simulation runs were done to calculate the five mentioned soil chemical and physical soil properties. This resulted in 1760 simulations for each soil property. The impact of soil variability versus that of PTF-uncertainty was evaluated through an analysis of variance.

Results showed, that the role of PTF-uncertainty is process-dependent. Soil factors that are mainly related to soil water transport (Days with a good workability, Days with sufficient aeration, days until 10% Chloride breakthrough) were sensitive to uncertainty of PTF (Fig. 2). Between 23.2% (Chloride breakthrough) and 63.7% (Aeration days) of total variance was explained by PTF-uncertainty. Variability of soil factors associated with adsorption and degradation processes (breakthrough of Cadmium and Isoproturon) however, was almost completely (99.9%) determined by soil variability (Fig. 2). For four of the five properties (Chloride breakthrough excluded), the variability of MHW and MLW explained approximately 50% of the total effect of soil variability.

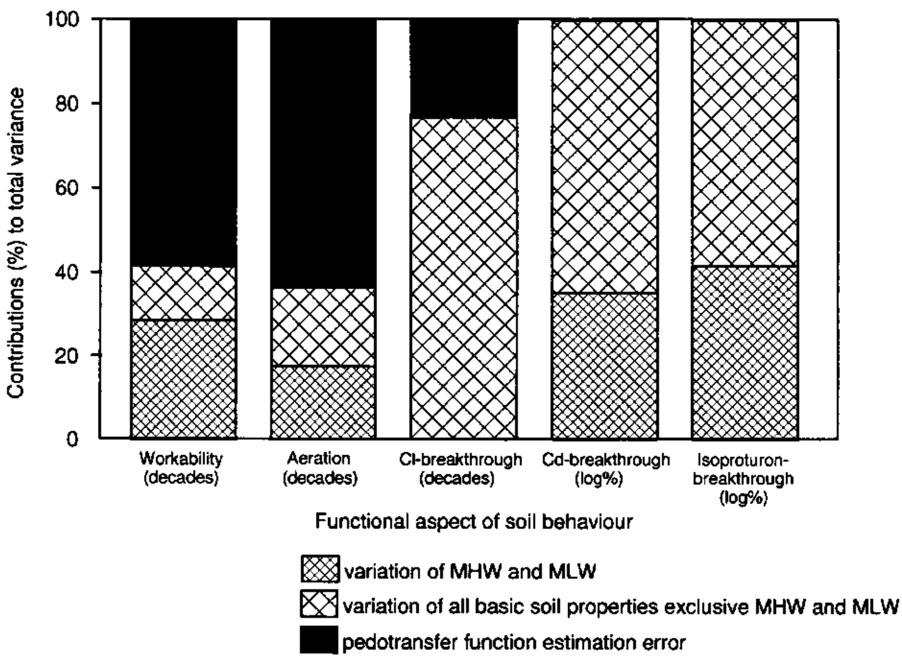


Fig. 2. Contributions of three sources of variation to total variance of five simulated soil properties.

The conclusions of this case study in the context of scenario studies can be summarized as follows:

- When the uncertainty in model outcomes is to be evaluated, soil variability should be sampled. The current PTF may or may not have an additional effect on total uncertainty, depending on the process studied. The considered PTF was sufficiently accurate for transport studies on degrading and adsorbing solutes. In case of soil properties mainly associated with soil water transport, error contributions of PTF to total uncertainty are distinct, and soil sampling should include the measuring of soil physical characteristics (or aim at more reliable PTF).

Model sensitivity and soil sampling

When few field data are available and research goals involve the use of complicated simulation models, a pragmatic approach to soil sampling is needed. An example of such approach is given from a case study in the Philippines.

Case study:

Sampling strategies for measurement of soil hydraulic properties to predict rice yield using simulation models. (Wopereis, et al., 1993)

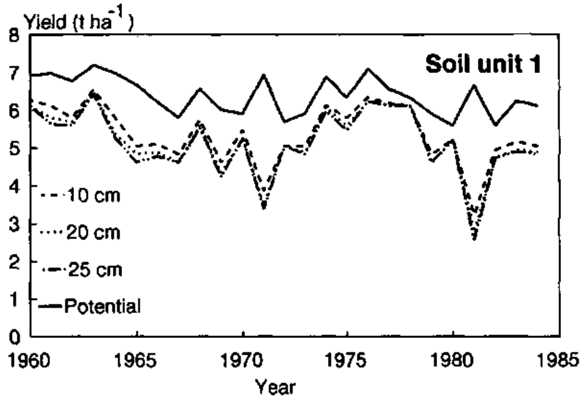
This study aimed at minimizing the sampling effort for soil hydraulic properties given the available meteorological data and a simulation model. The procedure followed was basically a functional sensivity analysis of the simulation model to the hydraulic properties of the topsoil. This model was the MACROS-L2C model for water limited crop production (Penning de Vries *et al.*, 1989) combined with the soil-water balance module SAWAH (Ten Berge *et al.*, 1992). The models were used to simulate the production of rainfed rice, grown in non-puddled soil.

The data needs for the combination MACROS-L2C/SAWAH and the availability of data in the case study are:

- Weather data: MACROS-L2C needs daily values of solar radiation, minimum and maximum temperature, rainfall, relative humidity and windspeed. Twenty-five years of weather data were derived from the IRRI dryland meteorological station.
- Crop data: Crop parameters for MACROS-L2C were taken from Penning de Vries *et al.* (1989) for rice variety IR36.
- Soil data: Representative sites were identified for six major soil units occurring in the study area and detailed profile descriptions were made. Hydraulic functional horizons (for details see Wopereis *et al.*, 1993a) were sampled for soil water retention and hydraulic conductivity measurements, needed for SAWAH. Groundwater table depth was set to 1.0 m, which was considered a reasonable average value.
- Management data: Simulations were conducted for direct seeded rice in non-puddled soil. Seeding of rice was assumed to start when cumulative rainfall exceeded 75 mm of rain during seven consecutive days after 1 June.

The functional sensivity analysis involved comparing the effect of two sources of variability on simulated yield: (i) variability of the thickness and hydraulic functions of the topsoil; (ii) variability of weather conditions.

The impact of temporal variation in weather on simulated rainfed rice yield was much larger than that of spatial variation in the thickness of the uppermost hydraulic-functional horizon (Fig. 3). An analysis of variance showed that for two contrasting soil units (soil unit 1 and 6), 98% of the variability in simulated rice yield is explained by weather



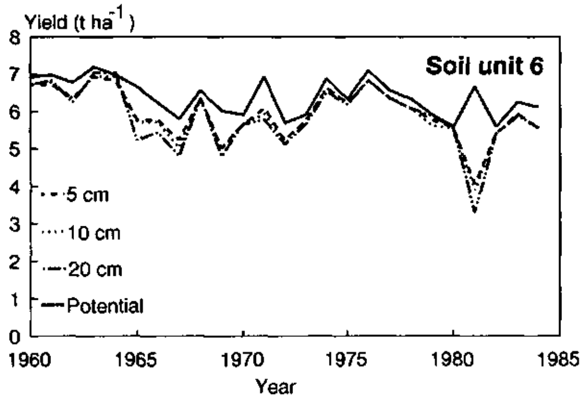


Fig. 3. Rainfed rice yield calculated for 25 consecutive wet seasons (1960-1984) for two contrasting soil units (1 and 6), varying the thickness of hydraulic-functional soil horizon 1. For comparison potential rice yields are plotted as well.

variability only. In soil unit 6, it was also much larger than that of spatial variability in hydraulic functions of the various soil horizons (Fig. 4). For soil unit 1, 65% of the variability in simulated rice yield is explained by weather variability. For soil unit 6, 91% of the variability in simulated rice yield is due to changing weather conditions. It was concluded, that the sampling of the hydraulic properties had been adequate, since the impact of the variability of weather conditions was dominant.

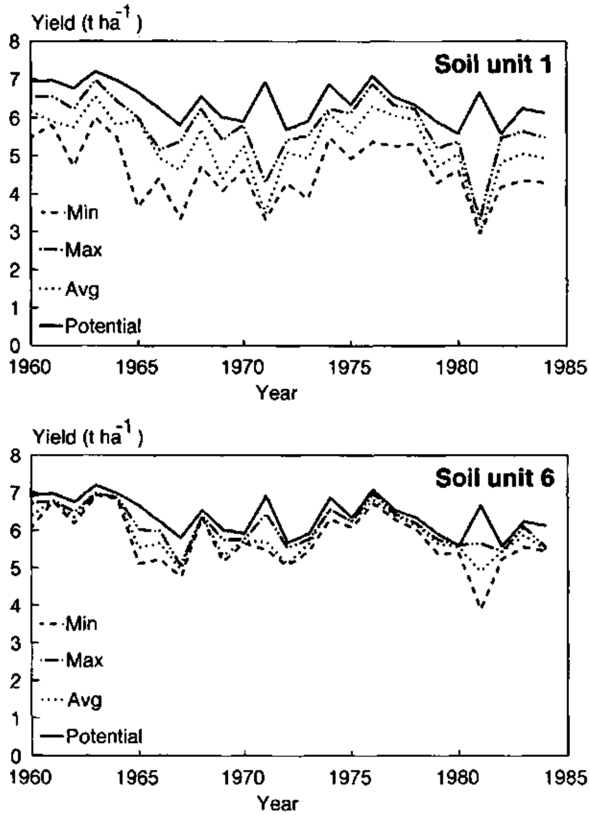


Fig. 4. Minimum, maximum and average simulated rainfed rice yields resulting from spatial variability in soil hydraulic functions for two contrasting soil units (1 and 6), and simulated potential rice yield for 25 wet seasons (1960-1984).

The conclusions of this case study in the context of scenario studies can be summarized as follows:

- A combination of simulation and sensitivity analyses should be used to design sampling strategies. For soil properties, a reconnaissance survey can give a first impression of the values of soil properties of interest and their spatial variability in a given area. These data may then be used to perform a sensitivity analysis with a simulation model in the range of the collected data values, and for a number of clearly different years (e.g. years with a relatively low and high rainfall). The results of such sensitivity analyses would indicate the desired level of accuracy and detail with which soil (hydraulic) data need to be collected. Sensitivity analyses may be conducted for any input parameter, and should take mutual correlations between these parameters into account (Bouman *et al.*, 1994).

Pragmatic solutions to the data crisis in scenario studies

Two reasons may be distinguished why the data crisis is felt more painfully in scenario studies than in other simulation studies. The first reason is, that scenario studies usually cover a longer time-period, which brings in a need for exogenous model inputs (i.e. inputs that are not generated by the scenario system). Examples of these type of data may be weather data and other boundary conditions. The second reason may exhibit itself when scenario studies are executed for areas of land and spatial variability is to be taken into account. The data crisis here applies to process parameters and to the model initialisation. Below we will mention some pragmatic solutions to the data crisis in the case of
- exogenous inputs;
- model initialisation;
- process parameters.

Exogenous inputs

Since most scenario studies relate to future conditions, exogenous inputs can not be measured but have to be estimated. One way of doing this, is the common practice of copying an existing time-series into the future. Another way is to use a time-series generator which has to be parametrized first using existing data. Supit (1986) gives an example for a weather-generator for agrohydrological scenario studies. In some cases, a spatial extension can be given to time-series of model boundary inputs. Finke *et al.* (1994a) use the MHW and MLW to translate a characteristic time-series of groundwater-tables to different locations. This transfer function took account of 87% of the variation at five independent plots. A more universal method for generating boundary inputs should eventually emerge from models describing the exogenous compartment. Stochastic space-time models are a significant development here.

Model initialisation

The data needed for model initialisation may be limited when the initial status shows spatial variation. This spatial variation may be caused by variation in soil properties, but also by variations in land use. When scenario studies cover a relatively short period, the errors caused by the uncertainty about the initialisation status may influence scenario results. In such a case, a pragmatic approach in obtaining a realistic, spatially varying initial model status is needed.

National scale scenario studies that are done in The Netherlands in the field of agricultural effects on water quality are initialized 30 years before the scenario period starts, estimating the initial nutrient status for each spatial unit. The water quality model is subsequently run for each spatial unit using soil data and data on land use, weather evolution, etc. The final status after the 30 years simulation period is then used as initial status for the actual scenario studies (Kroes *et al.*, 1990).

Process parameters

The lack of values of process parameters is strongly felt in many simulation studies. For this reason, efforts have been made to estimate these parameters from available soil data by PTF. Three approaches are possible for the construction of PTF:

(i) Translate soil map bodies to representative process parameters directly ('pedotransfer rules');

(ii) Translate a class of basic soil characteristics to a representative value of a process parameter (class-PTF, Bouma and Van Lanen, 1987);

(iii) Translate one or more basic soil characteristics to a value for a process parameter (continuous PTF, Bouma and Van Lanen, 1987).

Several examples of 'pedotransfer rules' are given by De Vries *et al.* (1994) for soil chemical process parameters (denitrification fraction, base cation weathering rate, selectivity constant for aluminum/base cation exchange) and state variables (calcium carbonate content, oxalate extractable aluminium). Assigning land qualities to soil bodies in the context of a qualitative land evaluation procedure is another example. Examples of class-PTF are the Dutch Staring Series, which assign Van Genuchten parameter values to texture classes (Wösten *et al.*, 1994), and a PTF that estimates oxygen diffusion coefficients in soils using texture class and soil structure class (Bakker *et al.*, 1987). An overview of continuous PTF which parametrize soil hydraulic functions is given by Tietje and Tapkenhinrichs (1993). Continuous PTF are also reported which estimate the bulk density (De Vries *et al.*, 1994), the Cation Exchange Capacity and Phosphate Sorption Capacity (Breeuwsma *et al.*, 1986), the yearly pyrite oxidation rate (Bronswijk *et al.*, 1994). Other examples exist, of which Larson and Pierce (1991) give an overview.

Options to present the combined effects of spatial and temporal variability on a response variable

When one or more sources of uncertainty exist, be it spatial or temporal, this uncertainty should be taken into account when analyzing and presenting the results of scenario studies. Incorporation of uncertainties is necessary when the evaluation of risks is a purpose of a study.

A few cases exist where the effect of one major source of variability is analyzed in the context of a variant-study. Finke (1993) performed multiple point simulations on a field scale, and interpreted the results on a yearly basis, thus integrating the effect of temporal variability in the response variable. The spatial variability is interpreted stochastically using the method of Disjunctive Kriging to create a map where the probability of exceeding a threshold value is indicated (Fig. 5). Another example is given by Wopereis (1993), who presents maps of percentiles of simulated rainfed rice yield for the province of Tarlac, Philippines. Spatial variability is addressed globally by simulating the behaviour of each soil unit using one representative profile, but temporal (meteorological) variability is addressed in detail by simulating 25 consecutive years. The output distribution of each soil unit is used for presentation purposes (Fig. 6).

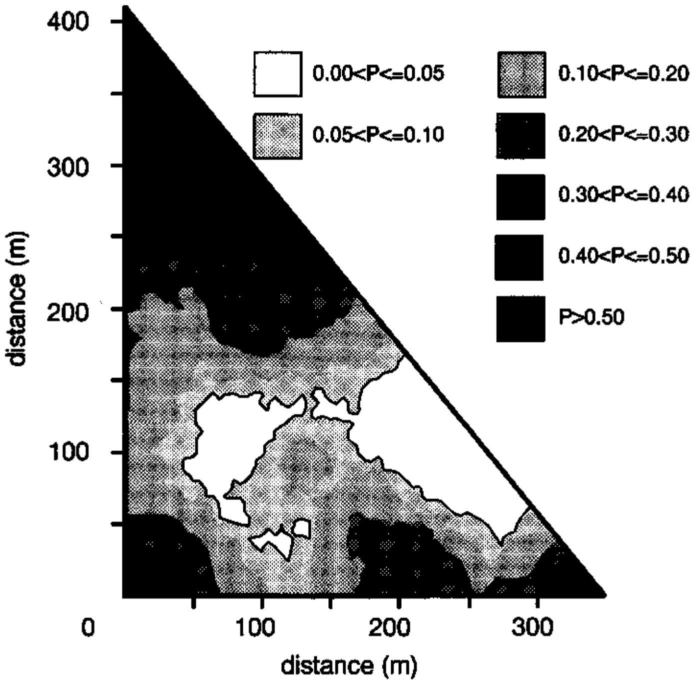


Fig. 5. Map showing the probability (P) that the yearly leaching concentration exceeds 50 mg NO_3/l at an annual addition of 400 kg N/ha as chicken slurry

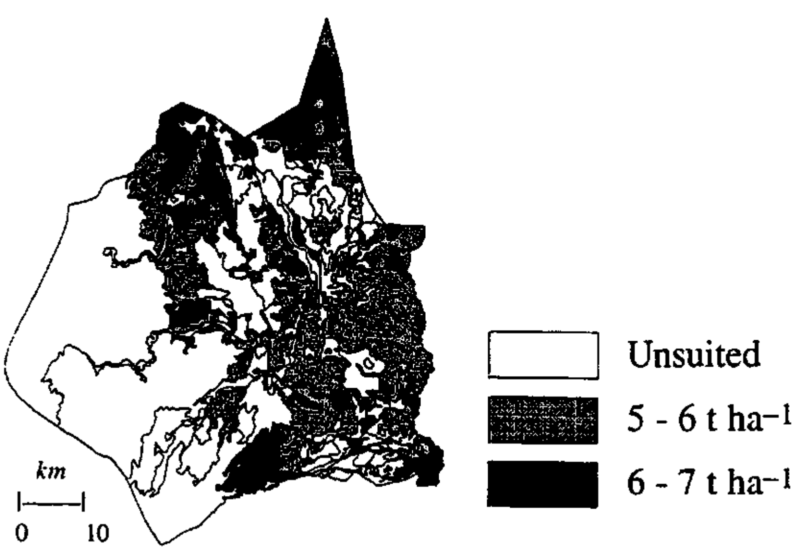


Fig. 6. Map of simulated rainfed rice yield (t ha^{-1}) at 90% cumulative probability

When more than one source of variation is important, the combined effects of both should be incorporated in the presentation. This approach has consequences for the research method. A possible method is to calculate the whole temporal sequence for each discrete spatial unit, and subsequently calculate cumulative probability densities for each spatial unit. This is basically the approach of Wopereis (1993), but the spatial discretization can be refined, for instance by running the model on random locations within each soil unit.

The conclusions in the context of scenario studies can be summarized as follows:
- The presentation of variable results of scenario studies in terms of probabilities (e.g. of exceedance of threshold values) is a powerful tool, whether the major source of variation is temporal or spatial.
- Presentation methods must be further developed to better analyze scenarios in terms of risks instead of trends only. This especially holds when evaluating combined effects of different sources of variation.

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8.2 Regionalization and parameterization of hydrological processes at the land surface

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Abstract
Hydrological processes at the land surface play a critical role in physically based hydrological and atmospheric modelling. A series of experiments have been initiated to test and develop parameterizations of spatial heterogeneity at the full range of spatial and temporal scales considered relevant. The methodology followed in these experiments is to combine small scale measurements of energy partitioning at a few relevant, typical, vegetation types with larger scale measurements obtained by aircraft and remote sensing and compare these with modelling results. The resulting improved understanding should help to include subgrid variability in large scale hydrological and atmospheric models in a more realistic way.
Keywords: *land surface atmosphere interaction, modelling, remote sensing, HAPEX, aggregation*

Introduction

Hydrological processes at the land surface play a critical role in physically based hydrological and atmospheric modelling. Coupled hydrological and meteorological models are the basic tools to study the effect of changes in land use on water resources and climate. These models operate on spatial scales many times larger than those for which the physics was originally developed, and at which the land surface changes appreciably. Testing the applicability of small scale physics on large scales and concurrent development of parameterizations which take into account the heterogeneity of the landscape form an exiting area of science with immediate applications for natural resource management on both regional and global scales. In the development of these models, aggregation and disaggregation methods meet through a physically based description of the relevant processes (Figure 1).

A series of experiments have been initiated by the World Climate Research Program (WCRP) and the International Geosphere Biosphere Program (IGBP) to provide the required data to test and develop parameterizations at the full range of spatial and temporal scales considered relevant (Shuttleworth, 1992). These experiments have taken place or are planned in areas which suffer from human induced or climatic pressure on natural resources such as the Mediterranean (Bolle et al., 1992), the Sahel (Goutorbe et al., 1993) and the Amazon basin (Dolman et al., 1994). The basic strategy in these experiments, in which the DLO Winand Staring Centre (SC-DLO) is participating, is to combine simultaneous measurement of water, CO_2 and energy fluxes across the landscape at various scales with interpretive modelling and remote sensing at these scales. The basic aim of

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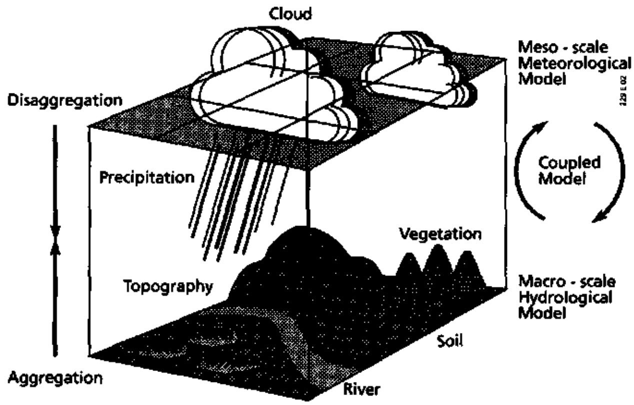

Fig. 1. Schematic diagram showing the linkages between aggregation, disaggregation and atmosphere and land surface hydrology.

the modelling is to test and develop rules for deriving "effective" parameters for large scale applications from a knowledge of the small scale variability and the physics involved in defining the area-averaged fluxes.

Methodology

The basic methodology followed in these experiments is to combine small scale measurements of energy partitioning at a few relevant, typical, vegetation types with larger scale measurements obtained by aircraft. In HAPEX-Sahel (Goutorbe et al., 1993) this strategy resulted in three so called supersites where micrometeorological measurements were made over the typical land cover of that region: fallow savannah, natural degraded forest and millet (Figure 2). At these supersites, aircraft flew specifically designed patterns to measure the regional fluxes of energy and momentum. Scattered over the square, a number of automated weatherstations measured standard synoptic variables. Remote sensing is used to provide areal integration of land surface characteristics and radiative properties. A comprehensive three-dimensional mesoscale modelling programme investigates the interaction of the different land surface types through advective processes.

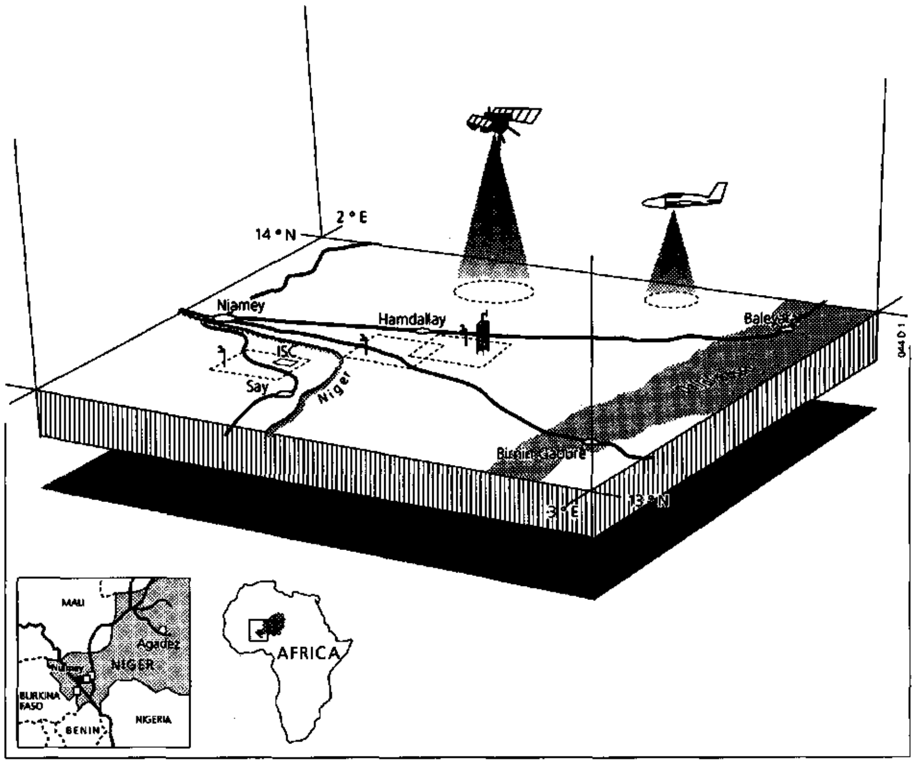

Fig. 2. Schematic diagram showing the typical layout of a HAPEX type experiment. This figure is for HAPEX-Sahel, showing three supersites and various measurement systems.

Measurements

Surface fluxes of heat, water vapour and momentum were measured by eddy correlation; a technique which measures turbulent fluxes by correlating high frequency deviations from a mean for vertical windspeed and temperature, CO_2 and humidity. Figure 3 shows the CO_2 flux for two days measured over fallow savannah in HAPEX-Sahel. A clear development in the magnitude of these fluxes can be observed. This is due to the growth of the vegetation. HAPEX-Sahel was the first experiment where these techniques were applied for such a long period under harsh environmental conditions. This data forms the basis for the development of detailed Soil Vegetation Atmosphere Transfer schemes (SVATs) which will link atmospheric exchange processes of energy and momentum with biophysiological control mechanisms in the vegetation.

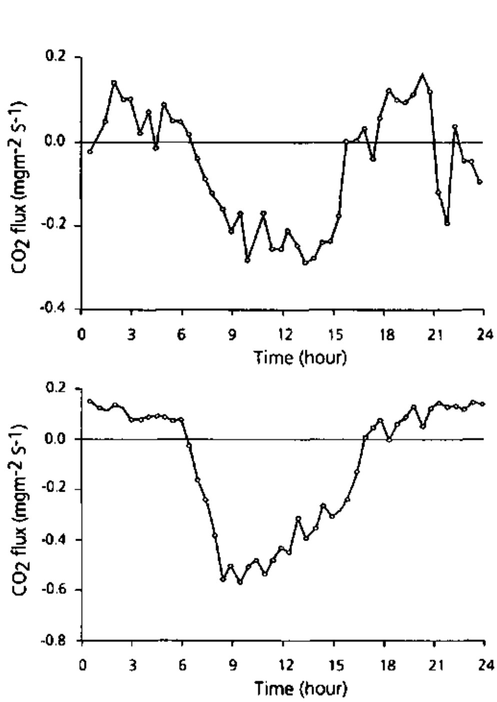

Fig. 3. CO_2 fluxes for two days during HAPEX-Sahel for fallow savannah. a) 21 August 1992 and b) 9 October 1992.

Modelling

Models representing the transfer of energy, CO2 and water for homogeneous land surfaces are calibrated with the measurements obtained by micrometeorological techniques. These SVAT schemes describe in detail the control the vegetation exerts over transpiration and the flow of water through the unsaturated soil to the groundwater. A version currently under development at SC-DLO is the combined unsaturated zone-vegetation model SWAP-MITRE (Kabat and Feddes, 1994, Dolman, 1993). SVAT models form the basic unit of the larger scale models (mesoscale) which operate on domains of several tens to a hundred kilometres. A non-hydrostatic mesoscale model (KAMM, Adrian and Fiedler, 1992) is used to study the effect of landscape heterogeneity on area-averaged fluxes. The area-averaged fluxes produced by this fully 3-D model are then compared with simpler representations (parameterizations) in which the heterogeneity is integrated into a single "effective parameter" for a large area.

Remote sensing

Remote sensing provides the third corner in the experimental strategy of these experiments by providing the means for areal extrapolation of locally obtained results. A new algorithm (SEBAL, Bastiaanssen, Roebeling and Hoekman, 1994) has been under development at

SC-DLO to produce regional fields of evaporation. Some of the parameters controlling evaporation are then derived by simple techniques such as inverse modelling.

Conclusions

The primary issues relating to today's regional and global environmental problems relate to the effect of spatial variability in soils and vegetation, viz. how to aggregate the current one-dimensional knowledge of physical processes to the full three-dimensional system of the real world. Within these experiments several techniques are applied to gain insight into the biophysical controls of the fluxes of energy, CO_2 and momentum at a range of spatial -and temporal- scales. This improved understanding should help to include subgrid variability in large scale hydrological and atmospheric models in a more realistic way.

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8.3 Uncertainty in long-term predictions of forest soil acidification due to neglecting seasonal variability

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Abstract
Soil and soil solution response simulated with a site-scale soil acidification model (NUCSAM) was compared with results obtained by a regional soil acidification model (RESAM). RESAM is a multi-layer model with a temporal resolution of one year. In addition to RESAM, NUCSAM takes seasonal variability into account since it simulates solute transport and biogeochemical processes on a daily basis. Uncertainty caused by the neglect of seasonal variability in long-term predictions was investigated by a comparison of long-term simulations with RESAM and NUCSAM. Although both the seasonal and the interannual variation in soil solution parameters were large, the trend in soil solution parameters of RESAM and NUCSAM corresponded quite well. Generally it appeared that the uncertainty due to time resolution in long-term predictions was relatively small.
Keywords: *soil acidification model, model comparison, uncertainty, seasonal variability, deposition scenario, Solling*

Introduction

Various models have been developed to analyze the long-term response of surface waters and soils to acid deposition, e.g. MAGIC (Cosby *et al.*, 1985), ILWAS (Chen *et al.*, 1983), SMART (De Vries *et al.* 1989) and RESAM (De Vries *et al.*, 1995). Except ILWAS, these models have generally been developed for a regional to continental application. Consequently, these models are relatively simple and have a high degree of process aggregation to minimize data requirements for applications at large scales. The opposite is true for models having relatively complex/detailed process formulations, which are often developed for application on a site-scale. Until now, very few site-scale models are available. In particular the ILWAS model, which was originally developed as a catchment model, can be considered as a site-scale model because of its daily, or even smaller, time scale and detailed level of process formulation. One common simplification that has been made in the large scale models is the neglect of seasonal variability of both model input and processes. Therefore these models use an annual time scale and require highly aggregated input (water routing and deposition). These simplifications may cause errors in long-term predictions. Seasonal variability is generally driven by climatic (e.g. precipitation, deposition, evaporation, snowmelt) and biotic factors (e.g. litterfall, mineralization, nutrient uptake).

Here, we report the application of a complex site-scale model including seasonal variability (NUCSAM; Groenenberg *et al.*, in press) and a relatively simple regional scale model (RESAM; De Vries *et al.*, 1995), which neglects seasonal variability, on an intensively monitored spruce site at Solling, Germany. Both models simulate the major bio-geochemical processes occurring in the canopy, litter layer and mineral soil horizons. RESAM has been developed for analyzing long term soil responses to acid deposition on a regional scale.

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In contrast to RESAM, NUCSAM is applicable on a daily basis, since it simulates solute transport and biogeochemical processes with this time resolution, while RESAM uses a yearly basis. Consequently, all the biochemical and geochemical processes are modelled in NUCSAM as a function of temperature, whereas RESAM neglects the effect of temperature.

The main objectives of this study are: (i) to validate both models using a data set from an intensively studied site in Solling, Germany, and (ii) to characterize the effect of neglecting seasonal variability on long-term predictions of soil and soil solution response, by comparing long-term results from NUCSAM with long-term results obtained by RESAM (cf Kros *et al.* 1995).

Methodology

NUCSAM was first validated on a site-scale by comparing simulated concentrations and leaching fluxes with measured values during the period 1973-1990, using monthly observed data from the Solling spruce site (cf Groenenberg *et al.* in press). In order to quantify the uncertainty caused by using a yearly instead of a daily time resolution, a comparison is made between long-term simulations of RESAM and NUCSAM using two deposition scenarios for the period 1990-2090, i.e. a *business as usual* scenario (acid deposition remains constant) and an *improved environment* scenario (acid deposition reduces by 75%; assuming a linear reduction from 1990 to 2090). For NUCSAM the hydrology between 1990 and 2090 was derived by repeating the meteorological data over the period 1976-1989, while the average hydrological fluxes over this period were used for RESAM. For the deposition during the observation period 1973-1990 yearly values were used for wet and dry components as described in Bredemeier *et al.* (in press). The comparison was made between the standard yearly RESAM output and flux-weighted annual average concentrations derived from the standard daily NUCSAM output.

Results

Simulated (by NUCSAM) and measured concentrations in the topsoil (the top 10 cm) and the subsoil (80-100 cm) for Al^{3+} and SO_4^{2-} are shown in Figure 1. Trends and dynamics in the concentrations of SO_4^{2-}, Al^{3+}, and base cations and pH between 1970 and 1990 simulated with NUCSAM compared favourably with time series of observed data during that period. NO_3^- concentrations in the subsoil were overestimated (cf Kros *et al.* 1995).

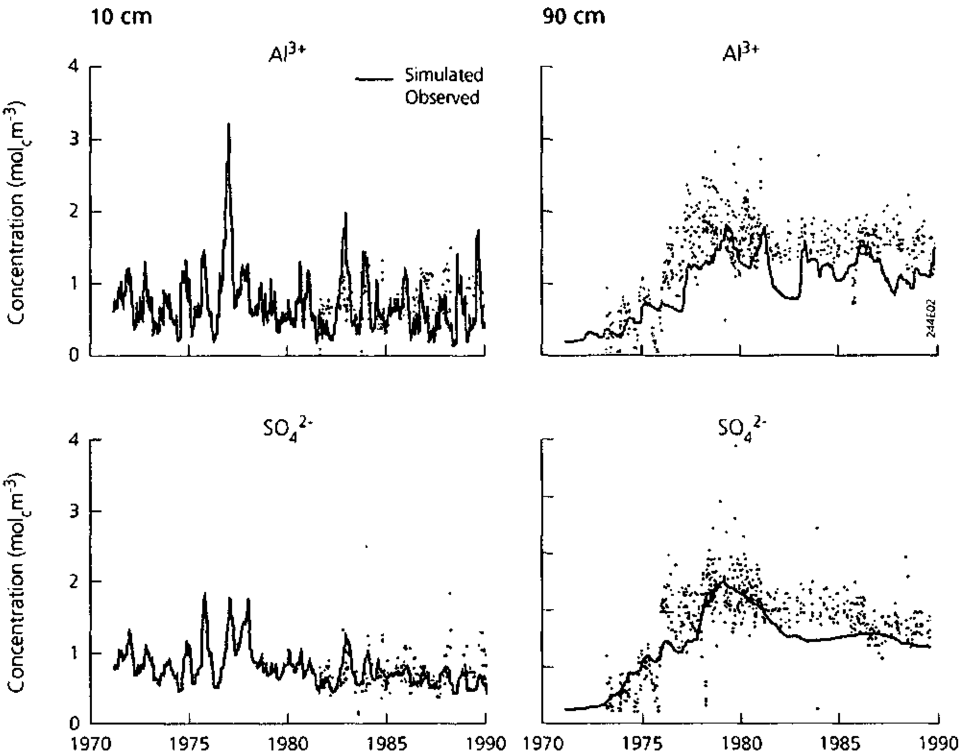

Fig. 1. Simulated (with NUCSAM) and observed concentrations of Al^{3+} and SO_4^{2-} at 10 cm (left-hand side) and 90 cm (right-hand side) depth

Flux-weighted annual average solute concentrations for Al^{3+} and SO_4^{2-} as simulated by NUCSAM and RESAM for the *Business as Usual* scenario are given in Figure 2. For the results, for the *Improved environment* scenario, we refer to Kros *et al.* (1995). Results show that the flux-weighted annual average variation in soil solution parameters predicted with NUCSAM appeared to be large, the trend in soil solution parameters of RESAM and NUCSAM corresponded quite well, while the leaching fluxes appeared to be almost similar (cf Kros *et al.* 1995). Generally it appears that the uncertainty due to time resolution in long-term predictions is rather small.

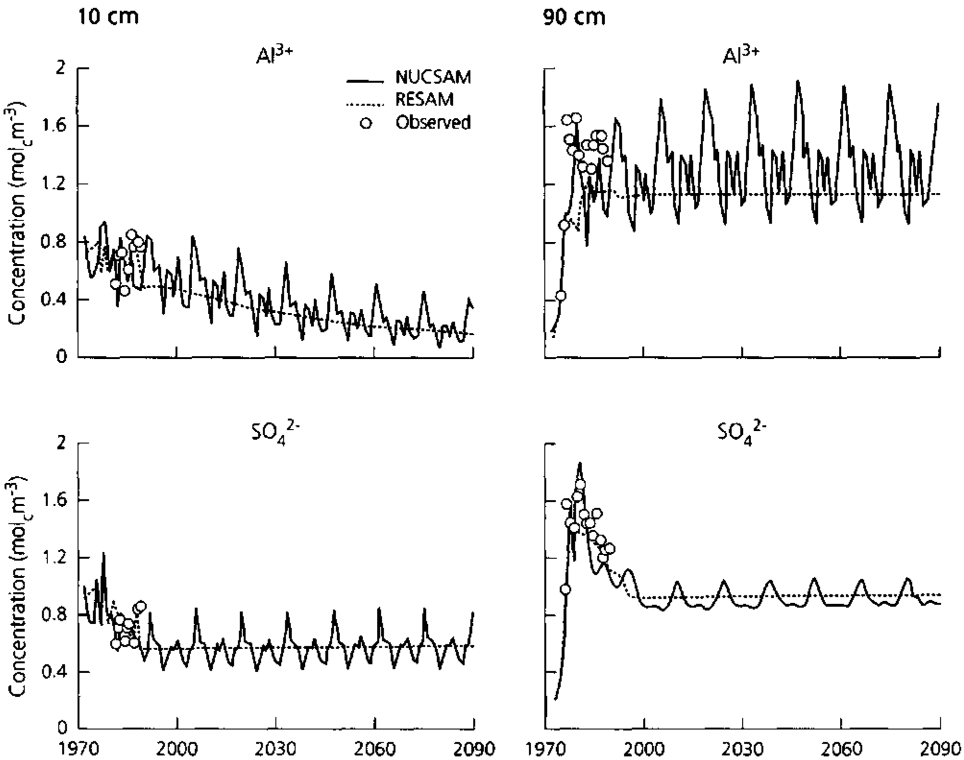

Fig. 2. Flux-weighted annual-averaged concentrations simulated with NUCSAM and with RESAM of Al^{3+} and SO_4^{2-} at 10 cm (left-hand side) and 90 cm (right-hand side) depth, under the Business as Usual scenario. The observed flux-weighted annual-averaged concentrations are also give

Conclusions

Regarding the validation of NUCSAM on the Solling site, it can be concluded that the model reproduces the main features of the concentration variations over time for most concentrations. In particular:

- trends and dynamics of the concentrations of SO_4^{2-} and Al^{3+} are reproduced well;
- simulated NO_3^- concentrations in the subsoil are too high which is of concern since NO_3^- leaching is important for the determination of critical N loads (cf De Vries, 1993);
- simulated Al^{3+}/Ca^{2+} ratios in the subsoil are too low which is of concern since the Al^{3+}/Ca^{2+} ratio is important for the determination of critical acid loads (cf De Vries, 1993).

Considering the capability of RESAM to simulate the observed flux-weighted annual-averaged concentrations (and ratios) we can conclude that this is comparable with or even better than NUCSAM. Because the uncertainties in long-term predictions of soil and soil solution response induced by neglecting seasonal variability are rather small, it can be concluded that RESAM, which neglects seasonal variability, is acceptable for making long-term annual average predictions. A model such as NUCSAM proved to be a valuable link between relatively short data records and long term predictions generated with RESAM.

Acknowledgements
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8.4 Spatial extension of a point water balance model

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Abstract

Regional scenario studies require spatial information. However, most process-based water balance models provide point simulations. This paper discusses the steps we followed to extend spatially a limited number of point simulations of the water balance using spatial continuous data on the soil moisture retention curve.

Keywords : *Soil water balance, Soil moisture retention curve, Simulation model, Kriging*

Introduction

Most of the human activities concerning the rural environment have a spatial dimension. Rarely, our interferences are restricted to an area which can be considered as a point. Yet most process-based simulation models, and water balance models in particular, are point models. The reason for this is the often large amount of input data required, inflating the sampling effort, and the spatial heterogeneity of these input data. The aim of this contribution was to extend the results of a simulation of such a point water balance model, the SOIL model of Jansson (1991a,b), spatially.

Materials and methods

Study area

The study area was a 1500 ha large state farm located in west Hungary. A reallotment of this farm is planned and soil heterogeneity is one of the criteria used. It is covered with quite homogeneous black loess soils (typic Calciustolls) evolved in loess sediments. The area is slightly undulating and mainly under agricultural use. Crops include winter wheat, maize, alfalfa and meadow.

Sampling

The topsoil was sampled at 446 locations and these samples were analysed for the moisture content held at 9 different pressure heads (0, 0.4, 1, 1.5, 2, 2.3, 2.7, 3.4 and 4.2 log(hPa)). Four soil profiles were sampled down to 1.2 m and the same measurements were done on samples of the different horizons (A, AC and C).

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Results

Map of the topsoil soil moisture retention curve (SMRC)
The SMRC of the topsoil samples was modelled using the Van Genuchten equation (3-parameter version, Van Genuchten, 1980). Fig. 1 shows the result of five SMRC's distributed over the area. It can be noticed that the moisture content at 0 hPa varied most and that the shape of the curves is quite uniform, indicating that the topsoil hydraulic properties are quite homogeneous over the area. Therefore, block-kriging was used to create a spatial continuous image of the moisture content at 0 hPa, based on a variogram modelled by an exponential function with a range of 475 m and a nugget to sill ratio of 40 %. Since the moisture content at 0 hPa determines the lower starting point of the SMRC, this image could be used to predict the SMRC of the topsoil of the study area, assuming the other parameters of the Van Genuchten equation to be constant.

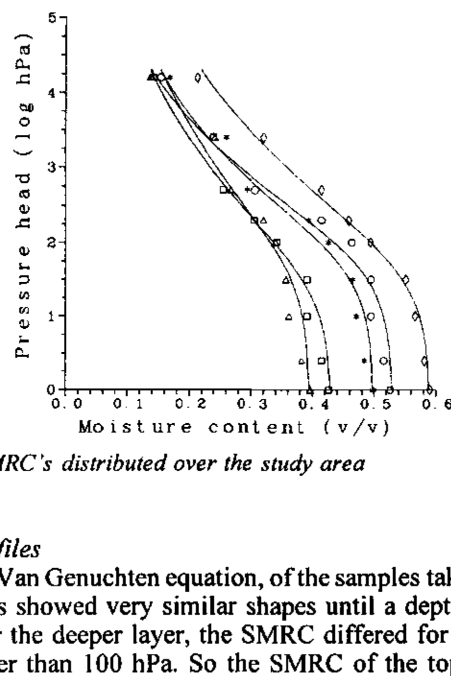

Fig. 1. Five topsoil SMRC's distributed over the study area

SMRC of the soil profiles
SMRC's, fitted by the Van Genuchten equation, of the samples taken at different horizons within the soil profiles showed very similar shapes until a depth of 80 cm (A and AC horizons - Fig. 2). For the deeper layer, the SMRC differed for moisture contents held at pressure heads larger than 100 hPa. So the SMRC of the topsoil could be taken to represent the soil profile down to 80 cm and a slight modification of the parameters of the Van Genuchten equation allowed us to model the SMRC of the deeper layer. In this way the map of the moisture content at 0 hPa could be used to obtain a prediction of the SMRC of the entire soil profile.

Simulations of the water balance
Using the SOIL model of Jansson (1991a,b), the accumulated evapotranspiration (ET) during the growing season of 1993 was simulated for each of the four soil profiles and the four crops cultivated at the farm. Fortnightly measured moisture contents of the soil profiles taken during the growing season of 1993 were used to calibrate the model.

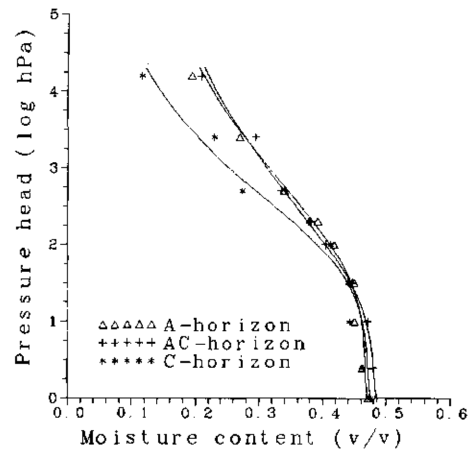

Fig. 2. SMRC's of the different horizons of one soil profile

Spatial extension of the point simulations

A crop-specific close linear relationship between the model output (accumulated ET) and the moisture content at 0 hPa of the topsoil was found. E.g. for winter wheat, variation in the topsoil moisture content at 0 hPa caused the ET to differ between 171 and 212 mm (Fig. 3). These relationships allowed us to extend the point simulations spatially using the block-kriged map of the topsoil moisture content at 0 hPa. Fig. 4 illustrates the spatial extension of the accumulated ET for winter wheat. It can be noticed how the spatial variability of the SMRC of the topsoil influences the output of the simulation of the water balance. Since the climatological conditions of this area can be considered to be constant over the area, variations in the ET reflect variations of the physical fertility of these soils.

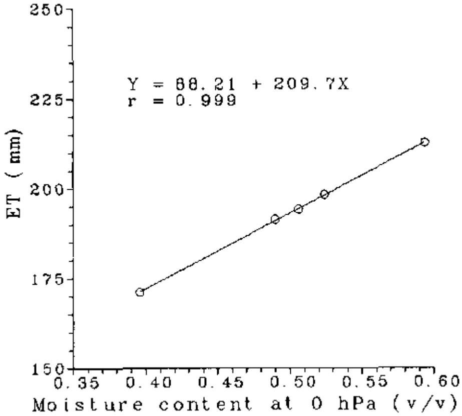

Fig. 3. Relationship between the model output (accumulated ET) and the topsoil moisture content at 0 hPa, using the assumptions described in the text

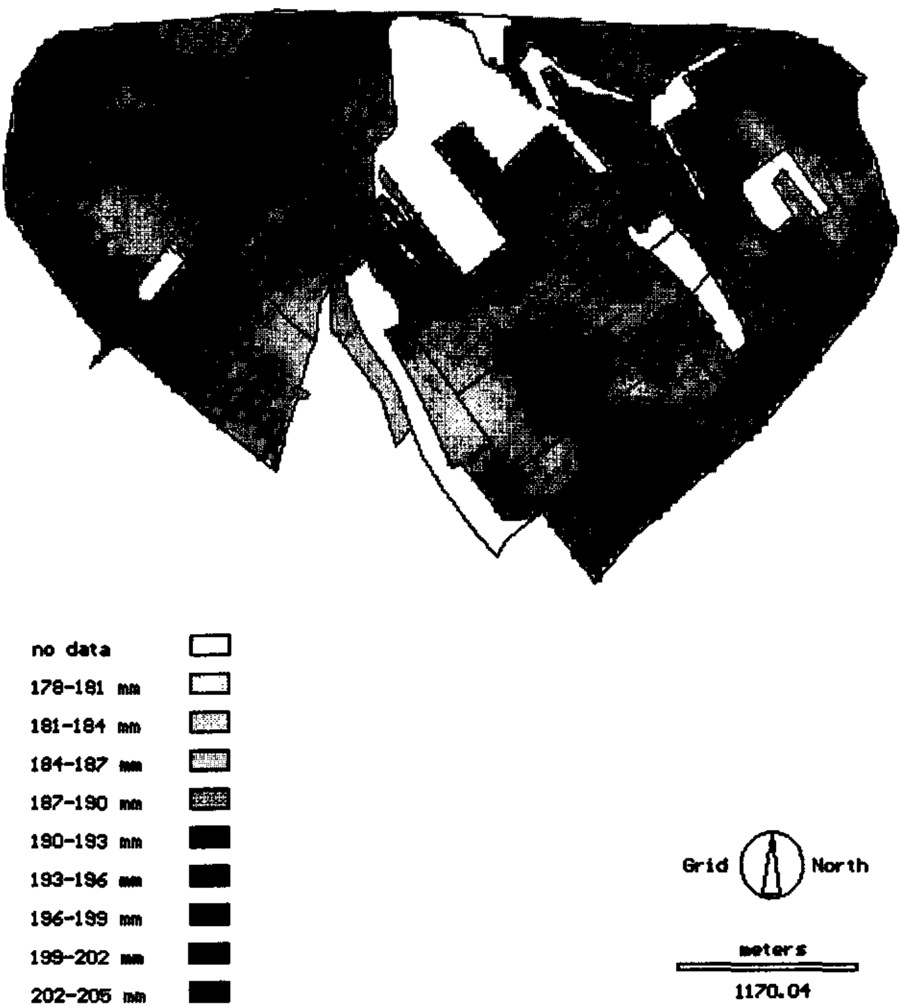

Fig. 4. Spatial continuous image of the accumulated ET for winter wheat during 1993

Conclusions

This study tried to elaborate a procedure which allowed us to extend the spatially limited results of a water balance simulation by combining it with spatial continuous information on the SMRC. Some soil-specific but, according to our results justified, assumptions had to be made. The result illustrates the impact of the spatial variability of soil hydraulic properties on the parameters of a water balance and hence on the physical fertility of soils.

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8.5 Combined calibration and sensitivity analysis for a water quality model of the Biebrza River, Poland

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Abstract
A study was performed to quantify the error in results of a water quality model of the Biebrza River, Poland, due to uncertainties in calibrated model parameters. The procedure used in this study combines calibration and sensitivity analysis. Finally, the model was validated to test the model capability, where the effect of calibration errors was filtered out. The water quality model with the best combination of parameter values simulates the observed concentrations very well, although the range of modelled concentrations at each location is rather wide, when other more or less equally eligible combinations of parameter values are taken into consideration.
Keywords : *water quality modelling, calibration, sensitivity analysis*

Introduction

Errors in model outcomes are caused by errors in model formulation, model parameters, and input variables (boundary and initial conditions). The term 'error' not only means 'mistake', but also the statistical concept of variation (Burrough, 1986). Errors in model formulation mostly result from an inadequate description or elimination of processes. Errors in input variables result from measurement errors, natural spatial and temporal variation, or uncertainties in scenarios. Errors in model parameters also result from measurement errors and natural variation, if the parameters are measured. When empirical models are used, model parameters have to be calibrated by 'trial and error' parameter fitting or inverse modelling techniques. These methods yield a best set of parameter values, given the model, the calibration data set and imposed initial- and boundary conditions.

The aim of this study is to quantify the variation of results of a one-dimensional steady state surface water quality model caused by errors in parameter values due to calibration errors. The sensitivity of the model results for parameter errors was examined using a method which combines parameter fitting and sensitivity analysis (Olsthoorn, 1989, Bierkens, 1994). The procedure of this method is as follows: First, the prior probability distribution of the model parameters is determined. Then, from the probability distributions, combinations of parameter values are drawn. For each combination of parameter values the water quality model is run and the model outcome is evaluated using an error criterion. The combination of parameter values that yields the minimum value of the error criterion is taken as the best parameter set (calibration). Additionally, according to the error criterion a number of combinations of parameter values is determined which are more or less as good as the best combination. The variance-covariance structure of these combinations gives insight into the sensitivity of the model results for the model parameters and the identifiability of the model parameters (sensitivity analysis). Finally, the model and the combinations of parameter values were verified for a different data set to examine model validity (validation).

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The water quality model was developed for the Biebrza River, NE Poland. The upstream reach of the Biebrza River is as good as unpolluted. In the study area two discharges of untreated domestic waste water occur. These discharges contribute substantially to the total nutrient load of the river. Diffuse sources of pollutants are absent. Therefore, this area is suitable for calibration of water quality models. Field data, collected in summer 1993 and 1994, were used for model calibration and validation.

Water quality model

The steady state water quality model simulates concentrations of ammonium, nitrate, phosphate, and chloride along a river, accounting for turnover processes, inflow of seepage water and tributary rivers (van der Perk, 1994).

The general differential equation is :

$$\frac{dC_k}{dx} = -\frac{q_s}{Q_x}C_k - \sum_{i=1}^{j} \frac{k_{eff,i}}{U_x}(C_k - C_{e,i}) + \frac{q_s}{Q_x}C_s + P \tag{1}$$

$$U_x = \frac{Q_x}{Bh}$$

For chloride:

$$j = 0$$
$$C_s = Cl_s$$
$$P = 0$$

For phosphate:

$$j = 1$$
$$k_{eff,1} = k_p$$
$$C_e = EPC$$
$$C_s = 0$$
$$P = 0$$

For ammonium:

$$j = 2$$
$$k_{eff,1} = k_f$$
$$C_{e,1} = EAC$$
$$k_{eff,2} = \left(\frac{[O_2]}{Mn+[O_2]}\right)(1.08^{T-20})$$
$$C_{e,2} = 0$$
$$C_s = 0$$
$$P = 0$$

For nitrate:

$$j = 1$$
$$k_{eff,1} = (1.04^{T-20})k_d$$
$$C_{e,1} = 0$$
$$C_s = 0$$
$$P = \frac{62}{18}\left(\frac{[O_2]}{Mn+[O_2]}\right)(1.08^{T-20})\frac{k_n}{U_x}[NH_4]$$

Where :

C_k	=	concentration of substance k	[$M.L^{-3}$]
x	=	place	[L]
q_s	=	seepage water input	[$L^2.T^{-1}$]
Q_r	=	discharge	[$L^3.T^{-1}$]
k_{eff}	=	effective reaction rate constant	[T^{-1}]
U_x	=	mean stream velocity	[$L.T^{-1}$]
B	=	river width	[L]
h	=	river depth	[L]
C_e	=	equilibrium concentration	[$M.L^{-3}$]
C_s	=	concentration of substance in seepage water	[$M.L^{-3}$]
P	=	production term	[$M.L^{-4}$]
k_f	=	ammonium fixation rate constant	[T^{-1}]
k_n	=	nitrification rate constant	[T^{-1}]
k_d	=	denitrification rate constant	[T^{-1}]
k_p	=	phosphate fixation rate constant	[T^{-1}]
Cl_s	=	chloride concentration in seepage water	[$M.L^{-3}$]
EAC	=	equilibrium ammonium concentration	[$M.L^{-3}$]
EPC	=	equilibrium phosphate concentration	[$M.L^{-3}$]
$[O_2]$	=	oxygen concentration	[$M.L^{-3}$]
Mn	=	Monod half saturation constant	[$M.L^{-3}$]
$[NH_4]$	=	ammonium concentration	[$M.L^{-3}$]
T	=	temperature in °C	[Θ]

The differential equation was solved using a fourth-order Runge-Kutta integration method

Calibration

Because little was known about the probability distributions of the parameters, we have varied the values of eight parameters in five steps between previously established boundaries, giving $5^8 = 390625$ combinations. The parameters which were varied are : q_s, Cl_s, k_f, k_n, k_d, k_p, EAC and EPC. These parameters were selected because their values were not known sufficiently accurately. The lower and upper boundaries of the parameter values were obtained from the literature and former 'trial and error' parameter fitting. The values of T, $[O_2]$, B, and h were obtained from field measurements; the value of Mn (= 0.5 mg $O_2.l^{-1}$) was obtained from the literature (Stenstrom and Poduska, 1980). Concentration data of a 40 km long reach of the upper course of the Biebrza River for June 1993, were used for calibration. The best fit is shown in figure 1.

Sensitivity analysis

To get insight into the variation of the model outcome due to the calibration error - given the model formulation, the calibration data set, and the imposed initial and boundary conditions - the model results with the 5,000 and 50,000 best combinations of parameter values were evaluated. These sets represent more or less equally eligible models. The range of the model outcomes for the 5,000 and 50,000 best combinations of parameter values, the mean of the model outcomes for the 50,000 best combinations, and the best fit are shown in Figure 1.

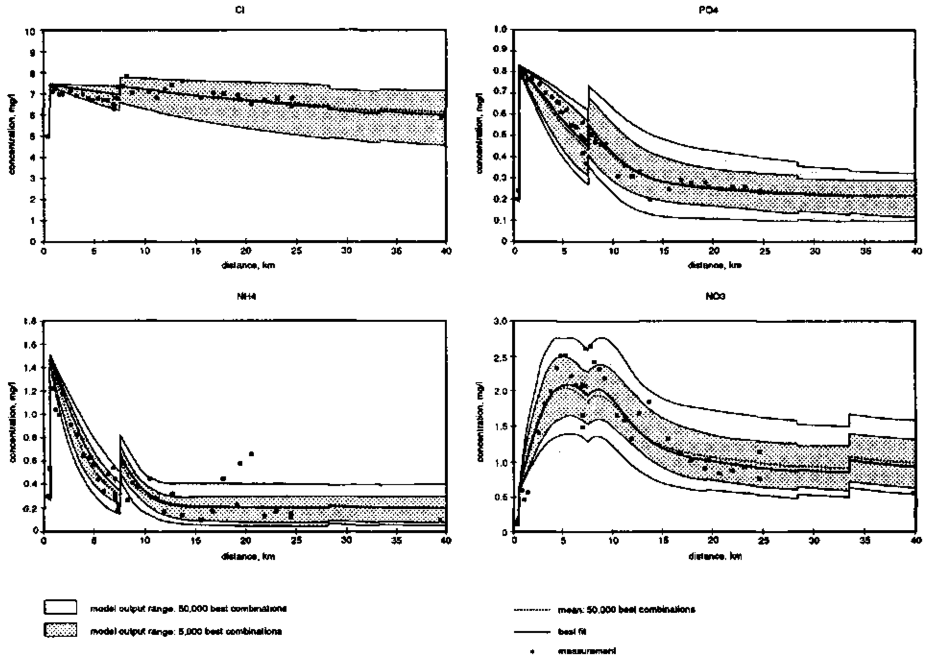

Fig. 1. Calibration results. Comparison of measured and simulated concentrations of chloride, phosphate, ammonium, and nitrate as function of distance in the Biebrza River in June 1993.

The best fit and the mean of the model outcomes for the 50,000 best combinations of parameter values describe the observed concentrations very well. However, the range between the minimum and maximum modelled concentration is rather wide, both for the 50,000 best combinations and for the 5,000 best combinations. Especially phosphate and nitrate have a relatively wide range; chloride has a relatively narrow range.

The variance-covariance structure for the eight parameters in the set of 50,000 best combinations was determined to get information about the sensitivity of the model results for the parameters and/or the identifiability of the model parameters. The correlation matrix is given in Table 1.

Table 1. Correlation matrix with correlation coefficients on the off-diagonal elements and coefficients of variation on the main diagonal.

	k_f	k_n	k_d	k_p	q_s	Cl_s	EAC	EPC
k_f	.448							
k_n	.235	.267						
k_d	.337	.661	.326					
k_p	.000	-.003	.004	.402				
q_s	-.027	.056	-.048	-.069	.413			
Cl_s	.008	.002	-.005	-.002	.061	.458		
EAC	-.045	.434	.631	.001	.026	-.010	.305	
EPC	.015	.001	.006	.369	.018	-.002	-.008	.314

Rather strong correlations exits between k_n and k_d, k_d and EAC, k_n and EAC, k_p and EPC, and between k_f and k_d. This means that these parameters are difficult to identify individually. The parameters q_s and Cl_s can be identified individually, because they correlate poorly with other parameters. The parameters k_n and k_d have a relatively low coefficient of variation. Therefore, the model is most sensitive to these parameters.

Validation

For model verification, the water quality model was run with the 50,000 best combinations of parameter values obtained from the calibration procedure. The initial and boundary conditions were obtained from concentration and discharge measurements of a 130 km long reach of the Biebrza River in June 1994. Results are shown in Figure 2.

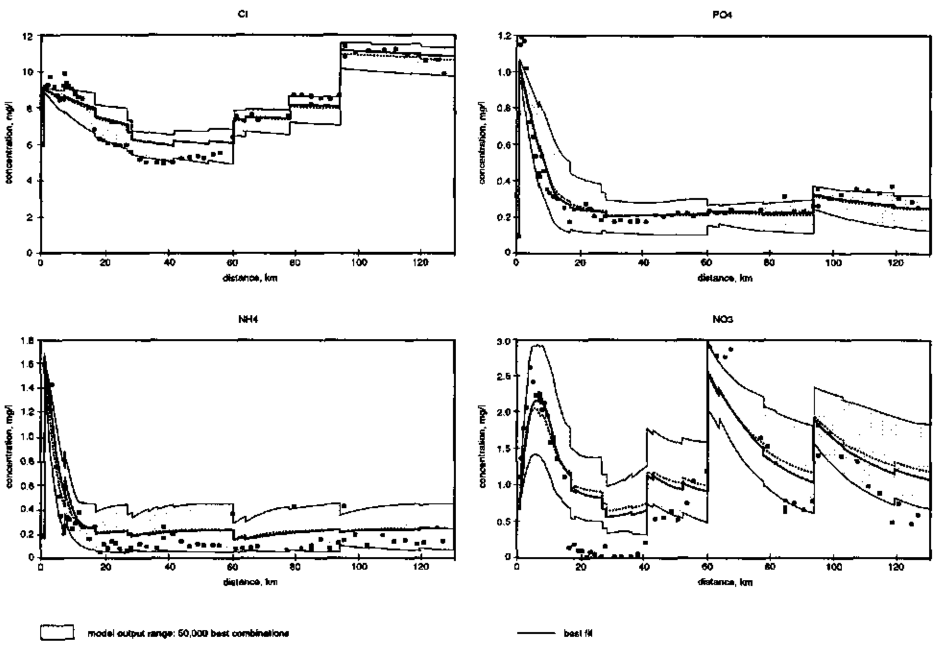

Fig. 2. Validation results. Comparison of measured and simulated concentrations of chloride, phosphate, ammonium, and nitrate as function of distance in the Biebrza River in June 1994.

In general, the model simulates the observed concentrations very well. The best fit, as well as the mean of model outcomes for the 50,000 best combinations of parameter values follow the observed concentrations very well. In some reaches of the river the measured concentrations are outside the modelled range. These discrepancies may be caused by errors in initial conditions, boundary conditions, or model assumptions, for example the steady state approach.

Conclusions

- A great advantage of the method of parameter estimation presented here is that the sensitivity analysis follows logically on the calibration procedure without further modelling effort.
- The model with the best combination of parameter values simulates the observed concentrations very well, although a rather wide range of concentrations are simulated when more or less equally eligible combinations of parameter values are taken into consideration.
- Therefore, it is just as important to know the correlation structure of the parameter values as to know the exact parameter values of the best fit.
- Most parameters (k_f, k_n, k_d, k_p, EAC, and EPC) are correlated. Therefore, these parameters are difficult to identify uniquely. The model is most sensitive to k_n and k_d. These parameters need special attention during data collection.
- The validation procedure is a test of model capability, where the effect of calibration errors are filtered out.

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8.6 Information requirements and availability for regional environmental planning in The Netherlands, illustrated by the problem of eutrophication

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Abstract

For regional environmental planning information is needed on land use, regional hydrology, contaminant fluxes and the effects of changes in hydrology and/or contamination on regional functions and activities. In this study the information requirements and availability in The Netherlands are analyzed, focusing on the effects of eutrophication related to agricultural land use on vegetation and fauna.

Keywords: *Regional planning, eutrophication, information requirements*

Introduction: information and regional planning

One of the central problems in regional environmental planning is the relation between land use and environmental quality: pollution resulting from land use can exceed the environmental carrying capacity.

For regional environmental planning information is required on: (1) the relationship between land use and the physical environment; (2) the claims on land use and the environmental utilisation space; (3) the possibilities for authorities to steer.

The following tasks can be distinguished relevant to regional planning; the task of developing, the task of steering and the task of planning (Tatenhove, 1994). The task of developing involves analyzing the consequences of existing claims on land use for the environmental utilisation space. The central question is: do the claims on land use exceed the possibilities offered by the natural capacity? The task of steering concerns the judgement and coordination of claims on land use and environmental utilisation space. Authorities and private interests have to discuss and decide about existing and future claims, especially about their contents and their legitimacy. On the basis of varying definitions various programs can be formulated. The task of planning focuses on how the process of operation is organised. This process involves repeated comparison of claims, as outcomes of the task of steering and inputs for the task of developing, and the consequences for land use and the utilisation of space; the essence of the task of developing. The end result is an area-specific approach.

In time, one can distinguish five steps in the environmental planning process: (1) formulation of objectives and conditions, (2) problem description and diagnoses, (3) plan construction, (4) analyses of consequences and (5) decision making. To support these planning processes with information the national government proposed (VROM, 1991) to produce area-documents in which all the information about the situation of the physical environment in relation to land use would be presented.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 305–308.

Analysis of required information: activity-schemes and criteria

To produce such a document for each step, (intermediate) products, data and methods needed to obtain this information, are defined (Van der Vlist et al., in prep.) with activity schemes for the entire planning process and for each distinctive step.

Table 1. Activity-scheme of the planning process

	Activity and product	Desired information
1.	activity: formulation of aims and objectives product: objectives and conditions	characteristics and potential of the area in study
2.	activity: definition of situation product: description and diagnoses problems	starget groups, nutrient inputs, processes, effects
3.	activity: plan construction product: plan alternatives	claims
4.	activity: evaluation of plan alternatives product: consequences on land use and utilisation space	influence on depositions, processes, effects
5.	activity: decision making product: decision	alternatives and consequences

To examine the available information three criteria were used: (1) thematic: are data/models adequate?; (2) geometric: have data/models the desired scale?; (3) temporal: is there enough information in time?

Results: the availability of information

The analyses show that the available information for steps one, three and five depends greatly on the outcomes of discussions between public and private interests in specific regional planning processes. Quantitative information is of minor importance for these steps. Therefore, we are focusing on the information necessary for the second and fourth steps of the planning process as key elements in the task of developing. Figure 1 shows the activity scheme and Table 2 the results of the analysis of available information about the problem of eutrophication.

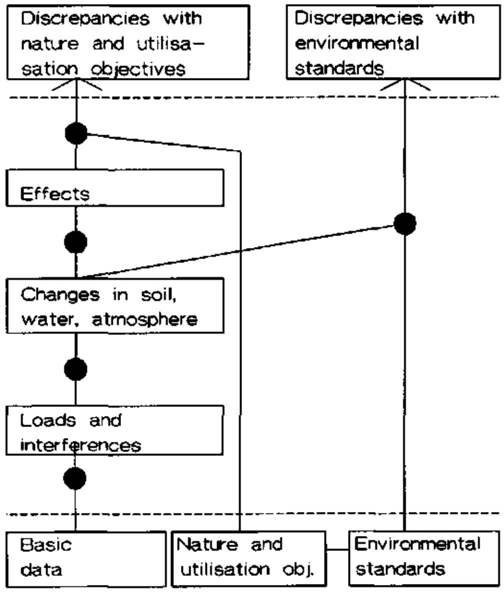

Figure 1: Activity scheme for the definition of the situation

Comparison (Table 2) of the information requirements with the available data and (numerical) models reveals that methods for description of the regional hydrology and pollutants fluxes are available. The necessary data on inputs and interferences however are lacking the required spatial detail. There is too little reliable quantitative information on the effects of changes in regional environmental conditions on vegetation and fauna. Related to agriculture, little information is available on the socio-economic possibilities for and effects of alternative environmental policies.

Conclusions

It can be concluded that for diagnoses and prognoses of regional environmental problems and qualities a lot of uncertainties still remain. In particular, the required geometric detail in input data and quantitative information on the effects of changes in the abiotic conditions are lacking.

Looking at the entire planning process and the perspectives of modelling the conclusion is that step one (the formulation of aims and objectives), three (the construction of plan alternatives) and five (decision making) are not suitable for modelling. Modelling is of particular importance for step two (description and diagnosis) and step four (evaluation of plan alternatives). This means that support of regional environmental planning in terms of modelling environmental processes is crucial for insight into the relationship between changes in land use and environmental utilisation space but limited.

Table 2. availability of information about eutrophication

	data/models	holder	comment
input			
farms	- use of land, nutrients - prognoses	national agencies: data and models	scale inadequate
nutrient loads	- act. situation	regional water management authorities,	data about private enterprises are secret, often not available
	- prognoses	unknown	
abiotic processes			
abiot. characteristics	- soil & water data	research centra/water authorities	soil data are digitized water data not
models	- hydrology - soil systems - surface water	many models available at research centra	often additional regional research is necessary
effects on land use			
land use	- decline of possibilities		often quantitative objectives are available
terrestrial nature	- community changes	universities and research centra (DEMNAT, MOVE)[1]	in development and availability is limited
aquatic nature	- community changes	universities and research centra	algal growth models available, few for vegetation (ICHORS)[1] and fauna

[1] DEMNAT is a model for the effects of changes in hydrology on vegetation (Dutch Research Institute for Inland Water Management, Wageningingen Agricultural University). MOVE is a model for hydrology, acidification and eutrophication and the effects on vegetation (Dutch Centre for Environmental Research). ICHORS is a model for the relation between physical and chemical conditions and aquatic vegetation (Utrecht University).

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8.7 The future role of soil information in planning the rural environment

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Abstract

The application of sustainable development principles to the planned use of land resources in rural areas is encouraged by the UK Strategy on Sustainable Development. Further pressure for the integration of environmental protection and land use planning comes from European and national legislation and planning guidance. Local planning authorities in England produce development plans that are important in promoting environmental protection through integrated land use planning policies. The functionality and quality of soils are increasingly recognised as key factors in the identification of sustainable patterns of land use, and their impact is set to expand. A framework for providing planners with the soil information they need to plan for sustainable development is proposed. Specific planning issues where soil information plays a key role were identified. The main functions of the soil information system will consist in supporting user information needs, public registers of environmental information and vertical/horizontal integration with other systems and Authorities. Information on the functional capacity, vulnerability and sensitivity of soils and selected soil quality indicators will assist authorities in planning appropriate forms of land use for a sustainable use of the soil resource.

Keywords: *sustainable development, soil information system, planning, soil quality indicators*

Introduction

Following commitments given at the 1992 United Nations Conference on Environment and Development, the United Kingdom government published a UK Strategy on Sustainable Development in 1994 (Department of the Environment, 1994b). This strategy adopts the guiding principles of sustainable development outlined in Agenda 21 of the UNCED agreement, namely that decisions affecting the environment should be based on the best available scientific information, that the precautionary principle should be employed as appropriate, and that ecological impacts must be considered particularly with respect to non-renewable resources and/or irreversible effects.

One area that will be affected by such a strategy is that of land use planning. The Department of the Environment, in partnership with Bedfordshire and Hertfordshire Planning Authorities, has funded a research project to explore ways in which soil information can assist in the sustainable development of the ecological, social and economic functions of land. This paper reports on some of the findings.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 309–313.

Land Use and Planning in the UK

In the UK, local planning authorities are responsible for the production of development plans that are the means by which economic and social priorities are integrated with environmental concerns. Guidance on the establishment and content of development plans is provided by national government via Planning (and Mineral) Policy Guidance Notes (PPG) covering the various relevant issues.

Development plans include Structure Plans which deal with principles and Local Plans which disaggregate policies on a spatial basis, and accurately delineate areas of land where relevant factors will constrain development options. At present constraining factors include the conservation of prime wildlife and archaeological features, and the natural stability of the land. The most productive and versatile agricultural land is afforded protection from larger housing or industrial developments.

In a recently published PPG, Planning and Pollution Control, the Department of the Environment (Department of the Environment 1994a), places responsibility for establishing policies that protect the wider environment with planning authorities. Guidance on the incorporation of sustainable development principles into development plans is summarised by the Department of the Environment (1994b) and many local planning authorities are already pursuing this objective in revisions of their development plans (e.g. Bedfordshire County Council 1994, Hertfordshire County Council 1994). Logically, the incorporation of sustainable development into land use plans leads to consideration of the ecological aspects of land, and thus for the first time all aspects of soil, not just its role in acting as a physical base for construction, will become material planning considerations.

Soil Function and Land Use Planning

In identifying and achieving patterns of land use that ensure a sustainable future for land and therefore soil resources, it is helpful to focus on the protection of soil functions since they act as an interface between human and natural systems. Blum (1993) identifies six fundamental soil functions, three ecological and three economic. These functions can be related to direct and indirect uses for land (Table 1). The functional capacity of individual soils varies according to their inherent properties and the impact of past human activity, and is therefore not uniform spatially.

Sustainable development principles dictate that all soil functions should be considered in planning the future use of land. However, the ecological functions of soil have historically been subordinated to the consideration of land as an economic asset. This is reflected in the fact that UK law does not recognise the degradation or contamination of soil as an offence per se. For soil functions and environmental capacity to become material considerations in formal development planning therefore represents a major change in policy. To address these issues, a local planning authority will need information on the properties, functional capacity, vulnerability and sensitivity of the soils within their region which, in most cases, they do not have.

Table 1. Direct and Indirect Uses of Land in Bedfordshire and Hertfordshire

Function	Direct land use	Indirect land use
- Production of biomass	- Agriculture/horticulture - Forestry - Bio-energy	- Soil microbial biomass - Plant biomass
- Filtering & transforming substances	- Treating organic wastes applied to land	- Neutralising atmospheric deposition - Protecting surface and groundwater from pollution (NO_3, P, organics, sediment) - Carbon storage
- Supporting biodiversity	- Supporting nature conservation	- Protecting soil biotic communities
- Provision of a spatial base	- Space for building, for transport routes, for recreation-(formal and informal) and for landfill.	
- Provision of raw materials	- Water and minerals supplies	
- Protection of heritage sites	- Archaeological and agricultural heritage sites	

Soil Information for Land Use Planning

The successful development, assessment and implementation of policies require information about land and about the local society and economy. The broad functions of a soil information system for local planning authorities are indicated in Figure 1. The hierarchical nature of development planning in the UK, whereby national policy directs regional, county and district policy in succession, requires that information systems can be integrated vertically, and that information can be transferred up or down tiers of the hierarchy. The increasing number of environmental and other agencies and interest groups, with which local planning authorities must consult, and which are also promoting land use policy, leads to a requirement for horizontal integration.

Soil information systems inevitably require spatial and attribute data on soils, and other data on factors such as topography, climate, land use and geology. They also require models by which such input data are translated into information that is both understandable and useful to the planning authority. The nature and range of such models will vary with local conditions and priorities, but all will fundamentally relate to the capacity of soils to support forms of land use, and the vulnerability and sensitivity of soils, and related environmental resources such as groundwater, to forms of degradation.

For county planning authorities, spatial soil information of sufficiently high resolution exists as a result of past strategic soil survey, and for England, Wales and Scotland this information is available digitally in raster format. For a pilot exercise in Bedfordshire and Hertfordshire, an aggregated soil dataset on a 1 km raster was chosen as the principal input data source for two pilot interpretative exercises. These yielded maps of soil

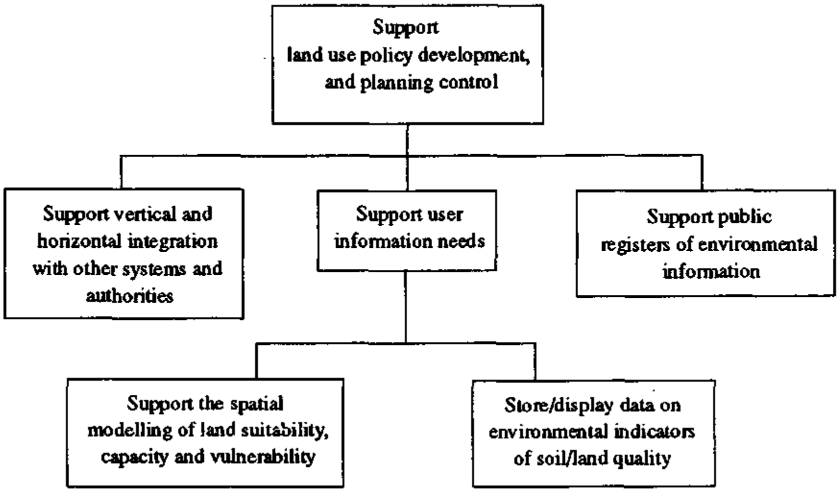

Fig. 1. The Functions of a Soil Information System for Local Planning Author

instability due to soil shrink/swell potential, and groundwater vulnerability to contamination according to a scheme adopted by the National Rivers Authority (National Rivers Authority, 1992).

The quality (i.e. physical, chemical and biological state) of soils within the planning region, and any trend in quality, are best represented by use of soil quality indicators (OECD 1993, Adriaanse 1993). The Department of the Environment (1993, and Department of the Environment 1994b) has indicated that proper tools of analysis should be applied in policy making, and quality indicators are regarded as having a dual role of pointing up desirable or undesirable trends in the quality of the environment, and of acting as performance indicators for policy makers. Data from geostatistically representative monitoring sites are needed if soil quality indicator data are to be reliable. The value of linking such data to economic factors is recognised, but the lack of time-series data and of a basic understanding of the cause-effect mechanisms controlling such linkages will limit immediate progress in this field. Priority should be given for developing soil state indicators to gain a better understanding and quantification of any pressure - state-response framework. The need for a small number of simple indicators of soil quality is emphasised by planners. Discriminant analysis is proposed as a method for deriving a single coefficient to represent the level of contamination of soils by a number of elements.

Conclusions

The twin incentives of sustainable development and environmental protection are encouraging land use planners in the United Kingdom to take a greater interest in the nature and broad functionality of soils. The approach to soil protection recommended by the Council of Europe (Blum, 1993) has been used in a pilot exercise to explore and test the principle of using soil function as the target for protection policies and practice, and has been found to be of value. To meet these new policy demands, planning authorities will require information on the functional capacity, vulnerability and sensitivity of their soils, and on a restricted number of key soil quality indicators.

Acknowledgements
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CHAPTER 9

Case studies on water and nutrient management

9.1 Land degradation

9.1.1 Measuring and modelling hillslope hydrology in the Loess region of The Netherlands

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Abstract

For the development of the Limburg Soil Erosion Model (LISEM), a validated hillslope hydrology module was needed. Therefore, hydraulic heads were monitored on four hillslopes in the southern part of The Netherlands during the years 1992 and 1993. The hydraulic heads were recorded automatically, using stand-alone measuring devices. Simultaneously, rainfall amounts and runoff were recorded as well. Observed changes in hydraulic head and runoff were simulated using the SWMS_2D computer program. Measured and simulated results are compared and correlated well.
Keywords: *runoff, hillslope hydrology, catchment hydrology, hydraulic head measurement*

Introduction

Runoff on a hillslope may be generated in case the rainfall intensity exceeds the infiltration capacity or in case the (top)soil is fully saturated. In both cases the actual infiltration rate plays a crucial role in the process of runoff generation.

Infiltration rates can be measured directly (e.g., ASAE, 1983; Al-Azawi, 1985; De Roo and Riezebos, 1992), however this is very time consuming. Calculation of the infiltration rate can be obtained by using an appropriate infiltration equation (e.g., Green and Ampt, 1911; Philip, 1975; Holtan, 1961; Parlange et al., 1982; Haverkamp et al., 1987). Use of such equations is only feasible in case the parameters involved are known. In general, measurements of soil physical properties are difficult and time consuming. Sometimes, parameters are estimated (e.g., Rawls et al., 1983; Haan, 1987). By using Richard's equation it is possible to calculate the infiltration rate and water flow through a soil profile (e.g., Binley and Beven, 1992), if the soil hydraulic conductivity and water retention characteristics are known for the various horizons.

This paper presents measurements on hydraulic heads and runoff on a selected hillslope during a single rain-event. Measured results are compared with simulated results of the SWMS_2D model, a computer code for simulating water flow in two-dimensional variably saturated media (Šimùnek et al., 1992).

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 317–321.

The results form part of a soil erosion study initiated in 1991 by the province of Limburg, the waterboard 'Roer & Overmaas', the ministry of Agriculture, Nature management and Fisheries and 14 municipalities in the loess region of The Netherlands. The objective of this study was to develop the computer model LISEM (Limburg Soil Erosion Model, De Roo et al., 1993) that is capable of predicting the soil and water erosion from a catchment under different land-use and tillage systems. Participating institutes in this study were the departments of Physical Geography of the Universities of Amsterdam and Utrecht, and the Soil Physics and Soil Management department of the Winand Staring Centre.

Materials and methods

On four hillslopes in the southern part of The Netherlands hydraulic heads were monitored during the years 1992 and 1993. The hillslopes were situated in three catchments. Within these three catchments, sub-catchments were distinguished. Tensiometers were installed at the top, middle and bottom part of each selected slope. At each measurement site, 10 tensiometers were installed at depths from 2.5 cm up to 180 cm below soil surface. The hydraulic heads were recorded automatically, using a stand alone measuring device (Van den Elsen and Bakker, 1992). Simultaneously, rainfall amounts and runoff were recorded at the outlet of each sub-catchment.

At each measurement site undisturbed soil samples (10 cm. diam., 8 cm high) were taken in duplicate from at least six depths and the hydraulic conductivity and water retention characteristics were measured. A fit procedure (Van Genuchten et al., 1991) was used to describe the hydraulic properties with a set of Mualem-Van Genuchten parameters (Mualem, 1976; Van Genuchten, 1980).

The SWMS_2D computer program was used to simulate changes in the hydraulic head and infiltration during single rain-events. The model considers two-dimensional Darcian flow described by a modified form of the Richard's equation.

Results

Measurements are presented for a rain-event in July 1992 on one hillslope. The water flow over and through this slope is simulated with the SWMS_2D computer program. For this, the slope is divided into 80 cells (10 lateral and 8 vertical). For each cell the direction and amount of water flow per calculation time are calculated. The measured pressure heads just before the rainfall actually started were used as initial pressure heads in the model calculations. Measured soil physical properties were merged to soil physical building blocks and assigned to the cells. Measured and calculated pressure heads are compared in Figure 1, and measured and calculated runoff in Figure 2.

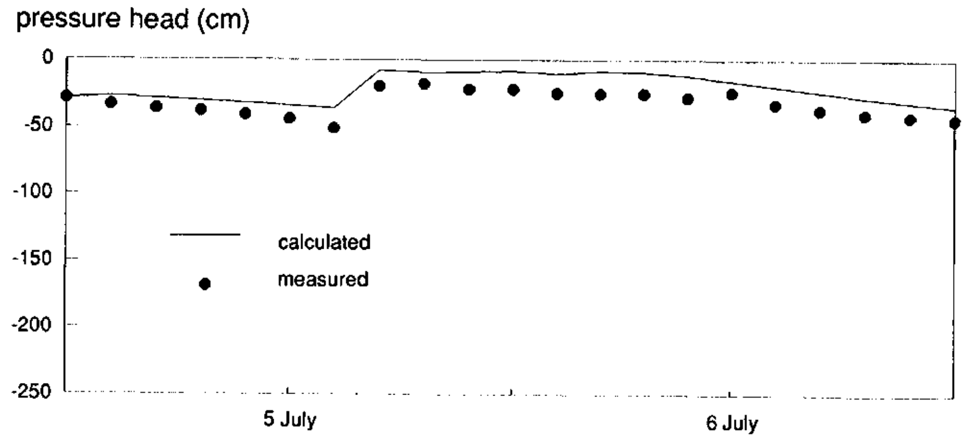

Fig. 1. Measured pressure head versus simulated pressure head, using the SWMS_2D program code.

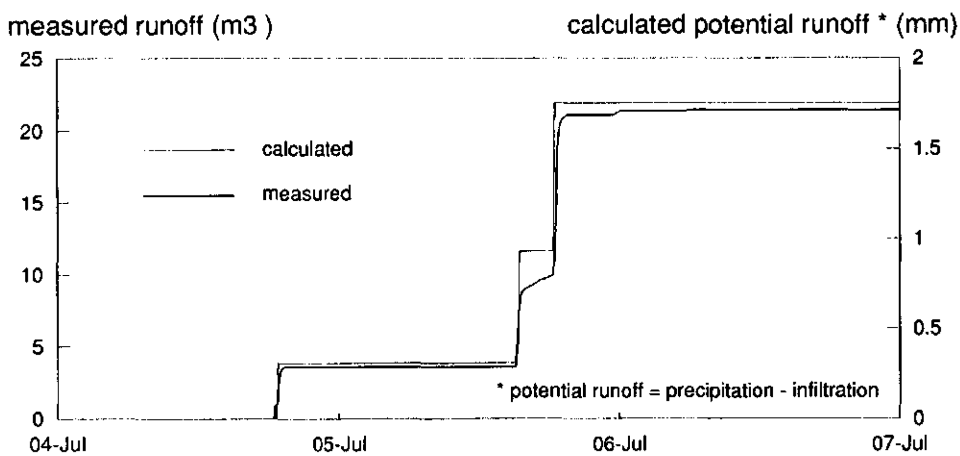

Fig. 2. Comparison of the measured runoff of a sub-catchment area and the simulated runoff of a hillslope, using the SWMS_2D program code.

Discussion

The SWMS_2D code calculates the potential runoff, i.e., rainfall minus infiltration. In Figure 7 this quantity is compared with the measured runoff. The measured runoff for the total sub-catchment appeared to be around 20 m^3. If runoff was generated uniformly over the entire sub-catchment (± 40 000 m^2), each square meter should generate 0.5 mm of runoff. For the selected hillslope the calculated potential runoff appeared to be a magnitude three higher (± 1.5 mm m^{-2}). The difference can be explained by (i) the fact that significant amounts of water probably ponded on the soil surface of the hillslope, thus decreasing the amount of 1.5 mm calculated potential runoff, and (ii) that the runoff was generated in specific areas of the sub-catchment. The selected hillslope was the steepest in the sub-catchment and was situated near the outlet and thus is likely to contribute more than the average of 0.5 mm to the runoff.

Conclusions

Fully automatic stand-alone devices are very useful to monitor the hillslope hydrology over long periods, and on a rain-event basis.

The SWMS_2D computer program is capable of predicting changes in pressure head and potential runoff on hillslopes, and thus may be used as a hillslope hydrology module in the LISEM computer program.

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9.1.2 Spatial and temporal variability of environmental factors and nature management in a rural arkosic landscape

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Abstract

The EU Agricultural Policy is profoundly affecting agricultural production systems in Spain. In the present situation, soils have physical problems - erosion and compaction - and a low fertility. The erosive effect of rainfall on soils is greater in those under fallow (top value 1180 g of soil/m^2) than for the grazed plots (185 g/m^2). In sites where the natural vegetation had returned the highest (out of 10 events) sediment value was 119 g/m^2.

Soil changes caused by burning can help growth and productivity of certain species that can reach, at least temporarily, a greater presence than in pasture communities before burning. The two main directions for the recovery of soil fertility in this landscape type are controlled grazing and the ecological study of ecotypes of herbaceous species suitable for bare soil revegetation.

Keywords: *cereal abandonment, sheep grazing, wild species recovery, erosive effects*

Introduction

The decrease in profitability of cereal cultivations is giving rise to land abandonment, especially in the Spanish semi-arid zones. To assess soil sustainability after cessation of the cultivation of cereals in formerly extensive agricultural land, the study of the new soil-vegetation system and the interactions between its elements is an important issue to solve emerging problems (Hernández *et al.*, 1993).

In the present situation occur both physical problems - erosion and compaction - and a low fertility of soils of the Mediterranean region. To assess the sustainability of alternatives for these agroecosystems, development scenarios have to take into account these problems. It is also necessary to consider a broad regional scale and a continuous monitoring of the new land management.

The study zone: former and present situation

The human intervention in the holm-oak wood of central Spain: former situation

The agricultural landscape consists of cereal fields that alternate with fallow, total abandoned areas and Mediterranean holm-oak forests (*Quercus rotundifolia*).

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 323–327.

In time, the continuous extension of cultivated fields has not only promoted the disappearance of the old holm-oak woods, but has also degraded the substitutive brushwood. The old vegetation has only remained in those sites where the pronounced slopes or particular economic interests, such as enclosed pastures, have avoided the breaking up of the ground and the destruction of the vegetation cover. The typical agricultural landscape of the southern Spanish Plateau consists now of dry farming land with cereal fields, fallow, old fields, vineyards, olive-groves and pastures in former areas of holm-oak forests.

The agrarian landscape and the CAP: present situation

In addition to developments having a negative influence on the semi-arid ecosystems, such as deforestation, improper revegetation, overexploitation by grazing, strongly mechanized agriculture, burning of stubble, etc., new problems have emerged, notably abandonment of dry farming land, loss of traditional agricultural activities and decreasing numbers of livestock.

In the aforementioned area two dangers can be observed. On the one hand, an increase in the scrub system with abundant necromass may trigger fires. On the other hand, if fallow is used, an increase in erosion will occur because of the non-existence of a proper plant cover that would facilitate rain infiltration.

Integrated monitoring approach

Our study has been carried out in a one-ha lot that has been cultivated with grain crops for many years. In 1987 the cultivation was abandoned on this lot. For seven consecutive years it has been subjected to three different uses: accidental grazing with itinerant sheep, mowing, and restitution of the plant cover. At the end of the fourth year there was a fire which affected some sectors under the three treatments. The experimental design took into account the effects of all these treatments on the change of the soil structure as well as the fostering of wild plant species. The soil variables and the vegetation have been systematically sampled along a transect consisting of three plots for each treatment. The transect followed the slope (plots are located in the high, middle and low parts). The vegetation and soil have been sampled in spring. The changes of the physical, chemical and biological variables in these years have been studied according to the analytical methods cited in Hernández & Pastor (1989).

Results

Although we are still continuing our experiment, we will refer to some of the variables that provide information about the risks of erosion, compaction and fire under the conditions of the different treatments. To evaluate erosion, we have collected sediments after rainfall on small-sized experimental plots located in the high, middle, and low parts of the slopes. In addition, in the same area, plots under fallow were located. The soil compaction is shown through the estimation of the bulk density of the soil surface layer

(0-10 cm.). The fire effect is evaluated by pH, a parameter that indicates the possibility of soil enrichment due to nutrient incorporation from the plant biomass in the soil.

The surface layer of the arkosic soils are strongly influenced by heavy precipitations that produce different rates of soil loss, and show different amounts of infiltrated water and surface flow. The erosive effect of heavy showers on soils subjected to different treatments or processes is greater in those under fallow (top value 1180 g of soil/m^2) than for the grazed plots (185 g/m^2). In sites where the natural vegetation had returned the highest (out of 10 events) sediment value was 119 g/m^2 (Table 1).

Table 1. Sediment (g/m^2) under the different treatments (10 events).

Use	1989					1991				
	1	2	3	4	5	6	7	8	9	10
Grazing	185,2	63,9	36,6	9,5	3,1	1,9	1,0	0,8	0,1	63,4
Annual mowing	74,4	25,2	51,2	9,4	3,5	1,1	0,4	0,1	0,4	8,3
Total abandon	118,6	42,4	38,6	8,3	3,9	1,2	1,3	2,2	1,0	28,1
Fallow	374,3	52,8	38,6	52,5	30,3	10,9	0,7	0,9	2,0	1180,0

The different erosion impacts of these soils has been further analyzed in relation to the percentage of vegetation cover, plant composition and differences in root systems. The losses are generally greater for finer elements (clay and silt) and depend upon run-off (De las Heras *et al.*, 1993).

The bulk density of the soil increases in all of the types of processes if the values reached after the first year (1988) of cereal abandonment are taken into consideration. In the fourth year (1991) the first stages of the vegetal succession seemed to have stabilized (Hernández *et al.* 1993b, Table 2). After the fire, this physical factor increased at an even greater rate (compare the results between 1991 and 1993 in Table 2). The compaction of the first centimetres of the soil profile impedes severely the establishment of leguminous species.

Table 2. Bulk density soil (g/cm^3)

Treatment	Plots	Before fire				After fire
		1988	1989	1990	1991	1993
Sheep grazing	high	1.41	1.51	1.45	1.46	1.46
	midd.	1.42	1.48	1.49	1.47	1.50
	low	-	1.50	1.45	1.48	1.55
Annual mowing	high	1.36	1.50	1.58	1.46	1.62
	midd.	1.33	1.43	1.46	1.42	1.68
	low	-	1,51	1,61	1,54	1,64
Total Abandon	high	1.47	1.52	1.43	1.55	1.49
	midd.	1.39	1.43	1.49	1.40	1.54
	low	1.45	1.57	1.54	1.53	1.66

Table 3 shows that leguminous species richness, which contribute to the natural fertility of the soil, diminished after the fire under the three types of treatments, while it would have otherwise increased.

Table 3. Development of the number of species for each treatment.

Botanic families	Sheep grazing			Annual mowing			Total abandon		
	1989	1991	1993	1989	1991	1993	1989	1991	1993
Legumes	4	9	4	7	10	6	5	11	2
Grasses	14	14	11	12	12	13	11	17	8
Others	37	57	60	30	43	53	45	54	33

Our hypothesis is that bulk density is a limiting factor for profitability, although nutrients can be incorporated into soil by stubble burning. pH increase after fire and rain (see Table 4) could induce the positive effect of burning with no effect on the interaction with the physical structure of the soil, but controlled burning can reduce the necromass produced by the system after total abandonment of the cultivation and no intervention. Table 5 shows that mean height of the plant cover increases under these conditions, but remains more or less constant in the grazed area.

Soil changes caused by burning can help growth and productivity of certain species that can obtain, at least temporarily, a greater presence than in pasture communities before burning (Table 3).

Table 4. Development of the soil pH in the different treatments.

Treatment	Before burning		After burning	
			no rain	rain
	1988	1991	1991	1991
Sheep grazing	7,59	7,76	7,70	8,01
Annual mowing	7,81	7,64	7,73	8,30
Total abandon	7,70	7,13	7,12	7,64

Table 5. Development of the mean height of the plant cover.

Treatment	Plots	1989	1990	1991
Sheep grazing	high	25	24	24
	midd.	23	26	32
	low	28	24	27
Annual mowing	high	15	31	30
	midd.	25	29	36
	low	27	29	39
Total abandon	high	30	42	60
	midd.	26	32	41
	low	23	22	35

Discussion

Overviewing these results, we can state that the management of this new Central Iberian agrarian landscape is something complex, mostly for its great spatial and temporal variability. It is difficult to underline conclusive aspects related to the different uses or alternatives to the cereal crop. Nonetheless, we can make the following observations.

The two main directions for the recovery of soil fertility in this landscape type are controlled grazing and the ecological study of ecotypes of herbaceous species suitable for bare soil revegetation. Wild ecotypes exhibit a good adaptation to compacted soils, as well as clear advantages for restoration programs of landscape as opposed to some commercial varieties. It has been confirmed that growing together several leguminous species is advantageous for overcoming the physical obstacles in the soil. Some species of wandering plants and other perennials supply a good soil cover even in soils without high sowing densities, and are very useful against erosive processes.

Within this ecological framework and taking into consideration the current initiatives promoted by the CAP, which is intended to reduce agricultural production, a number of species, which have decreased as a result of cereal agriculture, have a promising outlook.

Unfortunately, our capacity to predict what species will be able to take advantage of the new situation is, given the reduction of the intensity in the use of the land, limited. First, the effects of the new agricultural policy on soil management are uncertain and, secondly, we have little knowledge about the distribution and settling capabilities of wild species.

Acknowledgements
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9.2 Nutrient management

9.2.1 Simulation of different management options within integrated arable farming affecting nitrate leaching

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Abstract
Research on agricultural farming systems is more and more aimed at minimizing environmental effects. To reduce losses of herbicides, pesticides and nutrients whilst maintaining economic feasibility, integrated arable farming has been developed.

At two experimental farms, 'Vredepeel' and 'Borgerswold', integrated and conventional farming systems are compared. Measurements of nitrate concentrations from these two experimental farms were used to validate the simulation models SWACROP and ANIMO. A scenario study is carried out to predict the nitrate leaching under different management options. The first management option, using fertilizer instead of organic manure, did not result in less nitrate leaching; the second option, removing crop residues, produced slightly lower nitrate leaching. Calculations without winter catch crops, option 3, and calculations without irrigation (option 4), resulted in more nitrate leaching.
Keywords: *integrated arable farming, simulation, nitrate leaching, management options*

Introduction

Research on agricultural systems is more and more aimed at minimizing environmental effects. To reduce losses of herbicides, pesticides and nutrients whilst maintaining economic feasibility, integrated arable farming has been developed (Vereijken and Wijnands, 1990). Integrated farming systems have more extensive crop rotations to reduce occurrence of diseases, so that less herbicides and pesticides are needed. Furthermore catch crops are grown more frequently and organic manure is used.

At two experimental farms, 'Vredepeel' and 'Borgerswold', integrated and conventional farming systems are compared. At Vredepeel the eight year crop rotation consists of many crops and this is the same for conventional and integrated farming. At Borgerswold potato is the main crop. The conventional system has a four year crop rotation with potatoes once every two years. The integrated system has an eight year crop rotation with potatoes only once in four years. Table 1 shows the cultivated crops in 1990 - 1992 at the two experimental farms.

To examine if integrated farming systems meet the requirements of environmental aims (50 mg/l nitrate in the groundwater) for nitrate leaching a model study was carried out. Two questions are discussed: Is nitrate leaching really reduced with integrated farming systems, and is it possible to further reduce nitrate leaching with different management options? Using the simulation models SWACROP (Belmans et.al., 1983, Feddes et al., 1978) and ANIMO (Rijtema and Kroes, 1991) the effects of different options are calculated.

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Table 1. Cultivated crops

	Field number C*	I*	1990	1991	1992
Vredepeel	18.2	19.2	sugar beet	winter wheat	scorzonera
	23.1	22.1	pea and bean	potato	sugar beet
	24.2	25.2	potato	sugar beet	maize
	27.1	26.1	maize	pea and bean	potato
Borgerswold	3		potato	winter wheat	potato
		4	sugar beet	winter rye	potato
		7	spring wheat	rapeseed	grass seed
	10		sugar beet	potato	winter wheat
	13		potato	sugar beet	potato
		15	potato	winter wheat	rapeseed
		17	grass seed	potato	bean
	18		winter wheat	potato	sugar beet

* C = conventional, * I = integrated

Methods

Measurements of nitrate concentrations from the two experimental farms were used to validate the simulation models SWACROP and ANIMO. A comparison between the conventional and the integrated system is made by averaging the nitrate leaching for different crops over three years. A variant study was carried out to predict the nitrate leaching under different managent options. Nitrate leaching was calculated as a result of different cultivation measures. Two options are aiming at a further reduction of nitrate leaching within the integrated system. The first management option is using fertilizer instead of organic manure. In this option the same amount of nitrogen is applied as fertilizer. The effects of decreasing organic matter content have not been considered. The second option is removal of crop residues. This option refers to sugar beet and bean. Two other calculations quantified the effects of leaving out catch crops and irrigation on nitrate leaching within the current integrated system. Irrigation was the same as in reality. A higher level of nitrate leaching is expected under these circumstances.

Results

Conventional versus integrated farming

Table 2 shows the averaged amounts of nitrate leaching for different crops. Mostly the integrated farming system results in less nitrate leaching than the conventional system. In the integrated farming system less manuring is applied and more winter catch crops are grown. Winter wheat is the exception, because it is treated more or less similary in both systems.

Table 2. Mean simulated leaching (kg ha^{-1} y^{-1})

	Crop	conventional	integrated
Vredepeel	potato	154	60
	sugar beet	81	72
	pea and beans	165	29
	maize	201	81
	winter wheat	46	50
	scorzonera	72	55
Borgerswold	potato	100	67
	sugar beet	77	64
	winter wheat	71	75

Options

Table 3 shows the relative difference in nitrate leaching for the four options with respect to the integrated farming system. A negative value means less nitrate leaching than in the current integrated system; a positive value means a higher level of nitrate leaching. Option 1 does not seem to reduce nitrate leaching. In some cases nitrate leaching has even increased. Mineral nitrogen (fertilizer) is more easily available for plant uptake but also leaches more easily. In organic manure in total more nitrogen is given but it becomes available more gradually. Besides this effect on nitrogen availability, the organic matter content might decrease, which might negatively affect soil structure stability.

Option two reduces nitrate leaching with about 10 percent. A simple reason for this is the removal of nutrients in the crop residues. Labour costs are not considered.
Catch crops (option 3) are very effective for reducing nitrate leaching. When no winter catch crops are grown (as in this option) nitrate leaching is much higher, up to 140 %. The nitrogen uptake of catch crops can be about 40 kg per hectare during the winter period. In spring, catch crops are ploughed in and this is taken into account when manure is applied.

Option 4 only refers to Vredepeel, because at Borgerswold the crops are not irrigated. Except in 1990, nitrate leaching is higher without irrigation. The increase of nitrate leaching in 1990 suggests that, in 1990, irrigation has been inefficient (too much water), whilst, in the other years, irrigation water improved water uptake by the crop. This crop uptake results in better N-uptake, leaving less nitrate in the profile for leaching. Thus efficient irrigation might lead to less nitrate leaching. In reality no irrigation would mean application of less manure or fertilizer, but in this option this was not the case. For this reason it is logical that a higher nitrate leaching has been calculated.

Table 3. Difference in nitrate leaching (%) as a result of different options with respect to the integrated farming system. Option 0 nitrate leaching (kg ha^{-1} y^{-1})

	site number	year	option 0	1	2	3	4
Vredepeel	19.2	1990	57.3	-0.2	-0.7	-	-4.4
		1991	50.3	-2.2	-15.9	-	3.2
		1992	55.3	-4.5	3.1	-	6.9
	22.1	1990	18.1	0.0	0.0	8.8	-2.8
		1991	59.9	0.0	-18.0	129.0	22.2
		1992	72.0	0.1	-15.4	40.6	38.2
	25.2	1990	44.1	0.0	0.0	18.1	-7.7
		1991	93.7	-9.5	-5.5	14.8	47.4
		1992	99.9	6.2	-7.1	-10.1	71.1
	26.1	1990	58.6	0.0	0.0	4.6	-2.2
		1991	36.4	19.0	0.0	67.6	141.5
		1992	75.3	2.1	-20.8	48.5	121.3
Borgerswold	4	1990	63.8	0.0	-0.3	0.0	-
		1991	71.7	-0.8	-11.7	1.5	-
		1992	86.6	-1.3	-5.3	-3.9	-
	7	1990	76.5	0.0	-	-	-
		1991	56.5	0.0	-	-	-
		1992	69.3	0.0	-	-	-
	15	1990	91.9	0.1	0.0	-	-
		1991	78.0	-1.2	-0.3	-	-
		1992	99.9	-1.9	-7.1	-	-
	17	1990	49.6	0.0	0.0	4.8	-
		1991	22.8	0.4	-0.4	71.9	-
		1992	55.2	-7.4	-9.2	21.7	-

Conclusions

1. Integrated arable farming results in lower nitrate leaching than the conventional systems. Lower nitrate leaching was calculated.
2. Using fertilizer instead of organic manure does not reduce nitrate leaching.
3. Crop residues could be removed to slightly reduce nitrate leaching, but the effect is small and economics have not yet been considered.
4. Catch crops greatly affect nitrate leaching. During the winter, catch crops can take up about 40 kg N per hectare.
5. Too much irrigation water could result in higher nitrate leaching; efficient use of irrigation could induce better crop uptake and thus lower levels of nitrate leaching.

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9.2.2 Effects of management options for grazing cattle within dairy farming

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Abstract
At an experimental farm, water and nitrogen flows in the unsaturated zone have been monitored at two grazed permanent grassland plots since 1991, providing a basis for validation of simulation models. High variability of nitrate-N concentrations was probably caused by uneven spreading of urine and dung patches during grazing. Simulation studies with grazing options showed that high nitrate-N concentrations in the field could be explained with these options. Urine patches occurring later in the growing season resulted in higher nitrate-N concentrations with a more pronounced effect for the second year. On a relatively wet field effective grazing management might keep nitrate-N concentrations below 11.3 mg/l (EC-directive), but for the drier field other measures will be necessary to reach such nitrate-N levels.
Keywords: *nitrate leaching, dairy farming, grazing cattle, management options, simulation modelling*

Introduction

Dairy farming in The Netherlands is facing serious environmental problems. At 'De Marke', an experimental farm for sustainable dairy farming, a system is being developed which aims at meeting environmental goals (e.g. for nitrate leaching) and is economically feasible at the same time (Aarts *et al.*, 1992).

Nitrogen is added to the soil by human activities with animal manure, fertilizers, crop residues, through deposition, but also by grazing cattle. The effect of manure and urine droppings by grazing cattle on nitrogen flows to the groundwater can be of major importance. One urine patch can represent a local application of between 400 and 1200 kg/ha N (Addiscott *et al.*, 1991). It is obvious that this N cannot be utilized by the grass crop and will mainly leach to the groundwater.

Through simulation modelling a study was performed to assess the effects of different grazing management options. The defined grazing options or scenarios ranged from no cattle at all up to maximum grazing during the growing season. The objectives of the paper are i) to try to explain measured variability of nitrate-N concentrations in the soil solution with simulation options for grazing and ii) to explore the possibility of defining grazing management options that are environmentally acceptable.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 335–339.

Materials and methods

Experimental sites

At two sites with permanent pastures on sandy soils at the 'De Marke' experimental farm for sustainable dairy farming, nitrate concentrations were measured either in the soil solution at a depth of 1 m (using 20 suction cups) or in the groundwater. At site A groundwater depths vary between 0.5 and 2.0 m below soil surface and at site B between 1.0 and 2.8 m below soil surface. At site B it is often not possible to sample soil water with the suction cups at 1 m depth due to dry circumstances and then groundwater is sampled from piezometers. To characterize water transport in the soil, moisture content and pressure head were measured at eight different depths.

In field A the groundwater was sampled in April 1992 at 100 grid points, evenly distributed over the field at varying distances of 1, 5 and 25 m, to obtain data on variability of nitrate concentrations (Dijkstra *et al.*, 1993). At these grid points a soil profile description was made as well.

Modelling

The model SWACROP (Belmans *et al.*, 1983; Feddes *et al.*, 1978) was used for simulating unsaturated water flow and the model ANIMO (Rijtema and Kroes, 1991) for simulating the nitrogen dynamics. Both models were validated using the measured data (moisture content, pressure head and nitrate concentration) for comparison with the model output. After succesful validation, seven grazing management options were defined concerning the urine and dung patches produced by grazing cattle in the field. For the first option ('average') it is assumed that this urine and manure is spread evenly over the field. The second option ('none') considers no grazing at all. For the third option ('June') one urine patch is expected to be dropped at 1 June 1991 and a second urine patch on 1 June 1992. For the next options urine patches occur one month later, so the fourth option ('July') considers urine patches on 1 July 1991 and 1992 and finally the seventh option ('Oct.') has urine patches on 1 October 1991 and 1992. For 'De Marke' it was calculated that one urine patch contains 455 kg/ha N. The organic N in dung patches is slowly degradable and is not considered here.

Results and discussion

Measured concentrations and variability

Figure 1 represents the frequency distribution of the nitrate-N concentrations of the 100 groundwater samples of field A. The average, minimum and maximum concentration was 17.0, 0.0 and 109.7 mg/l nitrate-N respectively. The extreme values occurred at random locations within the field. No correlation was found between the measured concentrations and soil parameters, such as organic matter content, soil texture and groundwater depth (Aarts *et al.*, 1994). This could imply that the variability is caused by manure and urine patches.

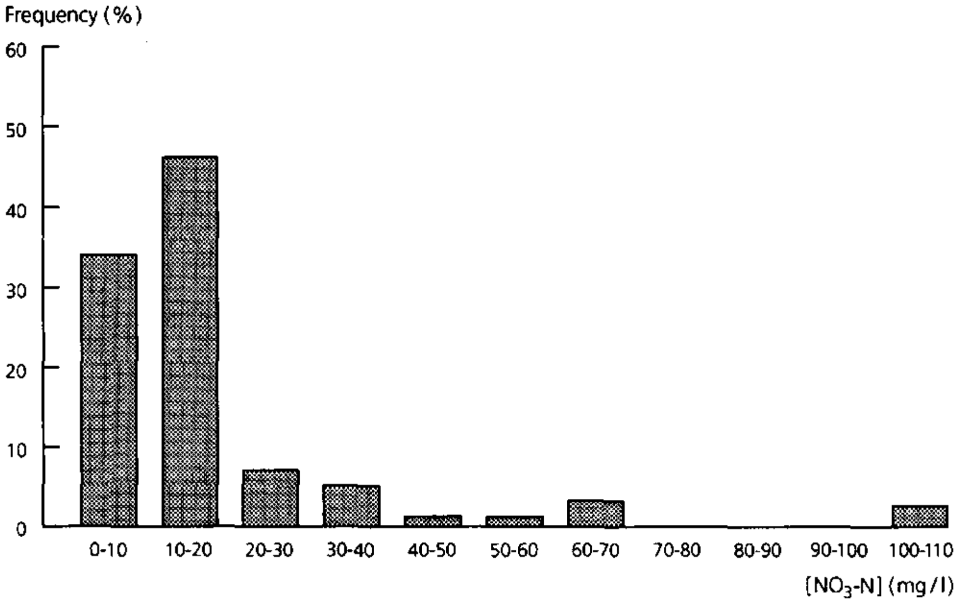

Fig. 1. Distribution of nitrate-N concentrations in the groundwater of field A in April 1992

Figure 2 shows the measured concentrations at 1 m depth for fields A and B. For field B in 1992 only groundwater sampling was possible. For all measurements the standard deviations are indicated. It is obvious from Figure 2A that at field A the levels are near the EC-directive of 11.3 mg/l nitrate-N, whereas at the drier field B (Fig. 2B) the concentrations exceed this level.

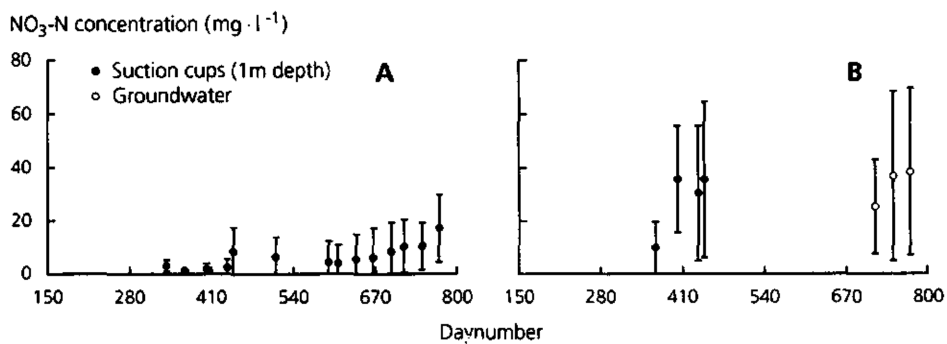

Fig. 2. Measured nitrate-N concentrations in field A (1-1-1991 = daynumber 1) and in field B (1-1-1991 = daynumber 1)

Simulated grazing options

With the simulated grazing options we hoped to explain the measured variability. In Table 1 the measured and simulated average nitrate concentrations for two hydrological years are presented. The average simulated option (option 1) is similar to the measured average values, whereas the 'no grazing' option did not explain the lowest measured concentrations, implying that factors other than grazing are more important for this. The highest measured values, however, are simulated quite well with the grazing options, with the highest output usually corresponding with the option 'urine in October'.

Table 1. Mean measured and simulated nitrate-N concentrations in the hydrological years 1991-1992 and 1992-1993

	Average	Minimum	Maximum
1991-1992			
Measured site A	4.7	0.2	31.8
Simulated site A	10.6	9.6	22.2
Measured site B	27.6	2.3	68.0
Simulated site B	29.0	29.0	67.5
1992-1993			
Measured site A	7.5	0.9	28.4
Simulated site A	9.0	4.9	27.0
Measured site B	33.3	7.6	79.6
Simulated site B	22.2	22.2	93.3

Finally Figure 3 shows the average simulated nitrate-N concentrations for all the options. The differences between the two fields are striking. At field A many options produce nitrate concentrations below the EC-directive, as indicated in the figure, making it possible to define environmentally acceptable grazing management. At field B none of the options result in such nitrate concentrations.

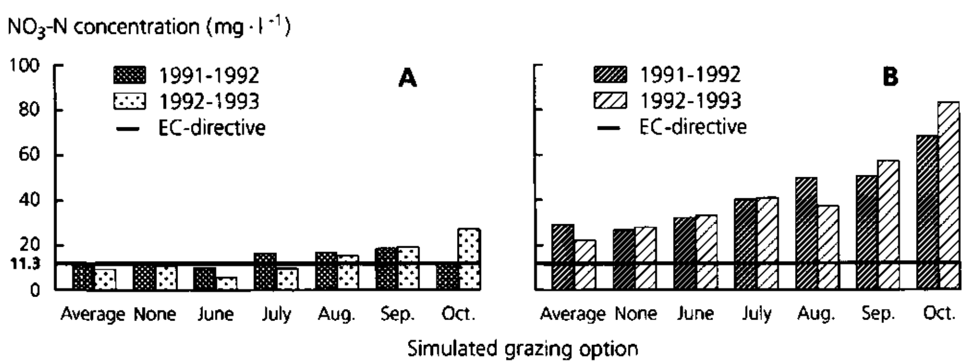

Fig. 3. Average simulated nitrate-N concentrations for the grazing options for field A and B

Conclusions

By simulating grazing options it is possible to explain high nitrate-N concentrations rather well. Urine patches, occurring later in the growing season, result in higher nitrate-N concentrations. This effect is more pronounced (for urine patches in the late autumn) in the second year than in the first year. In field A effective grazing management might keep nitrate-N concentrations below 11.3 mg/l (=50 mg/l nitrate, EC-directive). In field B other measures will be necessary to reduce the risk of exceeding nitrate-N levels of 11.3 mg/l.

Acknowledgements
Part of this work was made possible by funding of EC-DG XII within project STEP-CT90-0032. We thank Ir. A.H.J. van der Putten at AB-DLO for his helpful suggestions for the definition of grazing scenarios.

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9.2.3 Simulation of nitrogen balances of a crop rotation for crop and pig farms during 25 years of actual climate

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Abstract
Nitrogen balances at farm level for the crop rotation winter barley - winter rape - winter wheat - winter wheat - spring barley on a loamy soil were simulated with the DAISY model in the period 1966-1991 with the use of daily measured East-Danish climatic conditions. Simulations were performed for a pig farm with a production of 1.7 livestock units per ha and for a crop farm. Nitrogen applications were 100 and 60 per cent of Danish standard applications. The simulations showed that mean annual NO_3-N concentrations in percolating water were 63 and 20 ppm for the pig farm and 16 and 4 ppm for the crop farm at 100 and 60 per cent of standard nitrogen applications, respectively. Only the crop farm with 60 per cent of standard nitrogen application fulfilled the EU-requirement of maximum 11.3 ppm in drinking water.
Keywords: *nitrogen balance, crop farm, pig farm, actual climate*

Introduction

The nitrogen leaching of a cropping system is highly influenced by the climatic conditions with its elements of stochastic variation. This variation influences both the crop growth, crop nitrogen uptake and the turnover rate of organic material incorporated into the soil. In order to reduce nitrogen leaching without reducing crop yields the combined effects of nitrogen supply and climatic conditions should be taken into account.
This may require expensive long term experiments and it may take years before different cropping systems can be analyzed. However, by simulation with mechanistic models, it is feasible to analyze such combined long term consequences.

Methods

The DAISY-model (Hansen et al. 1990) was used to simulate nitrogen balances for a crop and a pig farm on a loamy soil. The model has been validated in several cases (Hansen et al., 1991a-c, Svendsen et al., 1994). The model simulates on daily basis water and nitrogen balances, with driving variables being global radiation, precipitation, air temperature and if available potential evapotranspiration.

In the model it is assumed that crop production is achieved with optimal plant protection for which reason simulated crop production only is limited by radiation, water or nitrogen supply. In practical agriculture the yields may be reduced because of diseases.
In the present simulations the potential yields therefore were reduced to the level normally achieved in practical agriculture by relatively reducing the photosynthetic radiation conversion efficiency by 10% for the winter crops.

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Climatic conditions for the period 1966-1991 were obtained from the Climate and Water Balance Station, The Royal Veterinary and Agricultural University, Copenhagen.
A typical cropping system for pig and crop farms was chosen (Table 1) which fulfills the law that at least 65 per cent of arable land must be cropped during winter.
For the pig farm, available manure was based on that produced by 1.7 livestock units per ha (Au/ha) which corresponds to 31 tons slurry per ha per year with a nitrogen content of 6.3 kg per ton. NH_4-N content was assumed to be 70 per cent of total N content (Håndbog for Plantedyrkning,1993). In the simulations NH_4-N volatilization was assumed to be 15 per cent of total NH_4-N content. Applications of nitrogen fertilizer were in accordance with the Danish standard values (Håndbog for Plantedyrkning,1993). Relatively, the nitrogen in manure was assumed to be utilized by 50-60 per cent dependent on the times of application, and supplementary fertilizers were applied. For the crop farm only fertilizers were applied in accordance with the standards.

Two levels of nitrogen application were chosen: 100 and 60 percent of the standard nitrogen applications rates (Table 1).

For the pig farm with 1.7 Au/ha the supplementary fertilizer applications were very close to 40 per cent of the standard values. Therefore, in the reduced case with 60 per cent applications, no additional fertilizers were applied.

Table 1. Crop rotation and nitrogen applications.

	Pig Farm				Crop Farm	
	100 % N		60 % N		100 % N	60 % N
	Manure kg N/ha	Fertilizer kg N/ha	Manure kg N/ha	Fertilizer kg N/ha	Fertilizer kg N/ha	
W.Barley	202	69	202	0	170	102
W.Rape	221	82	221	0	200	120
W.Wheat	189	65	189	0	160	96
W.Wheat	214	73	214	0	180	108
S.Barley	151	29	151	0	120	72
Total	977	318	977	0	830	498

Simulations

Simulations were initiated April 1 1966 but results for the first five years 1966-1970 were only used to bring the system into balance with regard to soil organic matter. For each farm type and level of nitrogen application 5 simulations were performed. Each of these 5 simulations was initiated with one of the crops in the crop rotation. The results were made up for the period from April 1 to March 31. The annual means of each set of 5 simulations thus characterize the crop rotation at farm level.

Results

Precipitation and simulated percolation for the period 1971-1991 are shown in Table 2. Mean annual precipitation for the period 1955-1979 is 583 mm (Hansen et at, 1981) which is close to the annual precipitation of 1978. Annual precipitation was less than the mean value only in the years 1971, 1975, 1976 and 1988, which might indicate a tendency toward higher annual precipitation. The percolation values follow mainly the precipitation values with exceptions in 1971, 1986 and 1988. These exceptions are related to the annual distribution of precipitation. A high value of precipitation and a corresponding small value of percolation means that summer precipitation is relatively high and winter precipitation relatively small.

Table 2. Precipitation and simulated percolation.

	Precipitation mm	Percolation mm
1971	478	0
1972	585	126
1973	637	133
1974	617	172
1975	442	35
1976	462	77
1977	555	65
1978	538	73
1979	571	119
1980	758	261
1981	666	210
1982	674	110
1983	613	188
1984	620	107
1985	680	171
1986	551	27
1987	763	318
1988	453	2
1989	625	113
1990	566	111

Mineralization showed only small variation over the period for both pig and crop farms with 100 and 60 per cent level of nitrogen application (Fig. 1). The small differences between the two nitrogen levels were caused by mineralization of crop residues where the crop residues for the 60 per cent nitrogen application had smaller nitrogen content. Mineralization at the pig farm was approximately twice the mineralization at the crop farm.

For the four treatments observed, the nitrogen yields did not vary much over the period (Fig. 2). Between the treatments, the differences between 100 and 60 per cent of application rates were most pronounced where mineral fertilizers alone were applied, while there were only minor differences where the crops were manured. The N-yields at 60 per cent application rates for manured crops were close to those supplied 100 per cent with mineral fertilizers. Although small, the variation of N-yield was highest at 100 per cent application rate.

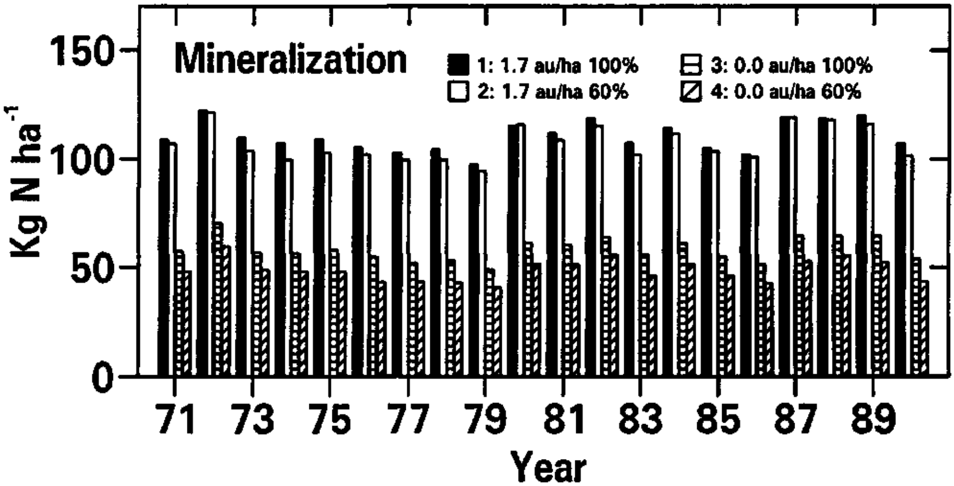

Fig. 1. Yearly mineralization for pig and crop farms

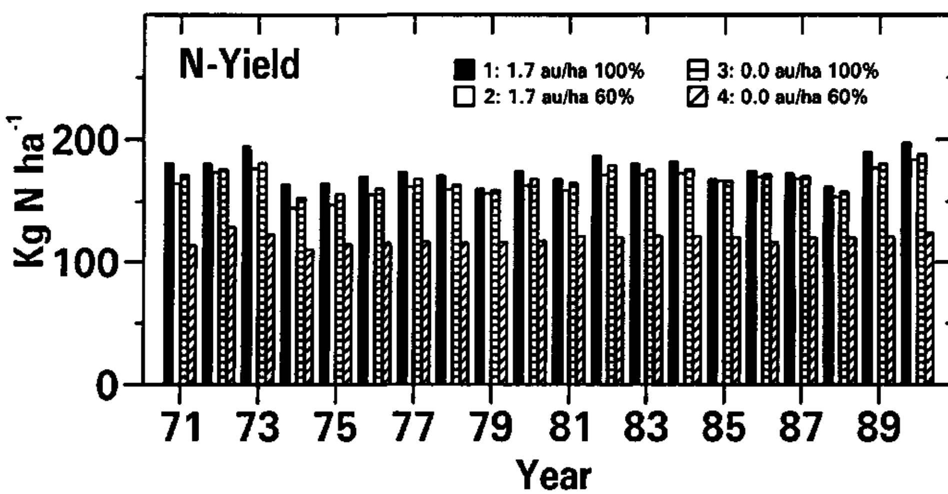

Fig. 2. Yearly nitrogen yield for pig and crop farms.

Leaching appeared to be very much higher for the pig farm supplementary supplied with mineral fertilizer to 100 per cent application level indicating surpluses (Fig. 3). By reducing nitrogen application for the pig farm to the 60 per cent level leaching was reduced to the level of 100 per cent fertilized crop farm, indicating that the manure available from 1.7 pig livestock per ha is nearly sufficient. Leaching varied very much over the years observed. The variations followed to a high degree the variation in percolation.

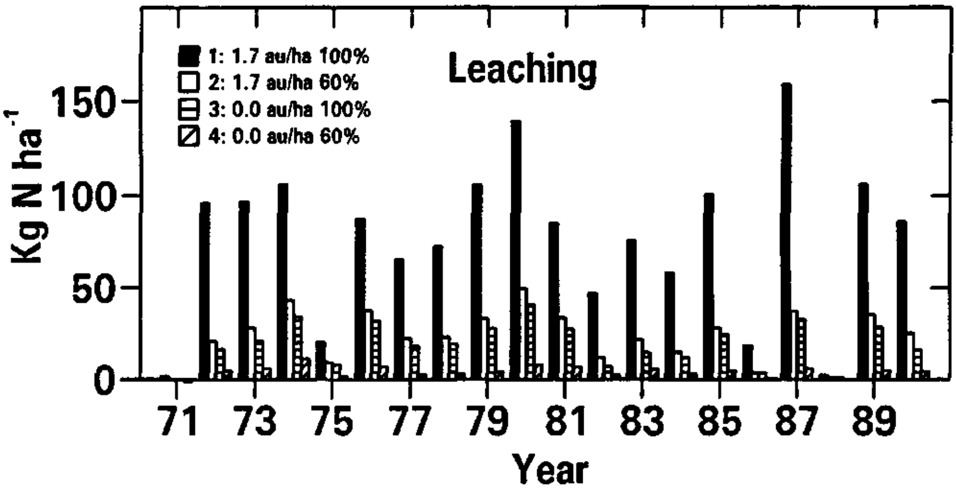

Fig. 3. Yearly leaching for pig and crop farms.

For the 60 per cent mineral fertilizer application the maximum leaching was 12 kg N per ha but for most years leaching was much smaller. Mean annual leachings for the pig farm were 77 and 24 kg N per ha for 100 and 60 per cent nitrogen application levels, respectively. For the crop farm the mean leachings were 19 and 4 kg N per ha, respectively.

The average NO_3-N concentration of the percolating water at 1 m depth was much higher (63 ppm) in the 100 per cent manured case than in the others (Fig. 4). For 1971 the concentrations were undefined as net percolation was 0.0. Only the crop farm with 60 per cent mineral fertilized level with mean concentration of 4 ppm met the EU requirement of 11.3 ppm NO_3-N in drinking water in each of the years observed.

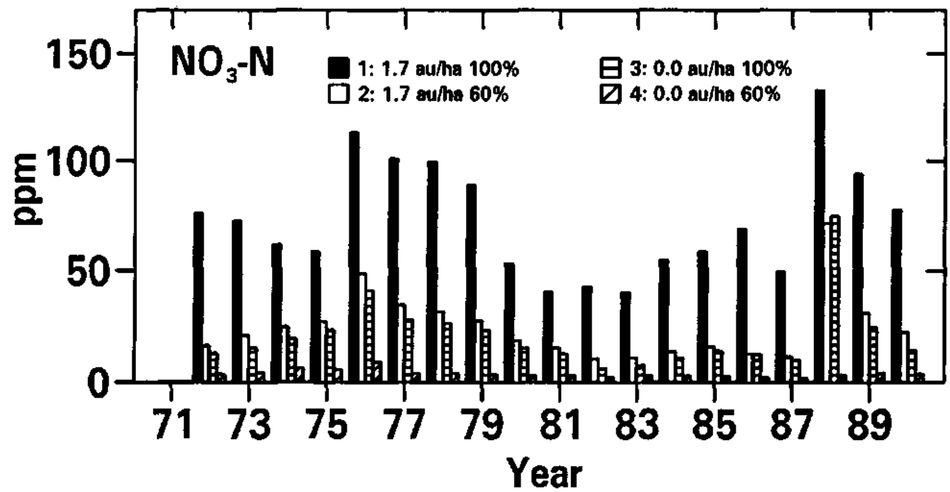

Fig. 4. Mean annual NO_3-N concentration in percolating water for pig and crop farms.

Conclusion

The scenario study clearly shows the yearly variation in leaching due to the variation in percolation. Decisions on regulating the application of nitrogen should therefore take into account the climatic variations and should not be based on only a few years of observation. Regulation by legislation has taken place in Denmark during the second half of the eighties and the beginning of the nineties. During this period the simulation results indicate a tendency toward climatic conditioned increase in leaching.

Leaching can, without a major decrease in yields, be considerably reduced on pig farms with 1.7 livestock units per ha.

Scenario studies on crop management and land use should take into account the climatic variations between years in cases where they influence the theme under consideration. This is necessary where political decisions are to be taken on the basis of scenarios, in order to convince farmers and society as a whole.

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9.2.4 An integrated economic analysis of a levy on the nitrogen surplus: the case of Dutch pig fattening farms

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Abstract

The Dutch government has formulated a control policy to reduce the harmful effects of the production and application of manure. Economic instruments are more cost-effective and will perhaps be used in the future. This paper deals with a scenario study on the effects in the long run of a regulatory levy on the nitrogen surplus of pig fattening farms. Results of several studies are integrated. Starting from cost minimizing behaviour, the method developed allows every farmer to react differently to a levy. A levy turns out to be very effective in the pig fattening sector. But even a levy of 2 guilders per kilogram nitrogen does not remove the total surplus and results in large profit losses. Further research is needed to underpin the empirical filling out of the model.

Keywords: *regulatory levy, manure problem, nitrogen surplus, pig fattening farms*

Introduction

Pig farms in The Netherlands pay a zero or low price for exploiting the environment. As a consequence, the environment is overexploited. The Dutch government wants to reduce the emissions of nitrogen and phosphorus and has used a control policy since 1987. Recently, economic instruments like levies on mineral surpluses have been considered. As demonstrated by Baumol and Oates (1988) economic instruments can in theory achieve policy targets, such as emission levels, at lower total resource costs than uniform physical regulation.

This paper deals with a scenario study on the effects of a regulatory levy on the nitrogen surplus of pig fattening farms. Starting point is the development for every pig farm of a relationship between the reduction of the nitrogen surplus and the costs per unit of nitrogen reduction. A new element of this study is that the results of several studies have been integrated into one framework.

Theory

We assume that the farm family minimizes the sum of the costs of the reduction of nitrogen on the farm and the levies which it has to pay:

$$\min \sum_{i=1}^{5} c_i(n_i) + t(s - \sum_{i=1}^{5} n_i) \tag{1}$$

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where n_i is the quantity of nitrogen reduction according to option i; c_i are the costs of using option i; s is the total amount of nitrogen production on the farm; t is the levy on the nitrogen surplus.

One of the options enabling the farmer to reduce the amount of nitrogen is to reduce the number of pigs and change the amount of feed within the existing technology. This option is analysed using an econometric model. According to Fontein *et al.* (1994) the relationship between the marginal cost and the nitrogen reduction is a straight line, which is estimated using data from Dutch pig farms for the period 1975-1989. We assume that the other options enabling the farmer to reduce the amount of nitrogen (acceptable application of nitrogen on land, feed containing less nitrogen, transportation to other farms, processing) have constant marginal costs.

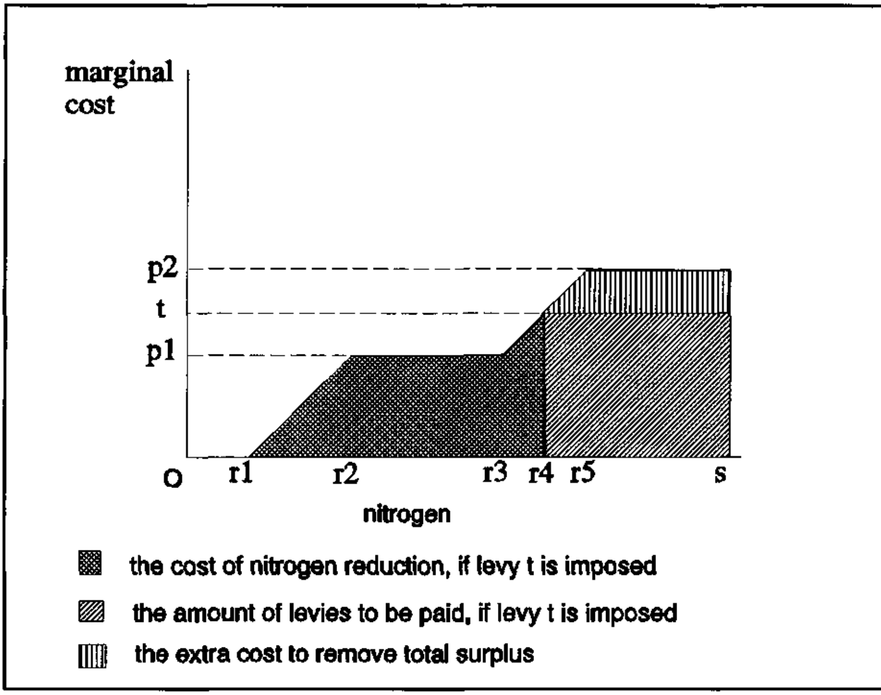

Fig. 1. The relationship between the marginal cost and the nitrogen reduction

Figure 1 gives an example of the marginal cost curve of a farmer with four options to reduce the amount of nitrogen. When a farmer is confronted with a levy t on nitrogen surpluses, the farmer will reduce the amount of nitrogen by r4, where the marginal cost of nitrogen reduction is equal to the levy according to the first order condition of equation (1). The farmer has a couple of hectares where he can put nitrogen according to the standards without extra cost (r1-0). Overviewing his alternatives, the farmer chooses to reduce the number of animals, which reduces his nitrogen surplus with r2-r1. He will choose for reduction as long as the marginal cost of reduction is lower than the marginal cost of his alternative options. The next alternative he uses is reducing the nitrogen content of feed at a price p1 per kilogram nitrogen. He can reduce his surplus by this new technology at most by r3-r2. The marginal cost of reducing the nitrogen content of feed is assumed to be constant. The farmer will dump the amount of nitrogen (s-r4) on his land. Although this will cause environmental damage, it is, for this farmer, cheaper to pay a levy than to reduce his nitrogen surplus further by (s-r4).

Empirical specification

In our study we assume that the farmer has five options for dealing with the total amount of nitrogen production of the farm. The marginal cost and the maximum use a farmer can make of an option are presented in Table 1.

Table 1. Cost and maximum attainable levels of different options for reducing the amount of nitrogen

	Option	Cost (guilder/kg nitrogen)	Maximums (% nitrogen emission)
1.	acceptable application on land	0	300 kg/ha
2.	reduction in number of pigs	variable[1)]	0 - 100
3.	feed containing less nitrogen	0.45[2)]	16
4.	transportation to other farms	1.23 or 1.71[3)]	7.9
5.	processing	2.63	15.5

1) depends on the number of pigs reduced, an increase in the reduction of nitrogen by 1 kg leads to an increase in the marginal cost of 0.000244 of a Dutch guilder (after a reduction of 1844 kg of nitrogen, the cost of this option is equal to the average cost of option 3)

2) average, depends on the amount of feed used

3) 1.23 for the provinces of Gelderland, Utrecht and Overijssel; 1.71 for the provinces of Limburg and Noord-Brabant

Using a linear programming model and straightforward calculations Baltussen and Van Horne (1992) give an insight into prices and possibilities of feed containing less nitrogen. Advantage of using the results of this study is that these can be combined with the results of Fontein *et al.*, because Baltussen and Van Horne make their calculations under the assumption of an unchanged relationship between the amount of feed and the output.

Farmers will also be influenced in their farm management by legislation to reduce ammonia emission. The Dutch government has passed several laws to reduce ammonia emission. In this study we assume that ammonia emission is decreased by regulations and not influenced by the levy, although we assume that a farmer has to pay a levy on that part of the emission which is emitted from the stable.

Results

The study is based on data from Dutch pig fattening farms for the period 1987-1989. A computer program is used to construct the relationship between nitrogen and marginal cost per farm. Figure 2 gives an overview of the farmers' choice of options for different levels of levies in the long run.

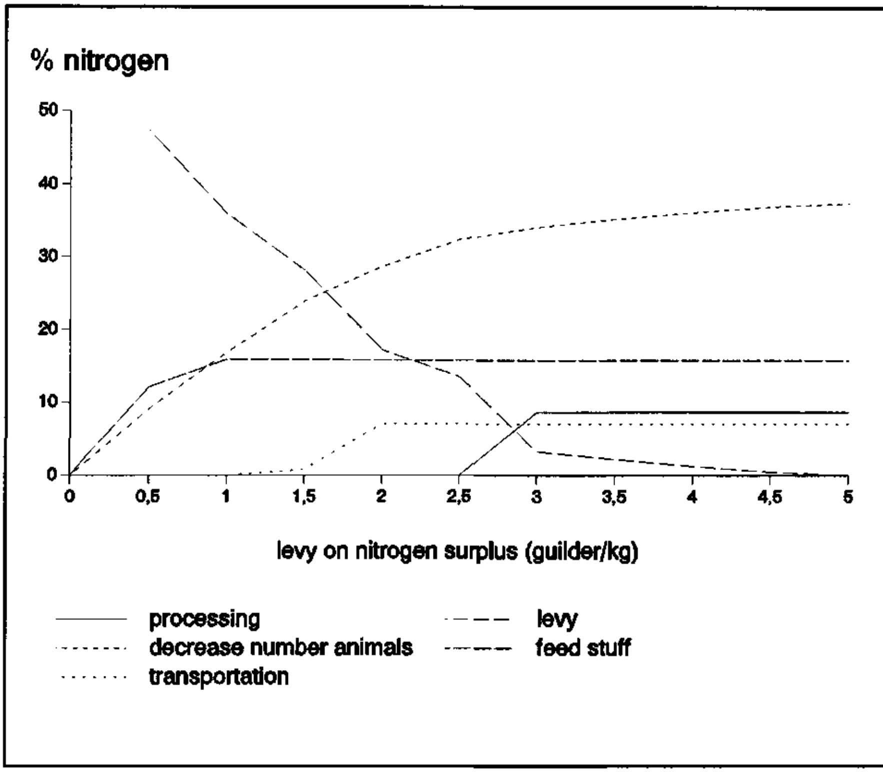

Fig. 2. Use of different options (in %) when a levy is imposed on the nitrogen surplus

Figure 3 shows that a 75 percent reduction in the nitrogen surplus will be achieved by a levy of 2 Dutch guilders in the pig fattening sector. The application of manure on land, according to acceptable standards, is not taken into account in this figure.

Conclusions

Starting from cost minimizing behaviour by pig farmers, a levy on the nitrogen surplus is investigated. The main conclusions obtained from the study are:

(a) The prices and possibilities of the options for processing manure and reducing the number of pigs are assumed to be the same for all farms. The application of options concerning land, less nitrogen in feed stuff and the costs of transportation are more differentiated. Therefore, in our model every farmer reacts differently to a levy.

(b) Farmers in the pig fattening sector use several options to reduce their nitrogen surplus. As a result, a regulatory levy in the pig fattening sector is very effective.

(c) The largest part of the reduction in the surplus comes from decreasing the number of animals. Adaptation of feed and transportation of manure is also of interest to the pig fattening sector. But even a levy of 2 guilders does not remove the total surplus and results in large profit losses.

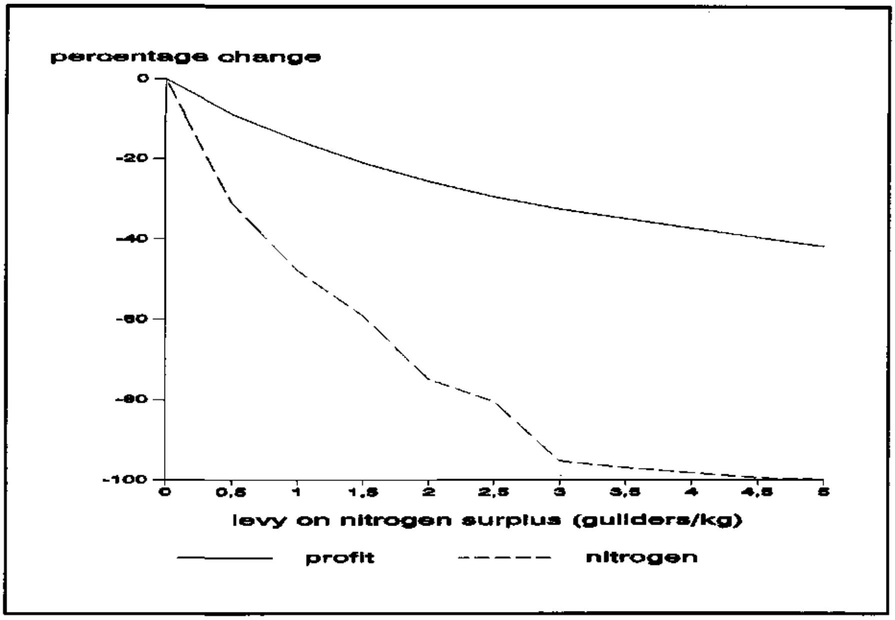

Fig. 3. Influence of a levy on the surplus of nitrogen and profits

(d) A central element of this study is to show that the integration of different types of studies within one framework is possible. Further research is needed to underpin the empirical specification of the model.

Acknowledgements
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9.3 Integrated water and nutrient management

9.3.1 Predicting the effects of measures to reduce eutrophication in surface water in rural areas - a case study

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Abstract
To reduce the nutrient concentrations in the surface water of the Bergambacht polder in The Netherlands, remedial measures are needed. To predict the effectiveness of measures, a combination of a nutrient leaching model for the groundwater system and a nutrient simulation model for the surface water system was used. Scenarios were formulated on the basis of several measures. Different combinations of drainage level and fertilizer use give slightly different leaching concentrations. Removing duckweed, dredging the total sediment layer and improving the sewage treatment plants and a combination of these measures will reduce the phosphorus concentration in the surface water in the summer substantially. For nitrogen, removing duckweed and improving the sewage treatment plants are important measures, but less effective than for phosphorus. Dredging will not reduce the nitrogen concentration.
Keywords: *scenario study, eutrophication, remedial measures, leaching model, surface water quality model*

Introduction

In The Netherlands large parts of the surface water system in rural areas are highly eutrophic. The nutrients nitrogen and phosphorus occur in high concentrations in these waters. In order to lower current eutrophication levels, remedial measures are required. In this study, we evaluated the effectiveness of a number of proposed measures intended to reduce the eutrophication of the surface water in the Bergambacht polder in the western part of The Netherlands. This polder can be characterized as a peat pasture area. Owing to the high eutrophication level, duckweed grows abundantly in this area. This is caused by high nutrient emissions from the soil, from sewage treatment plants, and from the phosphate-enriched underwater soil, and by inlets of nutrient-rich water. The emission from the soil is caused by fertilization, nutrient-rich upward seepage and mineralization of peat.

Material and methods

The effectiveness of measures was evaluated using a simulation tool that combines quantity and quality models for the groundwater and the surface water system (Fig. 1). To predict the emission of nutrients from the soil, the dynamic ANIMO simulation model was used (Rijtema *et al.*, in prep). ANIMO calculations were based on hydrological information provided by the hydrological model FLOCR (Oostindie and Bronswijk, 1992).

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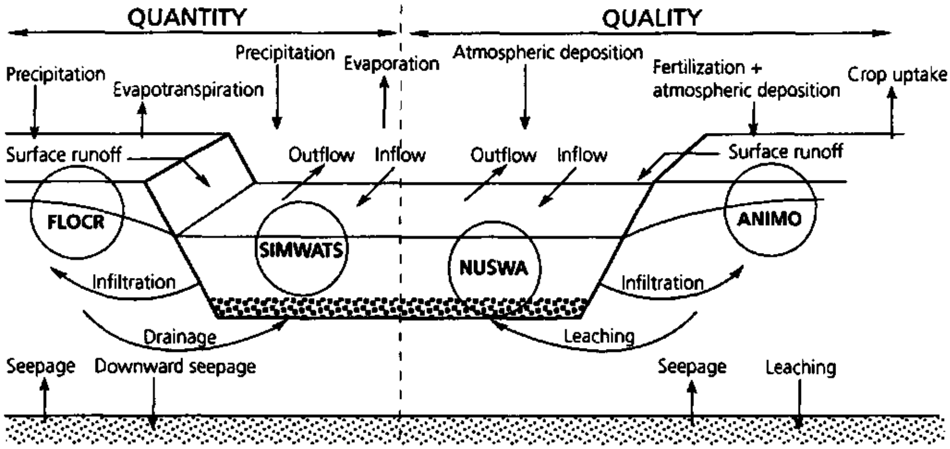

Fig. 1. Overview of incoming, outcoming and boundary fluxes which influence nutrient concentrations in the surface water system. Models, represented in the circles, were used to simulate processes.

The NUSWA model (Van der Kolk and Drent, in prep.) calculates the concentration of nitrogen and phosphorus compounds in the surface water on a regional scale. Transport of nutrients is calculated on the basis of discharges simulated by the hydraulic model SIMWATS (Hendriks, in prep.). The emission of nutrients from the soil is obtained from the ANIMO model.

Two types of measures were proposed: indirect measures to decrease the emission from the soil and direct measures to reduce the nutrient concentrations in the surface water. The indirect measures involve drainage level and fertilizer use. Two drainage levels are considered: the present level (A) and a lowered level (B). Three variants of fertilizer use are taken into account: (a) according to the present legislation; (b) accelerated to the lowest level defined in variant (a); (c) according to the regional crop uptake level. The direct measures are: removing duckweed, dredging the total sediment layer and improving the sewage treatment plants.

Different scenarios were formulated based on the proposed remedial measures. The six possible combinations of drainage level and fertilizer use form the six scenarios for the emission from the soil (I-VI in Fig. 2). For the nutrient concentrations in the surface water five scenarios are considered (I-V in Fig. 3): (I) autonomous scenario: present legislation for fertilizer use, dredging natural accretion of sediment, improving the sewage treatment plants according to the latest regulations; (II) removing duckweed: the autonomous scenario plus removing duckweed; (III) dredging: autonomous plus dredging the total sediment layer, in order to reduce the emission of phosphate to the overlying water layer; (IV) improving sewage treatment plants: autonomous, but further treatment of sewage according to best technical means; (V) total scenario: autonomous plus the three measures described in (II), (III) and (IV).

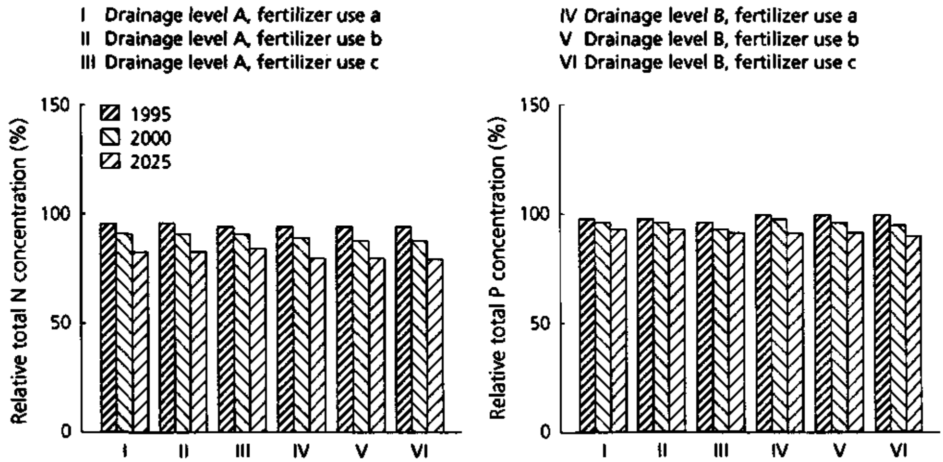

Fig. 2. Total N and total P emissions from the soil as average annual concentrations in the leaching water (in % relative to the reference year 1990) in the Bergambacht polder in 1995, 2000 and 2025, for the six scenarios (no. I-VI).

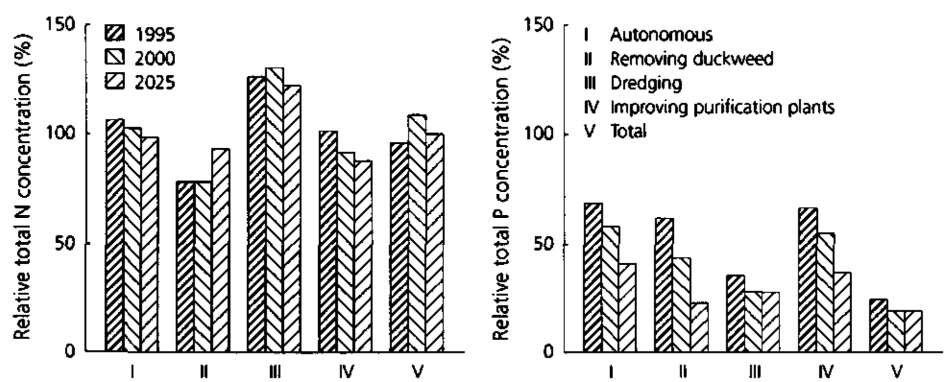

Fig. 3. Average concentrations of total N and total P in the surface water (in % relative to the reference year 1990) in summer in the Bergambacht polder in 1995, 2000 and 2025, for the five scenarios (no. I-V).

The scenarios are simulated with the models. The simulation period started in 1990. The concentrations calculated for this year were considered to be the reference concentrations. The simulation was carried out over a period of 35 years with meteorological data from the average year 1952. The measures were assumed to start in 1994.

Results

For the years 1995, 2000 and 2025 model output was analyzed. The concentrations of total phosphorus and total nitrogen in the leaching water and in the surface water were calculated as the weighted averages of the study area, the leaching concentrations as annual averages and the concentrations in the surface water as summer averages. The results of the scenario calculations for the emissions from the soil are represented relative to the average annual concentrations in the reference year 1990 (Fig. 2). The results for the nutrient concentrations in the surface water are relative to the average concentrations during summer in 1990 (Fig. 3).

Discussion and conclusions

Nitrogen and phosphorus concentrations in the leaching water decrease in time in all scenarios due to reduction of fertilization (Fig. 2). The three defined levels of fertilization give minimal differences in leaching concentration. The influence of the drainage level on the leaching concentration is small as well, but somewhat larger than the influence of the defined fertilization levels. The lower drainage level (variant B) reduces the leaching of fertilizer, but increases the upward seepage. In the scenarios the first effect is slightly dominant.

In the autonomous scenario for the surface water (no. I), both nitrogen and phosphorus concentrations in the surface water decrease in time due to the reduction in emissions from the soil and sewage treatment plants (Fig. 3). The reduction in the phosphorus concentration is more substantial, because the amount of phosphate adsorbed to the sediment decreases in time as well. Removing duckweed (no. II) causes a reduction in both nitrogen and phosphorus. Dredging the total sediment layer (no. III) causes a significant decrease in phosphorus concentrations just after this measure was carried out. The phosphorus concentration stabilizes a few years after the dredging. The nitrogen concentration increases because dredging removes most of the denitrification capacity. Further treatment of sewage (no. IV) results in a small decrease of nutrient concentrations. Only in the vicinity of the sewage treatment plants, this effect is significant. Implementing all three measures together (no. V), results in a reduction in the phosphorus concentration by 80 % in 2025 compared with the concentration calculated in 1990, but has hardly any effect on the nitrogen concentration.

Acknowledgements
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9.3.2 Integrated water resources management in East Veluwe, The Netherlands

A scenario based study of strategies in water management

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Abstract
The East Veluwe region in the province of Gelderland is one of the primary natural areas in The Netherlands. Yet, nature in the region suffers from desiccation (in wetlands) and eutrophication (in surface water). This is a result of increasing pressure on the region by increasing ground water abstraction, agriculture and waste water disposal. In 1992 the Provincial Board in cooperation with other authorities initiated a project to identify solutions for these problems. The aim of the project was to develop and evaluate scenarios that would restore a minimum of 25% of desiccated nature and to improve water quality up to the so-called "boundary levels".

In the project, four phases can be identified, three of which have been completed so far. In the first phase (inception) a number of tools were developed. In the second phase (development) different scenarios were formulated using the tools developed in the first phase. Major variables in the scenarios were: the source of public water supply, the function of the Apeldoorn Canal and the geographical distribution of the natural values targeted for restoration. In the third phase (selection) the scenarios were evaluated. It was concluded that implementation of the scenarios would result in the restoration of 42-75% of the desiccated nature, and an improvement in water quality up to the desired standards in most surface waters. Cost of implementation would be in the range of Dfl 340 - 810 million.
Keywords: *integrated water management, policy analysis through scenarios, ecology*

Introduction

In the 1990 Regional Policy Plan for Water Management of the Province of Gelderland, water systems were delineated and divided into a five scale functional category. For each category, the plan identifies targets with regard to water quality and quantity. In order to meet the targets, a number of projects have been undertaken. The project "East Veluwe Integrated Water Resource Management" is one of them. The study area is presented in Figure 1.

The primary objective of the project was to identify and evaluate scenarios that would lead to a restoration of a minimum of 25% of desiccated terrestrial ecosystems and an improvement of surface water quality up to the so-called "boundary levels".

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 359–365.

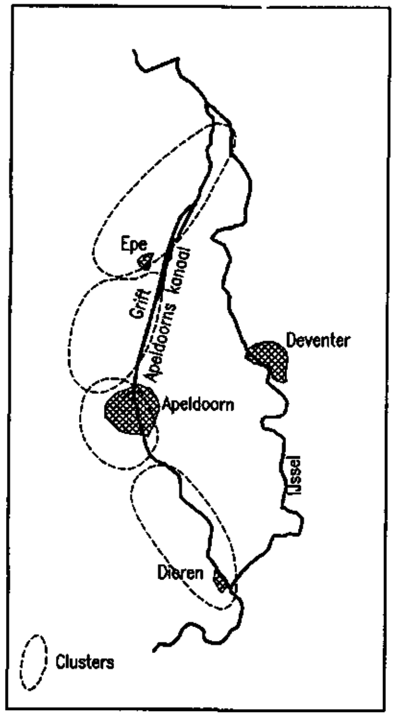

Fig. 1. The study area

Project approach

It was felt by the province of Gelderland that a scenario approach was suitable for achieving the objectives of the project, namely to come to a well-founded decision on the water management policy to be adopted for the region. In previous projects undertaken by the province, this approach had proven to be practical and flexible. But also in many other areas of policy analysis and decision making the approach is known to be effective (Petersen, 1984).

The approach to the East Veluwe project can be characterized by four phases (see also Marchand et al, 1993). In the first phase (inception), problem identification was the central issue. Essential steps in this phase were an integrated inventory and modelling of all relevant components and linkages in the nature-water-system.

In the second phase (development) possible solutions were prepared. This phase had both a conceptual component, namely the formulation of possible strategies for water management and a technical component. The latter involved calculation exercises with the models that had been developed, and a fine-tuning of the method to quantify effect. This was done in order to check and improve assumptions that were adopted in the modelling of the system, and in order to get a better understanding of reactions and linkages.

In the third phase (selection) an optimisation took place: scenarios were sought that maximized project outputs and minimized inputs in terms of cost, public health risks, etc. In the fourth phase (presentation) the solution that comes out best in phase three is translated into terms of policy making. This last phase was not part of the assignment to Iwaco.

Results

Inception phase

The problems of desiccation and eutrophication in the East Veluwe region are both well documented (Province of Gelderland, 1992; Veluwe Water Quality Board, 1987). With regard to desiccation, the region is reported to be moderately affected. This is a result of many factors, but ground water abstraction for domestic water supply and industries and agricultural intensification appear to be the most important. With regard to eutrophication, the two major surface water drains: Apeldoorn Canal and Grift, are severely affected, although the situation has already improved considerably over the last two decades. The problems that occur mainly in summer are by and large a result of effluent disposal from waste water treatment plants.

A comprehensive inventory of water management problems was carried out, covering both the nature aspects of the region, the ground water and the surface water system. Based on the inventory, classifications were made with respect to natural values. And water balances and models were developed to simulate the ground and surface water system. In addition to this, correlations were identified between natural values and hydrological parameters like ground water table, ground water quality, surface water flow velocity and surface water quality. This "linking" of nature and hydrological parameters, made it possible to translate hydrological changes (calculated with the models) into consequences for nature.

The ground water system was modelled with the TRIWACO package. This package is semi three-dimensional and can simulate both steady state and transient flow situations, but for this region only the first option was used. The surface water system was modelled using the DUFLOW package. Only the quantity model was used, as the quality model was not operational at the time of the study. Water quality processes (Phosphate) were simulated in a spreadsheet model, linked manually to the DUFLOW model. The spreadsheet was basically a mass balance, including various types of sinks and sources.
The ground and surface water models were also linked manually. Output from the ground water model could be fed into the surface water model and vice versa.

After calibrating and a number of trial calculations, the models were considered to be good enough for the evaluation of scenarios to be carried out in the next phases.

Development phase

In this phase, firstly possible strategies for integrated water management in the region were developed. Based on that, a number of scenarios were formulated. Secondly, a method was developed to evaluate the criteria that were selected to measure effects.

The formulation of possible water management strategies and scenarios took a relatively long time. As any strategy option would have negative consequences for at least one sector, it appeared difficult to reach consensus in the core-team that executed the project. Yet, after a number of unfruitful efforts a number of major variables was agreed upon as a guideline for formulating scenarios. These variables were:

- the source of domestic water supply (ground water or surface water after artificial recharge);
- the geographical distribution of the targeted nature restoration (focused or diffuse)
- the function of the Apeldoorn Canal (nature, public water supply, waste water conveyance).

In addition to these major variables, minor variables were agreed upon such as the number of treatment plants to be disconnected from the regional surface water system, the depth of the drainage basis in natural and agricultural areas, the surface under evergreen cover, the flow direction of the Apeldoorn Canal, the outlet of brooks (discharging into the Canal or the Grift). Using these variables, four scenarios were developed, as listed schematically in Table 1.

Table 1. Four scenarios according to major variables

Scenario	Source of public water supply		Function of Apeldoorn Canal	Geographical distribution targeted nature restoration
	domestic(*)	industry(**)		
1	ground water (no re-allocation)	surface water from Canal	industrial water supply	whole region
2	ground water (re-allocation)	surface water from River IJssel	waste water conveyance (north) nature (south)	north
3	artificial recharge from IJssel (40%)	surface water from Canal	public water supply	whole region
4	river bank filtration (50%)	surface water from Canal and river bank filtration	public water supply	whole region

(*) the percentages relate to the total water demand
(**) in all scenarios the industrial ground water abstraction is reduced by 85%

The second aspect in the development phase was to define a systematic method to evaluate the criteria that were to be used in the selection phase. The criteria could be roughly divided into two categories: those indicating "benefits", namely nature restoration and water quality improvement, and those indicating "cost", namely public health risk, environmental stress and financial cost. The method is described schematically in Table 2.

The table shows that most sub-criteria are quantified in a score on a 3 or 5 category scale. The scores per sub-criterion were aggregated into scores per criterium by summing them up. For some of the criteria, this was done directly, for others (public health risk and environmental stress), different weight factors per sub-criterion were applied.

Table 2. Selection criteria, sub-criteria and evaluation method

Criteria	Sub-criteria	Evaluation method	
Nature restoration	- change in ground water table	- change in m translated to a 3 category scale	
	- change in upward ground water flux	- change in mm/day translated to 3 category scale	
	- change in base flow in brooks	- increase in % translated to 5 category scale	
Surface water quality	- decrease in phosphate concentration	- concentration (mg/l) translated to 3 category scale	
Environmental stress	- chemical waste production as a result of surface water treatment for public water supply	- quantity (ton/yr) translated to 5 category scale	
	- additional electricity consumed	- energy consumption (kWh) translated to 5 category scale	
Public health risk	- inadequate protection of the source of domestic water supply	- expert judgement on a scale from 0 to 1	
	- undetectable hazardous chemicals in domestic water	- expert judgement on a scale from 0 to 1	
	- inadequate treatment technique for domestic water supply	- expert judgement on a scale from 0 to 1	
Financial cost	- water supply sector	- investment cost	(NPV)
	- agriculture	- crop damage based on TCGB	(")
	- forestry	- exploitation loss based on LUW	(")
	- urban drainage	- investment and operational cost	(")
	- nature protection	- investment and operational cost	(")
	- surface water management	- investment and operational cost	(")

NPV = Net Present Value
TCGB = Technical Board, Ground Water Management
LU = University of Wageningen

Selection phase

In this phase an optimisation took place: scenarios were sought that maximized project outputs in terms of nature restoration and water quality improvement whilst minimizing inputs in terms of cost, public health risks, etc. This was done through a trial and error approach. In the end four scenarios were presented and evaluated using the criteria and method described before.

The results are presented in Table 3. The table shows that execution of the scenarios would lead to a restoration of between 42 and 75% of desiccated nature. In addition to this it would result in a water quality that complies with boundary levels in 44 to 56% of the surface waters under consideration, not very distinctive as it appears. The costs on the other hand vary widely, ranging from Dfl 340 million to more than Dfl 800 million. Correlating the costs with the percentage of nature restored leads to a sum of Dfl 8.1 million per 1%, for scenarios 1 and 2, whereas scenarios 3 and 4 would cost around Dfl 10 million per 1%.

Table 3. Output of the scenarios for selection phase

Criteria	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
	Sub-criteria	Head-criteria	Sub-criteria	Head-criteria	Sub-criteria	Head-criteria	Sub-criteria	Head-criteria
Nature conservation		+32		+38		+51		+49
Quality of surface water		+7		+5		+7		+7
Environmental stress		-3		-3		-4		-4
Healthy aspects		0.11		0.00		0.51		0.55
Costs of the society		406		340		559		812
- changing infra structure of water supply systems	191		237		349		583	
- costs of agriculture	10		10		3		3	
- costs of urbanised areas	10		9		10		18	
- costs of forestry	3		3		5		5	
- costs of nature reserves	39		39		39		39	
- costs of management of water quantity	6		5		6		17	
- costs of management of water quality	146		37		146		146	

Conclusions and discussion

The scenario approach followed in this project enabled the Province of Gelderland to achieve a proper understanding of the problem-solving potential of integrated water management on the regional scale of the East Veluwe, but also of the difficulties ("who is going to pay the bill?") that are associated with it.

Based on the set of four water management scenarios, and on the knowledge obtained during the exercises that ultimately led to these scenarios, the Province can make a number of strategic choices relating to their policy concerning nature restoration, public water supply, agricultural water management, waste water disposal, etc. These choices may be abstract and regional, indicating directions, rather than concrete and local, indicating which ground water well field to re-allocate or which effluent disposal site to abandon. They need not be derived from just one of the four scenarios, but they can be a combination of two or more.

The evaluation of the scenarios which leaned heavily on the regional model of the water system has led to the discussion of whether the model results are sufficiently reliable. The ecologists involved in the project felt that small scale differences in biotopes, which are essential for the mosaic structure of the region, cannot be modelled adequately in a regional hydrological model.

Another point of discussion is the degree to which the criteria "surface water quality" and "environmental stress" had a distinctive value. As can be seen from table 3, the different scenarios all lead to more or less the same score.

In summary it can be stated the scenario approach in a regional water management policy analysis is a flexible tool. Using it may enhance knowledge of and insight into the multiple inter linkages in integrated water management. It may provide a solid basis for regional water policy choices. In this respect it is important that the criteria used to evaluate different scenarios are selected with care. Also one should be careful not to try to make policy decisions at a level of detail which does not correspond to the level of detail of the instruments (models) that are used. In this particular matter, a close interaction between hydrogeologists and ecologists is essential.

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9.3.3 Evaluation of the reduction of eutrophication by agricultural management: a conceptual method

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Abstract
The policy of the Dutch government concerning the eutrophication of surface waters by agricultural activities is directed towards relating the allowed emission of nutrients into surface waters to a maximum of acceptable losses in minerals accounting on the farm.

The relationship between mineral losses at the farm on one side and the emission of nutrients into the surface water on the other side is not clear yet. This paper presents a relatively simple method of estimating the relationship between the nitrogen flux to the surface water and the agricultural management for two characteristic hydrological situations in the Province of Friesland.

This method is called FLUNIT and has been built around the programs FLUZO (calculation of 1-dimensional flux in the unsaturated zone), NITRON (calculation of 1-dimensional nitrogen flux out of the unsaturated zone), ARC/INFO and the groundwater flow package TRIWACO (calculation of 3-dimensional groundwater flow). The method runs on a PC.

The resolution is sufficient for the evaluation of alternative surface water protection strategies. Moreover, detailed insight into the impact of agricultural management on the changes in surface water quality can be obtained quickly.
Keywords: *agricultural management, eutrophication, nitrogen leaching*

Introduction

The policy of the Dutch government concerning the eutrophication of surface waters by agricultural activities, is directed towards relating the allowed emission of nutrients into surface waters to a maximum of acceptable losses in minerals accounting on the farm. These mineral losses - the result of the difference in the total supply of minerals and the total output of minerals - may leach out of the soil system and may cause eutrophication of the surrounding surface waters.

The relationship between mineral losses at the farm and the emission of nutrients into the surface water is not clear yet. In order to know if, and to what extent, surface water quality is endangered, knowledge of changes in groundwater quality and the response characteristics of the surface water is needed. Accordingly, the impact of different protection policies on ground- and surface water quality should be quantified. In this context the Friesland Water Authority and the Province of Friesland took the initiative to start a programme to monitor the quality of ground and surface waters at three dairy farms at locations differing in soil type.

This paper presents a relatively simple method of estimating the relationship between the nitrogen flux to the surface water resulting from (changes in) agricultural management and the agricultural management for two characteristic hydrological situations. The method is called FLUNIT, after the programs FLUZO and NITRON, which are the core of the method. Differences in soil type, land use, manure and fertilizer application can be

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accounted for. The application of the system is illustrated by two out of three different hydrological situations, which are considered to be characteristic for most of the area in the Province of Friesland.

Tools

Several programs have been applied successfully to model various aspects of groundwater flow and contaminant transport. The programs NITRON[1] and FLUZO[2] are used for the unsaturated zone while TRIWACO[3] is used for the saturated groundwater flow (Van den Brink and Zaadnoordijk, 1995). The data storage and manipulation could be efficiently carried out by the GIS PC-ARC/INFO[4]. The programs will be briefly described.

NITRON
NITRON is a one-dimensional deterministic program that simulates the leaching of nitrogen from the unsaturated zone to the groundwater table. NITRON describes the nitrogen-cycle by four transformation reactions. These first-order transformation reactions connect four different types of nitrogen: slowly decaying organic nitrogen, quickly decaying organic nitrogen, ammonium and nitrate. Furthermore, volatilization and linear adsorption of ammonium are taken into account.
NITRON has been developed by the Dutch Province of Gelderland and IWACO (Broers, 1988; IWACO, 1990; IWACO, 1993). The program NITRON has been calibrated and verified on a local scale (Broers, 1988; Broers, 1990) and a regional scale (van Ommen et al., 1992; van den Brink et al., 1993a) and has been proven to be a useful tool for the prediction of nitrate concentration in the shallow groundwater (i.e. the groundwater just below the groundwater table).

FLUZO
The one-dimensional program FLUZO (FLow of water in the Unsaturated ZOne) simulates unsaturated groundwater flow. The program is based on a reservoir concept (root zone, sub soil and saturated zone) and uses relations developed by van Genuchten and co-workers (van Genuchten, 1980; van Genuchten and Nielsen, 1985). It has been developed by IWACO (Smidt and Emke, 1991).

TRIWACO
TRIWACO is a program package for numerical simulation of quasi three-dimensional groundwater flow based on the finite element technique (IWACO, 1992b). It has been developed by IWACO, based on programs of the Dutch National Institute of Public Health and Environmental Protection RIVM. TRIWACO is capable of handling a vast variety

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[1] NITRON, NITRate flux to shallOw grouNdwater, (c) Prov. Gelderland & IWACO B.V..

[2] FLUZO, FLow of water in the Unsaturated ZOne, (c) IWACO B.V..

[3] TRIWACO, finite element package for simulation of groundwater flow, (c) IWACO B.V..

[4] ARC/INFO is a registered trademark of Environment Systems Institute, Inc. Redlands, CA, USA.

of steady state and transient groundwater flow problems in multi-aquifer systems. It contains many options for calculating the exchange of water between the groundwater system and the surface water system. These options can be used together with FLUZO, the module for the unsaturated zone, to describe this flux even more accurately. The program TRACE also is a part of TRIWACO. It determines path lines and travel times of water particles.

Methodology

To predict and evaluate surface water contamination from non-point sources, several processes, which affect the quality of groundwater between infiltration at the soil surface and seepage into the drains, have to be assessed. A conceptual method has been set up, using the tools described earlier.

The method consists of four main steps:

1. discretisation of the model area;
2. determination of the response characteristics of the surface water;
3. calculation of the nitrogen leaching out of the unsaturated zone;
4. calculation of the nitrogen leaching to the surface water by a combination of steps 2 and 3.

Discretisation of the model area
FLUZO and NITRON, which are used for calculating the nitrogen leaching out of the unsaturated zone, perform one-dimensional vertical simulations. Therefore the model area has to be discretisized. This discretisation can be performed using a network generator, creating a relatively dense network, or, in a more sophisticated way, by using the concept of 'homogeneous areas': areas with input parameters which are unique for that specific area (Van den Brink et al., 1993b; Van den Brink and Zaadnoordijk, 1995).

Determination of the response characteristics of the surface water
Water that has leached out of the unsaturated zone moves towards the drains and ditches or contributes to a (sub)regional hydrological system. Only the water which moves to the drains and ditches is considered here. Furthermore, seepage originating from the (sub)regional hydrological system will influence the quality of the surface water. The effects of the regional hydrological situation such as the infiltration, seepage flux and travel times are determined by a TRIWACO model of the groundwater flow for each hydrological situation. The distribution of the recharge and travel times, response characteristics, is calculated for each homogeneous area by tracing path lines. These path lines are regularly distributed over the homogeneous areas and are traced using the program TRACE, part of TRIWACO.

Calculation of the nitrogen leaching out of the unsaturated zone
The leaching of nitrogen is calculated for each homogeneous area. The calculation of the nitrogen leaching out of the unsaturated zone to the saturated groundwater is based on the nitrogen load at the soil surface due to agricultural management. The leaching of nitrogen is quantified as a function of physical, chemical and microbial processes by the deterministic programs: FLUZO and NITRON. For each homogeneous area FLUZO and NITRON input files are generated, using ARC/INFO. The FLUZO-calculations produce

the hydrological input data for every time step and for each homogeneous area for NITRON. The resulting time-series of the leaching of nitrogen out of the unsaturated zone are stored in ARC/INFO. The leaching rates are averaged per year. As a result, two-dimensional maps of the leaching rates are obtained for each year of the simulation. The input for the programs FLUZO and NITRON, the data exchange between the programs and the output of NITRON has been automated and the resulting system is called FLUNIT (FLUzo-NITron linkage).

Calculation of the nitrogen leaching to the surface water by combination of step 2 and 3
The leaching of nitrogen to the surface water is calculated by combining the response characteristic and the leaching of nitrogen out of the unsaturated zone for each homogeneous area.

Results

The conceptual method will be illustrated by two dairy farms with different hydrological situations.
For both hydrological situations an estimation is made of the total supply of minerals and the nitrogen flux to the surrounding surface waters. The aim of this illustration is not so much the prediction of the surface water quality, but much more the evaluation of protection strategies based on the effectiveness of (changes in) agricultural management.

The calculations have been carried out in the four steps described previously. First, homogeneous areas are determined using the concept described by Van den Brink and Zaadnoordijk (1995). Secondly a groundwater flow model has been set up to determine the ratios between recharge and seepage for the two characteristic hydrological situations. Thirdly the leaching of nitrate out of the unsaturated zone has been calculated. The last step is the estimation of the changes in quality of the surface water.

Determination of the response characteristics
The first hydrological situation consists of semi-permeable sandy/loamy covering layer above a permeable aquifer. The rainfall excess (infiltration) equals the groundwater recharge during the summer period. During the winter period, part of the rainfall excess is discharged by the ditches. This situation is considered characteristic for a sandy brook valley.
The second hydrological situation consists of semi-permeable peaty covering layer above a permeable aquifer. The drains and ditches discharge the rainfall excess and the seepage. During the summer period the seepage/recharge ratio is higher than during the winter period and consequently, the interface between recharge and seepage water is higher during the summer than during the winter period. This situation is considered characteristic for a peaty area.
A cross section of the phreatic groundwater level for both hydrological situations during the winter (seepage and infiltration situation) is shown in Figure 1.

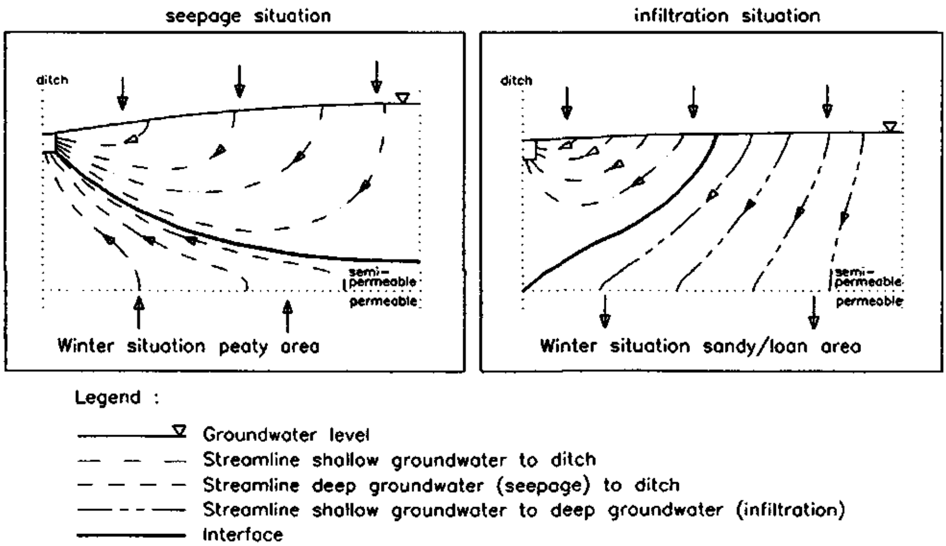

Fig. 1. Cross section of the path lines for two characteristic hydrological situations

The response characteristics have been calculated for every homogeneous area (based on the year 1993). The response characteristics are averaged over one year. This assumption can be made because of the relatively long travel times in the covering layer. In Figure 2 the resulting response characteristic of one homogeneous area for each of the hydrological situations is shown.

Calculation of the nitrogen leaching out of the unsaturated zone

The leaching of nitrate out of the unsaturated zone is calculated as a function of the manure and fertilizer application amounts and nitrogen uptake for each individual homogeneous area. The data concerning the application and plant uptake of nitrogen are collected by LEI (Beldman, pers. comm., 1994; IWACO, 1994). Figure 3 shows an example of the calculated nitrate concentrations of the shallow groundwater, averaged over a year, for the peaty area.

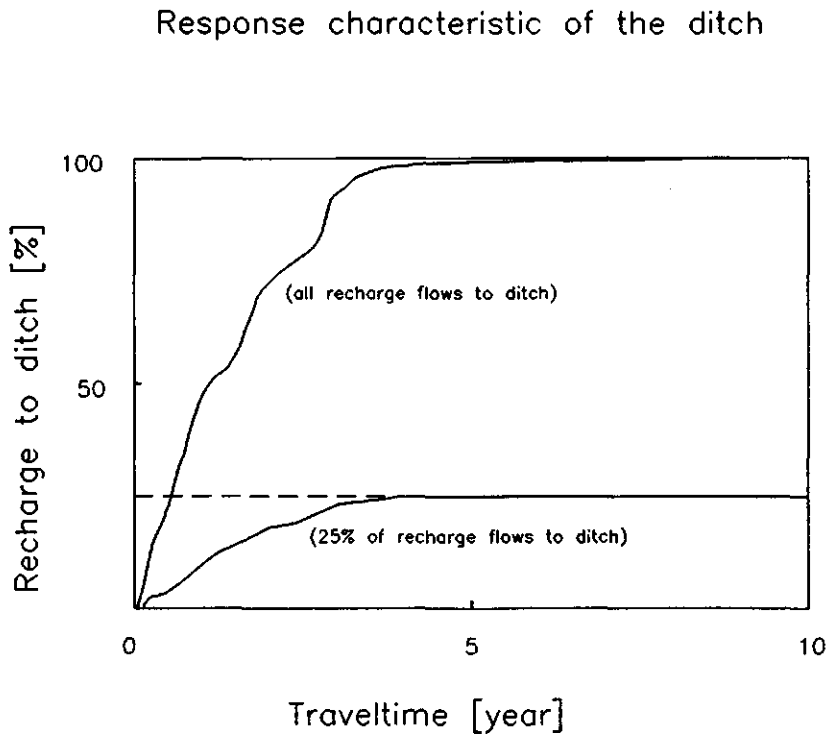

Fig. 2. Response characteristic of a representative parcel from the sandy/loamy and peaty area in which 25% and 100% respectively of the recharge is discharged by the ditch.

Calculation of the nitron leaching to the surface water

The nitrogen flux to the surface water is calculated by combining the yearly averaged response characteristics and the nitrogen leaching out of the unsaturated zone. This nitrogen flux to the surface water is corrected for the seasonal fluctuation of the seepage/recharge ratio. The nitrate concentration of the seepage is arbitrary set at 10 mgN/l. Figure 4 shows a decrease in the nitrogen concentration of the ditches because of an assumed change in agricultural management for the peaty area. This assumption leads to a reduction of nitrogen leaching out of the unsaturated zone. It is assumed that the, yearly averaged, nitrogen concentrations decrease due to remedial measures from 20 to 10 mgN/l in the sandy/loamy area, and from 15 to 7.5 mgN/l in the peaty area. It can be seen from the resulting nitrogen concentration in the ditch that the potential effects of remedial measures are increasing when the seepage/recharge ratio is decreasing.

As soon as the results of the monitoring program are available, the estimated values can be replaced by calculated and validated concentrations.

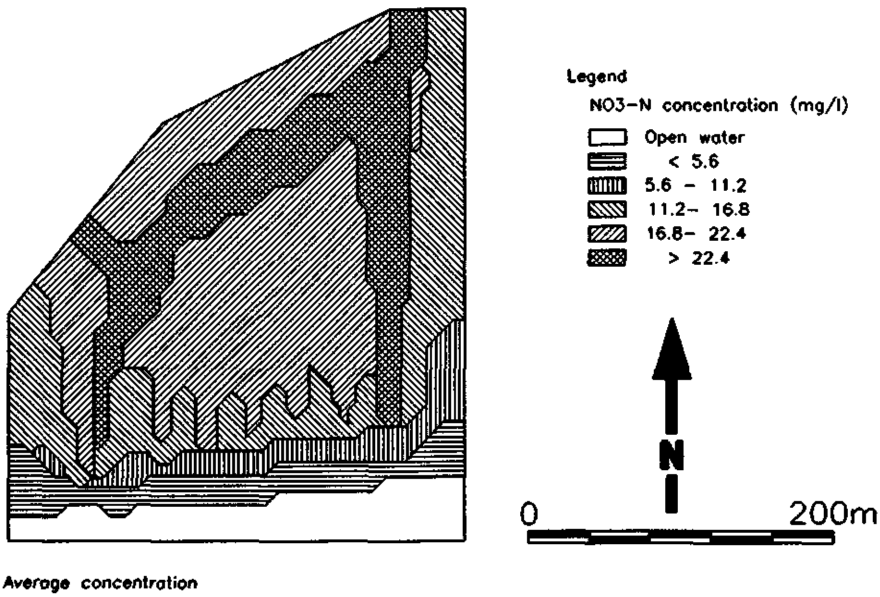

Fig. 3. Nitrate concentration leaching out of the unsaturated zone of a representative parcel from the peaty area

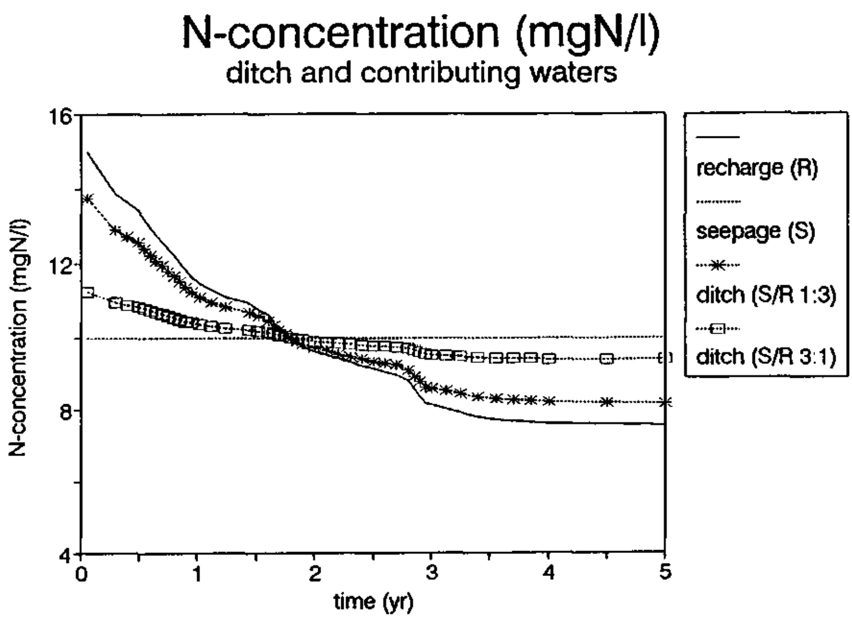

Fig. 4. Nitrate concentration of the ditch of a representative parcel from the peaty area in a low seepage situation (seepage/recharge ratio 1:3) and in a high seepage situation (seepage/recharge ratio 3:1)

Discussion

In the method presented in this paper, some aspects which may influence the quality of the surface water are not explicitly taken into account. These aspects are the changes in the quality of seepage and water originating from the regional surface water system. Both concentrations are treated as constant boundary concentrations.

Quality changes in the saturated zone will be taken into account as soon as the results of the monitoring program are available. Until now, the calculated nitrogen concentration and the change of this concentration in the ditch can be considered as both a potential concentration and a potential change. In this respect, the conceptual method estimates the potential effects of changes in agricultural management on the quality of the surrounding surface water.

Conclusions

The presented system FLUNIT has been used to predict the quality of the surface water for two characteristic hydrological situations. By combining the hydrological data (the seepage/recharge ratio) and the nitrate leaching out of the unsaturated zone, insight into the potential effects of remedial measures (agricultural management) is obtained. Potential effects of remedial measures are expected to be relatively high as the seepage/recharge ratio is relatively low.

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9.3.4 Causes of eutrophication in a rural watershed. An integrated approach in practice

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Abstract

The causes of eutrophication in a rural watershed were studied based on existing data. The annual load of phosphorous in the river exceeds the critical value threefold. 90 % of the load originates from agriculture. The heavy pollution is caused by natural factors like impermeable bedrock and anthropogenic factors like intensive stock farming. The most important measures to reduce P-input into the river are the reduction of stock densities and P-content in pig fodder. There is a severe deficiency in compliance with legislation regarding water protection. Despite this fact, the socio-economic factors have not been investigated until now.

Keywords: *eutrophication, phosphorous, intensive animal husbandry, watershed, Environmental Protection Agency, social actors*

Introduction

Lake Sempach (Canton Lucerne, Switzerland, Fig. 1) is one of the heavily eutrophicated lakes of the Swiss Plateau (e.g. Gächter & Stadelmann, 1993). About one fourth of the

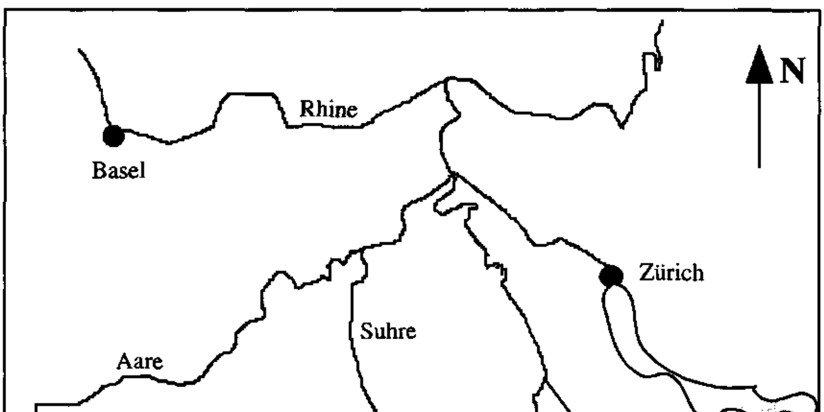

Fig. 1. Location of Lake Sempach in Northern Switzerland

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annual load of phosphorous is contributed by the "Grosse Aa" river. This paper presents a problem analysis which incorporates social and physical aspects. The study (Stamm, 1993) was conducted for the Environmental Protection Agency of the Canton Lucerne. It serves for developing measures to reduce the P-load below the critical value (4 t y^{-1} for the whole lake) deduced from Vollenweider (1976).

Methods

To link physical and social aspects, a three level concept was used. The levels relate to the *P-fluxes* (e.g. P-input into the catchment), to the *controlling factors* (e.g. stock density) and to the *social actors* (e.g. the farmers or the Environmental Protection Agency; Fig. 2). A distinction is made between direct and indirect actors. The former link the physical and social level by directly acting on the controlling factors.

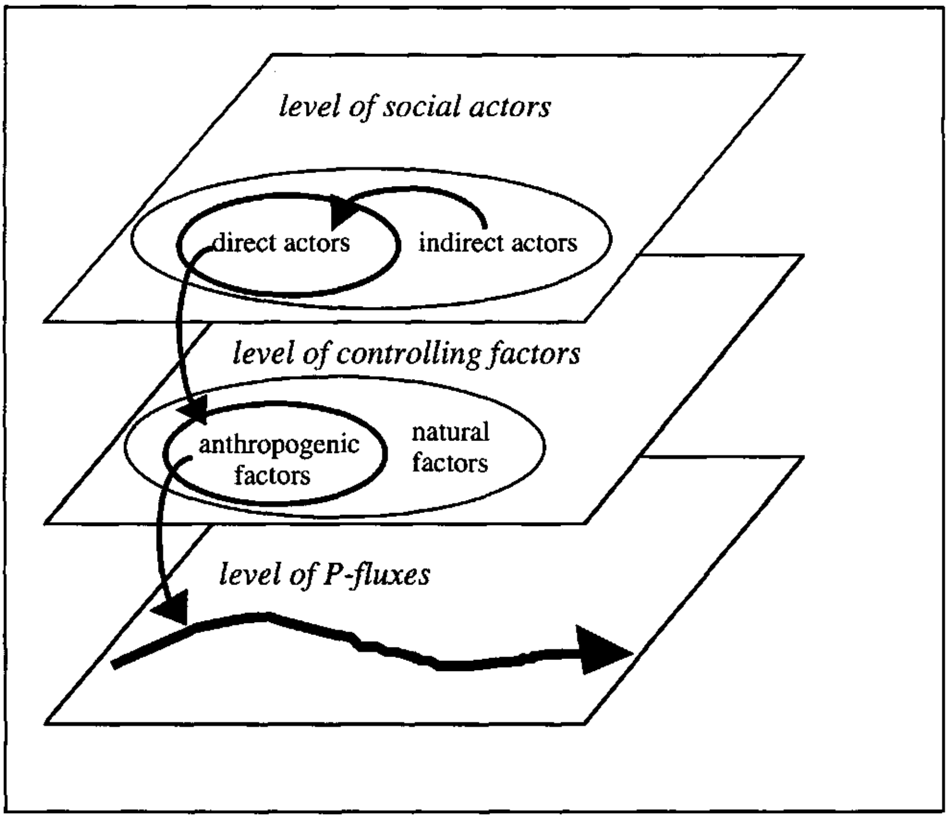

Fig. 2. The three level concept. The arrows between the levels indicate the way humans can influence the P-fluxes

The description of the situation was mainly based on studies previously conducted by the Environmental Protection Agency. To evaluate the situation, the actual state was compared to the goals defined by legislation. The effects of 16 measures on the P-load in the river were estimated. These measures concern farming and waste water treatment. The estimation is based on (i) a lumped model for non-point-source pollution at the watershed scale (Hurni et al., 1992), (ii) the results on the level of P-fluxes and controlling factors and (iii) some additional assumptions.

Results and discussion

The mean annual load of total P of the "Grosse Aa" amounts to 4.5 t y^{-1}. About half of the P is in the form of PO_4. These loads equal a loss of 2.8 kg total P and 1.4 kg PO_4 ha^{-1} y^{-1}. Compared with the critical load, the amount of total P exceeds the critical value threefold. Of this large amount of P, 90% originates from agriculture. The main processes of P-transport into the river are surface and probably drainage runoff.

The heavy pollution of the river results from the following factors (Fig. 3). There is a high natural risk for P-loss to the river. The very intensive stock farming (dairy cattle and pig production) leads to a large excess of P in the form of manure on the soil that

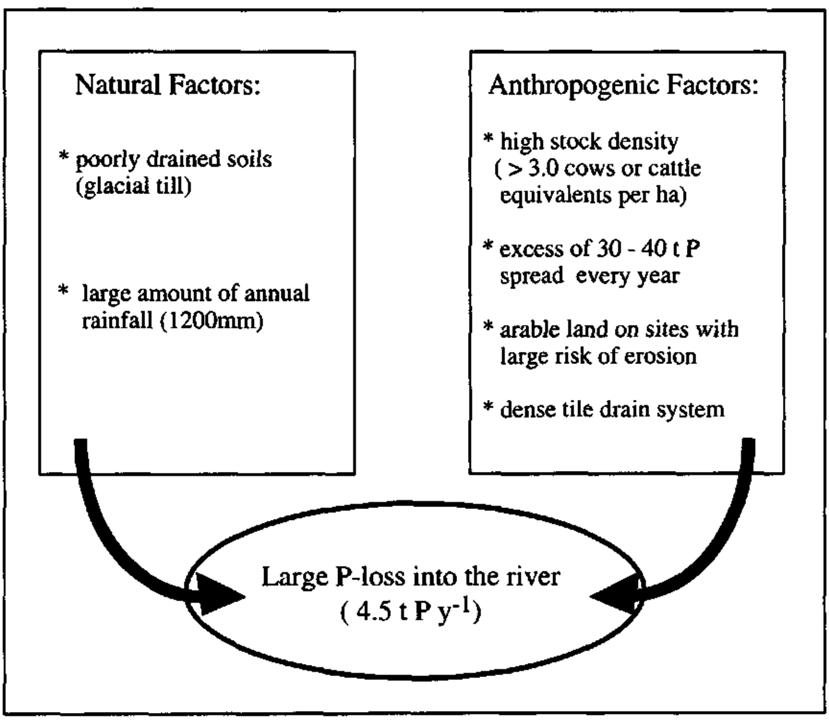

Fig. 3. Synergetic effect of natural and anthropogenic factors causing the large P-loss to the river "Grosse Aa"

is not taken up by the vegetation. About 10% of this excess is transported into the river every year. The transport is promoted by modifications of the drainage system of the catchment such as roads directly connected to the river by canalisation.

The problem of waste water has been solved during the last two decades. Almost all households and industries are connected to regional waste water treatment facilities.

The estimation of the effectiveness of the measures to reduce the P load shows that all important measures concern farming. Reducing the P-load below the critical level requires the reduction of the average stock density from 3.3 to 2.5 dairy cows or cattle equivalents ha^{-1}, the reduction of the P-content in pig fodder from 0.68 to 0.45% and soil conservation on arable land. Other measures like buffer belts of 3 meters width along the river seem not to be as effective as anticipated.

The social actors will decide whether the proposed measures will be implemented or not. To promote lake restoration, the communities in the lake catchment founded a political association and a special service centre for ecology in farming. Nevertheless, there is a severe deficiency in compliance to legislation regarding water protection in agriculture. For example, one third of all farmers has more animals ha^{-1} than allowed by legislation.

Despite the importance of the social level, the scientific projects have neglected the social system in the given context. Socio-economic factors crucial for the behaviour of farmers have not been investigated, contributing to the problems in executing legislation. Reasons for neglecting the social level might be:

1. There are no social scientists in the Environmental Protection Agency.
2. Compared to the analysis of water quality there are no standard methods for analysing social systems with respect to environmental protection. The success of strategies tested in this context can not be guaranteed (e.g. Renn & Webler, 1992).
3. Social studies might be rejected by the agency because the traditional status of natural scientists as pure observers would be lost.

Acknowledgements
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PART III

Nature development and landscape quality

CHAPTER

Introduction to Part III

The nature and landscape qualities of our future rural environment will be the result of various present-day developments in society as well as in nature itself. In densely populated parts of Europe, increasing urbanization and the associated needs of infrastructure have been threatening the natural values of landscapes for a long time. Reductions in the total area of agricultural land, due to increasing agricultural production surpluses in the European Union and environmental problems, will in the near future change some of the more vulnerable cultural landscapes. Recent political issues, such as sustainable exploitation of natural resources and biodiversity, will enhance the opportunities for the future expansion of natural areas to ecological networks. And, global climatic change accompanied by a rise in sea level will, in the long run, lead to changing patterns in natural processes and land use. The outcome of these different developments is, however, uncertain. Therefore, scenario studies incorporating nature development and landscape quality aspects are useful tools for policy makers in the decision making process.

Two currently available procedures for scenario studies, which have been developed as instruments for policy makers, are presented in Chapter 10. Harms concentrates on a backcasting scenario procedure for planning nature development. Scenarios are based on ecological objectives and spatial strategies in planning. An expert system for describing the development of vegetation and animal habitats provides the means for comparing different scenario outcomes. Jones and Emmelin depict alternative visions of future landscapes with the aid of artists' illustrations to demonstrate the possible impacts of alternative agricultural policy measures. Both types of scenario study are presented by them: forecasting is represented by trend extrapolation and studying the effects of concrete policy measures; backcasting, by studying both normative and surprising futures.

As part of the procedure, several tools can be incorporated in scenario studies. Some modelling tools which are currently operational are presented in Chapter 11. Verkaar starts this chapter with a discussion of the advantages and imperfections of various models which have been developed to predict the effects of various measures aimed at nature restoration. Above all, he stresses that the process of decision making requires not only the use of the models as creatively as possible, but also a good mutual communication between modellers and users. A tool for optimizing scenarios is presented by Farjon et al., who evaluated the ecological potentials for so-called target ecosystems by means of an analysis of the attributes and requirements of these systems and the evaluation of data using a geographical information system. Harms et al. present a decision-support system in which expert knowledge has been integrated in a geographical information system in order to evaluate scenarios for nature restoration. Vegetation developments and potential habitats of fauna species can be simulated after ten, thirty and one hundred years from the start of developments. Modelling effects of upward seepage, acid deposition and nutrient cycling on terrestrial ecosystems, as described by Kros et al., is an example of a more fundamental approach to be used as a tool in scenario studies. The chapter ends with a contribution

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by Emmelin, in which a method for analysing landscape impacts and presenting these in visual terms is presented, based on the construction of scenarios from policies.

How many and what aspects of nature and landscape should be involved in scenario studies, is dealt with in Chapter 12. From three case studies of coastal areas with various developments owing to different physico-ecological and socio-economic settings, Klijn derives a certain preference for scenario studies at a regional level by means of backcasting techniques, based on adequate data of patterns and processes. Vervloet focuses on the relevance of data on historical ecology and historical geography to scenario studies, which in his view are indispensable since most functional changes in land use have an impact on our cultural heritage of landscapes. Kemmers et al. stress the importance of a sound ecohydrological systems analysis in which features of the humus form profile provide useful information on potentials for nature restoration. Szabó and Molnár also use detailed soil and botanical surveys for determining future National Park management practises. Concerned with big changes in the countryside, Hellström emphasizes the analysis of historical developments and of current states as well as envisaging the future in scenarios, in order to develop tools for local planning purposes. Finally, in Chapter 12, the importance of studying the image of rural landscapes is indicated by Klinkers: different types of image styles may lead to different scenarios for rural planning.

Examples of the impact of scenarios on nature policy are elaborated in Chapter 13, in which the three components of scenarios, the present state of nature, possible futures and how to reach them, are translated into a political strategy. Jongman et al. consider ecological networks to be scenarios for developing nature in the context of socio-economic processes. In spite of different nature conservation planning frameworks, ecological networks have been developed in different parts of Europe, indicating good perspectives for extending the network into a pan-European system. How to set up an international common action plan aiming at a better and more holistic management of wildlife and natural resources is illustrated by Agger by means of the Nordic action plan.

In Chapter 14 some case studies are presented. Van Wezel et al. describe a scenario study aimed at developing new nature in a freshwater delta. Multicriteria analysis has been used as a tool to select the most preferential out of nine theoretically possible scenarios. In order to determine the effectiveness of plans and measures addressing the problem of badger habitat fragmentation, Knaapen et al. have modelled the demography and dispersal of badgers, in order to be able to evaluate three different scenarios reflecting various spatial developments in the future. The paper by Hommel et al. deals with the consequences of possible changes in water management for the potentials for conservation and restoration of riverine pastures. Three scenarios are evaluated on the basis of detailed studies of site factors and physiography of the river valley. Pauwels defines scenarios of agricultural transport by changing the road network or land use, for use in the management planning of woody road verges. Stressing the multifunctionalism of road verges, this study aims at an optimal and cost effective management.

Finally, the enthusiastic discussions during the symposium workshop on nature development and landscape quality are summarized by Udo de Haes, who ends with the conclusion that, although both forecasting and backcasting studies have important roles to play, it is the truly backcasting studies which focus directly on the question of what type of nature or landscape is wanted and thus link up directly with the core issue in the current policy discussions.

H.P. Wolfert

CHAPTER 10

Current procedures

10.1 Scenarios for nature development

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Abstract

A procedure in backcasting scenarios is presented. Two case studies differing in scale are used to illustrate the differences in ecological contribution to plan design and to plan evaluation. Scenarios for nature development are presented for both case studies, based on ecological objectives and spatial strategies in planning. In order to evaluate the ecological impact of the scenarios a computer model, LEDESS, using a geographical information system, was developed. The model is an expert system describing the development of vegetation and animal habitats in relation to abiotic conditions and management. It is more a tool for policy making in planning than an accurate predictive model.

Keywords: *physical planning, scenario, nature development, geographical information system, modelling*

Introduction

Scenario studies can be considered tools for policy makers to cope with future uncertainty. As the future of nature is also uncertain, scenario studies can help to determine an optimal nature policy. However, examples of scenario studies for nature policy are scarce. This paper will contribute to a methodology of scenario studies for nature policy.

Concerning the future, De Jong (1992) has presented an interesting concept of different domains (Fig. 1): what is possible, what is probable (located within the domain of what is possible), and what is desirable, which has overlaps with the other two domains. Predicting the future focuses on the probable domain. What is possible must be explored by designing and inventing the future, whereas the desirable domain is correlated with what we want in the future now. It is the domain of policy making. If the desirable future is also probable, one may state that 'there is no problem'. Problems arise, however, if the probable future is not desirable. Solutions must be sought in the overlap of possible and desirable domains.

In Figure 1, this image of the future is combined with the two categories of scenarios introduced earlier (Schoonenboom, this volume): the projective or forecasting and the prospective or backcasting scenarios.

Forecasting scenarios project present-day trends or expectations onto the domain of the probable future. Most environmental planning is involved with this sort of scenario: for example, what will be the probable impact of climatic change on different ecosystems. As dose-effect relations play an important role, these scenarios can also be appointed as dose-effect scenarios. Predicting models are important tools in searching for the most accurate impacts of changing factors.

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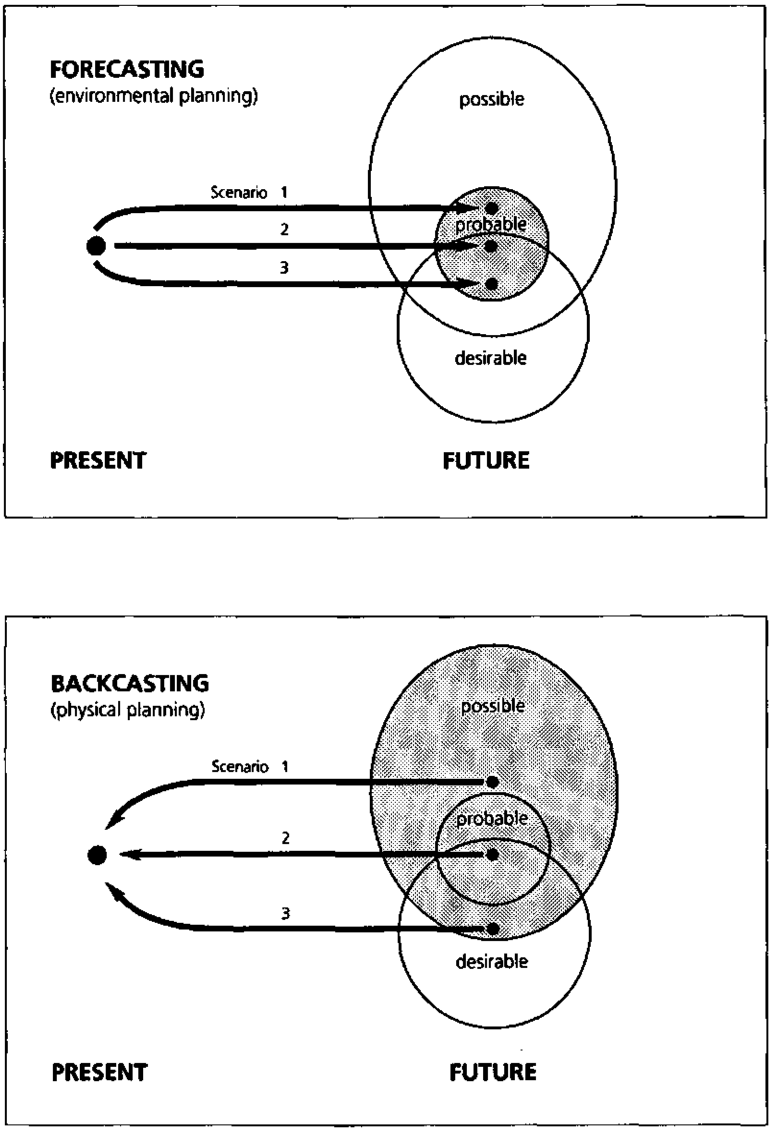

Fig. 1. Forecasting and backcasting scenarios

Other scenarios design possible alternatives and confront them with the present situation in order to determine the most desirable alternative. This backcasting procedure prevails in physical planning. Decision-support systems rather than predictive models are the tools here.

This paper is confined to the latter category: the backcasting scenarios, in particular for planning nature development.

Nature development and planning

The Dutch Nature Policy Plan in The Netherlands (Min. LNV, 1990) argues that, besides nature conservation in the proper sense, more attention must be paid to nature development. Nature development can be defined by all those activities aimed at restoring nature on land formerly used intensively for agriculture. This increasing attention for nature development is connected with:

- consciousness of environmental problems and loss of natural resources,
- the inevitable changes in agriculture,
- increasing demand for recreation.

As a contribution to the planning of nature development, a procedure is presented here. In the process of planning, two stages are distinguished (Fig. 2):

- plan design: the making of the alternative futures;
- plan evaluation: the proper backcasting activity delineating the possible path from the present to the future.

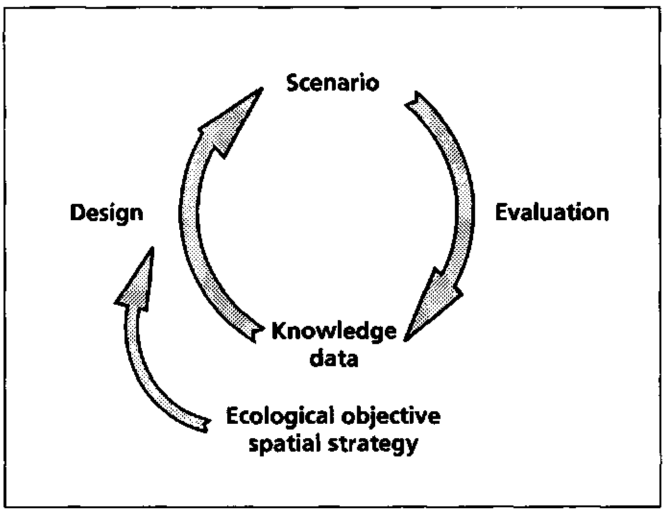

Fig. 2. The cyclic planning procedure

In the design stage, general ecological knowledge at ecosystem or landscape level contributes to a creative solution of the problem. A holistic approach predominates here. The plan evaluation is a more analytical activity. The plan must be checked: is the alternative realistic, feasible and what are the ecological benefits of each plan? This means a validation at the most concrete level of knowledge, viz. the individual species. Since the stages are not completed consecutively but may alternate cyclically, the results of the evaluation are input in a new planning cycle in order to adjust the scenarios and to re-evaluate them. Ultimately, a more comprehensive plan can be developed.

This cyclic procedure of backcasting for different planning problems on different scales has been developed and elaborated, for instance, the planning of new forests in the western part of The Netherlands (Harms, 1987; Harms & Knaapen, 1988), planning of new natural areas in the central part of The Netherlands (Harms et al., 1991; Harms et al., 1993), planning of river ecosystems (Harms & Roos-Klein Lankhorst (eds.), 1994) and more recently the ecological planning of urbanization (Harms et al., in prep.). Furthermore, many studies have been carried out in cooperation with the Institute for Forestry and Nature Research (IBN-DLO), such as a study in a brook valley in the northern part of The Netherlands, several ecological-network studies (for example, networks for the badger) and, on an international scale, the planning of ecological networks along the Lower Rhine in Germany and The Netherlands.

The procedure will be illustrated with the planning of scenarios for nature development in general and with the study of the river ecosystems in particular.

Plan design: scenarios for nature development

To understand the basic strategies in nature development, it is necessary to examine existing plans and schemes in order to reveal and clarify underlying concepts. Two questions are crucial here: what is the ecological objective, and what is the spatial strategy?
The first question is related to the level of the ecosystem. Several ecosystems can be developed on one site under different types of nature management. The choice of the system to be developed is a matter of nature policy.
The second question is related to the landscape as a whole, the spatial order of ecosystems. It is taken into account that other activities, such as farming, recreation, water supply and quarrying, also require space. Nature development cannot be considered independently from those activities. Therefore, a spatial strategy is required.

In the study for the Central Open Space, i.e. the western and central parts of The Netherlands, commissioned by the National Spatial Planning Agency, four different concepts for nature development were distinguished (Harms et al., 1991). Each scenario was given a motto referring to an animal species that could be favoured by realizing that scenario (Fig. 3).

In the "Godwit" scenario, a variety of ecosystems is obtained by integrating nature development with other land use types, especially extensive agriculture, which often requires long-term agreements with farmers, or other multifunctional uses. This scenario corresponds with the current trend in nature conservation policy. The "Otter" scenario aims at improving the dispersal of endangered species that are sensitive to habitat fragmentation by a network of corridors and stepping stones connected with the source areas. The "Elk" scenario is focused on self-sustaining complete ecosystems with free play for natural processes without human interference. This kind of nature requires large

scenario	ecological objective	spatial strategy
"GODWIT"	variety of ecosystems	integration and zoning of land use
"OTTER"	improvement of dispersal	development of corridors and networks
"ELK"	self-sustaining ecosystems	segregation of land use
"HARRIER"	variety of ecosystems	segregation of land use optimal site selection

Fig. 3. Ecological objectives and spatial strategies of the four scenarios for nature development in the Central Open Space (Harms et al., 1991).

areas segregated from other land uses. In the "Harrier" scenario, a variety of ecosystems in natural areas is planned in large tracts. Different communities will be controlled by different nature management techniques and located on optimal sites, such as transition zones and seepage areas.

The four concepts must be understood as the abstract domains delineating the possibilities in nature development in which only the corners have been surveyed. The consequences of implementing these extremes enable policy makers to choose a feasible and desirable compromise.

In a more recent study in the Gelderse Poort area (i.e. the Gateway of Gelderland, where the River Rhine enters The Netherlands) commissioned by the Province of Gelderland, these concepts for nature development were elaborated in more detail (Harms & Roos-Klein Lankhorst (eds.), 1994).
The Gelderse Poort is an area of 10 000 ha on the Dutch side of the Dutch-German border. It extends to the same size in Germany (Figure 4). In the Gelderse Poort, the River Rhine bifurcates into Waal and Lower Rhine. The area can be divided into three parts: the river bed with flood plains between the dykes, the area south of the Waal and the area north of the Rhine. The last includes an important area of old Rhine channels. The proper gateway is formed by the two ice-pushed ridges on both sides of the river. The area is indicated as a nature development area according to the Nature Policy Plan (Min. LNV, 1990).

For this area two strategies have been developed. The strategies chosen can be related to the four concepts mentioned before.

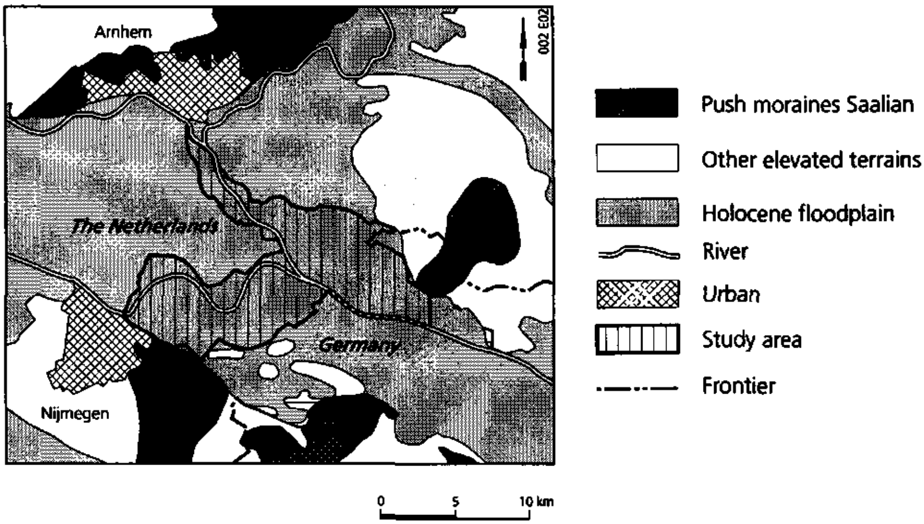

Fig. 4. The Gelderse Poort study area.

	ecological objective	management	spatial strategy
"Macrogradiënt"	biodiversity	nature management adjusted farming	integration / segregation of land uses
"Riverdynamics"	naturalness	non interference	segregation of land uses

Fig. 5. Two strategies for the Gelderse Poort area (Harms & Roos-Klein Lankhorst (eds.), 1994).

The "Macrogradient" strategy is directed towards the sequence of ecological potentials inside and outside the dykes, coupled with specific nature management. This refers back to the richness of the biodiversity during the nineteenth century. It should lead to a patterned spatial management, probably yielding results with less uncertainty, but often dependent on the sort of agriculture introduced, and labour-intensive nature management. Here, the "Godwit" and "Harrier" scenarios are actually combined.

In the "River Dynamics" strategy, the river processes are recognized as a driving force for nature development. Human influence is minimal and limited to creating essential conditions. This concept allows uncertainty in space and time in developing communities, which, in turn, allows a rich variety of species and communities to evolve. This, however, will only occur when space is adequate. This scenario is related to the "Elk" scenario mentioned before.

For the implementation of these two scenarios in the study area, 30% of the area was claimed for nature development, i.e. almost 3000 ha.

In Plan PV1, based on the "Macrogradient" strategy, the emphasis is on developing a pattern of nature in the old Rhine channel area inside the dykes. Here, a large reed marsh will be affected after most of the surface clay is removed. The water level control by the pumping station will be aimed at excluding the direct influence of the river. The preference is to preserve and regenerate nature in the area, including the flood plains, as seen in the old man-made landscape, to which adapted farming by management agreements is important. The landscape remains open. Beside the 3000 ha for nature development, modern agriculture remains in the less sensitive areas.
In Plan PV2, based on the "River Dynamics" strategy, the emphasis is on nature development under the influence of the river in the flood plains and in the western part of the old Rhine channels. In the flood plains, parts of the clay layer will be excavated, minor dykes removed and new channels dug, so that the river can take its own course again in some places, although within the constraints of river management. In the western part of the old Rhine channel area, the influence of the river is considerable because water may flow freely in and out to a maximum level, and the clay layer is excavated. Management is kept to a minimum. In large parts, natural grazing throughout the year will be reintroduced, thus creating a small-scale landscape. This plan has been made in cooperation with Bureau Stroming consultancy (Helmer et al., 1990).
A control plan (VV), based on the autonomous developments of the currently prevailing policy, has been made, too. For comparison with the other alternatives, this plan is similar to the present situation.

Plan evaluation: the backcasting model LEDESS

The backcasting procedure confronts the plans with the present situation. Questions must be answered such as: what is the suitability of the abiotic state factors, what measures must be taken to reach the future situation, what plant and animal species may be expected, what will be the ecological benefits, what will be the impact on other land use types, and last but not least, what will be the costs of implementing the plans?

A computer model has been developed in order to support the policy maker in making the right decisions when confronted with these questions. This model we call a LEDESS model (Landscape Ecological Decision-Support System). The first LEDESS model was constructed for the Central Open Space, the so-called COSMO model (see Harms et al., 1993). The model has been improved for the Gelderse Poort area, the DGP model.

Essentially, a LEDESS model is a knowledge-based system coupled to a grid-based geographical information system (GIS). Both the data on the present situation (vegetation, soil, land use) and the data on planned and expected development of site conditions, vegetation and fauna are processed in a grid, with cells of 250m x 250m for the Gelderse

Poort and 1 km x 1 km for the Central Open Space. The model is based on a deterministic concept of vegetation dynamics dependent on physiotope, target vegetation and management, and of faunal habitat requirements dependent on vegetation structure. The model provides, however, a systematic way to use available ecological knowledge. Owing to its GIS basis, the model can analyse, interpret and present.

The three main operations are:

- checking the ecological consistency by confrontation with the abiotic site conditions,
- simulating the vegetation development in space and time,
- determining the suitable habitats for fauna populations in space and time, based on the vegetation development.

The operation process using the model is as follows (Fig. 6):

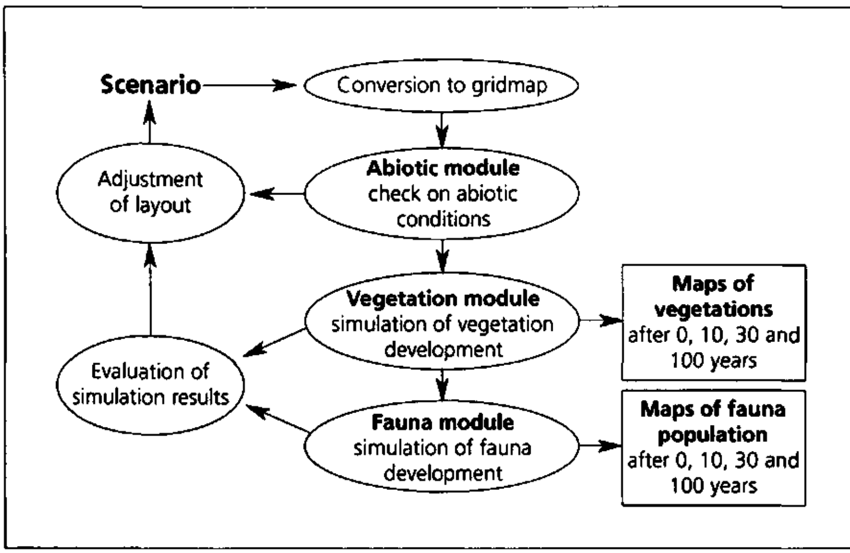

Fig. 6. Outline of the operation process of the LEDESS model.

The scenarios, or rather the plans, were translated into target vegetations and transferred to a grid map. The first evaluation concerns the suitability of the abiotic state factors (the physiotopes) for the objectives chosen. If a target vegetation does not correspond with the prevailing present abiotic conditions, the model can propose measures to modify the physiotope (e.g. raising the water-table or removing the topsoil). It is also capable of proposing alternative target vegetations. The planner can choose either solution, or both. Consequently, vegetation development was simulated in accordance with the target vegetation starting from the current or adapted abiotic conditions and vegetation. The results can be evaluated at 10, 30 and 100 years after the hypothetical start of the development.

The effects on the fauna were assessed by calculating the area of potential habitat. Species of birds, mammals and butterflies considered typical of the study area were selected for evaluation and are combined into ecological groups on the basis of an extensive literature survey. The areal requirements for the home range were determined for each group. Both foraging and breeding habitats of the groups were considered. For each group, all the vegetation types were classified as optimal or non-optimal habitats. Then, in order to evaluate the potential effects of the plans on the fauna, vegetation maps of 10, 30 and 100 years after the beginning of the vegetation development were translated into maps of the potential habitat. Contiguous areas of potential habitat were aggregated, to reveal the population sizes that could be attained. Aggregates smaller than the individual home range area were rejected (too small). Larger areas were classified according to their expected sustainable population size.
Results of vegetation and fauna simulations can be assessed with criteria derived from the prevailing nature policy. If the results do not belong to his desirable domain, the policy maker has another opportunity to adjust the scenarios.

Results, some illustrations

Figure 7 shows the results of the computer simulation with the DGP model for the marsh-harrier (*Circus aeruginosus*). This species is the representative of a group of birds which need reed areas for breeding and foraging and extensive agricultural land for foraging. The maps give the results for the present situation, the control plan, and both alternatives after 30 years. The control plan VV and plan PV1 both provide more suitable habitats, especially foraging areas contiguous to breeding areas within a radius of 4 km. In plan PV2 there are fewer foraging areas, because there is less extensive agricultural land. Therefore, a lasting population is more guaranteed in PV1 than it is in PV2.

The opposite results are shown in the maps for the beaver (*Castor fiber*) (Fig. 8). According to PV2, after 30 years there might be a suitable habitat for 10 to 25 pairs of beaver, a good opportunity to reintroduce this species, which became extinct in The Netherlands a century ago. Other plans and the present situation do not provide enough suitable habitats for a sustainable population.

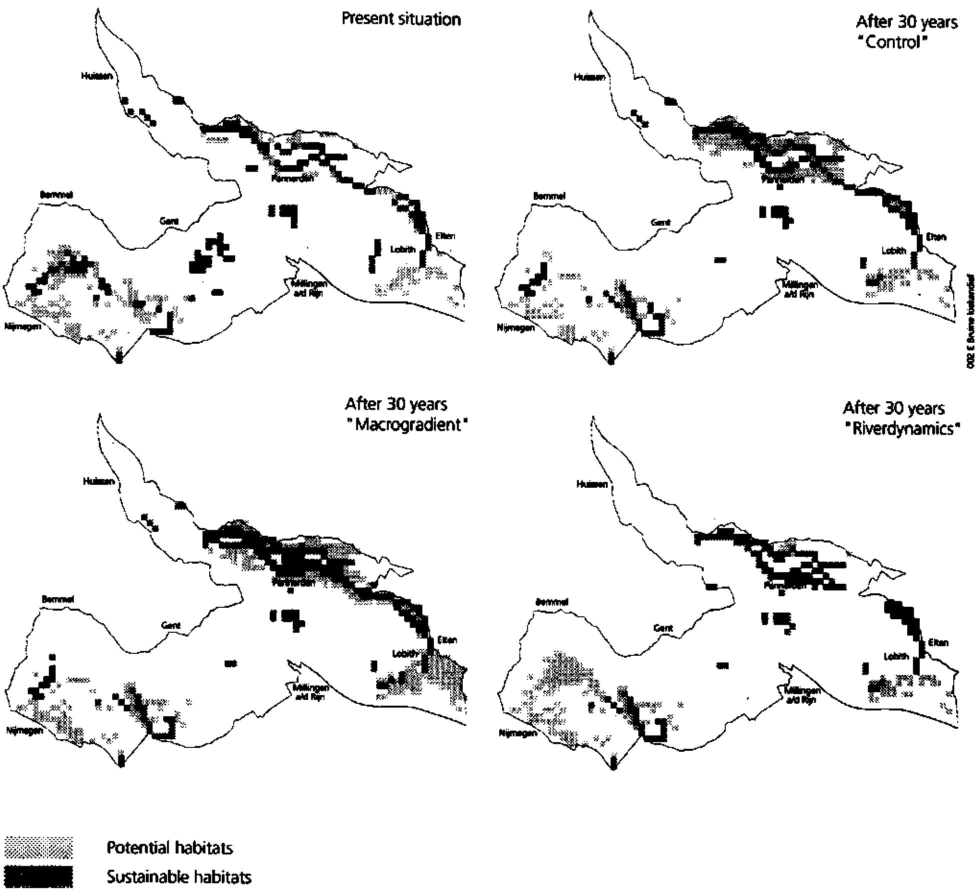

Fig. 7. Simulation of suitable habitats for the marsh-harrier in the Gelderse Poort area after thirty years, according to the present situation, the control plan (VV), plan Macrogradient (PV1) and plan Riverdynamics (PV2).

To provide policy makers with a final evaluation, all the computer results of the Gelderse Poort study can be combined into one synoptic figure (Fig. 9). The horizontal line represents the total spectrum of possible fauna species in the Gelderse Poort area ranked in river-dependent species (left) and river-independent species (right); the vertical line the area of suitable habitat with a species-specific threshold for sustainable population sizes.

The figure shows that in the control plan VV only a few species can grow into a sustainable population. This is improved in plan PV1 for the whole range of species. In plan PV2, however, the situation is improved only for part of the spectrum, but the improvement is considerable compared with the other plans, owing to the species dependent on river ecosystems.

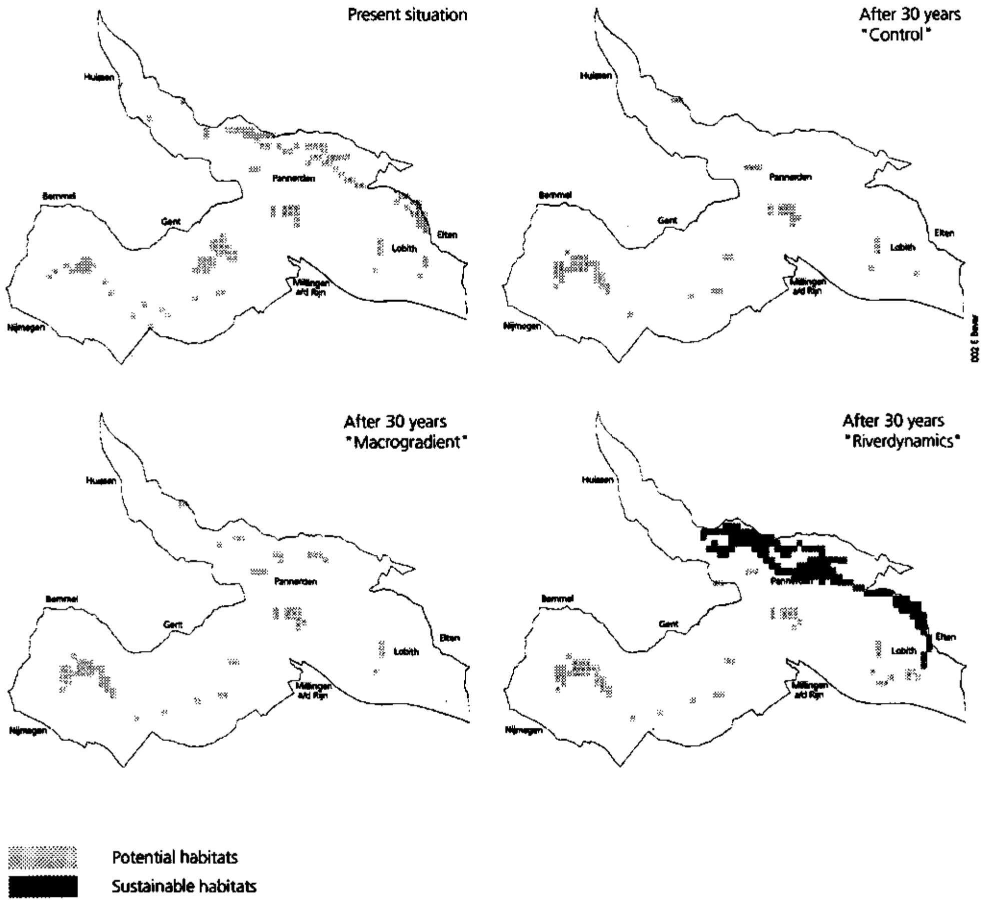

Fig. 8. Simulation of suitable habitats for the beaver in the Gelderse Poort area after thirty years, according to the present situation, the control plan (VV), plan Macrogradient (PV1) and plan Riverdynamics (PV2).

The option for policy makers are reduced now, but a difficult dilemma remains: is it preferable to develop good opportunities for species characteristic of river ecosystems only, or to improve biodiversity in the whole range, although with less suitable habitats for sustainable populations?

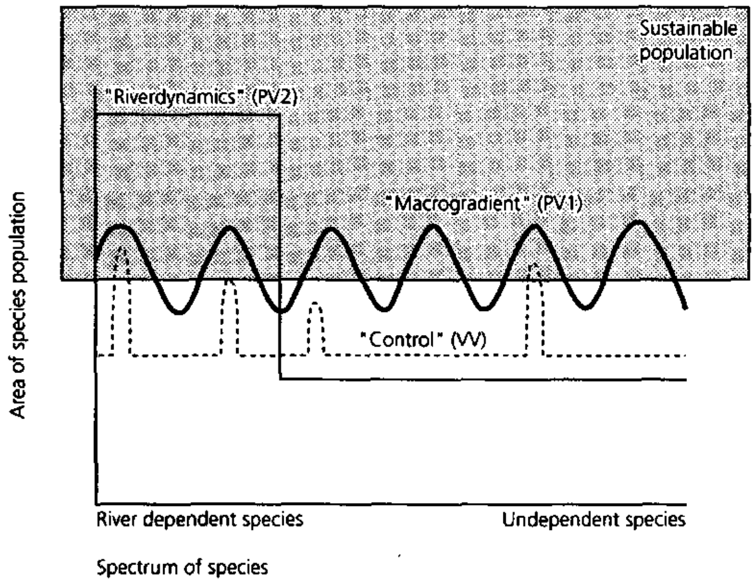

Fig. 9. Synoptic presentation of final results of the computer simulations for the Gelderse Poort area.

Discussion

It is not the final decision of the policy maker that prevails in this paper, but the methodology of making scenarios. Some general conclusions and remarks can be made on the presented procedure of backcasting scenarios.
Is the procedure presented a scenario procedure? Schoonenboom (this volume) has formulated three conditions for a scenario procedure: future alternatives, a description of the present situation, and a pathway leading from the present situation to the future alternatives. The procedure presented here complies with these conditions.

Some final remarks must be made on the LEDESS models. These models help to explain and compare the impact of nature development; they are not predictive models, but tools for policy makers to choose. This means that it is not the absolute impact that matters, but the relative differences between the alternatives.
Different studies using the same LEDESS model have shown that the same model can be used on different scales. The implementation depends on the prevailing data of the study area and the state of expert knowledge. Gaps must be filled by best professional judgement. The assumptions made in this sense are crucial. The reliability of the model depends highly on these assumptions. The structure of the model, however, makes the assumptions explicit. The model also provides a consistent way to apply existing knowledge in physical planning.

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10.2 Scenarios for the visual impact of agricultural policies in two Norway landscapes

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Abstract

The paper presents applications of the method of Landscape Impact Analysis (LIA), developed to depict alternative visions of future landscapes for discussion in planning. The fulfilment of central agricultural policy objectives in post-war Norway has led to negative environmental effects, especially water pollution in areas of intensive animal husbandry and soil erosion in areas of grain monoculture. Illustrated scenarios were constructed for two landscapes in, respectively, Jæren (SW Norway) and Romerike (SE Norway) to demonstrate possible impacts of alternative agricultural policy measures under discussion in Norway in the late 1980s. Alternative views of the landscapes in the year 2000 are seen against changes observed since the late 1960s. Four types of scenario are presented: trend extrapolation, effects of concrete policy measures, normative future and surprising future.

Keywords: *impact analysis, scenarios, agricultural policy, landscape analysis*

Agricultural policy and environment

Agricultural policies have had a significant influence on rural environments in Western Europe in the post-war period. Promoted by improved technology and government subsidies, input-intensive agricultural production has led in many areas to severe problems of pollution and erosion, as well as to detrimental effects on the biodiversity and cultural heritage of rural areas. Popular focus on the countryside as a visual expression of the environment has led to strong public concern over the future of rural landscapes. The second half of the 1980s saw, however, a certain shift in direction in agricultural policies. This was related to the growing environmental awareness among the general public and to the necessity of reducing production subsidies in accordance with the Uruguay round of the General Agreement on Tariffs and Trade (GATT), in which a shift towards environmentally oriented farming support was found acceptable.

With less than 3% of its land area under cultivation, Norway has among the highest per capita levels of agricultural subsidies in Europe. Agricultural policies have stimulated increased productivity through mechanization and the intensification of inputs, while maintaining agricultural incomes, promoting improved national self-sufficiency and supporting the maintainance of rural settlement. To counteract surplus production of animal produce, grain production has been encouraged in favourable areas (principally SE Norway) through a policy of regional specialization. This was achieved by a system of import control, high grain prices and regionally differentiated subsidies for animal produce. Environmental questions were not considered before the 1970s, and did not become a central concern until the second half of the 1980s. Regional specialization and the

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intensification of farming have led to serious problems of water pollution in areas of intensive animal husbandry and soil erosion in areas of grain monoculture. Rapid landscape change has also led to concern about the loss of the countryside's ecological and visual diversity. Increasing awareness of the negative environmental effects of agriculture led at the end of the 1980s to a search for new policy measures which would pay greater attention to the environment.

In 1988 and 1989, a multi-disciplinary research project on agricultural policies and environmental management was undertaken with the aim of finding effective measures for reducing water pollution and soil erosion. As part of this project, the method of illustrated scenarios known as Visual Impact Analysis (VIA) was applied to two study areas with the aim of indicating possible impacts of alternative agricultural policy measures on the landscape. The present paper presents this application of the method to the two selected landscapes, situated in Jæren (SW Norway) and Romerike (SE Norway) (Emmelin, Jones & Ree 1990; Jones 1992). The method was developed by Lars Emmelin in Sweden to depict different visions of future landscapes as a basis for discussion in environmental planning (Emmelin & Brusewitz 1982 & 1985).

Developments in the theoretical and methodological basis of Visual Impact Analysis, now renamed Landscape Impact Analysis (LIA), are presented by Emmelin (this volume).

Illustrated scenarios

The Norwegian study used illustrated scenarios to show alternative views of the selected landscapes as they might appear in the year 2000 as possible outcomes of various measures of agricultural policy that were under discussion at the end of the 1980s. These are seen in relation to the changes observed in the two landscapes during the previous 20-25 years. The points of departure for both the historical reconstructions and the scenarios were drawings of the landscapes made in the field in 1988 and 1989. Past, present and future landscapes were painted as aquarelles on the basis of these drawings by the artist, Nils Forshed.

The aims of the study were as follows:

1) To show the main features of change in the selected landscapes during a period of 20-25 years.
2) To illustrate possible consequences in the landscape of a continuation of the recent trends into the future.
3) To demonstrate how selected measures to reduce water pollution and soil erosion might influence the landscape.
4) To illustrate how the landscape might appear if agriculture paid more conscious attention to considerations of landscape ecology.
5) To illustrate how future landscapes may also contain surprises as a result of decisions made by individual farmers independently of agricultural policy measures.

The project was completed before the decision of the Norwegian government to apply for entry into the European Union. A scenario showing possible landscape impacts of the necessary adjustments of agricultural policy that entry would entail was not constructed. The project was also undertaken before the completion of the Uruguay round of the GATT negotiations. The direction of the negotiations was, however, evident, and Norwegian agricultural policy was already beginning to adjust its agricultural subsidies to support environmental measures of a type compatible with GATT principles.

Four types of scenario are presented:

1. *Trend extrapolation.* An observed trend in landscape change over a chosen period is extrapolated into the future. This provides a point of reference for examining alternative landscapes produced by new agricultural policies. A new policy, if effective, will represent a break with the previous trend.

2. *Effects of concrete policy measures.* Several of the scenarios take as their starting-point newly introduced or proposed agricultural policy measures. Possible consequences for the landscape of these measures have been analyzed by means of a logical argumentation based on structured discussions with agricultural economists and representatives of the county agricultural authorities.

3. *Normative future.* This type of scenario presents a future landscape containing features which are considered desirable from a chosen perspective. In the present study, normative futures are used to depict more environmentally conscious agriculture. Normative futures were constructed by introducing environmental features based on principles of landscape ecology which were already being applied in landscape planning in other European countries (in particular Germany, Denmark and Sweden). Normative scenarios can provide a point of departure for discussion of the types of policy measure which would be necessary to realize the desired landscape ("backcasting").

4. *Surprising future.* The final type of scenario expresses the role of the unexpected in landscape change. This recognizes the uncertainty inherent in any depiction of a future landscape based on the operation of policy measures alone. This uncertainty may take the form of individual farmers reacting in ways unpredicted by policy makers, or it may take the form of powerful forces outside agriculture influencing land-use decisions and overriding considerations of agricultural policy.

The scenarios presented here make use of water colours by artist Nils Forshed, who has a background in the natural sciences. This form of presentation was chosen in preference to either photographic manipulation or computer simulation. Although people intuitively think so, such techniques are not necessarily more precise nor more objective than artists' drawings. Photographic manipulation to produce change in a complete landscape in all its details is a highly complex procedure, involving much more than just placing single objects in an otherwise unchanged landscape. An artist, drawing a completely new picture, can easily adjust his picture to the subtle changes that occur everywhere in the landscape, such as growing vegetation, changes in the details of buildings, etc. Again, the use of computer-assisted graphics requires the operator to act as an artist, although he or she is generally not trained as such. The accurate reproduction of light and shade, colour and texture is an integral part of a qualified artist's training. The planner or landscape researcher can engage in a two-way communication with the artist during the construction of the scenarios.

The selected landscapes do not represent Norwegian stereotype landscapes with mountains and fjords, which are often economically marginal from an agricultural point of view. Both landscapes are in areas of input-intensive agriculture. The first is located in Time commune, Jæren, in the county of Rogaland in SW Norway. This is an area of intensive animal husbandry with serious problems of water pollution due to excess animal manure. The second is located on the border of Nannestad and Ullensaker communes, Romerike, in the county of Akershus in SE Norway. This is an area dominated by specialized grain farming with resultant problems of soil erosion.

A landscape in Time, Jæren

The landscape selected in Jæren is seen from a position at Løge in Time commune. The viewpoint lies 75 m above sea level and looks WNW towards the small town of Bryne, located south of Stavanger. The study area is situated in the transitional zone of undulating topography between the higher parts of Jæren and the flat coastal plain. The latter can be seen in the far distance. On the horizon is the North Sea. The natural terrain is formed by superficial deposits of Quaternary age. The last advance of the ice sheet left a thick deposit of ground moraine together with large boulders and erratics.

Plate 5a shows a *reconstruction of the landscape as it was in 1966*. The landscape has been reconstructed on the basis of air photos and a large-scale topographic map from 1966, as well as interviews with farmers and contemporary photographs. In the middle of the picture can be seen bogs and wetlands, formerly typical of the low-lying parts of the terrain. Typical were also the extensive areas of rough pasture, improved by fertilizing the heathland. Beyond this, small fields with their characteristic stone walls are visible. The farm in the centre of the picture appears as it was built in the 1940s under a land colonization scheme. The outhouses on all the farms are as they were before modernization.

Jæren has a long tradition of land reclamation. This was encouraged by Agricultural Societies in the last century, and has been stimulated by government support since early this century. A rapid expansion of the ploughed area occurred in the 1970s, a period of increased financial support for agriculture.

Plate 5b shows the *landscape in May 1988* (drawn by the artist in the terrain). The landscape indicates an ongoing process of farm rationalization, with land reclamation and field enlargement to the left. The landscape also retains elements of the characteristic Jæren landscape with stone walls and fertilized but stony pasture, as in the foreground and to the right. A new silo is under construction on the farm in the middle of the picture. Modernized farm buildings are found on the farms in the background. The heap of stones in the middle of the picture derives from the ploughing up of pasture and stone clearance.

Plate 6a is the first scenario and shows a *physical extrapolation of recent trends*. This is how the landscape could be expected to look if arable reclamation of the former heathland continued unabated. This scenario does not take into account the discontinuation of subsidies for land reclamation in the mid-1980s. All rough pasture is brought under the plough where technically feasible. Zero-grazing occurs on all farms. Stone walls have been removed except along property boundaries, and the stones piled up. This gives a visually and ecologically more monotonous landscape compared with 1988.

Plate 6b shows the probable landscape impact of the *introduction of a manure-spreading area requirement of 0.4 ha per livestock unit.* This measure came into force in 1989 in an attempt to reduce phosphate pollution of watercourses due to excess manure. A livestock manure unit is calculated on the basis of the manure produced by one dairy cow. Other types of livestock are weighted in relation to this. For each livestock manure unit a farm is required to have access to 0.4 ha cultivated land for spreading the manure. The requirement is reduced for grazing animals in accordance with the length of the grazing period. Farms with too little manure-spreading area had by 1993 either to reduce their livestock numbers or to lease manure-spreading area from neighbouring farms with excess capacity.

Calculations based on area, livestock and other data collected from the individual farms were made to assess probable reactions. The analysis indicated that in our study area rough pasture would probably be maintained, since the required manure-spreading area is reduced for the time animals are grazing. In the area as a whole, our calculations showed that there is enough excess manure-spreading area on larger farms to allow smaller farms with too little manure-spreading area to lease what they need. There would thus not be any reduction in livestock numbers, and hence no reduction in the total production of manure in the area. Although the manure would be somewhat more evenly spread, this would not be sufficient to solve the pollution problem.

Plate 7a shows the possible impact of the *introduction of a hypothetical 0.7 ha spreading-area requirement.* A stricter spreading-area requirement, for example 0.7 ha per livestock unit, would create a better balance between the phosphate added to the soil from manure and that removed in the harvest. This would reduce the pollution problem, but would have marked effects on the landscape. There would not, in this case, be a surplus of manure-spreading land in the area as a whole. Smaller farms would thus have to reduce their livestock numbers. To compensate for the loss of income, we would expect them to increase their income from non-farm activities.

In the picture, the farm owning the foreground has cut out labour-intensive dairy production to allow more time for non-farm activities. Without grazing animals, there is no longer any reason to retain the pasture land, which is thus ploughed to maximize manure-spreading capacity (e.g. for pigs or poultry). The farm in the middle has given up animal husbandry and instead diversified into greenhouse production. The new outhouse has been converted into a mechanical repair workshop. The land is rented to neighbours.

Plate 7b depicts a possible impact of more *environmentally conscious farming.* This scenario pictures the landscape as it might appear if agriculture paid more conscious attention to considerations of landscape ecology and other environmental concerns. Following examples from Sweden, Germany and Denmark, the stream has been reopened and a semi-natural watercourse re-created. Natural stream flow and the maintenance of unploughed strips along the stream serve as an effective filter against water pollution from agricultural sources. Lee planting and strips of permanent grass along field boundaries (unsprayed with pesticides) help to create a biotope network favourable for the maintenance of diversity in wild flora and fauna. A manure treatment tank has been set up on the farm in the centre. (A more radical environmental alternative could have shown a landscape resulting from organic farming.)

Plate 8 shows a *scenario of an unexpected future.* This scenario shows how a landscape can develop in ways which in the context were not envisaged by agricultural policy makers. Two farms have developed in unexpected ways. The farm in the middle has diversified beyond traditional agriculture and set up a riding centre, which also leases part of the foreground. The farm owning the foreground has also planted Christmas trees to supply the nearby urban market.

A landscape in Ullensaker, Romerike

The landscape selected in Romerike lies for the most part in Ullensaker commune, north of Oslo. It is viewed looking ENE from Eset farm in the neighbouring commune of Nannestad. The study area is situated in a zone of undulating topography between the higher parts of western Akershus and the flat Gardermoen plateau, the latter forming the horizon in the far distance. The height above sea level varies from 120 m to 237 m. Superficial deposits of Quaternary age form the main features of the natural terrain. The greater part of the area in the picture consists of marine clay deposited at the end of the last ice age. Characteristic of these deposits is the development of quick clay. Quick-clay landslides and river erosion have created the characteristic undulating, ravined landscape.

Plate 9a shows a reconstruction of the *landscape in 1969*. The area was formerly an important supplier of milk to Oslo. Mixed farming was typical, although by the mid-1960s some farms had begun to specialize in grain cultivation. Much of the untilled land was used for grazing. Deciduous scrub grew in the steepest parts of the ravines.

Plate 9b shows the *landscape in May 1989*. Since 1969, a transition to grain monoculture has occurred, with the exception of one farm. Grain farming is easy to combine with commuting to work in Oslo. Mechanized farming has been facilitated by land grading (cut-and-fill). Ravines are planed out and filled in. The remaining ravines are no longer grazed and have become overgrown by scrub woodland.

Plate 10a is a *trend extrapolation.* This scenario is a physical extrapolation of the trend of landscape change which predominated until the mid-1980s. It is assumed that subsidies for land grading were not removed in the late 1980s. All areas have been planed where technically possible. Grain monoculture characterizes all farms. The lowering of the terrain reveals the Leira river. River canalization has been undertaken, signalizing another trend from the 1970s.

Plate 10b depicts a possible landscape impact if *environmentally conscious mixed farming* were to be introduced. Livestock is found on all farms, and crop rotation is practised. The intensity of production is reduced. Pasture and grass production occur on the areas most susceptible to erosion. Contour ploughing is practised on all tilled land.

Plate 11a shows possible results of a *reversal of regional specialization.* The scenario illustrates a variety of impacts that might result from measures attempting to reverse the specialization into grain districts and livestock districts that has been a marked feature of post-war agricultural policy in Norway. Such measures might include the prohibition of autumn ploughing in areas of heavy marine clays. This would encourage grass rather than grain cultivation, and hence reduce erosion. It would lead to a return to animal husbandry, ley grass and improved pasture, as shown in the picture. There would, however, be a danger that more grass would be produced than the market could absorb. Furthermore, increased milk and meat production near Oslo would lead to farm abandonment in the marginal, peripheral regions of North and West Norway. A problem of overproduction nationally would have serious implications for regional policies.

The boxes in Plate 11a show alternatives within this scenario. While ravines might continue to be overgrown by scrub woodland, alternatives might be afforestation or pasture for meat-producing cattle. Other boxes indicate the use of different ploughing techniques. New farm buildings for the increased number of livestock are depicted in enlargements.

Plate 11b shows once again a *surprising future*. This scenario assumes weak protection of agricultural land against building development, and strong pressure from the regional labour market in Oslo. The main new development is the siting of a new airport for Oslo in the close vicinity of the study area. This was only a suggestion in 1989, although it has since been decided to construct a new civilian airport for Oslo at the former military airport of Gardermoen 10 kilometres from the study area. This leads in the scenario to industrial development along the motorway to Oslo (background right), ribbon development of new dwellings along roads in the area, and the building of a congress hotel with tennis courts and a golf course.

Conclusion - an EU scenario?

The illustrated scenarios shown here are taken from a project undertaken five years ago and are presented to demonstrate the application of the method. The underlying idea is that a landscape that can be seen can provide an arena upon which a planning dialogue can be conducted. Our experience is that agricultural advisers and farmers often find it easier to relate to the possible consequences of policy measures when these are depicted in concrete landscapes. The examples indicate how the influence of particular policies as well as of contextual factors can be illustrated. The examples at the same time demonstrate that the relationship between a particular policy and the physical environment is not straightforward: a multiplicity of local decision makers are reacting both to rapidly changing agricultural policies as well as to other policies and to other factors in society.

After the completion of our study, Norway's possible entry into the European Union became a major topic of debate. Since the problems of agriculture played a prominent part in the debate, Landscape Impact Analysis could have provided a method of illustrating possible impacts of the alternatives. While this has not been the subject of detailed study, some speculations on how entry might have affected our selected landscapes can made by way of conclusion.

Norway's negotiations with the EU were completed in March 1994. If the citizens of Norway had voted for rather than against entry in the referendum of November 1994, entry would have been timed for 1.1.1995. The agricultural agreement provided for a five-year transition period during which Norway's system of agricultural support was to be adjusted to that of the EU. This would have meant a general reduction in subsidies. However, additional support was to be made available in Less Favoured Areas (mountains and other areas with unfavourable conditions for agriculture, covering about 85% of

Norway's agricultural land), and for agri-environmental measures over the whole country. Furthermore, additional national support was to be permitted for areas designated as "Northern agriculture" (covering 52.7% of agricultural land). Communes bordering this zone were to be eligible for a lesser degree of national support. Negotiations on further details in the agricultural agreement were still underway during autumn 1994.

Both study areas fell outside the area of "Northern agriculture". However, Time in Jæren was a border commune. Extra farm support might have maintained a landscape such as that shown in Plate 6b. Without support, or with a low level of extra support, reduced profitability for particularly pig and egg production as well as for milk production would have led to small farmers becoming increasingly dependent on non-farm incomes or led them to find ways of diversifying, as illustrated in Plate 8. Increasing competition as the transitional period neared its end would have led to larger farms intensifying. Areas under corn would have been eligible for Arable Area Payments, subject to 15-18% of the land being set aside. This would have produced areas of rotational or non-rational fallow. There might have been the possibility of some introduction of landscape ecological measures if favourable support measures had been forthcoming (Plate 7b). A polarization of the landscape into areas of intensive production and areas taken out of production would have been a likely consequence (cf. Jones 1993).

Set-aside would have made a bigger impact in an area of specialized corn production such as the study area in Romerike. This could have taken the form of whole fields being left fallow, or strips along roads and small odd corners (such as the circular area in the foreground); afforestation might have been an attractive alternative (see boxes in Plate 11a). Rapidly falling grain prices might well have encouraged full-time farmers to concentrate on large-scale cattle production, with an increase in the amount of pasture in the landscape.

Apart from the question of entry into the EU, the decision of the Norwegian Parliament in 1992 to locate Oslo's new airport close by at Gardermoen (to be completed by 1998), combined with strong market pressures, make the surprising future in Plate 11b a strong contender. The unexpected future has since 1989 become much less so.

From an environmental viewpoint, scenarios illustrating possible landscape impacts of the EU's agri-environmental measures, as well as of environmentally oriented subsidies compatible with GATT, would have been useful in the discussion.

Note

The study presented here was undertaken as part of the research project "Agricultural policies and environmental management," which involved co-operation between a number of departments at the Agricultural University of Norway and the University of Trondheim. The project was financed by the former Norwegian Council for Scientific and Industrial Research.

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CHAPTER 11

Operational tools

11.1 Ecological modelling of nature restoration: science as a contemporary Pythia

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Abstract

Various models have been developed to predict the effects of various measures aimed at nature restoration. All have certain different advantages and imperfections. It is concluded that they never can provide blueprints of nature's future. They may only support the making of decisions, if there is a clear insight into the user's demands and if the advantages of all models are used as creatively as possible. Mechanistic models in combination with information of expert-based and statistical models are considered most useful to predict the impact of measures focused on nature restoration. The need for a good mutual communication between users and modellers is emphasized.

Keywords: *modelling, nature restoration, prediction*

The wish of knowledge on the future

In the ancient times

Already very early in human history, governors desired to know in advance the impact of their decisions. For example, monarch Kroisos, ruler of Asia Minor, whose life has been thoroughly described in the fifth century B.C. by the famous Greek author Herodotos, was concerned with the future of his kingdom and his own destiny. He therefore decided to consult various oracles, including the most eminent of his time. As he had some doubts on the quality of these, he first carried out a comparative test to assess the quality of each. Finally, only two out of six appeared to be quite reliable, i.e. the Delphian and Amfiaraos oracles.

Both were asked to answer the question whether Kroisos should take up arms against Persia and whether he should ensure himself of the support of a friendly power. From both oracles the answers on this question were similar, viz. monarch Kroisos would destroy a vast realm if he would take up arms against Persia, and moreover, he should become friends with the most powerful of the Greeks. At last, Kroisos asked the Delphian oracle whether his government would be long lasting. Apollo's priestess Pythia, overcome by natural gases from the earth's interior, replied: "Once a hinny will become the Medes' king, then the moment will be there for you, softened Lydian, to escape in great haste, and don't feel ashamed to be a coward".

With joy Kroisos received all these predictions. He expected a defeat of the empire of his enemy, the Persian ruler Kyros, and his power would be prolonged as a hinny never

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would replace a human being as the king of the Medes. As a consequence, Kroisos allied with the Spartans and fought Persia. However, Kroisos and his allies were hopelessly defeated and captured. Then he finally understood the meaning of the rather confusing pronouncements of the Delphian Pythia, i.e. the hinny was Kroisos himself as he was a bastard, and the vast realm that would be devastated, was his own!

Today

Kroisos' belief in predictions of future scenarios may be considered somewhat primitive because of its fairly metaphysical elements. However, if we compare this ancient example to contemporary predictions of our own future, there are striking similarities, and in some ways Kroisos' attitude was even more critical than that of some current policy makers. The strict division between those involved in making predictions and the users was very obvious in ancient times. Although nowadays this parting is generally less strict, too often the lack of communication between the two still seems to be as dramatic as in classical times.

Today, policy makers still repeatedly stress the importance of knowledge about the outcome of their decisions. This knowledge can be used in different ways, e.g. to come to the best solutions or to get unpopular decisions adopted. Ecological models may be helpful to find the best decisions on various hierarchical levels and on different stages in the process of decision making.

In advance, users and ecological modellers should agree at least about the next three questions:

1. Which measures and/or scenarios are the models for and which are the targets?
2. Which direct effects and which side-effects are supposed to be relevant?
3. How reliable should the models be and how should the results be interpreted?

Indeed, answering these questions requires good communication between the modellers and the users (civil servants, policy makers, etc.).

Ecological models have been developed for a variety of practices. In some cases the number of abiotic factors and species interactions is limited, and ecological models can be relatively simple. Since, for example, in agriculture the main objective is to maximize or to optimize yield under homogeneous conditions, the influences of unfavourable (a)biotic conditions are reduced (Van Wirdum, 1986). Generally, one of the major sources, viz. either light, water or nutrients, is assumed to be more or less lacking, whereas the other sources are amply available.

However, nature protection and restoration require a quite different approach. As nature conservancy focuses on the conservation of biological diversity, i.e. many millions of species, communities, etc. on a global scale, spatial and temporal variation in biotic and abiotic factors is vital. Many local (e.g. local abiotic conditions, herbivory, pathogen infection, mowing, cutting), regional (e.g. water management) and large-scale (e.g. geology, climate, atmospheric conditions) factors influence biological diversity.

This very much complicates the making of forecasts. Nevertheless, there is a great interest for forecasting models. In this paper the possibilities of making forecasts aimed at nature restoration are discussed.

The classification of models

Forecasting models can be categorized in various ways. From a technical point of view, three approaches have been developed for making models, viz. expert-based models, statistical models, and mechanistic models. In expert-based models, the sensitivity of organisms, populations and/or communities to changes in (a)biotic conditions is assessed basically by rules derived from the judgement of experts. Of course, this judgement largely depends on the expert's experience with ecological patterns and processes in the past. It may include delicate refinings on the basis of the expert's view. Statistical models use (large) datasets of which correlation between variables is described by statistical techniques. Mechanistic models are based on a conception of causal relationships between ecological factors and a quantification of these relationships (Mohren & Burkhardt, 1994). Often, more than one of these approaches have been adopted in current models. Mechanistic models can be classified into deterministic models, chaotic models, and stochastic models (Van Brakel, 1992). Whereas in deterministic models unequivocal relations are identified, stochastic models imply deterministic and stochastic elements. In chaotic models the outcome of simulated processes depends largely on the initial state. So far, the overwhelming majority of mechanistic models in ecology are purely deterministic.

Another important way to classify forecasting models can be made on the basis of various applications and scaling. Some models are mainly used for local natural resources management or for regional (water) management, whereas others are applied for national policies. The latter models generally cover all ecosystems on a national scale, while the first are confined to more specified landscape types. Thus, models may vary largely in the spatial scale and the limitation of the conditions which are described.

As nature restoration particularly aims at the creation and restoration of (a)biotic conditions that may lead to the occurrence of desired ecosystems (Van Wirdum & Kemmers, 1990), three important steps can be identified. First of all, the behaviour of matter flows in the soil, water, and air component of ecosystems and, in particular, their significance for the availability of mineral nutrients and other substances in the rooting layer of the soil are vital. Subsequently, the response of the vegetation as the primary producer on these flows and on management regimes is the second step. The last step focuses on the responses of animal and plant populations on vegetation structure and composition.

In the following section, most of the existing models used in The Netherlands are reviewed as an example, as there is no reason to believe that the experiences in The Netherlands strongly deviate from those in other countries. A first classification used in this summing-up is the division into the above-mentioned three steps. Then, models are categorized into their technical properties, spatial scale, etc. I gratefully use the reviews published recently on this subject (Van Bakel, 1992; Olff, 1992; Van Wirdum, 1986; 1991; Verboom et al., 1993; Verboom, 1994; Wassen & Schot, 1992).

A reconnaissance of models

Matter flows

Most models aiming at the understanding of element flows in the soil/water compartment are of the mechanistic type (Table 1). These flows can be simulated on a regional and a local scale as well. Often, a calibration per application is required entailing a need of a more or less extensive local data set. Some of the models mentioned in Table 1 (FEMSAT, SIMGRO, SWATRE, SMART) are aimed at certain aspects of the (water)

Table 1. Models on matter flows in soil and water applied in The Netherlands derived from Olff (1992). Abbreviations: e = expert-based model; s = statistical model; m = mechanistic model; ^{c} = calibration needed; valid. = Has the model been validated with an independent data set? (y = yes, n = no, ± = partially); r = regional scale; l = local scale; appl lim. = application limited to certain areas, conditions, etc.

model	type	valid.	spatial scale	appl lim.	aiming at
FEMSAT	m^c	±	r	±	groundwater flow
SIMGRO	m	+	r	±	groundwater flow
SIMWAT	m	±	r	±	surface water flow
MODFLOW	m	±	r	±	groundwater flow
ABOPOL	m	±	r	±	surface water flow
SWATRE	m^c	±	l	±	soil water movements
EPIDIM	m	+	l	y	transport of macro-ions
TRANSOL	m	+	l/r	y	solutes transport
ECONUM	m	-	l	y	transport of nutrients in soil/plants
SMART	m	-	l/n	±	pH, transport of Al, Ca, CEC, etc.
RESAM	m	-	l	±	idem, nutrients

flow and therefore supplementary. SIMGRO and SMART are mainly used for policy-making on a regional and national scale in order of setting criteria for atmospheric emission. FEMSAT, SIMWAT, MODFLOW, ABOPOL and TRANSOL are tools to set criteria for water management and physical planning on a regional scale, whereas

SWATRE and TRANSOL are applied for local water management. RESAM is initially developed for scientific objectives. None of the models have been developed for nature restoration in particular. Some models that aim to model flows of nutrients (e.g. TRANSOL and SMART) require inputs from models focused on modelling water flows (e.g. SIMGRO). So far, the application of the models either is limited to certain abiotic conditions because of its model structure, or has been limited yet to certain ecosystems or landscape types.

Van Bakel (1992) pointed out an important dilemma. On the one hand, hydrological models require simplification as too many variables may have influence. On the other hand, ignorance of variables, e.g. of spatial and temporal variability and linearization of non-linear relations, may lead to unrealistic results. This dilemma cannot be solved easily.

So far, only little attention has been paid to the validation of all these models.

Relation between environmental conditions and vegetation

All types of models have been developed for the description of the effects of matter flows on vegetation (Table 2). A marked differentiation is shown, i.e. all existing mechanistic and statistical models are aimed at a certain habitat type, whereas all expert-based models

Table 2. Models on the effects of matter flows on vegetation applied in The Netherlands derived from Van Wirdum (1986, 1991), Olff (1992), Wassen & Schot (1992) and Mohren & Burkhardt (1994). See for the abbreviations the caption of Table 1.

model	type scale	valid. lim.	spatial	appl	aiming at
NUCOM2	m	+	l	y	heathlands on wet soil
NUCOM3	m	-	l	y	heathlands on dry soil
GRASNU	m	+	l	y	unfertilized grasslands
SUCCESS1	m	-	l	y	wet habitats, sandy soil
SUBANG	m	±	l	y	submersed vegetation
SUCREED	m	-	l	y	reed vegetation
FORGRO	m^c	±	l	y	even-aged forest stands
VEDES/ECOTOPE	e	-	l/r	n	all Dutch biotopes
DEMNAT	e	-	r/n	n	all, impact water management
WAFLO	e	±	l/r	n	all, impact water management
WSN	e/s	±	l/r	n	all
MOVE	e/s	-	r/n	n	all
ICHORS	s	+	l	y	aquatic vegetation
HYVEG	s	±	l	y	dune vegetation
ECAM	s	-	l	y	mire vegetation

basically cover all Dutch habitats. Sometimes the expert models are also used on a regional scale, while the other two types are only applied locally. Most mechanistic models deal with a rather specific application. For example, NUCOM2 and NUCOM3 predict the outcome of atmospheric deposition scenarios and management regimes like sod removal and sheep grazing on the competitive relations between dwarf shrubs and grasses in heathlands. They therefore have a close link to certain applications, whereas other, expert-based models, e.g. DEMNAT, WAFLO, WSN, MOVE, pretend to cover a more extensive field of applications. They are used to set criteria for water management, atmospheric pollution and physical planning. So far, they are only occasionally applied for nature restoration. ICHORS, HYVEG, ECAM, WAFLO, WSN and VEDES aim at the management of certain habitats. SUCCESS1, SUBANG, SUCREED and FORGRO primarily have scientific importance. However, e.g. FORGRO has been applied for the forecasting of the carbon fixation in forests with great success.

This differentiation can be explained by the need for elaborate sets of statistical data (statistical models, and mechanistic models for calibration if needed) and of a quantitative insight into a huge number of relations in mechanistic models, which may not be requiredfor expert models. Most of the expert-based models largely rely on Ellenberg's indicator values of all vascular plants for Central European conditions at least initially when they were set up. Sometimes additional assessments of responses on Dutch local conditions have been made and assessments of species' responses which are lacking in Ellenberg's list have been included. At the moment, attempts are being carried out to correlate all these indicator values to sets of real abiotic data.

Again, there is a great need of a real validation of all these models. However, as many effects of changes in (a)biotic conditions become evident after decades, this validation is hard to realize. At least, a critical comparison of all models in an identical situation and a limited time scale is required to test the sensitivity and reality of their predictions. As long as there is a lack of real validation, caution is needed for the users not to overestimate the reality of the outcome of these models.

Processes in populations

In The Netherlands only four models on population behaviour in landscape mosaics have been applied (Table 3). Although the application of the two mechanistic models is not limited to a certain landscape (type), virtually it does have its restrictions, as both need calibration for applications on any spatial scale and for any species (group).

The model COSMO has been used to compare scenarios on wetland restoration and has therefore been closely linked to measures of spatial planning (Harms et al., 1993). The species on which COSMO has focussed are considered as identifiers which are associated with a certain landscape structure. Thus, it has a quite different background than the

Table 3. Models on the population behaviour in landscape mosaics applied in The Netherlands derived from Harms et al. (1993) and Verboom (1994). See for the abbreviations the caption of Table 1.

model	type	valid.	spatial scale	appl lim.	aiming at
COSMO	e	-	r	y	nature restoration
HEP	e	-	l	y	fresh water organisms
VORTEX	m^c	-	any	n	
METAPHOR	m^c	-	any	n	

mechanistic models which have a more fundamental ecological origin in the study of population dynamics and have been adapted for practical applications afterwards, e.g. METAPHOR. In METAPHOR colonization and survival rates of populations in heterogeneous landscapes are described. It forecasts the effects of habitat fragmentation for various types of living creatures on the basis of the description of causal relationships and on the basis of statistical data. Most of these models are used on a regional and local scale for physical planning, forecasting the effects of habitat fragmentation by the construction of infrastructure, and to forecast the effects of scenarios on nature restoration. Recently, METAPHOR has also been applied to assess the impact of some scenarios on wetland restoration on a national scale.

As was already mentioned in section 3.2, validation in population models is needed, but again is very difficult because of its complexity and the long period during which effects may occur.

Conclusions

Expert-based models

Clearly, these models have real advantages. They can be developed rather quickly and do not require extensive new and fundamental research. They aim at the synthesis of all aspects concerned to be relevant. Therefore, assessing the effects of complete scenarios is relatively easy. However, this approach also entails some risks. It is based upon observations and experiences on conditions of the past, which may be not very applicable for future conditions. Some of these models seem to be applicable for a very broad scale without any restraint. However, the reliability of these models may be fairly limited and should require serious tests. The approach does not contribute to increasing the knowledge of causal relations.

Statistical models

Statistical techniques provide a reproducible and verifiable approach. On the basis of these techniques, hypotheses can be formulated on the static relations between ecological variables, and these relations can be quantified. Sometimes, one may have serious doubts on the way variables are correlated, as it is fairly questionable whether they have a causal relation at all. Apart from the formulation of hypotheses of causal relations, they do not allow further causal analyses. Again, they rely on information of the past which is extrapolated to future conditions, and it is uncertain whether this extrapolation provides an acceptable prediction. Therefore, they have serious limitations for the prediction of the effects of dynamic and rapidly changing conditions. They often require the collection of much data and huge data processing and are therefore fairly elaborate. They may be a useful tool for setting criteria on landuse as long as other methods fail.

Mechanistic models

With the aid of mechanistic models, conceptions of causal relations can be implemented, and they may result in tools to predict the effects of still unknown and dynamic conditions. As ecological relations are generally very complex, the development of these models is time consuming. As was mentioned above, there is a marked dilemma (Van Bakel, 1992). May already noticed this and recommended distinguishing strategic models and tactical models for different objectives (May, 1973). Strategic models with a limited number of variables are simple and focused on obtaining a general insight without making precise predictions. Tactical models, however, consist of many variables and are therefore more complex. Their objective is to get realistic descriptions of a limited number of situations without generalization.

In spite of this, models cover reality only partially. As in both previous approaches mechanistic models may also oversimplify ecological relations. In general, they will be most applicable for the assessment of the effects of simple measures.

Prospects and limitations

In the whole world nature changes rapidly owing to human activity. The effects of this activity and the measures taken to diminish them may be visible after centuries. This underlines the need to get insight into these effects at the moment that measures are taken into consideration. Theoretically, mechanistic models based on the description of causal relations are the most reliable instruments for predicting the future, although one must notice that only parts of our surrounding world can be covered. Therefore, one should focus on models aimed at a well-defined application on a well-defined time and spatial scale, and avoid trying to explain the whole world. Furthermore, as the construction of mechanistic models is a time-consuming activity, modules derived from expert-based and statistical models should be built in to create a useful tool within an acceptable period of time. Whatever model will be used, much attention should be paid to model validation.

Some ecological factors (e.g. fires, floods, spells of drought and frost) behave more or less stochastically and are impossible to predict by definition. Moreover, this unpredictability can be considered one of the major features at which nature protection should aim (Van Wirdum, 1986; Van Wirdum & Kemmers, 1990). In fact, there is a lot of evidence that these stochastic processes are very crucial for species, populations and community performance and behaviour (White, 1979)! As a consequence, this complicates the making of models for nature protection and restoration. It is an illusion to expect that ecological models can provide a blueprint of nature. In the best case, they can only be used as a tool to compare the impacts of measures under various scenarios on the most valuable or vulnerable species, populations and communities in a qualitative way. Clearly, models cannot give an exact blueprint of these effects. However, they may clarify for decision makers which activities and measures are most likely positive and which are adverse.

This demands a very clear formulation on which measures models are focused on, and a very intensive communication on the interpretation of the results, as they will not be unequivocal or even reliable in general. This communication between users and modellers may prevent history repeating itself, as was illustrated by Kroisos' fate.

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11.2 A national survey of ecological potentials for developing natural areas in The Netherlands

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Abstract
Scenarios for nature restoration need information on ecological potentials in order to optimize scenarios. A method for a national survey is presented. The evaluation is based on an analysis of attributes and requirents of so-called target ecosystems and evaluation of data by a geographical information system. Three groups of requirements are distinguished: ecological site factors, abiotic processes and environmental load. In total about 50 abiotic characteristics were evaluated. The study resulted in maps indicating the abiotic potential in five relative classes on a square kilometre grid.

Keywords: *nature development land evaluation geographical information system*

Introduction

Scenario studies for nature policy need information on the ecological potentials in order to optimize scenarios. One scenario for nature policy is the Nature Policy Plan of The Netherlands (1990). Since its publication a lot of work has gone into establishing a National Ecological Network for which the Ministry of Agriculture, Nature Management and Fisheries has overall responsibility. In the next 30 years approximately 200 000 ha of new natural areas must be developed. At present, the focus is on the formulation of ecosystem and area perspectives (Figure 1). An ecosystem perspective provides a description of a particular group of ecosystems, such as fens or woods. The whole range of ecosystems within this group is defined into approximately ten types: target ecosystems. Per target ecosystem it is indicated which plant and animal species can be used to measure the natural value and biodiversity. These so-called target parameters are intended to be used as a check on the progress of the nature policy.

The results of the various ecosystem perspectives have been summarized in the Policy Document on Ecosystem Perspectives (Jansen et al., 1993). The policy document describes about 100 target ecosystems. These target types will be used, together with the results of other studies (see Figure 1) to produce the National Ecological Network both regionally and locally via so-called area perspectives. For the allocation the national policy will indicate how many hectares of a particular target ecosystem should be developed. For this purpose, the geographical distribution of potentials for developing a particular target ecosystem need to be known.

Three aspects determine the potentials for a target ecosystem, namely the abiotic circumstances, the biogeographical aspects (e.g. sources of seeds, dispersion of animals) and socioeconomic criteria (e.g. costs, planning flexibility, general acceptance). This article describes a national survey (Farjon et al., 1994) which was restricted to the abiotic

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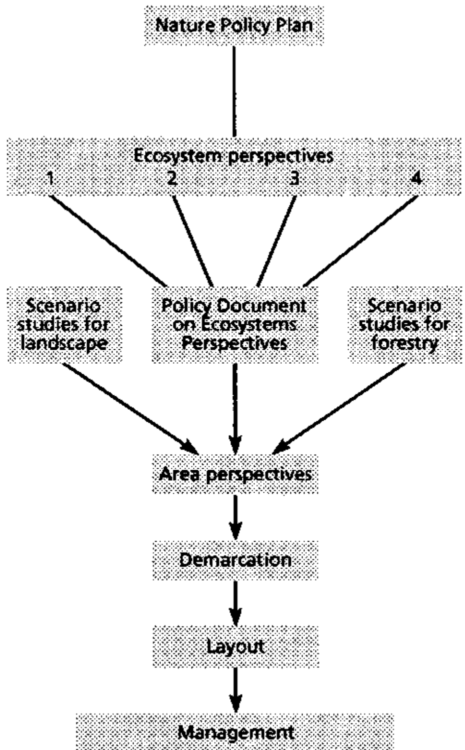

Fig. 1. The implementation of the National Ecological Network

potentials of eight target ecosystems that are characterized by large contiguous surfaces (500 to 1000 ha) and a near lack of management measures:
- wooded landscape on undulating to hilly sandy soils;
- wooded landscape on loamy soils;
- drift-sand inland dunes;
- alluvial wooded landscape (two types);
- marsh landscape (two types);
- semi-dynamic coastal dunes.

Three questions are relevant:
- What are the characteristics of the target ecosystem?
- Which abiotic circumstances are required by the target ecosystem?
- From which databases can the abiotic circumstances be derived?

Materials

The studied target ecosystems are characterized by a limited amount of human intervention. Only regional interventions are allowed and aim at imitating or simulating particular natural processes, such as flooding, seepage and natural grazing. Intervention on a more local scale, such as peat cutting, burning, felling and mowing, does not occur. Through this kind of management, a varied landscape of woods, naturally evolved scrubland, meadows and marshes will eventually come about. In due course, under the influence of the manipulated natural processes, the pattern will change in a somewhat unpredictable way, because in places where these intensive processes have their effect, natural succession will be slowed down or arrested altogether.

In order to determine an area's potentials, there are three requirements as far as the abiotic circumstances are concerned: namely, the presence of characteristic ecological sites of the target ecosystem, the qualities of abiotic processes that determine the dynamics of the target ecosystem and the environmental load. The last requirement is in general incorporated in the others. However, existing knowledge and the available databases, plus the wish of policy makers to give a high profile to environmental aspects of nature policy, have obliged us to examine the criteria for selecting sites and those associated with environmental load separately. The abiotic potentials of a target ecosystem were determined in three stages. Each stage covered one requirement.

The requirements of the various target ecosystems were determined by expert judgement and reference to the literature. It was extremely difficult to formulate well-defined standards, so definitive determination of the potentials was not possible. The potentials are therefore indicated in a relative sense. In order to gain more insight into the absolute potentials and the reliability of our results, we have compared the maps displaying the potentials with the distribution of seven plant species that are typical of the target ecosystem according to data (Mennema et al., 1985). The abiotic potentials of the selected target ecosystem were evaluated by existing databases such as the Landscape Ecological Survey of The Netherlands (Bolsius et al., 1994; Canters et al., 1991; Klijn, 1989) and the Dutch National Groundwater Model (Pastoors, 1993). In total, about 50 different abiotic and 70 biotic characteristics were applied. The geographical information system ARC-INFO with a square kilometre grid was used for analysis and map production. In addition, a computer-based decision-support system was developed. This system allows rather easy consultation of databases and requirements used in the evaluation procedure of each target ecosystem.

Results and discussion

One of the eight target ecosystems that was evaluated is the wooded landscape on undulating to hilly sandy soils. These are woodlands of at least 500 ha with natural grazing. Within these areas the most important ecological sites are (Figure 2):

- infiltration areas: poor in nutrients, dry;
- stagnation areas: poor in nutrients, wet;
- areas with richer substrates: moderately rich in nutrients, ranging from wet to dry;
- seepage areas: moderately rich in nutrients, wet;
- flood plains: rich in nutrients, ranging from wet to dry.

Through spontaneous afforestation, varied woods composed of oaks, birches and beeches will develop at the higher elevations, alder will grow at lower levels, and in the flood areas there will be riverine forests. In some places succession will be limited by natural grazing and abiotic processes such as stagnation (raised bogs), seepage water (fens), flood water from streams (silted up banks and reed marshes) and wind erosion (drift sands). These factors regulate the development of a varied ecosystem whose pattern changes over time.

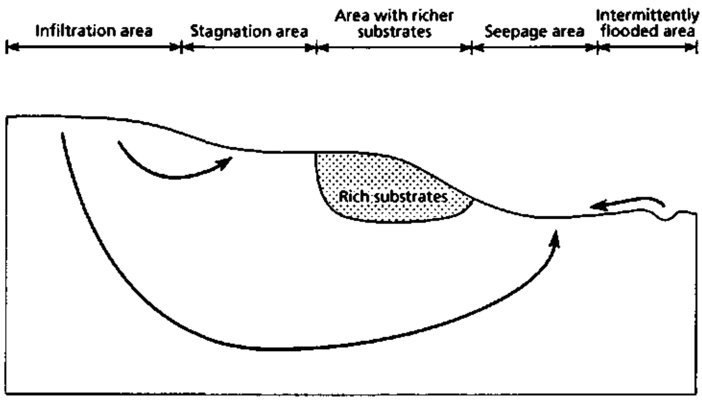

Fig. 2. The ecological sites of the wooded landscape on undulating to hilly sandy soils

The first stage evaluates to what extent the requisite variation in ecological sites occurs. It was checked over in what area the five site types mentioned earlier appear. In particular, sites which are moderately rich in nutrients (seepage areas and areas with richer substrates) appear to occur less extensively than the remaining types (Figure 3). Sites moderately rich in nutrients were considerd as more favourable than other sites. The second stage assessed the quality of the abiotic processes. Due to the importance of sites which are moderately rich in nutrients, this step concentrated on places where seepage water occurs. Both quantity and quality were evaluated (Figure 4). Areas with seepage of more than 1 mm/d and a so-called lithocline water quality proved to have the greatest potentials. Under these circumstances seepage makes an important contribution to the high base saturation of these sites. Finally, the environmental load was evaluated. The load exceeds accepted ecological standards almost everywhere. For instance, the atmospheric acid deposition, which is one of the factors to measure the environmental load, in the relatively lightly loaded northern provinces is approximately 3000 mol H^+ per hectare per year. The ecological norm of 500 mol H^+ per hectare per year is exceeded in this region by a factor of six. The environmental load therefore provides only a relative indication of potentials. Figure 5 shows that there are important differences in environmental load per catchment area.

Figure 6 shows the result of the three previous assessment stages. The areas with the greatest potentials lie on the northern and southwestern flank of the Drenthe Plateau, in Twente, on the northern and eastern flank of the Veluwe, parts of Central Brabant, and Central Limburg. The poor potentials of large parts of the Veluwe and North Brabant are noticeable. On the Veluwe there is little variation in ecological sites because of the small part of seepage areas and richer substrates. In North Brabant the capacity of seepage water is both quantitatively and qualitatively inadequate, and the environmental load is too high. The indication of the potentials of the Veluwe suggest that abiotic characteristics are merely one aspect of their determination. This area is a major component of the

National Ecological Network as it is the largest contiguous area of wood and heathlands in The Netherlands. So biogeographical and socio-economic aspects dominate over abiotic aspects.

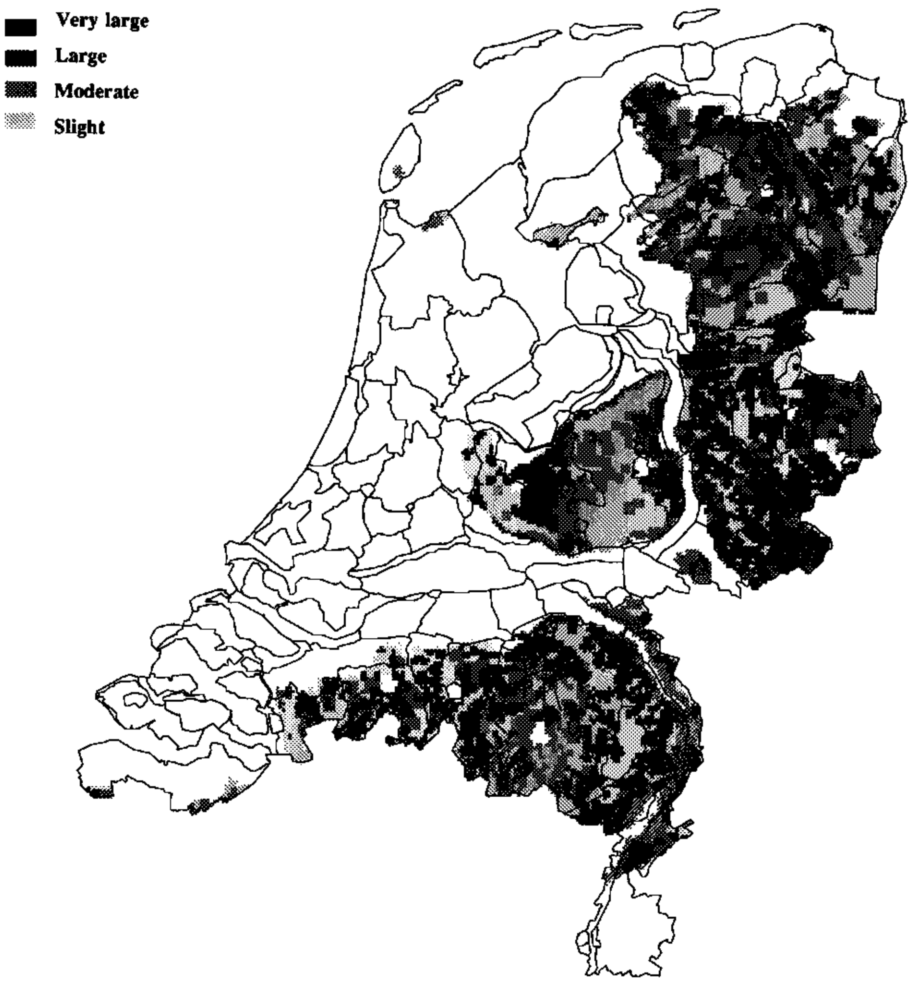

Fig. 3. The assessment of variety of ecological sites

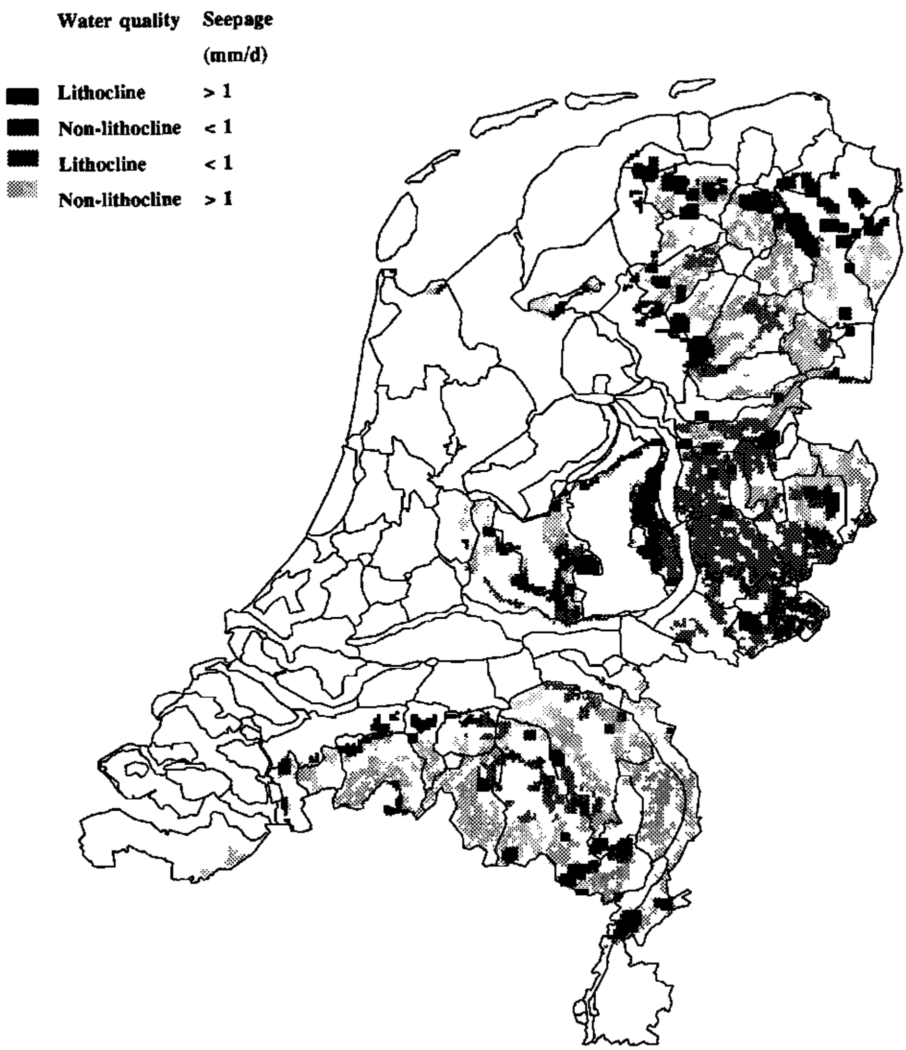

Fig. 4. The evaluation of groundwater seepage

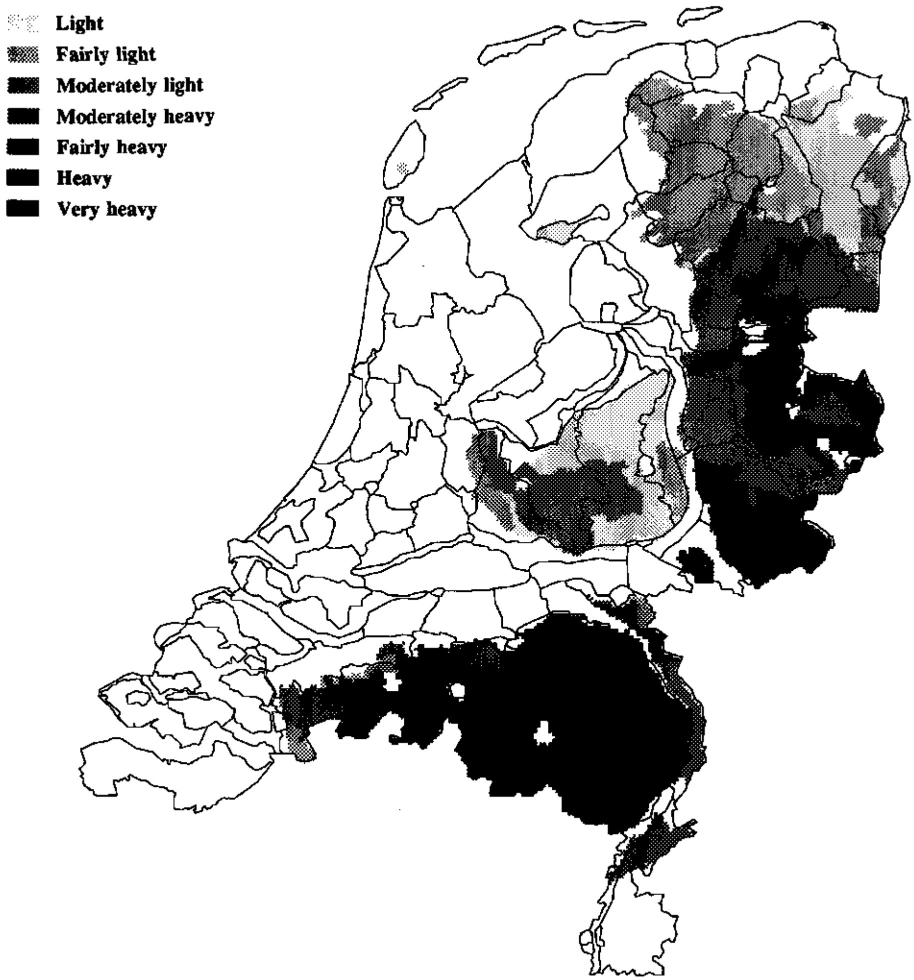

Fig. 5. The assessment of the environmental load

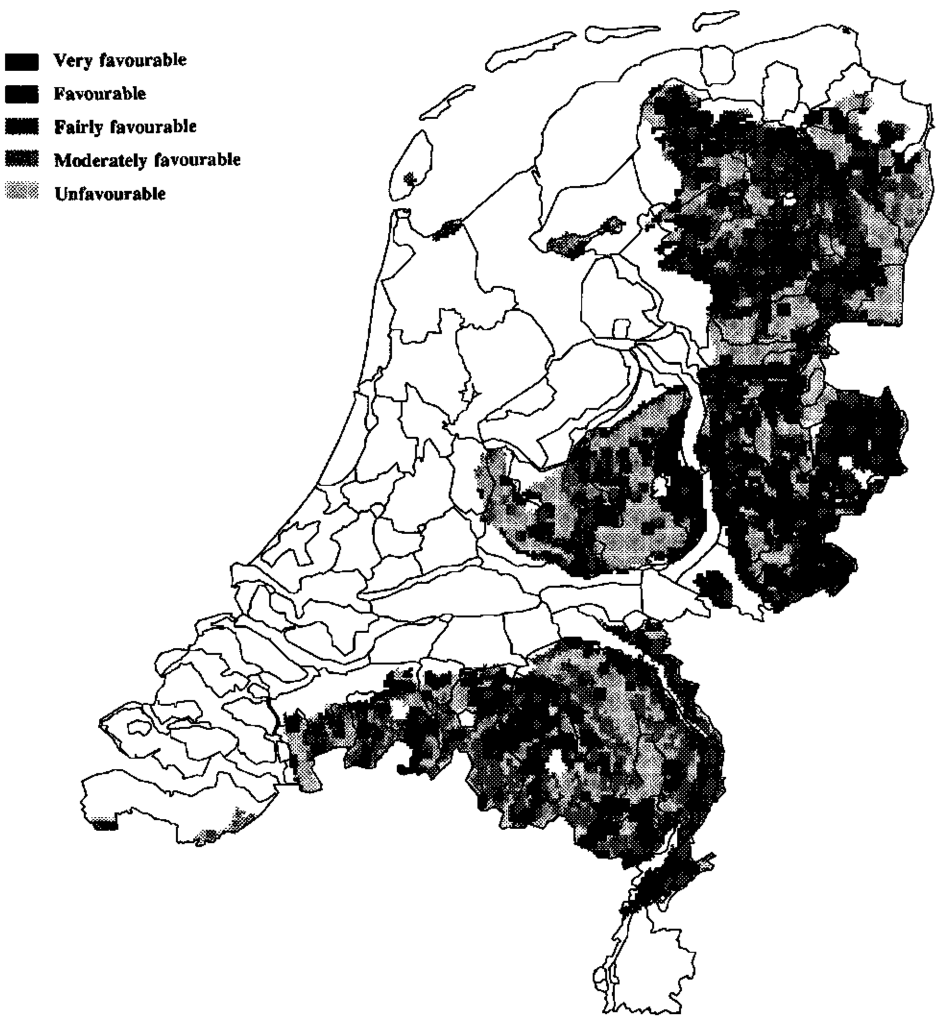

Fig. 6. Abiotic potentials of the wooded landscape on undulating to hilly sandy soils

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11.3 COSMO: A decision-support system for the central open space, The Netherlands

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Abstract
To evaluate scenarios for nature restoration, a landscape ecological decision-support system has been developed, a knowledge-based system integrated in a geographical information system. The grid-based application in the Central Open Space of The Netherlands (the COSMO model) is presented here. Four scenarios for nature restoration were evaluated. With the COSMO model, vegetation development and potential habitats of fauna species were simulated at 10, 30 and 100 years from the beginning. The results are discussed.
Keywords: *geographical information system, modelling, nature restoration, landscape ecology*

Introduction

According to the Fourth Report on Physical Planning (Min. VROM, 1989), the economic centre in the western part of the country, the so-called Randstad, should extend eastward. In the middle of this conurbation, there is a large open agricultural area of some 400 000 ha, called the Central Open Space. Here, nature restoration must counterbalance adverse developments, improve the environmental quality, and enhance the recreational attractiveness. Planning at a regional level guides the necessary reconstruction of the landscape and will find a new balance for all the land use objectives.

Four scenarios for nature restoration in the Central Open Space have been developed and evaluated to solve these planning problems and to implement the national physical planning programme on a regional scale. They are based on different ecological objectives and spatial strategies in landscape planning (Table 1).

Table 1. Ecological objectives and spatial strategies of the four scenarios

Scenario	Ecological objective	Spatial strategy
Godwit	variety of communities	interweaving and zoning
Otter	improvement of dispersal	developing networks
Elk	non-intervention	segregating land use types
Harrier	variety of communities	segregating and selecting optimal sites

Each scenario was given a motto referring to an animal species that could be favoured by it.

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The "Godwit" scenario aims at preserving and improving existing nature reserves. The ecological objective is an optimal variety of species and species communities.
The strategy aims at achieving a high diversity by integrating nature restoration with other land use types, especially agriculture, and is dependent on long-term agreements with farmers. These agreements may, however, be jeopardized by economic or other developments in the European Union, which might threaten the sustainability of the nature involved. This scenario corresponds to the trend in nature conservation policy during the last 15 years.

The "Otter" scenario aims at improving dispersal for species considered sensitive to habitat fragmentation. The concept of connectivity or ecological infrastructure underlies this scenario. Autonomous and planned developments lead to an increase in fragmentation of natural habitats. To compensate for this, a vast network of corridors and stepping stones is proposed in this scenario.

Developing wilderness, self-sustaining 'complete' ecosystems, is the goal of the "Elk" scenario. This is a rather new objective in the Dutch tradition of nature conservation. Emphasis is laid on ecosystems without human intervention and a minimum amount of management. To achieve this, a spatial strategy is needed that can secure the ecological prerequisites over a long period.

The "Harrier" scenario is the most drastic one. Like in "Godwit", the ecological objective is to achieve an optimal variety of species and communities, but contrary to "Godwit" it does not join the trends in nature conservation policy. All the expertise available in nature management will be exploited to achieve a maximum species diversity. The spatial strategy is focused on a concentration of natural areas in large tracts. This will promote interrelations between different communities. Moreover, large areas are less vulnerable to external influences. Segregation predominates, just as in "Elk". However, the role of management is far more important than it is in "Elk".

Figure 1 gives an impression of each of the scenarios.

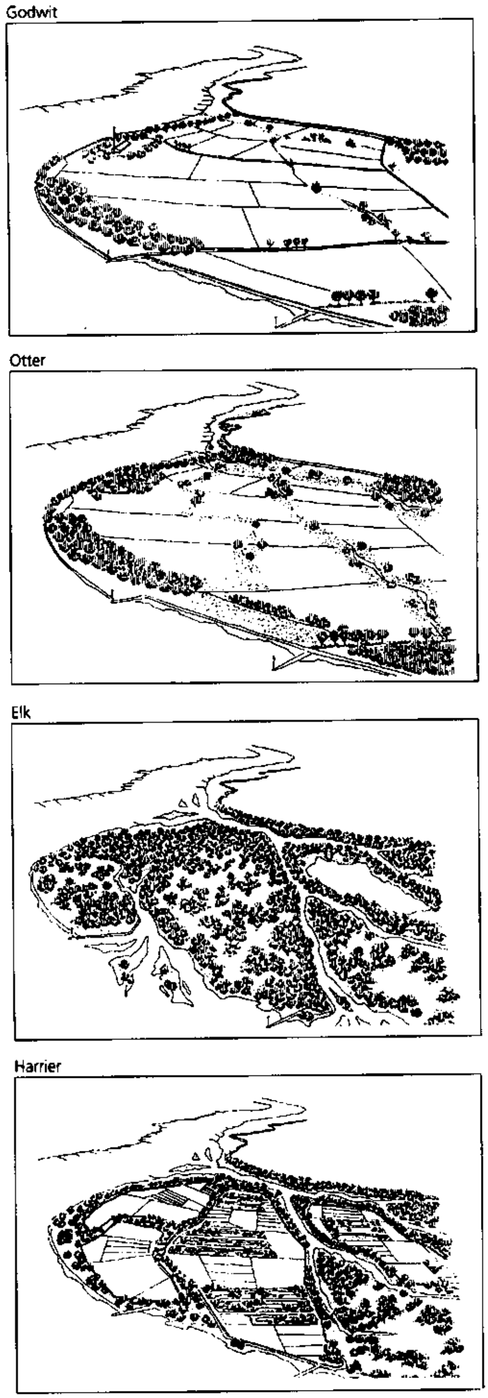

Fig. 1. Impressions of the four scenarios

The model

A model, called COSMO (Central Open Space Model), has been developed that links available landscape ecological knowledge to a geographical information system (GIS) to evaluate the scenarios. Both the data on the present situation (vegetation, soil, land use) and those on planned and expected development of site condition, vegetation and fauna are handled in a grid with cells of 1 km². The model provides a systematic way to use available ecological knowledge in evaluating the expected consequences of nature restoration plans. COSMO is based on a deterministic concept of vegetation dynamics (Fig. 2) dependent on physiotope, target vegetation and management, and of faunal habitat requirements that are also dependent on vegetation structure.

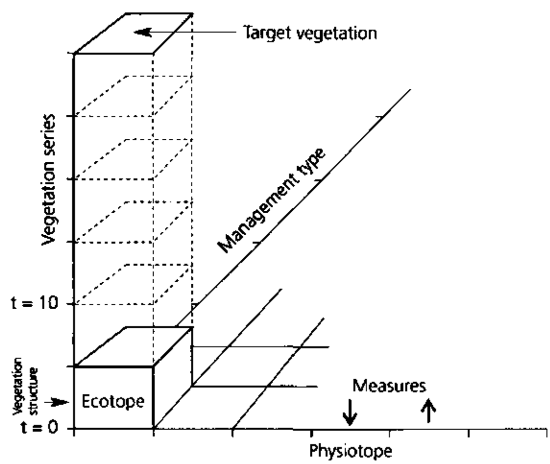

Fig. 2. The concept of the COSMO model

The GIS used is MAP2 (Tomlin, 1983; Van den Berg et al., 1984). The model contains grid maps of the present situation of the Central Open Space and aggregated ecological knowledge of nature development in The Netherlands. This aggregated knowledge is used as input for a set of predefined commands for the GIS program that process the data and produce maps and tables of the expected vegetation and fauna species. The input is a grid map of the nature restoration scenario, indicating place and type of the vegetation proposed.

For the Central Open Space project, the current data on soil type, hydrology and vegetation were derived from a nationwide database of ecological variables on a km² basis (Canters et al., 1991). Only the dominant vegetation and soil type in a grid cell were considered.

In the COSMO model, development of the vegetation is dependent on physiotope and management. A *physiotope* is a spatial unit characterized by independent state factors, primarily edaphic, hydrological and topographic. Each physiotope can carry a limited number of *vegetation types*. A specific unique combination of a vegetation type and a physiotope is called an *ecotope* (Leser, 1976). Ecotopes are the basic units of the model.

The type of *management* chosen determines the development of an ecotope, i.e. the pathway to be taken through the ecotopes. This pathway is called a *vegetation series* (Harms & Damen, 1978). The basis for the simulation of the vegetation development is formed by an extensive set of vegetation series, each describing the expected development in a certain physiotope under a certain management. The ecotope map of the present situation is the starting point of the simulation. Up till now, the development of the vegetation has been modelled for 10 different management types (including autogenous development) and 20 physiotope types, covering the mid-western part of The Netherlands.

The interface between the nature development plan and the model is formed by a set of *target vegetations*. These are less detailed vegetation types, more suitable for planning purposes than the rather refined classification of vegetation types or ecotopes. A target vegetation corresponds to a certain type of management and a range of suitable physiotopes. To use the COSMO model, the scenario must be converted into a grid map of target vegetations.

To assess the effects of the scenarios on the fauna, species of birds, mammals and butterflies considered typical of the Central Open Space are selected and combined in 48 *ecological groups* on the basis of an extensive literature survey. For each group, all the vegetation types are classified as optimal or non-optimal habitats. In addition, for each animal group the *areal requirements* are determined and classified into areas suitable for different population sizes.

The evaluation consists of four steps:

- First, the model tests the suitability of the abiotic conditions for the planned target vegetations. If a target vegetation does not match the abiotic conditions, the model proposes measures to adapt these conditions (e.g. raising the water-table or removing the topsoil). It also proposes alternative target vegetations. Thus, it helps the planner to update his target vegetations and/or the measures to be taken.
- In the next step, the model simulates the temporal and spatial developments of the vegetation, according to the proposed management. This results in maps of the expected vegetations after 10, 30 and 100 years.
- Then, the vegetation types are translated into their suitabilities as habitats for animal species. The resulting maps of the potential habitats (after 10, 30 and 100 years) also provide indications of the sizes of the populations that can be attained.
- By comparing the maps generated, the impact of the proposed management (required to obtain the target vegetations) on vegetation and fauna can be assessed. These results are finally evaluated, using criteria that are relevant to policy makers, such as diversity, international value and costs.

Results

By and large, the scenarios reach their objectives. Most of the **target vegetations** are developed as planned. Results concerning development time, diversity and international value of vegetation are presented (see Table 2). The score is indicative and gives the relative differences in value of the criteria concerned between the scenarios.

Table 2. Effects on the vegetation (development time, diversity and international value) of the four scenarios. (= low, ** = moderate, *** = high, **** = very high score of the corresponding criterion)*

Scenario	development time	diversity	international value
Godwit	*	*	*
Otter	**	**	***
Elk	***	*	**
Harrier	**	***	****

"Godwit" is the fastest developing scenario, because grasslands and other semi-natural vegetations form the major part. "Elk" takes the longest time to develop. Large areas of marshy woodland and hardwood flood-plain forests are planned here. It takes more than 100 years to develop these kinds of natural vegetation.
"Otter" is a comparatively fast developing scenario, because in a major part of the area grasslands and marshes are planned, which develop within 30 years. "Harrier" has a broad spectrum of target vegetations. Consequently, different parts are developed within different stages.
"Harrier" shows the greatest diversity from 10 years after the beginning onwards. This is in accordance with its objective. "Otter" and "Elk" have lower values, owing to their comparatively low number of target vegetations. Though "Godwit" has a fairly large number of target vegetations, its diversity is lower than expected. This is because grasslands form the major part of the area, which gives a skewed distribution of vegetation types. This is especially the case after 10 years, when many of the other target vegetations, such as recreation areas and estates, are still in the succession phase of grassland.
A high international value is assigned to lowland marshes including several succession stages towards marshy woodland, vegetations of hydrophytes, tidal forests, and vegetations of extremely oligotrophic environments, such as ombrogenous peat (raised bogs). Owing to substantial areas of reed and sedge vegetations and tidal forests, Harrier scores better than the other scenarios. "Harrier", "Otter" and "Elk" comprise fair areas of lowland marshes (different succession stages) which account for some 20% of the area. "Godwit" scores lowest, because the emphasis is put on grasslands that are not highly valued internationally.

Evaluation of the **fauna** reveals large differences between the scenarios. Table 3 summarizes the expected effects of the concepts on the fauna.
"Godwit" enables a rather broad spectrum of animals to build up moderate to large populations, especially meadow birds. Animals of wet biotopes are hardly favoured by this scenario.
"Otter" does not stand out in serving any of the ecological groups more than the other scenarios do, except for birds of clear shallow waters. The scenario does have a considerable positive effect on forest animals and, to a lesser extent, on animals preferring grasslands or open water and marshland. It is the only scenario that improves the situation for the otter. Animals requiring large areas will only be able to form very small populations.

Table 3. Effects on ecological groups of birds and mammals with small and large home-range areas. Ecological groups are classified according to biotope.
(- negative effect, = no effect, + positive effect)

Biotope	Godwit	Otter	Elk	Harrier
Small home-range area:				
open water	=	++	=	+
grassland	++	=	--	-
marsh/reed	+	+	=	+
park-like	+++	-	+	++
forest	++++	+++	+++	++++
Large home-range area:				
open water	=	+	=	=
grassland	++	-	-	=
marsh/reed	=	+	+	+
park-like	++	-	=	+++
forest	+++	++	+++	++++

"Elk" involves large tracts of primarily marshy woodland and flood-plain forest. As a result, the area of potential habitats for animals tied to such forests will increase strongly. Even large herbivores such as elk *(Alces alces)* will be able to form populations of considerable size. Also, the beaver *(Castor fiber)* will find its area of potential habitat enlarged and less fragmented compared with the present situation. Because most of the forests will have an open structure caused by grazing, small mammals and butterflies preferring wet or peaty grasslands will benefit from this scenario.

"Harrier" will lead to a considerable increase in the area of potential habitat in virtually all the ecological groups, owing to the development of a broad spectrum of biotopes. Each biotope is well concentrated in large clusters of similar vegetation. Especially for ecological groups preferring forest, marshy woodland and park-like biotopes, the area of potential habitat increases greatly. Because of the good clustering of forests and park forests in this scenario, wide-ranging animals such as pine marten *(Martes martes)* and red deer are able to form larger populations than in "Godwit". The only group that will suffer a decrease in area of potential habitat is the group of critical meadow birds (e.g. ruff), because existing habitats (grasslands on flood plains) will be afforested.

Discussion

The results of the plan evaluation by COSMO clarify a great number of consequences of a chosen scenario. It does not give an explicit answer to the question of which is the best overall scenario. That answer depends on the objectives determined by policy makers. The four scenarios are exaggerated as they suppose a consistent implementation of ecological objectives and spatial strategy. The four scenarios and their consequences on vegetation and fauna development must be understood as an abstract frame delineating the possibilities for nature restoration. Only the corners of the frame have been surveyed. The given consequences of these extremes enable policy makers to choose a feasible compromise. Consequently, more cyclic runs of the planning process are needed to adjust the new scenarios by revaluating through the model. The final result will be a comprehensive plan, better understood as to the consequences of the objectives chosen.

With respect to this planning purpose, the model must be valued as a tool for landscape planners rather than an accurate predictive model. For developing a predictive model, research is needed on poorly understood aspects such as marshland succession. The validity of the model must be tested by further monitoring of actual vegetation and fauna development.

One may ask why a model is needed to evaluate the consequences of a scenario for vegetation and fauna. These consequences may differ largely from the aims of the scenario for two reasons. First, it is neither possible to overview the ecological requirements of all the vegetation and fauna groups considered in designing the spatial layout of the scenario, nor to incorporate these explicitly in the spatial layout. Second, when the ideas of the scenarios are confronted with the actual spatial pattern of land use, many choices must be made, forcing one to deviate from the optimal spatial layout. Therefore, the consequences for vegetation and fauna are not a straightforward consequence of the target vegetations. Especially the extent to which certain fauna groups are favoured or hindered by a scenario is largely an emerging property of the scenario which must be demonstrated and clarified with the model.

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11.4 Modelling abiotic site factors in response to atmospheric deposition and upward seepage

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Abstract

Changes in vegetation are often caused by changes in abiotic site factors, such as pH, nitrogen availability and soil moisture. It has been recognized that abiotic site factors are affected by atmospheric deposition and groundwater-table changes. In order to evaluate the effect of eutrophication, acidification and desiccation on site factors, the model SMART2 has been developed. For The Netherlands combinations of two acidification and two seepage scenarios (1990-2050) were evaluated with SMART2. The results are focused on pH, nitrogen availability and base saturation. Calculations were made for combinations of five vegetation structures on seven soil types and the five groundwater-table classes, using a 1 km^2 grid. Results showed that deposition reductions lead to a relatively fast improvement of the site factors, increase in pH and base saturation and decrease in N availability. Whereas a reduction in groundwater abstractions of 25% has little or no effect on the pH and N availability.

Keywords: *Modelling, soil acidification, eutrophication, desiccation, national assessment*

Introduction

Changes in vegetation are often caused by changes in abiotic site factors, such as pH, nitrogen availability and soil moisture. It has been recognized that abiotic site factors are affected by atmospheric deposition and groundwater-table changes. In order to evaluate the effect of eutrophication, acidification and desiccation, Latour and Reiling (1991) developed a conceptual, species-centred, Multiple stress mOdel for VEgetation (MOVE). MOVE calculates the occurrence probability of plant species as a function of three abiotic site factors: pH, nitrogen availability and mean spring groundwater-table. To simulate changes in soil pH and nitrogen availability in response to acidification, desiccation and eutrophication scenarios, the model SMART2 has been developed (Kros *et al.* in press).

The objective of this research was to provide a simple, national applicable site model to evaluate the effect of seepage, acid deposition and nutrient cycling on terrestrial ecosystems. The SMART2 model was derived from a dynamic soil acidification model SMART (De Vries *et al.* 1989). SMART is a simple one-compartment model which only includes geochemical buffer processes (a.o. weathering and cation exchange). The major enhancements in SMART2 are the inclusion of a biocycle and an improved modelling of hydrology.

Apart from pH and nitrogen availability, SMART also predicts changes in aluminium, base cation, nitrate and sulphate concentrations in the soil solution and the occupation of the adsorption complex. Here we describe the application of SMART2 to The Netherlands. The results are focused on pH, nitrogen availability and base saturation. for

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combinations of five vegetation structures on seven soil types and five groundwater-table classes, using a 1 km^2 grid.

Methodology

All geographical information was used on a or transformed to a 1 km^2 grid. This because of portability reasons towards the National Groundwater Model (LGM; Pastoors, 1993) and the National Survey on landscape ecology (LKN; Klijn, 1989). Initial deposition values for the year 1989 were derived from a 5^2 km^2 grid database (Erisman, 1991). Hydrological information was derived from the National Groundwater Model, with a resolution of 1 km^2. Soil and groundwater-table classes were derived from the 1:50 000 soil map of The Netherlands. A distinction was made in seven soil types (poor sand, rich sand, calcareous sand, clay, calcareous clay, peat and loess) and five groundwater-table classes. The considered vegetation structures were lumped into five vegetation types (deciduous forest, spruce forest, Douglas fir, pine forest, heather and nutrient poor grassland). The areal distribution of the vegetation types was obtained by an overlay of the generalized soil map, the Dutch forest inventory (Anonymous, 1985) and a satellite observation map (LGN; Thunnissen *et al.*, 1992).

For each of the vegetation types considered, data were gathered on: (i) canopy interaction factors, (ii) nutrient cycling parameters and (iii) mineralization rate constants for fresh litter, old litter and root necromass. For each of the soil types considered, data were gathered on (i) soil variables, (ii) soil properties and (iii) soil constants, i.e. rate and equilibrium constants influencing the rate of the modelled soil processes. For all considered combinations of vegetation type and soil type, hydrologic data and growth data were collected. The rooting zone of the considered combinations of soil type and vegetation type varied between 30 and 100 cm. An extensive overview of all the soil and vegetation specific data and their origin has been given in Kros *et al.* (in press).

Combinations of two acidification and two seepage scenarios (1990-2050) were evaluated. The two deposition scenarios were: (i) a constant deposition scenario, and (ii) a reducing deposition scenario, reflecting the planned emission reductions in The Netherlands. Values for each grid between 1990 and 2050 were derived by linear interpolation, using initial deposition estimates (for the year 1989) and generic reduction fractions for SO_2, NO_x and NH_3 separately. The reducing scenario correspond with the following average values for potential acid deposition ($mol_c\ ha^{-1}\ a^{-1}$): 5400 in 1990, 2000 in 2010 and 1400 in 2050. The two seepage scenarios were: (i) a constant seepage flux, using the values for the year 1988 as presented by Pastoors (1993), and (ii) a 25% reduction of groundwater abstractions for public drinking water (cf Pastoors, 1993), resulting in increasing seepage fluxes.

Results

As an example, the geographic distribution of the dominant pH per grid cell for deciduous forest in the year 1990 and 2050 for the reducing acidification scenario and the increasing seepage scenario is presented in Plate 12a.

Results showed a high spatial variability in pH, which is mainly determined by the variability of soil types. For calcareous sandy soils and clay soils along the coast-line and clay soils along the rivers, relatively high pH values were simulated, whereas relatively low pH values were predicted for non-calcareous sandy soils in the central part and the southern part of the country. Plate 12a shows that deposition reductions and seepage increase results in an increase in pH values, especially for the non-calcareous soils. However, the effect of seepage increase is almost negligible compared to the effect of deposition reductions (cf Kros *et al.* in press).

The influence of vegetation type on the site factors is presented in Table 1. Vegetation type influences the soil chemistry by differences in nutrient cycling, filtering of dry deposition and transpiration. This effect was most pronounced for the base saturation. The relatively high pH and base saturation for grassland is biased by the fact that about 45% of the considered grassland sites are located on calcareous sandy soils or clay soils. Generally, the effect of vegetation type was relatively small.

Table 1. Effect of vegetation type on the predicted median pH, N availability and base saturation (BS) in the rooting zone of all soil types for 1990, 2010 and 2050 in response to the reducing acidification scenario and the increasing seepage scenario

Vegetation type	N[1)]	pH			N availability ($kmol_c\ ha^{-1}\ a^{-1}$)			BS (%)		
		1990	2010	2050	1990	2010	2050	1990	2010	2050
Spruce	2123	3.7	3.8	3.9	3.6	2.4	2.2	3	3	6
Pine	5566	3.8	3.9	3.9	4.4	2.7	2.4	2	2	3
Deciduous	6971	3.9	4.0	4.1	2.8	1.2	1.7	4	3	7
Heather	463	3.7	3.8	3.8	3.3	2.4	2.5	3	6	7
Grassland	1218	5.4	5.7	6.2	2.4	1.8	1.8	43	79	99

[1)] *N* represents the number of evaluated combinations

Effects of soil type (Table 2) is mainly influenced by parent material and the groundwater-table. The effect of soil type was much more pronounced than that of the vegetation type. Especially the results for calcareous and non-calcareous soils differ considerably. Simulations for calcareous soils resulted in high pH values and base saturation due to the presence of calcite, while the N availability was low due to a lower atmospheric input. Calcareous soils are generally located in areas with relatively low atmospheric input of N. The same is true for clay soils and peat soils. Lower values for N availability for these soils are also caused by enhanced denitrification rates due to higher pH values and/or lower groundwater-tables.

Conclusions

- Deposition reductions lead to a relatively fast improvement of the site factors, increase in pH and base saturation and to a decrease in N availability.

- A reduction in groundwater abstractions of 25% has little or no effect on the site factors pH and N availability.
- Except for grassland the differences in median model results between the various vegetation types are rather small compared to differences between soil types
- The spatial variability in pH is relatively large, which is mainly caused by the variability in soil type and atmospheric deposition.

Table 2. Effect of soil type on the predicted median pH, N availability and base saturation (BS) in the rooting zone of deciduous forests for 1990, 2010 and 2050 in response to the reducing acidification scenario and the increasing seepage scenario

Soil type	$N^{1)}$	pH			N availability ($kmol_c\ ha^{-1}\ a^{-1}$)			BS (%)		
		1990	2010	2050	1990	2010	2050	1990	2010	2050
Sand poor	3166	3.9	4.0	4.0	3.4	1.4	2.0	2	2	4
Sand rich	2283	3.8	4.0	4.1	2.4	1.1	1.5	4	3	7
Sand calc.	184	7.0	7.0	7.0	0.9	0.1	1.0	100	100	100
Peat	375	4.2	4.3	4.9	1.8	0.9	0.9	54	57	67
Loess	72	4.2	4.3	4.2	2.9	1.8	1.8	14	11	10
Clay	554	5.9	6.0	6.0	1.4	0.6	0.6	89	88	88
Clay calc.	337	6.8	6.8	6.8	0.6	0.4	0.4	100	100	100

[1)] *N* represents the number of evaluated combinations

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11.5 Landscape impact analysis: A method for strategic environmental impact analysis.

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Abstract

A method for analysis of landscape impacts and for presentation in visual terms was developed by the author and has been applied in Sweden and Norway to policy analysis. The method has successively been developed into a generalised method of landscape impact analysis of policies, programmes and plans - Landscape Impact Analysis (LIA). This deals with the interaction of human and natural systems and the resulting landscape. The method uses scenario techniques as a way to solve the problems of lack of specificity of policy, a problem which seems underestimated in the development of strategic environmental assessment. The paper describes the main steps of the method.

Keywords: *scenario techniques; strategic environmental assessment; policy analysis; landscape impacts; visual impact analysis*

The need for landscape futures

The landscape development caused by future global environmental change, by changes in national policies for agriculture, forestry and energy, or by the impact of public and private development plans is of considerable public and political interest (Clark 1989; Emmelin 1983). The future landscapes inherent in both conservation plans and development of forestry, agriculture, etc. need to be examined before large-scale programmes are implemented (Vedung 1991). Methods of communication of aggregate complex scientific information concerning landscape impacts are needed if the public is to understand and take informed part in policy making on these issues (Clark 1989). Since existing methods of analysis deal mainly with systems aspects of impacts, interest in the localised landscape aspects make a different approach necessary. A transformation of knowledge from a systems perspective to a spatial or "arena" perspective is needed. The need is for a method which disaggregates policy into the effects at a local level and for description and analysis of these in concrete and spatial terms (Emmelin 1982).

A method for analysis of landscape impacts of policy scenarios and for presentation in visual terms - Visual Impact Analysis (VIA) - was developed by the author and has been applied in Sweden and Norway to policy analysis (Emmelin 1982; Emmelin & Brusewitz 1985; Emmelin, Jones & Ree 1990). Interest in this method has led to applications both in the Nordic countries and elsewhere. The method has successively been developed into a generalised method of landscape impact analysis of policies, programmes and plans - Landscape Impact Analysis (LIA). This deals with the interaction of human and natural systems and the resulting landscape.

The method is based on construction of scenarios from policies. The role of scenarios is to provide consistent and concrete descriptions of a landscape undergoing a particular

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form of development under stated conditions of both policy influences and contextual factors.

Landscapes in space and time

The method is based on a simple model of landscape development (Figure 1) and on Hägerstrand's concept of "the landscape of process and continuity" (Figure 2) (Emmelin 1982; Hägerstrand 1992).

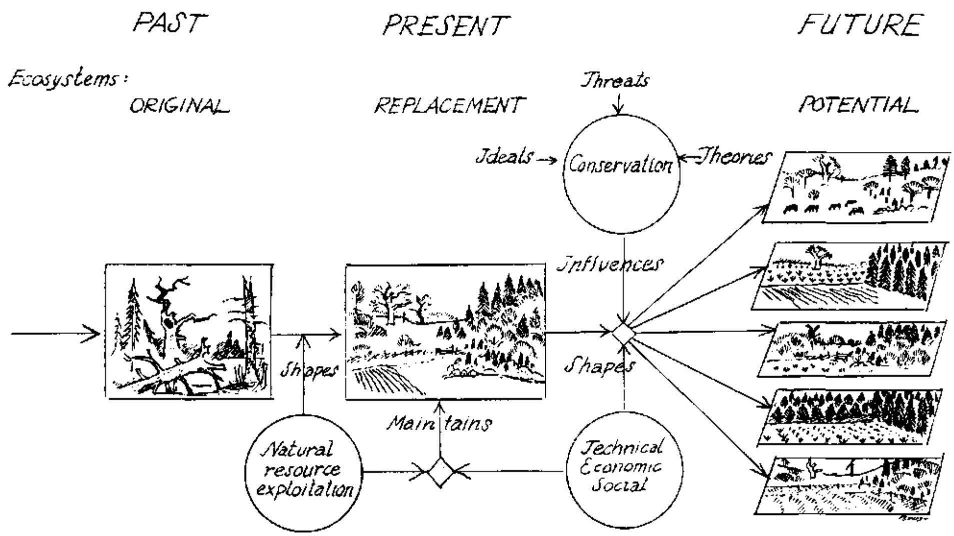

Fig. 1. A simple conceptual model of landscape development. Future landscapes are immanent in the present as a "fan of possibilities". They are determined by the interaction of the present landscape, forces of inertia and societal change.

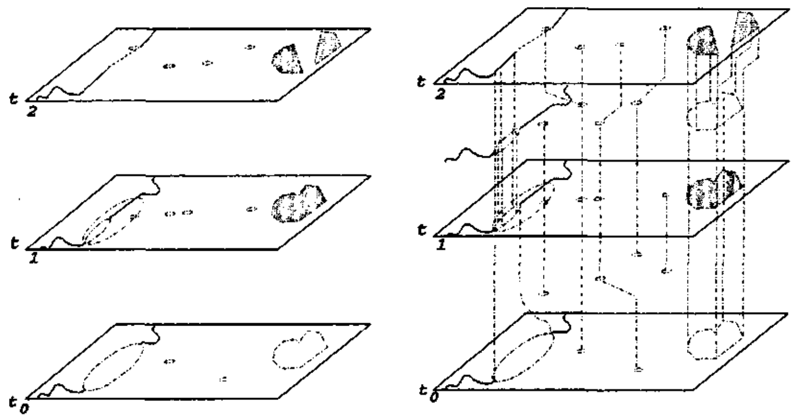

Fig. 2. Landscapes in time and space. The series on the left shows landscapes as we normally see them in maps from different times. In the series on the right, landscape objects trace trajectories in time and space: the landscape of process and continuity.

Outline of the LIA method

The method is presented in a figure for completeness and economy of space. Figure 3 illustrates a basic idea in LIA, which is to separate the main operations into a number of discrete steps because of the differences in methods, concepts, etc. between different types of analysis. The transition from one to the other will present both theoretical and practical problems, particularly since an iterative mode of working and a strong interconnection between steps are necessary.

Figure 3 shows the method in some detail. It underlines several important aspects both of the "landscape futures paradigm" and of the method. The figure shows a degree of methodological overlap between the steps which is a function of the iterative nature of the process.

The first step is a policy analysis which leads to the definition of the factors that are likely to have important impacts or are interesting to study as part of the policy process. These "policy end points" together with a set of contextual factors are used for the construction of scenarios. The "contextual factors" constitute a simplified description of the society of the future in which the policy is to be enacted, where a set of general conditions have been chosen which are likely either to influence the landscape independent of the policy or to interact with the policy factors.

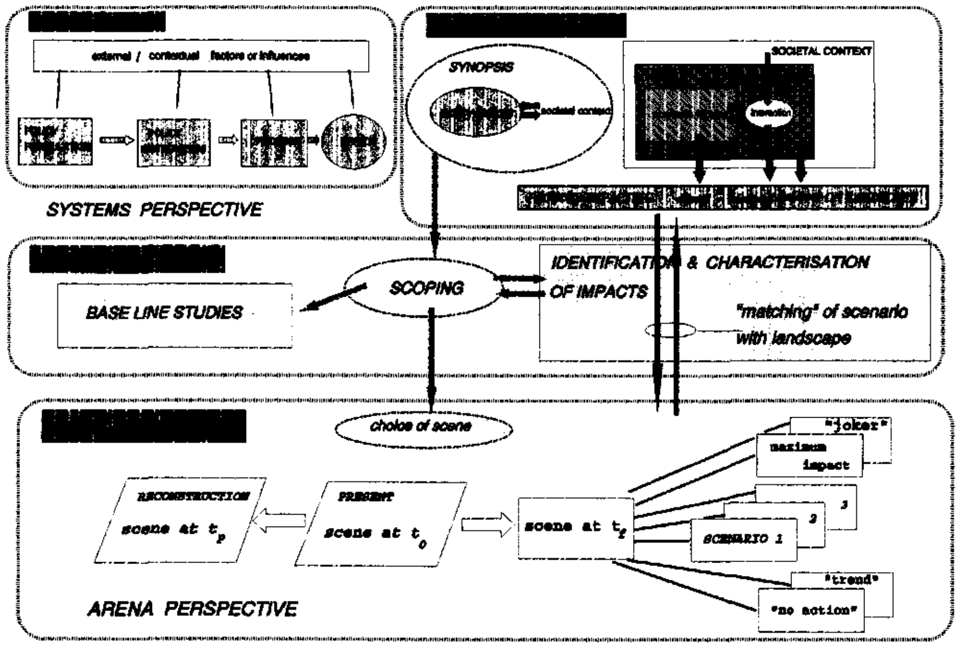

Fig. 3. Functional relationships in Landscape Impact Analysis (LIA). The main steps of the method are: policy analysis, scenario construction, impact analysis and landscape analysis including historical reconstruction. A crucial step is the transformation from an aggregate, sysems perspective of policy to the local, "arena" perspective of landscape, termed "matching".

To tie the policy analysis together with the landscape, a first sketch of a scenario, a synopsis, is used as a preliminary step in scenario construction. The synopsis is the basis for the first step in impact analysis: "scoping". With the aid of a synopsis, the scope of the impact analysis can be decided on, the need for further landscape analysis and the need for data, models, etc. in the impact analysis judged.

The operation "landscape analysis" includes the reconstruction and the visualisation of the present and past landscapes. It adds the temporal aspect and the idea that there is a range of futures immanent in a present landscape, tying the methods in with the conceptual model in Figure 1.

The construction of a "scene" as a surprise free trend extrapolation and a direct physical extrapolation of the landscape is the first step towards the construction of alternative scenarios. The scene is not the present landscape, but the present complemented with a knowledge of two independent processes. First, the time-dependent processes that would change the landscape irrespective of the scenario. Second, the interaction of the societal context and the landscape which can alter or obliterate the effects of the scenario factors.

A crucial step in the landscape impact analysis is the "matching" of the impact analysis with a given landscape. The role of the scenario is to provide a consistent and concrete combination of factors for the impact analysis. This is the methodological solution to the problems of the lack of specificity in a policy compared to a single construction project. Not only does the scenario impact on the landscape but a landscape will act as a modifying influence on a policy. Thus, the scenario may have to be modified or new alternative scenarios constructed as a result of the knowledge created in the analysis.

Results of the method

Series of alternative landscape developments have been produced during the process of developing the LIA method. Some of these are discussed by Jones and Emmelin (this volume).

The role of scenarios in strategic impact analysis

There is at present a call for strategic environmental assessment (SEA) in many countries (Therivel et al. 1992; Glasson et al. 1990). Lee and Walsh summarise the prevailing attitude when they claim that the necessary methods for such an analysis exist (Lee and Walsh 1992). This seems to underestimate the theoretical and practical complexity of policy analysis. The central problem, both practically and theoretically, in impact analysis of policies, programmes and plans ("PPP") is making the statements simultaneously concrete and consistent. Whereas a single project is concrete, specific and localised, PPP is essentially neither. The end results, the effects and impacts, are conditional, ambiguous and not necessarily clearly located in space. The impact analysis of PPP is thus essentially different from conventional project-oriented impact analysis in kind, not just in complexity. It is this problem that Landscape Impact Analysis (LIA) addresses.

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CHAPTER 12

Requirements and data

12.1 Scenarios for european coastal areas, a promising tool for making decisions at various levels?

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Abstract
European coasts, especially natural soft coasts (deltas, lagoons, tidal flats, salt-marshes, marshes, coastal dunes) are extremely rich biotopes and valuable landscapes. Rates of loss or serious degradation are alarming as are expectations for the future. Sea level rise is a large-scale, long-term process leading to accelerated losses of land. Its effects are exaggerated by human intervention in adjacent areas and the hinterland. Three cases in Turkey, Spain and Ireland indicate a variety of causes from both physico-ecological and socioeconomic origin. Regional scenarios could combine various data, but integrated modelling easily leads to unmanageable piles of data and large uncertainties in forecasting scenarios. Sometimes it may be better to start by designing a desirable layout and use backcasting procedures to establish adequate and timely decisions. Good inventories (maps), process-effect knowledge and an alert monitoring are always indispensable tools.
Keywords: *Coastal ecosystems, wetlands, landscape values, EU policy, climate change, sea level rise, forecasting, backcasting, regional plans, spatiotemporal domains*

Introduction

The central issue of this contribution is how we can use a scenario approach when we deal with coastal (eco)systems, considering their system characteristics and current and foreseeable problems. Within this context, attention is paid to spatial and temporal scales, the diversity of problems, driving forces in physical, socioeconomic and politico-legal contexts and possible solutions. As scenario building in a broader, more integrated sense is hardly practised, our approach is primarily a tentative one.

Section 2 sketches the background of why coastal areas deserve more attention than usual from policy makers and research.
Trends and threats are alarming, and in view of future developments a scenario approach could be worthwhile. Some case studies (Section 3) illustrate what are the major developments of large-scale and long-term character (climate change and related sea-level rise) or of more regional character (often as a result of socioeconomic dynamics). Three distinct areas (Turkey, South-West Spain and West Ireland) are dealt with. In Section 4 the possible role of both projective and backcasting scenarios is discussed, as well as the need to support modelling exercises with basic data.

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Coastal areas: characteristics and variety, trends and threats

It is hard to define what coasts or coastal zones exactly are. What are their limits on the seaward side and on the landward side, what is their length and their surface area? In the strict sense, coasts are the narrow borderland between land and sea, for instance between low water and high water, but in a more functional approach one could include shallow seas and a rather wide zone of land influenced by the sea, either physically (e.g. sedimentary system, tidal influence on inland waters, sea spray, biological relationships as seen in foraging routes) or economically (activities directly connected with the sea such as fisheries, harbour activities, coastal recreation). In most cases one should decide on a zone that is kilometres wide, or even dozens of kilometres. Not only is it hard to decide on a certain width, it is also difficult to indicate the length of a coastline. There is an amazing length of coastline in Europe. A rough calculation for the European Union counted 63 000 km (Coastline, 1994). Adding the remaining countries in Scandinavia, the Baltic region and the Mediterranean should easily exceed 100 000 km, which is two and a half times the circumference of the earth. This is a very conservative estimate, considering the fractal character of a strongly indented coastline. The fact is that we deal with an extremely long and narrow strip of land and adjacent shallows that belong to the most dynamic landscapes on earth from a geomorphological point of view (Davies, 1972; Klijn, 1990). Man-induced dynamics are equally important: coasts are known to attract human activities in both ancient and modern times. Some countries such as Greece or Norway exhibit an extreme preference of settlement and economic activity (agriculture, industry, transport) near coasts.

This contribution focuses on the most dynamic and vulnerable coastal systems, the so-called soft coasts.
All these systems are of sedimentary origin and of relatively young age, dynamic, susceptible to disturbance of their sedimentary balance, low-lying, wet or frequently flooded, saline to fresh, highly productive in the (agro)ecological sense, in a so-called sink or source/sink position with respect to pollution, and attractive for reclamation. These are common features, but there is of course an enormous variety in landscape ecological characteristics that make these areas the more important for reasons of biodiversity. In addition to all the physical and biological diversity found in these areas, an even more striking feature is the socioeconomic, sociocultural and politico-legal variety along European coasts. There is an enormous difference between i) the perception and appraisal of nature in for instance The Netherlands, Ireland or Turkey, ii) the relative importance of coastal areas to regional or national economies, iii) politico-legal possibilities of preventing abuse, and iv) technical or financial means to choosing adequate measures. As these differences are eventually decisive, scenarios must include socioeconomic (and sociocultural) aspects besides physico-ecological aspects that might have been the primary motive.

Ecological and scenic values in Europe are subject to a sometimes rapid decline in many countries. Areas that are famous for these qualities are often threatened, such as

mountainous areas, bogs, river systems, forests, extensively used grasslands, and coastal zones (Bennet Ed., 1991).
Coastal areas are well-known for their ecological, historical, archaeological and scenic values, which can still be found in unspoilt areas. Ecologically important wetlands are often found near the coastline, since more than 50% of all the European wetlands are coastal wetlands. Coastal dunes belong to a narrow but ecologically important border - aptly indicated as the golden fringe - of our European countries; migratory birds are often dependent on coastal areas for resting and feeding. Scenic and other recreational values need hardly be mentioned. Many coastal areas, for instance in the Mediterranean region, are of great historical importance since classical civilizations were strongly tied to coastal sites (Greece, Turkey, Italy, Spain are the well-known examples), but the same is true for archaeological remnants in Brittany, Scotland or Ireland (see Bakker et al., 1992). All these values are threatened, sometimes seriously. The rate of decline has been extremely fast in many areas, and in many countries a further large-scale deterioration is foreseeable. The international awareness of landscapes under extreme stress is formally accepted in international conventions (Ramsar on Wetlands, Bonn on Migratory Species, Bern on European Wildlife and Natural Habitats, Barcelona on Sea Pollution, the World Heritage Convention on Cultural and Natural heritage). The status of coastal areas, e.g. in Habitat Directives in the European Union, is undisputed (Tekke & Salman, 1993) . Notwithstanding formal acceptance of values and international statuses, it is clear that future threats are still serious.

Coastal areas, and more specifically soft coasts such as deltas, lagoons (Fig. 1), marshes, salt-marshes, coastal dunes, tidal flats and the near-shore zone (shallow seas), are attractive for all kinds of human activity. Land reclamation, agricultural development, sand extraction, freshwater extraction, oil and gas drilling, related soil subsidence, coastal defences, harbour development, industrial development, residential or recreational buildings, road construction, forestry, overfishing (including shellfish), hunting, and dredging activities form a well-known list. In addition, there are effects of pollution or water management in the hinterland and the cut-off of coastal systems from sediment supply by rivers owing to, for instance hydroelectric dams. Moreover, these areas are more or less vulnerable to sea-level rise, coastal erosion (partly related to sea-level rise), climatic change, acidification and atmospheric pollution (toxic substances, nutrients, acid deposition). Also, these processes seem to be related largely or at least partly to human-induced developments. In view of an ongoing deterioration and future threats, an urgent response of national and international policies and related management is required.

Some case studies

In the above, several aspects were made clear: 1) we have an internationally acknowledged responsibility for coastal landscapes, especially soft coasts, 2) the fact that coastal systems are threatened by an array of natural and man-induced influences in a specific regional

These predictions must be seen against mean rates of sea-level rise as registered in the last century: 10 to 15 cm per century (Pugh, 1990; Pirazzoli, 1991; Gornitz et al., 1982). An increase in the rise of the sea level on a worldwide scale (eustatic rise), however, has to be confronted with specific regional circumstances determined by tectonic or glacio-isostatic land subsidence or uplift to assess regional response. Moreover, it is well-known that climate change also leads to changes in wind regime (direction, frequencies, number of storms) and related wave attack (wave energy and incidence), whereas tidal regimes (e.g. tidal range) are subject to changes as well (see e.g. Christiansen & Bowman, 1990).

It should be stressed that a combination of a higher sea level and more frequent storm surges is especially detrimental (Klijn, 1990; Titus, 1990). Whatever the outcome of all these expectations and uncertainties may be when combined, their message is clear: increased erosion, especially affecting soft coasts (Bruun, 1962). This is especially true for natural, i.e. undefended areas, and to a lesser extent for reclaimed and artificially defended areas.

It is worthwhile to assess how natural areas would react. On first thoughts these systems seem dynamic and flexible by definition, judging by geological and historical data (Fletcher, 1992). These indicate that shifting coastlines are accompanied by shifting positions of, for instance, dunes, lagoons, salt-marshes or freshwater marshes. In general, on large time-scales and within a large geographical context, this is indeed the case. However, this built-in flexibility seems to have been undermined in many areas by the following causes: both the hinterland of natural systems and directly adjacent coastal stretches have been reclaimed, dyked, built-on for industrial or residential purposes, artificial coastal defences, etc. Natural flexibility is lost in these regions. The response of society to sea-level rise and imminent loss of land, given the investments in these areas, seems to be more or less predictable: more investments in rigid defences, resulting in an unproportional loss of natural systems. In other words, these systems are in danger of being squeezed between a rising sea and an unyielding society protecting its own goods. This development may be observed in, for instance, The Netherlands (Misdorp et al., 1990). Here, tidal flats and salt-marshes in the Wadden area, have been eroded, without compensation elsewhere, since dykes prevent any landward shift of salt-marshes. Especially in countries where natural systems are surrounded by a man-made world, this trend is quite logical; in less densely populated or cultivated coastal areas problems are less. Still, some of these will not be able to adjust to a sharp increase in sea-level rise, storm frequency and resulting erosion either, since rates of adjustments cannot meet increased erosion.

The south coast of Turkey

Material for this case study was collected by the author during a short mission for DHKD/WWF (Turkish Society for Nature Protection and World Wildlife Fund, respectively) in 1992 (see also: Laarakker, 1994).

The south coast of Turkey is of great scenic beauty, with steep cliffs, sandy beaches, dunes, salt-marshes and brackish to freshwater marshland. Natural areas are of great importance to breeding and migratory birds and other animals, such as sea turtles nesting on many beaches.

This coast combines a very mild and reliable climate, with beach facilities, a wealth of relics of classical cultures, low prices for food and accommodation, and cheap and quick transport by air. No wonder that tourism from western and northern Europe is booming and that its growth shows unequalled rates and perspectives for the future. In 1992 Turkey received 7 million tourists; bed capacity is planned to increase from 600 000 in 1992 to one million by 2000 (Turkish Daily News, 1992). Many visitors seem to be attracted by coasts, and many facilities under construction take advantage of that. East of Antalya, in the Belek region, a mammoth project, initiated by a public-private enterprise in which 28 companies and authorities participate, includes 19 apartment hotels of 600 beds each, as well as 4000 holiday houses and golf courses. Buildings are being constructed in and directly behind dune ridges along this 30 km previously unspoilt coast, famous for the nesting of sea-turtles (Withmore & Yazgan, 1991). Smaller scale projects can be found along the southern coast on, for instance, Patara beach and near Dalaman/Dalyan. It is quite obvious that the two driving forces are: airports (Antalya and Dalaman) and powerful consortia of investors, backed by the Ministry of Tourism, which even took the risk of giving financial guarantees. Tourist growth is accompanied by parallel developments such as population growth, mostly owing to employment in the tourist branches, urban expansion, infrastructure, the demand for food leading to reclamation, irrigation, intensive agriculture (horticulture), and an increased use of fertilizers and pesticides. Most of these activities take place in soft-coast areas. Of course, water supply, sewage water treatment and waste disposal should keep pace with this exponential growth. Most impacts seem to be expected in the areas mentioned earlier, as the surrounding mountainous areas are far less favourable for most of the activities. Of course, direct and indirect effects of mass tourism in previously natural areas are predictable: disturbing wildlife, trampling and damaging vegetation. As a general impression it may be stated that these landscapes are overridden by incomparably fast and powerful developments, hardly ever seen in the Mediterranean. Although national and international nature conservation bodies (e.g. the Turkish Society for Nature Protection, and the World Wildlife Fund, WWF) have been alerted and try to stop or change some of the most detrimental plans, the general development is an environmental and ecological decline. Public and political awareness of values is not strongly developed, neither are legal or planning instruments or the willingness to use them. One must realize that the situation in countries like Turkey with many poor and unemployed people is quite different from that in wealthy countries elsewhere in Europe. It is, however, possible to anticipate the future in a more comprehensive and balanced way, including both ecological and economic sustainability in an integrated planning approach, as was suggested by DHKD (1992) for the Göksu delta, where sustainable land use and fishery could probably be maintained in the area.

South-west Spain, the Doñana case

The Coto Doñana is a famous delta area at the mouth of the Guadalquivir (Figs. 3a+b). The area is well-known as a refuge for waterfowl, birds of prey, mammals and an important stepping stone for migratory birds. Its importance is acknowledged internationally and nationally (National Park). However, threats are many and serious.

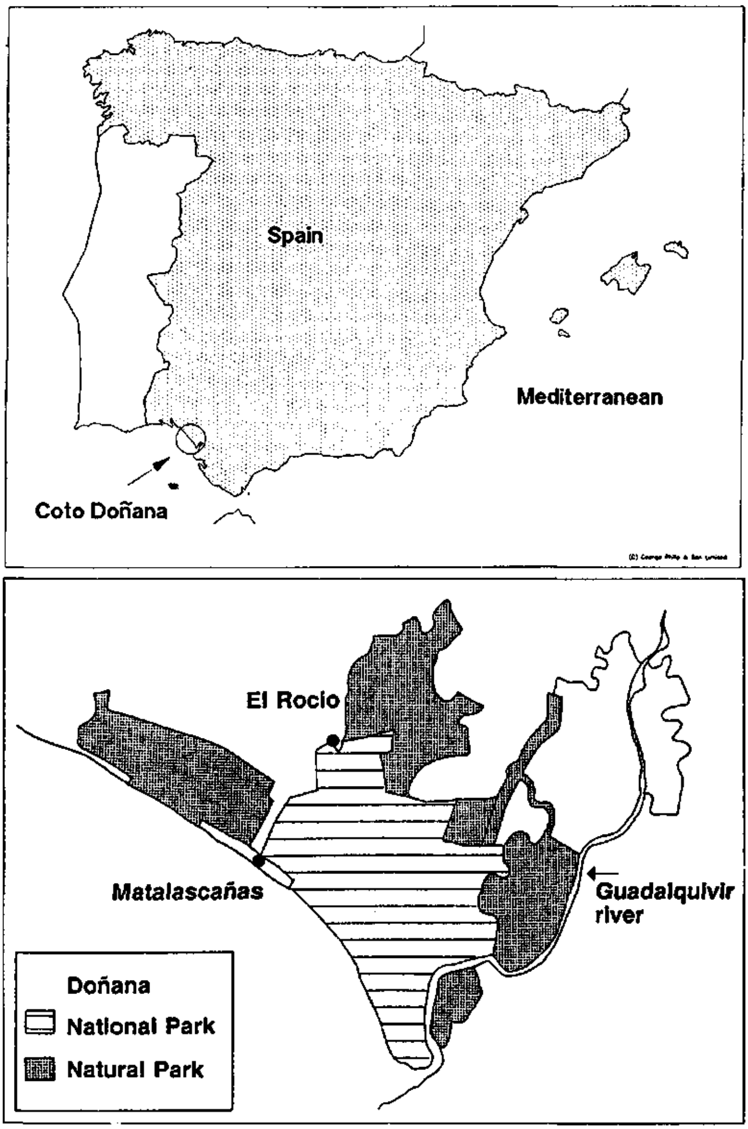

Fig. 3. The Coto Doñana area in South-West Spain. (From: Smart, 1992).

Apart from encroaching residential and recreational buildings, many threats stem from influences on water quantity and water quality from both inside and outside the area (Smart, 1992; Llamas, 1990). The discharge of water and sediment from the river Guadalquivir has been negatively affected by many impacts in upstream areas, while the load of fertilizers and pollutants from the drainage basin has increased. This leads to frequent drought, more saline influences and toxic or other adverse effects on the ecosystems. Activities in the area itself and its direct surroundings also have adverse consequences. Extracting groundwater from the area has caused a lowering of the water-table of some metres and subsequent drought or upconing of salt water (Llamas, 1990). Water is used as drinking water, but increasingly as irrigation water for intensive horticulture. The area is a leading export area for strawberries in early spring. Such intensive cultures are known for their high rates of pesticide use. Despite some successes in blocking further recreational building along the coast and strict rules to protect the National Park against hunting or disturbing by tourists, most influences from outside seem to have a far more serious effect in the long term: changes in water and sediment balances, pollution. The developments described for the Doñana area seem to be exemplary for most delta areas in the Mediterranean, such as the Ebro-delta(E-Spain), the Camargue (S-France), and delta areas in Greece and Turkey (Barnes, 1994; Smart, 1992; Smith, 1992; Tamisier, 1993).

The west coast of Ireland

Compared with the above cases in Mediterranean countries, the west coast of Ireland is rainy, rather cool, windswept and therefore less attractive for mass tourism. The west coast of Ireland is rocky and cliffy, but harbours a wealth of coastal dunes and related botanical and faunistic values in less exposed areas, such as embayments between promontories (Fig. 4). These dunes represent a typical 'north-west Atlantic' geomorphology and vegetation related to climate, land use history and geographical position, features that are also found in western Scotland. Their international ecological and archaeological importance has been described by Basset & Curtis (1985), Quigley (1991) and Bakker et al. (1992). In general, they are relatively unspoilt, but adverse developments seem to be increasing rapidly. From Bakker et al. (1992) we derive the following main trends and threats.

The majority of the sites is subject to ongoing erosion, attributed to both sea-level rise and an increase in storm surge frequencies. The effect of the latter is strongly reinforced by the former process. Other causes that reinforce these developments are sand mining by locals for building or for improving peat soils, and wind erosion, triggered by over-recreation and overgrazing.

The decline of traditional land management also affects dune grassland and brackish to salt-marsh areas. These management practices are still applied in many small farmer communities using common grazing areas. Low grazing intensities have contributed to botanically interesting ecosystems and still unspoilt pastoral landscapes. Especially owing to EU measures meant to reinforce regional economies in marginal areas, a major

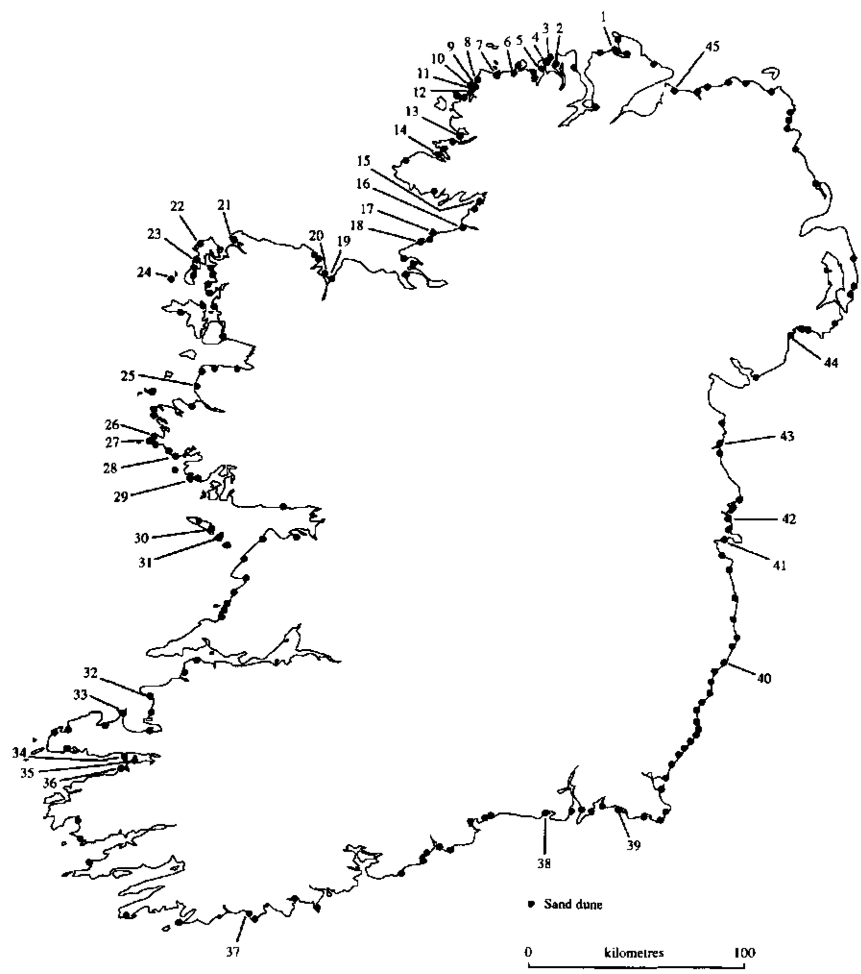

Fig. 4. Distribution of coastal dunes and dune grassland ('machair') along the coast of Ireland. (From: Doody, Ed., 1991).

disturbance of a delicate socioeconomic system and an equally delicate ecological balance can be observed. EU measures, including subsidies, promote private landownership and management, larger numbers of livestock per hectare, the use of fences, fertilizers and so on. This results in a decline of botanical and landscape values and erosion in some areas; other, more remote or marginal areas seem to become subject to land abandonment. Both processes result in a loss of ecological values. It is striking how EU measures aimed at regional development are in collision with other EU policy, e.g. the EU Habitat Directive, on which these dune grassland areas (the so-called machair) are listed. Similar observations for pastoral farming systems in other, non-coastal areas were noted by Bignal & McCracken (1990).

Conclusions from the case studies

From the cases dealt with above, the following can be learnt:

i) Processes in coastal systems are complex, in the physico-ecological, the socioeconomic as well as the politico-legal sense. Attempts to grasp possible future developments should cope with this.

ii) One should distinguish between large-scale (international) and regional or local processes and long-term and short-term developments, respectively. Stated in a different way: it is necessary to define spatiotemporal domains of processes.

iii) Many processes in coastal systems are closely related to what is happening in adjacent areas and in the hinterland, e.g. in drainage basins.

iv) Mediterranean countries undergo major changes in tourism and recreation, processes followed or accompanied by population growth, intensifying land use, waste problems, competition for water and so on. There is sometimes a distinct cause-effect chain.

v) Certain regions, e.g. in Ireland, show delicate balances in both the physical sense (sediment balances related to coastal processes) and the socioeconomic sense, which seem to be easily disturbed by large-scale processes (sea-level rise, climate change, and adverse effects of EU measures, respectively).

vi) Climate change, sea-level rise and resulting coastal erosion disturb all the ecosystems in soft-coast areas. Though geologically or historically such systems tend to shift with changing coastlines, this flexible response is seriously hampered by man-made constructions and investments. Natural systems seem to be crushed between the rising sea and an unyielding society.

vii) Both for natural processes and for man-induced changes a regional approach is required (see section 4).

Discussion: role of scenarios; concepts, data, modelling, monitoring

The role of scenarios

Scenarios, apart from playing a scientific role in scanning the future in an analytical manner, are primarily tools for communication. Whatever the appraisal may be, their communicative power is undisputed since they act as i) early-warning signals; ii) tools to delimit the area of the reasonably conceivable from the really impossible; and iii) to envisage desirable futures and ways to reach the goals. The role of science is to offer a) a consistent, coherent and transparent framework of thinking, b) overviews of relevant trends, c) insight into cause-effect chains and networks, d) feedback mechanisms that may dampen or reinforce certain developments, e) critical or threshold values of which systems tend to break down, and f) key variables (instruments, scope and timing) for policy or management to interfere. Then eventually, scenarios should tell how, when, where and by whom measures should be taken in order to efficiently and effectively counteract undesirable or downright dangerous developments.

Forecasting scenarios

Scenarios - in so far as forecasting scenarios are concerned - should include a description of the present situation, an analysis of current trends and extensions to the future, for instance by introduction of 'worst case' or 'business-as-usual' or mere extrapolation of current rates and an assessment of future situations (see e.g. Veeneklaas & Van den Berg, this volume). They can provide (early) warning signals, like scenarios for climate change and sea-level rise intend to do. The same (early) warning signal could be derived from socioeconomic developments in, for instance, Mediterranean countries where ongoing tourism could turn into a main threat. All these scenarios may be seen as forecasting scenarios. Such scenarios may be thematic and one-dimensional (e.g. sea-level rise and its direct effects), but a more ambitious branch of scenario-building could aim at more complex interactions (e.g. Wind, 1987). Of course this is not the easiest job one can imagine. Could we really make predictions on the combined effects of sea-level rise in combination with demographic growth, intensifying agriculture and recreational development including all the internal feedback loops? The complexity of models describing real-world responses to a variety of causes and numerous interactions will increase exponentially. Integrated-scenario builders should use very complex models and solve many equations with an extreme number of unknown parameters or a wide range of uncertainties. It is quite predictable that both scenario and model builders and policy makers could be choked by too much data and an extremely wide range of possible futures. In other words, the outcome will be far from simple, transparent or decision-oriented. Still, it is felt necessary to make integrated products, and the main challenge for scenario builders is to simplify the outcome to manageable proportions, e.g. by presenting an integrated 'worst case', a relatively optimistic case, and a 'middle-of-the-road' course. In such cases it will pay off when the model architecture is made modular, i.e. when partial systems are modelled separately and when simplified versions are linked. When results indicate an undesirable or dangerous development, there is reason for timely intervention. A necessary extension is therefore to include policies and measures, as well as their urgency and their effectiveness and efficiency (in terms of cost-benefit ratios).

Backcasting scenarios (designs)

The approach described above could be characterized as reactive. Extrapolated trends or a certain mixture of trends stir the public opinion. Policy makers try to respond by choosing effective and cheap policies, but mostly from rather sectoral viewpoints (e.g. the protection of cities, investments). In most cases, as experience shows, those strategies tend to lack an integrated approach. Other approaches could be conceived starting at the other end, i.e. a desired future, designing one or more new situations that are more in equilibrium with predicted circumstances or more robust with respect to undesirable trends. From there, using backcasting scenarios, an attempt could be made to present necessary pathways and decisions to reach goals. Such methods are often more appealing, convincing and - when used professionally - internally balanced. Of course these scenarios are normative by definition. Still, many of the considerations and motives are the same as those used in forecasting scenarios, as is the knowledge to evaluate those designs. An additional profit is their appeal to target groups and their communicative role in discussions and involvement of people.

Scale

In the above (Section 3), a certain need emerged for scenarios on a regional level, since both natural and socioeconomic processes and possible solutions in an integrated context can be specified at this level. Nevertheless, matters cannot be reduced to this level alone. We would emphasize this from two points of view: i) the natural spatiotemporal domain of processes leading to adverse effects at regional levels, and ii) the need to aggregate and generalize knowledge and data from regional studies to national and international levels to clarify what the total outcome of regional developments and solutions is when set against such a higher-scaled background.

These points can be illustrated as follows: climate change and related sea-level rise find their origin in processes at the level of the hemisphere or the globe. Both the understanding of these processes and an effective combat require a large-scale approach. Basic solutions cannot be found at regional levels. The second point is that we need insights into the cumulated regional effects of natural or man-induced processes in order to assess whether the sum of predictions or strategies for regions are in harmony or in conflict with national and international aims and whether policies and measures are sufficiently effective and efficient. At an international level, measures or investments to conserve or restore local or regional natural resources might be a losing battle against high costs, whereas neighbouring countries may have more opportunities against lower costs. Of course this line of thinking requires a community feeling at EU level, which until now has rarely been seen.

Data

Scenarios, either by forecasting or by backcasting from a desired future situation, can only be built thanks to adequate data on patterns, processes, cause-effect relationships, threshold values and insights into decision tools. For that reason sufficient knowledge from mapping, remote sensing, historical time series, monitoring, and on systems behaviour of all sorts should be available. The state of the art in many regions along Europeans coasts is extremely variable. In many countries even basic geographical knowledge is still lacking, regardless of the fact that more specific historical data or process-response knowledge is available (Klijn et al., 1991).

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12.2 The relevance of historical data to scenario research for the physical environment

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Summary
Historical data are relevant to scenario research. Scenario studies mostly deal with functional changes in land use. These changes almost inevitably mean that part of the cultural heritage of the landscapes will disappear.
Applied historical geography and historical ecology must guide this cultural erosion process. Unacceptable damages must be avoided. The relevance of five fields of research is discussed: survey, assessment and vulnerability analysis; 'historically sound' landscape designs; 'reference images'; 'historical processes in time'; and 'planning concepts'.
Keywords: *Historical geography, archaelogy, landscape architecture, historical ecology, physical planning*

Introduction

Landscapes are made up of different elements with various backgrounds. In building scenarios for future developments in landscapes, many disciplines are involved: economy, sociology, ecology, soil science, hydrology, anthropology, etc. Landscapes also have historical and cultural roots. Generally, they are man-made: the results of human intervention during a long time have marked their identity. The landscape elements are relics of different phases of cultural influence and old land use systems. They give a lot of information on how our ancestors lived in the past. The importance of this cultural dimension is often underestimated. In this paper, I want to present a contribution to understanding the relevance of the historical aspect to scenario studies for future land use.
Scenario studies mostly deal with functional changes in land use. These changes may have morphological effects: new land use systems and all kinds of planning activity almost inevitably mean that part of our cultural heritage will disappear.
The key question is where and how this disappearance can be controlled without unacceptable damages. Clear choices are urgently needed. Applied historical geography and historical ecology are the disciplines most responsible for a good guidance of the process of modification. They must give planners the right tools and advice to develop responsible plans in which cultural and historical values of the landscapes can survive as much as possible.
Within this framework five fields of research can be discussed that can be applied in scenario studies:
1. contribution by survey, assessment and vulnerability analysis
2. development of 'historically sound' landscape designs
3. study of so-called 'reference images'
4. research on historical processes in time
5. research of planning concepts

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 473–487.

This is not an arbitrary list, as to a large extent it reflects how the views of this matter have developed in time.

Survey, assessment and vulnerability analysis

The main objective of this field of research is to perform a warning function. The typical traditional landscape types and landscape elements must be safeguarded for the future (Fig.1). This information must be used in policy documents, rural development plans, regional plans and land development plans. The underlying ideas and land use strategies can be influenced in this way. New aims and functions in the landscape must be taken into consideration. Of course, the main question is the future location of old and new elements. Changes in the landscape cannot be avoided, and not everything can be spared. Choices must be made. Assessment can be helpful in this process. For instance, areas can be designated for landscape conservation, either as reserves or in relation to other functions.

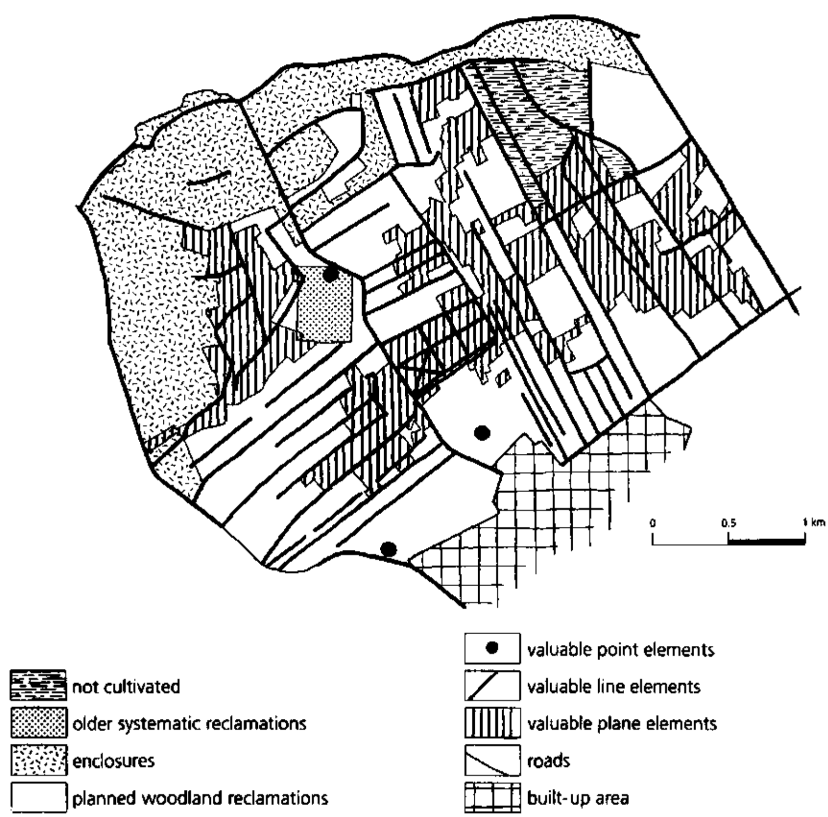

Fig. 1. Traditional landscape types and valuable landscape elements; example of a historical geographical survey in a sample area of the Leijen-West land redevelopment area (Van der Haar & Schöne, 1993).

Especially in the latter case, where functions are interwoven, it should be investigated whether these functions go well together. Therefore, the vulnerability of cultural historical structures and elements to certain interventions should be investigated. This is indeed fully comparable with other nature and landscape research as carried out by biologists, geomorphologists, ecologists and other landscape researchers.

It was expected that these methods could safeguard the future of important cultural historical landscape elements, when changes in land use were planned. But it soon turned out that not everything was going as planned.

This was partly caused by shortcomings in the legal tools. Legislation does not, or hardly, provide means to protect structures and elements that are interesting from a historical, geographical point of view.

Furthermore, we must blame ourselves and those who use our information for the ongoing decay of our traditional man-made landscapes. The making of inventories as such is rather passive in nature. One cannot automatically deduce a vision towards a certain development from them. A further problem is that there is hardly any feedback to the researchers once the work has been completed. Furthermore, not all the users are professional and motivated to use cultural historical basic material.

Therefore, our work is no guarantee that the results may actually contribute to the planning process. This more or less alarming situation gradually led to the idea that more decisiveness was required, to grant the aspect of cultural history the position in the landscape that it deserves.

Landscape designs

In order to stimulate the practical use of the surveys, cooperation with landscape architects seemed to be useful. Together with them we made some progress in 'historically sound' landscape design. We did some exercises at local level:

a. in and around a settlement of historical interest, in the village of Hoekelum;
b. in a pilot area in the "De Leijen-West" land redevelopment project near the town of Oisterwijk
c. in a nature reserve with many cultural historical elements in the Gooi area near the town of Hilversum

Hoekelum

The thesis by Kuijpers and Van Sikkelerus (1991) is a good example of how this approach can be worked out. The aim of their study was to make a new design of the village green of Hoekelum (Province of Gelderland) and the surrounding area. A village green is an open space which was used to graze livestock within a settlement. Nowadays, such greens can be recognized as roads with wide verges, and some have become village squares. In Dutch they are called "brink" and in German "Anger".

The main assignment of the Hoekelum study was to preserve the essential nature of the green, and it turned out that there are several ways to spare the character of the green depending on the circumstances.

The nature of the new provisions to be made and the degree to which the former structure was still present were of major importance. In a case like this, the first theoretical option could be that so many reference points are still present in the landscape that the entire structure can be maintained as a spatial network or even be emphasized by reconstruction.

The second option in the planning process occurs when there are not sufficient reference points. Then, designing a new spatial network must be considered in which the green is regarded in a broader context of the landscape. The position of the green in a transition zone could be taken as a starting point, attention could be paid to the function of the green as a junction of rural or farm roads, or the green could be re-developed as a concentration point for rural buildings in the neighbourhood.

In the project an attempt was made to work out both theoretical options as soundly as possible. This resulted in two models. The first one takes the former main structure as a starting point, whereas the aim of the second is to come to a new historicizing spatial network.

When, a few years after the study had been completed, a development plan was made for the immediate vicinity of the green, the results of the study could be integrated in the plans and made a considerable contribution to a very satisfactory re-design of the green and the surrounding area.

De Leijen-West

The more one gets involved in the field of designing, the more one becomes aware of the problems connected with historically sound planning. A fine example is the design and basis of the layout of a sample area in the "De Leijen-West" land redevelopment area near Oisterwijk (Province of North Brabant). This study by Van der Haar and Schöne was completed in 1993. The project was commissioned by the Government Service for Land and Water Use and aimed at investigating whether the data collected could be applied in the planning process.

First, the results of cultural historical research (Dirkx & Soonius, 1993) were studied and assessed with regard to their accessibility to planners. This part of the research led to the conclusion that a summary of the cultural historical research was needed, whose text and presentation should be more adapted to the requirements of the planning process. Terminology and presentation of the available report failed to adequately meet the experience of the users, the landscape architects. Next, it was examined whether the information in the more user-friendly summary had suitable links with the planning process. To that end, the planning process was simulated in a sample area in the land redevelopment area. To enable design proposals to be made, it was necessary to enter more into the future functions of the area, and some bottlenecks in the sectors of agriculture, nature management and recreation were indicated.

As regards farming, some of the items considered were the sizes of farms, the sizes of plots adjacent to farms, and the total number of plots to one farm. In addition, the accessibility of the farms and remoter plots was assessed. This resulted in a classification of the sample areas into sub-areas with different agricultural problems. (Fig. 2)

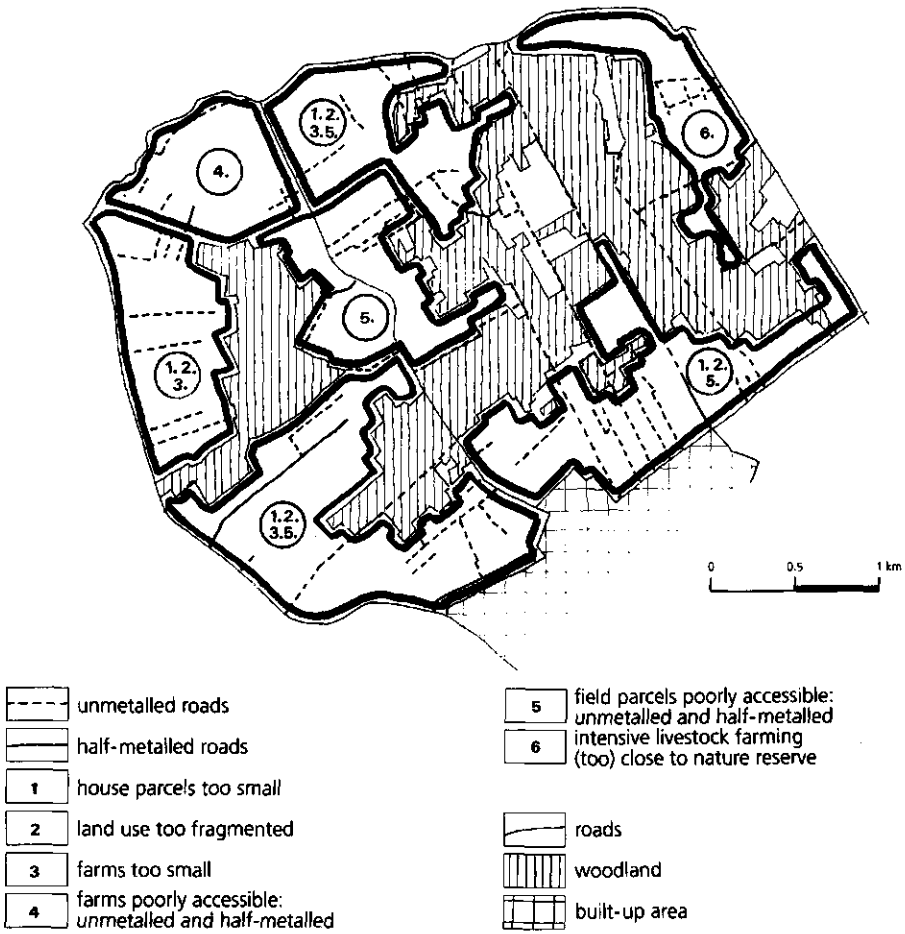

Fig. 2. Major problems of the agricultural sector; analysis of the agricultural situation in a sample area of the Leijen-West land redevelopment area (Van der Haar & Schöne, 1993).

Items such as man-induced drought, flooding and barrier functions were also surveyed. (Fig. 3)

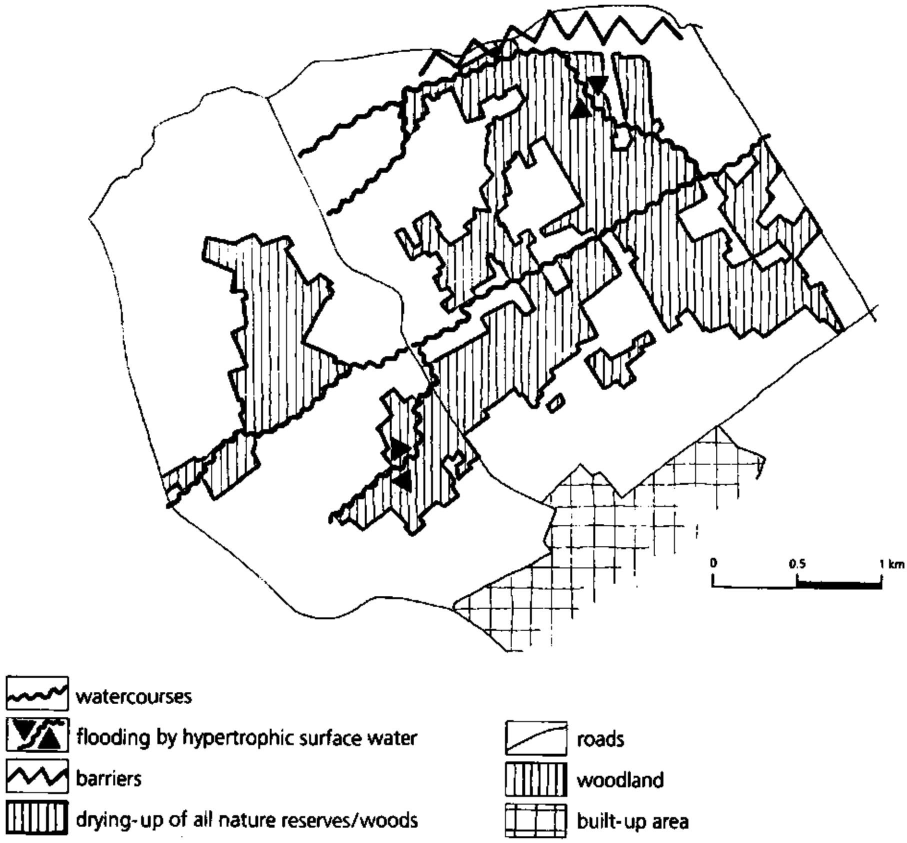

Fig. 3. Major problems of nature conservation; analysis of the agricultural situation in a sample area of the Leijen-West land redevelopment area (Van der Haar & Schöne, 1993).

With regard to recreation, the restrictions to cycling and walking were inventoried (Fig. 4).

The bottlenecks were then compared with the cultural historical elements of the inventory, which resulted in a final design (Fig. 5).

With respect to the methodology, the lack of synchronization between cultural historical research and planning was felt as a shortcoming. The present preliminary phase does not yet allow a clear insight into the specific problems of the area at the stage of the first land development preparations. The recommendations for the individual sectors of agriculture, nature management and recreation are not yet available. Consequently, the researchers have to start without knowing what changes will take place in the area. It is difficult to anticipate these when land development plans are being made.

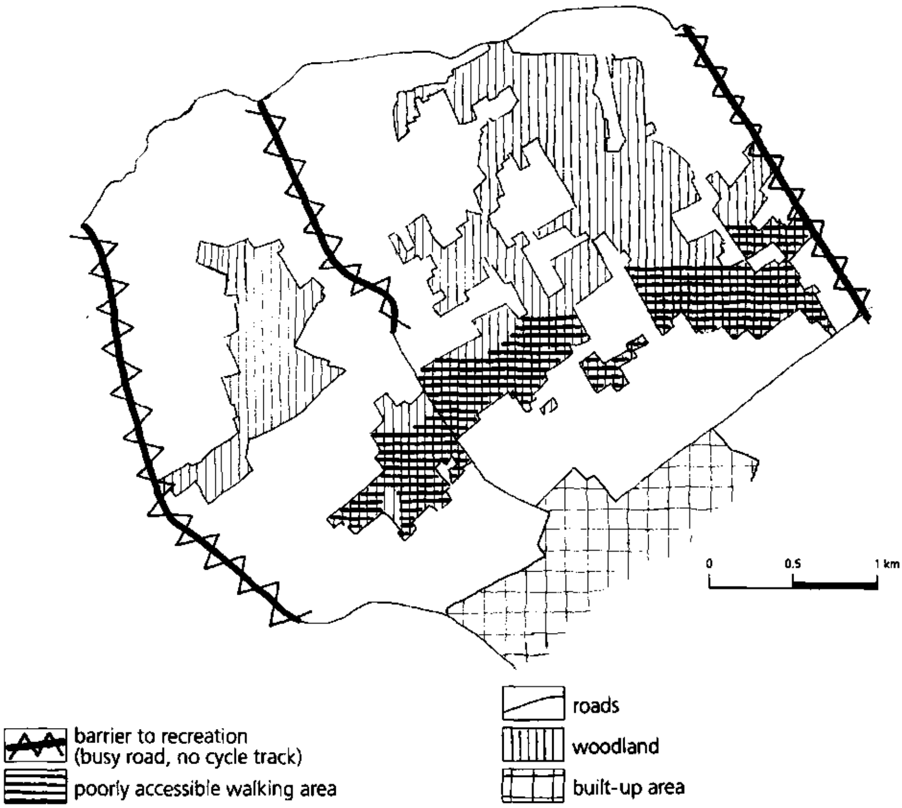

Fig. 4. Major problems of recreation; analysis of the recreational situation in a sample area of the Leijen-West land redevelopment area (Van der Haar & Schöne, 1993).

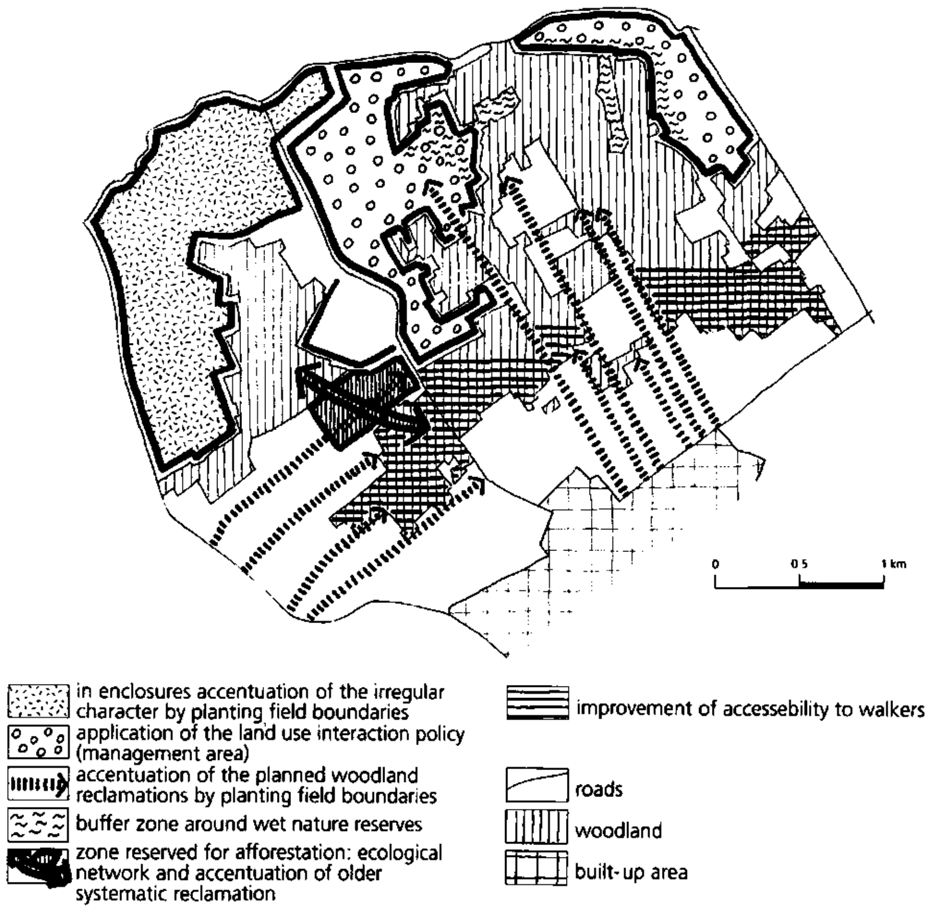

Fig. 5. Possible solutions

Gooi

A detailed management plan was already available for the Gooi heathlands (Bussumerheide, Westerheide and Zuiderheide) near Hilversum (Province of North Holland). This made it easier to design a plan in which an extra cultural historical dimension could be added by improving the visibility of barrows, old roads, walling systems and quarries. The underlying idea of this design is to restore the openness of the heath as it was about a century ago (Kuijpers 1991).

Figure 6 shows the present situation. The hatched areas are woodland, the open space is heath; the thick dark lines are green belts, or rather roads with vegetation on either side. Figure 7 shows how the future situation is pictured. The position of woodland also depends on the relief so that horizons with unsightly urban buildings are kept to an absolute minimum.

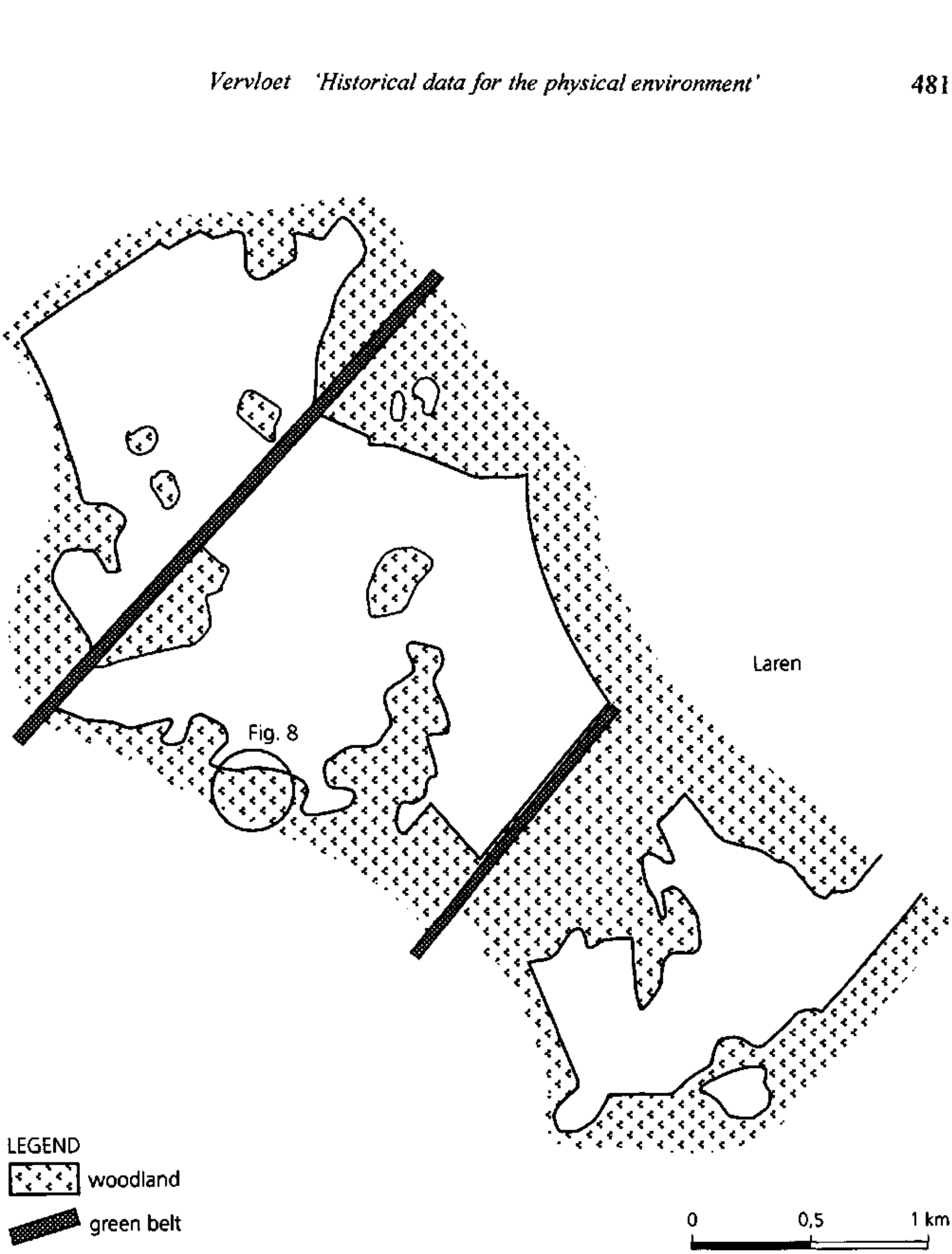

Fig. 6. Present situation of the Gooi area

In addition to these statements on large-scale modifications of the landscape, ideas are also brought forward about the spatial options for each element and a few specific situations, for instance in Figure 8, which shows the present situation (A) and the most desirable future situation (B) with regard to a group of barrows.

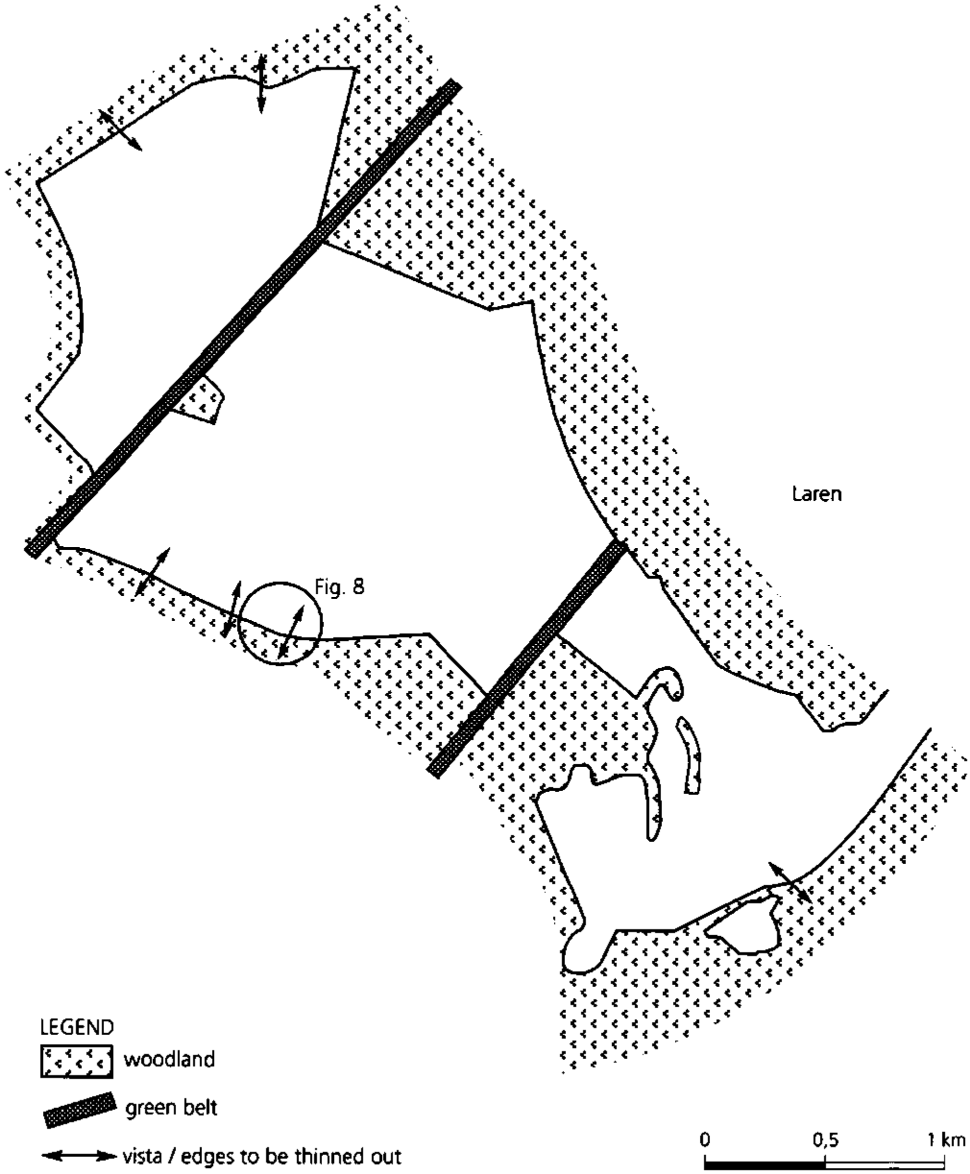

Fig. 7. Future situation of the Gooi area

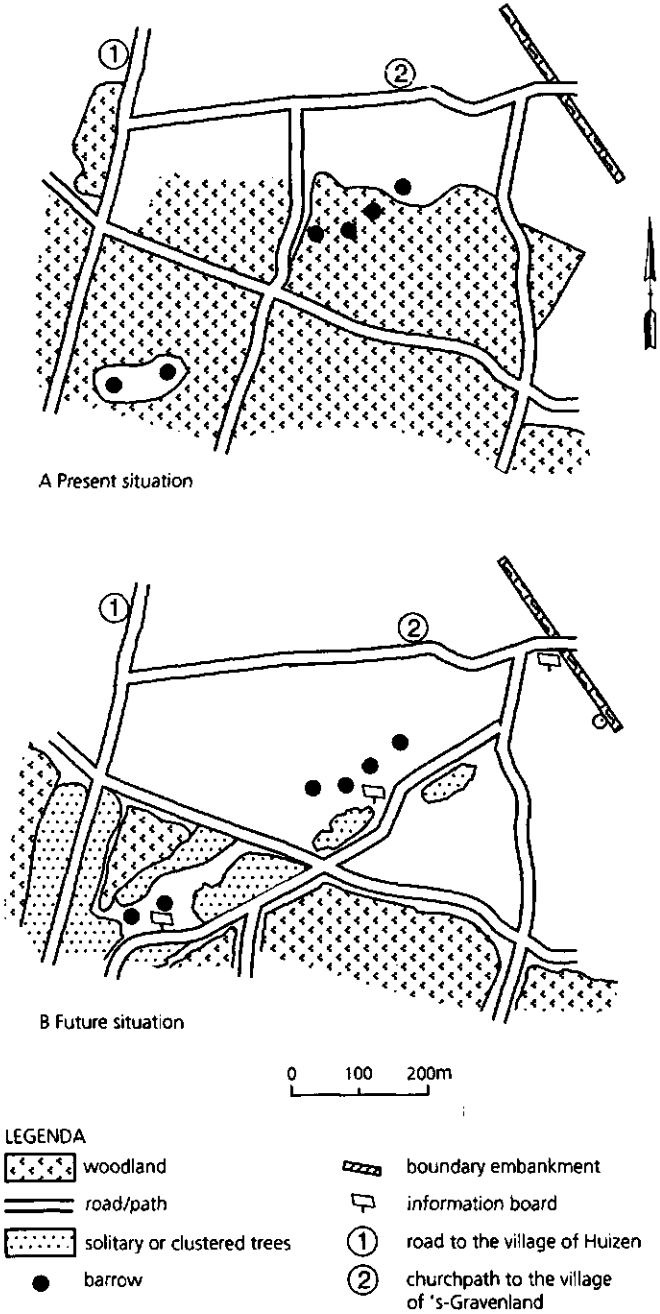

Fig. 8. Modifications of the landscape in a specific situation

Reference images

So far, we have described only part of the historical input in scenario studies: the way in which visible cultural historical elements in the landscape can find a place to survive, within the framework of planning and the planning process. The potential input based on the results of historical research itself has not been mentioned so far. What I mean here is the **research of reference images** (Dirkx, Hommel & Vervloet 1992).

The term "reference image" has come into use recently, especially after the publication of the Dutch Nature Policy Plan, in which it is used in the discussion on nature development. For the purpose of nature development, and elaborating on the ideas of the Nature Policy Plan, several target ecosystems are described, which serve as guides for the future development of nature.

The situation of nature as it was at a certain point in the past is sometimes taken as a reference. This situation is considered the ideal ecosystem which should be developed, simply because it was there once. The question as to what moment in time one should refer to as the starting point for this cannot be answered very easily and, in fact, is a very subjective one.

Basing themselves on the idea that only prehistoric nature is good enough, some tend to choose the ecosystem which is believed to have prevailed before man had manifested himself there!

In the past there have been all kinds of irreversible processes, such as soil degradation, and there used to be very different ecological and climatic conditions. So, we can safely assume that this extreme point of view - how attractive and appealing it may be to townspeople who have lost touch with nature - can be regarded as one of the absurdities of present-day thinking of some conservationists.

Yet it would be wrong if such phenomena prevent us from trying to make a sound reconstruction of nature in certain periods in the past. Reflecting upon this will generally increase our knowledge of ecosystems. And this improved knowledge might enable us to realize target ecosystems more quickly and at lower expense.

The reconstruction of former ecosystems is one of the tasks of historical ecology, also called historical landscape ecology. This is a new field of study, arising from historical geography and landscape ecology, which has grown into a fully fledged discipline in the past few years.

To gain more in-depth knowledge of ecosystems, historical ecology utilizes as many sources of information as possible. First, there are written sources such as climatic data, invoices, treatises on agricultural subjects and lists of herbaria. Secondly, information is also obtained from natural phenomena such as soil structure, soil fertility, presence of pollen, seeds, diatoms and wood rests in the soil and whatever other sources might appear to be useful.

This integrated approach enables gaps in our knowledge to be filled so that ecosystems can be monitored better. From that perspective it is necessary to study human intervention, and how and to what extent this occurred, expressed in time-specific forms of land use and socioeconomically limiting conditions in the past. Again and again, nature proves to be largely the product of human activity. As a consequence, the target ecosystems we formulated can also be considered products of the human mind, dependent as they are on the decisions and choices we make.

In a number of nature development plans which are presently being formulated, it would seem that one is hardly aware of this. A better historical input from historical ecology can no doubt have a beneficial effect on the scientific level of this type of scenario studies.

Historical processes

By considering historical management forms or the use of fields, heathland, hedges or woodland in the past, we can often see that there have been substantial changes in the course of time. Furthermore, ecosystems also appear to be subject to changes.

It is tempting to relate "reference images" to firmness and stability. A reference image, however, is often not much more than a picture at a given point in time. The film is stopped for a moment. If we study just enough successive cross-sections in time, we shall have to admit that landscapes and the cultural and natural elements they contain often show a dynamic development. Under the influence of changing social, economic and natural relationships, the process of change may be either continuous or intermittent. The research into the where, why and who of such changes is usually called research on historical processes.

Together with research on reference images, this type of research is necessary to generate ideas in scenario studies. Perspective in time is needed to come to a better balanced opinion as regards the direction to be taken. It also teaches us how to better deal with and negotiate all kinds of concepts which are involved in scenario studies, such as natural quality, continuity and sustainability. For instance, sustainability is often connected with an almost childlike faith in the harmonious relationship of man to his environment in the past. A more detailed study revealed that there was in fact a series of subsequent environmental disasters. Research on historical processes is a field of historical ecology and offers good prospects as regards:

- climatic studies,
- the study of erosion, and
- soil subsidence owing to drainage and the lowering of the water-table.

Planning concepts

This is a young member of the family of cultural history which deserves to be developed. In my opinion, it is an essential part of the contribution of cultural history to scenario studies on the physical environment. This point goes beyond exercises with respect to the integration of cultural historical elements in the future landscape; it is about the broader vision behind it.

We must find a range of attractive solutions, strategies that guarantee the conservation and restoration of historical landscapes and landscape elements, looking for alternative functions to ensure a sustainable economic and social basis for them. We have not succeeded in this yet, though a report is in preparation now. We are in need of concepts, analogous to the "National Ecological Network" used as planning concepts by ecologists. Ecological networks are currently being developed as corridors between isolated habitats, whereas ecological framework planning refers to a drastic separation of functions in the countryside, which puts an end to mixed natural and cultural areas.

If we were to adopt these concepts simply in a "national cultural historical network", this would hardly be innovative and would not do justice to the present situation of the cultural historical elements.

Considering the use of the concept of a "cultural historical network", it should be stated that the position of cultural history is comparable with that of nature. The first priority of the National Ecological Network is the survival of natural elements through connections. Elements of cultural history, unfortunately, do not spread through such connections, and they need not necessarily be connected to each other.

The concept of the framework also seems difficult to introduce in cultural history because the elements of cultural history are often strongly interwoven, whereas the framework idea is aimed at separating functions in the landscape.

If cultural history wants to maintain its position in the planning process, the sector itself will have to come up with renewing ideas. Solutions are urgently called for. One of the consequences of international trade agreements is a rapid change in the position of farming. Changes in land use will make themselves increasingly felt. Farmers will start looking for additional sources of income and means of existence. The rural area will evolve even further into a countryside where townspeople appreciate that landscape quality very much. This quality should not only offer a fine view, the visual aspect, but also a sound inner character, which is more explicitly determined by cultural and natural elements present in the landscape.

Conclusions

The introduction of new land use systems and planning activities in a region almost inevitably implies that parts of our cultural landscape heritage will disappear. In order to avoid such a cultural erosion, clear choices are urgently needed. Applied historical geography and historical ecology must guide this process from a cultural historical viewpoint. Within this framework several fields of research are useful:
Survey, assessment and vulnerability analyses are basic necessities but do not always guarantee the right application in the planning process. To stimulate practical use, cooperation with landscape architects is necessary to develop *'historically sound' landscape designs.* In order to develop ideas on the most desirable land use, retrospection can be

fruitful. In this way knowledge of *historical processes* and of *reference images* is recommended as a good basis of prospective research. It teaches us how to better deal with concepts such as 'natural quality', 'continuity' and 'sustainability'
Last but not least the study of *planning concepts* must to be promoted. We must find a range of innovative attractive solutions and strategies which guarantee the conservation and restoration of historical landscape and landscape elements, looking for alternative functions to ensure a sustainable economic and social basis.

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12.3 Humus form profiles and ecohydrological systems analysis

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Abstract
Soil maps are frequently used to evaluate perspectives for nature restoration in scenario's of rural landuse planning. Hydro-factors are a decisive criterion on the higher levels of the Soil Classification System of The Netherlands. A case study at the Wildenborch estate showed that traditional soil maps may give information on fossil hydrological conditions. Features of the humus form profile provide actual information on the base and nutrient status of soils, being dependent on the hydrological factor. Humus form profiles must be incorporated in ecological land inventory.
Keywords: *ecohydrology, humus form, soil map*

Introduction

Scenario studies to evaluate possible impacts of changing environmental conditions on nature restoration have to be based on sound information on ecosystem characteristics. The suitability of rural areas for nature restoration is dependent on ecologically relevant soil factors related to dynamic processes such as soil acidity control and nutrient cycling. These factors are not taken into consideration in the traditional soil classification system of The Netherlands, which is founded on independent factors. Independent factors are considered to be constant, since they are controlled by processes on a time scale beyond human perception. Consequently, soil maps may contain information on fossil ecologically relevant factors and hence be less reliable.

Ecologically relevant soil factors proved to be especially sensitive to hydrological processes, which have been severely influenced by human interferences during the last decades. A case study at the Wildenborch estate (Jansen et al., 1994) showed that features of the humus form profile, ignored in traditional soil survey, can be used in predicting the actual base and nutrient status of soils. These features are a promising contribution to the development of an ecological soil typology.

Material and methods

We carried out an ecohydrological systems analysis, involving hydrological, hydrochemical and soil chemical research. The purpose of this analysis is to establish the recent position of soils in the hydrological cycle and to compare our findings with the results of a traditional soil survey. We tested our hypothesis about changing processes in soil and ecosystem development on features of the humus form profiles in the estate.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 489–494.

Ecohydrological systems analysis

Ecohydrological systems analysis describes the vegetation as a function of regional hydrological processes and parent material. One of the main items of ecohydrology is the analysis of the influence of the hydrological system on soil factors controlling ecosystem development. Both local hydrology and hydrochemistry are determining pedological processes and ecosystem development.

We assumed that according to Jenny's concept (1941), topography on a regional scale is the predominant factor in the differentiation of ecosystem development by the impact of relief on regional hydrology. The relief is the driving force of transport of water and dissolved cations through the landscape. Groundwater changes fundamentally in macro-ionic composition during its flow from recharge areas, through the aquifers, to discharge areas. The former areas are dominated by mineral-poor, acid water types, whereas the latter contain mineral-rich water of the calcium bicarbonate type. Van Wirdum (1991) constructed a framework using the hydrochemical composition of the main compartments of the hydrological cycle (atmosphere, lithosphere, hydrosphere) as benchmarks to interpret positional relationships between soils and the hydrological system. We collected water samples from 1 meter below the soil surface, using groundwater tubes installed along three transsects across the estate. We analysed the macro-ionic composition and calculated their similarity to the atmotrophic and lithotrophic references of the framework. We used the results to determine the recent position of soils in the hydrological system.

Soil survey

Since hydrology also controls soil development, we carried out a soil survey focussed on those factors that inform about hydrological processes. These hydro-factors are considered not to change in time and treated as independent factors in the Dutch Soil Classification System. Apparently, distinct soil types have a firm position in the hydrological system (Kemmers, 1986). Those positioned in recharge areas will ultimately develop acid conditions and podzolic features, whereas soils in discharge areas are supplied by base cations, providing optimal conditions for homogenization of organic matter with underlying mineral soil by bioturbation. The latter soils are characterised by topsoils with a pronounced humus content, belonging to humic and peaty gley soils. These features reflect the result of processes that remained unchanged during centuries but may not fit to the actual hydrological conditions. Our soil survey focussed on soil characteristics, indicating long-term prevailing hydrological conditions.

Humus form profiles

A humus form profile (Klinka et al., 1981) is a sequence of distinct organic and mineral horizons, which have been formed on top of the mineral soil (ectorganic: L-, F-, H-horizons) or which have become part of the mineral subsoil by homogenization (endorganic: Ah-horizon). Depending on the base status and humidity of the soil, plant litter will decompose or accumulate, rendering distinct types of humus form profiles. As base status and humidity are dependent on the hydrological position of soils, hydrological changes may affect humus form development fundamentally. Humus forms will adapt quickly to changed conditions. F-horizons may develop within 15 and H-horizons within 30 years (Emmer and Sevink, in press). We described humus form profiles of different sites belonging to the same soil type of the Dutch classification system. We sampled distinct horizons to be analysed chemically for pH, base cations, nutrients and organic carbon content.

Study area

The estate is part of an original wetland area where cover sand deposits were frequently flooded by small rivulets. Soil development was controlled by the hydrological and hydrochemical conditions that remained unchanged for centuries. In 1959 the surrounding area was drained by the digging of ditches. Nowadays, the ecosystem of the estate suffers severely from desiccation and acidification.

Results and conclusions

We compared the results of the chemical water analyses to the reference samples of atmotrophic and lithotrophic water in order to determine the share of both water types in the local water balance. In Figure 1 we constructed contour lines to indicate the volumetric share of atmotrophic water in the local water balance, supposing that only mixtures with lithoptrophic water will occur. We concluded that rainwater infiltrates into the subsoil all over the area. The absence of atmotrophic water in the southern middle part (less than 25%) is rather to be interpreted as infiltrating rainwater through calcareous deposits in the subsoil than to the occurence of discharging lithotrophic water. We never registered hydraulic potentials indicating discharge.

In Figure 1 the results of the soil survey are presented. It is apparent that humic (pZg) and peaty (Wz) gleysoils are the predominant soil types, reflecting a long history of suppletion with base cations by groundwater discharge. Around the build-up area soils with a thick layer of plaggen (EZ) are present, bordered by soils with only a thin layer covering the original soil profile (cZg). In some places with a dominating presence of rainwater, podzolic soils appear (Hn, vWp, Zn).

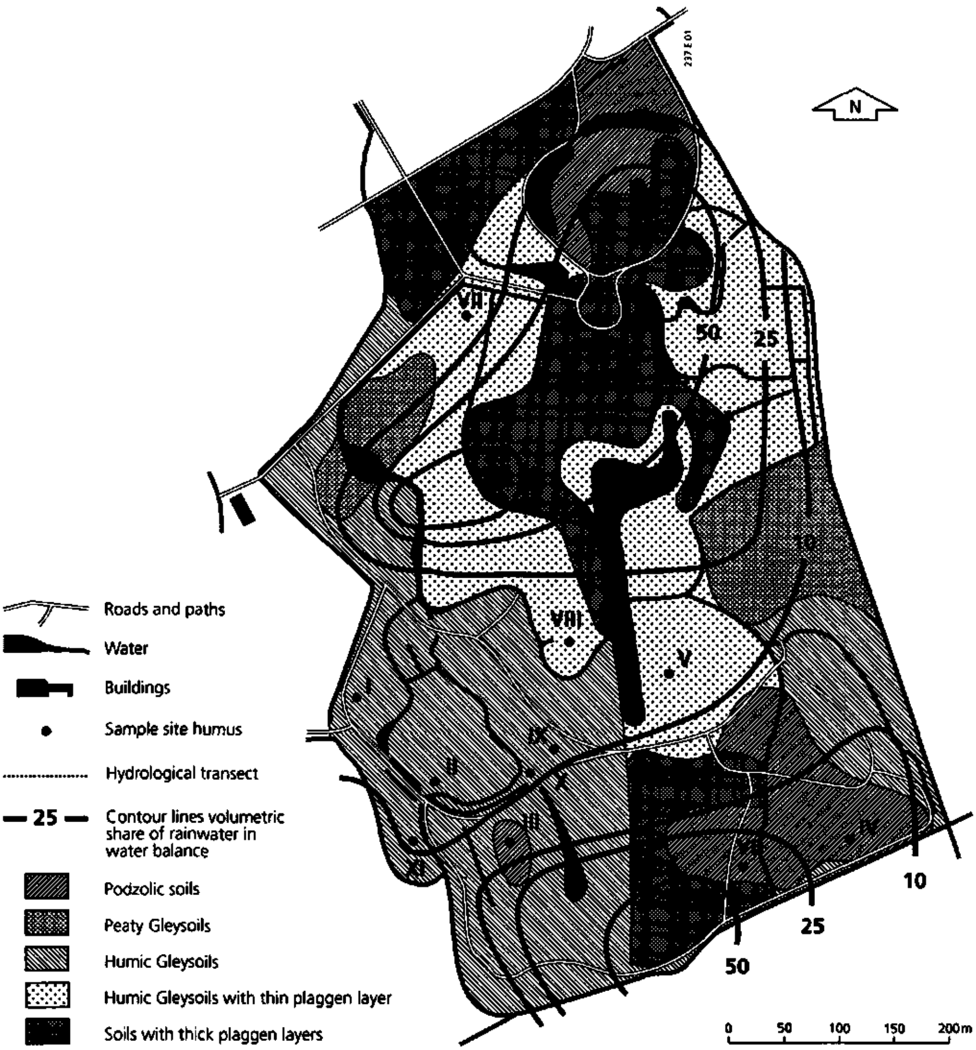

Fig. 1. Simplified soil map, with contour lines of volumetric share of rainwater in the water balance

Figure 2 presents the morphology of the actual humus form profiles as well as the soil types that they cover. Locations of sampling sites are indicated in Figure 1. Pronounced ectorganic humus form profiles, with a distinct horizon differentiation are found on the podzolic soils.

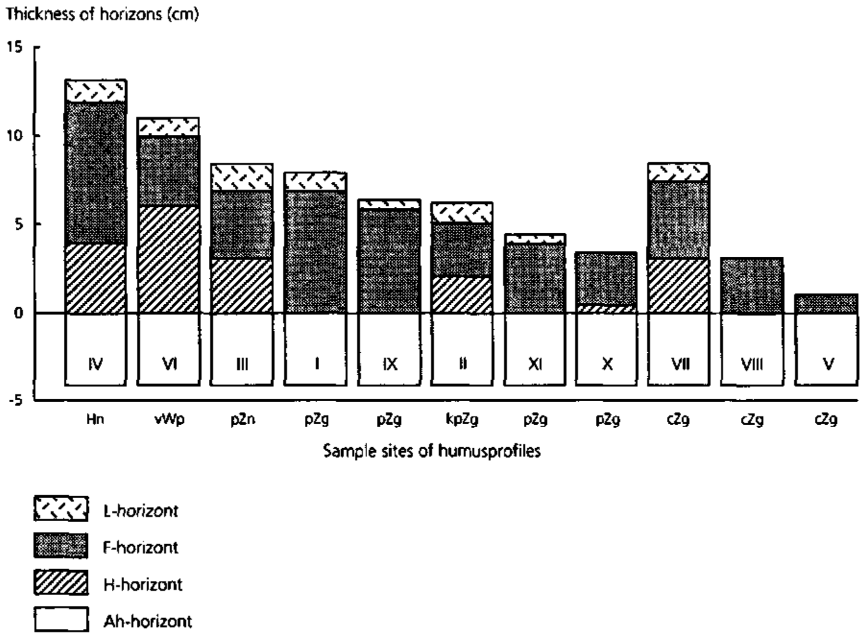

Fig. 2. Humus form profiles of different sites and soils. (See text for explanation)

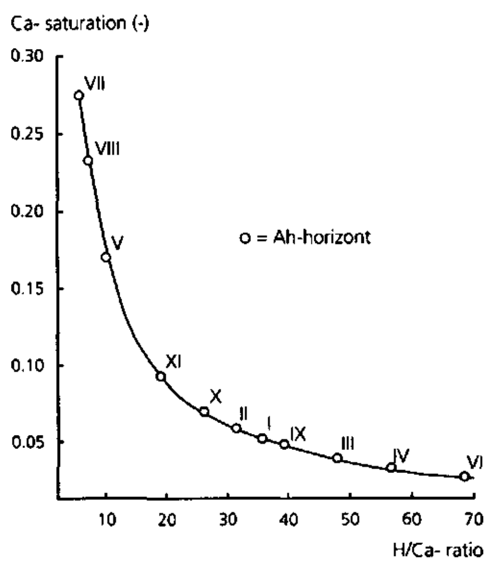

Fig. 3. Base status of Ah-horizons of the humus form profiles on the different sites

Considering the natural low base status of these soils (see Figure 3), conditions are unfavourable for decay or bioturbation, as had to be expected. Endorganic humus form profiles with ectorganic F-horizons of minor importance can be found on humic gleysoils with a thin plaggen layer (cZg). We concluded that the base status of these soils is still suited for litter decomposition, bioturbation and nutrient cycling, unless the litter is strongly resistent to decomposition, as is the case with a *Fagus sylvatica* stand at site VII. Humic gleysoils that lack a plaggen layer ((k)pZg) have a low proton neutralisation capacity, which is evidently demonstrated by H/Ca-ratios approaching those of podzolic soils. On these soils a clear ectorganic humus form profile with appearances of H-horizons locally is developing, indicating an accumulation of nutrients.

We concluded that the humic gleysoils are severely acidifying, which directs nutrient cycling towards oligotrophication. The spatial implications of this ongoing process cannot be detected with the traditional soil map, suggesting that conditions will remain unaltered for centuries. Incorporating humus form features in soil survey provides a method to diagnose actual changes in ecosystem development.

Discussion

Because the hydrological position of humic gley soils is not different from those with a plaggen layer, we think that in the past both soils have continuously been supplied with base cations by groundwater discharge. The difference between them is the capacity of their cation exchange complex, that has been increased by the addition of organic matter by plaggen manuring.

As a consequence of the digging of ditches bordering the estate, the drainage basis is drastically lowered. Groundwater discharge is directed to the ditches, and rainwater started to infiltrate the system some 30 years ago. The topsoils are depleted with basic cations by leaching, generating unfavourable conditions for litter decomposition. On the original endorganic humus form profile of the humic gleysoils, an ectorganic profile will develop unless the soil can maintain its base status at a high level by a buffering system. This is the case with the humic gleysoils with a thin plaggen layer. The appearance of a H-horizon 35 years after the hydrological impact fairly well agrees with results of Emmer and Sevink (in press).

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12.4 Landscape quality and management practice of a sandy region in Hungary

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Abstract

The Kiskunság National Park was established in 1975, having a complex of several separated land units, covering about 35,000 ha of strictly protected as well as nature conservation areas. One of the vast valuable parts of the Park is the Bugac biosphere reserve which is located in the Danube-Tisza mid-region and is covered by coarse sand. The most important factors forming the unique landscape are:

- the alteration of the topography (sand dunes and depressions),
- the actual soil moisture pattern,
- the environmentally greatly sensitive soil-water-vegetation relationships.

On the basis of a detailed soil as well as botanical survey, the complete sand-steppe successional series were investigated. As a result of this study, the evaluation of the soil-water vegetation relationship led to the characterization of the different biotopes of the protected sandy areas. Advice for the necessary management practice was also elaborated for maintaining the nearly natural status and the beautiful landscape of this unique territory.

Introduction

The study area is located in the middle part of Hungary (latitude 46° N, longitude 19° E), in the Danube-Tisza mid-region, at an elevation of 120 m. The calcareous, coarse sand covering the area is a young (Pleistocene) deposit of the river Danube from which wind has formed a dune land (1). The soil of the area is a slightly humic sandy soil with less than 1% humus content. Due to its low water retention capacity and capillary conductivity, the upper soil layers can dry out extremely during summer (even below the wilting point), causing considerable drought stress for plants. During the summer droughts a whole month can pass without any rainfall, and the average annual precipitation seldom exceeds 500-600 mm. Groundwater also migrates towards these local cavities. The prevailing micro-environment has great importance in the development of the area. The morphological differences of the one-time surface often resulted in the development of different sedimentary environments. On the other hand, significant water resources exist approximately 60 cm under the surface even in summer, but the soil water table can fall below 2 m.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 495–499.

Research activities

The following research activities, carried out during the last years, can serve as tools for setting up scenarios for National Park management purposes to the area given.

Soil research

The main objectives of soil research, starting in 1979 in the Kiskunság National Park, can be summarized as follows:

- assessment, characterization and mapping of soil forming factors, soil processes and soil properties,
- analysis of the microrelief - hydrological conditions - soil cover - natural vegetation relationships,
- evaluation of human activities on the natural conditions, and on this basis
- to give recommendations for the re-establishment of the original conditions, as well as for the maintenance of protected ecosystems.

During the detailed survey soil profiles were described, sampled and analyzed. On the basis of field surveys, aerial photo interpretation and analytical data, a 1:25,000 scale land-site map was prepared for this unit of the National Park.

The main soil-forming processes are as follows:

1. Accumulation of organic substances, development of a more or less expressed humus horizon.
2. Development of soil structure (highly varied in development, shape, size, spatial arrangement and stability of structural elements).
3. Formation of carbonate (mainly $CaCO_3$) accumulation horizons (sometimes cemented hardpans) as combined consequences of two processes: slight leaching from the root zone and accumulation from the groundwater.

There are very close relationships between microrelief, hydrological conditions, soils and natural vegetation or land use practice.

The following land-site types were distinguished in the National Park:

I. Sand regions

1. Wind-blown sand without permanent vegetation.
2. Wind-blown sand and humous sandy soils with open sand "puszta" (desert) vegetation.
3. Wind-blown sands and humous sandy soils covered by *Populus* and *Juniperus* stands.
4. Humous sandy soils covered by sandy grasslands.
5. Humous sandy soils under agricultural or sylvicultural use.
6. "Cover-sands" (other soils covered by aeolian sand of various thickness) with sand grassland.
7. "Cover-sand" under agricultural use.

Botanical and ecological research

The research programme is focused upon the ecological, dynamical and geobotanical (flora, vegetation, community and succession processes) analysis of the Biosphere Reserve (3,5). The studies offer a possibility for the development, improvement and testing of new methods. Some results have already been used to improve the management of the national park.

The present flora and vegetation, and their changes: during the flora and vegetation surveys 300 lower and 166 higher plants were found, some of those being either newly recorded or relict species. The flora is rich in endemic, subendemic, relict and protected species (15% of the flora). Noted species are, for example, *Botrychium lunaria, Ephedra distachya, Centaurea sadleriana* and *Colchicum arenarium*. Species categories for expressing the conservation value of this flora were proposed. The analysis of the vascular flora of the Bugac with respect to the nature conservation values illustrates that the natural elements predominate in the area.

The natural components, including strongly protected elements, together account for a relatively high percentage in both species number and score. The percentage of degradation indicator species, as cosmopolitan weeds, adventive plants and disturbance-tolerating species is low or even negligible. The distribution of the total Hungarian vascular flora, including 2200 higher plant species is: natural components 55.7%, indicating degradation species 44.3%. In comparison to this, the results show that the study area is only slightly disturbed and still has a high nature conservation value (4).

Stands of 15 plant communities were registered in the study area, seven of them are suggested to be intensively protected. The complete sand-steppe successional series is described, and the diversity values (species-genus, species-relative cover) for each stage are provided. The plant communities representing the individual stages of succession follow each other in such niche space where the humus and moisture content of the soil and the light conditions are its axes. In the course of vegetation succession on a given site, newer associations occur. These new communities following each other represent certain stages of succession of the vegetation. The communities have their own organization. The extent of their organization can be expressed by diversity. Diversity is related to stability, by means of its ability to resist perturbations; therefore it may be an essential feature in qualifying the condition of the environment. Therefore, in the ecological approach to environmental protection, diversity has a major part to play (2).

One of the most widely occurring communities in the Bugac area is the perennial open grassland community (*Festucetum vaginatae*), representing a natural successional stage on sandy areas. The local water shortage does not allow a closed plant cover to develop, bare sand surfaces - partly inhabited by spring and autumn ephemerals and drought-tolerant mosses and lichens - can be found between tufts of perennial monocots and dicots.

The closing (climax) community of the succession is the *Convallaria* oak forest (*Convallario-Quercetum roboris*) characteristic for depressions with moist soils. In the canopy layer *Quercus robur, Populus alba* and *Populus canescens* are dominant.

Most genera and species can be found in the closed perennial grassland (*Festucetum rupicolae*) and in the poplar forest with juniper (*Ligustro-Populetum*). In these plant communities the genus-species diversity (calculated by means of Shannon's function) are the highest among the five stages of the succession.

In the initial (*Brometum tectorum*) and the closing (*Convallario-Quercetum*) communities of the succession, the genus-species diversities are the lowest. The species-relative cover diversity is the highest in the case of *Festucetum rupicolae*, and the lowest in the *Brometum tectorum*.

The changes of the DS (Numata index, as a degree of succession) shows a remarkable increasing tendency during the succession from 40 to 1494 (2).

As can be seen the different stages of succession are clearly distinguishable from the results.

Conclusion for further management of the area

- The reconstruction of territories under the influence of non-adequate water management practice. Ceasing further drainage activity, recharge of water (quality and quantity same as that before canalization) for renewing open water surfaces and preventing further sinking of groundwater.
- Better planning and implementation of reforestation of the area. It would be better to use native tree and shrub species (e.g. *Quercus robur, Quercus pubescens, Populus alba, Populus canescens*) for reforestation instead of using introduced ones like *Robinia pseudoacacia* and *Pinus nigra.*
- For preserving biodiversity it is necessary to maintain the circumstances regulating the microheterogeneity of biotopes (i.e. soil moisture pattern, nutrient status, plant canopy, etc.). This is a consequence of the time and space variability of available moisture and nutrients as the main limiting environmental factors.
- Strict protection of rare plants, birds and other animals from the harmful side-effects of increasing tourism, the extension of agricultural activities, and prevention of trampling effect.
- To maintain the equilibrium between plants and herbivores, because the effects of consumers on vegetation pattern, production and diversity involves complex combination of factors. Herbivores stimulate the primary productivity, they transport seeds and influence vegetation diversity and succession processes through selective feeding.
- Special landscape management for the prevention of summer fires.

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12.5 Landscape planning on the island of Hiiumaa, Estonia. Presentation of a research project 1993-1998

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Abstract

As in other East European countries, Estonian society is undergoing a total transition. The development will without doubt affect the current land use and the quality of the Estonian landscapes. This paper describes a research project that aims at developing a model for landscape planning by using landscape scenarios as a tool in the local planning process on the island of Hiiumaa. The project consists of the following parts: analysing the historical background and the current situation, visioning the future in scenarios, discussing the results with the local authorities and comparing the experience gained in Estonia with the Swedish planning practices.

Keywords: *Hiiumaa, Estonia, landscape planning, scenarios*

Introduction

Yesterday, Estonia was a closed and centrally governed Soviet republic. Today, it is a country rapidly developing into an open and democratic society. The whole institutional framework is being reconstructed. The legislation is undergoing major changes. The transition to a market economy together with land reform (restoring the ownership structure of 1938) has put Estonian agriculture into a very difficult position. The collective farm system has fallen apart, and private farming is still very underdeveloped. Thus, the agricultural production is decreasing rapidly, while the market is flooded with food products from Western Europe. Inevitably, the Estonian countryside is facing big changes.

There is a crying need for working out strategies for future development at all levels of society. Unfortunately, there is no sign of coherent agricultural, environmental and regional policies being elaborated at the governmental level. The message seems to be: learn to swim or drown. It is alarming because of the social problems created by the present development. There is also a risk of losing great natural and cultural values by planless abandonment of agricultural land. On the other hand, the chaotic situation also gives an opportunity to exercise real bottom-up planning based on local initiative and local participation. It matches well with the demand of decentralisation from the new local governments. The main obstacle is the Soviet heritage in many peoples' attitudes: a passivity regarding public matters and a well-founded distrust in any kind of authority.

This paper describes the outlines of a bilateral research project started in 1993 between the Department of Landscape Planning at the Swedish University of Agricultural Sciences and the Hiiumaa Centre of the West-Estonian Archipelago Biosphere Reserve. The question posed in this project is: how the landscape appearance and the environmental qualities of the rural areas on the island of Hiiumaa will be effected by the changes in land use.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 501–504.

The aim is to develop a model for landscape planning in a society in transition. The results of the project will be available at the earliest in 1998.

The objectives of this research project are:
1) to describe the evolution of Hiiumaa's landscapes from 1900 to the present day;
2) to develop landscape scenarios and use them as a tool in the local planning process on Hiiumaa in order to stimulate discussion about future alternatives;
3) to compare some aspects of the Swedish planning practices with the experience gained on Hiiumaa.

Why Hiiumaa?

The island of Hiiumaa, situated near the western coast of Estonia, is well suited as a research object for the following reasons. First of all, it is an island with well defined borders and with a homogeneous and relatively stable community of nearly 12 000 people. Second, Hiiumaa is small enough (1000 sq. km) to be easily overviewed and big enough to contain a diversity of landscape types: natural coniferous and deciduous forests, wetlands, unexploited coastal landscapes, traditional villages surrounded by centuries-old farming landscape, large-scaled collective farm fields and urban style settlements. Two major turning points during the present century have had a decisive influence on the development of Hiiumaa's landscapes: the land reform starting in 1919, shortly after Estonia was declared independent, and the collectivisation campaign starting in the late 1940s. (The third turning point is of course now.) Furthermore, since 1990, Hiiumaa has been a part of the West-Estonian Archipelago Biosphere Reserve. One of the aims of the Hiiumaa Centre of the Biosphere Reserve (besides traditional nature protection) is to work out strategies for sustainable development on the island in close co-operation with the local community members. This is where the planning comes into the picture. For the time being, Hiiumaa lacks an official structure for regional planning, so there is space for improvising and testing unconventional methods.

Present problems

The economic changes include the decline of the previously very important agricultural sector. It has already brought along rising unemployment and social problems in rural areas. It could also cause a big emigration wave to the mainland. The emigration and the abandonment of agricultural land will endanger the existence of the remaining small traditional villages and the "relict" cultural landscape surrounding them. (Permanent grasslands - pastures and meadows - are an important part of the cultural heritage and the identity of the island. There are also great biological values connected with these grasslands.) On the other hand, one expects a considerable rise in the importance of tourism (Development Concept for Hiiumaa, 1993). Developing tourism on Hiiumaa could mean a threat to the previously unexploited coasts and valuable wildlife areas. But it also creates an economic incentive to preserve the cultural landscape for recreational and aesthetic reasons, which could lead to a fruitful symbiosis between agriculture and tourism.

The scope of work

The project consists of the following parts.

1) Historical background analysis:
   - the changing of the factors defining land use from the beginning of this century to the present day;
   - the changing of the appearance and the environmental qualities of the landscapes during the same period;
   - changing of the methods used in agriculture and forestry.

The evolution of landscapes of Hiiumaa is described as a whole and also studied in detail in at least two case studies of representative agricultural areas.

2) Current situation analysis:
   - the emerging of the institutional framework in Estonia;
   - present changes in agriculture and in the rural society of Hiiumaa due to the reforms;
   - opinions and attitudes of local residents concerning the present development as well as the future of the island.

The last part is being studied by using a questionnaire (involving over 400 islanders) and interviews of key-persons.

3) Visioning the future or the scenario-making:
   - alternative scenarios of future development based on the information gained in previous steps and in discussions with the local authorities;
   - visions of possible future landscapes based on the historic case studies and the scenarios.

The visions should include some extreme development alternatives (dreams, nightmares...) as well as examples of sustainable land management.

4) Continuously presenting the results:
   - in exhibitions, seminars, articles in the local press, etc.

Presenting the past, present and future of the landscapes in visual form should make it easier to communicate with the local authorities and different interest groups, and also invite the residents to express their opinions. The most important thing is to stimulate the local debate about future development by showing that the future is not exclusively determined by some *force majeure* (Soviet Power, Market Economy, EU etc.), but is also shaped by the people living and acting in the environment. It is also important to show that there is more than one road to the future.

5) Evaluating the contribution of scenarios to the planning process:
   - interviews and discussions with the participants in the process.

Objective results cannot of course be expected before a couple of decenniums...

6) Comparing the Hiiumaa experience with the Swedish planning practices concerning the preservation of the historic, aesthetic and biological values of the agricultural landscape.

Benefits

The experiences of this project could be used to create similar planning models for other regions of Estonia, possibly even for other East European states. By comparing the Estonian and Swedish planning experiences, new insights could be gained on both sides.

There are also educational aspects to this project - creating an awareness in the local community of the threats and problems associated with the changing of landscapes, and making known the ideas and strategies of sustainable development.

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12.6 Recreational images of a rural landscape

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Abstract

Which is the image recreationists have of a rural landscape? To answer this question, a study was undertaken concerning the key-elements in a destination image. Emphasis was put on the image as a product, as contrasted to the process by which an image is formed. Interviews were held with recreationists who stayed at a campsite near Utrecht. Images seem to consist of two distinct levels: a regional level and a local one. These levels differ in kind of detail and accordance by recreationists. In the perception of a rural landscape three types of image-styles were found: a structural style, a functional style and a visual one. These types may lead to different scenarios for the corresponding types of tourists.

Keywords: *landscape perception, landscape images, recreation research, image styles, environmental psychology*

Introduction

Landscape plays an important role in the decision of tourists and recreationists to visit a region. Before their visit, even the first one, tourists and recreationists have expectations of the landscape they are going to see. These expectations are part of their destination image, together with other psychological aspects like beliefs, ideas, impressions and the relation between them (Chon, Kye-Sung, 1990). In The Netherlands many people visit the rural area for leisure purposes. Despite this intensive use little is known about the image tourists have of rural areas. Because of its theoretical and practical relevance, DLO Winand Staring Centre, section Recreation and Tourism did research on this topic (Klinkers, 1994).

Method

In the autumn of 1991, 18 recreationists who stayed at a campsite near Utrecht were interviewed about their image of the landscape at a nearby region: the Utrechtse Heuvelrug/Langbroeker Wetering. This region is about 2500 ha. In the interviews, open-ended questions were used as well as a schematic map of the area and colour photographs of the landscape. Recreationists were asked to give a verbal description of the area as a whole, to make an analysis in subareas and to describe each subarea in terms of relevant attributes. The photographs contained realistic pictures of landscape scenes from all over the region. One of the tasks for the respondents was to make groupings of photographs on the basis of the resemblance they perceived between landscapes. They could make as many groupings as they liked. Afterwards, they were asked to label each group of photographs. This method, by Verhallen (1988) described as "natural grouping", allows respondents to use their own concepts and categorization-schemes. Many respondents used the same label for a photograph.

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This made it possible to perform a cluster-analysis on groupings of photographs. For this analysis, an asymmetric matrix was build in which each photograph was counted for all the labels the respondents attached to it. Besides, a content analysis was performed on the verbal descriptions of each grouping.

Results

As a result of the content-analysis on verbal descriptions from the respondents, a "perception-map" of the region was drawn (Figure 1). This map shows the perceived subareas and the description the respondents gave to them. Boundaries between subareas differ in "hardness", i.e. frequency of mentioning by the respondents. As can be seen, the most prominent boundary is between the forest-part of the area and the open polder.

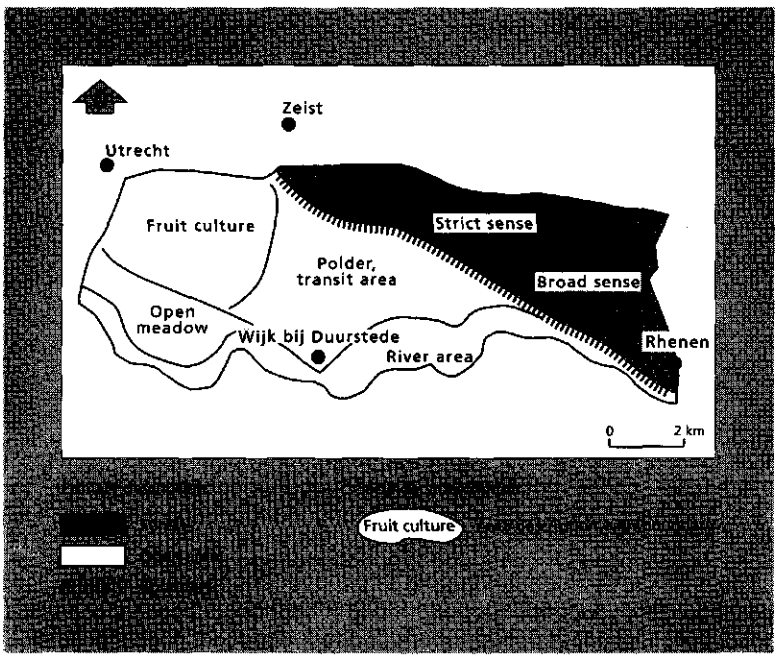

Fig. 1. Regional perception map of the area as a result of verbal descriptions from respondents

Although the clustering of the photographs as well as the labels ascribed to them show a great deal of variety, it is possible to detect an overall structure in the groupings, by means of a cluster-analysis on the labels ascribed to the photographs (Figure 2).

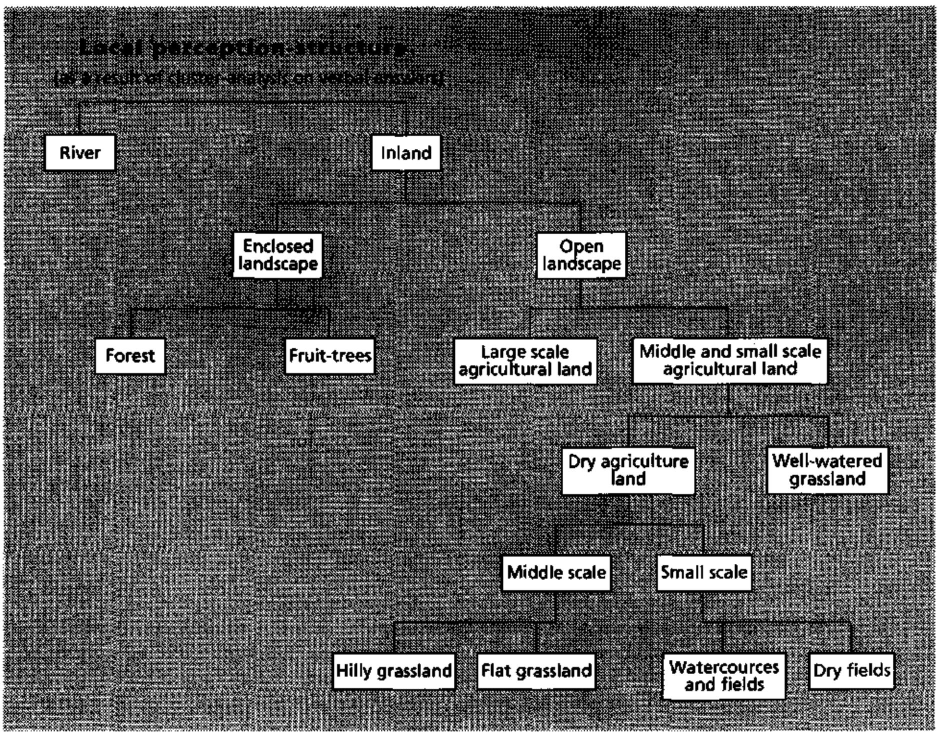

Fig. 2. Perception structure of colour photographs, as a result of cluster analysis on verbal labels

The labels of the photographs can, according to their meaning, be divided into three groups. The first group is called structural labels; this group contains concepts which refer to the landscape as a totality, for example river landscape, polder, rural land. The second group, called functional labels, contains concepts referring to landuse like grassland, roads, fruit-trees. Finally there is a group called visual labels, with descriptions like flat, open, dry land. Each respondent used labels from all the groups, but always one group was most frequently used.

Prominent boundaries in the "perception-map" of the region (Figure 1) correspond with the main divisions of the cluster-analysis on the labels of the photographs (Figure 2). Apparently there is a correspondence between the perception of the region as a whole and the landscape in it at a local scale. This gives rise to the hypothesis that the image of a landscape exists at two levels: a regional level and a local level (Figure 3). In the regional image of a landscape, a few salient environmental characteristics are used by all recreationists. As to the local image, many environmental characteristics are used, and these are attributed to the landscape scenes in different ways, dependent on the vision of the individual. The differences in attribution of landscape features at the local level are not totally distinct between individuals. These differences also show common features, which could be typed as a way-of-perceiving or an image-style. From an analysis of the labels, three such styles were found; a structural style, a functional style and a visual one. These styles differ in the principal elements in each style: the landscape as totality, kind of landuse aesthetic look. Although respondents used all of the three styles, one style was most frequently used. This is called the dominant one.

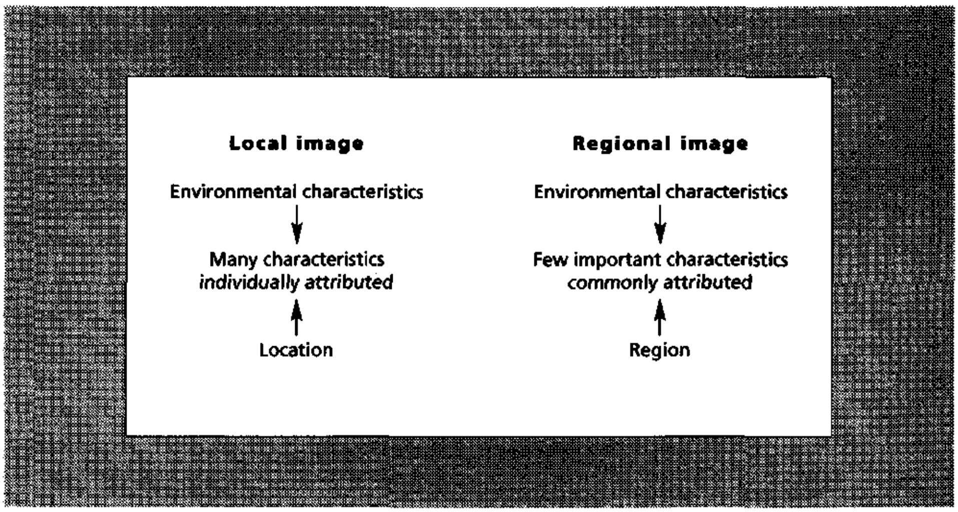

Fig. 3. Assumption of the influence of environmental characteristics on the local and regional image

Conclusions

There are indications that the image recreationists have of a landscape is not a uniform concept but consists of at least two levels: a regional level and a local one. On a local scale, places and characteristics are supposed to be linked according to different types of image-styles. Further research is needed on the implications of these image-styles for scenarios on rural planning.

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CHAPTER 13

Policies

13.1 Ecological networks in Europe. Strategies, criteria and perspectives

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Abstract

Ecological networks can be considered as scenarios for the development of nature in the context of social and economic processes. They have been developed all over Europe within different frameworks of planning: nature conservation planning and integrated planning. In the Netherlands the national ecological network as the core of the nature conservation plan is worked out through provincial nature conservation plans. In the Czech Republic the establishment of the ecological network is part of the nature conservation law. The network is a hierarchical system of biocentres. Development of the networks will interfere with other land uses. There will be differences in development between intensive farming areas and marginal lands. The European perspective is that the national networks can merge into a pan-European system although the strategies of the countries are different. However, the lack of finances in central, eastern and southern Europe and the early stage of nature conservation development must not be a reason not to develop the ecological networks. We must learn from the past.

Keywords: *ecological networks, The Netherlands, Czech Republic, nature conservation planning*

Introduction

In nature, succession and other natural processes allow it to develop according to its own laws: primary forests develop in the direction of old growth forests. If man does not interfere, river systems will build their own environment consisting of alluvial plains, sand dunes, backwaters, islands and flooding areas. These evolutions can be considered as trend scenarios described in many succession studies and river development studies. However, since man interferes in nature, spatial structures and succession processes cannot develop freely. They develop in the framework of the mutual relationship between natural processes and socioeconomic processes. Land use, development of infrastructure and harvesting are important influencing processes. Nature and nature management have to be planned, and we need new scenarios for development to judge what is the right development in time and space. Ecological networks can be considered as a way of developing scenarios based on this mutual relationship between nature and society.

In several countries in Europe, scientists and planners have thought about coherence in nature conservation by designing ecological networks. Ideas based on landscape

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ecological principles have been developed recently in all parts of Europe. National and regional plans for nature conservation are made which result in a more or less coherent structure of nature reserves. In Hungary, for example, over 630 000 ha (7.6% of the land) is protected, covering many important habitat types but coherence is not yet clear (Tardy, 1994). In countries like Denmark and Estonia, nature conservation plans have been integrated in the physical planning system, while elsewhere as in the Netherlands nature conservation strategy is translated into plans for a nationwide ecological network.

The background of this increasing attention is the continuous decline of species and their habitats in number and area. In Spain and Hungary the Great Bustard (*Otis tarda*) is under threat. In Germany a large number of the plant species is endangered, and the number of extinct and threatened bird species increased from less than 100 in 1971 to 110 in 1986 (Umweltbundesamt, 1989). This trend can be confirmed for the Netherlands, where already in the 1950s the decline of species was a serious problem (Westhof, 1956). In spite of increasing activities on nature protection since then, no improvement occurred in the status of the species of oligotrophic environments or wet and dry grasslands. Meadowbirds and birds of small-scale agricultural landscapes are declining, and at least two species have become extinct in the Netherlands.

Landscape-ecological research indicates that for the survival of species and their populations not only habitat quality is vital, but also the size of nature areas and the spatial relation between them for dispersal and migration. The main elements in the landscape of importance for dispersal are the area of biotope sites, the distance between them, the presence of corridors and the barrier effect of landscape and land use between (Opdam, 1991). The combined effect of area reduction and isolation will cause a reduction of the populations that can be supported and in this way increase the risk of extinction. Now dynamic biotopes dominate the landscape. Populations of species of formerly large stable biotopes have become metapopulations and are dispersed over several subpopulations in relatively small sites.

Ecological Networks

Nature conservation policy is common in all countries in Europe, although differences exist in ideas and strategies. In all countries the history of nature conservation policy developed from a phase of origin, through a consolidation phase onto landscape ecology based nature conservation (Bischoff and Jongman, 1993). In countries of northwestern Europe these phases were more or less synchronous. It started in the context of the liberalism of the 19th century when governments were reluctant to take a leading role. The Dutch government did not take initiatives in the field of nature conservation until the end of the 1930s. After the Second World War nature conservation became accepted and consolidated its political position. In the last decennia of the 20th century, nature conservation strategy is developing its scientific basis in landscape ecology. This takes shape in new strategies formulated in policy documents on nature conservation and nature

Table 1. Ecological networks in Europe indicated by English names where available. References to the networks are given in the text. Policy plans are adopted by governments and in the phase of realization. The other plans are considered to be concepts. Integrative plans are those plans that are considered to be part of physical plans and plans that include regional development as well.

name of the network	European	national	regional/ local	policy plan	nature/ integrative plan (np/ip)
Diploma Sites (Council of Europe)	X			pp	np
Biogenetic reserves (Council of Europe)	X			pp	np
EECONET	X			--	np
National Ecological Network (The Netherlands)		X		pp	np
Groene hoofdstructuur Noord Brabant (The Netherlands)			X	pp	np
Nature frame of Lithuania		X	X	pp	ip
Territorial system of landscape ecological stability (TSLES), Czech Republic		X	X	pp	ip
Territorial System of Ecological Stability (TSES), Slovak Republic		X	X	pp	ip
Groene Hoofdstructuur van Vlaanderen (Belgium)			X	pp	np
Network of compensative areas (Estonia)		X	X	pp	ip
Vernetzter Biotopsysteme (Rheinland Pfalz, FRG)			X	pp	np
Zonas de interes potencial para la red "NATURA 2000" en el estado Español		X		--	np
Design of a Nature reserve system in Greece		X		--	np
Naturområder /økologisk forbindsele (Denmark)			X	pp	ip
Green lungs of Poland		X	X	--	ip

rehabilitation of former or potential natural areas. The ecological concept behind these new nature conservation strategies is the development of coherent structures of nature through ecological networks.

An analysis of ecological networks in Europe has been carried out, and in this analysis it appeared that three networks out of fifteen have been designed at the European level (Table 1, Jongman, 1995). Two of them are networks of the council of Europe. These are pioneer activities, the European Diploma Sites dating from 1965 and the Biogenetic Reserves from 1976 (Council of Europe, 1991). They cover nature reserves in countries through all of Europe. The other is the European ECOlogical NETwork (EECONET; Bennet, 1991), a scientific concept that has been developed as an example study at the level of the European Community.

Other networks have been designed at the national or at the regional level. The Dutch national ecological network is made in the context of a nature conservation plan (Ministry of Agriculture, Nature Conservation and Fisheries, 1990). The networks of Spain (Ruiz Perez and Gonzalez Vela, 1991) and Greece (Troumbis and Skrimpas, 1993) are meant to be an incentive for the improvement of national nature conservation policy in relation to the realisation of NATURA 2000 as regulated in the EC-habitat directive (Council Directive 92/43/EEC). The networks of the Czech republic (Bucek and Lacina, 1992), Slovakia (Húsenicová and Ruzicková, 1992), Lithuania (Kavaliauskas, 1992), Estonia (Mander et al, 1988) and Poland (Nationale Stiftung für Umweltschutz, 1991) are part of integrative planning systems and include national, regional and local level.

In some countries nature conservation is delegated to the lower authorities rather than the national level. Ecological networks have been developed in Germany and Belgium which are federal states. The level of planning in Flanders (Den Blust et al, 1992) is more or less between the national and regional level, while the planning system in Germany in Rheinland Pfalz is regional to local (Ministerium für Umwelt, Landesamt für Umwelt und Gewerbeaufsicht, 1991). In Denmark the responsibility for nature conservation is divided between the national government and the regional governments (National Foresty and Nature Agency, 1992). The Danish physical planning system includes areal claims for nature conservation, and it is mainly the responsibility of the counties (amte) to realize them. That causes differences between counties within the country. The nature conservation plan (Natuurbeleidsplan) of the Dutch province of Noord Brabant is a regional plan related to the national Ecological Network of The Netherlands, and it is also one of the basic documents for physical planning at the regional level (Provincie Noord Brabant, 1993).

Ecological Networks in The Netherlands

In the last decades nature conservation has developed from a policy field of minor importance into an accepted activity in society. Knowledge and ideas from landscape ecological research found their way into nature conservation policy strategies. Coherent spatial structures are the most obvious part of it. Based on especially the development of the theory on island-biogeography and metapopulation theory, new solutions were searched for to stop the continuing decline of nature. Causes were identified as (1) the loss in habitat quality, (2) fragmentation and (3) isolation of natural areas. It was also concluded that too often problems were discussed within their local context only, without taking into account the national or international relationships of an area.

The result was that the concept of a national ecological network was introduced in nature conservation policy. It was decided that the network should be built up in four categories: core areas, nature development areas, ecological corridors, and buffer zones. Core areas had to be of national or international significance. They had to include all the categories of protected areas available in the Netherlands.

Not all areas included in the Dutch ecological network are of high natural value now. Areas offering realistic prospects for the redevelopment of nature are included in the ecological network as nature development areas. They include areas suitable for the development of nutrient-poor wetland, marshland, marshy woodland and alluvial forests. Ecological networks have been developed at the national level, but realised at the provincial and local level (Figure 1). The green network of the Dutch province of Noord Brabant (Provincie Noord Brabant, 1993) is comparable to the national ecological network but functions at the regional level. It is not only part of the nature conservation plan, but also a basic report for the regional physical plan consisting of forests, nature reserves, nature development areas and ecological corridors.

Ecological networks in the Czech Republic

Mainly in central and eastern European countries integrated planning has a strong tradition. Nature conservation as an independent policy had a minor position, but it developed in the framework of physical planning and other forms of integrative planning. In this framework ecological networks consist of several hierarchic levels. It is especially a problem of lack of money for realization and also an organizational problem in connection with changes in ownership of the land. Realization and implementation of the territorial system of landscape ecological stability have their basis in Czech nature conservation law that mentions the ecological network as the core of Czech nature conservation policy (Czech National Council, 1992).

The concept of territorial systems supporting landscape ecological stability (TSLES) was already developed in Czechoslovakia in the 1980s (Miklós, 1992, Bucek and Lacina, 1992). TSLES is built by a network of ecologically important landscape segments purposefully located according to functional and spatial criteria. The existing system of relatively ecologically stable segments - disregarding their functional relations - is considered to be a skeleton of landscape ecological stability. TSLES is formed by selecting the most valuable parts of the landscape and adding missing segments.

The first draft of the TSLES on national (supraregional) and regional levels for the entire territory of the Czech and Slovak Federal Republic has been published in the Atlas of the Environment and Health of the Population of the ČSFR (1992). The newest version (Bínová et al., 1994) is designed on maps on the scale 1:50 000 and 1:200 000 for the whole Czech Republic. It consists of 122 supraregional biocentres (the core area of each of them has about 1000 ha) and 1526 regional biocentres (area of 30-70 ha) connected by corridors. Within the Czech Republic the area of local biocentres is proposed to be at least 1 to 5 ha depending on the type of habitat. The minimum area for water habitats is 1 ha, minimum area for forest and grass communities is 3 ha, and the minimum width of the local biocorridor is 10-20 m (according to the type of communities). Ninety new bioregions substituted cover the entire state territory of the Czech Republic (Culek, 1994). At least one representative biocentre should be chosen in every bioregion.

Criteria for local biocentres are mainly their location and to a lesser extent their representativeness for certain biotopes. Regional elements are selected for their biological diversity. The criteria for the supraregional biocentres are representativeness, location and protection status. The TSLES is based on data on hydrology and climate, species composition, species diversity and edge composition. Data of actual vegetation have been compared with natural vegetation composition and the gene pool. Historical documents (historical maps, air photographs, cadaster data) have been used as a tool to confirm the consistency of the landscape structure and for planning of ecological corridors for both fauna and flora (Lipsky 1992).

Perspectives and consequences

In The Netherlands plans have been developed to realise the scenarios of ecological networks. The question, however, is how realistic the plans are. Van den Aarsen (1994) carried out an ex ante-evaluation of the policy plan concerning the green network in the catchment areas of Beerze and Reusel, two lowland streams in Noord-Brabant (Figure 1). The pivotal question in this research was whether or not the proposals for core areas, corridor zones and nature development areas are adequate in terms of sustainable conservation of the desired ecosystems. Here intensive agriculture is mixed with small areas of nature conservation interest. The study comprised three parts: the conservation of forests and heathlands as core areas, the realisation of corridor zones for forest birds, and the creation of nature expansion areas in stream valleys.

As boundary conditions for the persistence of the desired ecosystems, limits to changes in the environmental preconditions were regarded. Important preconditions are the quality of soil and groundwater and the groundwater table, the minimum viable population size of characteristic species, defined as the population size that will ensure (at some statistical level) its persistence for a specified time, area and spatial heterogeneity indicating the connection with similar ecosystems.

The knowledge of these limits proved to be patchy. The values of the critical loads of acid deposition in nature ecosystems are in part arbitrary. Knowledge concerning limits to desiccation and eutrophication is limited to estimated original values. No general rule for the minimum viable population size can be given. Knowledge concerning the size, location and quality of corridor zones between core areas, required for the dispersal of species, was mostly qualitative.

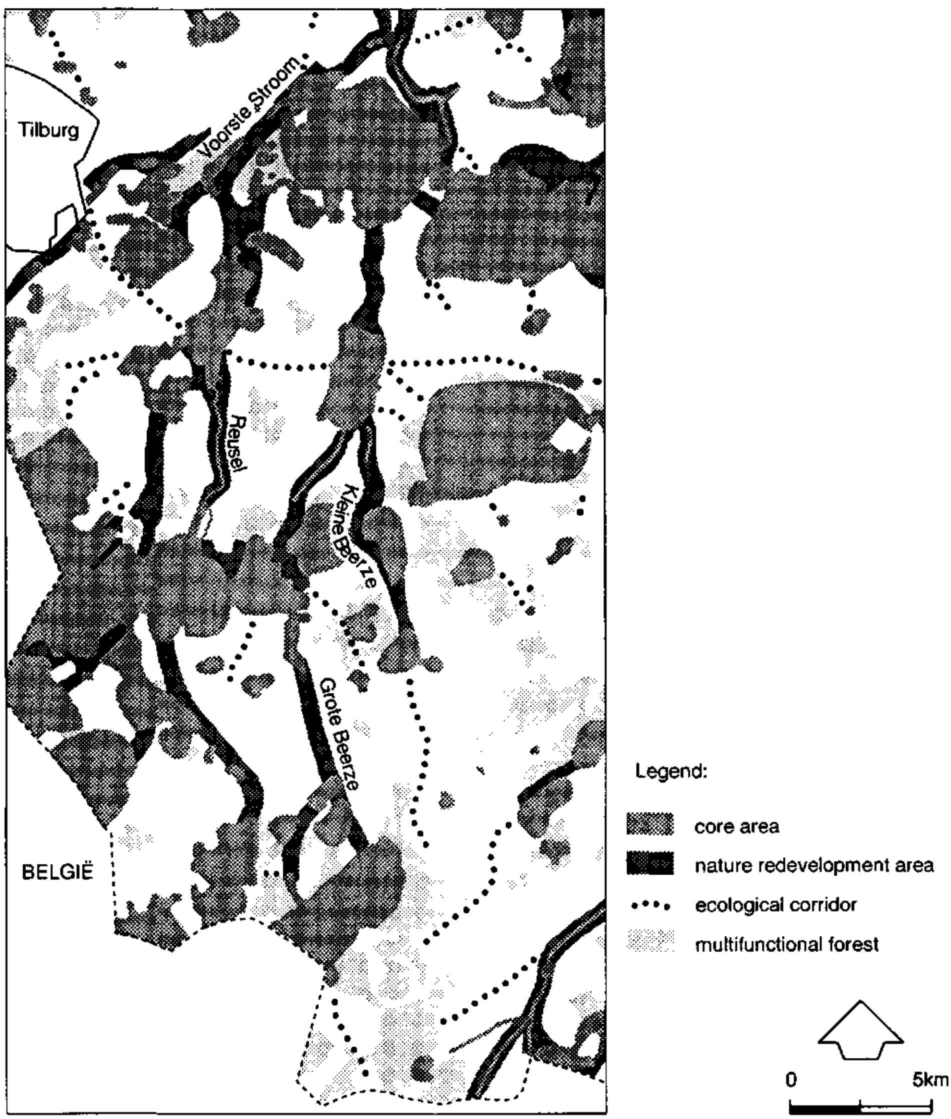

Fig. 1. The green network in the Beerze-Reusel area according to the plan of the province of Noord-Brabant (Van den Aarsen, 1994)

As far as possible, the environmental quality that can be realised on the basis of proposed policy measures was compared with the level of quality necessary to ensure the persistence of nature-ecosystems. The results of this comparison show a big gap between measures and conditions; some ecological conditions have not been taken into account at all. The realization of both adequate corridor zones and nature expansion areas in stream valleys seems doubtful. Lack of both knowledge and instruments hampers the implementation in such a way that it shows that the proposed scenarios for ecological networks have to cope with much uncertainty. It is impossible to give reliable estimates of possible trends in ecological developments in the European landscapes.

On the other hand, meeting the conditions for the quality of nature-ecosystems would seriously affect the outlook for agriculture in intensive farming areas like the Beerze-Reusel area. Besides a reduction in acreage, the consequences include the necessity to reduce the release of nitrogenous compounds and phosphate and the use of ground-water; in some zones the creation of stepping stones and/or corridor zones requires both space and maintenance. Standards for the translation of the conditions for persistence of nature-ecosystems into acceptable agricultural management guidelines have yet to be developed.

The extent to which different agro-ecosystems in the Beerze-Reusel area should be confronted with restrictions, stemming from the intention of realizing a green network, depends strongly on their location with respect to the nature ecosystems concerned. For example, a reduction of the local emission of ammonia is especially necessary in the zones of 500-1000 meters downwind of susceptible nature ecosystems; restrictions in the appliance of manure are important in those agricultural areas from which ground- and surface water flows towards nature areas. On a local scale, a cumulation of restrictions can be expected, because, in order to realize the ecological network, all relevant boundary conditions should be taken into account.

Another question is whether policy makers have anticipated and accepted these consequences for agricultural land use. To counteract unwanted consequences, the design of an ecological network leaving adequate perspectives for agriculture requires tailor-made regional and/or local plans. Moreover, at least in the Netherlands there are nearly no means to stimulate extensive agriculture except for the policy on Environmental Sensitive Areas (ESA) and the policy to stimulate biological farming. That means that the scenario of the ecological networks gives a nice outlook for a better future, but it is difficult to achieve results.

In the Czech republic there is a rather clear separation between the intensive farming zone and the areas of low intensive farming. There is now a beginning of a national policy on rural areas dealing with recent problems. Some segments of TSLES might only be selected on local level (ca 2-3 % of the total land) especially in the intensive farming area, and the farmers shall be financially compensated for it. On less fertile soils and in less favourable climatic conditions it will be easier to develop the ecological network. Especially in zones of drinking water production, protected areas for water management, which are concentrated in highlands and sub-mountaineous regions, the area of semi-natural grasslands can be extended and reach about 30 percent of the total land, and in this way it will have positive effects on water quality, landscape stability and erosion. In the mountains higher than 600-700 m above sea level, marginalization of agricultural land is becoming a problem resulting in disappearing of characteristic features and aesthetic values of the traditional rural landscape. State subsidies in these regions have to be oriented to maintaining landscape, keeping aesthetic and environmental values and supporting human activities like agrotourism keeping rural communities alive. Special regional programmes could help to avoid abandonment of the land.

Economic conditions such as overproduction of most basic food products and free market rules are driving forces for land use changes. The common agricultural policy (CAP) of the European Union but also the official environmental policy of the Ministry of Environment and the Ministry of Agriculture of the Czech Republic are now beginning to be directed to the reduction of subsidies on agricultural production and slowly to support landscape multifunctionality to keep traditional settlements in the rural landscape. Serious changes in land use and landscape structure are expected in the near future. It is estimated that in the Czech Republic about 15 percent of the total agricultural land will be available for set-aside programmes. Land use policy of the Ministry of Agriculture declares to subsidize afforestation on agricultural lands and conversion of arable land into grassland. Great regional differences in land use development depending on natural conditions, especially on soil fertility and land suitability for agricultural production, will prevail. Only in the most productive agricultural regions like the Bohemian and Moravian lowlands, which are able to compete within Europe in food production, intensification of agricultural production can be expected. Changes in ownership directed to privatization of the land has not changed the main features of the Czech rural landscape till now. Large collective open fields and low landscape stability prevail at least in the major farming areas.

Towards an Ecological Network for Europe

In the last decennia of the 20th century, a change took place in nature conservation policy both in East and West. Planning of ecological networks within a wide diversity of planning systems and political different systems is the result. There is a perspective to merge the national and regional networks into one system without denying the political differences. Scenarios on nature conservation can take into account the ecological, social, economic and political differences in Europe.

It is one of the policy objectives to conserve nature, landscapes and open spaces within a re-establishing Europe where new economic developments are immanent and where boundaries become less and less important. We must be able to develop Europe in such a way that there is a potential for urban development, transport systems, agricultural development and forestry and where is still enough space left for nature. It appeared possible to develop such a plan for the European Community claiming about 30% of the European territory (Bischoff and Jongman, 1993). Confrontation with claims for agriculture and forestry showed that this seemingly enormous claim can be reality without great economic conflicts (Netherlands Scientific Council for Government Policy, 1992).

Within a claim for nature for Europe there are ecological differences. There are biogeographical differences; it is not correct to compare the Irish flora with the

Portuguese flora, because one is Atlantic and the other Mediterranean. Due to its history, climate and geomorphology the Portuguese flora is richer. The importance of the Irish flora is in its heathlands and bogs. However, there are gradients in vegetation as for instance from the Irish heathlands onto the Portuguese (Atlantic) heathlands and Mediterranean shrubs (Oudhof and Barendregt 1987). These gradients show that nature in Europe must be approached as one system.

There are social and economic differences within Europe. The border between Slovakia and Poland can easily be observed from air: the parcel size differs about one hundred times. In Slovakia there was a land reform in the 1960s, and in Poland there was no land reform. That causes differences in nature and in economic perspectives. Should we wait until the Portuguese and the Polish are rich enough to pay the expensive nature management or should we be prepared to think of better ways to conserve this agricultural land and nature now?

Planning of nature will be as important as the planning of agriculture, infrastructure and urban areas. There is a good perspective for the realization of such a nature conservation policy. A European scenario must be built with the help of a diversity of planning methods which varies between countries and within countries. This requires not only a physical network, but also a planning network, financial and legislative instruments and a network of cooperating politicians, planners, land users and scientists. The European ecological network is built from these local, regional and national bricks.

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13.2 Nordic countries: scenario studies and nature development policies

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Abstract

The Nordic countries have proposed a common action plan for nature conservation. The plan is based upon common practice, a number of international conventions, agreements and recommendations which all or most of the Nordic countries have signed. The paper describes how habitat loss, pollution and disturbance are the three main threats to wildlife and environment. It describes the principles in the plan and suggests that they now are being "translated" and applied in a Nordic context. The proposed plan presents eight politically formulated objectives for a better and more holistic management of wildlife and natural resources. All species, habitats and landscapes should be included. Nature protection should be an integral part of mainstream public policy and planning as well as an integrated part of the natural resource based production sectors. It should involve all people and be both far sighted and global in its view.

Keywords: *nature conservation, action plan, wildlife, natural resources, principles*

Introduction

A scenario may be defined as a coherent picture of a possible future. This may not be true of the present study. The scope is, however, similar in the way in which it looks upon present state, possible futures and how to reach them. The objective is to develop policies for nature protection that are able to cope with the present and coming challenges of a withdrawing agriculture and an ever expanding urbanity in the rural landscape. The purpose is not only to activate governments and officials but also to help people to think in another way than today.

Changes in the EU Common Agricultural Policy, political changes in Central and Eastern Europe, expected decisions within GATT/EU and wishes among non-member countries in the North to become members have all developed within a few years time. These processes have stimulated the need of an inter-Nordic policy and approach to nature protection and natural resource management. (The Nordic Countries consist of Denmark, Finland, Iceland, Norway and Sweden plus the three autonomous territories: Faroe Islands, Greenland and The Aaland Islands).

In 1991 The Nordic Council asked the The Nordic Council of Ministers to develop a proposal for a Nordic action plan concerning the protection of nature. The Standing Committee for Environmental Affairs (Nordisk Ministerråd 1993) therefore took the initiative to form a task force consisting of members from the ministries in each country. It started in late 1991 and finished its work by the end of 1994. The draft report by this task force is the main source for the present contribution (Johansson 1995).

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Originally, the proposal should have had the status as a "proposal for the council" formally approved by the council of ministers. During the process, however, this has been changed to a far less binding status as being "basis for trans-sectorial cooperation" to be taken up in the negotiations with other committees and giving input to a general debate on nature protection to be taken up in 1995 at a meeting attended by the ministers of environment and the committee for the environment within the Nordic Council.

The Nordic countries are indeed very different, but they also share a great deal of similarity. Total size of the area is 3.5 million square kilometres where Greenland covers 2.2 and tiny Faroe Islands only 0.0014. The total human population is 23 million with 8.5 million Swedes and 30 000 Faroe islanders. Compared to Southern and Western Europe population density is rather low. Large areas remains without significant human impact.

Natural resources are unevenly distributed. Weather, wildlife and landscape vary from densely populated undulating rural landscapes in Denmark and southern Sweden to the wildlands of arctic tundra, glaciers and high mountains in Norway and Greenland.

On the other hand, the Nordic countries also have some important traditions in common. In particular, their linguistic, cultural and political history are alike over large areas and across borders. The Nordic countries also have a long tradition for nature protection, and basically similar administrative structures, i.e. rather similar physical planning in both substance and in procedure. This includes a detailed and sometimes thorough hearing system, and to the contribution of interest groups to the planning process.

Trends and challenges

A broad and quantified documentation of the state of the Nordic environment was issued by the Council of Ministers in 1993 (Bernes 1993). This report gives the following summary of the situation:
"Various forms of physical interference in the landscape - modern methods of forestry and farming, road building, hydroelectric schemes and other forms of exploitation - represent the biggest threats to biological diversity and attractiveness, at least in the short term. In this respect, the environmental situation of the Nordic countries and other Western industrial nations differs very little from that existing in many other parts of the world, such as the tropical rain forest belt, about which so much concern is felt."(Bernes 1993)

Whereas the problems with greenhouse effects, ozone layer, acidic rain and radioactivity to a large extent come from outside, the same may not be said about eutrophication which results in severe problems in agricultural areas and their surroundings in all the Nordic countries. In fresh water and in closed parts of the sea, and nowadays also in the open sea, the result may be oxygen deficit and death of organisms that live on the sea bed (Fig. 1b), and in terrestrial environments loss of plant and animal species.

Eutrophication is only one of the problems with modern agriculture. In agriculture as well as in forestry the tendency is an ever increasing rationalization. Larger machines, larger fields, larger farms, larger clear cuttings and the use of labour-saving means like pesticides have impoverished the rural landscape.

Natural and semi-natural habitats have decreased drastically not only in the traditional intensively cultivated landscapes as in Denmark and southern Sweden, but also in extensively used agricultural areas. In all countries semi-natural areas like heath land and permanent pastures have also recently been lost to cropland. In Iceland and Finland thousands of hectares of meadows, mires and forest swamps have been drained. The severe loss of habitats for wildlife that has been going on for decades and even centuries in some regions has meant a serious fragmentation of landscape pattern as well as populations of animal and plants. Consequently, there has been a decrease in biodiversity.

Recently, the trend has changed in many parts of Scandinavia. In the most intensively cultivated areas the different schemes for set-aside have relieved the pressure on wildlife. Also, the further reduction of natural and semi-natural habitats has slowed down. In the less intensively used areas, the marginalization and abandonment of land has, however, turned out to be a serious threat to the traditional agricultural landscape with its cultural and aesthetic values and its biodiversity.

The trend has also recently changed in forest areas. Falling prices on the world's pulp market and increased competition from Eastern Europe and Third World countries have contributed to a broader and deeper consciousness of the ideas of multipurpose use of the forest landscape and to a better protection of biodiversity.

Compared with the effects of physical interference, the impact of pollution is limited. In the Nordic region, industrial emissions were as uncontrolled a few decades ago as they still are in Eastern Europe, but now they have generally been very substantially reduced (Bernes 1993).

Pollutants with a long life can disperse over large areas. The dominant air pollution problems of the Nordic region are those resulting from long-range pollutants transported from other countries. Acid rain has killed the fish in thousands of lakes in Sweden and southern Norway (Henriksen et al. 1990). The environmental effects of air pollutants that have dispersed on a global scale are still moderate, but they could become a dominant threat in the next century. Increasingly, the Nordic countries' own contributions to global pollution of air and water and their remaining local pollution problems are the result of their inhabitants' way of life.

The distribution and severity of pollution impacts vary from country to country even where the source may be the same, i.e. the greenhouse effect, the thinning of the ozone layer, acid rain and the radioactive fallout from the Chernobyl disaster (Fig. 1a). In general, the problems are more pronounced in the southern part of the Nordic countries, but some problems seem to increase the further north one goes. In some cases this may be explained by the simplicity and therefore clear-cut cause-response that can be observed here compared to the more densely populated, intensively used, and therefore more complex ecosystems further south. But in other cases the explanation has to do with the sensitivity of the fragile arctic and sub-arctic environment.

After habitat loss and pollution, increased disturbance by human activities is the third important trend to be mentioned. Each spot of the North Sea bottom is on average covered 1-2 times a year by a fishing trawl (North Sea Task Force 1993). Each square meter of agricultural field in Denmark is on average sprayed 2-3 times a year with pesticide. To this "professional" disturbance can then be added the disturbance from outdoor recreation, from mobile homes, off-roaders, snow-scooters, jet-skis, sailing boats and airborne vehicles of any kind. The new forms of transportation and the more frequent visits are a threat to wildlife, especially in sparsely populated districts (Nordisk Ministerråd 1994).

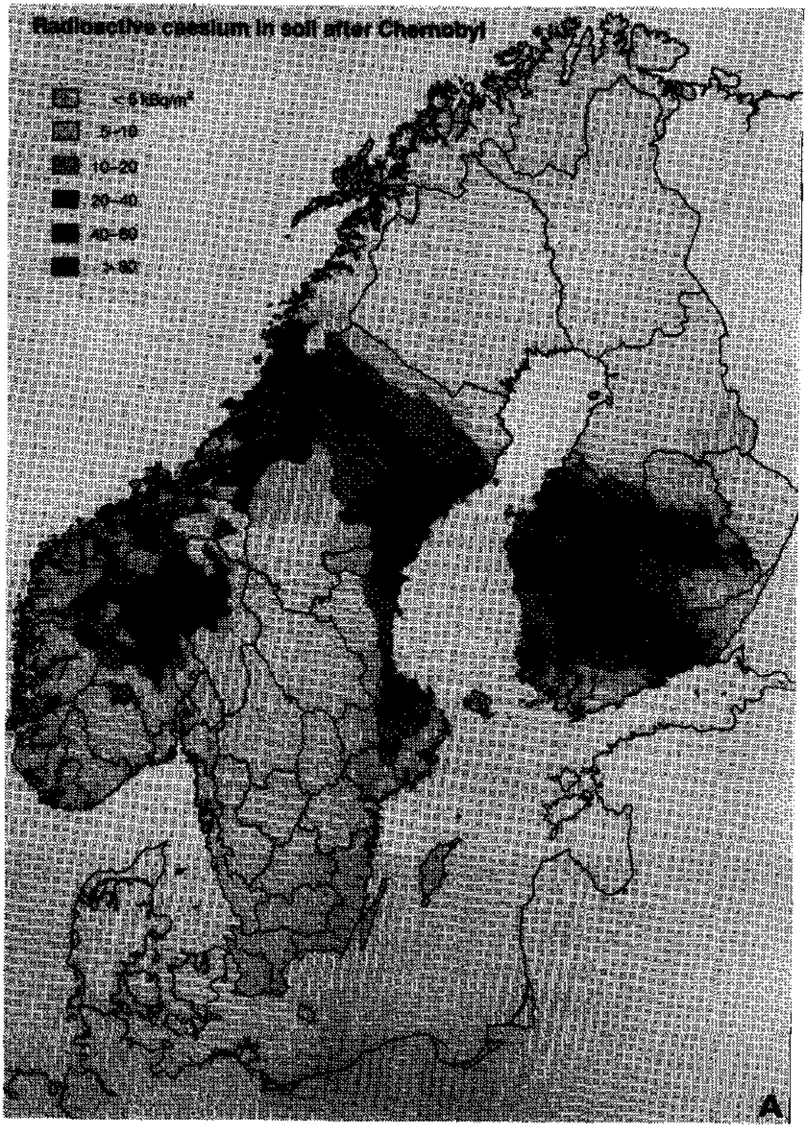
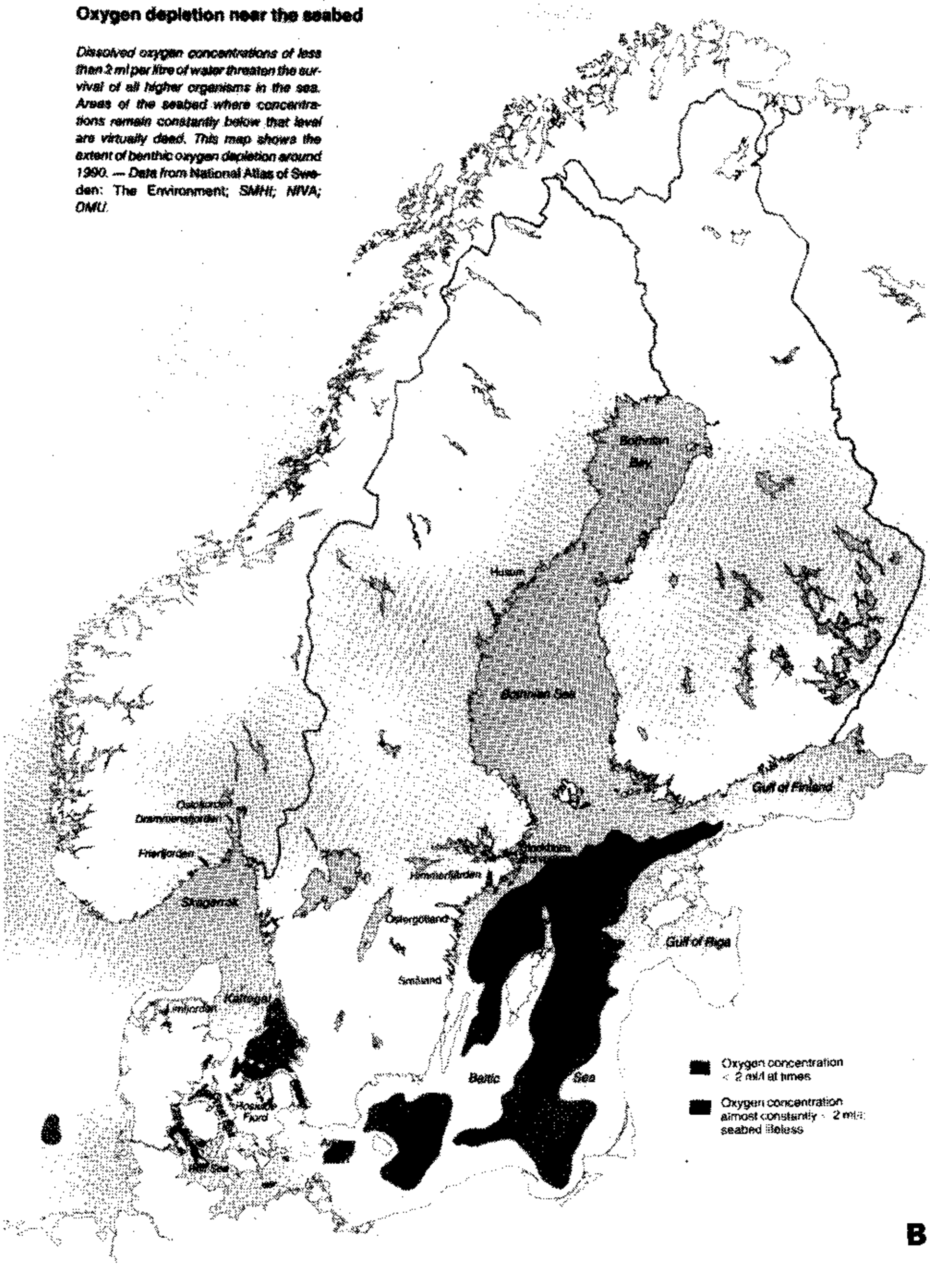


Fig. 1A Radioactive cesium in the soil after Chernobyl. Map showing the average concentration of caesium in soil in each municipality following the accident in 1986 (Bernes 1993).



B

Fig. 1B Oxygen depletion near the sea bed. Dissolved oxygen concentrations of less than 2 ml per litre of water threaten survival of all higher organisms in the sea. This map shows extent of benthic oxygen depletion around 1990 (Bernes 1993).

But tourism and outdoor recreation are not only a disturbance in the same way as pollution and habitat loss. Tourism and outdoor recreation represent an even more dominating and conscious way of using the landscape, as a space for physical exercise, social activity, and discovery. This process might, for several years, have been much more pronounced in other countries. Nature management should no longer just preserve as much as possible of what still remains of wildlife and undisturbed landscapes for the benefit of scientific and historical interests. Increasingly, it shall also guarantee supply and admittance to sufficient "playing grounds" for modern outdoor recreation.

The task is now to keep and create variation and opportunities for discovery in the landscape without interfering with the authenticity of the object or the landscape where it is located. Even far from the nearest city, urbanity is also in this indirect way expanding its influence where agriculture is withdrawing.

Nature conservation has now three main tasks. Beside preserving **wildlife and landscapes** it should contribute to the maintenance of the **ecological services** that regulate the stability of biosphere and create and maintain **opportunities** for recreation.

Weighing the threats

Bernes (1993) tries to weigh up, as far as possible, the different environmental threats and assess which of them are most serious. This has been done for the seven types of landscapes into which the different parts of the whole territory have been classified: forests, mires, heaths and mountains, farmland, lakes and watercourses, coasts and seas, towns and transport networks.

For each landscape type this has been done in relation to four themes: biological diversity, natural resources, attractiveness and (human) health. The result of the weighing is presented in four diagrams (Fig. 2) where the problem is "plotted" according to how widespread it is (the vertical axis) and how severe its detrimental effects are when it does occur.

Weighing threats is tricky. First of all, the ranking will depend on how you delimit the subject. All things being equal, will for example pollution with heavy metals be a more serious problem than pollution with for example mercury, which is just one out of these pollutants. Furthermore, the ranking must be a result of a multidimensional analysis including a geographical scale, a time axis, the degree of reversibility and other measurements of the seriousness of the impact in itself. And these should be seen in relation to the environment and society in which the problem develops.

Therefore, such estimations leave ample room for subjectivity, which again depends on the physical, economical and cultural distance between the estimator and the phenomenon he is analysing. Bernes underlines this by saying: "The diagrams should be seen only as an initial attempt to outline the major threats, with room for further development in several respects" (Bernes 1993).

A reader coming from a warmer and more densely populated part of the world should be aware of the quite different spatiotemporal dimensions of the environmental problems in the Nordic countries. The further north we go, the more widely the effects are often distributed and the longer the time will often be before the ecosystems have recovered from any damage. For instance the track of an off-road vehicle in the fragile cover of lichens can remain dozens of years.

The way in which the proposed action plan has been produced is, beside taking notice of the report cited above, a simple and straight forward collection of information in each country on existing practice, commitments and visions. Thereafter, the information was systematized, edited and revised in eight issues, and in two rounds submitted for comments in relevant ministries and organizations. But the text has not been the subject of negotiations with other sectors as such. Therefore, the plan is to be considered as the nature management sector's own proposal for a sustainable management of biodiversity and use of natural resources in the Nordic countries.

The scope is not only to activate governments and governmental bodies to whom more than 80 endorsements and recommendations are given, but also to help people to think in another way than today. Therefore, the presentation and discussion of guiding principles have been given high priority.

Concepts and principles of the action plan

The central concept in the plan is **sustainable development**, which means that the natural resources and the landscape can be used to meet present needs without compromising the possibilities for coming generations to satisfy their needs (World Commission 1987).

The plan requires a responsible household with renewable and non-renewable resources, and also a safeguarding of biodiversity and natural processes in the landscape and in principle in all landscapes. This should be done in the way that the **biodiversity** is maintained at its present state or increased, and multipurpose use of the rural landscape should be stimulated.

As guidelines for how to achieve an adequate management, a list in hierarchical order, of well known **guiding principles** for wise use is suggested. These are to be applied (in consecutive order) where and whenever new activities that might have significant impact on the environment are considered. These are

- the principle of careful decision-making,
- the principle of avoidance,
- the precautionary principle,
- the principle of translocation,
- the principle of compensation,
- the principle of restoration,
- the principle of best available technology (BAT),
- the principle of best environmental practice.

To these are added the polluter pays principle (PPP), the user pay principle (UPP) and the principle that the burden of proof should rest on the party intending to affect the environment, not on the party opposing the alterations.

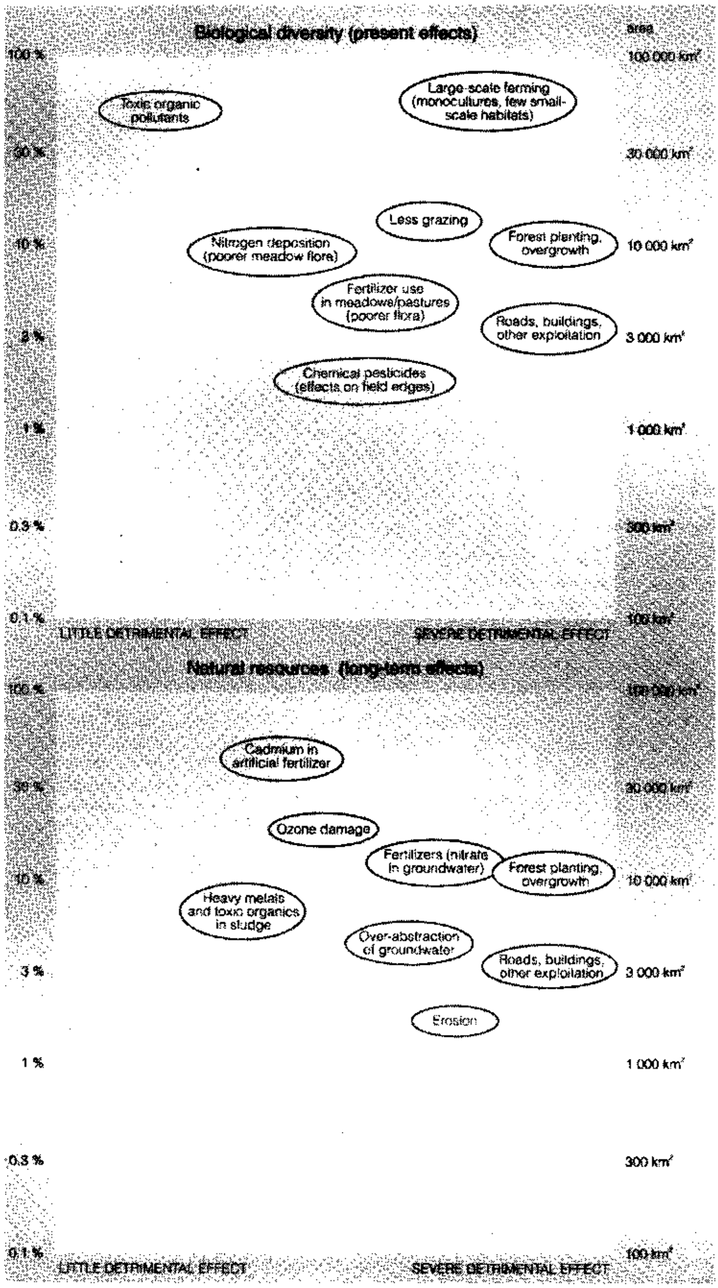


Fig. 2. Threats in the agricultural landscape. Modern farming itself is far and away the most serious environmental threat to the agricultural landscape as it was at the beginning of this century (Bernes 1993).

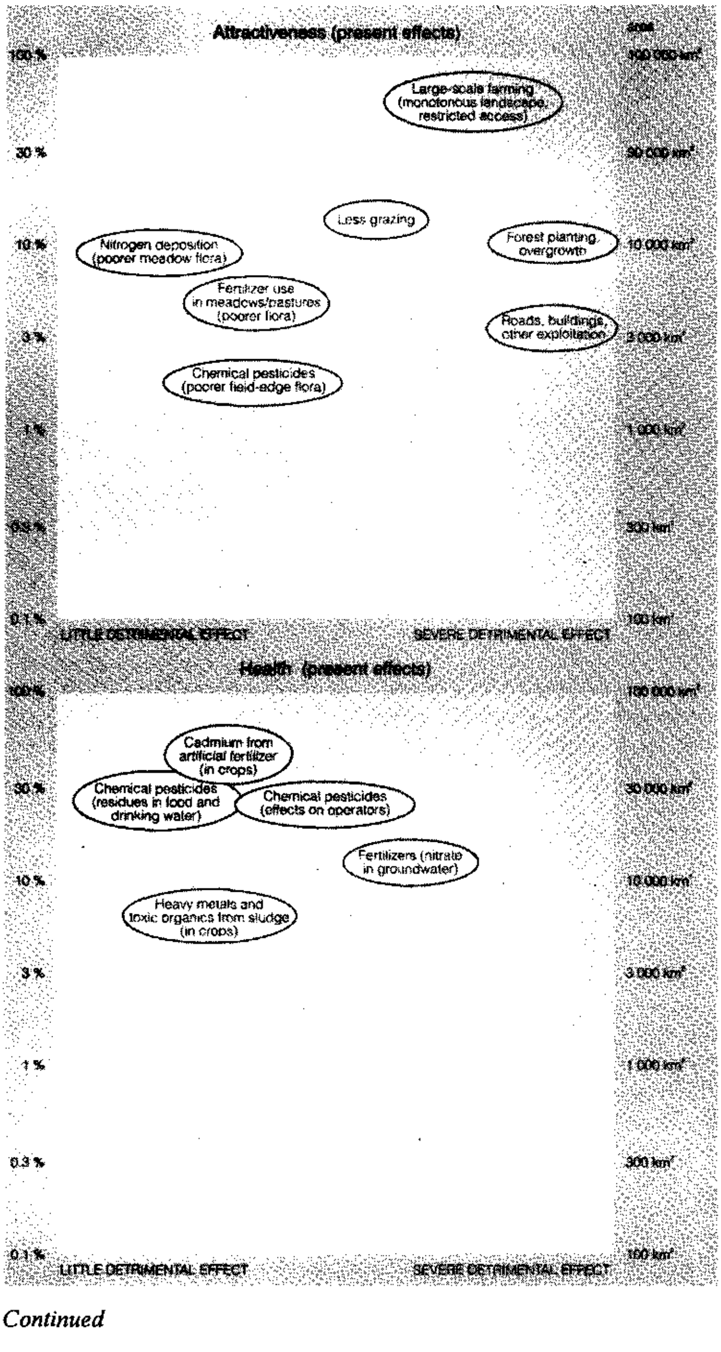


Fig. 2. Continued

Sector integration means integration of responsibility for wildlife and environment into each productive sector in the society. It is the other cornerstone of the suggested action plan. Like the concept of sustainable development this is also propounded by the Brundtland Commission and it is a commitment for all the signatories of the Convention on Biodiversity. All Nordic countries are preparing (or have already finished) country reports on status of biodiversity in the country and on how it is or will be safeguarded in the future. To varying degree these reports also include action plans for each sector (agriculture, forestry, etc.).

To the responsibility for the sector is attached the request of **environmental impact assessment** (EIA) where and when new significant enterprises in the environment are considered. It is suggested that EIA should be used more in agriculture and forestry, for example when the introduction of new crops or new methods of cultivation are being considered.

The authorities and organisations with environmental protection and management duties are considered as a sector like the other sectors. But at the same time they are considered superior to all other sectors when it comes to more general guidance and control with the state and needs in the environment.

In this way it is proposed that each sector according to some general guidelines from the environmental sector adjust the principles, implement them in the sector in order to make the daily production more friendly towards the environment, wildlife and landscape. An important way of protecting habitats that increasingly is being used in the Nordic countries is the **general protection** given in the law of certain types of biotopes and species without any compensation having been paid to the owners. In Denmark, for example, all permanent grasslands, heaths, and bogs larger than 0.25 hectare are protected in this way (Koester 1984).

Together with the **comprehensive physical planning system** that regulates land use including raw material extraction and water resource protection, these instruments are expected to give sufficient protection against unintended changes in the major part of the landscape (Koester 1994).

Besides supervising the other sectors the environmental sector should itself be responsible for **special protected areas and protected species**. Together with sector integration and physical planning, special protected areas and species are considered as prerequisite for achieving sustainable development. Compared to what traditionally has been done in this field, the importance of having **natural processes** as much or even more in focus than the structures is underlined. It is considered as the best way to keep the rural landscape alive and able to deliver its part of ecological services including being habitat for wildlife.

Another aspect underlined is the importance of using **authenticity** as a guiding principle for what is being aimed at in the protection of areas and species. The more authentic the better; for example a natural pond is better compared to an artificial one or a spontaneous immigration population compared to an introduced one.

Finally, two more principles in the proposed plan should be mentioned. They have directly to do with people. The one is the principle of **subsidiarity**, which in accordance with the Brundtland Commissions recommendations for sustainable development stresses the importance of involving the people that are affected negatively by a development in the decision processes. But it also includes a broader involvement of citizens in environmental affairs. Nature protection and management should involve people as far up in the country and as low down in the social hierarchy as is deemed sensible. A site-specific and consensus-oriented process is thus given priority.

On the other side the Nordic countries are rather centralized in the sense that when a decision or plan (as the present proposal) has been approved, then it will be implemented. This also explain why a plan (like the present) often has to be under debate in several rounds before it can be approved (Primdahl 1990).

The other is the principle of the individual's **free access** as long as it does not seriously disturb land-use interests or privacy. This, of course, has much to do with historical traditions and a relatively sparse population. In Greenland nobody is allowed to own land and thus keep other people out. But generally there is also rather freer access to private land in the Nordic countries than in others. In Sweden for instance it is a right to be able to camp, pick mushrooms, berries and on many large localities, e.g. at the coasts and in the five largest lakes, to fish. The suggested action plan wants to maintain and even in some places widen these rights.

Problems

The proposed action plan for nature protection is a first generation product. For the first time the attempt has been to present a coherent proposal covering all five nations and three territories at a time. Therefore, it may not be surprising that the plan has already met problems. As said previously it has not obtained the status originally planned.

There has not been enough time for negotiations with the relevant sectors. This has to do with the broad subject. Compared to other action plans, for example IUCN's "Action for Protected Areas in Europe" (IUCN 1993), the Nordic plan covers not only protected areas but the whole range of ways and means to manage wildlife and natural resources. But it has of course also to do with political contradictions between sectors and between trade interests and public authorities.

Large differences between the countries and regions makes things complicated. For example, the view on how whales should be managed is not the same in a traditional whaling community as in the suburbs of a capital. It is stated in the Nordic Council of Ministers strategy for the environment (Nordisk Ministerråd 1994/Miljøministrene), that cooperation in any matter should go as far as the most advanced party. Experience has taught us that the outcome can sometimes be either the contrary or a status quo.

Conclusion

The strategy can in a popular way be formulated as eight political statements:

1. The plan should cover nature as a whole, in the sense that it is not only rare and threatened species and types of habitats that should be subject to management but also common species and ordinary habitats, and not only the structures but also the processes are of importance.

2. The plan should cover all landscapes, not only the species-rich natural or semi-natural sites. Also in the landscapes where the production of goods takes place and in the urban landscape and in the sea is there a need for management.

3. The plan should be a part of a whole, in the sense that it should be an integrated part of the rest of a physical planning system and management of the environment with its cultural as well as natural content.

4. The plan should be integrated into all sectors, both into the productive sectors like agriculture, forestry and fisheries and into sectors like transport and recreation.

5. The plan should lead to involvement of all people, in the sense that it should be something that both offers the citizen opportunities for influence and requires something back for him or her to do or not to do.

6. The plan should be for the benefit of all, in the sense that it safeguards accessibility and varied outdoor recreation, as an important part of Nordic culture, and contributes to the quality of life.

7. The plan should be valid for all periods of time, in the sense that it should be far sighted - more far sighted than we are used to, in order to safeguard a good framework for a continuation of long term processes such as the biological evolution.

8. The plan should be for the whole world, in the sense that it ought to be considered at all levels from the local ecosystem to the global biosphere. The Nordic Countries should thus work for nature protection and in mutual understanding both nationally, inter-Nordic and at a broader international and global scene.

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Johansson, C.E.(ed.) (1995). Nordisk Naturvård. *TEMA NORD*. Nordisk Ministerråd. Köpenhamn. in prep. It inform that the project group consists of C.E.Johansson (chairman) and J. Terstad (S), P.Agger (DK), A.Haapanen and L.Nordberg (SF), T.Thoroddsson (IS), O.Skauge (N) and P.Nielsen(GRL). Besides the project report mentioned also a booklet will be issued by Nordisk Ministerråd, giving the strategic parts of it (in English and the Nordic languages).

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Nordisk Ministerråd (1993). *Nordic Cooperation Organs 1993/94.*Copenhagen. It explain that *The Nordic Council* consists of 87 parliamentarians. Since 1955 it has taken initiatives and given advice in matters that could strengthen nordic cooperation. It has 6 standing committees. One of these is The Environmental Commission. The Nordic Council of Ministers is a parallel cooperation among the Nordic governments. It has 17 committees of Senior Officials one of which is The Committee for Environmental Affairs, which again has 5 working groups one of which is The Working Group for Nature and Outdoor Recreation, which has been responsible for the project.

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CHAPTER 14

Case Studies

14.1 Nature development in the delta of the river IJssel, The Netherlands

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Abstract
In order to investigate the possibilities for nature development in the delta of the river IJssel (Lake Ketelmeer), a scenario study is carried out. The selected scenario that is worked out in detail can be characterized as a fresh water throughflow marsh. The multicriteria analysis that has been used showed it to be an useful tool in selecting the most preferable scenario.
Keywords: *nature development, scenario study, freshwater delta, river IJssel, Ketelmeer, multicriteria analysis, throughflow marsh*

Introduction

The third Dutch National Policy Document on Water Management describes what water management should look like around the turn of the century (Ministry of Transport and Public Works, 1989). This policy can be summarized as to have and maintain a safe and habitable country as the prior condition and to develop and maintain healthy water systems which guarantee sustained use. Nature development projects in the rivers area contribute to this concept of Integral Water Management.

In The Netherlands the strategy for nature conservation is related to a National Ecological Network (Ministry of Agriculture, Nature Management and Fisheries, 1990), which consists of:

- core areas:	nature areas with ecological values of (inter)national interest;
- nature development areas:	areas planned to become part of the core areas by means of nature development;
- ecological corridors:	corridors between core areas to be made suitable for migration of species.

In order to investigate possibilities for nature development in the delta of the river IJssel (Lake Ketelmeer), a scenario study is carried out. After weighing the ecological, environmental and landscape perspectives against the impacts of scenarios on various other functions and interests, one scenario is chosen and worked out in more detail. The

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goal of this nature development project is to attain a natural freshwater delta of the river IJssel (1100 ha), i.e. a wetland of major (inter)national interest.

Method

In this scenario study the following steps are carried out:
- drawing up of scenarios;
- judging of impacts for each scenario;
- weighing the scenarios;
- selecting one scenario to work out in more detail;
- optimizing the selected scenario.

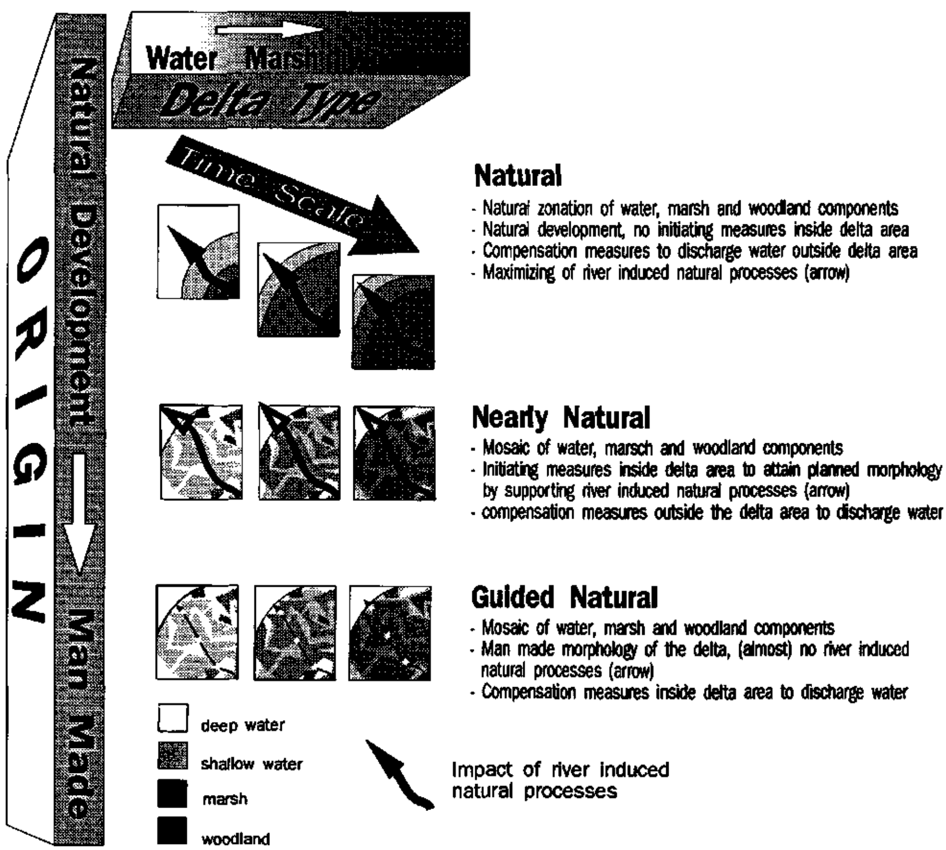

Fig. 1. Scheme of scenarios

Scenarios

Nine different scenarios are drawn up according to two tracks, namely the origin (genesis) of the delta and the delta type to be attained (Figure 1). According to the origin track, a guided natural, a nearly natural and a natural development are distinguished. In this order there is a successively decreasing human intervention in both the origin and management of the delta. Furthermore, according to the delta type track, there are three delta types in which respectively -shallow- water, marsh and woodland dominate. The nine resulting scenarios can be regarded as 'extreme' theoretical possibilities. Analysing these scenarios will therefore lead to a wide range of conceivable impacts and measures involved in realizing nature development in this area.

Impacts

In order to judge impacts of the scenarios, a set of criteria has been selected (table 3). The impacts themselves are based on both quantitative estimations and qualitative reasoning (expert judgement). Special attention, however, is paid to the impacts on the upstream waterlevels in various cases of high water discharge. In this low part of The Netherlands, water flooding over dikes can cause severe damage to property and livestock. To predict resulting waterlevels both simple and advanced hydraulic models are used.

Weighing and selecting

In this paper we will confine ourselves to explaining the general idea of the multicriteria analysis (MCA) used as a decision-support tool for weighing and selecting scenarios. The applied MCA works with two kinds of information, namely information on technique and information with regard to policy.

In order to select the most preferential scenario it is necessary to know the impacts of the scenarios (technique) at first. With solely technical information, however, it is difficult to reach an agreement on the most preferential scenario. Each interest group will weigh the impacts on the criteria differently. In this knowledge some visions are drawn up (policy). For each vision, a different sequence -weighing- of the selected criteria is used, according to the importance attached to them by the interest groups (Table 1). In this study the visions are assessed by the members of the project group (policy makers). In vision 1 criteria related to 'nature and environment' and 'landscape' are weighed highest. In visions 2 and 3 criteria related to 'economic use' and 'costs' are weighed highest, respectively. The criterion 'nature and environment' is weighed high in each vision, which is self-evident in the case of a nature development project.

Table 1. Some applied visions

vision 1: ECOLOGY	vision 2: ECONOMY	vision 3: COSTS
nature and environment	economic use	costs
landscape	nature and environment	realisation term
sediment input	sediment input	nature and environment
realisation term	costs	economic use
costs	morphological development	sediment input
morphological development	landscape	administrative procedures
administrative procedures	administrative procedures	morphological development
economic use	realisation term	landscape

On the basis of the complete table with impacts on judgement-criteria, the scenarios are placed in the preferred order for each vision. For this purpose a calculation with the EVAMIX-algorithm (Voogd, 1982) was used in the MCA. This particular calculation analyses the two different types of information -technique and policy- in a methodically reliable way.

Results

Selected scenario

According to the ecological vision (Table 1) a marsh delta was clearly pointed out to be the preferential delta type. This can be explained by the presence of large areas and a great diversity of ecologically preferred ecotopes for this particular area. These are shallow water, bullrush or reedmarsh, woodland and small streams with running water. Of these marsh deltas, only the guided natural marsh delta reached high preferences when other visions were applied (Table 2). The main reasons for this are that in both natural and

Table 2. Results of multicriteria analysis

	Natural deltas			Nearly natural deltas			Guided natural deltas		
Visions	water	marsh	wood	water	marsh	wood	water	marsh	wood
1. ECOLOGY	7	3	9	6	2	8	5	1	4
2. ECONOMIC USE	5	9	7	6	8	4	3	2	1
3. COSTS	4	6	9	5	8	7	1	3	2

1, 2, 3 etc. preference order

guided natural very high costs and complex administrative procedures are involved in realizing compensation measures outside the delta area in order to prevent upstream floods in cases of extreme water discharge.

So, in general, the guided natural marsh delta appeared to be the most preferable. Therefore, this scenario was selected to be worked out in more detail. Some aspects concerning nature and landscape, however, are less than optimal when compared with a natural development of a marsh delta (Table 3).

Table 3. Impacts of some scenarios compared to the present situation (simplified)

criteria	natural marsh delta	guided natural marsh delta before optimization	guided natural marsh delta after optimization
- nature values, natural processes, environment	+++	+	++
- landscape	+	0	+
- sediment input	0	++	+
- realisation term	--	-	-
- economic use[1)]	--	-	0
- costs	0	-	-
- certainty of morphological development	-	0	0
- administrative procedures	-	0	0

1) such as recreation, agriculture, culture of reed, professional fishery
Relative to present situation:
0 = neutral or nearly neutral
(-)- = (strongly) negative
(+)+ = (strongly) positive

Optimized scenario

Optimization of the guided natural marsh delta is carried out for the following aspects:

- dimensioning of the morphology (riverbeds and upthrown sediments) based on calculated water levels (hydraulic model) in order to prevent upstream flooding of agricultural fields and the city of Kampen in cases of extreme water discharge;
- maximizing the area of a coherent marsh ecosystem by concentrating the water discharge in one river channel and replacing this main river channel to the southside of the delta;
- attaining waterflow-induced morphological processes inside the marsh ecosystem by creating small streams and zones of shallow water;
- retaining wind-induced morphological processes at the westside of the delta as much as possible by throwing up 'natural' sandbanks instead of using breakwaters;
- spatial design of a natural zonation with woodland, marsh and shallow water from

the sides to the centre, respectively, to maintain current landscape values related to the openness of the delta;
- incorporation of functions like water recreation, professional fishery and eco-tourism, by concentrating limited activities of these functions along both the main river channel and the margins of the delta area.

The guided natural scenario, before and after optimization, is compared with both the natural scenario (marsh delta) and the present delta (Table 3 and Figure 2). The working out of the optimized guided natural marsh delta led to a spatial design (Plate 12b) and a detailed description of measures to be taken in the delta (Tauw Milieu bv, 1994). In average conditions approximately 55% and 45% of the river water entering the delta will be discharged to the Ketelmeer by the main river channel and small streams/shallow zones, respectively. During high floods this latter percentage increases up to 70%. The optimized delta can therefore be characterized as a throughflow marsh.

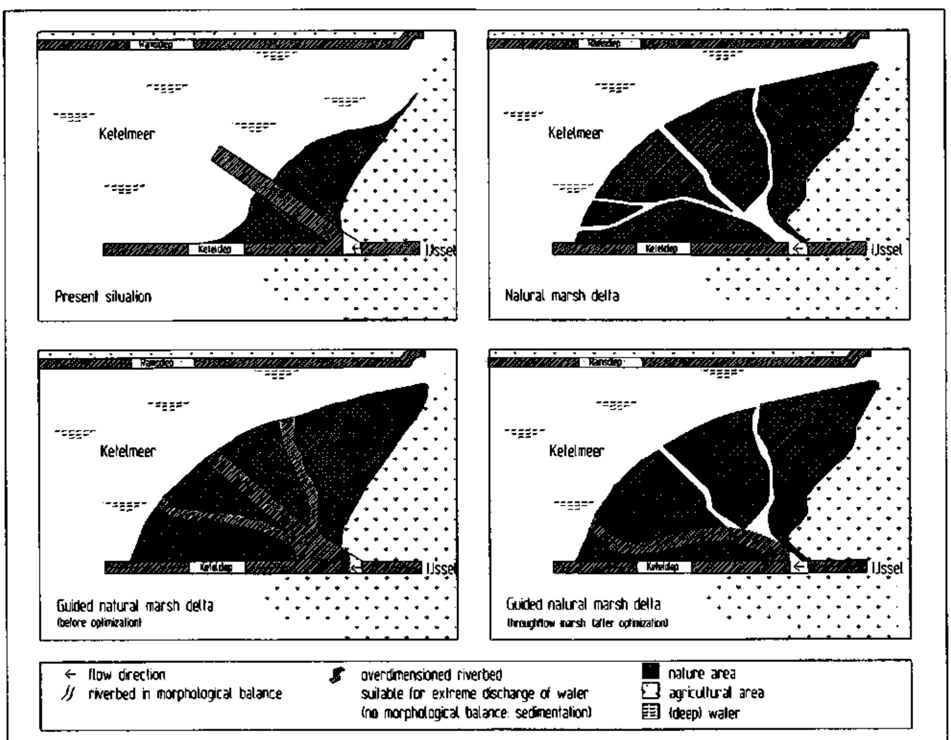

Fig. 2. Actual situation and some scenarios (simplified)

Conclusions

The scenario study concerning nature development in the delta of the river IJssel led to a preferred scenario that can be characterized as a freshwater throughflow marsh. To prevent flooding of upstream land in a situation of extreme water discharge, the main river channel must be kept in adequate dimensions by dredging sedimented silt and sand. This scenario also leaves room for other functions, like water recreation and fishery along the main river channel and eco-tourism.

The applied MCA proved to be an useful tool for decision-making. The main reason is that both information on technique (impacts of scenarios) and policy (visions of interest groups) could be analyzed integratedly to select the most preferential scenario.

Acknowledgements
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14.2 Badgers in The Netherlands: evaluation of scenarios with models

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Abstract
The problem of habitat fragmentation is affecting the survival chances of an increasing number of species. The Eurasian badger is a typical example of such a species. Plans and measures addressing the problem of habitat fragmentation have to provide for ecological qualities both within nature areas and in connecting areas in between. A computer model was developed for determining the effectiveness of such plans and measures regarding both elements for the badger. As a test the model was applied to three different scenarios that reflect different spatial developments in the future.
Keywords: *habitat fragmentation, badger, dispersal, model, nature restoration*

Introduction

Landscape Fragmentation in The Netherlands

Fragmentation is one of the major processes influencing landscapes at the present time. It may influence size, quality and connectedness of natural habitats (*e.g.* Harms and Knaapen, 1988). A decrease in size and quality of habitats may cause changes in birth rate and mortality and, as a result, local populations may go extinct. Connectedness may be seen as the effect of both distance between habitats and the suitability for dispersal of the interjacent landscape. When either factor is affected, recolonization of empty habitats may be hindered. Since connectedness depends upon the quality of the interjacent landscape, conservation and restoration of natural phenomena in man-dominated areas is needed. Consequently, within the Dutch government policy on nature conservation, a more offensive attitude with respect to the cultural landscape is taken (Ministerie LNV, 1990). In order to determine the ecological effectiveness of nature restoration plans and scenarios addressing the problem of landscape fragmentation, there is a need for instruments which can assess the effects on specific ecosystems or species. Since the above-mentioned processes depend upon species-specific factors, an approach based on species-specific data, such as birth rate and dispersal capacity, is preferable.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 549–554.

Badgers in The Netherlands

Eurasian badgers (*Meles meles* L.) live in social groups which use a main sett (burrow), where reproduction takes place, and several more or less important subsetts (Neal, 1986). Social groups can be linked together by dispersers or mating excursions of adult males. A number of linked social groups is called a regional group.
The number of badgers in the study area has declined in the last decades. Town expansion, intensification of agriculture and disturbance have led to deterioration and decrease of the habitat and of connecting landscape elements (Van Der Zee, 1992). An increase in the number of roads and traffic density has led to a greater isolation between habitat patches and to a high local mortality. This was confirmed in model simulations of a system of interacting social groups (Lankester, 1989). The viability of the system appeared to be most sensitive to adult mortality, the number of social groups and the rate of dispersal.

The aim of this study was to develop a model for evaluating nature restoration scenarios and conservation measures with respect to their effects on the badger (*Meles meles* L.).

Methods

The first aim of this study was to develop a model for evaluation of conservation policies or spatial plans. A second aim was the development of some scenarios of possible spatial developments, in order to test the model's feasibility. The evaluation of the scenarios by the model gives an indication of the kind of results that may be obtained when the procedure is applied to real conservation policies or spatial plans (Figure 1).

Study area

The study area is bounded by the North Sea, the rivers IJssel and Rhine and the IJssellake. The western part is a densely populated area with the four large cities Amsterdam, Rotterdam, The Hague and Utrecht. The eastern part contains a large woodland area, called the Veluwe. Here the majority of the badger population of the study area is found. A second wooded area located east of Utrecht, called the Utrechtse Heuvelrug, is also inhabited by the badger.

The Model

The model consists of a demographic and a dispersal module. The demographic module describes the dynamics of social groups. It uses transition probabilities between states, where each state reflects demographic stochastic processes such as reproduction, mortality and dispersal (Verboom et al., 1991). The behavior of dispersing badgers is described in the dispersal module GRIDWALK (Schippers et al., 1994). It simulates dispersal of

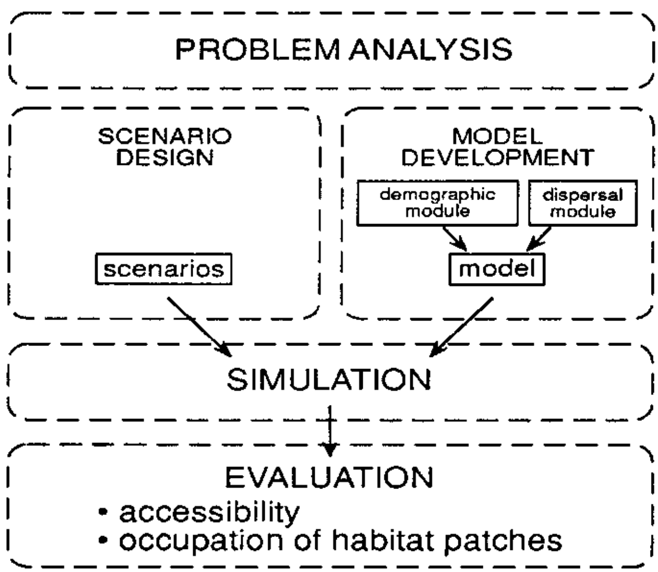

Fig. 1. Illustration of the method

individual badgers on a km^2 grid map as a stochastic process. Dispersal choices, such as residence time, direction and speed of movement, crossing of barriers and mortality, are determined by quality and dispersal resistance of the landscape. They are determined by landscape parameters (such as vegetation type and soil characteristics) which are stored in a km^2 GIS.

In the simulations, first the demographic module determines the state of every social group after one reproduction season, including the number of badgers that go on dispersal. Then the dispersal module determines the fate of dispersing badgers. They may die or reach an empty or occupied sett. After all dispersal events in a certain year have taken place, the whole number of social groups goes through the demographic module again.

The Scenarios

Scenarios can be considered a way of forecasting. Two kinds of forecasting can be distinguished. *Projective* forecasting is engaged in projections and trends, based on the assumption that the future is a logical extension of (parts of) the present. *Prospective* forecasting refers to the measures that have to be taken in order to attain a defined future objective (Van Doorn and Van Vught, 1978). One scenario of each kind was developed and evaluated by the model. The outcome was compared to (a continuation of) the present situation, which was evaluated also. For building scenarios one needs to reduce the manifold of choices by choosing a small number of master factors, since future spatial developments depend upon many interrelated factors in different (economic) sectors.

Factors were chosen that may affect habitat area or habitat quality and isolation of badger setts. These factors were: town expansion, traffic density, road construction, forest development and recreation. In order to obtain ideas of possible changes in these factors, relevant information on physical planning and economic development was used.
The projective scenario that was developed was called Metropolis. This entails endorsing maximal economic growth and a *laissez faire* policy regarding the badger. It is characterised by a vast expansion of house-building in the areas adjacent to the major cities and towns, an increasing urbanization of the rural area and an increase in traffic density and road building. No additional badger-directed measures are taken.
The prospective scenario that was developed was called Promeles. Its objective was to optimize the circumstances for the badger, within realistic spatial and economic limits. In the scenario a maximum of positive badger-directed efforts were taken. Badger targets were set, and the model results were used to adjust the scenarios in order to obtain better accordance with the targets. Several measures can be taken to influence the circumstance for the badger in a positive way. Apart from protection and restoration of potential habitats, important measures are: restoration or development of dispersal corridors (woodlots, hedgerows), construction of tunnels or ecoducts for crossing roads, reduction of speed limits and closure of roads for traffic at night.
GIS was used as interface between spatial data and scenarios on one hand and the model on the other hand. The scenarios were first designed as global drafts of land use changes. These drafts were translated into GIS maps indicating the changes in model parameters. Then the new maps were evaluated by the model.

Results

Plate 13a shows the land use in the present situation and after realization of the scenarios Metropolis and Promeles. Plate 13b shows the expected results after 50 years, in terms of size of populations and intensity of dispersal.

In the Metropolis scenario there is a decrease of (potential) badger habitats. Due to disturbance and increase of traffic intensity, local mortality increases. This causes social groups to become smaller or to go extinct. Increase of roads and traffic causes a decrease in connectivity. Areas where extinction occurs are less likely to be recolonized. This is the case in more isolated areas (Utrechtse Heuvelrug and the south-east part of the Veluwe). Compared to the present situation this scenarios shows a marked decline of social groups.
In the Promeles scenarios badger setts are protected, and traffic intensity in badger habitats is lowered. This causes social groups to remain steady or even grow. There is a higher number of dispersers. Because of measures that enhance connectivity and prevent traffic mortality, more dispersers reach isolated areas such as the Utrechtse Heuvelrug. As a combined result, the total number of social groups is expected to increase significantly after 50 years, and empty habitats can be colonized.

In order to gain insight into the separate and combined effects of improvement of connectivity (construction of corridors and tunnels, lowering traffic mortality) and habitat protection with measures reducing mortality (sett protection and lowering of traffic intensity), nine combinations of degree of connectivity and mortality rate were evaluated by the model. These include the combinations used in the scenarios. It is shown that both have a strong and more or less independent influence on the persistence of social groups (Figure 2).

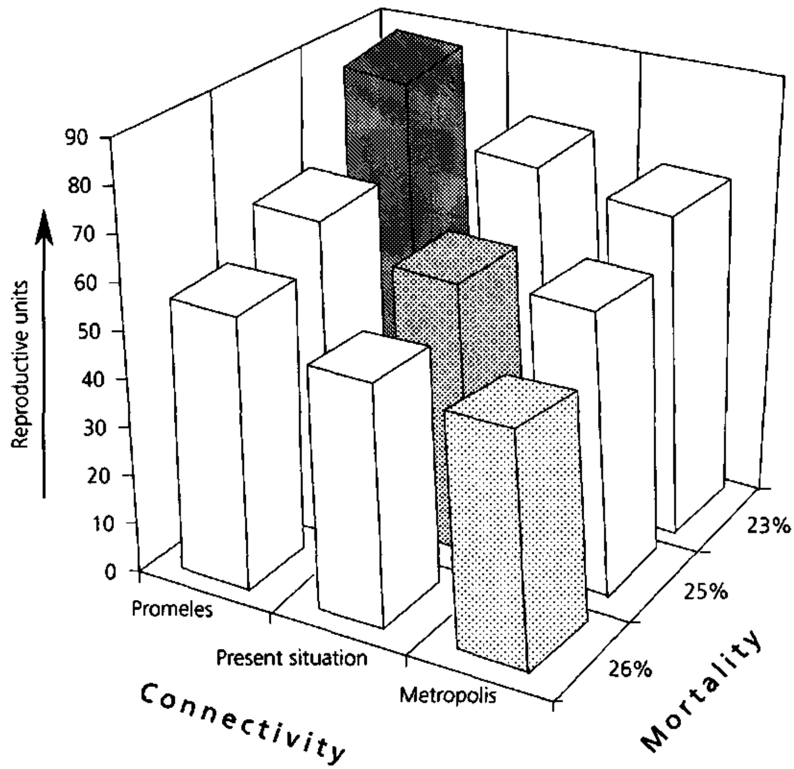

Fig. 2. Effects of mortality and connectivity on persistence of badger populations. The expected number of social groups after 50 years is indicated. The scenario names indicate the combinations that were used in the scenarios.

Discussion and conclusions

The method used is subject to many uncertainties regarding both the translation of spatial development to factors influencing badgers and the parameterization of the model. Research on the relevant data is scarce, and much is based on casual observation.

However, sensitivity analysis shows that the model is quite robust and more sensitive to the parameterization than to the algorithm (Schippers *et al.*., 1994). The results indicate that the effects of different future developments on badgers may differ strongly. This indicates the need for scenario studies that explore the possible pathways of the future. The method described is thought to be a helpful tool for evaluation ex ante of scenarios and optimization of conservation plans and strategies. It may be used in choosing alternatives and in finding critical locations and factors in spatial developments.

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14.3 Evaluation of flooding scenarios for riverine pastures along the river Dinkel, The Netherlands

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Abstract
On relatively high natural levees in the Dinkel valley, a specific type of grassland is found: the *Diantho-Armerietum* (Dinkel pastures). This plant community is best developed on dry, nutrient-poor, sandy and relatively young soils. Occasional flooding is essential to the conservation and restoration of Dinkel pastures. The altitude above the bankful discharge water level is of great importance. The lower zone is strongly influenced by the nutrient-rich surface water; the higher zones are vulnerable to soil acidification. Maintaining the current flooding frequency is favourable to the conservation of existing Dinkel pastures; a higher frequency favours the development of new ones.
Keywords: *river dynamics, riverine grassland, nature conservation, nature restoration.*

Introduction

The Dinkel is a small river crossing the eastern part of the Province of Overijssel (The Netherlands). It rises in a limestone area near Münster in northwest Germany and flows into the river Vecht near Neuenhaus, also in Germany.

This study focused on the Dutch part of the Dinkel valley. There, over a distance of some 17.5 km, the Dinkel is still a high-sinuosity meandering river. Occasionally, very high discharges cause large parts of the valley to be flooded, which hampers agriculture. These floodings are, however, a natural phenomenon and, as far as could be traced in historical records, have always taken place. During the floodings, the land is exposed to erosion and sedimentation.

The conservation value of ecosystems in this part of the Dinkel valley is strongly related to the influence of the surface water. The extremely nutrient-rich water clearly reduces the potentials for mesotrophic vegetations. Various ecosystems are, on the other hand, dependent on river dynamics, including occasional flooding.

One of the most valuable and characteristic vegetation types of the Dinkel valley is a type of grassland in which the maiden pink (*Dianthus deltoides*) occurs. These grasslands are exceptionally rich in colour with, besides *Dianthus*, species such as large thyme (*Thymus pulegioides*), lesser burnet saxifrage (*Pimpinella saxifraga*) and Our Lady's bedstraw (*Galium verum*). In The Netherlands, this community type only occurs in the valleys of the rivers Dinkel and Vecht. They are often referred to as 'Dinkel pastures'; the syntaxonomic name is *Diantho-Armerietum* (Bos and Hagman, 1981).

It is assumed that the problems caused by flooding of agricultural land will increase owing to the urbanization upstream. Especially in winter, there will be more floods with higher water levels. Constructing retention basins could reduce the river dynamics, resulting in a stabilization of or even a decrease in the flooding frequency.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 555–559.

This paper deals with the consequences of possible changes in water management in the Dinkel valley for the conservation and restoration of the *Diantho-Armerietum*. Three scenarios have been defined: (1) increasing the flooding frequency up to an average of four to five floodings per year, (2) stabilizing the current frequency of two to three floodings per year on average, and (3) preventing floodings. Scenario 1 is the assumed autogenous development; Scenarios 2 and 3 imply the construction of retention basins.

Methods

Three research phases can be discerned: (1) studying site factors, possibly related to the occurrence of the *Diantho-Armerietum*, (2) mapping the physiography of the part of the Dinkel valley that contains the relatively undisturbed river reach, on a scale of 1 : 10 000, and (3) evaluating the three flooding scenarios in terms of potentials for conservation and restoration of the *Diantho-Armerietum*.

Soils, land forms and vegetation of nine representative sites on the banks of the Dinkel were mapped in detail (scale 1 : 200). Special attention was paid to the height above the level of the surface water. Therefore, the elevation of each site was translated into the altitude above the bankful discharge level (15 m^3/s). The vegetation survey implied mapping community types, and the four species mentioned above, which are characteristic of the *Diantho-Armerietum*.

The geographical information system ARC/INFO (ESRI, 1989) was used for data processing. The occurrence of community types and species was related to the various site factors (agricultural pressure, soil type, depth of recent sandy deposits, texture of soil at various depths, organic-matter content, water-table class, and elevation above bankful discharge level) using frequency diagrams; the procedure was derived from Hommel *et al.* (1990).

The physiographical map was compiled mainly using data from existing geological, soil, and contour maps. The legend was based mainly on the results of the study of site factors mentioned above. A fragment of the physiographical map is shown in Figure 1.

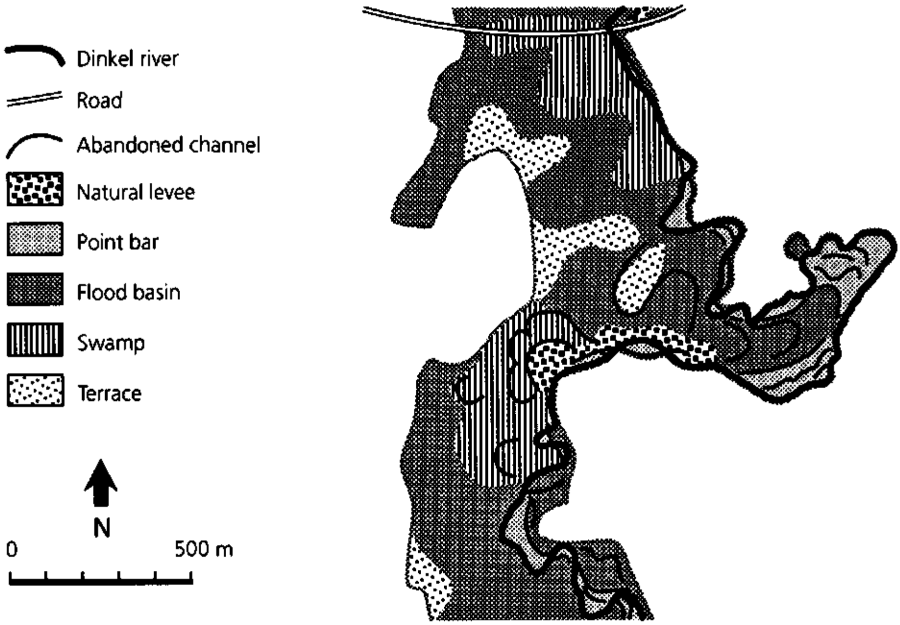

Fig. 1. Fragment of the physiographical map: the "Groene Staart" area in the Dinkel valley near De Lutte (after: Hommel et al., 1994).

Results

Dinkel pastures with *Dianthus deltoides* and other characteristic species prove to be restricted to dry, nutrient poor, sandy and young soils which have developed in relatively high natural levees (see also Hommel *et al.*, 1994).

The elevation above the water level is of great importance. Botanically rich Dinkel pastures, i.e. including the four characteristic species mentioned above, occur almost exclusively in the zone of 30 to 50 cm above the bankful discharge level. Lower zones (< 30 cm) are less suitable for the *Diantho-Armerietum* because of groundwater influences and too frequent flooding by very nutrient-rich river water. The higher zones (> 50 cm) are flooded rarely if ever. Although eutrophication by river water does not occur at this height, the lack of flooding is not favourable to the *Diantho-Armerietum*, since the sandy soils of the natural levees are very vulnerable to acidification. The acidity of the soil (pH 4.5 to 5.5) corresponds to the lower limit of the pH range which allows effective acid buffering by calcium. When a further input of H^+ ions takes place, no exchange with calcium ions is possible and acidification is accelerated. Such an input is a natural process, but it is reinforced by atmospheric deposition of nitrogen. For the *Diantho-Armerietum*, the resulting acidification is a fatal process, which can only be counteracted by periodical flooding with calcium-rich water. The various factors which either favour or impede the occurrence of Dinkel pastures with *Dianthus deltoides* are shown schematically in Figure 2.

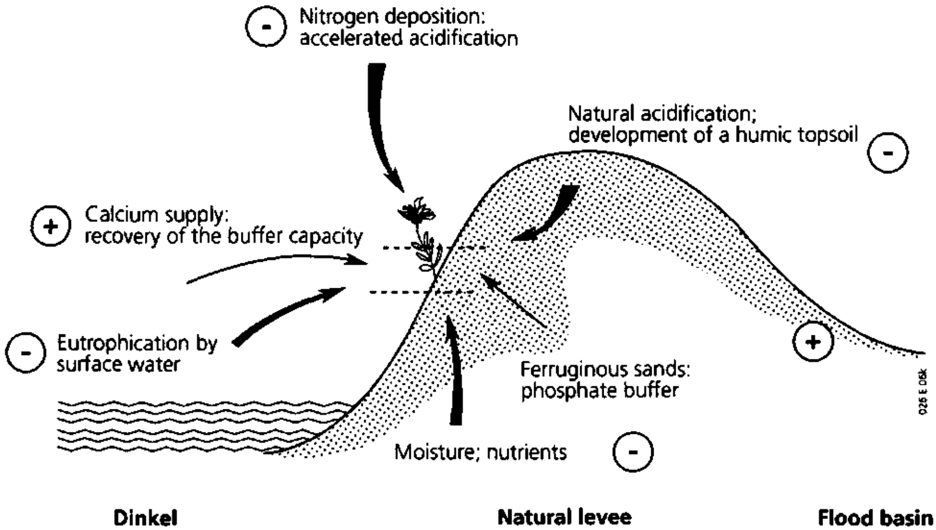

Fig. 2. The various factors which either favour (+) or impede (-) 'Dinkel patures' with Dianthus deltoides (after: Hommel et al., 1994).

Conclusions

The results of the study of site factors related to the occurrence of the *Diantho-Armerietum* imply that the three scenarios defined differ strongly as far as the potentials for conservation and/or restoration of 'Dinkel pastures' are concerned. It is also evident that the optimal conditions for conservation and restoration are not identical.

The main conclusion is that when flooding of riverine pastures is prevented completely (Scenario 3), restoration is not possible and, in the long run, even successful conservation is uncertain. Autogenous development (Scenario 1) is assumed to lead to the other extreme: an increase in flooding frequency. This scenario is not very favourable to the conservation of the existing Dinkel pastures, since eutrophication by nutrient-rich river water also increases. On the other hand, Scenario 1 offers the best potentials for restoration, especially along river reaches where relatively high natural levees occur and much sand is deposited. Stabilizing the current frequency (Scenario 2) provides the best possibility of preserving Dinkel pastures, but will allow restoration only on a very limited scale.

Discussion

The results of this study may be useful in regional water management, in seeking a balance between agricultural interests and nature conservation. The physiographical map, which is based on ecologically relevant fluvial processes, is a useful tool in physical planning. Moreover, the results are useful in defining a strategy for future restoration projects in the Dinkel valley.

The flowery pastures with *Dianthus deltoides* which occur on the banks of both Dinkel and Vecht belong to the traditional agricultural landscape of the eastern part of The Netherlands. Conservation and restoration of these vegetations fit in well with a policy aimed at 'semi-natural ecosystems': small areas of nature maintained by a specific management, which is not infrequently based on the traditional agricultural management (Jansen et al., 1993). The results of the study, however, point out that the Dinkel valley also has great potentials for developing 'near-natural ecosystems'. These are more extensive systems, which may be maintained almost without any human interference, in many cases with the help of large herbivores. The great potentials for developing such conservation areas in the Dinkel valley are owing to geomorphological processes, such as inundation, erosion and sedimentation, still being very active here, unlike in most other parts of The Netherlands. However, whatever strategy is chosen, semi-natural or near-natural, spatial layout and management of the future conservation areas must be based on the physiography of the valley and the landscape ecological relations between the various geomorphological units. It must be stressed that restoring the *Diantho-Armerietum* is not possible all along the river. High potentials are restricted to the river reaches in which sedimentation is still the dominant process or can be restored, and where natural levees of sufficient height can develop (Figure 1: natural levees). Whether or not sand will be deposited within these river reaches depends strongly on the management of river reaches upstream, in which erosion is the dominant process. These (potential) erosion zones are located in reaches characterized by point bars (see also Figure 1). Artificial fixation of river banks, especially in these river reaches, will considerably frustrate restoration projects further downstream.

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14.4 Scenario studies of agricultural transport in landscape and green management planning

Management planning for rural roads with woody verges

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Abstract
A procedure is presented, for use in management planning of woody road verges, to describe actual and potential value, and to define priorities. The method was implemented in Bierbeek, Central Belgium, a rural landscape with a dense network of often sunken roads. As agriculture still is the most important user group of this landscape, scenario studies of agricultural transport play an important role in the landscape and management planning process. Simulating transport patterns by changing the road network or the land use allows better insight in existing or potential qualities and user-problems for verges and their surrounding landscape.
Keywords: *rural roads, woody verges, Bierbeek, green management planning, landscape planning, agricultural transport*

Introduction

In the city-countryside transition zone where the agricultural function is still dominant, the more urban-originated demands, such as living and recreation, are increasingly interpreted as important landscape functions. Scenario studies, in combination with a structured assessment of qualities, and of potential and actual use of the rural road network, help planners and managers in tackling these problems of multifunctionality. In short, this paper describes such a procedure based on easily available information.

The study site Bierbeek, where the method was implemented, is a representative example of a rural landscape with important urban-generated functions. Bierbeek is situated in the loess belt of Central Belgium, at the edge of the city of Leuven. The dense network of roads, often sunken and with woody verges, forms the basis of the high recreational and landscape ecological potential of the site (Vervaeke, 1992; Van Hoye, 1993).
As the site is intensively used by agriculture, study of agricultural transport patterns was the starting point for the management planning.

Agricultural Transport

Changing farming systems generate shifts on the level of the individual farmer's land use. This in turn alters the agricultural use and transport pattern of the local rural road network, in which the roads and their verges are defined as one. As both agricultural roads and transport have an important landscape ecological role, their impact on the rural landscape cannot be neglected (Gulinck, 1986; Van Meldert *et al.*, 1991; Gulinck and Pauwels, 1993).

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Management and structure of roads and their adjacent verges, and as a consequence, actual and potential values of the road network for the different interest groups, will also change. New user conflicts or functional incompatibilities can rise, existing problems can be sharpened, or on the contrary, be solved.

In this study, we limited ourselves to the internal agricultural transport: transport between farmstead and fields. All important farmers using fields within the 500 hectare study site, in total 32, were questioned in detail. Emphasis during the enquiries was on transport routes and annual frequencies for each crop and for each functional operation (e.g. fertilization, sowing ...), the location of fields and crops, and crop rotation (Vervaeke, 1992). Using these data, actual transport routes and annual frequencies for each road segment were determined. Using the ARC/INFO PC-NETWORK module (ESRI, 1989), a scenario was studied in which farmers would use routes with shortest distances, using the same road network, farm-field constellations and annual transport frequencies. Comparison of both transport patterns allowed the location of "black spots", problem road segments where possible improvements of the road structure, initially its surface and width, would lower transport costs. Most of the problem "points" indicated by the farmers as part of the questionnaire were identified by comparing these two patterns. A model was developed to simulate actual routing, using shortest distances, but multiplying each road segment distance by an impedance factor related to the road surface quality and width (Vervaeke, 1992). No difficult and time-consuming attempt was made to optimize the impedance factors with respect to "observed" transport patterns and in function of crop type (fruit,...) or season. Nevertheless, the chosen impedance factors already gave very satisfactory results since it almost matched the actual transport pattern (Vervaeke, 1992).

This kind of scenario-building simulates quickly and easily, in a rough but workable way, how changes in road network, land use (crop rotation), and field and farm allocation influence transport patterns and frequencies, and thus the significance of each road segment for agriculture, eventually split up by farm(s) or group(s) of fields.

Management Planning for Rural Roads with Woody Verges

The method presented takes into account all available information whatever its level of detail, but is still easy to implement and transparent. This procedure is straightforward and flexible in showing immediately management and cost consequences of planning options or alternatives. New and more detailed information and analyses, for instance concerning use of the verges by fauna, can be incorporated without any problem. The difference between what can or should be done in "ideal" conditions and what is actually done, is also clear, which can be an important stimulus for more attention and means for the management of the woody verges. Policy, planning and management transparency are enhanced. Figure 1 summarizes the developed procedure for the management of minor rural roads and their woody verges (Van Hoye, 1993).

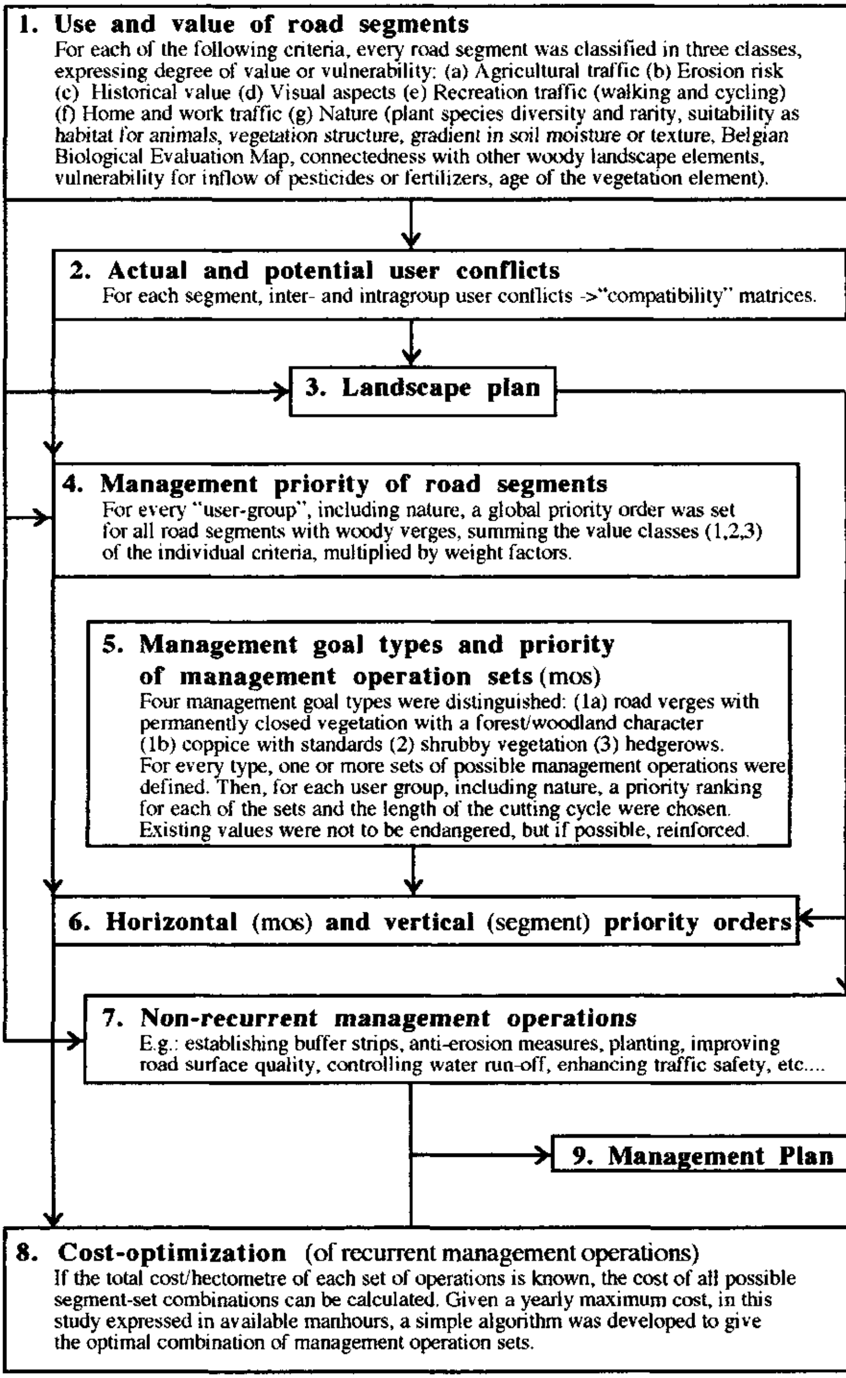

Fig. 1. Management planning scheme of rural roads with woody verges

Discussion

In this study, attention was given to roads with woody verges. Woody verges, as especially is the case in the Bierbeek study site (Van Hoye, 1993), contribute to a high degree to the ecological value (e.g. Burel, 1984; Baudry, 1988; Burel and Baudry, 1990), the attractiveness and the positive perception of the rural landscape. Management of herbaceous verges with mowing schemes have already found their way into normal local green management. Management of woody verges, on the contrary, is nowadays still less evident and too often restricted to a minimum because of insufficient budgets and lack of habit or attention by local politicians and inhabitants. As not every segment is treated every year, it also demands long-term planning. So, a continuity and coherence in the planning should be incorporated. A procedure as proposed here in a simple way, takes into consideration, from the planning perspective, both problems: cost (what can optimally be achieved ?) and longterm consistency.

Bierbeek can be considered as representative for much of the Flemish countryside. While agriculture is still a very important driving force in landscape structure and dynamics, other sectors and interests increasingly raise their voices and push agriculture into a defensive position. In the Bierbeek case, a management plan of roads and woody verges was seen as a necessity because of the proliferation of the user conflicts of agriculture versus "nature" and recreation or home and work traffic, and of recreation versus "nature" (Vervaeke, 1992). More attention should also be devoted to alternative road structures which can contribute greatly to a multifunctional, conflict avoiding solution (e.g. Gulinck and Pauwels, 1990; Pauwels and Vervaeke, 1992). Optimization of the road system with regard to agricultural transport routes, now and in the future, is an important aspect of increasing the viability of the remaining farms.

A network approach is necessary because individual segment use, by whatever "group", is always part of a pattern. Closing roads for mechanized transport for the benefit of nature or recreation, for instance, can have important impacts on agriculture (Gulinck and Pauwels, 1990), which can only be predicted by transport scenario studies.

Conclusions

The increasing multifunctionalization of the rural road network demands for long-term planning and cost optimization with, on the one hand, flexible inbuilt procedures of multicriteria analysis for describing existing values and properties, whilst on the other hand a kind of multiple goal planning to define priorities. A network approach and scenario studies concerning the most important "user" groups, like in this case, agricultural transport, are an indispensable help. An optimal, cost effective management of the woody road verges can rehabilitate these important linear landscape elements conforming to the demands of all user groups.

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Discussion and conclusions

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Abstract

The discussion in the workshop "Nature development and landscape quality" is summarized. The use of the terms forecasting and backcasting scenarios was preferred. The cyclical process of backcasting scenarios was emphasized. The need for science-based scenario studies was clearly endorsed.

Keywords: *scenario studies, forecasting studies, backcasting studies, nature development, landscape quality, policy*

Introduction

The present contribution summarizes the discussions in the workshop "Nature development and landscape quality". Some remarks will be made on definitions and terminology, on methodological aspects and on the need for scenario studies for nature and landscape policies.

Definitions and terminology

Van den Berg and Veeneklaas (this volume) define a scenario as "a description of the current situation, of a possible or desirable future state as well as of the series of events that could lead from the current state of affairs to this future state". Schoonenboom (this volume) distinguishes the same three main elements. He discusses in some detail the way in which we can define the series of events leading from the present to the future state. He further distinguishes two types of scenarios: projective scenarios, in which the line of reasoning runs from the present to the future; and prospective scenarios, in which the line of reasoning goes from designed future situations back to the present situation.

The workshop took as a starting point that in projective scenario studies forecasting techniques, and in prospective scenarios studies backcasting techniques are used. In the workshop the latter two terms were preferred: they give a clear description of the core of the process, whereas the other two terms (projective and prospective) were thought to be rather confusing. In this contribution we will therefore further only speak of forecasting and backcasting scenarios (and the corresponding studies).

Because there still seems to be some unclarity about the terms used I suggest, mainly in line with the contribution from Schoonenboom, to make the following distinctions:

- predictive studies, focusing on probable events;

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- scenario studies, focusing on plausible events; further to be distinguished into:
  - forecasting studies;
  - backcasting studies.

The boundaries between the forecasting and backcasting scenario studies are not always sharp. If a set of starting points is defined for nature development, we can regard this as a forecasting study, performed under a given number of limiting conditions. At the same time we can regard this set of starting points as a first sketch of the desired situation for which we will try to backcast the route to reach it. For instance, if we define a desired future landscape in terms of percentages of woodland, grassland and water surface we can carry out a backcasting study in order to specify the measures to realise this. Next we may then go into forecasting if we want to predict the species composition in these habitats, depending e.g. on the measures defined in the backcasting.

Some methodological aspects

In forecasting studies plausible, yet relevant possibilities are investigated. It is a unidirectional process, in which the uncertainties constitute the points for bifurcation. During the forecasting process itself normative aspects can steer the choices. Thus, we can develop a "worst case scenario", in which at all points of choice the least desirable direction is followed. Formalised, mechanistic models, if provided with the necessary open points, can very well support this type of study from the beginning to the end.

Backcasting studies start with the design of several future desirable (or undesirable) states. Starting from that, a possible route back to the present is explored. In this type of study different steps can be distinguished. The first step is the design of desirable (or undesirable) states. This is a creative process with ample place for vision and debate but also for normative-scientific inputs with respect to nature quality, future generations and political equity. In this first step formalised models may rather be inhibiting than stimulating. Then the next step is the check for consistency: is it a possible state, or is it at variance with scientific knowledge in any field? The last step is the way back to the present.

In fact backcasting is a cyclical process, instead of unidirectional. Problems with the consistency of the designed state or with the linking up with the present may well lead to an adaptation of the designed future image, thus increasing its plausibility and explicitness. In this cyclic procedure the models used in forecasting studies can also play a role, not to tell us what will happen if ..., but to tell us what conditions have to be fulfilled in order to reach such-and-such a future state.

A further point of interest was how comprehensive a scenario study should be. How many aspects should be involved and how to cope with the time and money constraints? This principally depends on the goal of the study. One cannot say apodeictic that such a study should always include both physical and social science aspects. The weather forecast, cited by Schoonenboom as an example of a forecasting scenario study, should preferably do without social sciences. However, this example may be less convincing, because this rather seems to be an example of a predictive study and not of a scenario study; here maximum probability is the core criterion, not plausibility. However, we can also take nature development in Dutch floodplains after summer dike removal as an example. What may possibly happen here, in the field of geomorphology, hydrology and biology? Which types of landscapes may result, and which plant and bird species? Also without social science input this can be a very interesting undertaking. But of course in other examples the reverse may be true.

The starting point is that all relevant aspects have to be taken into account, but precisely that may lead to an unmanageable extensiveness of the study. A few remarks can be made here. First, the whole study may be performed in a number of cyclical phases, going from a quick scan to a detailed study. During this process one may successively limit the number of aspects included, if properly reasoned and stated. Secondly, one can try to leave out unnecessary detail. Biologists may well have to suppress their natural inclination to make a full-fledged inventory of the study region of all fashionable species groups concerned. Or even one step further: a scenario of ecological developments may even leave out single species altogether and focus on species groups or just on habitat types. In line with this also the scale level should be well chosen. An unnecessary detailed scale may burden budget, time and scientific expressiveness.

From this it should not be implied that sufficient biological knowledge is already available regarding scenario research for nature development. In particular, knowledge about chorological aspects, such as those connected with the reappearance of species in a nature development situation, is still very fragmented. But scenario studies should not wait until all relevant knowledge is present, because then they will be never performed. Conversely, they may show what type of research should be carried out with top priority.

The need for scenario studies

In the workshop the need for science-based scenario studies, in particular in the field of nature development and regeneration, was clearly endorsed. Advantages over simple expert reports were thought to be: (1) the explicit and objectified character of the alternative development routes, with strong emphasis on their internal consistency; (2) the explicit dealing with uncertainties, to be mirrored in the possibility to identify and analyze surprises; and (3) the resulting means of communication in the policy debate.

In this debate there are two groups of users of the results of scenario studies: the interest groups involved, and the responsible decision makers. By identifying these two groups of users, a stand was made against simplistic ideas about "basic democracy", in which the local participants should be the only actors in policy development.

Both forecasting and backcasting studies obviously have an important role to play. However, my personal preference would be towards greater emphasis on the truly backcasting studies. They directly address the question of what type of nature development and what type of landscape quality is actually wanted and thus link up directly with a core issue in the current nature policy discussion.

PART IV

Rural planning and the future regions

CHAPTER

Introduction to Part IV

For planners a scenario study is just another tool in the long bargaining process between opposing interest groups, since only negotiation and compromise can lead to implementation. What exactly is the gap to be bridged between scenario studies and actual rural physical planning? To what extent do, or should, the results of scenario studies influence the practice of policy formulation and implementation for the rural environment? And, what are the practical experiences in drawing up scenarios supportive of policy and regional development? These are the central questions in this part of the Proceedings.

In Chapter 15 the changing insight in rural planning is discussed, both from a theoretical point of view and in its practical consequences. Both Couix & Vissac and Girot et al. overview the political and scientific changes in viewpoints on rural planning over the last quarter of a century in France. Couix & Vissac illustrate the transition from substantive to procedural rationality with a case study of a forest fire prevention scheme in the Mediterranean area. Girot et al., landscape architects, describe the tension in rural areas between the ongoing urbanisation and the aim to preserve both the natural and cultural heritage of the landscape. Bryant stresses the importance of participation and involvement of rural communities in the process of planning. He also addresses the question of what role scenarios can play in this process.

Chapter 16 presents a number of operational methods to generate scenarios. Both the choice of method and the scope of scenarios vary widely. In methodological terms, one will find strongly model-based approaches (e.g Hengsdijk et al.), informal expert judgement methods (e.g. Muller et al.) and a number of mixed approaches (e.g. Van Os et al., Veeneklaas & Slothouwer). Also, the focus varies from being implementation oriented to drawing up a conceptual framework (e.g. Hetsen). Moreover, the cases discussed deal with very different spatial scales: the supra-national level (the European Union), a large watershed (Rhine Basin), the national level (the Netherlands) and the regional level are represented.

An emerging issue concerning land use in the European Union, induced by the MacSharry CAP reforms, is the set-aside of arable land. In Chapter 17 three contributions on this topic are presented. Set-aside offers both opportunities - for instance, nature conservation or clean water production - and threats. Ansell gives a broad overview of the evolution of the set-aside programme in the EU, in general, and in the United Kingdom, in particular. It focuses on the possible impact on the farm economy, considering the multiple functions which land management fulfils. Taking arable land out of production affects the processes in the soil: large changes occur in management, in the application of nutrients and in liming. The short paper of Ter Meulen et al. points at the effects in terms of increased cadmium release on former agricultural land. Magid et al. investigate the potentially beneficial and detrimental effects of set-aside on water recharge and soil

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quality. By comparing an arable, a grassland and a heathland site in terms of nutrient dynamics, they make an original and important contribution in this not very well researched field.

Scenarios of the rural environment can play a role in the making of development plans for specific regions. They can show the options available and the potentials, but also the dangers of different developments. Furthermore, they can act as catalyst in mobilizing the parties involved in regional development. Chapter 18 gives some examples.

It starts however with some general observations on regional development, both from a theoretical point of view (Hoekveld) and from the practical point of view of a regional authority (D'Abreu). Hoekveld stresses the importance of 'images' of regions and how one can trace these down. The region in question is the Gelderse Vallei in the Netherlands. Dietvorst looks at the marketing of the same region in relation to its tourism potential. D'Abreu's paper gives an inside look at the process of drawing up a development plan for the coastal region of the Portuguese Alentejo, a region as yet outside the mainstream of mass tourism. Another inside view is offered by Beukema in his paper on the revolutionary idea of the construction of the so-called Blue City in the Oldambt in the north-east of the Netherlands. In stark contrast with Dutch tradition, polder land will be inundated to create a new lake, along with residential and recreational facilities, on former agricultural land. The transition of middle and east European countries from communist rule to a new economic and political system brings with it the necessity to reorganize degraded regions and give new designations and perspectives to areas formerly in use, for example, by the military and for border patrols. An example of an attempt to upgrade a region is given by Woźniakowa et al. and concerns a mountainous area in south-west Poland with large potential, amongst other things, for being a health resort. Mejstřík et al. discuss the case of - sometimes forcefully - abandoned areas in Czechia, where their post-war use (military training and border areas) has given way to developments with natural control prevailing on a regional scale, which is rather unique for Europe.

F.R. Veeneklaas

CHAPTER 15

Regional rural planning

15.1 System modelling and social construction of a land use planning and management project

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Abstract

Political change over the last 25 years has altered the view scientists have on the role of the territory in relation to environment-linked agricultural issues. As a result, reasoning modes have progressively evolved from substantive to procedural rationality: a "project" is no longer predesigned or its model predefined, rather it is built by systems modelling procedures through cooperation between the actors.

Research in France is illustrated by a case-study on forest fire prevention in the Mediterranean area. It provides a basis for generalizing this approach to other types of agro-environmental constraints. Such scenarios are components of a "tool box" available to help manage this approach.

Keywords: *land use planning, system modelling, procedural rationality, forest fire prevention, Mediterranean area*

From substantive to procedural planning and management

Strong local roots and regional diversity partially explain the century old French tradition of a synthetic approach to agricultural science (e.g. Olivier de Serres in the 17th century) as well as national resistance to internationalisation of trade and introduction of technical innovation. The 20th century, and particularly the unavoidable need to modernise which emerged after the Second World War under the influence of the Marshall Plan, marked a turning point in French agriculture. By drawing on the support of young farmers strongly impregnated by Catholic ideology, the Gaullist government completed the technological evolution which had started in the 19th century with the introduction of innovations from England, known in France as "anglomania". Research, with the creation of Institut National de la Recherche Agronomique (INRA) in 1945, was to be a cornerstone of the new deal of agriculture, while cooperative and mutualist structures were to ensure the implementation of scientific recommendations by farmers, despite the small size of the farms.

As early as 1955, some agronomists, such as René Dumont, showed concern for the rift existing in France as well as in other countries between the technical recommendations and the actual capacities of farming systems. Dumont's questioning triggered new thinking in the field of agricultural sciences: agronomy, animal production science, ecology, sociology, modelling.

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These spontaneous and dispersed interests became later organized under the General Delegation for Scientific Research (DGRST) which, in 1970, established the basis for the future Ministry of Research. One of the objectives of this new governmental body was to develop multidisciplinary research involving the natural, technical and social sciences, to tackle difficult issues arising in the fields of agricultural and rural development, and in those of land planning and management. This initiative, combined with the crisis which farm advisory services were undergoing, led Institut National de la Recherche Agronomique to create a new research division, in 1979: the Département de Recherches sur les Systèmes Agraires et le Développement, known as S.A.D.

Space and the local people (the "actors") have always had a central, although changing, status in these research approaches, depending on the questions which emerged successively over the last 30 years (Deffontaines, 1994 and Fig. 1).

DATE	POLITICAL AND SOCIO-ECONOMICAL CONTEXT	RESEARCH THEME ON LAND USE
1965	Technical progress Mansholt Plan : local rural communities threatened	"Focus of studies" on the technical potentialities Preservation of cultural patrimony (concept of **practice**)
1970	Regional disparities of agricultural development Maladjustement of the agricultural advisory service	"Structure" resulting from the joint effects of human activities and environment **(Typologies of functioning)**
1975	Crisis in protein and energy supply production systems more economical and self-sufficient	"Factor" of operating human activities - ruralism (concept of **landscape**)
1980	Emergency of the CAP : quotas (1984), subsidies Initiative of local-based development	"Continuous and functional territories" - Perceived space (concept of **"local agrarian system"**)
1985 to 1990	Considering the effects of agri-environmental constraints on agricultural development	"Collective land use management" integrating the perceptions of the different actors and users

Fig. 1. Historical development of emerging questions and research themes about land use in France

- Through the resources it produced, space first (1965) became the focus of studies on the agricultural potential of fields. It was carried out on a regional level (Langlet *et al.*, 1969), at a time when some farming systems were being increasingly marginalised. The perspectives contained in the Mansholt Plan even promoted research on some local rural communities whose survival was considered to be threatened, to study and preserve their heritage in the Archives of a Museum. The cooperative research carried out in Aubrac, a remote area of the French Massif Central, originated from these concern, as well as the creation of the Musée des Arts et Traditions Populaires in Paris.

- Around 1970, the exposure of regional disparities in agricultural development led scientists to view the territory as the joint result of human activity and environmental conditions, or as the memory of a collective history (Deffontaines, 1972). The inadaptation of advisory institutions which were controlled by the farmers' Union following a Government Act of 1964, led to defining "functional typologies" of farms which took into account aspects such as location in a territory, and relations with the history and goals of the farm family, in order to target technical advice more precisely.

- In the mid-1970s, the crisis in energy and protein supply which resulted from the opening up of markets, stimulated research into more self-sufficient and economical forms of agriculture (Poly's report, 1975). Interest was shown for the productive potential of marginal zones seen as potential producers of "pétrole vert" in the words of the French president Giscard d'Estaing. The territory, in particular in livestock farm situations, was to be reorganised according to the resources' complementarity and resources' accessibility for animals with a new combination of farming structures. The territory is viewed as a factor in agricultural activity, in a context where the wider dimension of ruralism is now being taken into account. The landscape, considered simultaneously as a factor, a "product" of past agricultural activity and a basic resource for agriculture, is seen as an integrative entity to organize multidisciplinary research (INRA-ENSSA, 1977).

- From 1980, the introduction of the Common Agricultural Policy (CAP), onwards, the resulting constraints imposed on production systems through the system of prices and quotas, and a rising interest for locally based development, induced researchers to investigate the functional organization of continuous areas of land with their farming techniques and practices (Auricoste *et al.*, 1983). From this emerged the concept of the "local agricultural system" (Deffontaines *et al.*, 1977) whose last two terms are included in the new research department created by INRA. Here, the territory is perceived from the standpoint of the local "actors".

- Finally, after 1985, the increasing demands of society to integrate environmental aspects and constraints into agricultural and rural development led to considering the broader issue of spatial management, taking into account simultaneously the different decision levels of the "actors", those of the production subsectors and those of people responsible for land planning and management. The different, often conflicting, perceptions of their respective objectives are confronted with the help of representations built through discussion between the actors.

The increasing complexity of social goals and of the resulting status of space, rapidly showed the limitations of conventional approaches, based on the neo-classical paradigm. This latter is developed for and applied to "well-structured problems", i.e. in which, given a context and a goal, optimal solutions may be derived from an algorithmic model. These approaches then turned increasingly to knowledge evolved in the area of the "sciences of complexity" (see Simon in the US and Le Moigne in France) which applied to "ill-structured problems" (see Fig. 2).

RATIONALITY	
From	To
SUBSTANTIVE	**PROCEDURAL**
DEDUCING the RESULT Given the context Chosen the goal	INFERING the NEXT STEP of the PROCESS from the changing perceptions of context and goals
WHAT TO DECIDE ?	**HOW TO DECIDE WHAT TO DO ?**
"Well structured problem" Well known stable context Mono-dimensional problem Clearly defined goal	**"Ill-structured problem"** Complex evolving context (multi-actors, multi-criteria) Multi-dimensional problem Ill-defined goals
To determine a COMPUTABLE MODEL	TO DESIGN a RICH MODEL and a TELEOLOGICAL MODELLING PROCESS
focusing on	
The ALGORITHMICAL SOLVING Process	HEURISTIC CODING and MODELLING Process
to CHECK the OPTIMUM solution, seen as a RESULT	to INVENT some ADEQUATE (SATISFICING) solutions, seen as a PROCESS

Fig. 2. From substantive to procedural rationality for social planning (adapted from Le Moigne et al., 1991)

A heuristic modelling process was needed which would take into account the changing perceptions of a situation, and at the same time, aim at defining common objectives and satisficing partial solutions. A "procedural approach" of this kind is able to deal with the complexity arising throughout the elaboration process of any land management project. The different statuses attributed to space which emerged and were successively combined from 1965 to 1990, have progressively led to representing agricultural systems as self-organising systems ("organized-organizing systems" in the sense of the French sociologist E. Morin, 1980). In brief, views about organized systems have progressed from the operative system to the information system and more recently to decision making.

This approach is illustrated here by recent work on modelling of self-organizing systems. It is inspired by previous research from the 1970s and 1980s. We invite you to turn your attention from the northern landscapes you are familiar with and scenarios related to them and consider the problems of Mediterranean landscapes and the issue of forest fire prevention.

An illustration: forest fire prevention in the Mediterranean region

In the Mediterranean part of France, forests extend over some 4.6 million ha, 1.8 million ha of which consist of scrub and sparse vegetation (*maquis* in Corsica, *garrigue* on the continent). 35,000 ha have been destroyed annually by fire since 1973 (Turlan, 1991; Fig. 3)

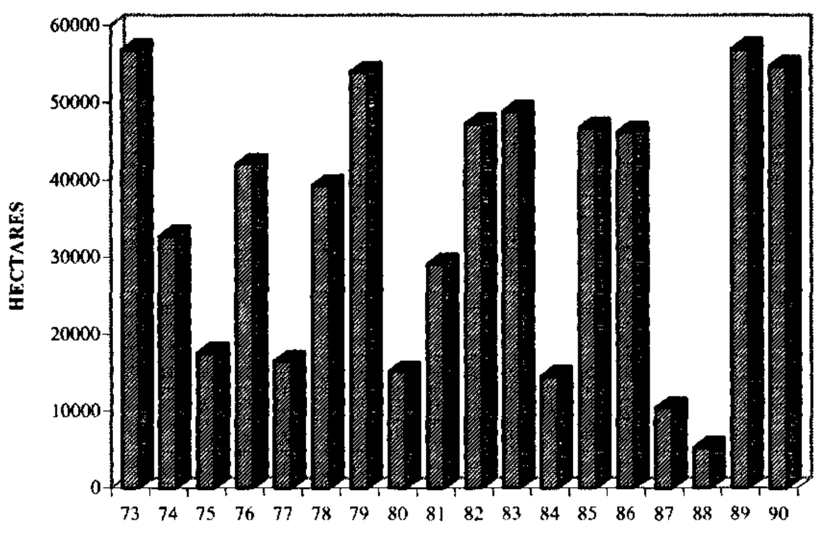

Fig. 3. Acreages destroyed by fire, 1973-1990 (from Turlan, 1991)

Methods for controlling fires at their inception are derived from the traditional sector-related approaches and have made considerable headway: indeed most fire outbreaks are now extinguished within the following half hour and destroy a few hectares only. In spite of this, the annual area ravaged by fire in France remains unchanged due to an increase in areas destroyed by a few major catastrophic fires: less than 1% of the fire outbreaks recorded burn 80% of the total area burnt each year (Hubert *et al.*, 1991). This rise is due to lack of clearing of scrub-invaded forest undergrowth as well as to increasingly uniform landscapes, a result of land abandonment by agriculture and of the effects of more and more destructive fires.

After a large fire, in 1985, in a area of the Cevennes hills, which had been considered as a representative example of a special fire-prevention zone[1], the decision was taken to develop land use planning methodology which could renew current approaches to the protection of forests against fire risks. Since then, many research works and actual operations have contributed to enrich the methodological approach.

Forest scientists have shown that the resulting vertical and horizontal continuity of layers of inflammable vegetation is the main risk factor (Delabraze, 1987). They propose to move from a "fuel-break" policy to a forest management one (Delabraze *et al.*, 1991). Thus, the general objective of land use planning is to organize the heterogeneity of the landscape: breaking the continuity of the plant cover by alternating wooded areas of different age and species, mechanically cleared land, land used for production objectives other than forest (cultivation, extensive-type livestock farming, game farming, for example), depending on spatial distribution of fire risk. To carry out such a project, it is advisable to design combinations of forest, farming and pastoral activities since these structure the rural landscape most. Other users such as residents, hunters, hikers, who are less involved in physical management of the land and whose interests regarding land use are often at odds among themselves and with the above "actors", are also involved in such fire prevention projects.
This causes us to move from a "well-structured problem" of forest protection against fire to a more complex and "ill-structured problem" of land use planning. This lead us to consider the agrarian system, i.e. the organization of relationships between social groups and their territory to meet their objectives.

[1]zone DFCI (Défense de la Forêt Contre les Incendies): area provided with a network of wide fire-breaks which were meant to ensure its protection, according to the guidelines prevailing in the seventies.

Combining activities and linking the projects of the local people

Land use planning through multi-partner projects

The problem set out above goes well beyond the provision of optimum technical answers to prevent fire outbreak or spread; these are already available, costly to implement and not always efficient. It also goes far beyond finding the most appropriate combinations of different vegetation types. The project first requires information about the land management practices of those using the land and of their objectives in doing so.

The underlying assumption is that the landscape can be structured by the functioning of farming systems, in our case mainly livestock grazing maquis, garrigues and more generally woodland, as well as by forest management. The protection of the forested areas is thus directly related to the management of the production, to the intervention, or lack of it, by farmers and foresters to structure the landscape. The land use planning project is thus based on the practices of the "actors" and their ability to readjust their system of action to the new objective of landscape structuring.

All these activities are part of a complex system which is organized by individual "actors" or groups of actors, such as local hunting associations or the Forest Service. However, beyond the practices of individuals and the supposed effects these practices have on structuring the landscape, one must also consider their capacity and willingness to coordinate the actions of each of them.

The assumption is that the processes of design and carrying out of land use organization projects on a given territory can only be collective ones. Beyond specific questions raised in the technical field, this assumption poses the problem of "how to organize multi-partner actions".

How to articulate constantly evolving projects

In Mediterranean forests, the tempo of wood production is about 20-30 years for coppiced forests, according to type of use, 50-90 years for *Pinus nigra* plantations and even longer for cedar, stone pine or red oak. Such scales of time give an idea of the span of these land use planning projects.

The landscape is a living entity which changes with the dynamics of the plant cover (Etienne *et al.*,1994; Lepart *et al.*,1983). The way it is structured has to be understood as an on-going process (in its procedural dimension) and not only as the result of specific interventions in the environment. As soon as one intervenes in the landscape organization, the resulting structure changes. It is necessary to understand this structure evolution so as to maintain a landscape compartmentation whereas plant formations, themselves, are dynamic.

Forestry and agricultural activities can contribute to master this evolution in a satisfactory way. However, the way they use the resources also evolves in relation with:

- the individual "actors" objectives;
- those of their successors;
- socio-economic changes and technological advances;
- the functioning of the production systems themselves.

The place of change in forestry and agricultural activities and in those of their determinants influence, as a result, the structuring processes of the landscape, and vice versa.

Models are now available on plant community dynamics under the effect of human practices and are being increasingly perfected. In another area, advances in landscape ecology (Baudry, 1993) provide information on the factors which determine the spatial organization of landscape patterns and mosaic. With the help of management simulations, the consequences of intervention, or non-intervention, on the environment may be anticipated. On the other side, we lack information to predict the evolution of the projects and activities of the actors as well as of the socio-economic context which influences them.

The design and carrying out of a land planning and management project are neither finite nor limited processes. They have to continuously keep pace with the dynamics of the "object" that is to be organized. For example, in the Cevennes operation, the designing aspect only corresponds to the initial stage of a process which changes as the project is being carried out. This a good illustration of complex and partially unpredictable situations which lead to "ill-structured problems" according to Le Moigne (see fig. 2). Simon (1981) suggests that in such cases one proceeds with work that has no final goals.

How to design collectively an "evolving artefact"

Designing an "evolving artefact" means recognizing that one is designing something of which neither the final form, nor the evolutive process of the complex system producing this form, are known. Here procedural rationality is opposed to substantive or "positivist" rationality. The first one underscores the importance of the procedures involved in elaborating satisficing solutions, as opposed to seeking optimal solutions for the "final" scheme. Once objectives are defined, the range of possible options builds up as the process advances. This means that, as perception of the situation evolves, reasoning processes are constantly reassessing and readjusting (Fig.4):

- the relevance of the representations;
- the design and operational rules adopted;
- the criteria used in deciding the actions to be carried out and the information to be taken into account, and even
- the objectives.

The reasoning processes translate the on-going interactions between the process of identification of goals, and those of understanding/design/implementation of solutions.

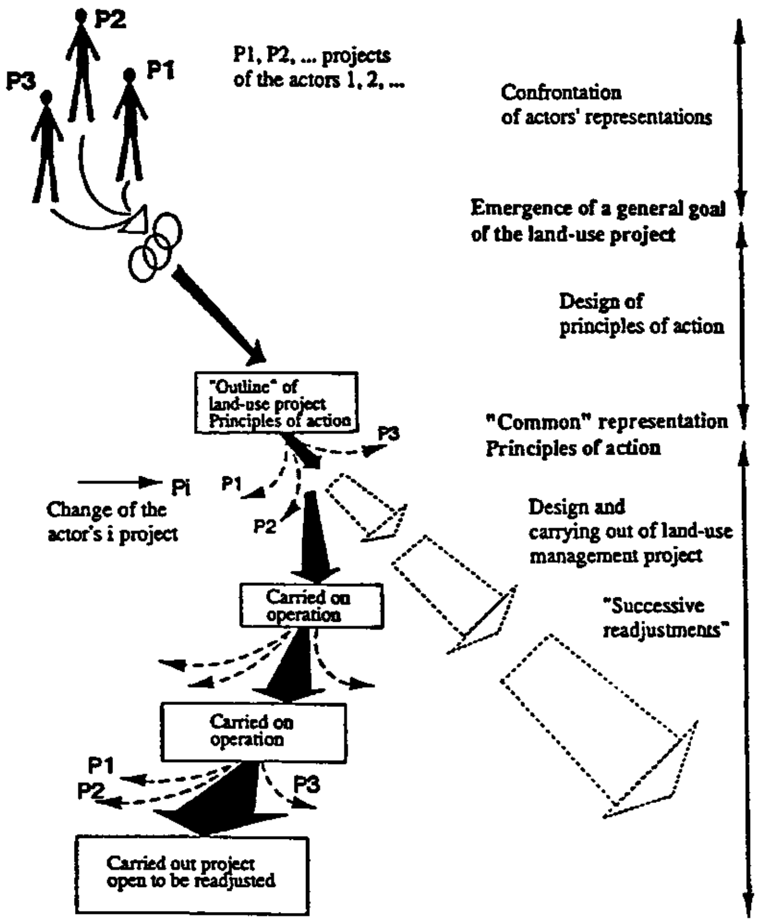

Fig. 4. Design and carrying out of a land use management project: successive readjustments (from Couix, 1993)

These reasoning processes also bypass the risk of achieving goals that are not adapted to the perceived situations, at a finite moment in the plan of action devised by the actors.

Regarding land management projects, this approach highlights the limitations
- of pre-established sequences of operations that do not allow for possibilities of stepping backwards;
- of the distinction between the time span of the study and the subsequent time set for carrying out the operations.

This raises some problems owing to the "rigidity" of administrative procedures: multiannual programming can partially mitigate this effect. Yet, it is desirable to devise modes of action in which the process of identification of goals and decision could interact.

This is especially paramount since, during a land use planning operation, the categories of actors are involved at different times, according to their diversity and to their recognised legitimacy as partners. Further, in the context of such operations, as was seen previously in the case of Cevennes, this type of procedure is paramount since the problem is as much that of the management of the land in question as that of the landscape to be structured.

How then can such an approach be handled collectively through procedural rationality (Simon, 1976), which takes into account the dynamic linking of the actors' projects and operations ? The Cevennes example, with 8 years of experience, contributes some answers to this question.

- The partners first defined a series of principles and criteria in order to study the different options for each situation (actor x plot), taking into account the more or less strategic position with regard to fire outbreak or extension risks.
- For each category of land, principles were defined regarding the possible modes of resources use which are compatible with other activities.
- From an economic standpoint, capital requirements are assessed as a whole and allocated to each type of activity according to its links with the other activities within the overall project.
- Each partner designs and carries out in his area of competence the operations relating to his own project, in accordance with the principles of the overall project and in concertation with the other partners.

Prospects for generalising the procedural approach in land use projects

The situation chosen to illustrate this approach is somewhat unfamiliar to North-European scientists. This approach is presently confronted to other French situations using system modelling: in all these situations, the implementation of CAP decisions requires that the complexity of land use in agrarian systems be taken into account, with the multiplicity of actors or combinations of actors involved in these systems. Here are some examples:

- Mastering the quality of mineral water affected by rising rates of nitrates (involvement of a private mineral water company) or that of drinking water (local organization supply) (see Deffontaines *et al.*, 1993);
- Management of interactions between areas of intensive agriculture, protected areas (for migrating birds) and areas dedicated to shell culture in the Marshlands of Atlantic France (Marais de l'Ouest, Périchon, 1992; Steyaert pers. com.);
- Management of farming systems and prevention of erosion in Normandy (Pays de Caux, Papy *et al.* 1992).

These situations all concern the "steering" of an agrarian system by the people using the territory and its resources or using it through interactions between production subsectors and agencies responsible for land use management in accordance with the agro-environmental objectives of EU.

The research described above is one aspect of wider research carried out by SAD. This research deals in particular with:

- spatial modelling of activity systems in relation to territories;
- understanding the practices, logics and relationships networks at work in the management of territories.

This research work draws its inspiration from current thinking in systems modelling of complex projects. Land management is but one of many focusses of investigation of this emergent branch represented by a European Association: AEMCX, Association Européenne du Programme Modélisation de la Complexité (Le Moigne).

In brief, the project is not predesigned and its model is not defined. It is built through cooperation between the actors. This construction process is at the center of our research. Use of scenarios which are components of the "tool box" provides some help towards managing this approach.

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15.2 The evolving French rural landscape: what influence do landscape projects have?

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Abstract

French rural landscapes are evolving presently under the combined influence of the Common Agricultural Policy (CAP) and of urban and environmental policies related to urban development and the protection of sites, monuments and natural habitats. Over the past thirty years, in response to public pressure for a better environment, state regulations have become more stringent.

Keywords: *rural landscape, landscape project, heritage, France*

The Legal Framework

During the 1960s and 1970s the question of landscape was considered by most, and more particularly by rural folk, as "elitist and belonging to the city" (Sgard and Zarmati, 1993). Most landscape architects, who were not numerous in France during that period, worked exclusively on urban projects. Following the Lurs-en-Provence colloquium held in 1966, the state instituted a policy for regional natural parks as "refuges of cultural identity" (Sgard and Zarmati, 1993) as a first measure to contain urban sprawl and avoid environmental degradation. The 1976 law for the protection of nature made environmental impact reports mandatory. The Conservatory for Coastal and Lakefront Zones had been founded a year earlier, in 1975. As a result of these two measures, landscape architects became involved in site planning and took on a role as mediator beween the state and the people.

In 1983, the law on decentralization gave more power to local governments and provided a framework for a public debate on the subject of landscape. Laws passed in 1985 and 1986 on the development of coastal and mountain areas provided government guidelines. But it was only in January 1993 that a comprehensive law on the preservation and enhancement of landscapes was adopted, making it mandatory to integrate landscape factors in all urban planning documents, in rural development procedures and in the management of regional natural parks. This new law supplemented two already existing laws which are essential for landscape protection: the 1913 law "concerning historic monuments" and the 1930 law for "the protection of natural monuments and sites of historic, scientific, legendary or picturesque character", which instituted protected areas in a defined perimeter of natural monuments and historic sites.

Today the main landscape questions of concern to government bodies are related to the conservation of rural landscapes having natural and cultural significance. Some recently adopted policies of limited range, such as the "landscape labels policy" launched in 1992 by the Ministry of the Environment, tend to link the quality of agricultural and aquacultural products to the specific quality of rural landscapes. This policy has been used to favor the protection of cider apple trees in the Segre hedgerow region of Anjou,

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of salt produced by the Guérande salt marshes close to Nantes and of the oysters in the Marennes basin near Rochefort. Since the 1993 landscape law came into effect, there have been discussions between the Ministry of the Environment and local elected bodies about nature and the quality of landscapes of several regional natural parks located near big cities. This has led to adopting "landscape charters", which act as guidelines for the management of a given area and which must be adhered to by all local governments involved. This type of policy document allows landscape legislation to regulate all types of change, particularly in the context of planning regulations and zoning ordinances. In recent years, landscape architects have been commissioned to work on drafting these charters. They will be increasingly involved in carrying out legally mandated "landscape studies" required prior to any landscape transformation due to urban development, agricultural practices or forestry management.

Finally, in the area of agri-environmental measures, France has adopted an experimental policy for a Durable Development Plan (DDP) procedure to be applied to large scale agriculture. The DDP includes both environmental and landscape goals. The French Ministry of Construction and Public Works has called upon landscape architects to produce landscape plans for the management of latent landscape transformation problems linked either to the implementation of Common Agricultural Policy or to regional planning (more particularly to new roads and railway lines). A landscape atlas, covering both regional and local scales and undertaken with the support of this ministry's architecture and town planning office, is currently being completed.

Different Projects, Different Approaches

French landscape architects have rather pragmatic approaches. Whether it be in response to field studies commissioned by public bodies such as the regional offices of the Ministry of Construction and Public Works, the department level architectural, town planning and environmental advisory bureaux (CAUE), the Ile-de-France Region Development and Town Planning Agency (IAURIF) or by mayors, local, department or regional councils, the landscape designer undertakes site analysis that leads to a proposal for design strategies or concepts that must prove convincing for decision makers.

For the small "Val Suzon" valley, north of Dijon in Burgundy, the landscape architect Jacques Sgard conceived a project (Sgard, 1993) whose aim was to enhance archaeological vestiges and picturesque forests and meadows for the enjoyment of the nearby Dijon population. For the Marquise quarry basin in the Pas-de-Calais, he proposed to shape sterile lands in forms that echo the general topography of the site. At the request of the Haut Rhin department council in Alsace, he identified open landscapes in the Alsatian plains to be protected from urban sprawl, using the idea of a landscape park representing the identity of Alsatian landscape embodied in the spectacle of pictureqes vineyards.

In a similar way, another landscape architect, Michel Corajoud, has commented on the separation between the industrial, urban and rural landscapes of the port of Dunkirk (Corajoud, 1993) and proposed to weave a network of new relationships between city, industry and the countryside. By choosing to reveal existing green belts and intricate water systems, he had produced the framework for a landscape charter to be further developed and defined in coordination with local governments. While his proposal welcomes new development, it also recognizes as valid landscape features existing industrial complexes which had not been considered as such by prior Dunkirk town planning policy.

Both Sgard and Corajoud - and it would be possible to cite many other landscape architects who have reacted in the same way - have proposed interdependent urban and rural design principles as a basis for constituting coherent landscapes.

Another type of landscape approach is based on using a land ownership grid (Blumenfeld, 1993; Vivien, 1993) as a framework for landscape projects. This approach, developed in the 1960s by the late G. Hanning, town planner at the Ile-de-France Region Development and Town Planning Agency (IAURIF), uses the geometric cartography of property grids to plan new development. Its principles for future development are based on reading topography and identifying the traces of land parcels, roads and networks such as waterways. When applied to the Saclay plateau, south of Paris, whose landscape is comprised of forests, fields and villages, in depth analysis reveals dominant features to be enhanced, such as runnels and lakes draining the plateau and forest edges. The IAURIF project for this area identifies agricultural and forest lands to be protected, integrates new roads and new urban developments linked to a green grid concept. Its main strategy is based on the idea of an equilibrium between the natural and urban environments of an entire region whose evolution is planned on the basis of a coherent integration with existing landscape structures. This strategy is designed to give the viewer inside the area the impression of being part of a vast plateau landscape entity, to provide the viewer outside with good access to the plateau and essential landmarks for comprehending the plateau as a whole and to create an initial basis for new development.

Over the past ten years, other landscape approaches have been used in France, but one must note a relative lack of ecologically based planning methods more widely developed in Anglo-Saxon and Germanic countries.

Following the theory of the aesthetician Alain Roger, Alain Mazas believes that landscape appreciation depends on models which artistic culture transmits to society (Mazas, 1993). According to this theory, to perceive a landscape one must have memorized different motifs coming from painting, photography and literature. A landscape project therefore attempts to connect different motifs in the landscape, such as a lake, a meadow, a village and its church spire. His project for Settons Lake in the Morvan region and his landscape plan for Decize-la-Machine in the Nièvre region use this type of principle for identifying landscape motifs in a process which requires lengthy discussion with local authorities. As in the case of the first approach mentioned, the goal is to recreate, at a local scale, a sensitive relationship between a society and its landscape by modifying perceptions while landscape transformations are taking place.

Recognizing that a landscape project must be preceded by a site assessment taking into account the potential and the resources of the region or municipality involved, Yves Luginbuhl has developed a landscape atlas approach (Luginbuhl, 1994). His method refuses the idea of a single, correct definition of landscape and considers landscape as a polysemic concept, grounded as much in science as in social reality. Landscape atlases must therefore take into account not only the various physical and natural facets of site analysis, but also the pictorial and literary dimension of landscape, as well at its social and symbolic dimension via local inquiries directed at local officials and individual and collective sector-based projects. These local inquiries heighten local officials' awareness of their landscape and the necessity of considering its evolution. In the various instances where such inquiries have been made (more than one thousand municipalities in the Loire valley and in the Finistère, Lot-et-Garonne and Dordogne departments) the level of response has always exceeded 70%. Similar methods have been used for drafting natural regional park landscape charters which legally require not only a survey of landscapes of national and local significance but also the effective participation of local users and elected officials (Bouillon, 1994; Gorgeu, Jenkins and Coudray, 1994).

The Evolving Future of Rural Landscapes: Naturalization, Heritage Preservation or Urban Development?

Although it is too early to evaluate the impact of all these new methods of rural landscape management, a provisional assessment can be made of the role of different types of projects in landscape evolution.

The most prevalent tendency is the conservation or preservation of preexisting forms (hedgerow plantations, wetland reclamation, genetic banks, etc.) in the rural landscape, mainly for economic (green tourism, labeled products), ecological (biodiversity) and social (national heritage, social identity and solidarity) reasons.

Despite the weight of this tendency, more and more frequently landscape architects opt for projects that create "new landscapes" by taking into account their aesthetic, economic, ecological and social dimensions. This is the case of projects for new motorways, for nature reserve or historic garden visitor centres or for derelict quarry and mine tips, etc. Considering the mediating role of landscape image and aims has become essential for projects involving the restoration of abandoned Mediterranean agricultural terraces, the replanting of hedgerows destroyed by past agricultural land consolidation policies or the drafting of landscape management plans for rural municipalities or to avoid poplar overgrowth in wet prairie environments. However, because these practices evolve slowly, it is difficult to provide dramatic examples.

The most important observation to be made is that the future of French landscapes depends more and more on planning practices that provide a social and economic basis for development. These practices are called into play for the extension of high-speed railway and motorway networks, the application of new Common Agricultural Policy measures (agro-environmental measures, fallow lands, durable development plans) and the strengthening of environmental protection systems in the form of new natural regional parks.

In this new context, which governmental environmental planning policy has attempted to define, the distinction that was traditionally made between urban society and rural society has gradually lost its meaning for at least three reasons:

- environmental planning philosophy is in fact urban because it deals with rural agricultural spaces in aesthetic and ethical terms. Town planning documents treat agricultural and forest areas as multifunctional natural spaces for economic, ecological and recreational activities. Sgard's landscape park concept (Sgard, 1993), which is a direct result of this phenomenon, expresses a broad social trend towards "naturalization", i.e. nature considered as a natural heritage.

- for the last twenty years landscape architects have been dealing with a broadening range and scale of projects, from urban parks and gardens to counties or entire regions. At least four ministries have integrated policy and technical aspects of landscape in their course of action and therefore require studies at all scales (from village squares to entire mountain ranges or coastal areas). The Ministry of Planning and Public Works deals with architectural and urban design matters as well as with site protection (1930 law), the Ministry of Environment deals with environmental matters, the implementation of the 1993 landscape law (all of whose decrees have not yet been published) and protected areas (parks and nature reserves), the Ministry of Agriculture deals with forestry and the implementation of the new Common Agricultural Policy, the Ministry of Culture deals with the protection of historic monuments and the management of cultural heritage.

- because the sectoral fragmentation of governmental management resulted in a monofunctional vision of landscape areas, which has been recognized as insufficient, landscape architects have been called on to provide global approaches to landscape problems. However, their approaches reflect essentially urban based concepts.

Today French rural landscapes are split between two poles of evolution: on the one hand, an urban development pole which is a direct consequence of new transportation infrastructures, of tourism and of residential urban sprawl; on the other hand, a national heritage and "naturalization" pole which tends to preserve the natural and cultural memory of rural spaces. "Caught between desirable spaces and left-over spaces, agrarian spaces are subject to contradictory logics and will have great difficulty developing their own landscape logic." (Brunet, 1992). If it is true, as the authors underline in the conclusion of the Atlas of Rural Landscapes of France (Brunet, 1992), that rural landscapes run the risk of being relegated to the status of relics, it seems more probable that perceptions of non urban spaces will develop according to new social uses linked to these areas: high speed travel in TGV trains or on motorways, rambling for nature lovers, landscape décors for tourists and weekenders. The role of those who now create landscapes - engineers, foresters and farmers - could very well rank second to the social expectations of urban societies. It is precisely at this level that the landscape project could help those who create and use rural areas to render these landscapes worthy of being looked at, liveable and attractive. Because today's rural landscapes are not only agricultural, they will become more and more diversified and will be managed increasingly as a natural and cultural heritage.

The Essential Role of the Image in Social Mediation

Images of landscape projects produced by landscape architects at the request of public authorities (whether they be a municipality, a group of municipalities or a department) play several roles. They offer a schematic representation of landscape analysis and design proposals corresponding to the conditions of a particular place and the development of an economic and social programme, whether explicitly stated or not. Images not only facilitate communication, they also express a designer's choice. For this reason they are not meant to be scenarios to help decision makers, but rather an ideal proposal of forms for an area with multiple actors and on which community representatives project their needs and social expectations. For landscape architects in quest of social and economic answers through spatial design, the somewhat blurry and only partially defined landscape project is the initial stage of mediation for planning practices using comparative scenario techniques.

The most common criticism of landscape projects is that they do not offer a choice to decision makers who would like to weigh the pros and cons of several proposals and decide according to their own hierarchy of criteria. To avoid this problem, it is preferable to use design competitions which make it possible to compare several proposals and sometimes choose several designers. The study of landscape design practice (Faccioli, 1994) shows that the dialectic between client and designer makes it possible to consider several scenarios in an informal manner, but to pursue in depth only the one which interests or convinces the client. This practice implies frequent meetings between the client of the design project and the designer. The result of the design project thus becomes an action strategy co-produced by a landscape architect and his client. It is illustrated with maps, perspective views or axonometric drawings, sections and referential images which in practice produce the interpretive context of the project. From this point of view, the design project is a particular mode of communication which creates the social conditions for the appropriation of the designer's intention by social representatives. In other words, the designer as practioner seeks to get his project built by seducing and convincing. It is therefore essential to spend much time carrying the plan around and talking about it with all those who have a stake in the area concerned.

The main difference between a landscape project and other types of development projects, such as civil engineering, geographic information systems (GIS) monitoring or socio-economic strategies, is that the former relies on a landscape concept which is created, invented and ordered at different scales, with modes of representation and images that literally stage the space to be developed. From this point of view, it becomes obvious that there is a direct correlation with architectural design methods apart from the fact that the result in this case is not a built object (Conan, 1990; Donadieu, 1993). If the role of the image is to inform, it also serves to transmit aesthetic schemata that Alain Mazas (Mazas, 1993) calls motifs and which enable us to look at the landscape according to the designer's wishes. Such collective memorization of perceptive schemata is essential to understand social expectations of landscape, as shown by Luginbuhl (Luginbuhl, 1994) and Berque (Berque, 1992). One must also admit as Brugière did (Brugière, 1991) that the countryside was previously governed by an aesthetic which owes nothing to the landscape profession, and agree with sociologists like Dubost (Dubost, 1994) that today's tourists are not all searching for a picturesque spectacle.

Therefore, it is predictable that the will to produce landscape (gardens, parks, landscaped countryside) will remain as a distinct social practice, but that the total landscaping of France will remain a utopia.

Conclusions

To each his own area of competence:

- the landscape architect's role as a designer is to invent, reveal and build living environments and a way of looking at the world.
- the role of the town planner is to phase the different stages of project design and predict their life span.
- the role of the manager is to specify clear criteria for implementing projects (monitoring).

At all levels, the democratic process and the appropriation of projects by local users is an essential goal, but the role of the state as a regulator remains important to guarantee the social and spatial transition of landscapes that belonged to a rural-agrarian society to those of a predominantly urban-industrial society.

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*Fig. 1. Windmills for valley farming irrigation
Photo: M. Sevrac, landscape architect*

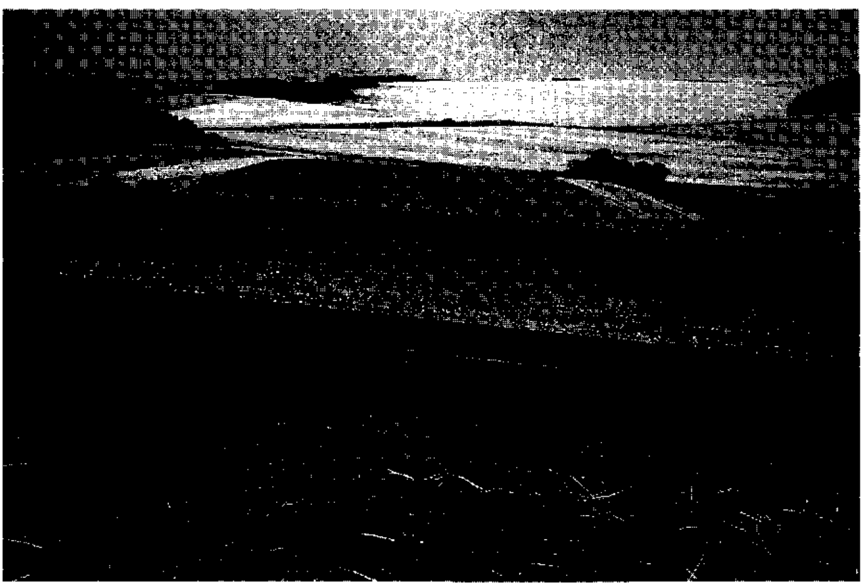

Fig. 2. Stubble being burned off a grain crop landscape in La Puisaye region, south-east of Paris (Photo: A. Petzold, landscape architect)

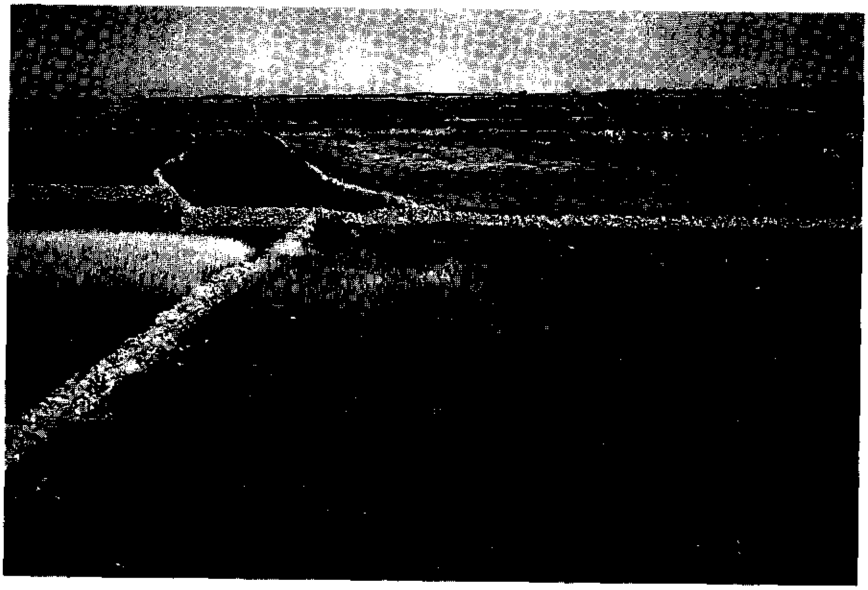

Fig. 3. Fields surrounded by dry stone walls,with marshy area in the foreground, Cotentin peninsula, western France (Photo: A. Petzold, landscape architect)

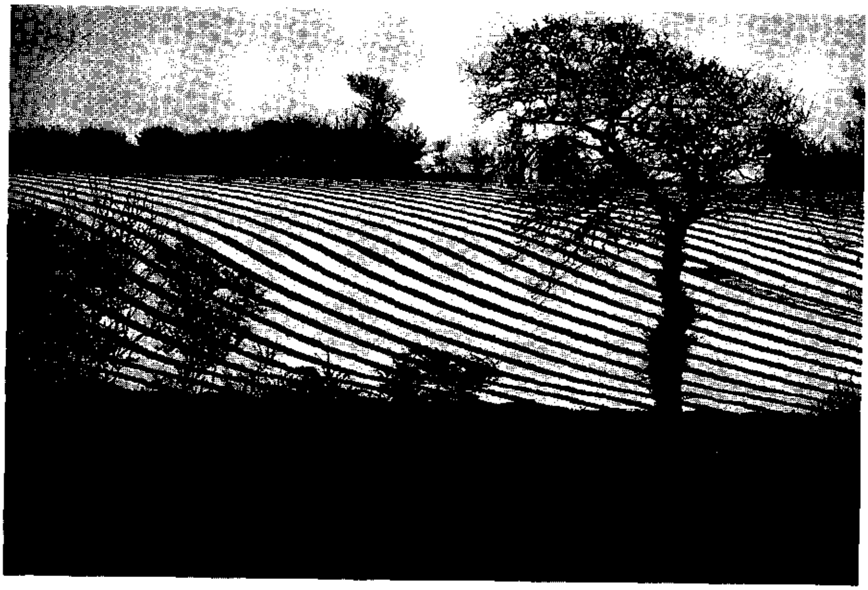

Fig. 4. Cotentin peninsula agrarian landscape of maize planting protected by plastic sheeting (Photo: A. Petzold, landscape architect)

15.3 Interest groups, policy makers and the challenge of modelled or perceived futures for the rural environment

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Abstract

With increased demands from communities for effective involvement in the management and planning of change, it is important to identify the legitimate interests in rural communities and find ways of including them. It is argued that this can be first achieved through the identification of strategic segments within the community. These can be used as vehicles for mobilising interests and for organising the long term strategic planning process. Scenario analyses have an important role to play because of their ability to help people participate more effectively in the political process of negotiating and planning for the community.

Keywords: *interest groups, strategic planning, sustainable community development*

Introduction

Rural areas of all types have been experiencing profound changes. In metropolitan regions, they have often been confronted with a declining agricultural population combined with an influx of other population groups such as exurbanites, commuters, retirees and seasonal populations (Bryant *et al.*, 1982; Marsden *et al.*, 1993). The variety of different groups is considerable both in North America and Western Europe. Furthermore, the patterns are dynamic as population groups and their associated values and interests change.

In rural peripheries, there is also great heterogeneity. Many areas have experienced population stagnation and decline, and erosion of their economic base. In others, growth may occur, for instance related to particular resource developments; here, different interests may come together to interact or conflict, e.g. corporate interests and environmental groups, local interests and non-local interests.

A common thread in all rural areas since the 1970s has been the increased desire of populations to participate in the management and planning of their own environment. This is partly related to people's increased disenchantment with top-down, technocratic planning schemes. In addition, many interest groups have acquired high levels of competence and confidence in making their own positions and values heard. Frequently, this simply leads to increased levels of lobbying, the results of which reflect the power relationships of the different groups involved.

In many respects, these changes pose real challenges to orderly management and planning. 'Orderly' suggests the management of change to achieve some defined set of goals. It does not imply a technocratic or top-down management process. It cannot ignore the existence of the variety of interests and values present in today's heterogeneous rural environments. Any institutional attempts to plan and manage development without

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understanding and incorporating the range of legitimate segments and values is ultimately doomed to failure or at least disappointment. This argument is consistent with the democratic traditions of western society. It suggests that planning and management need to work with a plurality of interests in mind. This is the central thrust of this paper.

First, some brief comments are made on the interests in rural areas and on approaches to identifying them. Second, some comments are made on the links between the identification of the population groups and their interests, and their participation in management and planning. Drawing the interests together necessitates the management of a process termed 'sustainable community development' which can be articulated through strategic management and planning. Then, attention is turned to the role of scenarios, particularly in terms of using them to model perceived futures and enabling a process of negotiation to begin. Obstacles to introducing this approach are briefly considered in the conclusions.

Interests, Interest Groups and the Rural Environment

In any rural environment, there may be many different interests present. Interests can be related to people's 'basic needs' in terms of food, shelter and clothing, their preoccupations about the maintenance and development of their own activities, environmental concerns, or, in short, anything which affects the perceived quality of life. Interests can be economic, political, social, cultural or environmental. They can be espoused by local residents and non-residents, and can be expressed by individuals, informally or formally organised groups, and firms, local institutions, and external agencies and institutions. Conflicts are common even within the public sector (Bryant *et al.*, 1982).

From the management and planning perspective, the critical question is how to identify the interests. While this is not always easy, they must be defined in any democratically based process. This can be accomplished through appropriate **segmentation**.

The population and activity of any area can be analysed through the identification of different **segments**. These are the significant dimensions that help us understand the structure and dynamics of a given area and community (Beaudoin and Bryant, 1993). They can either be of actual importance in the area's current state of development or might be of future significance to the area's development. Segments can be activity **sectors** (e.g. economic sectors), **themes** cutting across different sectors (e.g. environmental concerns) or **geographic** (e.g. downtown development). Segments may also be defined by a combination of sector, theme and locality characteristics (e.g. agricultural development in a specific locality with environmental vulnerability).

Identifying the important segments is a first step towards community management and planning. At this point, simply remember that the segmentation of a community can change; furthermore, segmentation is a subjective process; thus, its effectiveness is very much a function of **who** has participated in the identification of segments, **what** are their perceptions of the community and **whether they are representative** of the interests there.

An appropriate segmentation of a community's population and activities is much more than a good description of the community. It is also an instrument to help organise and mobilise interests and interest groups into a coherent management and planning process.

The Participation of Interest Groups in Management and Planning for the Rural Environment

Each segment can be associated with an interest or a set of interests, albeit not always in harmony. Therefore, it is possible to see the segments as the organising vehicles for managing change. This is already common in many communities, e.g. the creation of working groups bringing together people with a common set of interests or with a common object as their focus (e.g. wetlands).

How the segments and the people with different interests associated with these segments participate in management and planning processes depends partly upon how they are organised. In a community, interests can be organised vertically and horizontally (Figure 1).

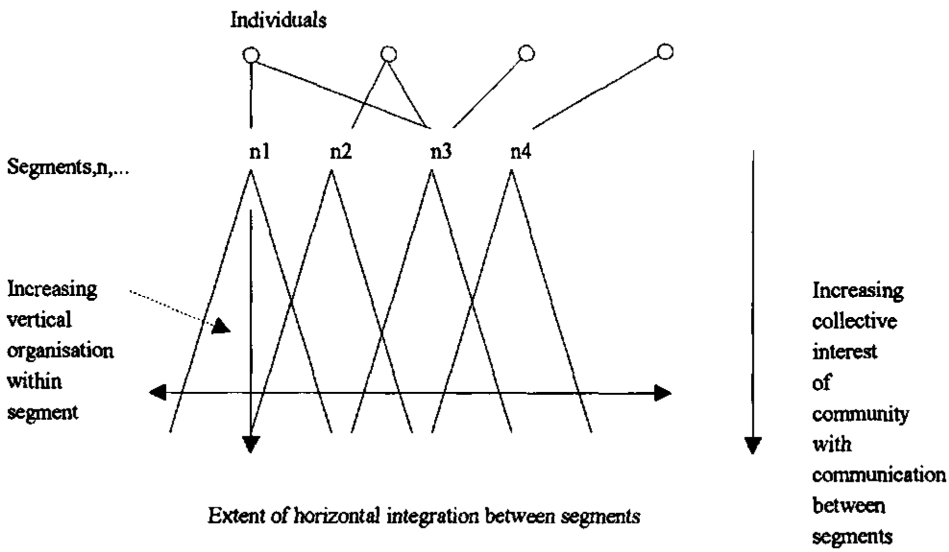

Fig. 1. Interests and segments in the local community

Vertically, a segment can be characterised by the degree of organisation of the interests associated with it. At one level, there may simply be individuals with a common interest (or conflicting interests) in relation to a particular segment, but there is no communication between them and no mechanism to permit discussion. At another level, some mobilisation may take place as people sharing the same personal, and collective, interest collaborate or cooperate, leading to the initiation of projects within the segment. Where people have come together to defend a cause or to protect something they see as essential to their survival or their quality of life, the first stages of mobilisation tend to be oriented to lobbying aimed at government or other players with power and influence. At an even higher level, the organisation within a segment may implicate different actors and people with a common object as focus but with conflicting interests, e.g. for a segment involving the future of wetlands in an area surrounded by relatively intensive agricultural development, a working group may have been constituted to draw together the differing interests and engage in a strategic discussion on how to tackle the concerns.

Clearly, the power and influence associated with the different interests involved in the different segments of a community's activities and population vary substantially. Recognising some legitimate interests and segments in some communities may first require substantial changes in attitudes from people with power and influence.

Horizontal organisation is therefore the other important dimension. This involves linkages across the different segments to provide a broader community perspective. Theoretically, only when there is adequate communication between all the different segments and their planning and development processes can we talk about a true community perspective. In reality, integration is often limited to just a subset of segments; and in many cases, virtually no integration exists between the different segments when local government agencies appropriate all of the planning and development processes and do not recognize the legitimacy of other interests becoming involved.

This is so even where a particular initiative has been developed that encompasses potentially all of the development activities in an area and has led to the creation of an area-wide institutional framework. The institution of the *Parc Naturel Régional* in France provides many examples of this. As one example, the *Parc Naturel de Chevreuse* south of Paris is cited (Bryant, 1986; Squarcioni, 1983). This development, involving 19 communes, covers a picturesque area comprising deeply cut valleys alternating with small agricultural plateaux. Being close to Paris, in the mid-1970s this attractive area came under pressure for development. Already home to many wealthy families who had sought peace and tranquillity there, the idea for a *Parc* arose amongst a small number of concerned citizens. They were articulate and had the ability to deal with the local and regional political system. The development of the *Parc* and its Charter took over a decade to negotiate and put in place; its existence has daily ramifications for all the local municipalities involved and the management structure for the *Parc* includes a fairly wide variety of interests. In this case, an environmental theme segment spawned more than a lobby group, and has led to a relatively permanent feature in the Paris urban fringe with both local and regional impacts.

The *Parc de Chevreuse* started as an initiative centred around an environmental theme segment and subsequently broadened into an institutional arrangement including both local and non-local (mainly public sector) participants. However, action within segments usually originates with a particular set of interests; if these are brought to the community table, it likely says something about the power and influence of the people involved in the first place. However much other interests are integrated into the project, the project is still generally defined in relation to the initial concerns, e.g. in this case, the control of residential and other development to maintain the special landscape character of the area. Furthermore, the interests represented in the *Conseil d'administration* of this *Parc* tend to represent formal institutions and organisations from within and outside the area. On the one hand, it is not clear that all the important segments in the area's development have been effectively integrated into the planning and management process and, on the other hand, it is far from clear that the interests actually represented (on a *Conseil d'administration* with close to 40 people) have an effective voice in what happens.

Clearly, the dynamics linking interests, segments and local agency vary among rural communities. The dynamics of community change are linked to the nature of the power relationships in a community, the changing composition of interests in the community and the nature of the social (or informal) relationships within the community. In short, communities can be characterised by different community cultures regarding the management of change and the recognition and inclusion of legitimate interests and segments therein. This provides us with an important key into management and planning for rural areas and the role of scenario studies in this process.

Sustainable Community Development, Strategic Planning and Scenario Studies

Ultimately, management and planning for a rural community must deal with the totality of community change. Managing change essentially means some sort of long term planning, particularly strategic planning. In the past, local management and planning of change has been undertaken frequently by a small elite group, directly or indirectly involving the local government; not infrequently, it led to conflict between such groups and the community at large. By contrast, a broader community perspective implies the integration of as many legitimate interests and segments in the community as possible. When this happens we can talk of one of the conditions for a **sustainable community development** process. Long term opportunities are created for all legitimate interests in the community to have a say in the definition of vision and objectives and in participating in project implementation. Sustainable community development involves the search for development solutions that help the community attain its vision with initiatives that are culturally acceptable, economically feasible and environmentally compatible (Bryant, 1991). Since experience has shown us that even the best educated scientists, politicians and technocrats do not have a monopoly on wisdom, a broader participation from the different interests within the community provides an important input and, as well, contributes to creating a vision that is multi-faceted and has broader appeal.

Therefore, such an effective community perspective can only exist if first, the different interests and segments are indeed recognised and second, there is adequate communication between the different segments and effective representation of the segments in the overall process of managing community change. This does not mean that a single agency or organisation must take the lead and include representation from all segments within it. But it does mean that an effective system of communication is required.

The whole process of sustainable community development in a rural area can be managed. One robust approach that is developing rapidly in many Canadian rural communities is strategic management and planning for sustainable community development (e.g. Bryant and Preston, 1987; Beaudoin and Bryant, 1993; Bryant, 1994; Bryant, forthcoming). It involves the realistic analysis of a community with the involvement of the community, the identification of a realistic vision for the community and the identification of strategies to achieve that vision. The key is the management and planning of change BY the community FOR the community, taking into account and integrating with the resources and preoccupations of senior levels of government.

It is important to recognise that real development projects often take place in clusters or segments. When these are planned, we can say they take place in strategic orientations or segments - strategic because they involve planned choices to focus energies on some orientations rather than others, particularly those that appear more likely to bring the community closer to its vision. Similarly, within these strategic segments or orientations, choices are made regarding specific actions and projects. Once more, these are strategic when they result from reflection, analysis and evaluation.

So, not only can the identification of strategic segments be used to mobilise the interests in the community, they also provide one of the primary vehicles by which discussion and negotiation between the different interests and interest groups can be organised. In short, while some important coordinating and communication functions of management and planning must occur at the community level, and while there must ultimately be a community level vision developed, the real development and management of rural change comes through processes that are developed within each strategic orientation or segment. Community round tables can be used to help identify the interests and the important segments in the community in the first place, of course; other community level exercises such as through a coordinating group can also provide an important vehicle through which to discuss and negotiate matters that arise from the potential interaction (complementarities or conflicts) between development planning in the different strategic orientations or segments.

Thus, strategic planning - realistic analysis of constraints, resources and opportunities, development of a (segment) vision, specification of objectives and identification and implementation of specific projects to achieve the vision - takes place within each segment. Each strategic segment can become the focal point for organising community round tables and working groups that develop actual plans. The plans are not simply land use or management plans; they are plans in which real people have agreed to take responsibility to carry out a real project, usually in partnership with other people and agencies.

Part of strategic planning involves the elaboration of a realistic segment vision. This involves dealing with the variety of interests associated with a given segment and sorting out conflicts. The process inevitably involves debate, evaluation and negotiation. One of the most important tools by which the integration of the different interests can be achieved and acceptable solutions and strategies developed is through scenario analysis. In reality, many communities have already used **elements of** scenario elaboration and analysis in their management and planning activities. What has often been missing is the incorporation of as wide a variety of pertinent interests as possible. Thus, the development of the charters for the *Parcs Naturels Régionaux* in France is based on extensive discussions between the various municipal representatives and those from other agencies, as well as input from professional staff of the *pre-Parc* institution (the *Mission du Parc*) (e.g. PNR du Vexin, 1994). In those processes, different scenarios are certainly envisaged but they often lack the input from a representative cross-section of local population and activity segments.

Scenario analysis can be developed at a number of different levels of sophistication. At the relatively 'soft' scenario development level, different interest groups and actors can become involved in creating vision statements either for the whole rural community or for a particular segment. When the whole range of known legitimate interests are included, such vision statements can be multi-faceted and enjoy broad support. Visioning exercises carried out in a workshop format characteristically bring people together in a non-threatening environment, i.e. there is no intent to force decisions. Otherwise, people who represent different interests formally (e.g. mayors, agency representatives) frequently participate with pre-determined positions, making debate and negotiation difficult. When visioning is undertaken in a non-threatening environment, it encourages the sharing of ideas and greater participation, and reduces confrontation.

Backcasting from vision statements can lead to the assessment of obstacles to change and the elaboration of courses of action. This process is not generally concentrated into a single meeting! When visioning is carried out in a non-threatening environment to develop shared, albeit complex visions, and is linked to the development of appropriate courses of action, the creation of scenarios and their evaluation can substitute for part of the more traditional negotiation processes. This form of visioning is consistent with the sustainable community development process because it depends upon the participants defining what is important for them in their vision, and then sorting out the consequences (economically, socially, environmentally) for themselves and their own environment.

More sophisticated scenario elaboration and evaluation exercises also involve the creation of visions. Quantitative approaches to the assessment of alternative scenarios, the creation of scenarios based upon specific assumptions and actions, and the evaluation of alternative courses of action have been developed (e.g. Hoffman and Newkirk, 1987; Bryant, 1987; Martin and Bryant, 1987). There are significant technical problems involved in these approaches, particularly relating to the ability to model interacting sub-systems dynamically and to formulate results so that users (the interests groups and the actors) can both use and feel able to maintain some degree of control. This is valid both for the whole 'scientific' scenario modelling approach as well as for specific components of it such as GIS (Bryant, 1993). On the other hand, the combination of the 'soft' scenario construction and evaluation approach for different segment working groups holds out considerable promise of substituting a more easily accessible political process for many of the more traditional political and technocratic processes that have characterised rural development efforts.

Conclusions

The interests concerned with development in most rural areas are varied and dynamic. Demographic structures change both internally and from migration, and values change. The management and planning of change to achieve sustainable rural community development must confront the reality of this multitude of interests (and therefore perceptions) and find ways to include them. Of course, this does not mean that conflict is eliminated! But it does mean that stresses resulting from differences in interests, values and perceptions are brought out into the open from the outset.

Scenario elaboration and analysis either for the whole community or for each strategic segment provides a critical approach to bringing people together, potentially in non-threatening situations, to discuss and sort out their values and perceptions regarding the community's or the segment's vision. The debate and discussion characteristic of the 'soft' approach to scenario analysis is easily assimilable for many people. It allows them to become part of the political process of management and planning, i.e. the process of making choices and taking decisions. Making choices, it may be presumed, is better when it is informed by appropriate information and analysis. Hence, the technical or more 'scientific' approaches to scenario elaboration and analysis provide potentially significant input into the process of debate and negotiation. Such approaches can bring out interrelationships between different actions or assumptions about the future and may lead interest groups and actors to modify their perceptions of what is appropriate and feasible. However, these technical approaches can never completely substitute for the 'soft' approach. After all, they are generally composed of sets of rules and procedures that are themselves the result of subjective judgements made by researchers and professional planners.

Obstacles to effective use of scenarios in decision-making management and planning for rural development are twofold. First, the different legitimate interests concerned by a particular project or development in a segment must be recognised and brought into the process. This is easier said than done. In some communities, the power structure excludes many legitimate interests from debate and discussion. This means that some conflict situations may never be openly debated and in the worst cases, groups without any significant power must bear the costs of decisions taken without their involvement. Senior government policy and programmes can play an important part in reducing such barriers to effective participation through creating an enabling environment favourable to appropriate segmentation and participation.

Second, in relation to the more technical aspects of scenario elaboration and analysis, significant barriers still exist in terms of the communicability and accessibility of the results. Approaches that are difficult to access because of the technical language or the nature of the analytic procedures and equipment used alienate users, including politicians. It is difficult to obtain constructive input when users are faced with a 'black box' situation or are told they must 'trust' the architects of the system! Such concerns lie behind some relatively recent efforts to eliminate all but the simplest calculations from scenario modelling and to involve the user as an integral part of the modelling process (Hoffman and Newkirk, 1987).

In short, sustainable community development involves the redemocratisation of local and regional institutions for managing and planning change. And in order for scenario analysis to be able to play a constructive role in the process, this redemocratisation must also affect the conditions surrounding the utilisation of scenario analysis, both in terms of the recognition and inclusion of the legitimate interests in the process and in terms of ensuring that the most effective tools available to people for scenario analysis are accessible to them.

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CHAPTER 16

Operational methods for land use scenarios

16.1 Back to the future

New functions for rural areas in Europe

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Abstract
As part of the project Rural Areas & Europe of the Netherlands Spatial Planning Department (RPD) a study has been carried out in which integrated rural development is one of the answers to the economic and environmental problems of agriculture. The study focuses on four possible new functions: water production, pluri-activity on farms, recreation & tourism and new rural residential options. Maps have been compiled of the potentials for new functions in the European Union. The presence of large population concentrations, the accessibility and the landscape attractiveness appear to be important indicators of the demand for new functions. Such qualities are often rooted in long historical processes.
Keywords: *rural development, marginalisation, coregional planning, European Union*

Looking for new functions

Rural areas are becoming increasingly dynamic. A hands-off government, international free trade and environmental problems lead to lower prices for agricultural products and higher production costs. These developments combined with technological progress result in a decreasing economic importance and employment of agriculture. Where agriculture is the main function of a rural area, its marginalisation becomes imminent. Without intervention such regions are threatened by depopulation and degradation of spatial quality. Several answers are possible:

- industrialisation of agriculture with closed cycles (agriculture without land);
- agriculture making place for nature development (land without agriculture);
- introduction of new functions (integrated rural development).

Each answer can be considered as a different scenario for possible development of a region. In this paper one scenario, the third option, is elaborated.

Four new functions are analyzed: water production, pluriactivity on farms, recreation & tourism, rural residential options. For each function, the key factors which determine the potential for that function are investigated and maps are made of areas with high potentials. Because of the availability of data this research is restricted to the European Union (EU).

Four reference regions, which combine an expected surplus of agricultural land with good perspectives for new functions, are investigated in more detail as to possible combinations of new functions and ways of realising these.

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Analyses of potentials

Expected withdrawal of agriculture

Indicators for land becoming available for non-agricultural use are:

- physical production potential based on characteristics of soil and climate; production potential is estimated for four different crop groups: cereals, root crops/vegetables, grass and permanent crops;
- the income per agricultural worker related to the regional average income;
- average farm size in hectares.

Chances for supply of land from agriculture are high if agricultural land is suited for one crop group only, if the relative income per agricultural worker is less than half of the regional average and if average farm size is less than 15 hectares. If in a future situation the benefit-cost ratio decreases, all areas with a low physical production potential are likely to experience changes in land use.

Water production

There are two possibilities for water production in rural areas:

- shallow and deep groundwater extraction;
- retention basins for surface water.

The character of the subsoil, the transmissibility and the risk of groundwater pollution are important indicators.

The perspective of ground water production as a new function for marginal rural areas is of minor economic interest. Combinations are possible with extensive agriculture or nature development. A high transmissivity of the subsoil and a high water balance are necessary.

Retention basins for surface water require large-scale government investments. Often there are good possibilities for combination with recreation and new forms of rural housing. The right amount of relief, a good water quality and a solid subsoil are indispensable.

Pluriactivity on farms

Four different types of pluriactivity on farms are distinguished. Each type has its own indicators:

- semi-agricultural activities, especially sales of agricultural products at the farm: indicators are population density and relative purchasing power with regard to the EU-average;
- farm-based recreation & tourism: indicators are based on landscape attractiveness (presence of woods, coast or mountains) and on presence of cultural heritage;

- landscape maintenance by farmers: indicators are the presence of enclosed or semi-enclosed landscapes with many wooded banks or hedges or a juxtaposition of agricultural areas with small nature areas;
- off-farm employment: indicator is the present unemployment rate; it is assumed that a low rate coincides with larger opportunities for off-farm employment in the future.

For each type it holds that if agriculture income is relatively low and labour surplus is high, pluri-activity will be more likely to develop.

Especially in regions where different types of diversification can be combined, there is a good perspective for pluriactivity on farms. 'Bottom up' initiatives of farmers play an essential role; a facilitating role of the government is desired.

Recreation & tourism

Recreation & tourism can be divided into day-trips and holidays, but also into cultural tourism, nature tourism and coastal tourism. Indicators are:
- population density (day-trips);
- location within 500 km of main conurbations;
- appreciation for cultural tourism based on valuation in tourist guides;
- summer and seawater temperatures;
- attractiveness of the landscape: presence of relief, open waters, woods and national parks.

The indicators are related to the present frequency of holiday nights. Most promising are areas with a low frequency of holiday nights and a high attractiveness score.
Combination of different types of tourism is a success factor. A good accessibility and good access of a region to large marketing networks are important. The main role of government lies in creating general conditions and providing guidance to investors in order to prevent degradation of the qualities of a region.

Rural residential options

Two main types of new rural residential options can be distinguished:
- for commuters;
- for seasonal, footloose or retired residents.

Important indicators are:
- an attractive landscape: based on the presence of small and large watercourses, relief, woodlands, coastal water (with a proper temperature) and national parks;
- accessibility from main conurbations: based on 50 km zones around conurbations (for commuters) and location close by airports and motorways.

Often only small areas within a region are suited for new rural residential options. A high architectural quality of new houses is required to maintain an attractive landscape.

Possibilities are:
- renewal of existing buildings, with a regional ('parochial') architecture;
- new buildings, integrated in the landscape, preferably 'ecological';
- a colony of new buildings with a high value of itself;
- combination with other functions, for example retention basins or tourism.

Reference regions

Portugal: Norte and Centro

The regions Norte and Centro of Portugal are characterized by an economically important agricultural sector, consisting of a large number of small family farms. Its main agricultural activities are viticulture (Port), cereals and forestry (cork oaks). Many farmers have additional income from cottage industries or small businesses. Because this combination is now under pressure due to low incomes from agriculture, these rural areas are threatened with depopulation. Interesting new options for these regions are: small-scale tourism, restoration of abandoned buildings and exploitation of the enormous water surplus through the building of retention basins linked to recreation. It is vital that these activities should not compromise the character of the region.

France: Auvergne and Limousin

The agricultural sector in Auvergne and Limousin consists mainly of beef and dairy production, with limited arable and sheep farming. A long process of depopulation has resulted in very low population densities in rural areas. The Auvergne has exploited many opportunities for the development of tourism. Among the new development options which have been examined, specific product-market combinations would appear to be most likely to succeed, e.g.:
- organic farming and eco-tourism;
- landscape conservation and nature tourism;
- industrial heritage and cultural tourism.

These options can be mutually supportive through links between local amenities and products and culinary tourism. Modern accommodation can also provide a boost to the regional economy. Strengthening the image of genuine rural lifestyles of this area seems to be very important. All this places a considerable demand on local organizing ability.

Germany: Baden-Württemberg

Agricultural production is mainly focused on stock-breeding, cereals, wine and forestry. Baden-Württemberg is a densely populated region with a high level of industrialization and a good infrastructure. Parts of the Black Forest and areas around the Bodensee appear to have reached a saturation point in terms of tourist development. There appear to be interesting opportunities for linking recreation & tourism to construction retention basins, for new rural residential options, as well as for farm-based tourism and nature and landscape conservation. There are good prospects for expanding on-farm sales, particularly in view of the high population density. A possible strategy for realising all these options might be the creation of 'super estates', collaborative associations between neighbouring estates pursuing an overall land development and management plan.

United Kingdom: West Midlands

Important agricultural products in the West Midlands are fruit, vegetables, dairy products, cereals and beef. The West Midlands are characterised by a contrast between further urbanisation of the already urbanized areas and conservation of the rural areas. The rural development outlook for the region is heavily influenced by strong autonomous developments such as re-industrialization and urbanisation. New residential options for commuters in part of the region can provide a springboard for other developments. In another part of the region, the promotion of day-trips and cultural tourism could provide a major development opportunity. If these developments continue, they will create more opportunities for pluriactivity on farms.

Conclusions

The direct economic importance of water production and new rural residential options seems limited. Pluriactivity on farms can be of substantial economic importance for a region, while recreation and tourism can lead to a large increase of regional income, financial investments and employment, both directly and indirectly.

From the analyses of reference regions it can be concluded that combinations of different new functions are important. It appeared that particularly pluriactivity on farms and the presence of surface water have laid the foundation for development of other new functions.

Historically developed qualities of landscape, nature and culture form a basis for further development of rural areas.

The theory of the *life-cycle* of a product can also be applied on functions of rural areas. The development of a function can be distinguished in several stages: introduction, acceptance, (rapid) growth, consolidation and decline. In the first stages, development is ruled by demand, in the second growth stage by supply, resulting in a loss of alignment with demand. Growth can become unbalanced because of differences in development rate of parts of the supply. If a function 'over-develops' often serious damage is done to the qualities of a region. Examples are intensive agriculture or coastal tourism in parts of the east coast of Spain. From this point of view important items are:

- a clear judgement of the basic qualities of a region;
- monitoring development of functions to identify the point of the change-over from demand-led to supply-led growth;
- synchronisation of problems, political agendas and ideas for solutions;
- prevention of an accumulation of different, mutually unrelating or even contradictory policy proposals;
- the situation of an area with regard to other attractive areas or a major transport axis.

Some functions require large scale government investments, for example the creation of retention basins. More often a more facilitating role of the government is desired: providing guidance to local enterprise and enabling mutual strengthening. But sometimes active interference will be needed to avoid either deterioration of existing qualities or overshooting of new developments. The institution of regional innovation centres, united in an international network, can be of great help in this process. To bring together comparable problems or comparable solutions in different regions by a method of *coregional planning* within this network can bring a new perspective for development of marginalising rural areas in Europe within reach.

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16.2 Land use projections for the Rhine Basin under possible future climates

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Abstract

Possible future land uses in the Rhine Basin are presented, both as a result of technical, economic, political and demographic developments and in view of changing climatic conditions due to an increase in greenhouse gases in the atmosphere. For the decade 2040-2049 land use projections are made under both unchanged and changed climatic conditions. Under both conditions, land use has been calculated for a so-called Central Projection and for two variants, one with a minimum urban and agricultural claim on land and one with a maximum claim. These projections are based on: (i) fundamental scientific and technical principles, (ii) secular historic trends, (iii) basic assumptions and (iv) other long term surveys of the future.

Keywords: *land use, climate change, Rhine Basin, greenhouse effect, projections, scenarios*

Background

In 1989 a large research project was initiated by the International Commission of the Hydrology of the Rhine Basin (CHR/KHR) to explore the consequences of changes in climate and land use for the discharge regime of the river Rhine. Several institutes from the countries in the Rhine basin are collaborating in this project. On the Dutch side, work in the project is being undertaken by the Institute for Inland Water Management and Waste Water Treatment (RIZA) and Utrecht University. RIZA is, among other things, responsible for the development of land use "scenarios", conceived as projections of future land use. This research has been subcontracted to the DLO-Winand Staring Centre (SC-DLO); some selected results will be presented in this paper.

In the study both biophysical and socioeconomic factors are considered to arrive at land use projections (we prefer to use the term 'projections' rather than 'scenarios' as the time path towards the future situation is not specified). An extensive report, in four volumes, has been published. Volume 1 presents a biophysical classification needed for identifying geo-referenced agro-ecological zones serving as a basis for region-wide land use projections under current and future conditions (Rötter, 1994). Volume 2 describes the impact analysis of the possible climate changes on crop suitability, on crop (including grass) productivity, and on the water use of these crops (Rötter & Van Diepen, 1994). Volume 3 deals with similar impacts on forestry (Hendriks, 1995).
This paper, based on Volume 4 (Veeneklaas et al., 1994), deals with the possible impact on land use of both biophysical and socioeconomic developments. Two times three projections of possible land use in the Rhine Basin in the decade 2040-2049 are calculated and presented. The first group of projections is based on 'socioeconomic' developments assuming no change in climate; the second group represents the combined impact on land

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use of socioeconomic and climatic change. The differences between the two groups can be interpreted as the net climate change effect on land use.

Relations between biophysical and socioeconomic factors

The influence of biophysical factors on land use proceeds along two lines: suitability of soil/climate combinations for agricultural and forestry production, and agricultural yields. Both suitability and yields will change under changing climatic conditions. For climatic change we have chosen the so-called "Business-as-Usual, best estimate" scenario, based on one of the emission scenarios of the Intergovernmental Panel on Climatic Change (IPCC; Houghton et al., 1990), focusing on the decade 2040-2049. In that scenario a 1.5 °C (summer) to 2.0 °C (winter) average temperature increase is foreseen and a 10% increase in precipitation in wintertime.

The Central Projection and its variants

The first step was to construct a Central Projection of land use. This Central Projection describes the long term tendency in land use, and is based on (i) fundamental scientific and technical principles (often in the form of restrictions), (ii) secular historic trends and (iii) basic assumptions. Differences in attainable agricultural yield levels and in land suitability for agriculture may cause land use to differ under different climatic conditions. Hence, in our case *two* Central Projections for the decade 2040-2049 are presented: one under assumption of no climatic change and one under changed climatic conditions.

Scientific and technical restrictions are derived from land evaluation and agronomic knowledge with respect to plant growth and animal production. They refer mainly to maximum attainable agricultural production levels and suitability of land to grow certain crops.

The basic assumptions are the most controversial input in long term surveys of the future. They are explicit statements, but they cannot - by nature - be proven to be valid for the period in question. They can, however, be made plausible to a greater or lesser degree, for instance by referring to other studies on future developments. For this reason, an inventory of surveys of the future with reference to land use in the Rhine Basin has been carried out. This did not, however, result in clear-cut statements. Contradiction and vagueness remain. In case of a great deal of uncertainty with respect to assumptions that have a large impact on land use, variants to the Central Projection have been formulated. In the end, the alternative assumptions are lumped together in one 'Plus-variant' which combines the highest land claims of urbanisation and agriculture, and a 'Minus-variant' representing the lowest land claims of these two categories of land use, thus leaving the largest area for woodlands and nature (Figure 1).

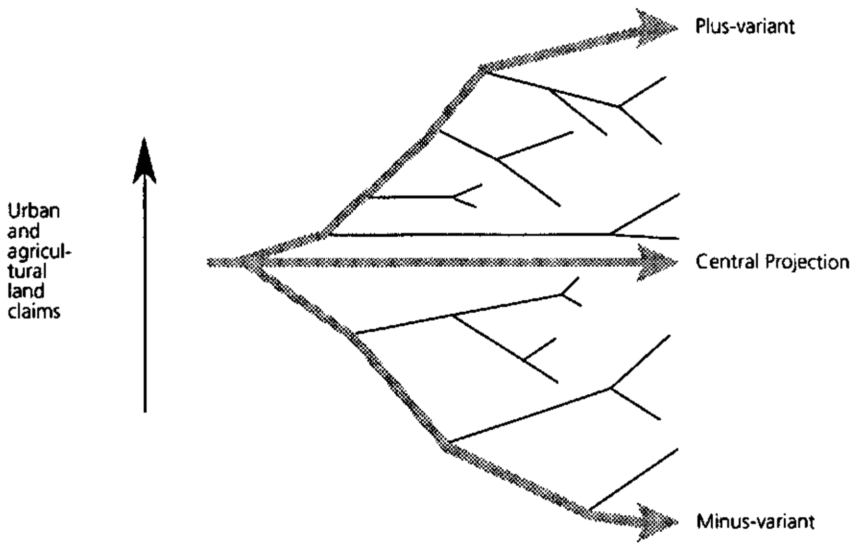

Fig. 1. Construction of the Plus and Minus variant

Hierarchies in demand categories

Land use is assumed in the long run to be demand induced. The various demand categories (urban, agriculture, forestry, etc.) are ranked according to an explicit hierarchy. First, the urban land needs (and areas earmarked for nature development in official long-term policy plans) are met; secondly those of agriculture and then the remaining land is allocated to forestry and other use. The rationale behind this classification is found in the price of land paid by these different categories of land use.
Nested in this hierarchy, a second hierarchy in the category 'agriculture' is applied:
1. Horticulture, permanent crops.
2. Root crops.
3. Cereals and oil seed.
4. Grassland and fodder crops.

The rationale behind this classification lies in the profitability (per ha) of the various crops and the requirements of the different crops in terms of quality of land.

The regional distribution of agriculture

The total Rhine Basin area is 18.7 million ha. It includes parts of Switzerland (and a small part of Austria), of France (Alsace, Lorraine), Luxembourg (and a tiny part in Belgium), of Germany and of The Netherlands. In the study 13 regions, based on administrative boundaries, are distinguished, ranging from 2.5 million ha (Neckar - Südlicher Oberrhein in Baden Württemberg) to 0.25 million ha (Saarland).

The general assumption is that - within limits and gradually - production will concentrate in those areas with the highest yield potentials. This implies that shifts will take place in the regional shares of total Rhine Basin production. These shifts are based on the ranking of calculated 'attainable' yield levels of the various regions. 'Attainable yield' is defined as 90% of (simulated) water-limited yield, taking into account the area availability of the highest yielding soil/climate combinations. The general assumption is here that within a region - like between Regions - crops will be grown on those soil/climate combinations with the highest yield potential. In case of competition, the above mentioned hierarchy is applied.

Resulting land use

In the Central Projection under an unchanged climate around one million ha would become available for other than agricultural or urban use in the middle of the next century. In the Minus-variant this surplus would be around 3 million ha; in the Plus-variant no substantial surplus would be available. Changing climatic conditions according to the BaU-best scenario adds approx. 0.2 million ha in comparison with unchanged climate, due to higher agricultural yields.

It is mainly the acreage of cereals that is responsible for the shrinking of the agricultural area: in the Central Projection (and the Plus-variant) areas growing these crops will be halved. In the Minus-variant the decrease in cereal area is 62% (unchanged climate) to 66% (changed climate). Grasslands, another major agricultural land use category, are expected to decrease by 8% (Central Projection), 24% (Minus-variant) or to remain more or less constant in acreage (Plus-variant). Urban land use is expected to increase by one third in the Central Projection in the next 50 years, two thirds in the Plus-variant, whereas in the Minus-variant a contraction of almost 10% is foreseen.

Regions where more than 100 000 ha would be vacated in the Central Projection under changed climate, are to be found in Germany: Neckar-Südlicher Oberrhein (0.15 million ha), Rheinland Pfalz (0.22 Mha), Bayern NW (0.35 Mha) and in the French part of the Basin: France Est (0.18 Mha). Under the same conditions, more than 50 000 ha will become available in Alpen Vorland (0.08 Mha), Hessen West (0.07 Mha), Nordrhein (0.09 Mha) and Nederland Oost (0.05 Mha).

Figure 2 shows the changes in land use over the next 50 years for the Rhine Basin as a whole under the different sets of assumptions.

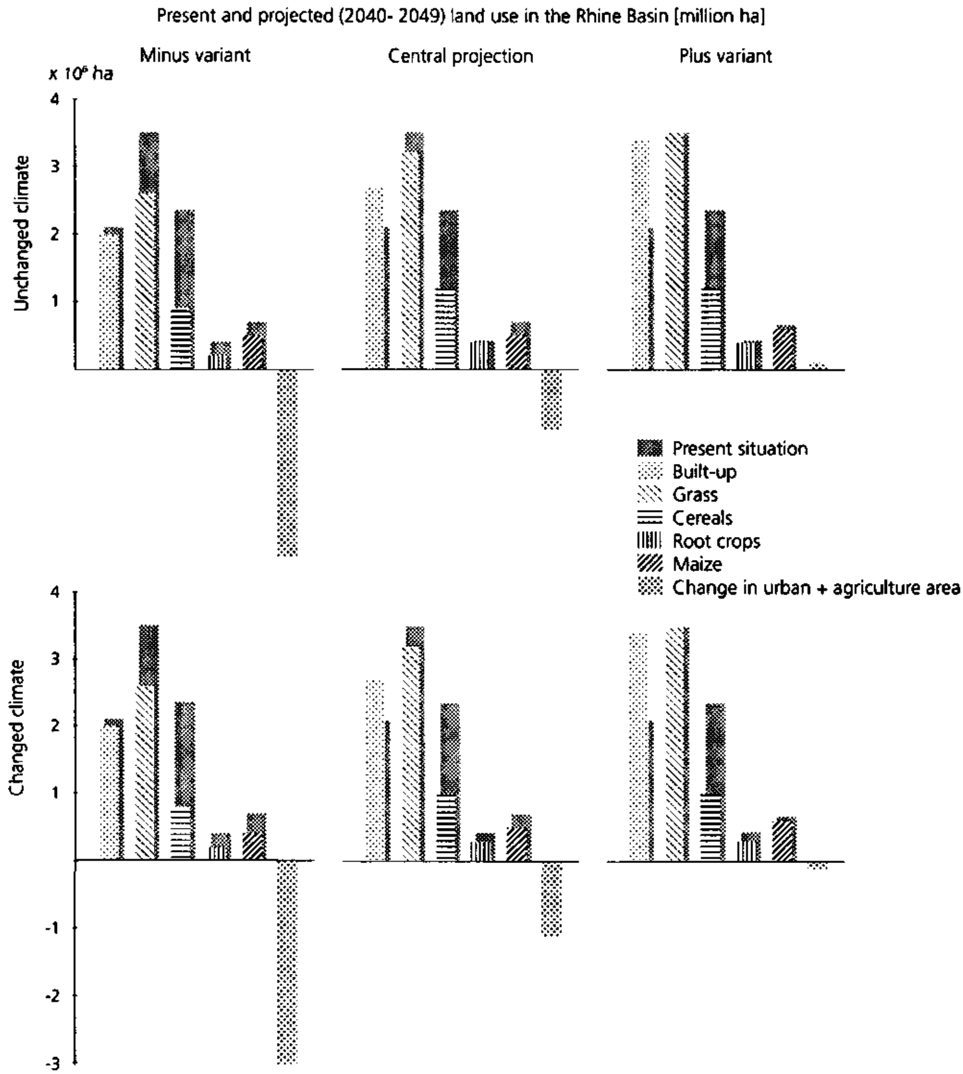

Fig. 2. Present and projected (2040-2049) land use in the Rhine Basin

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16.3 An integrated approach for analysis of sustainable land use

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Abstract

A methodology to identify policy options for sustainable land use is presented using two types of models, each addressing specific questions. An explorative regional model is used to identify land use options whereas a farm household model is employed to evaluate the effectiveness of policy measures aimed at stimulating land use changes. Methods to link the results from both models are proposed. The approach is illustrated with a case study carried out in the Koutiala region of South Mali.

Keywords: *farm household model, interactive multiple goal linear programming, policy options, land use*

Introduction

In the identification of policy options for sustainable land use various approaches with different aims can distinguished (Rabbinge & Van Ittersum, 1994). Possibilities and limitations of land use can be investigated in *explorative studies*, in which agro-ecological and socioeconomic information on land use is confronted with quantifiable objectives derived from different policy views (Veeneklaas et al., 1991; Rabbinge & Van Latesteijn, 1992). These studies emphasize the strategic long term choices at stake concerning land use. By contrast, to evaluate policy measures aimed at influencing land use, decisions at the farm level are investigated using *farm household studies* (Singh et al., 1986; Kruseman et al., 1994). These studies focus on the identification of the most suitable policy measures to induce resource allocation into more desired directions which can be deduced from explorative studies.

In the paper presented both types of models are described and a linkage between both models is proposed with the aim to identify policy options for sustainable land use in the Koutiala region in South Mali.

Methodology

The methodology is based on two model approaches: (i) a *regional* Interactive Multiple Goal Linear Programming (IMGLP) model that explores limitations and potentials for agro-ecological sustainable agriculture in Koutiala under various regional objectives and constraints, and (ii) a *farm* household model (FHM) that evaluates the effectiveness of

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various policy measures on land use and socioeconomic conditions at a particular farm type in Koutiala.

Both models make use of linear programming techniques that optimize a mix of production activities, subject to a set of constraints. The production activities include cropping, rangeland and animal production activities and are quantitatively defined in terms of inputs and outputs and determined by prevailing soil and climate conditions, crop characteristics, and available production techniques. In addition to agro-ecological unsustainable production activities, representing the actual production systems, alternative production activities are defined that are based on maintenance of the soil carbon and nutrient reserves in the long run.

Interactive multiple goal linear programming model

Interactive Multiple Goal Linear Programming techniques are used to analyze a linear optimization problem with a number of (at least partially) conflicting objectives. The IMGLP model developed optimizes one objective by selecting a set of agro-ecological sustainable production activities subject to a set of variable and fixed constraints. The latter, for example, relate to the availability of land and labour. Variable constraints express wishes to the volume of production, employment, etc. These restrictions can be derived from different opinions and objectives of stakeholders. In the IMGLP procedure different limits can be imposed on the various objectives, thus using them as variable restrictions.

In the IMGLP model three goals have been operationalized: maximization of the monetary revenue, maximization of the cereal production, and maximization of the number of animals.

In a first optimization round the goals are optimized separately, resulting in the most favourable value that can be expected and the most unfavourable value that has to be accepted. Further tightening of one or more of the goal restrictions and repeating optimization of one or more of the other goals will identify a 'solution space'. In subsequent steps a situation is reached where the goals cannot be improved without sacrificing on another one.

Farm household model

The FHM includes separable production and consumption decisions, which implies maximization of a utility function subject to a budget and time constraint. The FHM contains several modules: (i) a price module which includes a procedure to calculate prices that farmers expect at the start of the growing season, (ii) an expenditure module in which consumption of commodities is converted into utility, (iii) a production activity module defining production activities, and (iv) a goal weighting module quantifying the relative importance of farmers objectives (Romero, 1993). In this latter procedure weights for two objectives (utility maximization and maximization of the soil carbon balance) have been determined.

The model is completed in two subsequent steps: First, the optimal production structure of the farm is calculated for each of the two objectives, using the information of the various modules. Subsequently, the weights determined in the goal weight module are attached to the distinguished farmers' goals to simulate the actual production structure of the farm. The model is used to analyze the effects of three policy measures: a reduction in the fertilizer price, the introduction of sustainable technology assuming an unchanged price level and the combination of the introduction of sustainable technology and improved access to rural financial markets.

Integration of both models

The IMGLP model elucidates to what extent alternative production techniques can contribute to agro-ecological sustainable land use options, while the FHM illustrates which policy instruments are most suitable to change the current production activities in a more sustainable direction.

Integration of both levels of analysis can be achieved, linking results of the regional model with parameters used in the farm household model, and vice versa. There are two ways to establish such a linkage: (i) adjustment of prices used in the FHM for limiting factors according to the results in the IMGLP model, i.e. making use of shadow prices, or (ii) adjustment of prices used in the IMGLP model according to the results of the FHM model, i.e. making use of those price measures with the highest impact. In both approaches several iterative steps are required to match the results of both models as well as possible according to the explored possibilities and determined feasibilities.

An illustration

Both models are still in development and it should therefore be noted that the results are tentative; however, they illustrate the type of information generated by the methodology described.

Results of the IMGLP model applied in Koutiala, a semi-arid region in South Mali, indicate that the regional revenue can be raised by 80% compared with the current situation when the monetary target is pursued. The production structure will shift in that situation towards more arable crops and less livestock. Cereal production can be more than doubled when self-sufficiency of cereals is pursued but the production of cotton will disappear then. The regional income will decline to one third of the current situation when the development of the livestock sector is aimed for.

The results of the FHM show that a reduction of the fertilizer price by 5% or the introduction of alternative technologies has almost no effect on the net revenue per cultivated ha and production structure. The introduction of alternative technologies only has a moderately positive effect on the soil carbon balance. The combination of the introduction of alternative technologies and the development of the rural financial markets seem to be more appropriate measures to induce changes in land use. Net revenue per ha can be raised by more than 50%. Major shifts occur in the number of animals and the C-balance. However, even with the introduction of these two measures the C-balance is still negative indicating that farmers will still tend to deplete their natural resource base, although at a lower pace than in the current situation.

Discussion

Results of the IMGLP model indicate that the relative importance attached to the distinguished goals determines the scope for land use changes. Results of the FHM indicate that a combination of policy measures is required to induce the desired changes in land use at farm level. Further research should identify in which way tighter restrictions on goals will reduce the 'solution space' and which other measures are feasible to induce land use changes. Linkage of both models seems an appropriate method to integrate agro-ecological and socioeconomic information at a regional and farm level and can contribute to a sound formulation of policy options for sustainable land use.

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16.4 Basic alternatives as "scenarios" in Dutch land development practice

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Abstract

This paper describes the so-called BASALT-method which is used to devise systematically realistic planning alternatives in the Dutch land development practice. The main topic is how plans are formulated. The BASALT-method is in need of revision due to planning developments like the tendency towards more general plans, the introduction of the environmental impact assessment and the use of planning concepts. These developments are being discussed with special attention to the research questions they call up to in respect to the necessary modifications of BASALT.
Keywords: *land development, planning, Netherlands*

Introduction

Land development is an indispensable tool in improving the layout of rural areas. This is borne out not only by experiences in The Netherlands, but in many other European countries as well. An example that springs to mind is the major significance different types of land development have had for the restructuring of agriculture in the rural areas of Eastern Germany, the former GDR (Thöne, 1993). The prominent position of land development as an instrument - both in The Netherlands and elsewhere - can be attributed to the project-based and region-specific approach taken to planning issues, with reallocation of land taking a central place. This approach creates excellent opportunities for the integration and coordination of land uses and interests.

The scope of land development has gradually broadened and become better attuned to land use in rural areas. This has to do with society's changing conceptions concerning the desired planning of the rural area. Dutch planning policy has taken a completely new tack in recent years, with the multi-functional character of land development being stressed and, concomitantly, nature, the environment and the landscape receiving much more attention. Consequently, the implications of land development for agriculture have diminished proportionately, although they remain substantial (Ministerie van Landbouw, Natuurbeheer en Visserij, 1993).

This process of change has increased the complexity of land development projects. Various uses and interests place demands on the layout of an area, while a range of requirements and limitations resulting from spatial, water and environmental policies must still be considered. That is why a method was developed in the eighties with which to systematically devise realistic planning alternatives (Dessing and Smit, 1989). This is what is called the BASALT method. BASALT is an acronym formed from the words BASic ALTernatives. Though the name might not suggest as much, the method makes it possible to accelerate the planning process. I will return to this later. More important than its name

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is the fact that, due to recent developments in planning, some aspects of this method became obsolete, rendering revision necessary. These developments and the required modifications are the topic of the second part of this paper. First, I will provide a brief description of the land development process and of the BASALT method. The main topic is how plans are formulated.

The planning process in land development projects

The formulation of plans in land development projects can best be described as a process of design that results in concrete, technically feasible measures. It is an area in which different fields converge. At the end of this design process in land development projects, which can take an average of 5 to 6 years, a decision is made on the implementation of the measures proposed in the plan. Hence, the goal of planning is systematic preparation for decisions on whether or not to proceed with implementation. In other words, planning is focused on concrete future action. A second crucial aspect is that planning be based on specific objectives and on knowledge of the area and the uses to be developed, knowledge acquired through research.

Based on these perspectives, the overall planning process of land development projects can be divided into three phases: the initiation phase, the preparation phase and the implementation phase. The procedures for each of these phases are set out in the Land Development Act.

The *initiation* phase is concerned with the identification of a specific problem which can be solved by land development. In order to draw up a sound draft plan, it is necessary that the initiative results in a problem definition stated in clear terms and accompanied by one or more lucid objectives. At a later stage, alternative drafts will have to be evaluated on the basis of these objectives, which also form the frame of reference for evaluation when making a decision on the final land development plan. The objectives must be in line with the spatial policy that applies to the planning area.

The subsequent stage is *plan preparation*, a stage that can be divided into two parts. First, data is collected on the structure and functioning of the area in question, as well as on the factors causing the planning problem. The results of this study provide leads for potential solutions to the formulated problem. They may also reveal that a problem has been incorrectly formulated, consequently requiring revision of the set objectives. In addition, they can pinpoint problems previously not identified but which clearly necessitate supplementary measures.

Actual plan conception takes place in the second part of the preparation stage, when the project team's expertise and creativity are called upon. In this stage, the BASALT method is used to devise and compare planning alternatives. This process results in the selection of the best plan, on which is based the decision on whether or not to proceed with *implementation*. If this decision is affirmative, the implementation stage will finally follow, with the measures included in the plan being accomplished.

The BASALT method

What exactly is the BASALT method and what contribution does it make towards planning? The answer to this question is in a sense very simple. BASALT is nothing but a structured working method which is used to plot out and compare systematically the merits of planning alternatives. Moreover, the method can be used to quickly verify the social, political, technical and financial feasibility of the respective alternatives. Countless alternatives are, after all, conceivable, not all of which are advisable or possible. This prevents expectations that will never come to fruition from being harboured until far into the preparation stage. In other words, the use of the BASALT method can save time in the preparation stage.

Stated in simple terms, the BASALT method works by converting planning requirements concerning uses and interests into variants. These are based on the policy requirements and prerequisites set by spatial, water and environmental policy. Variants are sub-plans for, e.g. water management for agriculture or development of nature. The variants are then combined to form basic alternatives. Combinations of conflicting variants are scrapped. This process of elimination leaves only the practicable basic alternatives. Subsequently, a limited number of all of the possible basic alternatives are elaborated upon as planning alternatives. Together, these should cover the entire range of possible options.

A simple example are the forelands along the Waal River as part of the Ooijpolder land development project. Variants were devised for the following plan elements: river dynamics, agriculture, nature and recreation. River dynamics is a crucial factor in the development of the natural river landscape. The interplay between such processes as flooding, erosion and sedimentation determines the variation of sites of natural growth.

The variants are:
- whether or not to permit river dynamics in the forelands;
- whether to maintain or restrict agricultural use;
- whether there should be a large nature area or none at all;
- whether to maintain or restrict recreational use.

The following combinations of variants are considered to be conflicting:
- maintaining both river dynamics and agricultural use;
- maintaining river dynamics but not a nature area;
- having a large nature area while maintaining agriculture;
- having a large nature area while maintaining recreation.

Figure 1 shows the process of combining variants to form basic alternatives. The process stops when combinations of variants are considered to be conflicting. The figure reveals that a total of six basic alternatives are possible. Two of these are eliminated since maintaining or limiting both agriculture and recreation are not realistic options. Ultimately, a choice can be made from the four remaining basic alternatives.

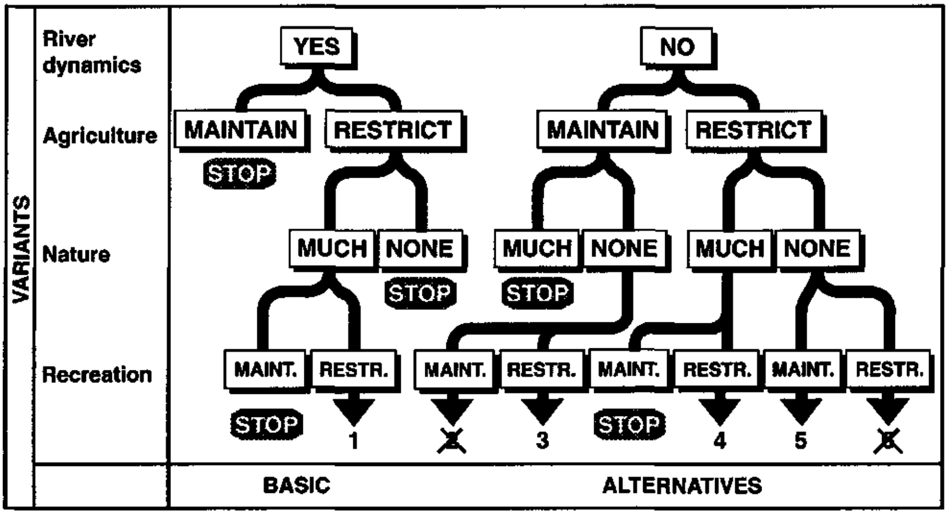

Fig. 1. Combining variants to form basic alternatives; an example concerning the Ooijpolder land development project.

I would like to underscore the fact that BASALT is not intended as a detailed manual for planning that can be applied to every project in the same way. Rather, it is a working method which is flexible enough to be used in a specific way in each project. The extent to which the different elements of BASALT should be applied depends on the planning problem at hand, which differs from project to project. This method allows customized work. The result must usually be a number of realistic alternatives. BASALT is, in fact, a sort of script, in which the activities are included which *might* be required in the planning process, but without a fixed cast or stage directions or plot.

If required, the activities of the script are repeated a few times during the planning stage. This is a cyclical process. In this way, a progression is made from abstract to concrete, from partial areas to total land development area, from many to few basic alternatives, and so on. By repeating the activities, new data and policy changes can be considered.

BASALT is also a tool for what is termed evaluative design. This signifies that solutions are not only devised, but also evaluated. This allows useful variants and alternatives to be selected and others to be eliminated. BASALT comprises a number of test criteria, namely:
- *Satisfaction of demands.* This relates to the question of whether the planning requirements are being met;
- *Feasibility.* Are the variants or alternatives feasible? In order to determine this, account can be taken of current policy, cost-effectiveness of the investments, or the possibilities for land acquisition;
- *Structure.* This criterion pertains to the question of whether a balanced, coherent structure exists in the total land development area. Here we could mention examples such as landscape structure or the road network;
- *Contrast.* The variants and alternatives must be sufficiently different from each other;

- *Range.* The variants and alternatives must represent the entire range of realistic options.

These criteria are cumulative, i.e. the variants and alternatives are only worth considering if they satisfy all criteria. That is rarely the case in actual practice. This partly has to do with the tendency to quickly limit the options in the planning process to one plan for which the implementation decision is made. Potential planning alternatives are disregarded, as a result of which the criteria of 'contrast' and 'range' play virtually no role. This lack of alternatives is an impoverishment of the plan formulation process and detracts from the evaluative design targeted by the method. It is precisely the aim of the 'range' criterion, for example, to motivate planners to look at the extreme ends of the scale in search of potential alternatives. This counteracts potentially biased standpoints. In relation to the 'structure' criterion, I would like to mention that a good method of operationalizing this criterion was lacking for a long time. From landscape architecture planning concepts are introduced, and are being experimented with in a number of projects. I will return to these concepts and to the issue of alternatives later.

With respect to BASALT, I would like to point out a few advantages of working with this method. In the first place, the method facilitates rapid commencement of planning. Using the BASALT script, the required activities can be quickly determined. A second advantage is that planning is careful and controllable. At each stage of each project, it is possible to determine which activities are required in order to arrive at sound, well-substantiated alternatives. Interim results are evaluated and, if necessary, plans are revised. Finally, the method ensures that the different uses are given equal weight, irrespective of their relative importance in the land development area.

By now it will be clear that the alternatives developed with BASALT are, strictly speaking, not scenarios. They are potential directions in which to seek solutions to certain planning problems. This does not detract from the fact that, as I mentioned earlier, planning is an activity which focuses on the future. Consequently, a vision of the future development of the planning area is required. When such a vision is lacking, there is a risk that land development projects end up being a mere response to the short-term planning problems at issue, while paying insufficient attention to long-term problems. This may give rise to the feeling that the plan is already outdated before it has been fully implemented, which is a sign that greater attention to future study is required as a basis for plan formulation.

Developments in plan formulation

BASALT has been successfully used in a great many projects in the past ten years, notwithstanding the short comments I just made regarding its practical use. They do, however, form a springboard for continued method development. Furthermore, a number of developments in planning have occurred which can also have an impact on the BASALT method. Some points of the method are outdated and must be revised. The method of revision is still the subject of intense discussion.

I see three recent developments with respect to plan formulation;

- from concrete to more general plans;

- introduction of the environmental impact assessment;
- introduction of planning concepts.

The tendency towards more general plans is mainly an extension of the realization that new developments often occur during the implementation stage which necessitate plan revision. In recent years, for example, a great deal of energy has been invested in plan changes allowing the incorporation of new national policies on nature and the fight against the man-induced drought of lands into the implementation of projects underway (Centrale Landinrichtingscommissie, 1994). In addition, the arrangement of certain planning elements, such as nature development and recreational areas, are no longer worked out in detail during the preparation stage but rather postponed until the implementation stage. This shortens the preparation time, prevents double work and enhances the flexibility of the planning process (Moen and Van Rheenen, 1994). I would like to add that endeavours are being made to formulate the objectives in more concrete terms during the initiation stage than was previously the case. The consequence is that the emphasis in the discussion of planning alternatives has shifted from detailed elaboration of the spatial division into uses to concrete planning measures. By this, the term 'basic alternatives' as used within the BASALT system is given a different meaning.

Of great importance to planning is also the second development I mentioned: the introduction of environmental impact assessment. As of 1 September 1994, the majority of land development projects are required to include an environmental impact assessment. This applies to new projects as well as to a number of projects already in preparation. This development did not come out of the blue. It has been anticipated for the past few years in order to avoid delays in plan preparation wherever possible. The environmental impact assessment process is subject to its own legal procedures which must be incorporated into the land development procedure as well as possible. This is a fascinating process about which there is a lot to say (Van Rheenen and Van Vugt, 1994). I would like to limit myself, however, to the issue of plan alternatives. My comments on that are in line with what I just said about the development to more general plans.

As I said earlier, planning has, thus far, been virtually exclusively focused on devising one plan. This alternative was derived from the basic alternatives developed with the aid of the BASALT method, subsequently detailed and then submitted to the inhabitants for their input. The advantage of this was that the inhabitants' contributions were kept very concrete, focusing on the nature and effects of the measures proposed in the plan. The drawback, however, was that input was in fact limited to one, very concrete solution to the planning problem identified in the initiation stage. Other solutions were disregarded; they had already been considered and found inadequate during the preceding planning stage. That made the planning process very inwardly directed, i.e. the debate on potential solutions was limited to the circle of bodies directly responsible for planning. The possibilities of BASALT in regard to the choice between realistic alternatives were used insufficiently.

The environmental impact assessment changes all this, because it requires that different alternatives be presented to citizens, including what is called the most environmentally sound alternative. Each of these alternatives represents its own solution to the planning problem at issue in the area in question. Obviously, it would be a waste of energy if all of these alternatives would be worked out as concretely as has been customary until now. So the current trend towards more general plans can be expected to continue. This also implies that the debate on citizen input will become more highly focused on the choice from potential solutions. Consequently, the test criteria 'contrast' and 'range' will gain in importance. Moreover, planning will become an outwardly rather than an inwardly focused activity. This is a major development, because it does not give central importance to the final state to be reached with land development but rather the means to that end. The point is that the process is conducted in such a way that an open dialogue between the area's inhabitants, the authorities involved and the social interest groups yields a result that is acceptable to all parties (Van den Brink, 1994).

It may be clear that BASALT must be attuned to this development, taking account of the nature and content of basic alternatives and the role of the environmental aspect in evaluative design. Furthermore, BASALT will become a better tool for communication on the planning process. Linking the method to geographical information systems may yield new perspectives and merits further study.

Finally, I would like to explore the significance of concepts in planning. Concepts provide direction to planning and make the final design coherent. Such planning concepts are, moreover, future-oriented, area-specific, both in spatial and socio-cultural terms, and promote the shift of decision-making to a lower level (Boogert, 1992/3). A recent study pointed out the visual power of the concepts which simultaneously transcends and unites the other features. The visual power of the concept must persuade and bring together the parties involved. The goal of this study was to gain experience with planning concepts for land development. The researchers comment that the less in agreement parties are about the course to be followed, the greater the significance of the concept. Based on this finding, they conclude that generating concepts must be made an optional step in the procedure, the importance of which must be laid down as early as possible in the plan preparation (H+N+S, 1994).

I would like to say a few words about the capacity of concepts to promote coherence, which is essential to the cooperation between technicians and planners. Technicians are, to a certain degree, planners themselves, or, to put it more accurately, constructors of certain elements of the plan. The danger exists that these elements are worked out and completed as if they were more or less detached from each other. In contrast, the planners who focus on design of the landscape use planning concepts as a means of making projects coherent. Such concepts provide direction, depict potential solutions and offer technicians a common thread tying the different elements of the plan together. It might be stretching it, but one could say that these are "planning scenarios". In any case, it seems possible to use planning concepts to give substance to 'structure' as a test criterion. This will occur on the basis of further research into the utility of planning concepts within land development.

Conclusion

I hope I have enlightened you on the formulation of plans in land development and the use of the BASALT method in doing so. The BASALT method is used to systematically distinguish between planning variants from which basic alternatives for the final plan are derived. The method is in need of revision due to diverse planning developments. The developments I mentioned are the tendency towards more general plans, the introduction of the environmental impact assessment and the use of planning concepts. There are just as many research questions connected to the necessary modification of BASALT to keep up with these developments. I touched upon some of those earlier. In addition to questions of content, there are also questions of an organizational nature. After all, planning is a group process, and the point is to organize that process in such a way as to pool the creative resources of all those involved in order to yield a result everyone supports.

The *Winand Staring Centre* has made various contributions in the past to research in the field of methodical planning. It is crucial that the institute give this study ample attention in its new programme. This will benefit the integral approach to rural renewal.

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16.5 Alternative perspectives on agriculture and spatial organization in The Netherlands

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Abstract

The relationship between agriculture and spatial organization is a mutual one. Analysis shows that spatial conditions for and spatial effects of agriculture vary widely over the country. Three main types of problems can be distinguished. They apply to the relationship between:

- urban development and the development of agro-industrial complexes in the Central zone;
- agricultural and regional development in the Peripheral zone;
- agricultural land use, environmental quality and other forms of land use in the sand areas.

To reckon with these problems as well as with possible developments in agriculture and spatial organization, three different spatial perspectives have been elaborated here.

Keywords: *agriculture, spatial organization, spatial strategies, rural development, The Netherlands*

Introduction

Since the 1950s Dutch agriculture has been highly dynamic, accompanied with an extremely high growth of production per ha. As a result, spatial requirements for and spatial effects of agriculture were rapidly changing.

This paper, based on a study by Hetsen and Hidding (1991, 1992, 1993), firstly aims at analyzing the regional differences in spatial conditions for and effects of agriculture within The Netherlands. Secondly, it aims at reconnoitring different options for the development of agriculture and spatial organization, with special attention to the northern part of the country. Finally, some recent trends are discussed.

The methodological framework (Figure 1) reflects the two central theoretical concepts underlying the study, i.e.:

- the concept of 'reconnaissance planning'; according to this planning concept, plans are primarily seen as instruments for policy oriented discussion; analysis and reconnaissance are its main methodical components (Kleefmann, 1984);
- the concept of 'spatial organization', defined in terms of 'location structure'; two suborganizations are distinguished, i.e. of social activities and of physical objects, either technically shaped or transformed or naturally given.

Different kinds of data have been used: statistical data, research notes, policy documents and maps. As part of the study, maps about the regional differentiation in agriculture have been produced by processing statistical data with a GIS, regarding the period 1973-1988.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 635–644.

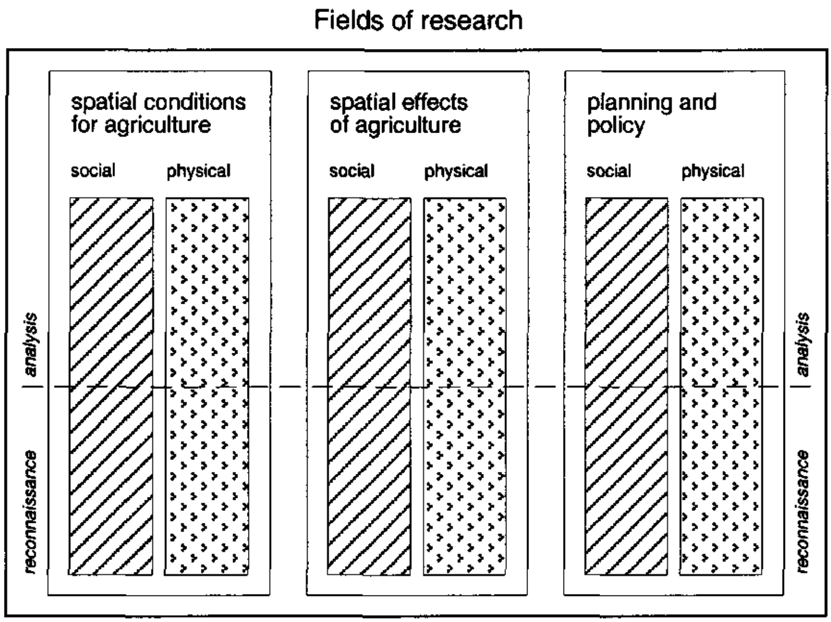

Fig. 1. Methodological framework

Dutch agriculture within Europe

Within the European Union, Dutch agriculture is characterised by a relatively high labour productivity (see e.g. Jansen & Hetsen, 1991). Labour productivity (expressed in ECU per labour unit) can be seen as the product of two factors:
- the scale of agricultural production (in hectares per labour unit);
- the intensity of agricultural production (in ECU per hectare).

Figures 2 and 3 illustrate the special position of Dutch agriculture within Europe; a relatively small scale goes together with a very high intensity. The next sections show that problems in the relationship between agriculture and spatial organization are strongly related to these typical features of Dutch agriculture.

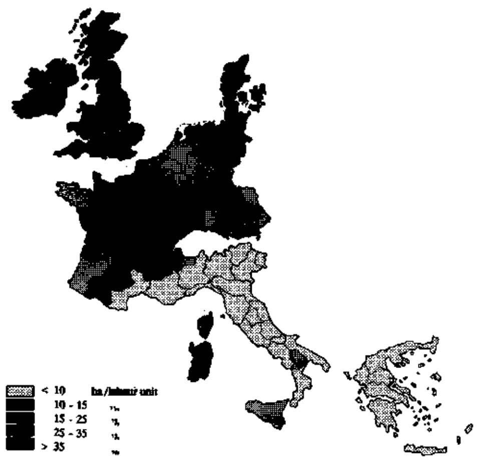

Fig. 2. Scale of agriculture (hectares per labour unit) in EC-10, 1983

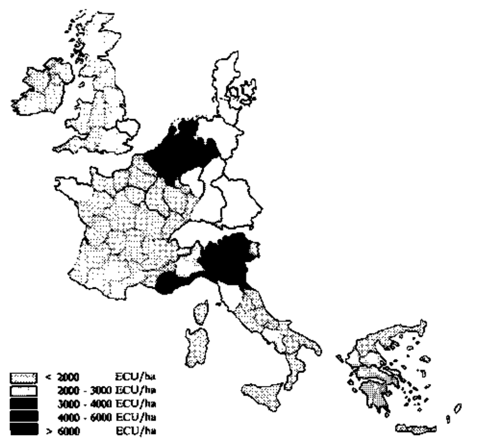

Fig. 3. Intensity of agriculture (ECU per ha) in EC-10, 1983
Source: Meeus *et al.*, 1988

Analysis

Analysis from a social perspective

Regarding the social aspects of the location structure, special attention has been paid to the relationship of regional-economic development and urbanization on the one hand and agricultural development on the other. The main conclusions are presented below.

Spatial conditions for agriculture

- Economically more developed regions, as the West and South, have offered comparative advantages for the development of intensive forms of agricultural production, like glasshouse horticulture and animal husbandry. Intensive production has rapidly grown in these areas (Figure 4). Their actual score on economic health (Figure 5) is still relatively high.
- The ongoing urbanization process and the actual problems of congestion within existing agro-industrial complexes will check the further growth of highly dynamic production like glasshouse horticulture or bulb growing in these regions. So, further strengthening of the centrality of the agro-industrial complexes will become more and more difficult here.

Spatial effects of agriculture

- Regional differences in agricultural development have evidently influenced the scale of regional development problems in The Netherlands. In the more developed regions labour productivity mainly increased by intensification, i.e. by increasing the production per hectare. In the economically less developed North the increase of labour productivity was mainly realised by increasing the man-land ratio. Because of the relatively high significance of agriculture to employment in the North, this agricultural development pattern resulted in a considerable outflow of labour from agriculture. It also strengthened the loss of functions of small rural settlements.

Conclusions

The results of the analysis suggest at least some relationship between the development of agriculture in terms of intensity and land-man ratio on the one hand and the level of regional economic development and urbanization on the other. Against the background of the above mentioned conclusions three zones are distinguished: a Central zone, a Peripheral zone and an Intermediary zone (Figure 8). Problems of spatial organization particularly manifest themselves in the Central zone (urban-agricultural congestion) and the Peripheral zone (problems of regional development).

Analysis from a physical perspective

Regarding the physical aspects of the location structure special attention has been paid to changes in the physical conditions for agriculture, also in relation with those for nature conservation and the recovery of drinking water from ground water. The main conclusions follow below.

Spatial conditions for agriculture

- During the past decades spatial conditions for agriculture have thoroughly been altered, especially by interventions in the water balance in large parts of the country. As a result, suitability of the soil for agriculture has been improved in many areas. However, in large sections of the higher parts of The Netherlands interventions in the water balance and the application of sprinkling have contributed to the desiccation of sensitive parts of the cultivated land. In addition, intensive land use has threatened soil fertility: this problem also manifests itself most evidently in the higher parts of The Netherlands.

Spatial effects of agriculture

- The extremely high intensity of Dutch agriculture has had extremely harmful effects. The character and scale of the problems vary widely from region to region. Harmful effects on nature and on natural drinking water supplies manifest themselves particularly in the higher parts of The Netherlands. This can largely be attributed to the presence of concentrations of intensive agricultural production, like intensive animal husbandry. Figure 6 shows considerable regional differences in the use of manure. The high vulnerability of sandy soils to processes like desiccation, acidification, the leaching of nutrients and pesticides and the presence of vulnerable ecosystems and phreatic ground water supplies worsen the problems even more. Figure 7 shows regional differences in vulnerability to acidification.
- Regarding the higher parts of the country, there are still considerable differences in the scale of the problems caused by agriculture. Because of a lower concentration of animal production in the northern sand area, problems of excessive use of manure and acidification are less than in the Central, East and Southern sand areas.
- In the lower parts of The Netherlands the negative effects of agriculture on nature and on potential for drinking water recovery are generally less serious, although they do exist.

Conclusions

The analysis shows that the relationship between agriculture and spatial organization varies widely from region to region. Most serious spatial problems occur in the higher parts of The Netherlands and particularly in the sand area. Problems in the lower parts are much less, although existent. Within the higher parts of The Netherlands, the northern sand area occupies a favourable position compared with the other ones. The regional typology (Figure 8) reflects these conclusions by a borderline between the higher and the lower parts of The Netherlands.

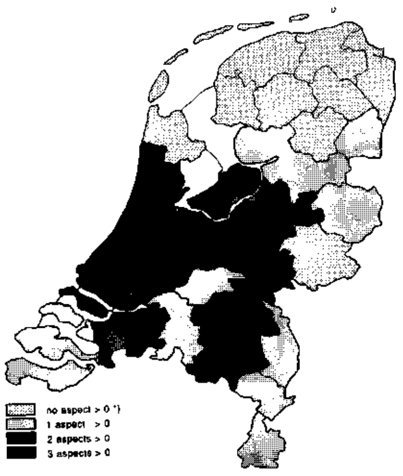

Fig. 4
Intensity (production value per ha) of total agricultural production, 1988
*) 1.0 = national average
Source: Hetsen & Hidding, 1991

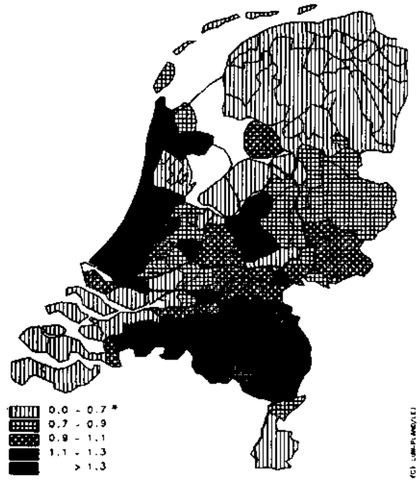

Fig. 5
Typology of regional economic development for three aspects: welfare, potentials based on technology and on distribution & information
> 0 = above national average
Source: Van der Knaap & Louter, 1988

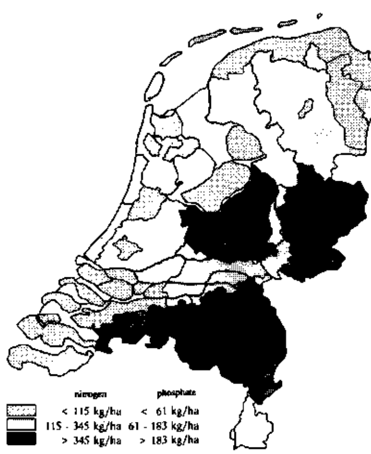

Fig. 6
Application of manure in kg minerals per ha, 1986
Source: CBS

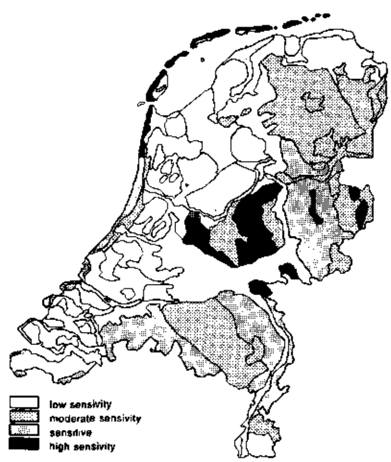

Fig. 7
Vulnerability to acidification
Source: Asman & Jaarsveld, 1990

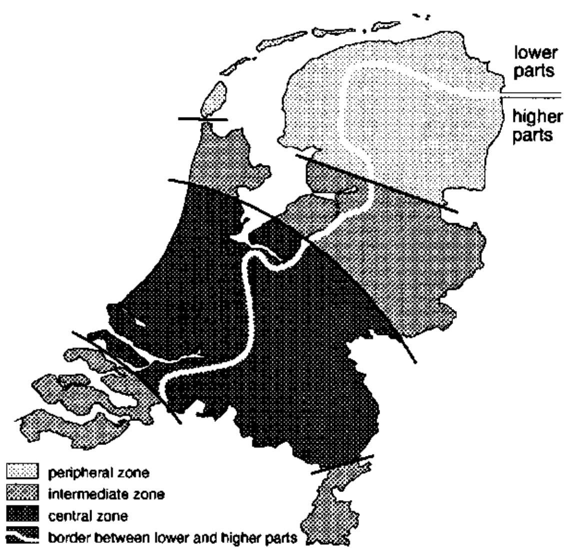

Fig. 8. Regional typology (summarizing the above analysis)

Reconnaissance

As a result of technological developments and far-reaching changes in market and price policy as well as in environmental policy, Dutch agriculture is actively reorienting itself. The direction of this process is highly uncertain however. Within the boundary conditions set by market, price and environmental policy there are still many options for agricultural development. As future agricultural developments will heavily influence spatial organization too, it is an important task for spatial planning to reconnoitre different options for the development of agriculture and spatial organization. These options are not to be seen as blueprints. According to the concept of reconnaissance planning, they are primarily meant as a contribution to a policy oriented debate. Three alternatives with special attention to the regional problems and physical potentials of the North are presented here.

Alternative 1: Reallocation of the (growth of) agricultural production to the North
The realization of this strategy (Figure 9) contributes to the solution of problems in the Central zone and the Peripheral zone. Moreover, this strategy will strengthen the opportunities to recover the natural potential for nature conservancy, drinking water supply and agriculture in the areas of concentrated agricultural production within the Central zone.

In the relatively clean areas of the Peripheral zone, however, the existing high potential for nature conservancy and drinking water supply is influenced negatively. The differences between clean and polluted areas will level out, i.e. a 'grey blanket' will cover the whole country.

Alternative 2: The North as an experimental area for clean and integrated agriculture
This strategy (Figure 10) focuses on making full use of the high environmental qualities in the North. The available natural potential for nature conservancy and drinking water supply is also exploited.

As a consequence, the opportunities for reallocation of agricultural production to the North are restricted. Therefore, this strategy hardly contributes to the necessary reconstruction of the concentration areas and to the decrease of regional development problems in the North.

Alternative 3: Reallocation of agricultural production, safeguarding nature conservancy and drinking water resources
This strategy (Figure 11) not only focuses on decreasing the problems within the Central zone and the Peripheral zone. It also limits the negative influences of reallocation of agricultural production on the natural potential for nature conservancy and drinking water supply by separating agricultural and other functions spatially.

Within the context of alternatives 1 and 2 a separation was only argued for the sandy areas in the Eastern and Southern parts of The Netherlands, where intensive forms of agriculture cause serious environmental damage. In this alternative spatial separation of agricultural functions and other ones is also pleaded for the sand area in the North, which is still relatively clean now.

Conclusions
From the reconnaissances it can be concluded that solutions for the above mentioned problems are conflicting in different respects. The conflicts are becoming acute with respect to the reallocation of production to the North. It can be questioned whether the benefits of reallocation really countervail its disadvantages, especially with respect to environmental quality, nature conservancy and drinking water supply in the North.

Recent trends

Analysis of recent trends in agricultural development from 1991 up to and including 1993 (by means of CBS data), suggests continuing concentration as well as relatively reallocation of agricultural sectors. The increase of glasshouse horticulture in the concentration areas seems to stagnate (Aalsmeer) or to fall behind the average growth in The Netherlands (Westland). On the other hand, glasshouse horticulture is increasing rapidly in many regions scattered over the country. The continuation of this trend could favour spatial strategies according to the first alternative.

The number of animals in intensive husbandry is still increasing. In the main concentration area (de Peel) the increase of pigs (16%) even exceeds the Dutch average (13%). Remarkably, the number of pigs and poultry has been growing in many northern areas too. This development is a major hindrance to a more rapid recovery of environmental quality, a threat to the relative clean northern area and contrary to the second alternative.

Fig. 9
Alternative 1

Fig. 10
Alternative 2

Legend

- reallocation of the (growth of) agricultural production in the indicated direction
- spatial reconstruction on a local level in behalf of agriculture and other functions
- recovery of agricultural circumstances, utilizing chances for nature conservancy on a local level
- utilization of chances for a joined development of agriculture and nature, especially in wet areas
- utilization of chances for a joined development of agriculture, nature and drinking water supply
- spatially seperate development of agriculture, nature and drinking water supply
- general environmental quality
- special environmental quality on a local level
- special environmental quality on a regional level

Fig. 11
Alternative 3

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16.6 A GIS based planning for the re-use of agricultural land; a case-study of West Brabant, The Netherlands

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Abstract

For the Netherlands, the planned allocation of agricultural activities within the European Union is going to lead to conversion of land currently used for agricultural production. This could provide solutions for already stated national policy, described in Fourth Report on Physical Planning Extra (VINEX), namely:

- protection of mobility and
- increasing environmental quality.

In the academic debate of re-use of former productive agriculture land most often it is suggested to develop forestry, nature, recreation or environmentally friendly forms of agriculture, or a combination of those activities, whereas housing is rarely mentioned. This shows an evident lack of approaches that combine housing with "rural space activities".

In The Netherlands, the areas which offer the best possibilities for interventions in this regard, are the border-areas between urban and rural space, their designation being not strictly defined. Borders play a leading role in the architectural and urban design and ecology, as those are the places with more opportunities than homogenous areas.

The essence of this research is the proposition to use some portion of the vacated agricultural area for the combined development of nature and housing, here named "new estates". The border areas are analyzed using the Geographical Informational System MAP II for Macintosh in the case of western Noord Brabant. Furthermore three typologies were made: a typology of urban fringe, one of vegetation and one of housing. They were used in different combinations in order to make example designs for the selected three locations.

Keywords: *re-use of agricultural land, GIS, urban fringe, new estates, Noord Brabant*

Introduction

Agriculture in the European Union today is facing problems. On the one hand, it has reached a level of safe production, with respect to the amount and quality of products, while on the other the costs of agricultural policy are rising dramatically (WRR, 1992). Subsidised surpluses of products and increasing environmental problems resulting from current intensive production methods are the main reasons to think about new scenarios for EU agriculture in the future. A first conclusion appears to be that, within the EU, agriculture occupies too much space and therefore that a significant area of agricultural land will have to be taken out of production.

For centuries, the Dutch have devoted major efforts to reclaim arable land from the sea and the marshes; they also drastically decreased the forested area. Now there is enough agricultural land and some part of it may be returned to its previous use. In the Dutch national physical planning documents, space is divided into urban and rural areas. Housing is always planned within the urban area, while the rural space is reserved for agriculture, forestry, recreation, nature and landscape development. There are many discussions on different levels - from national to local - going on in The Netherlands about the re-use of agricultural land. Academic debates on the re-use of formerly productive agricultural

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land favour developing forestry, nature (Harms *et al.*, 1991), recreation or environmentally friendly forms of agriculture, or a combination of these activities, while housing is rarely mentioned. This shows an evident lack of an approach that combines housing with "rural space activities".

Goal of the research

This paper presents some results of a post-graduate research at the Delft Faculty of Architecture. It included three phases:
1. GIS analyses of the existing situation according to stated criteria.
2. Design of chosen example-locations.
3. Multimedia evaluation of the results of the research.

The research aims to offer multifunctional solutions for agricultural land that will be taken out of production, by combining traditionally urban and rural functions. The idea arose from the realisation that there is both very little nature in Holland and housing needs are growing rapidly. According to different reports (Gans and Oskamp, 1992) the projection of the number of dwellings in the Randstad alone - the urban ring defined by Amsterdam, Rotterdam, Utrecht and The Hague - up to the year 2015 ranges from 700,000 to one million. Shifts in agricultural policy may cause a conversion of agricultural land into nature, but there are always double costs involved: eliminating production decreases income and nature development increases costs as potential economic and social benefits have not yet been quantified. Therefore, in times of economic depression nature has little chance.

A more realistic solution is suggested in this research:
- combining nature development with low density housing, financed by private/public partnership;
- building in natural areas, but carefully;
- finding a balance between two contradictory activities in the special regime of nature exploitation;
- developing "new estates" with several variants of housing densities, concentrations and types;
- locating these at urban fringes, as boundaries play a leading role in architectural and urban design and ecology, as those are the places with more opportunities than homogenous areas (De Jong, 1992).

Case Study area - West Brabant

The region of West Brabant was chosen as a case study because of its interesting geographical position and natural characteristics. As a buffer zone between the harbours of Rotterdam and Antwerp, the importance of this area within the international city network will grow in the years to come. With respect to creating housing in combination with nature development, the area of West Brabant offers great possibilities because of the contrasts between clay soils with open, large-scale landscape and extended crop fields on one hand, and sandy soils with closed, small-scale landscapes and a variety of agricultural productions on the other.

Results and discussion

GIS analyses

A series of GIS analyses were conducted in order to find the best locations for the "new estates" in West Brabant. As input data, digitised soil and ground water table maps and satellite land use images with cell resolution of 25m were used. Directive to the analyses were stated criteria based on an ABC model of environmental components.

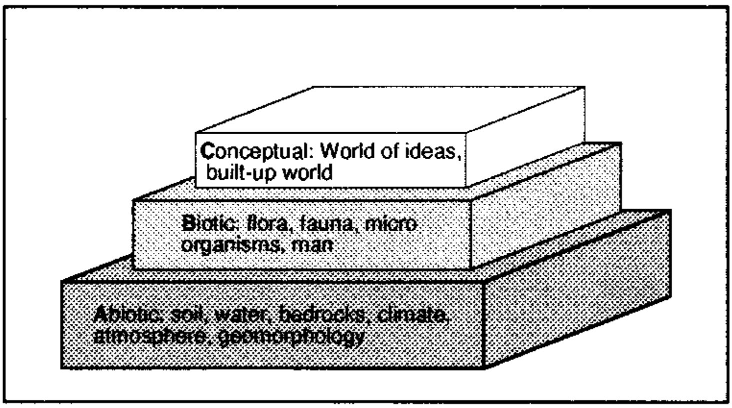

Fig. 1. ABC model of environmental components (Duijvenstein, 1993)

Criteria were partly entered into the system (Figure 2 - GIS criteria) and partly used in traditional ways (background criteria - landscape types, ex-ecosystems and their characteristics, connection with ecological infrastructure, ownership etc.). GIS criteria were formulated such that these must be fulfilled by any cell with a value other than VOID.

This means that new estates will be located on sandy or clay soil (a third type of soil in The Netherlands - peat - is excluded because of its unsuitability for building), on the drier places (ground water table lower than 40 cm in the most part of the year), not further than 1 km from the body of surface water, forest or natural area, on agricultural land (arable or grasslands) and not further than 500m from the built-up area (cities, villages, roads).

As the result of GIS operations and intersections, a network of possible locations appeared for the "new estates" in West Brabant (Plate 14). The parcels identified in Plate 14 represent 6611 ha, hence 11% of the total surface of the area examined fulfils all the GIS criteria.

Background criteria were used to reduce the number of locations, to make deeper analyses of these and as a starting point for urban fringe typology.

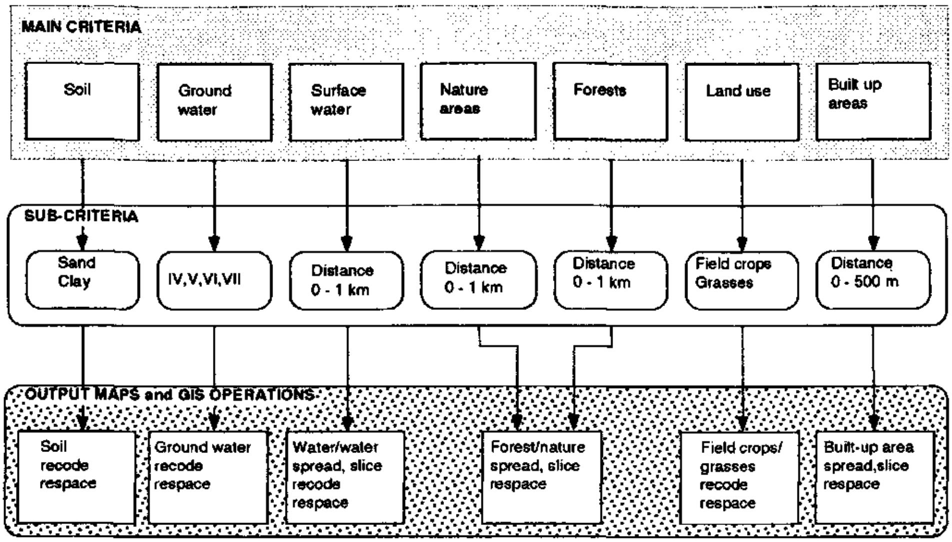

Fig. 2. GIS criteria, subcriteria, output maps and operations

The distribution of locations corresponds to a large extent with the network of former estates in West Brabant. The criteria chosen for the system unintentionally linked this past-present striving for a better place to live. The image in Plate 14 is not a regional plan or scenario for urbanisation; it only represents the potentials of those sites. These sites can, of course, be used for all other purposes, but it is useful for planners to know that they score high in integrating natural and residential uses. In this case the GIS showed a great accuracy and advantages compared with traditional analysis.

Example designs

In the next step of the research, three typologies were developed in order to be able to make several variants of example designs for some of the locations.

Typology of urban fringe

Typology of urban fringe is meant to analyse the main morphological characteristics, spatial consequences and main activities within the fringe. The type of urban fringe will influence the housing type in a particular location.

Typology of housing

Includes low density housing types in different variants. The densities can vary from 5 to 200 inhabitants per ha, concentrated in one building or spread over several units. Housing will not exceed 3 storeys and will range from low cost to expensive. The surrounding parcel that will be used for nature development will be open to the public within set limits and conditions. The estate owners would be its inhabitants.

Typology of vegetation
The typology of vegetation is based on Leeuwen & Doing Kraft (1959) classification of natural vegetation in The Netherlands, suggesting development of original plant associations, i.e. the ones that used to grow on a particular location before agriculture came. The classification is based mostly on soil and ground water conditions and it indicates the main woody and herbaceous plants associated with these conditions.

These three typologies were used to design the example locations. In those examples it was aimed to achieve the harmonic relationship between housing type and nature through careful integration of functions. The designs were presented as plans in scale 1:5000 and visualised by computer photomontage.

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16.7 Grazing in the future. Dutch dairy, beef and sheep production in the year 2005

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Abstract

This study gives a view of Dutch dairy, beef and sheep production in the year 2005, based on expert opinions, model calculations and literature. Dairy, beef and sheep sectors are expected to change as a result of market developments, agricultural policy and technical developments. It is expected that the dairy quota system will still exist in 2005 and that 7% of the total agricultural area will be used for urbanization and nature. The number of dairy cows will decrease from 1.9 million to 1.2 million. The number of dairy farms will decrease from 47 000 to 26 000. The number of large intensive beef production units will decrease from 800 to 250. Ewe numbers will decrease from 800 000 to 650 000.

Keywords: *animal husbandry, prediction, expert judgment, The Netherlands*

Introduction

Several developments have enhanced the uncertainty about the future of the Dutch animal production. Will farmers be able to adapt their farms to changing consumer markets and society demands? Which number of animals and farms will be left after the implementation of environmental legislation and a reduction of the agricultural area? What will be the effect of these and other changes on farm structure, size and farm management?

This study gives an expert opinion, based on interviews, model calculations and literature, on the future of the dairy, beef and sheep sector in The Netherlands. Its goal is to support policy makers and strategy developers by giving an overall outlook of these sectors.

Method

The basis of the study are expert opinions of about 50 experts on various technical and economical fields in livestock production. A structure of interviews, discussions and revisions was set up to combine the different opinions of these experts into one report (Muller *et al.*, 1993). The interviews took place in the first three months of 1993. The years 1990 and 2005 were chosen, the first as reference year, the second as target year. The authors used the information from the interviews together with government policy plans, statistical information and other literature in compiling the report. A computer model was made to support and to check the expert statements. The model describes the sector development under the circumstances expected by the experts. People working in various places in the dairy, beef and sheep sector were asked to give their reactions on drafts of the report. Discussions were organized on items showing large differences of opinion.

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Results

The results were divided into four groups: determining factors in animal production, primary sector development, development in the processing industry and services and in farm management. The last two are not described in this paper.

Determining factors in animal production

Six main driving forces were identified for the Dutch dairy, beef and sheep sector. These are: the market, the availability of agricultural land, environmental policy, animal health and welfare policy, animal production levels and the distribution of land and milk quota over agricultural enterprises. For these factors, the development and their effect on agriculture were described.

The market
The amount of production of milk and beef is determined by market possibilities and by the Common Agricultural Policy of the European Union (EU). For milk, it is expected that the quota in the year 2005 will be reduced by 10% compared to 1990. The GATT-agreement, free-trade deals with Eastern European countries and a reduction of budget costs for agricultural policy in the EU, will cause this reduction, in spite of a small growth of consumption per capita and enlargement of EU with EFTA (European Free Trade Association) countries. Milk quotas will still exist in 2005, and milk prices in The Netherlands will be the same as in 1990.

In beef production, the price support system will be replaced by a direct premium system, according to the 1992 MacSharry agreements. Intensive beef production units (common in The Netherlands) are disadvantaged by this policy, because the premium right is coupled to farm size and to the number of beef per hectare. Beef prices were expected to be lower than in 1990.

Agricultural land policy
The agricultural area in The Netherlands will decrease by 135 000 hectares between 1990 and 2005 (7% of the total agricultural area). Agricultural land will be used for urban development, road building and nature development. On the remaining agricultural area, there will be more emphasis on landscape and nature management. Of the agricultural area, dairy farmers will take a relatively larger share. If they have to move because of urban development or nature management, they will often buy land from arable farmers. Total grass and forage area will decrease to 80 000 ha (in 1990: 1.3 million ha).

Environmental pressure
The environmental policy is aimed at decreasing mineral surpluses from the agricultural sector and at decreasing ammonia emission. For this, a policy instrument will be developed, which gives farmers maximum freedom in the choice of measures to meet the legal standards. If a farmer exceeds a limit, he is obliged to pay a levy. Standards of emission and mineral surpluses will be more difficult to reach in the more intensive animal production regions in the south and nearby vulnerable nature areas. Because of

this policy, a large number of farms in these areas will be forced to cease production or to move to other parts of the country.

Animal health and welfare
The Dutch animal health and welfare policy will change for several reasons. The most important reasons are the European free internal market, a Dutch government that wants to interfere less in the agricultural sector and the wish to maintain the Dutch export position. Another reason is the consumer's concern about animal health and welfare and animal product safety. The change will result in a larger producer responsibility. The farmer will have to take more preventive action and he will be careful to maintain a good health status on the farm. That will minimize animal transport and the use of medicines.

Growth of milk and meat production ability per animal
Milk production levels are expected to increase from 6500 kg per cow in 1990 to 8500 kg in 2005, caused by a higher genetic ability, an improvement of farm management and because relatively more farms with low production levels will cease operation. Because of this rise in production, fewer cows will be needed to attain the Dutch milk quota.

Beef and sheep production levels are also expected to rise. Slaughter weights of beef bulls will be higher and slaughter quality will improve. In the sheep sector, a more uniform lamb will be produced throughout the year.

Distribution of land and milk quotas
The amounts of agricultural land and milk quotas will be restricted. A dairy farmer will only be able to increase his production by buying land or milk quotas from another farmer. Generally, land and quotas will be sold by small farmers who retire without a successor. Another reason to cease operations in the coming years will be the burden of environmental investments. The total amount of land and quotas offered for sale will determine the amount of land and quotas that can be bought by the remaining farmers. Structural developments in land-based animal production will therefore be highly dependent on the amount of land and quotas sold.

Primary sector development

The most important effects of the developments mentioned above are a strong decrease in the number of animals (Table 1) and the number of farms (Table 2).

Table 1. Numbers of animals in 1990 and 2005 (x 1000).

	1990	2005
dairy cows	1878	1205
calves and heifers	1686	904
beef bulls	451	277
white veal calves	601	320
alternative calf production	0	160
other fattening cattle and suckler cows	273	200
ewes	790	643

Source 1990: LEI/CBS 1992

Table 2. Number of specialized agricultural enterprises in 1990 and 2005.

	1990	2005
dairy farms[1)]	46977	25750
beef bull farms[2)]	810	250
veal calf farms[2)]		
- white veal	1594	750
- alternative veal production	0	350
other fattening cattle and suckler cow farms[2)]	100	150
sheep farms[3)]	634	500

Source 1990: LEI/CBS 1992
[1)] All enterprises with dairy cattle.
[2)] Enterprises with on average more than 100 beef bulls, veal calves or suckler cows.
[3)] Enterprises with more than 300 sheep (125 to 150 ewes).

Dairy
Only 1.2 million cows will be needed to attain the milk quota in 2005. Environmental regulations will lead to an even stronger reduction in the number of calves and heifers. 21 000 dairy enterprises will stop production between 1990 and 2005 and sell or lease their land and milk quota to the remaining enterprises. The average milk quota per enterprise will increase from 240 to 400 tons per year. The average acreage will rise from 26 to 44 ha. Due to the increasing milk production per cow, the number of cows per farm will only increase from 40 to 47 cows.

Average income on the remaining dairy farms is not expected to differ much from the income in 1990. Costs will rise on dairy farms. Housing will become more expensive because of environmental measures. Machinery and other equipment will become more expensive because of the increase in automation, mainly in milking systems. Interest costs will increase because of investments in land and quota. Due to the larger scale of farming, these costs can be spread out over a larger amount of production.

Beef, veal and sheep
The number of beef bulls will decrease strongly, both on specialized beef production farms and on agricultural enterprises with a small number of beef bulls. The latter will disappear because of environmental reasons: there will be no space left for beef bulls on dairy farms, if these have to meet environmental regulations. The EU market policy and environmental regulations will force a large number of specialized farms to cease.

The decrease of the European dairy sector will lead to a smaller number of calves. That is the main reason why the veal sector will decrease. The veal sector will shift from traditional white veal production (based on milk feeding) to alternative ways of fattening till 300 kg live weight calves (based on feeding of concentrates and roughage), to reduce costs and meet consumer demands for more variation and better animal welfare. Because many former beef bull producers will also change to these new ways of fattening, many of the present-day veal producers will have disappeared in 2005.

Dairy farms that have sheep will strongly reduce the number of sheep to meet environmental regulations. The sheep sector will concentrate in the north and the west of The Netherlands.

Income in specialized beef, veal and sheep farms will stay low and possibly deteriorate a bit. The farms still in business in these sectors will on average have more land and often an income from outside agriculture (part-time farmers).

Land use and environmental effects
Cattle and sheep farmers will take measures to reduce mineral surpluses and ammonia emission. They will buy land, change fertilizing methods and feeding, change buildings and reduce the number of animals. For farms with a high number of animals per hectare, farms in the south of the country (where intensive pig husbandry is also producing large amounts of ammonia and manure) and farms near vulnerable nature areas, these measures will be expensive and severe. For hundreds of dairy farmers this will be a reason to move the enterprise to another part of the country. Farmers that have to move often will not have the ability to invest in a milk quota to increase production. For specialized beef producers large investments, like buying land, cannot be made at all.

The use of fertilizers will be reduced. Because of this, grassland output per hectare will decrease by 15 to 25%. Maize output will decrease 5% per hectare. Combined with the reduction of agricultural land, total roughage production will decrease. The reduction of animal numbers will be stronger than this reduction in roughage production. Therefore a growing number of farmers will start to grow their own concentrates. In The Netherlands this will be a new development.

On average, dairy, beef and sheep farms will not have a manure surplus. Many individual farms, however, will have surpluses and therefore be obliged to transfer the manure surplus, especially in the south of The Netherlands. The average number of livestock units[1] per ha will be reduced from 2.55 in 1990 to 1.95 in 2005. Ammonia emissions will be reduced from 107 kg per ha per year in 1990 to 31 in 2005.

Discussion

Only one scenario has been worked out. The main reasons to restrict ourselves to one was to force the experts to choose what they thought would be the most likely development. In addition, it made it possible to discuss the developments in one field integrated with developments in other fields. If two or more scenarios were chosen, discussion would often focus on the differences between the scenarios, instead of the general direction of the development. If the aim is to address specific questions, the use of more scenarios would be more suitable. If the questions are, as in this study, of a more general nature, an integrated single scenario is more apt.

The general view of the experts, supported by the model calculations, is that dairy farmers can have a rather optimistic view of the future. Many dairy farmers will cease production, but the percentage of reduction is not higher than in the 15 years before 1990. Income expectations are rather promising in the long term, although many experts expect some serious difficulties.

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[1] A dairy cow with a milk production of 6000 kg is 1 livestock unit. For other types of grazing animals, the number of livestock units is based on the feed input, compared to the feed input of this dairy cow.

The beef, veal and sheep sectors will do less well, because of a number of reasons. Beef and sheep will lose mainly because of the high production costs compared to other EU countries. EU agricultural policy and Dutch environmental policy will cause an increase of these costs, which are insufficiently compensated by premiums.

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17.1 Set-aside options and their impact on the planning process. Farmland in the United Kingdom

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Abstract

The paper describes the evolution of the set-aside programme in the EU in general and the UK in particular. It assessesthe impact of the scheme on the farm economy, the wider rural economy, and on environmental variables. It suggests that the effects on farm economy are complex and subtle and that as yet, insufficient evidence is at hand to enable confident predictions to be made as to the long term adjustments which will occur. The introduction of new set-aside options during the last cropping year and further options which will become available during coming years widen the range of objectives which can be targetted, but raise additional uncertainties about the future use of farmland.

Keywords: *Set-aside, Agricultural policy, Farm economy, United Kingdom*

Introduction

The Common Agricultural Policy has been criticized from many points of view, including its cost to the taxpayer and the consumers of agricultural products, its ineffectiveness in achieving primary objectives, because farm incomes have continued to fall, its effects on world trade patterns harming third party exporters, and its effect on the rural environment as high farm prices have encouraged intensive methods of agricultural production.

These criticisms led to a change of direction that took place in 1992, involving a switch of emphasis away from price support towards supply control. For an array of arable crops (the most important of which are cereals) farmers are made payments for each hectare of crop grown, in return for an undertaking to set-aside a percentage of their previously cropped area.

These changes were introduced as a result of both internal pressures within the EU, and external pressures, notably arising from the then ongoing General Agreement on Tariffs and Trade (GATT) negotiations.

The policy reform options

There were several possible responses to the problem of over-production which threatened the financial sustainability of the EU and the future of attempts to liberalise world trade in agricultural products. Some have advocated the introduction of constraints on the use of inputs, like nitrogen quotas, others the use of direct payments to farmers, related more

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to need, than production. Almost all analysts argued that there was a need to link farmers production decisions far more to free market conditions than the highly distorted prices which had prevailed in the past.

What eventually emerged from the 1992 reforms was a move towards world prices phased over a number of years, with farmers being compensated for their loss of market protection by area payments for a list of scheduled crops. In order to qualify for these area payments, farmers had to agree to take some land out of production. This requirement to idle agricultural land is referred to as set-aside. The primary objective of set-aside is to reduce production.

Experiences with set-aside

There are few agricultural policy measures which have provoked such controversy as set-aside. The public are bewildered and in some cases outraged by the phenomenon of farmers apparently being paid to grow nothing, farmers themselves find difficulty in letting productive land remain idle, and policy analysts suggest that it leads to distortions in factor prices, and is in any case ineffective as farmers seek to ensure that it minimises the effects on their revenues from crop sales.

The USA has the most experience of set-aside as a policy instrument, having had such programmes intermittantly for 50 years. The American experience is that reduction in cropped area resulting from set-aside invariably exceeds the associated reduction in production (Ervin 1988). This phenomenon is usually referred to as "slippage". This can occur for a number of reasons, depending on the design of the set-aside scheme. Obvious explanations are that farmers will set aside their least productive fields, or if the scheme is voluntary, only those farmers least able to grow good crops will be induced to take part. There may, in addition, be some substitution of non-land factors of production for land. A reduction in the area which farmers have to manage may mean that fixed factors of production like labour and machinery are more carefully deployed over remaining areas of cropland. Where farmers are required to set aside different fields each year, there is the likelihood that the fallowing of land during the set-aside period will enhance the yields in those fields in succeeding seasons. As a result of the "slippage" factor, set-aside is generally regarded as an ineffective means of reducing production at acceptable costs to the community.

Whilst the main objective of set-aside schemes is usually to reduce production, there may be other benefits which can be built into set-aside programmes. The management of set-aside land to bring environmental benefits is a clear example, which we shall return to later. It is inevitable, of course that when the same policy instument is being used to simultaneously achieve more than one objective, difficult compromises often have to be made.

The set-aside scheme in the EU

The current scheme was introduced for the 1992/3 harvest year. If farmers wished to apply for arable area payments which were introduced at the same time, they had to set aside 15% of the combined total of arable area. The land set aside must have been cultivated with a view to harvest in 1992. To be eligible for compensation payments a number of other regulations were stipulated by the Commission. The most important of these are summarised below :

1. The minimum block size of set - aside land was to be 0.3 hectares.
2. Land was to be kept in good agricultural condition, with precise management arrangements left to the discretion of each member state.
3. Land had to be set aside for at least 7 months between December 15th and August 15th, with individual countries setting the precise dates themselves.
4. Set-aside land had to be rotated each year so that, in effect, the entire arable area of a farm would be set-aside over a period of six years.
5. Set-aside land could be used for the production of suitable crops for non-food uses. This was referred to as 'industrial' set-aside.

'Small' farmers were to be eligible for the arable area payments without the requirement to set-aside land. Small producers are defined as those making a claim for an area which is no bigger than that necessary to produce 92 tonnes of cereals. This area was to be determined using regional yield figures. The proportion of farmers falling into the small category clearly varies from country to country, as shown in Table 1.

Changes introduced in the second year of the scheme

A number of important changes were introduced for the 1993/4 harvest year. The most important of these was the introduction of a non-rotational option allowing farmers to keep the same land in set-aside for 5 years. If farmers wish to adopt the non-rotational option they have to set-aside 20% rather than 15% of their arable area (apart from in the UK where the requirement is 18% at present). Farmers may also have a mixture of rotational and non-rotational set-aside, but if they choose to do this the whole set-aside area must equal 18% of the arable area. A further important change to the rules, permitted farmers to set aside more than the minimum required, as long as the total area set aside does not exceed the total upon which crop compensation payments are claimed (Voluntary set-aside).

The results for the first year

The total areas entering set aside in 1992/3 are shown in Table 1, together with the total claims under both the main and the simplified schemes. The evidence presented in Table 1 suggests that the impact of the set-aside scheme has been very different across the EU, reflecting differences in farm strucure. Whilst over half of all set-aside land is to be found in France and Germany it is in the UK that the relative effect has been greatest, with only a small proportion of farms qualifying for the simplified scheme 9%, i.e. not having to meet the set-aside requirement. Consequently the UK has the highest proportion of set-aside land in the EU. In the southern European countries set-aside has had little impact, neither has it in Holland. For the EU as a whole about 10% of formerly arable land is now under set-aside.

Table 1 Arable and set-aside areas in EU 1992/3 ('000ha)

Country	Main scheme (1)	Simplified scheme (2)	Set aside (3)	(3) as % of (1)+(2)
Bel/Lux	143	302	21	4.7
Denmark	1328	477	205	11.3
Eire	153	117	24	8.9
France	10409	2511	1589	12.2
Germany	7091	2236	1063	11.3
Greece	104	1163	17	1.3
Italy	1293	2409	207	5.6
Neth.	51	282	8	2.4
Portugal	433	250	78	12.3
Spain	5765	2670	909	10.7
UK	3664	314	556	14.0
EU-12	30435	12731	4674	10.8

Source CEC 1993 Green Europe.

The management of set-aside land within the EU

When set-aside was introduced for the 1992/3 harvest year individual countries were left to decide in detail what management practices were to be required, encouraged or banned on set-aside land. This has important differential effects on agronomic management and on conservation interests. The most important differences are summarised below.

Management rules for rotational set-aside

Establishment of cover crop

Most countries require that farmers establish some form of cover crop, although in some of the southern European countries this is not required, or indeed discouraged because of the fire risk during the dry seasons. Where cover crops are required, the establishment dates vary between country and country. In Denmark, for example, the cover crop must be established by October 1st whilst in France it is May 1st. Other countries set dates somewhere between these two, and with varying degrees of flexibility for seasonal variations in climatic circumstances. In most countries farmers are given the option of establishing a cover crop, either by the natural regeneration of the seed bank in the soil, or by sowing certain permitted seed mixtures. In Denmark, however it is compulsory for farmers to sow a cover crop. These varying requirements reflect to some extent differences in climatic conditions (it is difficult in more northern climates, for example, to get a good cover with natural regeneration) and partly a different ranking of objectives. The Danish insistence on a planted cover crop is a reflection of the importance there of the nitrate leaching problem. Planted covers on set-aside land reduce nitrate leaching better than the sometimes patchy cover provided by natural regeneration. In countries where nitrate leaching is less of a problem, natural regeneration may be preferred, because it will produce a more diverse flora, and habitat for a greater array of fauna.

These rules also affect farm economy. There are additional costs associated with planting cover crops, and the cost of farm operations will also vary throughout the growing season. Those farmers given the greatest flexibility are likely to be given a comparative advantage compared to those in other countries where the establishment rules are drawn more tightly.

Maintenance of cover crops

The rules which national goverments have made with respect to the maintenance of set aside land relate mainly to the control of weeds. The limited experience so far available suggests that weed control is the principle agronomic problem associated with set-aside. In order to prevent weeds seeding they either have to be cut before seeding takes place or destroyed by herbicide. Whether or not to permit farmers to use herbicides is one of the most contentious issues in set-aside management. It has considerable significance from both environmental and agronomic standpoints. We shall discuss this in more detail later with respect to the UK

In the second year of the scheme the important change has been introduced allowing farmers the option of non-rotational set-aside. In most countries the rules are broadly similar to those for rotation but the UK has developed a rather more structured set of options.

The consequences of set-aside on the rural economy and environment in the UK

As the distribution of set-aside is skewed across the EU, it is also unevenly distributed within the UK. Forty per cent of all set-aside land is in the 7 eastern counties of England (Cambridgeshire, Essex, Lincolnshire, Norfolk, Suffolk, Humberside and North Yorkshire). Large areas of the western side of the UK and most of the hill and upland areas have been virtually unaffected by the set-aside scheme.

The management rules in the UK have been designed to effect a satisfactory compromise between the desire to allow farmers to pursue good agronomic practice by avoiding a build-up of weed species, and the wish to incorporate environmental benefits within the set-aside scheme.

The control of weeds is perhaps the central issue in the management of set-aside land.

To farmers they represent a threat to long term successful management of their farms, to conservationists they represent bio-diversity and habitat for wildlife. In the first year of the scheme there was criticism of the fact that farmers were permitted to cut the cover crop on set-aside land from April 15th in order to prevent seeding, and plough in the cover crop from May 1st. This resulted in the nests and young of many ground-nesting birds being destroyed. Delaying cutting was judged to be ineffective in weed control because by that time many weed species had seeded. Rather surprisingly, there was consensus between farming and conservation lobbies that the use of herbicides to control weeds was to be preferred to mechanical methods of weed control.

The most controversial remaining aspect of the rules is that permitting farmers to cultivate or plough their land after 1st May (although they are discouraged from so doing). Early ploughing results in a lifeless, bare fallow during the summer months. Survey work is currently under way to ascertain the proportions of farmers managing their land in different ways. Until the data collected in such exercises has been analysed there is no way of ascertaining the aggregate effects of set-aside on the rural environment. Unfortunately, the considerable changes in set-aside rules between the first and second years and the introduction of new set-aside options means that much of the early monitoring of farmers practices is already out of date.

Impact on the farm economy

Farmers are still in a learning situation with set-aside and farm systems will continue to adjust over the next few years. The introduction of non-rotational forms of set-aside introduce new management options. Policy makers are also learning and the changes in management rules reflect the lessons of experience. In judging the impact of set aside on farm incomes it is also to be remembered that it was introduced as part of a package of policy changes, the most important of which was a phased reduction in the level of guaranteed prices. Unless there are unexpected movements in the level of world prices, gross margins for cereals and oilseeds are likely to fall, and farm systems will need to adjust to accommodate these narrowing margins.

Modelling exercises have been undertaken to try and predict the financial implications of these changes on farm incomes in the UK (Fearne et al 1994). Using linear programming techniques on a typical specialist cereal farm, the model suggested that the farm gross margin (difference between gross output and variable costs) would fall by 23% as a result of the new arable farming compensation scheme.

There are a number of observations to make on the result quoted above:

1. It refers to a 'typical' farm situation. The more productive the land being forced into set-aside or the greater the management skills of the farmer in producing high gross margins the more the income loss will be, since compensation levels are related to regional yield levels, not individual farm levels. The more productive the farm the more heavy the financial penalty that set aside imposes.
2. The modelling restricted itself to to changes in farm gross margins. No account has been taken of possible adjustments in fixed costs. This is more difficult to predict. Most fixed costs, like labour and machinery are not specific to particular farm

enterprises, and so their level of utilization will not vary with the type of set-aside undertaken. Nevertheless adjustments in fixed costs do take place and earlier research on the original 5-year scheme suggested that savings in fixed costs, both labour and machinery could be substantial (Ansell and Tranter 1992). Clearly, the larger the farm, the greater the opportunity for shedding lumpy inputs like labour and machinery. Smaller farms will experience more difficulty in achieving cost reductions.

3. Additional earnings may be obtained from resources released from current uses through set aside. It is difficult to assess the extent of such opportunities or even to generalise as to their nature, but it may include such things as renting out cottages made surplus by redundant farm workers, contracting out underutilized men and machines, and more non-farming activities undertaken by farm families.
4. The extent of savings on fixed costs will vary with the set-aside option chosen. Rotational set-aside will result in a smaller reduction in labour and machinery requirements than non-rotational forms. Early evidence suggests that non-rotational set-aside will attract more farmers in the less favoured cereal growing areas who have significant parcels of less productive land.
5. The long term effects of set-aside on the productivity of land are as yet unknown. Experimental work is under way to measure the agronomic consequences of set aside in terms of such things as weed populations, the incidence of pests and diseases and long term effects on fertility (Clarke 1993), but given the different options farmers now face in choosing their set-aside strategy, and variations in soil type between farms, many of the long term consequences are as yet unknown.
6. The set-aside payment is not the net return from set-aside land. Farmers are realizing that set-aside land has to be managed, and costs are incurred.

The above discussion suggests that the most likely scenario is a decline in farm incomes, particularly on the most productive arable farms, but that the effects will be modified at the individual farm level in a number of ways. Most of these will take time to emerge. Savings in fixed costs, like machinery may only be possible when replacement decisions are made. However, new structures are already emerging. For example, 'machinery rings' (an arrangement by which farmers syndicate the use of machinery) predate set-aside but have been given an impetus through the excess capacity which set-aside generates.

The wider rural economy

The most obvious effects of set-aside on the non-farm component of the rural economy is through the demand for inputs and the supply of products. The use of inputs like seed and fertilizers must fall. Changes in the level of herbicide used will depend upon the practices which are permitted on set-aside land.

The fertilizer, seed and crop protection industries are however highly concentrated and there has been a contraction in the number of independent locally based agricultural merchants over the last several decades. The same is true of industries downstream of farming. Cereal marketing takes place mainly through national companies and whilst there will doubtless be employment losses in such companies, these will not necessarily be rural jobs. One aspect of set-aside which will ameliorate its effects on the local economy is the fact that the extent of linkages between farms and locally based industries varies with the size of farm. Small farms deal more with local industries than large farms (Harrison-Mayfield 1994). As in absolute terms most set aside land is found on large farms, the effects on local firms will initially be disproportionately small. However, as competition in a shrinking market intensifies, the longer term future of the few surviving locally based industries looks no more secure.

The effects on farm employment

UK agriculture consists of some 200,000 farms, about half of which are classified as being unable to provide full-time employment for one person. Of the rest, an increasing proportion are worked mainly by family labour, with part time or 'casual' labour helping out at busy periods. There remain only some 80,000 full-time, hired farm workers in UK agriculture so the number of full - time job losses is likely to be relatively small, certainly when a 15% rate of rotational set-aside was the norm.With the introduction of a non-rotational option, and with farmers now able to set-side up to 50% of their arable land, job displacement is likely to marginally increase. The main employment effects of set-aside are more likely to be a reduction in the amount of 'extra' labour required at peak periods and an increase in the amount of underemployment amongst members of the family labour force.

The effects on the rural environment

The evolution of set-aside management policy in the UK indicates an increasing recognition of the need to include environmental objectives alongside those relating to agronomy and supply control. Indeed the changes in the management rules between 1992/3 and 1993/4 reflect the greater influence of environmental interest groups in the decision-making process. The main environmental benefits are additional feeding and breeding grounds for birds and mammals, and some reduction in the level of nitrates leaching into water courses. There are, to some perceptions, environmental costs, particularly the detrimental effects which set-aside land has on rural landscapes, particularly when cover crops are desiccated through non-selective herbicides in the early spring. The introduction of non-rotational forms of set-aside offer considerable additional opportunities to augment the environmental benefits which can be obtained through set-aside. There are four options open to farmers, two of which explicitly seek to enhance habitat for wildlife, the first by allowing farmers to set aside field margins and the second through the establishment of suitable cover crops for wild birds. The other two do not have specific environmental features. No information is as yet available as to the numbers of farmers who have chosen these non-rotational options.

To a large extent, the environmental consequences of set-aside depend on how farmers manage their land. There is considerable flexibility within the rules for farmers to act in an environmentally friendly or environmentally unfriendly way. Considerable concerted effort is being made by Government departments, farmers organisations and environmental groups to educate and persuade farmers to manage their set-aside land in ways which will enhance the rural environment. It is, as yet, too early to conclude how effectively these messages have been communicated, but the primary data collection exercises are now under way which will enable such evaluations to be made.

Set-aside and planning for the future

In England alone in 1992/3 decisions as to how to manage set-aside were made by 26,783 separate farmers. It is therefore difficult to envisage how a more coordinated approach to the selection of land for set-aside and its subsequent management can be achieved, particularly as for all parties, it is an early stage of the learning process. The priorities for planners at this stage must be to monitor and evaluate the consequences of current policies and before such information is available, it is difficult to see how rational modifications can be made. Amongst the questions which are as yet unanswered, and which have great bearing on planning for the future are the following:

1. How serious will be the problem of slippage? In 1993, the overall area planted to cereals fell by 15%, and total cereal production fell by 11% (MAFF 1993). As yields were higher in 1993 than 1992 because of climatic factors, the extent of slippage directly associated with set-aside seems to have been quite small. It remains to be seen what will be the effect on output of the non-rotational and guaranteed set-aside options at the 18% level introduced this year. Given that in the first year it was generally expected that farmers would put their less productive land into set-aside, the 1993 harvest evidence seems to suggest that the problem of slippage may have been exaggerated, and that in the UK at least, set-aside seems to be achieving its primary objective of reducing production.
2. What will be the long-term effects of set-aside on farm systems? A new 'crop' has now appeared in farm systems in arable areas and it is the third largest after wheat and barley. The area planted to wheat has fallen by more than the area planted to barley indicating that farmers do not simply cut back on the enterprises with the lowest gross margin (wheat has a higher gross margin than barley). More complex rotational considerations seem to be involved. There are also agronomic issues which may take several years to emerge. Changes in the growth habit of annual weeds have been observed (Froud-Williams 1988) and the effects on perennial weeds is even more uncertain.
3. How many farmers will transfer their set-aside obligation? From 1995 onwards, provision exists for farmers to transfer their set-aside obligation to other farmers within 20 kms who have land of similar quality, or to farmers within areas where specific environmental objectives are being sought. When such transfers occur, an extra 3% set-aside requirement is imposed. If this option was taken up by a significant proportion of farmers it would have implications for both slippage and environmental objectives.

4. What will be the uptake of the 20-year set-aside scheme? This scheme will be introduced as part of the 1992 CAP reform agri-environmental package. Farmers under the original 5-year set-aside scheme may be eligible (which accounted for 130,000 ha. in the UK in 1993), and farmers in other environmentally sensitive areas.
5. What will be the effect on land prices? Economists predict that set-aside will incease land prices (Swinbank 1992), as it increases the marginal productivity of land and there is some empirical evidence that this happening in some European countries (Ansell and Vincent 1994)

Conclusions

Set-aside was introduced to reduce production, other considerations were secondary. It is now a major source of land use, particularly in eastern England. Despite perceptions that farmers are being paid large sums to keep land idle, it will lead to a fall in farm incomes. It penalises particularly those farms which achieve the highest yields. As a result of pressures from many quarters, attempts are now being made to incorporate environmental objectives in planning for set-aside. Substantial improvements in the ability of set-aside to deliver environmental goods will be difficult to obtain, however, without compromising its main objective which is to reduce production. At the moment, the priority for planning is to monitor carefully farming practices on set-aside land, and evaluate the effects of these practices on the rural economy and environment.

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17.2 Effects of land use changes on cadmium release on former agricultural land

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Keywords: *Cadmium release, acidification, set-aside, forest*

The EU plans to take more than 15% of the agricultural land out of production (MacSharry plan). This land will be used predominantly for forestry and nature development or will be set aside. Due to atmospheric deposition and fertilizer use, the cadmium content has increased, but due to liming the mobility of this metal is low and not harmful under present management conditions.

Field data and model predictions show that the pH in the topsoil of forests planted on former arable land may drop from about 5.5 to 3.5 within 30 to 60 years. The results also indicate that this pH drop causes an increase in the dissolved cadmium concentration by a factor two to ten. The field data are based on (i) a chronosequence of eight forest stands that were planted on former agricultural land between 1920 and 1992 (pH decline) and (ii) a survey of 30 agricultural and forest soils. The latter showed that mainly due to the low soil pH (3-4.5) the dissolved cadmium concentration in forests was two to ten times higher compared to arable soils, despite of higher total metal contents in arable soils.

Model predictions are given on a national scale, scenario of Douglas fir planting, assuming constant acid deposition levels with time. Despite the rather simple approach, not taking into account various dynamic system feedbacks, there is a good agreement between model results and field data. Plants and soil organisms in close contact with the soil solution will be confronted with increased concentrations, probably resulting in higher exposure.

A biomagnification model was linked to a soil model to calculate the risks of abandoning of meadows. The model predicts high risks for earthworms and their predators, even 50 years after abandoning. Risks for herbivorous mice became higher after abandoning, but did not reach critical levels. The results are very sensitive to the way in which bioavailability is modelled.

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 669.

CHAPTER 17

Set-aside

17.3 Set-aside areas as strategic tools for surface and groundwater production

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Abstract

As much land is currently set aside from arable usage it is important to assess potential beneficial or detrimental effects of set-aside on the environment and on soil quality. We examined the soil solution composition from an arable plot, an adjacent recently set-aside grassland plot, and a reference *Calluna* heathland system, and modelled the discharge, based on soil moisture and climatic measurements. Due to the differences in evapotranspiration between different vegetation types the model predictions of ground water and freshwater recharge during the two year period were 2000 (arable site), 3800 (grassland site) and 5800 (heathland site) m^3 ha^{-1}, corresponding to 20%, 37% and 57% of the precipitation for the same period. Concurrent losses of nitrate-N were 40 kg (arable), 4 kg (set-aside grassland) and 2 kg (heathland). Generally, it can be envisaged that where little recharge is formed under adequately fertilized crops, it may be possible to accelerate the formation and increase the quality of recharge considerably, by proper choice of set-aside vegetation, and by adequate management.

Keywords: *set-aside, water quality, recharge, groundwater production, grassland, heathland*

Introduction

The retirement of land in order to cut down agricultural production, either as a medium or long-term remedy, raises questions about the management and possible benefits or drawbacks of set-aside land. In regions where the groundwater recharge from arable land is crucial to the supply of drinking water, and to freshwater in streams and lakes of densely populated areas, hydrological aspects pertaining quantity and quality of recharge from set-aside land are of particular interest. In such areas the aspect of groundwater recharge may be considered to be crucial, among many other social and economic considerations.

After a comprehensive literature search we have found very few references to nutrient dynamics, water balances and water-use in low productivity grassland and heathland. In a recent study (Magid et al., 1994) it was necessary to assume a 40% reduction in reference potential evapotranspiration on a non-grazed unfertilized recently set-aside grassland in order to simulate soil moisture measurements adequately. Similarly that of a heathland plot was reduced by 60%.

Based on these findings the derived mass-balances for water and nitrate, for an arable, a set-aside grassland and a heathland plot will be discussed here, along with key features determining ecosystem productivity in terms of groundwater recharge.

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Materials

For a detailed description of soils and methods of analysis please refer to Magid et al. (1994). Briefly: The arable site was located at St. Lyngby on the island of Zealand, Denmark, and a *Calluna* heathland site was located at Melby (Figure 1). Adjacent to the arable soil, a study area was set-aside in spring 1987 and sown in with a mixture of grasses and alfalfa, referred to here as the St. Lyngby grassland site. The arable site was sown with winter barley in 1987-1988, and winter rye in 1988-1990. The St. Lyngby soil has developed from windblown sand, on top of alternating layers of diluvial sand and silt. The Melby *Calluna* heathland soil has developed on post-glacial sandy marine sediments. Soil solution was sampled fortnightly below the root-zones with suction cells whereas rainwater was sampled concurrently 2 m above the soil surface and at the vegetation level. Rainwater and soil solutions were analysed for nitrate, chloride, sulphate, phosphate, calcium, magnesium, sodium and potassium. Global radiation and temperature data were obtained from a nearby climate station, and potential evapotranspiration was estimated from these based on a modified Makkink equation (Hansen, 1984). Estimates of water usage by the different vegetations were made by linear reservoir models (Magid et al., 1994).

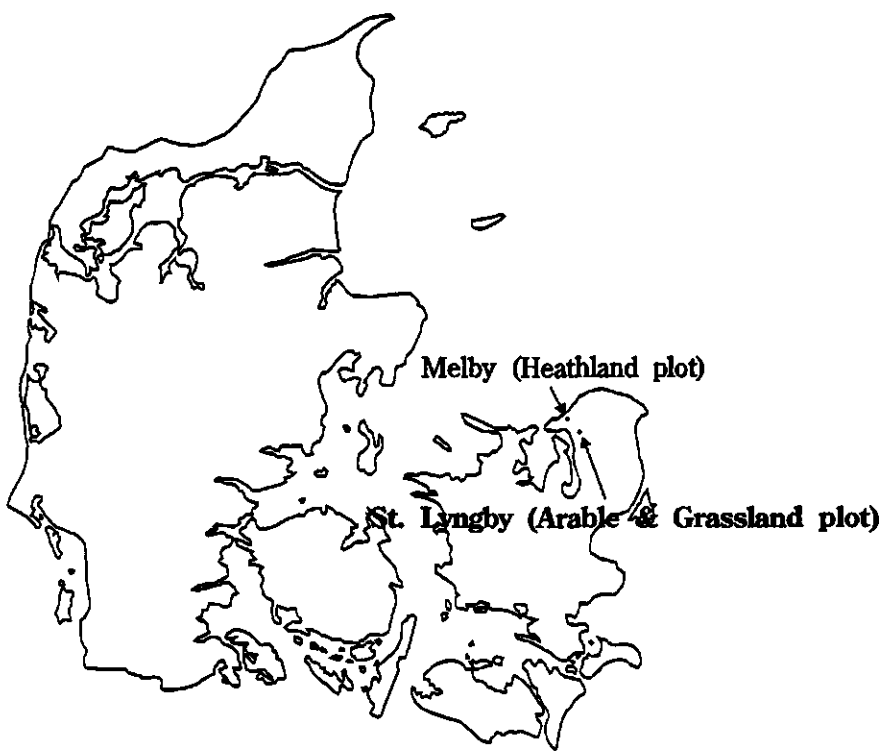

Fig. 1. Study areas in Denmark

Results

The arable soil had consistently higher amounts of nitrate, phosphate, potassium and calcium in soil solution, and even though the arable soil was planted with winter barley or winter rye, nitrate concentrations at 90 cm depth during winter, reached levels above 2 mM. (Figure 2). When arable soil was planted as a set-aside low productivity non-grazed grassland soil, the soil solution almost immediately converged to the level of heathland with regard to nitrate. Notably the grassland was lower in phosphate, potassium, chloride and sodium than heathland, presumably due to the accumulation of biomass and litter (Figure 2). The measurements of soil moisture showed significant differences in the vegetations water use (Magid et al., 1994). In order to simulate the water content in the root zone of the heathland soil, it was necessary to decrease the vegetation-specific potential evapotranspiration to 40% of that required to simulate the water content of the arable plot. Similarly that of the grassland was reduced to 60% (Figure 3). Based on the differences in evapotranspiration between vegetations, model predictions of groundwater and freshwater recharge were 2000 (arable site), 3800 (grassland site) and 5800 (heathland site) $m^3\ ha^{-1}$, corresponding to 20%, 37% and 57% of the precipitation for the same two year period (Figure 4). Concurrently losses of nitrate-N were 40 kg (arable), 4 kg (set-aside grassland) and 2 kg (heathland), Figure 4.

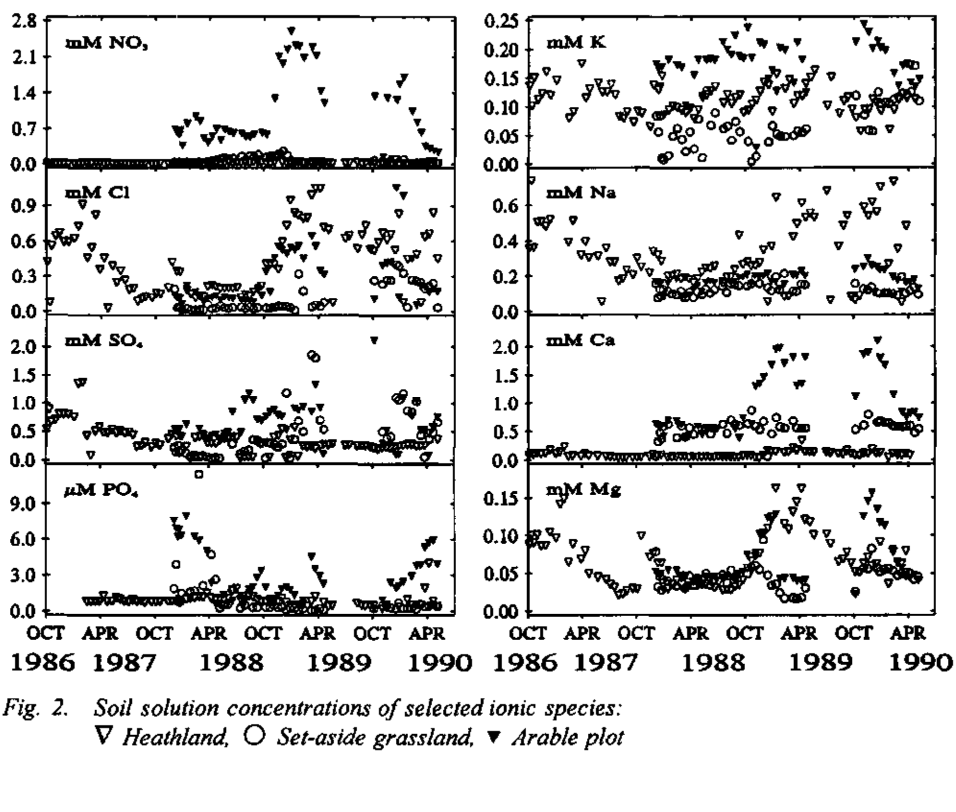

Fig. 2. Soil solution concentrations of selected ionic species:
∇ Heathland, O Set-aside grassland, ▾ Arable plot

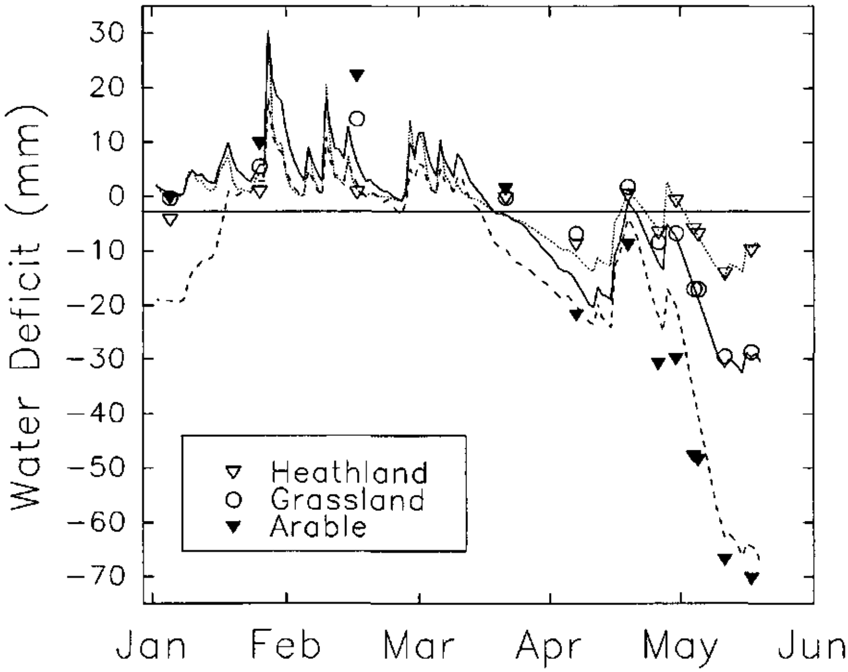

Fig. 3. Observed and simulated water deficits

Discussion

These findings add to a field of research in which the knowledge is sparse and contradictory. According to Dunin and Reyenga (1978) natural grasslands, often deficient in nutrients, are conservative in water use. On the other hand Renger et al. (1986) stated that grassland was intermediate in water use compared to arable land (low) and coniferous forest (high). While it is probably valid that recharge rates for intensively managed grassland systems are lower than under arable systems, this does not agree with recent findings for a non-grazed, unfertilized set-aside grassland (Magid et al., 1994), for which it was nescessary to assume a 40% reduction in reference potential evapotranspiration, in order to simulate soil moisture measurements adequately. Our data indicates that a reduction of transpiration due to nutrient restriction on photosynthesis may be of considerable importance to the overall water balance. Thus, the set-aside grassland was predominantly yellow until midsummer in the 2nd and 3rd year, while the heathland was inherently low unproductive in terms of biomass. The reduction in the vegetation's potential evapotranspiration dramatically affected model predictions of recharge (Figure 4) for both heathland and set-aside grassland.

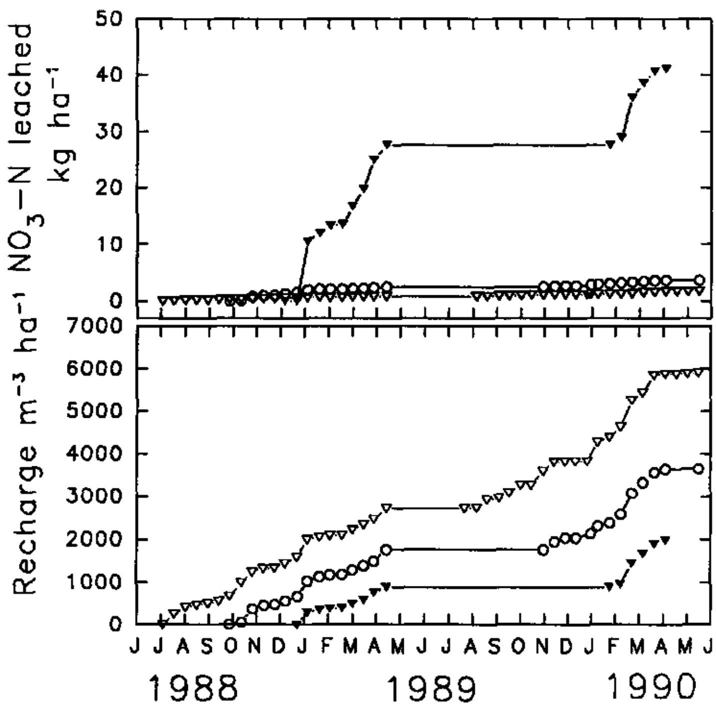

Fig. 4. Nitrate leaching and groundwater recharge:
∇ *Heathland,* O *Set-aside grassland,* ▼ Arable plot

The basic characteristic of the non-arable ecosystems in this study was their very low dry matter productivity. This was primarily a result of nitrogen strongly limiting the photosynthetic activity, and thus the associated evapotranspiration. Previously published results (Magid et al., 1994) indicate that the maximum potential evapotranspiration was ca. 33% lower in the heathland system than in the set-aside grassland system, but just as important, the root system was very shallow (80 mm) compared to that of the grassland (600 mm). Thus the water resource available to the heathland vegetation in drier periods was very limited.

The findings of Wallace et al. (1982) that the annual evaporation of a heathland was only 13 % less than Penman potential evaporation are in contrast with our results. In this study it was shown that while the heathland potential evapotranspiration was less than half of Penman potential evapotranspiration, an increased evaporation from wet canopies made up most of the difference. Because the water remaining on vegetation after a rainfall will evaporate freely, the size of this vegetation specific interception capacity is especially important in regions where the rainfall occurs as a series of smaller events, compared to regions where the rainfall is distributed over few occurrences. Thus depending on the local climatic conditions, the losses due to evaporation of intercepted water may be dominant over transpiration losses.

The management of set-aside grassland is likely to be crucial for recharge quantity as well as quality. Thus, grazing will presumably decrease the amounts of water formed on a set-aside grassland, as the nutrient cycle will be accelerated, and a stimulation of regrowth of photosynthetically active tissues will occur. It has also been shown that cattle grazing may considerably increase the losses of nitrate through leaching (Ryden et al., 1984).

In non-arid temperate areas where drinking water is scarce due to high consumption rates, regulating the biomass production in favour of more groundwater production in set-aside land could increase the water supply. Choosing low productivity grassland as a prominent vegetation in areas with a scarcity of water has some advantages. Firstly it is easy to revert to arable usage should the need arise, as opposed to forest that ties up the soil resource for at least one tree generation (30-150 years) once planted. Secondly, it compares favourably to both boreal and heathland vegetation with regard to long-term effects on soil fertility (Magid, 1993).

Generally, in areas where nutrient losses from arable soils are detrimental to the surrounding environment, a regional policy for set-aside could substantially increase the supply of clean soil water to the freshwater bodies, and thus provide a partial substitution for re-purified sewage water.

The scope of the present study is limited, and it is not possible to say if the beneficial hydrological characteristics of the grassland site we studied will remain constant over time. Certainly more research will be needed in order to optimize the management of set-aside systems for production of recharge, as the current knowledge in this area is limited and contradictory.

Conclusions

1. The setting aside of arable land into low productivity non-grazed grassland resulted in a considerable increase in the purity and a doubling of the estimated quantity of groundwater and freshwater recharge. The increase in recharge rates resulted from a decrease in potential evapotranspiration, presumably due to the vegetations' depressed photosynthesis.
2. The highest rates of recharge were simulated in a heathland system with a low potential evapotranspiration, a low vegetation specific interception capacity for rainfall, and a shallow root system.
3. Generally it can be envisaged that for non-arid regions where little recharge occurs under arable land, formation may be considerably increased but also decreased depending on the choice and management of the set-aside vegetation.
4. As the current knowledge in this area is minimal and contradictory we believe that more research is justifiable, and certainly necessary in order to optimize the management of set-aside systems for production of recharge.

Acknowledgements
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CHAPTER 18

New futures for specific regions

18.1 The case of the Gelderse Vallei, The Netherlands

18.1.1 Images of a region: a dangerous makeshift. The case of the Gelderse Vallei

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Abstract

'Images' belong to a family of related concepts of representations. According to modern views on the concept of the region, regions are in principle dynamic entities. They manifest themselves in four different 'shapes', as Paasi has demonstrated. Images concern one or more aspects of those shapes. The images of the Gelderse Vallei (Guelders Valley) tend to focus too narrowly on the agricultural aspects of the region's functional shape. A regional-geographic interpretation based on Lamb's model of the urban field offers a much more balanced image of the region.

Keywords: *region, image, regional geographic model, scenario, shapes of regions*

Images and scenarios both a matter of selection

The term image refers to "the mental picture that may be called to mind when the object, person, place or area is not part of the current sensory information" (Gold, 1980, 41). But an image is also "a vivid or graphic representation or description" as Longman's *Dictionary of the English Language* states. In the latter sense, the image is an externalization of that mental picture. This double meaning is also connected with the term 'representation'. Marsden *et al.* (1993) elaborate a number of very useful concepts in relation to rural development. One of these is representation. I have brought some of their concepts together in Figure 1. This figure demonstrates that the images about areas, as entertained by actors with different positions, interests and preferences regarding to those areas, can perform a function within regional restructuring processes.

There are many types of images, however. Lynch (1960) collected a large number of individual representations (sketched maps) of landscape. This collection, demonstrates an impressive selectivity with regard to landscape characteristics as well as cognitive and emotive aspects connected with these landscapes. At the same time, an effort has been made to avoid those subjective influences in landscape studies. For example, in The Netherlands, landscapes are officially defined as "the visually observable part of the earth that is created by the mutual relationships and the interdependence of the factors climate, relief, water, soil, flora, fauna and human activity" (Ministerie van Landbouw, Natuurbeheer en Visserij, 1992, 10). This type of landscape image can be analyzed in

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 681–690.

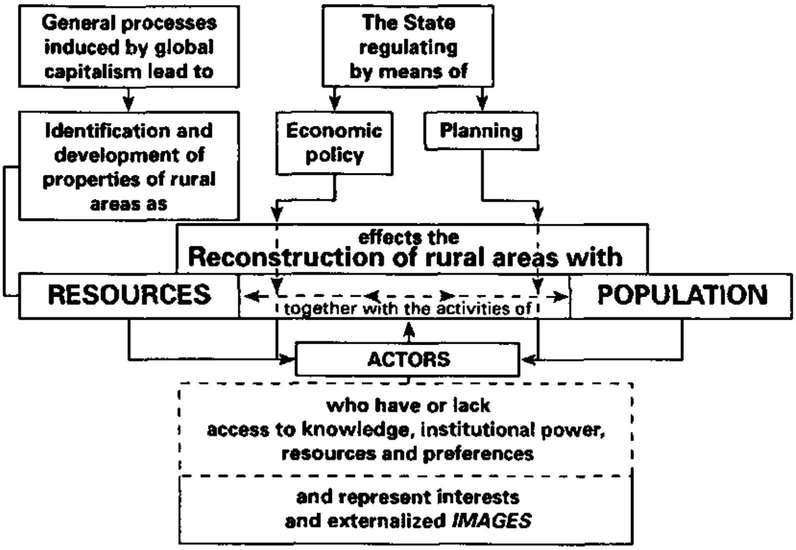

Fig. 1. The place of images in a model of the development of rural areas

its components as "a topological structure" (Burrough *et al.*, 1982, 22) and according to its components and relationships as "an ecological structure" (Schroevers, 1982, 38). It can also be 'experienced', be observed and evaluated, for instance in terms of its aesthetic, utilitarian, cognitive, affective or symbolic value (Ministerie van Volkshuisvesting en Ruimtelijke Ordening, 1992, 28, 375).

In the family of planning concepts, images have been given a concrete translation in spatial concepts, 'Leitbilder', 'sketches of spatial structure', and 'blueprints and scenarios'. 'Spatial concepts' are defined by Zonneveld (1991, I, 222) as follows: "A spatial concept expresses through words and images in a summarized way, the view of a planning subject in respect to the desired spatial development of society and the nature of the interventions which are considered necessary". Scenarios are defined by De Vries (1985, 96) as descriptions of the current situation of a society or its parts, desired and attainable states of that society, and chains of events linking contemporary and future states. Projective scenarios extrapolate separate trends, whereas prospective scenarios present alternative designs vis à vis the present. These scenarios may create spatial images (Van Houten and De Vries, 1985, 16; Verbaan *et al.*, 1991 W.R.R., 1992).

The German geographer Blotevogel (1993) reviews several typologies of spatial concepts. One of these is the concrete concept of space in everyday experience, filled with and made up of material objects. Apart from that one, all those concepts of spaces are constructed by abstraction and by selection of supposed properties of the real world. The selection may be problem-driven or theory-driven.

Regional geographers are not equipped to design scenarios. However, they may contribute to the designs by making their regional geographic models of the regions.

The region: construction of a changing pluriform spatial reality

According to the classic and still popular concept, the region is a more or less clearly delineated part of the earth's surface. That concept presumes a certain coincidence of spatially overlapping variables that are present within the limits of a region. The modern idea recognizes the existence of many variables that are not or only partly spatially overlapping and seldom have the same areal extent. This means that in reality, the regional limits are not firm. The researcher has to impose those limits on 'his' region, often crudely intersecting the extent of variables. Thus, he creates an 'inside' and an 'outside', as well as 'internal' and 'external' relationships (Fig. 2). This construct is a pluriform regional reality. It supplies the contents of the observations of the researcher and thus determines his experiences.

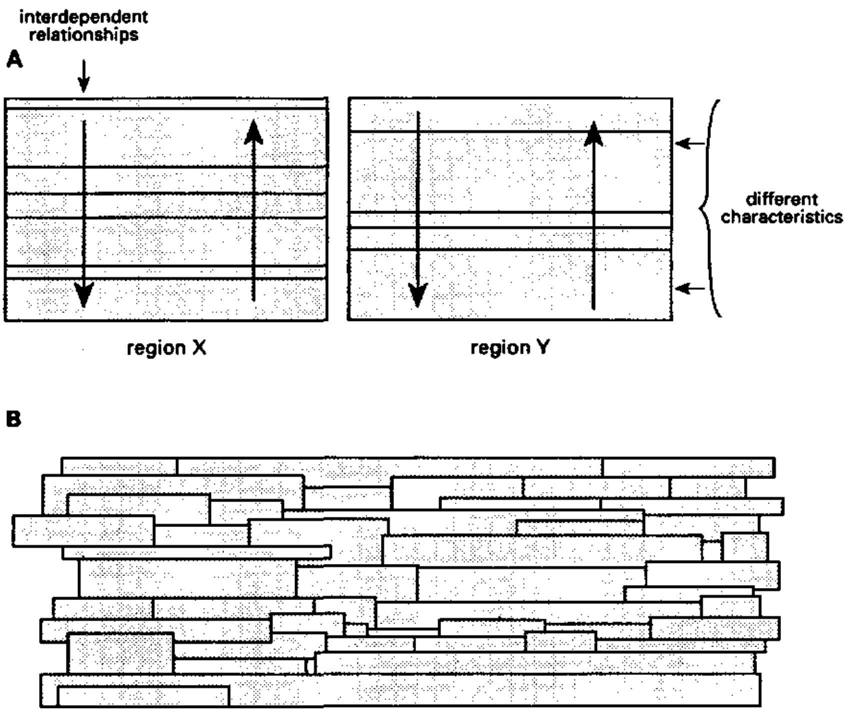

Fig. 2. A traditional and a modern view of regions

Paasi (1986, 1991) has concluded that 'regions' are dynamic entities, originating, extending, fusing, and disappearing in the course of time. They manifest themselves in different 'shapes'.

The 'territorial shape' (the region gets a name and some sort of boundaries and is situated in a larger world) is the first one.

The second is the 'symbolic' or 'conceptual shape' (symbols are attached to it, whereby spatial images and -consciousness are formed).
The 'institutional shape' is instrumental in producing the other shapes.
Finally, the 'functional shape' or 'established role' of the region is its functioning, particularly in an economic sense, in the wider world.

These shapes need not coincide in time and space, in fact, they rarely do. With respect to images, this means that the selection of variables can be based on just one or a few shapes. Moreover, as a consequence of the dynamism of regions, these shapes may be behind or ahead of the other shapes (if all shapes have materialized, but that need not necessarily be so).

The Gelderse Vallei: regional images and shapes

The territorial shape

Paasi's four shapes can be connected with different images of the Gelderse Vallei. The territorial shape is based on its physical-geographic and historical conditions. The funnel-shaped area between the glacial ice-pushed ridges of the Veluwe and the Utrechtse Heuvelrug (Utrechts Hills), the Rhine in the south, and the IJsselmeer in the north has a specific natural ecosystem. That system is based on seepage and runoff from the surrounding sand hills. On the valley floor; a mosaic of low sand ridges, brooks, peat, and even clays in the south and north have made the area relatively inaccessible. Only in the late Middle Ages did colonization from the perimeter to the centre change this poorly drained area. It remained, however, a border region (Deijs, 1988). The great stability of the border in time did not prevent many hostilities between the Bishopric of Utrecht and the Duchy of Guelders (often fuelled by conflicts over the drainage of superfluous water). In 1742 the border function was enhanced by the construction of the 'Grebbelinie'. This was a zone of eleven inundatable lowland compartments guarded by fortifications near sluices. They were meant to defend Holland, say Amsterdam, against attack from the east. This line of water defence works did not stimulate economic development, to say the least. Though it served the battles during the German invasion in Word War II in May 1940, it was abolished after World War II because it had become outdated. Its territorial shape became connected with an image of a marginal or in-between region.

The functional shape

Agriculture
The Gelderse Vallei has a predominantly agrarian image, despite twentieth century industrial development which made the medieval city of Amersfoort, the eighteenth century peat-diggers' village of Veenendaal, and the old agricultural village of Ede, together account for nearly half the population of the whole region. A strong drive to intensify production on the small farms with unfavourable soils led to specialization, particularly

in the centre and near the perimeter of the Veluwe. Poultry, pig and cattle breeding also stimulated the creation of a major agribusiness complex, creating 470 million guilders in annual income (Bolsius 1990). This complex is not spatially concentrated but dispersed over the region. Public awareness of the severe environmental pollution created by intensive livestock farming strengthens the agrarian bias of the image. Similarly, the public (wrongly) associates orthodox religious affiliations with farming (which do indeed prevail in many parts of the area).

Recreation

Nevertheless, other functional shapes are important too. In fact, they generate more income and employment than agriculture. Before the Second World War the recreational functions of the wooded ice-pushed ridges were developed in the contiguous provinces of Gelderland and Utrecht. After the war, campings replaced hotels as the influx of day-trippers grew. This recreational function was originally limited to the slopes, but is now encroaching upon the Vallei proper. In doing so, it conflicts with intensive agriculture, which produces a stench. Although recreation is a rapidly growing factor, also in the Vallei itself, it is not part of its image. Recreation remains a key element of the image of the Veluwe and the Utrecht Hills.

Residential development

At the same time, the residential development, also originally confined to the wooded higher grounds, is extending itself and is penetrating the whole Vallei. The local population, which is often poor, has had to accommodate an influx of newcomers. Previously, the migrants came predominantly from the Randstad; nowadays they come from all parts of The Netherlands. Many of them are retired or commute to the centres of employment, either in the Vallei or in the Randstad. Many activists for preservation of the natural qualities of the region are probably recruited from these in-migrants. The population pressure in the central parts of the region increases as the wooded areas become better protected against residential development.

Manufacturing and services

Finally, developments in manufacturing and services are triggered by the main west-east corridors running from Amsterdam via Amersfoort to Enschede and Groningen (the A1 highway) and from Rotterdam/The Hague via Utrecht to Germany (the A12).

Consequently, there are in total seven zones. These include the municipalities in the two corridor zones that are confronted with increasing pressure of expanding economic activities and residential development (in the north near Amersfoort, in the south near Veenendaal-Ede). In addition, there are three areas that have a strong agricultural imprint: respectively to the north and to the south of these corridors. Finally, the last two zones lie on the two slopes of the ice-pushed ridges, with their old villages, agriculture, agribusiness, and their diverse recreational and residential functions. Still, the overall images of the region are not very diverse. They are dominated by agriculture and its effects upon nature.

The institutional shape

The Gelderse Vallei has no particular institutional shape of its own. The two provinces through which it runs did not cooperate until recently. Even their common drainage problems did not lead to a unification of their respective water boards until this year. Recently, however, the central government designated the Vallei as an area where a combined regional planning and an environmental policy should be devised, implemented and executed (Vierde Nota, 1990; Actieplan Gebiedsgericht Milieubeleid 1990, Plan for area-specific integrated environmental policy). The decision created a new situation. The Vallei became one of the 11 regions where this so-called R.O.M. policy (Regionaal Ontwikkelings- en Milieubeleid - Regional Development and Environmental Policy) was instituted as a government-stimulated development from below. In 1989, a policy commission ('Valleicommissie') was set up. It consisted of 17 municipalities, the provinces of Utrecht and Gelderland, representatives of three central government departments, and 11 other private or semi-public institutions like farmers' organizations, the Rabo (Raiffeisen) Bank, environmentalist groups etc. An agreement signed on the 24th of July 1994 commits all parties to cooperate and act according to the jointly endorsed 'Project for the Renovation of the Vallei' in 1993. A foundation was established in order to serve as a platform for negotiations. This approach precluded an adaption of the administrative institutional shape of the region and - at the same time - is an incentive for a regional development from below.

The conceptual shape

At times the Grebbelinie and too abundant rain has made people companions in distress. Yet the old cleavages between the provinces of Utrecht and Gelderland were too deep to allow some common conceptual or symbolic shape of the Vallei to develop. Another factor was the orientation for services and shopping. The population of the northern part of the Vallei and the N.W. Veluwe was focused on Amersfoort, while the population of the southern part was focused on the cities of Arnhem or Utrecht. Outsiders, like governmental services also had only partial concepts and commitments, relating to their own tasks. But this situation is now changing. During the eighties, planners designated some agricultural, industrial, recreational, residential and other functions to all areas. Thus, the planning process raised the awareness of potential conflicts in this area and stimulated the activity of regional interest groups. Particularly, the four P's - Production, Place for residents, Pleasure for recreationists and Preservation for those who make a stand for historic monuments, scenic beauty and nature - proved to be interdependent (Bryant and Johnston, 1990). The cooperation in the commission, however, has created an awareness of common problems as well as of a common task and destiny (Glasbergen and Driessen, 1993, 94). This may produce the first contours of a conceptual shape.

A regional-geographic interpretation of the Gelderse Vallei

From a regional-geographic perspective, the Vallei is part of the urban field of the Randstad (Hoekveld, 1990). In the middle of the twentieth century, the suburbanized zone of the Gooi area and the Utrechtse Heuvelrug on the western side expanded enormously. Planners succeeded in halting the expansion of the settlements in these amenity-rich zones. Then, population growth started to affect more easterly areas. Now even Amersfoort and Ede provoke suburbanization in their surrounding municipalities.

According to Lamb (1975), the urban field is patterned in two types of zones. The first is amenity-rich. This zone has amenities, normally in the residential and recreational sphere, that attract specific residents (mostly rich and well-educated) and the services that cater for these residents. The second is amenity-poor. This zone is not being transformed as quickly. Indeed, it preserves a lot of traditional activities and functions that need cheap space and little regulation. According to the model outlined by Lamb, these two zones should alternate radiating out from the central city.

But the reality of the Vallei is different. Instead, it has a parallel patterning, perpendicular to the radials extending from the Randstad. The first amenity-rich zone is the Utrecht Hills. Then there is an amenity-poor zone in the centre of the Vallei. Finally, the Veluwe is another amenity-rich zone. This model should be completed by adding two corridor zones: the A1 and A12 highways (Figure 3).

Generally speaking, the model, fits. The processes that occur in the subregions are consonant with expected processes (e.g. the stagnation of population growth in the amenity-rich zones due to lack of space, and a declining contribution by the Randstad to in-migration). Nonetheless, there are some anomalies. The central part of the Vallei, the amenity-poor part, has been designated as an 'ecological core zone' in the Plan van Aanpak (Section 3). In that zone, covering about 4000 ha., agriculture is subordinated to nature and sometimes even to recreation. Scenic beauty is emphasized too. This set of planning priorities is a result of a re-evaluation of that amenity-poor zone from the perspective of the urbanized population (not from that of the agriculturalists). It also reflects a new balance of forces, which has produced the compromises in the Plan van Aanpak. Not only are the wooded areas now considered amenities. The agricultural landscapes, with their winding narrow roads, old trees and farmhouses, and the diversity of views, are also considered amenities. Like the natural or ecological components of the landscapes, these amenities, too, are deemed worthy of conservation. This re-definition of amenities is understandable in the light of pressure on space and overcrowding in the Western part of The Netherlands. Although these new priorities require a new operationalization of the model, that re-definition does not change the model fundamentally. The prime causes are consequences of situatedness and urban metabolic processes.

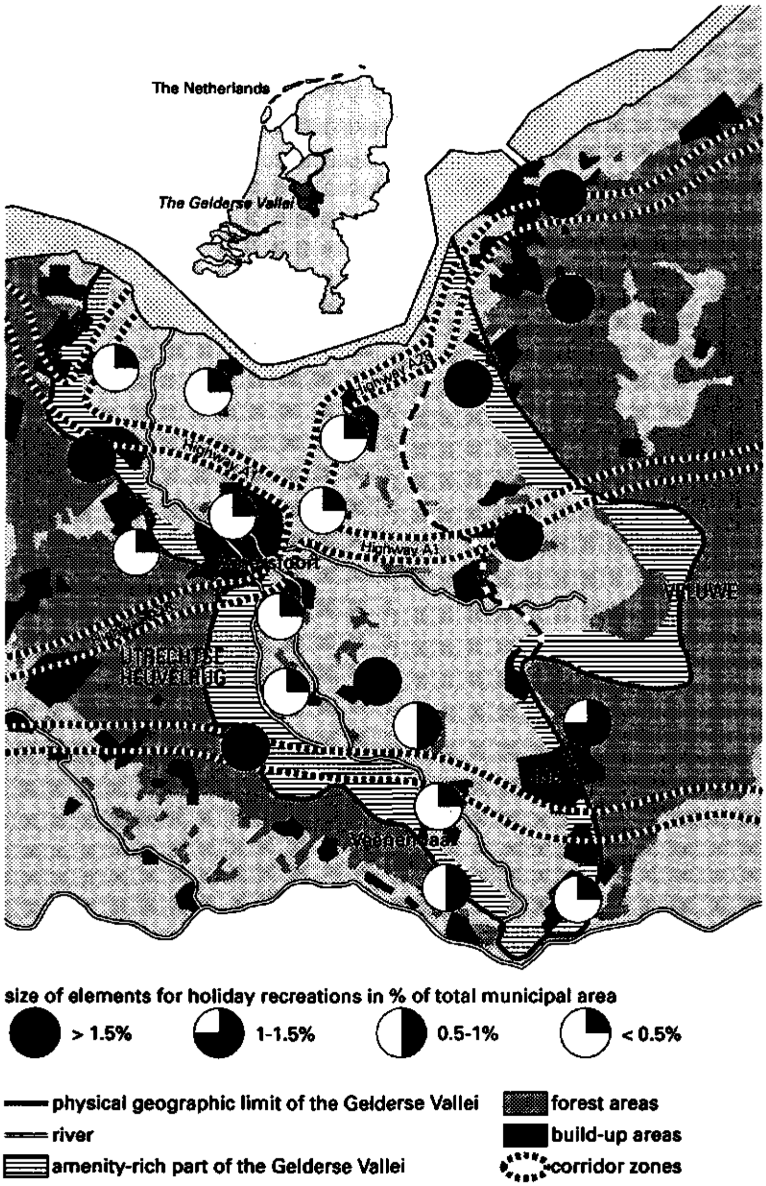

Fig. 3. The Gelderse Vallei interpreted as part of the urban field of the Randstad

The image of the Gelderse Vallei that should emanate from the regional-geographic model is that of a dispersedly urbanized region. Yet the prevailing images of the Vallei are still imbued with its agricultural importance. The image (not reality) is concerned with the endeavour to reconcile agriculture with nature, scenic landscapes and recreation. Thus, in the Gelderse Vallei, the 'four P's' have been focused on the P of agricultural production, which provides less than five per cent of all jobs. In fact, the processes of regional development, including the planning and regional policy, tend to operate according to the regional-geographic model. Development follows that model more than one would expect, especially when the agricultural image leads one to believe that agriculture is the motor of the development.

Conclusion

The model of Figure 1 is composed of some concepts formulated by Marsden *et al.*. It gives a fairly accurate description of the processes that have culminated in the creation and functioning of the Valleicommissie. Its activities create a foundation for the renovation of the Vallei. In that reconstruction, images and spatial concepts have different degrees of abstraction regarding the positions of the actors. Compared to local or regional actors outsiders will tend to hold more abstract images and to frame these images in broader societal and spatial contexts. Abstract images prevail in scenarios that are too generalized to take unique local/regional circumstances into account. Top-down processes are at the centre of these scenarios. Regional (rural) development is believed to result from the assumed responses of regional actors to those top-down processes. The spatial context, with its horizontal causation, is very important too.

The spatial context is crucial not only to the way agriculture is conducted (Bryant and Johnston, 1992) but to the total interplay of factors and actors. As long as the regional shapes neither exist nor coincide with a good institutional shape, a region cannot develop the power to protect itself or wage the battle from the bottom against the top-down processes. However, when the functional, conceptual and institutional shapes coincide spatially, a region has a chance to defy the processes that are expected by the scenario-makers.

Images will be weaker and even misleading when they are based on only one shape, on parts of a shape (which might well be the case with functional shapes), or on shapes that do not coincide spatially or are rapidly changing. This last dimension is difficult to include in the scenario builders' assessment - as it too is based on images of regions. The trajectories of the shapes of regions can change rather suddenly, leading to unexpected results. Images of a region are indispensable and inevitable, but they are makeshift constructs and are therefore inherently unstable.

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18.1.2 Gelderse Vallei, Marketing of a region

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Abstract
To sell tourist destinations, the image of the region is of extreme importance.
Does the Gelderse Vallei have a tangible image as a tourist destination? To answer this question, the main characteristics of the tourist development process are elaborated (including some comments on modern tourist behaviour) and then the way producers put the valley into the tourism market is verified.
Keywords: *Marketing, Image, Region, Tourism, Gelderse Vallei*

Introduction

Considering the marketing of a region one has to deal with two central concepts: marketing and region. What does the term marketing mean? According to Kotler (1980) 'Marketing is a human activity directed at satisfying needs and wants through exchange processes'. The exchange process presupposes the existence of products and it can be easily assumed that places, regions or more generally destinations are typical tourism products.
However, the tourism product is not in every respect a 'normal' product. Ashworth and Voogd (1990) have made this extremely clear by posing the question 'Can places be sold for tourism?' They put forward a number of fundamental differences between a place as a tourism destination and a marketable good or service purchased by consumers. Places and regions both contain marketable facilities (such as hotels or museums) and are tourism products themselves. Ashworth and Voogd further emphasize the problem of the spatial scale. A place is just one component in a hierarchy of spatial scales (see also the comments made by Hoekveld in this publication). By purchasing a specific accommodation in Barneveld undoubtedly the Gelderse Vallei or even the Veluwe is included in the perception of the consumer. This raises the question of the existence of a tangible image of the Gelderse Vallei as a tourist destination. Finally, Ashworth and Voogd point to the fact that places are multi-sold. The same physical space including the various elements is sold simultaneously to the industry as promising office locations, to civilians as exciting places to build or rent a house, to event organisers to locate an international congress and to tour operators as a worthwhile destination.

It is obvious that the marketing of a region to potential visitors has to deal with a number of particular aspects compared with 'normal' industrial or commercial products. To sell a tourism region the complexity of the tourism region has to be linked up with the tourist's holiday choice process. Goodall (1990: 261):

"Marketing of the tourism place product needs to be tailored to where the potential tourist is in this choice process: it must seek to change the tourist's attitudes, opinions, perceptions, image, desires, expectations, knowledge, awareness and inclination to buy in favour of that place product."

J. F. Th. Schoute et al. (eds.), Scenario Studies for the Rural Environment, 691–698.

The making of a tourism product

Tourist recreation product development is a highly complicated process. In order to emphasize the dynamic character of the tourist recreation product development and to have an overarching concept that integrates both supply and demand, the so-called transformation model was developed (Dietvorst, 1994). This model shows the continuing transformation of the original tourist recreation resource (whether a landscape, a monument, an urban public space, a national park or other elements) by activities and interventions by producers and consumers of many types, wittingly or not for a variety of objectives. It embraces material practices as well as the role of image production and interpretation.

The principle behind the proposed transformation model is the assumption that people through a variety of symbolic and material interventions determine the transformation of the original physical and socio-economic space valuable for tourism and recreation. The main types of such transformations will now be described.

Material transformation by producers

Producers transform the original resource (such as the landscape, the city) by direct actions: building facilities, transforming coastal landscapes into resorts, transforming historic buildings into restaurants or museums, all kinds of planning activities, by constructing cycle paths etc. Frequently a kind of non-intervention is possible when public authorities restrict or forbid certain activities. All kinds of public authorities, entrepreneurs, private organisations and local communities are involved in this 'production' process. The different functions in a region compete to have their share of the scarce space available. Owing to the current changes in farming practice in the EU, the European landscape is undergoing a process of transformation. In regions with marginalising agriculture, nature development and tourism compete to use the abandoned agricultural areas. In densely populated regions the urban usage of space has increased significantly and although the population growth rate is diminishing, high prosperity life-styles need more and more space for living, working and leisure. In some regions resistance against the (spatial) extension of the tourist industry is already perceptible and especially nature conservationists are worried about the affection of nature and landscape by campings, hotels and chalet parks.

Symbolic transformation by producers

It is widely acknowledged in the field of marketing (Goossens, 1993) that the acquisition of product information is influenced by a personal interpretation of the design or package. Because the tourist product often has a specific spatial character, people's view of the environment and the resultant mental image is subject to manipulation by producers. The producers transform the physical structure of a region more or less indirectly through coding. A certain coding is added to the already transformed material resource. In many cases this is the real added value of the tourist recreation product (TRP) i.e. the illusion: Resources are converted into products through interpretation. The TRP (tourist recreation product) is packaged, designed and assembled: a <u>romantic</u> holiday in Paris is offered by a tour operator, <u>peacefulness</u> and a <u>fascinating</u> landscape could be enjoyed in the southern part of France (according to the local tourist board) and so on. The movement from any station in Europe to Paris Gare du Nord as such is not a tourist product, but the consciously promoted 'romantic weekend in Paris' is. Cycling in the countryside is not the tourist product but rather the feeling of having a day off.

Lengkeek (1994) has argued that attractions are increasingly being created in this way today: "You should have been there....didn't you visit the Bonnie and Clyde Shootout Area?". These attractions get a 'signifying' function in modern society because they are designated as beautiful, worth-while and entertaining. It is through coding that the producer can manipulate the consumer market.

A specific category of producers is the group of intermediaries (tour operators, travel agencies) because they do not transform the original tourist recreation resource directly but by offering package tours and other kind of services they could be very influential in transforming the authentic character of destination areas.

Symbolic transformation by consumers

Consumers or visitors transform the physical structure of the region or the area visited by them through their distinctive interpretation of the offered product. According to Boorstin (1964) tourists do not even directly experience 'reality' but thrive on 'pseudo-events'. Especially the mass tourist travels in guided groups and finds pleasure in attractions that are unauthentic and contrived, gullibly enjoying the 'pseudo-events'. However, according to MacCannell (1989) all tourists embody a quest for authenticity, which may only be 'staged' (the constructed tourist attractions as for instance the 'authentic' folklore event). The motives, needs, preferences etc. of tourists are so to say 'matched' by them with advertisements in newspapers, the recommendations by friends and other relatives, and with former experiences influencing their decision of whether or not to go for a day out or a holiday or a visit to a museum. This transformation or assemblage is indirect because the supplier reacts to the trends in the market i.e. the behaviour of the visitors. Lifestyle changes are important explanatory variables here.

Different lifestyle and/or recreation styles also compete for the use of the same space at the same time leading to conflicts between local inhabitants and visitors for many facilities.

Material transformation by consumers

The decision to take a walk in the neighbourhood or a holiday to Greece results in a contribution to the transformation of the physical and social structures of the areas visited. Space consumption, crowding, wear of infrastructure, deterioration of historic monuments, erosion in vulnerable landscapes, disturbance of birds and other animals, traffic congestion and all kinds of environmental impacts, belong to the direct transformation of the original tourist recreation resource.

Recent changes in consumer behaviour

Among the various transformations in the cultural, political, economic and organisational structure of contemporary society, two can be interpreted as extremely influential to modern tourist behaviour and experience.

First, the strong emphasis on the visual element in our culture. The present western society is dominated by pictures: the image takes precedence over narrative. Adventure and challenge is no longer looked for in stories or printed material but increasingly in visualised fiction and personally sensed authentic experiences. Pictures, movies, television and CD-i replace verbal contacts or written sources. Sensory and more especially visual experiences are important today: visiting restaurants, theatres, pop concerts and museums are popular activities. Recent technological developments have transformed our culture into a much more visual one. On the basis of research into trends in leisure activities, Knulst (1993) observes the development of a culture greatly oriented towards sensory experience.There is a shift from the 'Gutenberg generation' to the 'MTV generation'. The Gutenberg generation was educated with the printed word and with logical, sequential thinking, the MTV generation likes soap stories with crossing and fragmented stories: no linear logic, no consistency, no separation between private and public, between commerce and arts, between illusion and reality. The transformation of a genuine resource into a tourist recreation product is no longer just a matter of material transformation, but increasingly also a symbolic transformation in which the image takes precedence over the material product (the accommodation, the region as such) and the illusion is made up of a collection of visual and aural images. Zukin's (1991: 38) analysis of the postmodern urban landscape summarizes this transformation as follows: 'Spaces of production recede into the historic vernacular; more than ever, the urban landscape relies on image consumption'.

Much of tourist behaviour too seems to be characterised by a search for the photogenic. The aesthetic is dominant and what is being recorded are 'purified landscapes', stripped of disturbing infrastructure, parking places, energy plants, polluted canals and waste. The aesthetic judgement has gained in significance. Urry (1990, 1992) comments on this fundamental feature of the tourist experience:

* The influence of professionals and experts on how the environment has to be gazed upon is considerable. Evidence can be found in the great amount and variety of tourist guides, travelogues, specialised journals, TV programmes and video-tapes.
* Our gazing is culturally determinated. Health, for instance, is an important main-spring for the search to challenging landscapes to practise all kinds of sport.

Second, the shift towards what can be termed as 'instantaneous time'. Nowadays we can verify a literal time-space compression in such form that some speak about 'a three-minute culture'. Instantaneous time takes different forms: time-sharing, flexible working times, part-time labour, short term labour contracts, instant food, drive-in facilities, short-break holidays, last-minute bookings and so on. Producers are forced to respond quickly to market shifts and short-term action seems to be more important than long term planning. The volatility is apparent in the increasing significance of design, taste, fashion and image to manipulate the consumer market. Especially the tourist industry specialises in the acceleration of turnover time through the production and marketing of images.

Furthermore, the dominant influence of instantaneous time is attended by a lack of confidence in the future. There is much uncertainty and the period of long-term decision has faded away. The reaction is a remarkable interest in the past: "Nostalgia is everywhere...This nostalgia for an idealised past, for a sanitised version of not of history but heritage" (Clark *et al.*, 1994: 42). Many people of mature age are looking for contemplation and 'lieux de mémoires'. They opt for a cultural return from their travel and use the educational opportunities of cultural tours to experience a mental pilgrimage to the past (for example the route to Santiago de Compostela).

The coding of the Gelderse Vallei

The Gelderse Vallei is located in the central part of The Netherlands. The Vallei (valley) actually derives its name from the Ice Age when the surrounding land was pushed upwards into the present hilly ridges of the Utrechtse Heuvelrug and the Veluwe. The area is dominated by intensive animal husbandry and is considered as a problem area as a result of existing environmental problems.

How do destination tourism agencies communicate the existence of the Gelderse Vallei to potential holiday-makers in tourist-origin areas? (See Goodall, 1990: 272).
Research into the image of destination areas is scarce in The Netherlands. Markant/Scanmar analysed the image of the Dutch provinces through a survey among the Dutch population (Markant/Scanmar, 1987). In 1991 NRIT did another image analysis (NRIT, 1992). The problem with this research is that in many cases the province as an administrative unity does not determine the images, but some remarkable region within a province does. A good example is the predominance of the natural area De Veluwe in the image of the province of Gelderland. The location of the Gelderse Vallei as the western border region of De Veluwe could therefore be responsible for the almost complete neglect of the Gelderse Vallei in for instance the Michelin Guide in The Netherlands. Fortunately the National Tourist Board and the local Tourist Information Offices present material useful for preliminary explorative research on the symbolic transformation of the Gelderse Vallei into a tourist product.

We used a mix of brochures and guides which in some way pay attention to this specific region (Jansen, 1994). The material cannot be characterised as abundant and a first impression of the status of this region (its position in the Dutch Tourism Market) is that it holds no prominent position.

The promotion brochures of the National Tourist Board, which are designed for the tourism market in Western Europe can be obtained in three languages, German, English and French. Lay-out and composition of the brochures are more or less similar, but the German brochures look different by offering five specific issues: (in translation) 'Holland, a paradise for cyclists'; 'Holland, fresh air at the sea'; 'Holland, a country of wind and water'; 'Holland, a land with culture'; 'Holland, for the family'. The English and French brochures, however, contain more or less the same text on the Gelderse Vallei. In the German brochure the valley is presented as 'the Valley of impressions' (Das Tal der Eindrücke).

Given the space available in these brochures it is not surprising to verify that detailed information on specific characteristics of the Vallei cannot be given. It can be questioned whether the rough explanation of the slogan 'The Valley of impressions' is typical for the Vallei-landscape in general. The route description scarcely provides the tourist with information on the Vallei. The pictures in the brochure are definitely not specific to the Vallei. It looks as if the author is happy to leave the Vallei by entering the Veluwe region.

The little map in the brochure is misleading for the potential tourist. It suggests a route quite different than the route described in the text (see Figure 1).

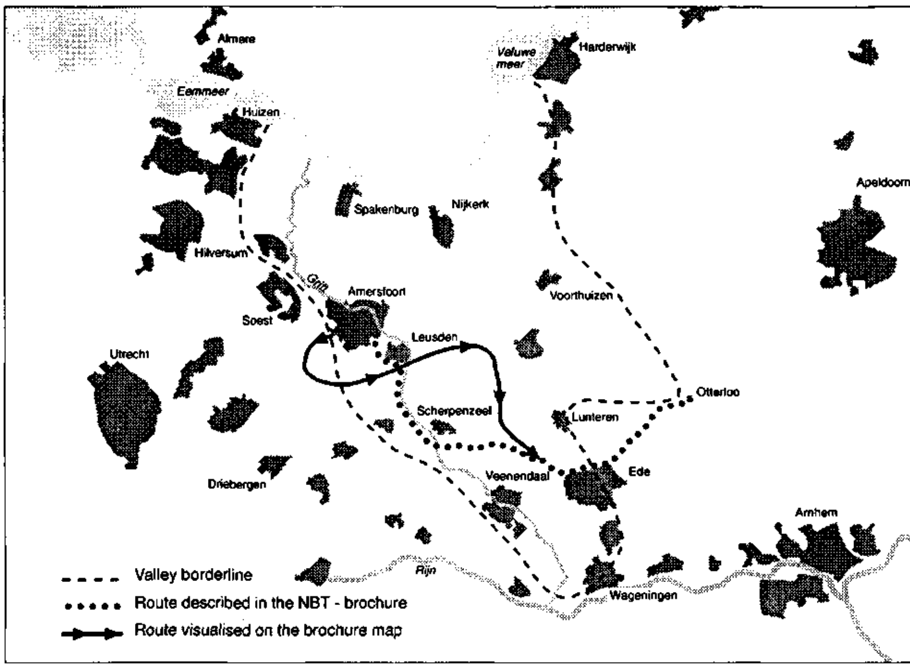

Fig. 1. Different routes in the Gelderse Vallei

Recently the Royal Dutch Touring Club (ANWB) launched a new series of travel guides for The Netherlands (in Dutch). One of the first published volumes deals with the Veluwe and the Gelderse Vallei. This gives a concise but fairly thorough overview on landscape, cultural heritage and attractions in this part of The Netherlands. Despite the title of this guide 'Veluwe met Gelderse Vallei', the Gelderse Vallei itself is described in only 6 pages (out of 124 pages text). This minor position is honestly acknowledged by the author in the beginning sentence of the chapter: "The landscapes to the west of the Veluwe are not known as top tourist attractions. Partly this is correct; the wind-swept coastal plain of the former Zuiderzee and the bio-industry of the Gelderse Vallei don't offer much, although beautiful old farms can be found in unexpected places. But the landscape too offers pretty exceptions". The variety caused by numerous wooded banks and remnants of the heath lands and especially the region between Nijkerk and Voorthuizen is much more attractive than most visitors suspect and the same holds for the countryside west of Barneveld. Both the surroundings of Barneveld and Nijkerk receive remarkable attention from the author, but about the remaining parts of the Gelderse Vallei not a single word is said.

Finally, we have to consider the brochures and leaflets of the regional local Tourist Boards. The 1993 tourist guide of the Province of Utrecht presents the Gelderse Vallei as a differentiated landscape with variety of forests and estates. The historical defensive function of using the opportunity to flood the lower parts of the Vallei (the so-called

Grebbelinie) is also mentioned. This old defense system dates back to the seventeenth century, and it should have functioned as such in the first days of the German invasion in World War II. However, the potential of the remnants of this historic monument to become an attraction for tourists interested in cultural history and/or landscape development are not acknowledged. The remaining text in this brochure pays attention to Leusden, Woudenberg, Renswoude and Veenendaal and their surroundings. The characteristics of the Gelderse Vallei as such are not emphasized.

The brochure of the Tourist Information Office of the municipality of Veenendaal hardly mentions the Gelderse Vallei as such but accentuates its location between the hilly forest areas of the Utrechtse Heuvelrug and the Veluwe: "From Veenendaal the most beautiful spots of The Netherlands are within reach such as de Veluwe, the River Area and the Utrechtse Heuvelrug". The landscape of the Gelderse Vallei seems to be of no tourist value.

The same applies to the little brochures of the Tourist Information Office of Barneveld, a municipality located in the middle of the Gelderse Vallei. Attractions as museums are promoted and only indirectly is the Gelderse Vallei presented (in the Poultry Farming Museum). The Nairac Museum of local history is called a 'Veluwe Museum'.

Finally a pleasant exception was discovered in the very modest information material (some type-written pages) of the Tourist Information Office of Scherpenzeel. It pays explicit attention to the development of the landscape in the valley. It is emphasized that the Gelderse Vallei has a very varied landscape. This differentiation is promoted as the most unique characteristic. Further the attraction value of the old defense system (the Grebbelinie) is fully used by creating a cycle route of 40 km along a part of the historical defense works.

Conclusion

In a way it is not surprising to observe verification of the minor position of the Gelderse Vallei on the tourism market and as a consequence note the scantiness of the promotional activities. The region belongs to the most polluted agricultural regions of The Netherlands and due to the agricultural developments of the past decades the aesthetic qualities have deteriorated in many parts of the Gelderse Vallei. Considering the place or regional marketing of the different Tourist Boards (national, regional and local) the Gelderse Vallei is often neglected. On the national level the Gelderse Vallei as such is attractively promoted, but the description of the suggested cycle-route is also used to promote the qualities of the Veluwe region. On the regional level neither the intrinsic cultural historic nor landscape qualities are converted into tourist attractions. With one exception this holds also for the promotional activities on the local level.

Taken into account the wide variety in motives and preferences among modern consumers, tourism product marketing has to deal with different target groups. An obvious but actually not addressed group is the international scientific community of the Wageningen Agricultural University and the several DLO-research institutes. For this group the Gelderse Vallei can be promoted as an outstanding example of Dutch experience with rural and environmental planning policies. That promotion campaigns aimed to attract specific target groups can be very successful is demonstrated in the promotion of the constructed natural landscape 'De Blauwe Kamer', the river flooded area bordered by the Grebbeberg and the most south-western corner of the Gelderse Vallei.

The creation of new high value aesthetic landscape qualities can be fostered by taking into account the tourist experiences. As yet, however, the tourist interest for an aesthetically interesting landscape is almost totally neglected in the present policy plans. Planning's concern with sustaining landscape quality and improving the quality of the visual environment in general, has frequently disregarded the way ordinary people make use of and experience landscapes in leisure time. It can be doubted if the modern planning principles are appropriate to guarantee the development of a 'tourist landscape' i.e. a landscape which has the potency to integrate the three relevant aspects, the user value, the experience value and the attraction value. The user space of the casco concept is designated for agriculture, the framework for nature development. Visser (1994) called this 'a landscape of distance'. The planner opts for the detachment of the computer-aided design. I am afraid the interests of the tourist are of minor relevance on his screen.

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18.2 Regional landscape plan for the Alentejo coastal area

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Abstract

The Alentejo coastline is 130 km long, 90 km of which are beaches. This stretch of the Portuguese coast stands out as being the one which has suffered the least changes over time. It has a wealth of natural and man-made assets, some of which are rare even at European level. Together with a low human density factor, this creates a high ecological and aesthetic value and strong tourist potential for the area.

After the massive occupation of the country's south coast and the areas around the main urban centres, during the last decade the tourism developers were directing their attention towards the Alentejo coast.

In 1989, the Government decided to have a Regional Plan drawn up to get an overall vision of the area. Criteria and standards were set to organise and optimise land use and to assess the different possibilities. Also, in a view of protecting natural and cultural assets, two protected areas were created.

Keywords: *Regional development, tourism pressure, population carrying capacity, Alentejo Coast*

Introduction

Bearing in mind the role oceans have played for more than 500 years in world trade, communication between cultures and exchanges between peoples, the importance of coastal zones in sheltering and supporting communities and their multiple activities (human, plant and animal communities) is immediately evident.

The needs of such communities and the conditions offered by coastal interfaces have changed substantially over the centuries, and in the last two decades this has led decision-makers and researchers to concern themselves with management of coastal areas. This concern has taken concrete form in various international conferences, documents and plans, from the "Action Plan for the Mediterranean" in 1975 (the so-called "Plan Bleu") and the European Coastal Charter in 1981, to the Conferences of Peripheral Maritime Regions and laws on "Coastal Planning", "Heritage Coasts" and "Schémas de Mise en Valeur de la Mer" (Outlines for Developing the Sea).

These activities have resulted in an awareness that the European coast is part of an international system affected by the reciprocal effects of global currents and tides and that the seas of Europe constitute a common heritage that all countries and generations should be able to enjoy.

While recognising that uncontrolled development destroys the basis of a viable coastal economy, it is also true that tourism is often a vital element of local and national economies. It is fundamental that forms of urban and tourist occupation respect principles

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of conservation and even recovery of the natural coast, ensuring environmental quality in general and water quality in particular.

Today the great challenge in planning and management of coastal areas consists in making the following compatible:

- Urban, port, recreational, fishing and agricultural uses, which put pressure above all on a strip 2 km wide;
- Application of nature conservancy policies, namely the "Ramsar and Berne Conventions", the "Corine-Biotopes Programme", Protected Areas and Areas of Scenic and Heritage Value;
- The strategy of locating urban concentrations and major development projects outside coastal areas, coordinated with a policy of redeveloping existing urban and port areas to accommodate forms of integrated tourism and redeveloping commercial docks to create marinas;
- Making sure that mineral extraction operations, power stations and activities in high risk areas comply with the applicable legislation and are preceded by environmental impact studies.

These days most European countries' strategy for use of their coastline is of a relatively restrictive nature: reduction of access in general, limited access to sites/areas of environmental value, limits on new construction in a strip of varying width and even a prohibition on the sale of property to foreigners within this strip. At the same time it has been felt that, in Portugal's case, advance planning with an outlook to sustainable development is still possible for some coastal areas.

However, because of the slowness of planning and the complexity of the extensive coordination and consensus that has been achieved, these plans are no longer entirely in advance of events, nor wholly drawn up from the perspective of balanced and coherent planning. Rather, they are plans which in part incorporate previous commitments and decisions.

The situation in Portugal manifests a number of relatively striking contradictions. On the one hand, technical knowledge, research and the planning outlook in relation to occupation of coastal areas fit in perfectly with the European strategies and policies which have been being put forward. But on the other hand, actual occupation along the 943 km of the Portuguese coastline has rendered asymmetries of demography and development more acute and has given rise to the environmental degradation of extensive coastal areas.

The Alentejo Coast in Portugal

The area which is the subject of this report - the Alentejo Coast - is part of the Alentejo region, situated south of Lisbon, between the Setúbal peninsula and the Algarve. This sub-region takes in five municipalities with a total population of approximately 100 000. It covers an area of 5160 km^2 and extends along a 130 km coastline, of which 90 km are beaches.

This sub-region constitutes an exceptional heritage. Among the coastal areas of highest environmental quality in Portugal and even in Europe, it is also one of the best preserved.

Moreover, this heritage belongs not only to the resident population but to a wider universe: to the Alentejo as a whole, to Portugal and to Europe. The most important natural heritage is made up of two estuaries, coastal lagoons, preserved dunes, and fauna and flora of great interest.

Prominent aspects of the Alentejo Coast are furthermore the industrial port complex of Sines (which dates from the 70s) and growing pressure for tourist development. But inland, in the areas of the Serra de Grândola and Cercal, a worrying process of human and environmental desertification is evident. The spoiling and even destruction of extensive areas previously devoted to "montado", a balanced system of agriculture and forestry, and the introduction in their place of extremely extensive cropping systems (cereal crops grown in rotation with fallow periods of 3 to 5 years) which have now in turn been abandoned and replaced by vast swathes of eucalyptus monoculture, has served to make life even more difficult for a resident population which was never very numerous.

The regional land use plan

In 1989 the Council of Ministers decided to draw up a Regional Land Use Plan (Portuguese acronym = PROTALI). It felt it was important to have an overall vision for the Alentejo Coast and at the same time to promote an operational programme to identify and finance projects inspired by the proposals envisaged in the land use study. The following terms of reference were established for the study:

- To make socioeconomic development compatible with the need to safeguard environmental and cultural values;
- To promote integrated development of the whole area so as to ensure balanced interaction between the coastal strip and the rural interior, establishing priority domains and strategies for intervention;
- To ensure the compatibility of the sectorial policies of the various entities with the capability to intervene in the region;
- To define base sectors and investments so as to create a technical back-up for dialogue with economic agents.

In this perspective, it would be necessary to take the following factors into account:

- Investment in tourism, development of agricultural and forestry systems and ensuring profitability of irrigated areas.
- Access and the overall transport system, giving priority to transverse connections within the area of the PROTALI and also within the interior of the Alentejo region;
- The Sines complex from the point of view of regional development;
- Equilibrium of the urban network;
- The PROTALI area's recreational designation in a multimodal perspective ensuring the resident population to enjoy the benefits;
- Balanced management of natural resources and limitations on the use of them, especially as regards water and marine resources;
- Protection of natural ecosystems and the most vulnerable areas;
- Population carrying capacity of the land studied.

A tender for the contract to draw up this study was held and won by a consortium of companies. The University of Évora was engaged to work on a major part of the analysis, diagnosis and proposals most directly related to the environmental sub-system and natural resources.

In the first phase of the study special attention was paid to how the various components of the land system fitted in together. A large and highly diversified team (more than thirty people trained in very different areas: architects, engineers, geographers, economists, landscape architects, geologists, agronomists, etc.) together drew up a matrix of the relationships between the various components identified and the system as a whole.

Next, using multivaried analysis methods, the components were organised into a hierarchy according to the manner in which they affect development and land use in the area under examination. This phase was closely supervised by the central administration, it being considered of utmost importance to avoid a situation where decisions on the uses and roles of land were taken from a sectoral point of view. It also allowed the members of the team to gain an awareness of the many and varied questions related to land use and development in the sub-region. In addition, it enabled them to discuss among themselves the more or less specialised research to be carried out with relative independence and the decisive components thereof.

The environmental approach

Special reference should here be made to the analysis and diagnosis of the environmental subsystem, which covers the following resources and aspects of the subject:

- Geology and mineral resources
- Climate
- Relief
- Coastal strip and fluvio-maritime areas
- Hydrogeology and underground water resources
- Hydrography, hydrology and surface water resources
- Soil and "National Agricultural Reserve"
- Uses and roles of land, vegetation and flora
- Fauna and game species
- Marine and aquacultural resources
- Environmental degradation
- "National Ecological Reserve"
- Natural and Landscape Heritage

These aspects were examined in the light of the various relationships between them, so as to obtain an integrated picture of this sub-system.

Research into the last three topics - Environmental degradation, National Ecological Reserve and Natural and Landscape Heritage - made a major contribution to that integrated picture, summarised a large part of the problems and possibilities in relation to natural resources and highlighted the synergies present.

After six months a draft of a land use and development plan was presented. This consisted of proposals for broad guidelines and objectives which were transposed to plans drawn to a scale of 1:100,000. These documents were of basic importance in guiding discussions with the various agents involved in transforming the territory: central administration, local government authorities, representatives of economic activities, representatives of cultural associations, etc.

Following on from prospective diagnoses, land use and development scenarios were drawn up, with a view to solving the problems analysed, making balanced use of the potential of the sub-region and influencing the detected trends, as desired. The plan was supervised by 17 entities (including the five municipal councils concerned) and was the object of public consultation in September 1992.

In this context, the PROTALI proposes that an "Environmental Protection and Valorisation Network" be set up in the context of a process of sustainable development. This network covers not only areas with natural assets of undeniable interest but also situations which interfere with the processes that safeguard the environmental balance. It consists of a continuous network which, assuming a variety of status imposes different levels of restriction on the various forms of land use:

- Areas of national or international interest for nature conservancy: Sado Estuary Nature Reserve, the Southwest Alentejo and Vicentina Coast Protected Landscape Area, the Coast Protection Area between Sines and Santo André.
- Areas of regional or local interest for nature conservancy: sites of interest for conservation identified by the "Biotopes" project of the "Corine" programme and not included in the areas mentioned above.
- Other areas indispensable to nature conservancy, ecological stability and sustainable use of natural resources: areas outside the Nature Reserves scope, the "National Ecological Reserve", forestry or pastoral-woodland systems to be protected and enhanced ("montados" and pine woods).
- Coastal strips, of varying widths, to which principles and rules apply as regards occupation, use and transformation (national and Community rules).
- Also in the domain of environmental protection and valorisation, the PROTALI proposes support for those entities which have the greatest responsibility for controlling and combating pollution of the sea and coastal margin, and also atmospheric pollution.

Agriculture and forests

As far as land use in areas of agriculture and forestry is concerned, the PROTALI proposes:

- A drastic reduction in the areas currently occupied by dry cropping systems, and specifically those on poor, degraded soils.
- Recovery and correct use of current irrigated areas, along with the development of new forms of use which will complement other agricultural, forestry or tertiary sector activities. Special support for horticulture in the coastal area, subject to the conditions imposed by the presence of important natural assets and landscapes.
- Protection and recovery of existing "montados", together with expansion of such areas in relation to a balanced forestry use in areas with troublesome conditions of soil and relief. This within an overall perspective of multiple use (i.e. productive activities, at the same time as protection and valorisation of resources).

- Ordered expansion of forestry systems, and specifically of wild and cultivated pine, mixed pine and cork oak woods. Mainly in places where edaphic conditions are very poor and sensitive and where such plantations are economically profitable. This offers at the same time a significant contribution to environmental protection and valorisation.
- In some places, conversion of the broad swathes of eucalyptus currently present in sensitive and degraded areas, according to the rules and constraints contained in legislation. In particular cases, ordered expansion of these plantations, also in line with such legislation.
- Encouragement of uses and activities to complement the forestry and pastoral systems dominant in the area covered by the PROTALI, as a means of countering human desertification.
- Protection and valorisation of the areas included in the "National Agricultural Reserve", with the objective of preserving one of the region's permanent assets.

Manufacturing

In relation to manufacturing, the PROTALI essentially voices two concerns and sets two objectives:
- Revitalisation of the Sines complex within the framework of its position on the international and regional scene. With emphasis on making sure that projects related to developing port and road infrastructures are compatible with safeguarding environment and natural resources.
- Stimulating, diversifying and tailoring the remaining industrial fabric of the Alentejo Coast, by improving the supply of infrastructures for industrial plants. To this end the PROTALI sets out means of creating a network of "Light Industry Areas", distributed in a balanced fashion over the territory of the sub-region.

Tourism

There is an accelerating trend towards a growing urbanisation of the coast and depopulation of the interior of the Alentejo Coast. This is aggravated by an intensification of the pressures exerted by tourism on the environmentally sensitive coastal area, and is linked to the low level of investment in tourism inland. This situation had a powerful influence on the Policy of Land Use for Tourism on the Alentejo Coast.

The various documents of the PROTALI sought to give shape to a strategy aiming at containing tourist development on the coast and encouraging the location of tourist activities inland. They thus sought to safeguard the environment and natural resources, to attenuate the imbalances between the coast and the interior, which are tending to become more pronounced, and also to respond to new trends as regards the products tourists want, trends which are founded on respecting and promoting natural and cultural assets as the chief sources of pleasure.

Safeguarding nature protection areas is thus foremost among the concerns of the PROTALI. Nevertheless, constraints of a social, cultural and urban nature all came into play in defining a model for land use. The preservation of a sociocultural identity is upheld as a decisive factor in achieving successful, enduring activity in the region and in creating adequate living conditions for the resident population. The PROTALI further sought to provide the tourism market along the coastal strip with a broad range of types of accommodation, to diversify supply and thus covering the various segments of tourist consumption. Priority, however, is given to investment which mobilises employment-generating activities over investment which simply increases the housing stock.

In terms of land use, the PROTALI sets very strict conditions on construction along the coast. Buildings are to be concentrated in wedge-shaped nuclei of clearly defined magnitude extending perpendicular to the coast. They must be sufficiently distant from each other to ensure that construction along the coastline is genuinely discontinuous.

Urban network

One of the fundamental objectives of the PROTALI is to reinforce and establish a hierarchy within the sub-regional urban network, with the general aim of providing adequate urban living conditions for the population resident in its territory. More specifically:

- Equipping the Alentejo Coast with an urban centre of appropriate size. Capable of fulfilling functions on a sub-regional scale, so as to meet the area's needs internally and thus avoid its current heavy dependence on urban centres elsewhere, chiefly Lisbon and Setúbal;
- Avoiding excessive urban growth close to the coast;
- Making support services and facilities for tourists and the resident population compatible and profitable;
- Maximising the benefits to the interior of the advantages provided by coastal development.
- Providing balanced territorial development, enabling efficient use to be made of internal potential and avoiding depopulation of vast areas, by creating a network of sub-municipal and secondary centres with the capacity to act as poles for the rural population and to counteract the increasingly visible trend towards concentration. In this respect, population concentration is proposed with a view to strengthening the urban network and creating a hierarchy of four levels, taking into account consolidation of the sub-regional centre, the operational specialisation of towns which are the seat of a municipality and the creation of a network of sub-municipal and secondary centres.

Conclusion

Of these proposals the most controversial part concerns the maximum tourist capacity. This capacity is based a combination of environmental criteria (estimated beach capacity, with some beaches and strategic surrounding areas left unoccupied), sociocultural criteria (to avoid loss of its original character, a ratio of 2 tourists for every 1 resident is being considered desirable) and economic criteria (national and international demand, necessary investment per tourist bed, etc.). Weighing up these factors resulted in an estimate of

100,000 beds, distributed as follows: 55% tourism, 20% camping and 25% real estate (second homes).

For reasons of caution, it was proposed that during an initial period of 10 years, corresponding to the time horizon of the PROTALI, a figure of 50,000 beds should be taken as reference, so as to allow an assessment of the impact on the coastal area (above all in environmental terms) and of demand.

The plan cannot claim to be able to determine the future of this territory, even if it is backed up by the administrative decisions inherent to it. The ways in which the area changes will be very much linked to the participation of numerous agents at a variety of levels and to a substantial change in attitudes and behaviour.

18.3 A new landscape in the Dutch wheat belt: the Oldambt-case

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Abstract

The declining prospects of the agriculture in the Oldambt, a region in the most north-easterly part of The Netherlands, have prompted the question whether the rural economy can be broadened by taking agricultural land out of production in favour of recreational functions (the creation of a large lake), nature and forest areas, and housing. This results in the elaboration of the concept of the Blue City, a large scale functional change in an area of over 2500 hectares.

A development company has been formed. This paper deals about the background, the summary and the effects of the Blue City concept.

Keywords: *regional development, artificial lake, arable farming, set-aside, Oldambt*

Present situation and perspectives

The Oldambt is a region of Groningen, the most north-easterly province of The Netherlands. It is 31,000 hectares (77,000 acres) in size, of which about 90% is used for agriculture. Over the past century agriculture has supported the upkeep of the rural area, both commercially and from a landscape point of view. A change has now come about in that historical role as a consequence of developments in the European agricultural policy (CAP). Agriculture in the Oldambt is very dependent on the European pricing policy, as 95% of the arable crops fall under the market regulation by the European Union. With the acceptance of the MacSharry proposals, a major change in European agricultural policy has begun, with important implications for Oldambt arable farming. Without describing the implications of that policy, it can be concluded that the position of arable farming as the linchpin of the rural area in the Oldambt is no longer invulnerable. It is, moreover, a structural problem resulting in an autonomous development of cattle husbandry substituting the traditional arable farming.

The declining prospects faced by Oldambt agriculture are not the region's only problem. The region has long had high structural unemployment, because it is situated far from the economic centre of Western Europe. Furthermore, as a result of economies of scale facilities are under pressure. The population is declining in number and is ageing. The autonomous changes taking place in agriculture make the question of broadening the rural economy progressively acute. I am referring here to taking agricultural land out of production in favour of recreational functions and of nature and forest, in order to contribute towards solving the area's structural economic problems. Based on this question a plan has been put forward to create a 3,000 hectare lake in the area (Plate 15a) - a radical plan, which aroused uproar.

The idea is based on reversing the relief of the landscape. Looking at a relief map of the area one sees that the ring of villages in the Oldambt was founded on the fringe of land and water. From the year 1500 onwards, people from these villages drained the land

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and created the polders in the area. From that moment on, a process of reversal of the relief of the landscape commenced: as a result of settlement the new polders became higher than the old ones. What was once the highest point in the area, is now the lowest. In fact a basin has been created.

In the framework of the discussion on town and country planning in The Netherlands, the Oldambt has been designated as an experimental area for rural development. This policy framework has been seized upon by local and regional government in order to study further the feasibility of a 3,000 hectare lake. The conclusions of this study can be summarised as follows:

1. Developments in agriculture offer scope for a change in designation, though it is difficult to establish this on the scale of the Oldambt, for present agricultural policy is still oriented towards the retention of the present agricultural acreage by means of set-aside;
2. Creating a lake is technically feasible;
3. Creating a lake is economically feasible, if the government is prepared to subsidise it to the tune of 100 to 150 million guilders.

From this, regional policy-makers have concluded that the feasibility of the scheme must be doubted. In their view the enormous government grant was out of proportion to the expected economic effects. Alternatives were then sought, and ultimately the concept of the so-called Blue City was developed (Plate 15b).

The Blue City

The starting point of the concept is planning which includes only limited government grants. The concept of the Blue City still takes the ring of the seven villages in the Oldambt as point of departure. Large-scale functional change is proposed for the area *within* this ring of villages. The proposed lake is reduced in size from 3,000 to just over 800 hectares. Such a lake would perhaps not be internationally outstanding but by domestic standards it would still be extensive. In addition, a nature development area of over 500 hectares is included. Funding of the latter can be found within the framework of the national nature policy. Woodlands of some hundreds of hectares are proposed also, to be financed by the existing European and national grant schemes. What remains is the crucial question how the creation of the lake can be financed. A solution to this has been found by utilising part of the banks of the lake for house-building and recreational purposes.

This makes the concept of the Blue City feasible and fills the financing gap, except for a few million guilders.

The concept of the Blue City has been elaborated in detail by two urban planning consultancies. The first design is by Hamhuis, Van Nieuwenhuyse and Sijmons Consultancy in Utrecht in collaboration with the Heeling, Bekkering and Krop Consultancy in Groningen (Plate 15c).

The second design is by Hagenbeek and Yap in Amsterdam (Plate 16a). A community discussion, in which many inhabitants of the Oldambt participated, has taken place on these two designs. Ultimately, the municipal councils of the municipalities concerned and the provincial government of Groningen unanimously decided in favour of the Blue City concept along the lines of the Hagenbeek-Yap concept. During the four years of discussion the original resistance has partly disappeared; the reaction of organized agriculture being an indication of the social support for the concept. Organized agriculture has formed a working group which is monitoring the details of the plan in a positive sense. The nature protection organisations fully support the plan. A development company has now been founded and given two years to elaborate the concept in detail (Plate 16b).

The main task for the development company is to seek commercial partners who are prepared to implement the plans. It must be possible to take a decision within two years. Two years was the time set to avoid the plan casting a shadow of uncertainty over the region for a longer period. All in all, the likelihood that this originally agricultural area of 2,500 hectares will undergo a metamorphosis has increased considerably (see the artist's impression, Plate 16c).

Effects

What is the expected impact of implementation of the plans on the area? First, there are favourable employment effects: we estimate net job creation as a result of house building and recreation and the loss of jobs in agriculture at a permanent figure of 300. Although an important development for the Oldambt, it is not the decisive argument in favour of implementing the plans. Terminating the negative development spiral in the area we consider to be of more importance. The centre of the Oldambt, Winschoten, has lost some 2000 inhabitants over the last 10 years. Similar drops in population have occurred in other villages in the region. Implementation of the Blue City could signify a change for the better; being a historical act of intervention. The image of the area would change radically and improving its image could also indirectly lead to positive, albeit hard to assess, employment effects.

Regionalized agricultural policy

Our experience with planning over the last four years has taught us above all that a rural development policy on a European and national scale does not exist. The present European agricultural policy is focused mainly on the status quo and offers no new structural prospects for regional development, neither for agriculture nor for the countryside in general.

I therefore like to support experiments with a form of regionalized agricultural policy. Individual set-aside does not fit, or fits only partly, into a policy of this kind. Rather, farmers decide on a form of regional set-aside in which set-aside land is given a permanent different use. If, for example, two thirds of the agricultural area in the Oldambt is placed under the scheme, then in the case of obligatory 20 % set-aside, over 3,000 hectares of agricultural land can be taken out of production for good. Only in this way can effective functional change in favour of recreation and nature be brought about. It then cuts both ways. First, as a result of this acreage of agricultural land being taken out of production, the set-aside obligation for the remaining arable farms then lapses. Secondly, because supportive subsidies are received, scope is created for a further development of the remaining farms, for instance by innovation. In fact a win-win situation is created, for both agriculture and the region as a whole. With the help of policies of this kind, plans for functional change could be implemented more easily than is the case at present in the context of the Blue City concept.

The Blue City plan, however, can also be realized without radical changes in the European agricultural policy. The region Oldambt will wait no longer, but is seizing its chance.

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18.4 Scenarios for development of the decayed mountain rural and health resort area in South-West Poland

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Abstract
The paper describes a case study and is an example of a "step by step" methodological approach to the problem of restructuring a degraded, mountainous and agricultural environment.
The scenario approach has been recognized as best suited to solve region-development problems and was adapted to find solutions to the complicated economic and social problems of the Kłodzko Valley. The Social Pedagogics method has been used to stimulate essential processes of self-organization and self-development of the local communities.
Keywords: *Poland, Kłodzko Valley, Scenario approach, ecotourism, agrotourism, rural revitalization, local communities*

Problem statement

Its climate together with high touristic and health protecting values, have made the region of Kłodzko Valley famous. The valley is surrounded by picturesque mountains, the gentle slopes of which are covered with forests and immense pastures and in the lower area arable lands.

Some statistical data: area 1580 km^2, arable land 48%, forest 41%. Population 150,000 approx., village population 36%, population density 95 persons per km^2. Health resort accommodation 8,290 hotel beds. Recreational objects 14,826; Landscape parks 6; Nature reserves 10. Natural resources: marble, dolomite, lime, semi-precious stones, mineral water.

The economic position of the Kłodzko Valley detoriated badly just ten years before the end of the so-called socialistic rule. Even worse was the state of local agriculture and small industry. Most of the farms and factories high in the mountains were unprofitable and in the last twenty years many of the villages and small towns have been gradually abandoned. After the fall of the communist regime in 1989, the overall transformation of the socio-economic system began. The subregion, which was previously handicapped by a lack of proper management and financial policy, then became doubly handicapped because of its old-fashioned and unprofitable agriculture and industry, very old and dilapidated infrastructure and buildings, and also as a result of various environmental threats. All the conditions above and immense unemployment problems, were a major reason for emerging regional and local plans of economic restoration. Different scenarios for development were drawn up.

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Scenarios

Scenario I	- Improvement and modification of the present state.
Scenario II	- Tourist and health services for wealthy foreigners.
Scenario III	- Use of the subregion's own values and resources to change its economic structure.
Scenario IV	- Revitalization with initiatives and help of the local community.

The last scenario stresses the need to organize local communities as a method of achieving important economic, social and educational aims through collective actions with more regard to the quality of the revitalization's effects.

Origins

Kłodzko Valley is a part of a heavy industrialized Wałbrzych Voivodeship (administrative district, ed.) and it has been included into a restructuring programme based on general restructuring methodology. (Expertise 1990). The Kłodzko Valley's specific position and problems called for distinct solutions. On one side, there existed strong expectations with regard to governmental assistance; on the other, there were local actions aimed to arrive at scenarios (Klasik,1987) which would show the possibilities and means to utilize the local resources and wealth.

Ideas and aims

During the years 1990-1993 such scenarios have been worked out. They were based on an inventory of the area, special diagnoses and publications (Prognosis Report, 1989; Richter, 1992). Those scenarios expressed in substance the following:
a) articulation of the reconstruction ideas;
b) notification of a fact that departure from a policy of superiority of material produce over a service oriented economy constitutes a chance for development;
c) the local communities' commitment to the reconstruction and development of the Kłodzko Valley.

Table 1. Comparative characteristics of the scenarios

Factors	SCENARIO I	SCENARIO II	SCENARIO III	SCENARIO IV
1.Initiative come from (place, year)	National Government with help of French Mission (Warszawa 1990)	Nearest University Centrum (Wrocław 1991)	District (voivodeship) (Wałbrzych 1991)	Local communities (Bystrzyca Kłodzka 1992)
2.Methodical option	all ways of reconstruction in conservative mode	creation of package of selective aims	system approach	holistic approach
3.Prevailing sector of economic development	solving problems of unemployment by development of services sector	highest level of tourist and medical services standards	changes of regional output from material products to market of services	to harmonize and utilize all regional own resources as: tourist and health services, ecological agriculture and small local industry
4.The major objectives	adaptation the standards of services to needs of customers from Western Europe	revitalization of the socio-economic environment to achieve the highest level of tourist and medical services	formulation of the legal principles from ecological point of view for each sector of the economy	a) promotion of active and economic successful local people as an instance of potential possibilities b) to organize mass education (languages, economy, professional services)
5.Sources of capital for investment	foreign capital (mostly from Germany)	foreign capital (mostly from the United States)	income from all kinds of services (a large share from foreign customers)	from economic output and various Foundations and Agencies: national, regional and from abroad
6.Period of realization (years)	3-5	4	undefined	5-10

Discussion

Reasons for starting difficulties

It has to be definitely stated that none of the presented scenarios was accepted by the local communities. The projects did not come up to people's expectations.
Each particular group formulated its own expectations as to new development directions of the district of Wałbrzych and Kłodzko Valley Subregion.

The rejection of the schemes has much to do with lack of acceptation of the projects inspired by the authorities, which were still treated as a group of strangers who wanted to impose their visions and ideas on local communities without taking into account the community's real needs. Similar feelings were felt towards the ideas of the Solidarity union. To some people, its scheme was intended as preparation for the parliamentary elections. The negative attitude manifests itself in:

a) a too weak articulation of a restructuring idea;
b) lack of promotion;
c) the appearance of strong local particularism.

This situation, which seems to be typical for communities strongly oppressed by economic problems, is however changing. People begin to understand that both the revitalization process and further development are impossible without assistance from outside, in areas of education and proper organization.

Present state of realization

Recently (Aug.1994) all activities have been concentrated on:

1. Activating of villages through tourism. Many farmers are stimulated to present the attractions and serve as tourist centers. At the beginning of 1993, five such farms were registered. At present, there are thirty nine of them and fifty have declared their willingness to serve as tourist farms.
2. Consolidation of the prosperous communes and town health resorts. To enhance efficiency of tourist sources the Consortium "Tourist Six" has been founded, which includes one fourth of the subregion area. This union of communes has a great influence on such factors as creation of new jobs and education of people connected with tourism on a more professional level.

Thanks to the above activities a new "image" of the subregion has been created.

Emphasis on the development of tourism, especially of rural- and agro-tourism, is economically well-founded. According to the writings of von Moltke "tourism affects the region's economy on a basis of a multiplying effect..." (von Moltke,1992). It should be acknowledged, in this context, that the realization processes of the scenario's aims have begun.

It also has to be remembered that the restructuring processes are complex and they take many years to be completed. (Prognosis report, 1989).

The outlined directions of those transformations are, without any doubt, beneficial to the economy of Kłodzko Valley because they promote economic activities of farmers and other groups of inhabitants who, with the help of domestic and foreign consulting firms and with financial help from the PHARE fund, are striving to change their cultural, natural and social environment.

Conclusions

Drawing up scenarios and public debate on the possibilities of their implementation, acted as a stimulus on local communities, giving way to some sort of self-development. Local leaders and leading groups have emerged, e.g. citizens engaged in economic groups such as the Consortium "Tourist Six". The factors that may hinder a successful development of the Subregion are:

a) the existence of conflicts of individual and group interests and the presence of similar conflicts among industrial branches, e.g. mining industry vs tourism;
b) the low educational standard of the inhabitants - one of the lowest in Poland,
c) the existing and deepening gap between rich and poor centers, and between towns and villages,
d) the lack of a legitimate and administrative separation of the Kłodzko Valley, as a separate economically and geographically district, from the Wałbrzych Voivodship.

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18.5 Abandoned landscapes in the Czech Republic

Šumava Mts. case

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Abstract
In this paper, abandoned landscapes are defined as areas abandoned by people and without settlements. Abandonment is documented in an European context and in the Šumava Mts. example (3500 km^2, Central Europe, proclaimed a National Park in 1991). Positive and negative aspects of the Šumava region are discussed with special attention to nature conservation and migration tides in terms of historical aspects, national economy transformation processes, and land-use strategies. Discrepancies are pinpointed between the ideas of nature conservation and the emerging free market economy. A strategy of sustainable development is recommended as the only way for managing the area.
Keywords: *abandoned landscape, Šumava Mts., military terrains, sustainable development*

Introduction

The term 'abandoned landscape' is very suggestive. It evokes a feeling of sadness and loss, but only few people can relate to it as something concrete. The abandoned landscape cannot be understood as just a landscape without people. Landscapes gain their attribute 'abandoned' only if people, originally living in or tied to such a landscape, abandoned them for various reasons.

In terms of landscape ecology, abandonment of an area opens a possibility to substitute nature-man interrelations with nature-nature ones, generating landscapes with prevalent natural control on a regional scale.

In case an area is 'reinhabited' a couple of years after its abandonment, the main problem seems to be 'incorporation' in the context of the larger surrounding area with its undisturbed, continually ongoing development.

We can find many examples of abandonment in history, as in the Near East, in the Midwest of the USA, etc. A recent, well-known example is the region around the Aral Sea where after a quick and unexpected lowering of water level caused by ecologically unsound land utilization, many fishermen and agricultural villages vanished (Alexandrova, 1994).

Some landscapes were abandoned for other reasons than deteriorating natural conditions, for instance, because of political decisions. In the former Soviet Union under Stalin's leadership, a consistent liquidation of the peasantry was carried out by evacuation of populations from large areas. On the other hand, the landscape in Corsica was abandoned for distinctly economical reasons.

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The Czech Republic has its own history of abandonment, in particular with respect to large military training areas, such as the 700 km^2 area in the central part of Bohemia at Neveklov, which served as a German Wehrmacht training base during World War II. As a consequence, the continuity in economic and sociocultural development was interrupted. After World War II, this area was used again for common agricultural and forestry economic purposes.

In North Bohemia, in the Ralsko region, we can find an area of approximately 250 km^2. This area served as a training base for the Soviet Army during the last 25 years. Nowadays the landscape is nearly abandoned, and far-reaching disputes are taking place about its future utilization.

Šumava Mts. case

The Šumava Mts. region, situated in the southern part of the Czech Republic (an area of about 3 500 km^2), is one of the 'neuralgic points' standing on a development crossing (Figures 1 and 2).

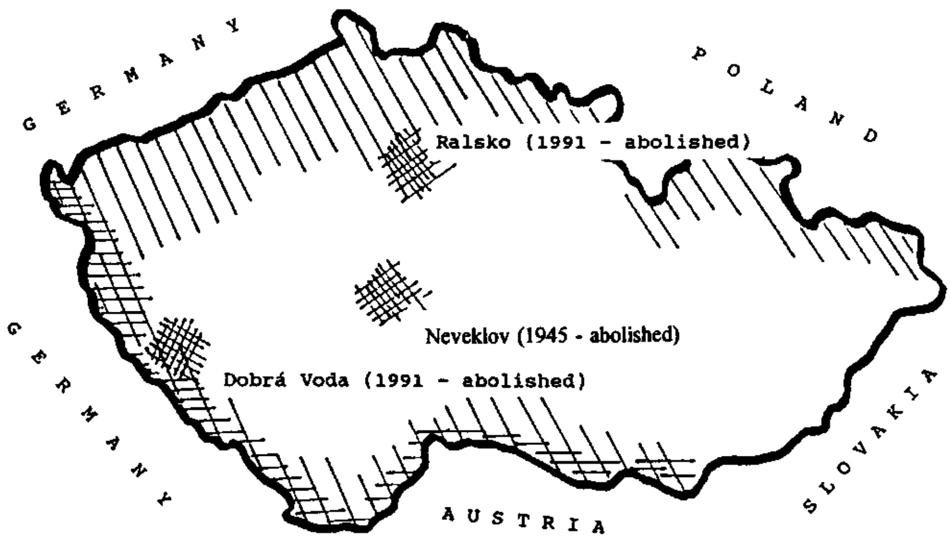

Fig. 1. Different reasons for landscape abandonment. Examples.
(X military training territories, = boundary zones, \\ transfer of German population (1945-1946))

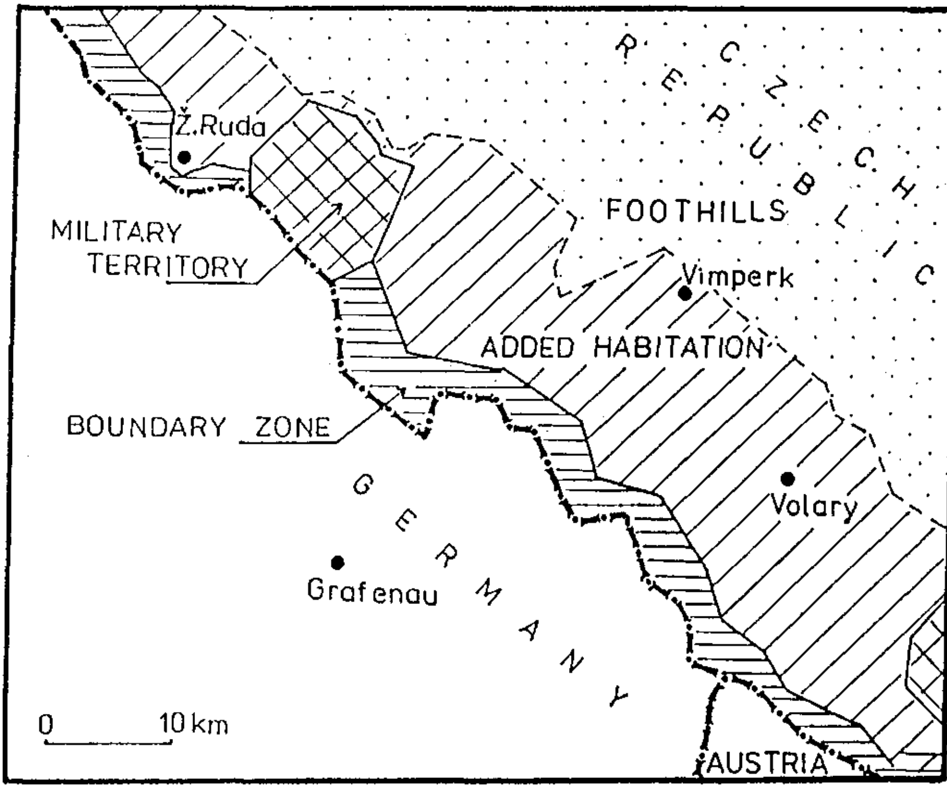

Fig. 2. Abandoned landscape Šumava Mts. and its regional differentiation.

The history

The Šumava Mts. region underwent several emigration and immigration movements during its history and can thus serve as an example of an landscape abandoned for various periods.

Colonization of the Šumava Mts. began to all intents and purposes in the second half of 12th century through cloisters supported by royal power. The colonists coming from Germany were given preferential treatment by a royal decree (1226) in order to help settle the so far uninhabited region. The next wave of colonization took place in the second half of the 16th century and the last one in the 18th century. The colonizers were both German and Czech, as it is evident from the local settlement names (Jelínek, 1987).

The first emigration wave was the movement of rustic Šumava inhabitants in search of seasonal jobs in Bavaria, Saxony and Austria. A number of Šumava families and individuals have moved to North America for economic reasons since the second half of the 19th century. This wave lasted up to World War I (Starý, 1991). Šumava used to be rather densely populated ever since the middle of the 19th century (Fig. 3). In this mountainous environment people lived in numerous villages often situated near the state boundary.

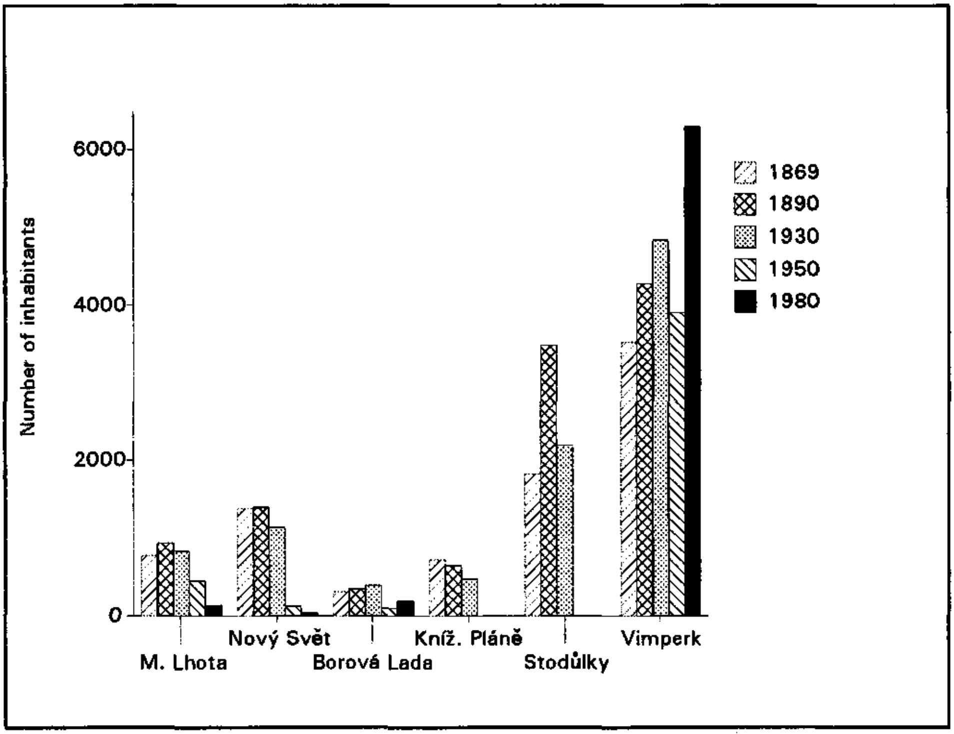

Fig. 3. Changes of settlements document the movement of inhabitants from small villages to industrial centres.

The development after World War II, e.g. the transfer of the German population and the subsequent unfavourable political conditions after 1948, resulted in large numbers of localities being forcibly abandoned, and settlements vanished. At the same time various forbidden zones were established, such as the boundary area, the military area Dobrá Voda and others.

Šumava subregions

Based on the latest historical development, the Šumava region can be divided into four subregions. Their relative sizes are approx.: A = 50%, B = 35%, C = 10% and D = 5%.

A. 'Czech Šumava foothills' subregion, with a minimum amount of influence of political and national factors in its development (Bartoš at al., 1992). The natural conditions and great distance from industrial, political and cultural centres caused this part of the republic to be on the periphery of social interest.

The greatest part of this area has gone through hectic development since the beginning of this century. A severe interruption of the historical development began in the early 1930s with the growing propagation of fascism and nazism among the German inhabitants. It meant the destruction of centuries of national solidarity of Czechs and Germans in Šumava. The overwhelming majority of Czech inhabitants were forced to leave their homes after the year 1938. On the other hand, in the years 1945-1946, German inhabitants were repatriated to German areas under the victorious powers' rule. On the land vacated by the German inhabitants, three types of subregions developed:

B. The subregion of 'added habitation' characterized by immigration of new inhabitants: predominantly Volyně Czechs, Romanian Slovaks and Slovak gypsies, i.e. people with a quite different cultural background and therefore out of touch with the Šumava tradition.

C. The subregion of 'boundary zone'. An up to six kilometres wide band along the border with Bavaria and Austria was established in 1951. It was hermetically closed to create so-called 'iron curtain'. No new inhabitants were allowed into this subregion, and all domiciles were destroyed. The only temporary inhabitants were soldiers guarding the state border.

D. The subregion of 'military training territory'. In the area evacuated after World War II, two extensive military territories were established: Dobrá Voda and Boletice. The latter still serves as a military training area of the Czech Army. The Dobrá Voda territory was a military terrain for 42 years. The establishment of this military subregion was carried out without reference to the preceding historical development of the region. In this way it resembles the boundary zone.

Present state and future possibilities

There are both negative and positive consequences of above-mentioned regional developments in the Šumava Mts. The negative ones are forced marginality and social and economical underdevelopment.

The positive consequences concern allowing nature to follow its own development, especially in the most forbidden areas of boundary zone and military training sectors. Forty years of natural succession have enabled the creation of relatively stable ecosystems in the main mountainous areas.

To save this treasure, Šumava Mts. was proclaimed a National Park in 1991. This leads to special treatment of the whole area. By law, productive activities can be curbed, and priority can be given to integrated landscape protection, according to the type of protected zone.

Evidences indicate, however, that there are severe discrepancies between the ideas of nature conservation and the emerging market economy. The most important problem may be the loss of work opportunities and hence of former 'life certainties' and income or at least the anxiety thus perceived by the local inhabitants.

In other words, recent developments imply a 'destruction of their known world' and present the problem of building another one. In an area where agriculture and forestry are practically the only sources of employment, the sudden change presents almost a social shock, which could lead (contingently or temporarily) to social instability in the whole system.

Unfortunately, the role of the state as an intervening body in the transformation of agriculture and forestry from their production role into a landscape protecting one is not yet satisfactorily developed. The result is that the National Park is perceived by most of the local inhabitants as a burden and even as threatening their existence. Developments in the area cannot be considered as sustainable. Moreover, the area is likely to come under enormous land-use pressure because of its attractiveness.

Scenarios

If the area is left to manage the process of transformation on its own, two extreme 'catastrophic scenarios' can be envisaged:

1. Ongoing emigration, i.e. repeated abandonment and an economic, social and cultural decline.
2. An uncontrolled influx of capital (also from abroad, especially German) into a 'free zone' and uncontrolled development of (short term) economic activities - the parallel of the post-war 'gold-diggers'. Commercialization would be the most probable feature and the devastation of natural and cultural Šumava values the most probable consequence.

To prevent the above-mentioned developments, a solution must be found incorporating both nature conservation and appropriate social development. The National Park is a phenomenon of national and international importance. Therefore, the strengthening of the role of the state (including economic support to the National Park) is necessary. The government has to realize that the proclamation of the National Park implies bearing responsibility for its successful functioning.

It is necessary to elaborate different scenarios for three types of land use: nature conservation, agriculture and forest management, and recreation. The most important role of the resulting scenario will consist in mutual compromises between entrepreneurs bringing their activities into harmony with the landscape capability.

Conclusions

Abandoned landscapes are becoming relatively frequent phenomena both in West Europe (e.g. North Italy, France) and East and Central Europe (Czech Republic, Poland), where large marginal areas are being abandoned partly because of the continuing process of reduction of agricultural production and of concentration in the most fertile areas only.

The outlook of such areas depends mostly on the long-term state strategy of landscape utilization. In overpopulated Europe these areas could serve as a reserve for the future only if they are properly maintained.

In this context, research focussing on social, economical and ecological bases and consequences of the process should be started, on local to international levels. The information gained could help support sustainable management of these areas.

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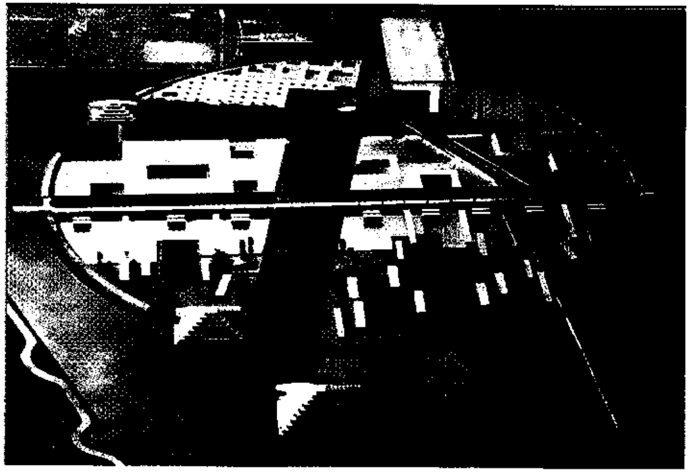
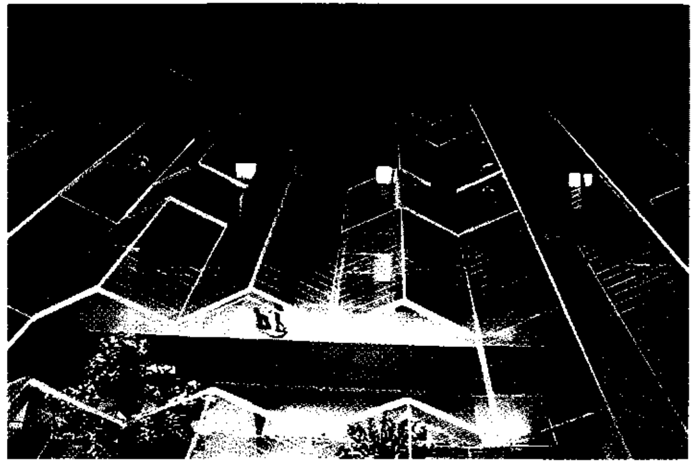

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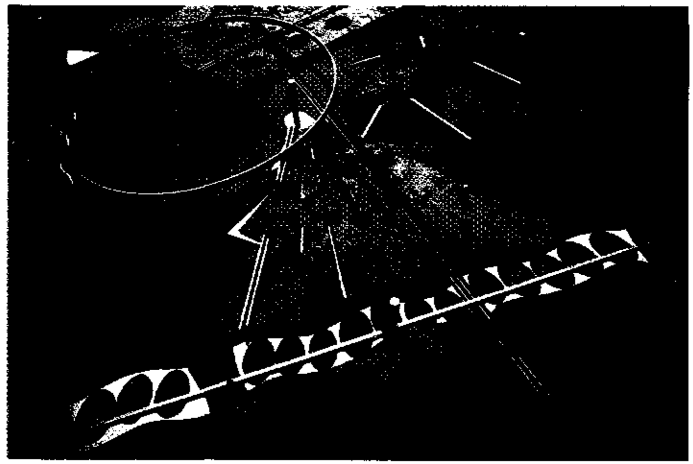

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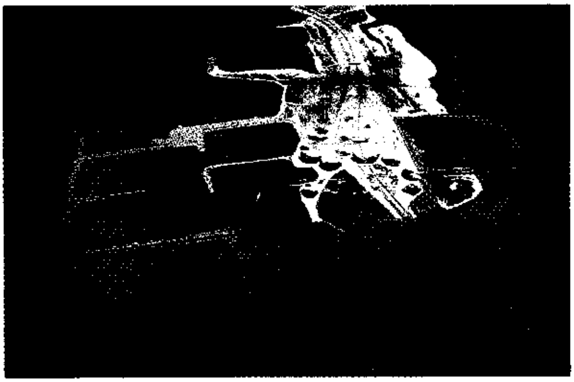


Plate 2a and 2b *Neeltje Jans, model and architectural concept of the water pavilion, draft* (Chapter 2.4: Ashok Bhalotra).

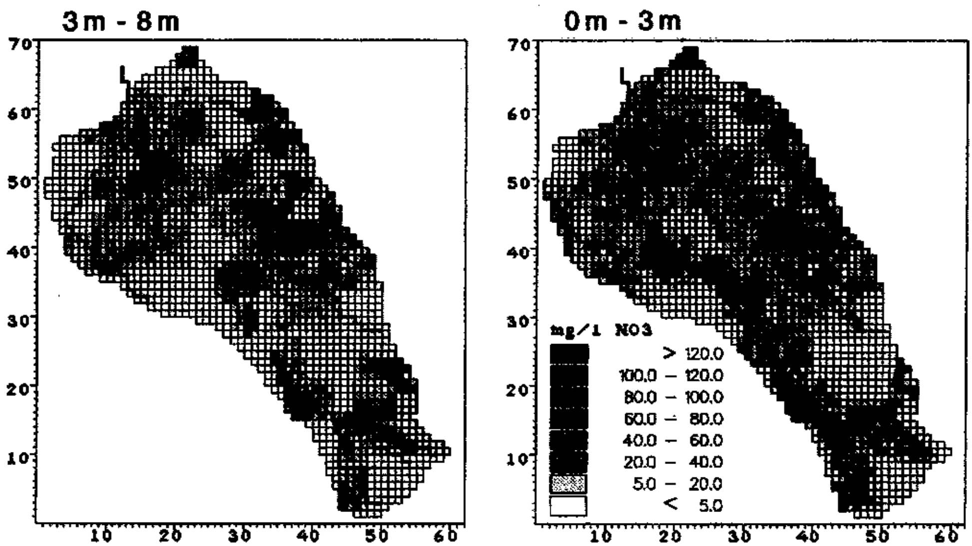


Plate 2c. *Spatial variation in simulated nitrate concentration of the upper groundwater layers during autumn 1988 for the Karup stream catchment. From Storm et al (1990)* (Chapter 5.2: Styczen).

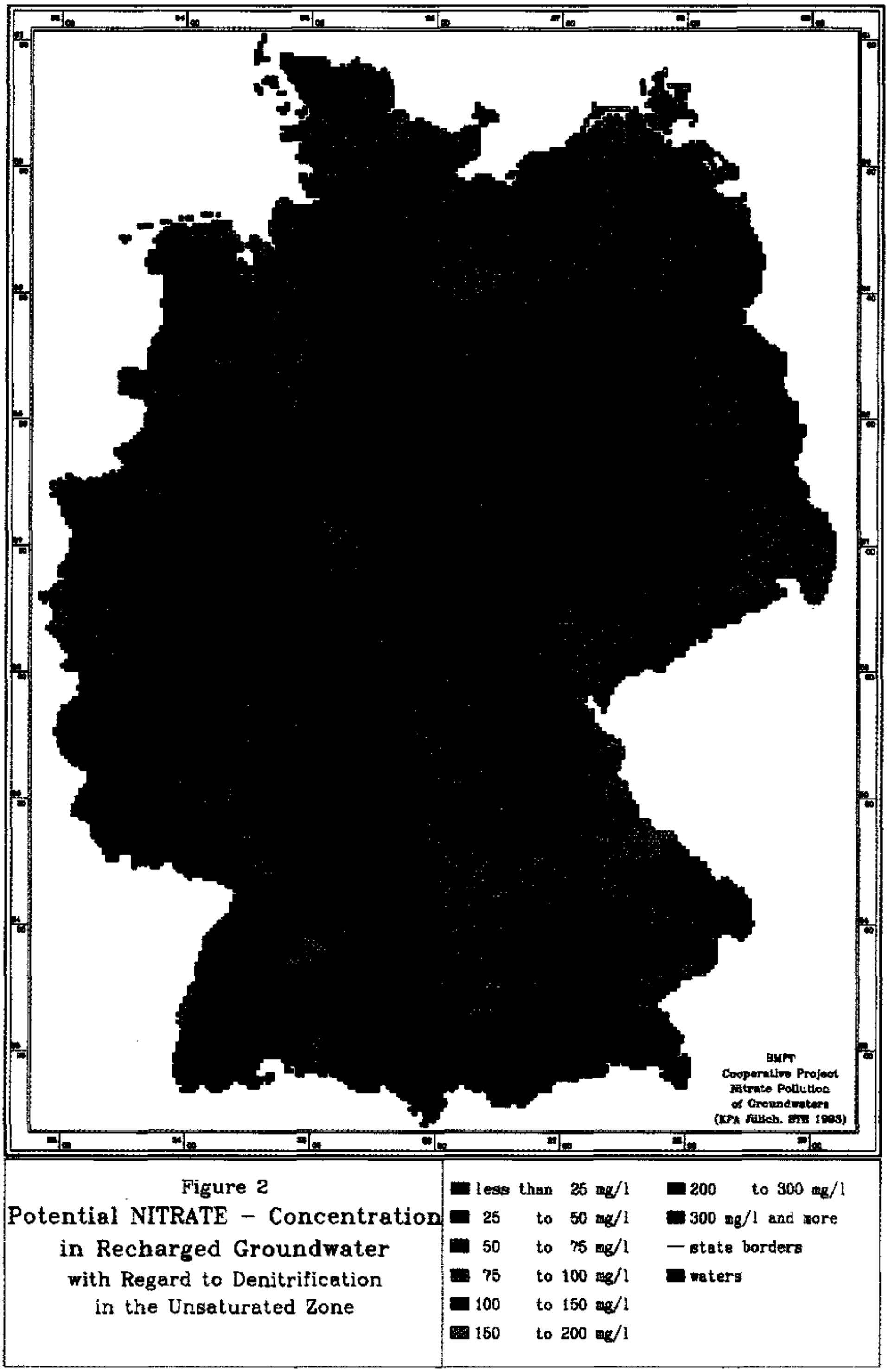


Plate 3. *Potential Nitrate. Concentration in recharged groundwater with regard to denitrification in the unsaturated zone*
(Chapter 6.4: Wendland & Bach).

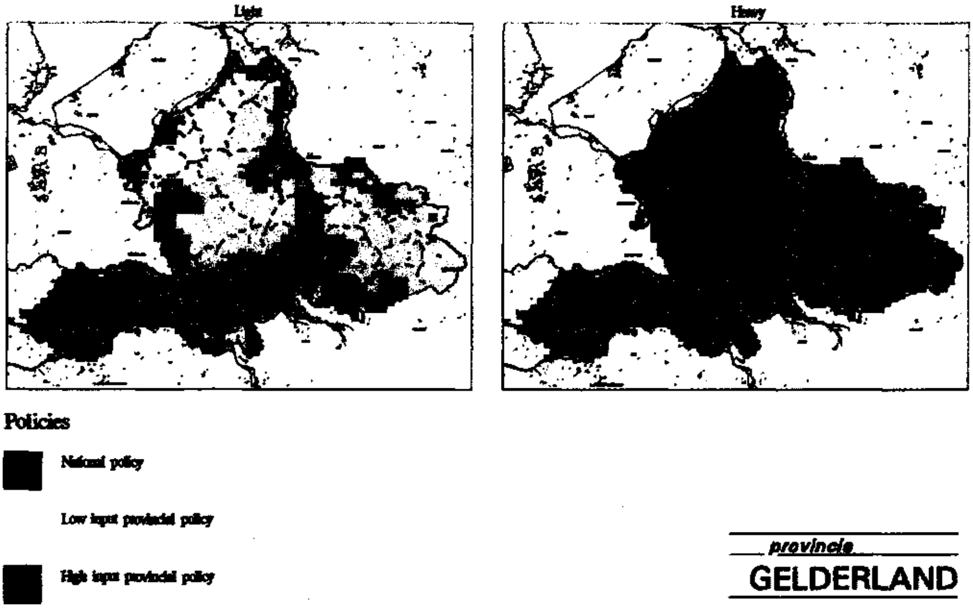


Plate 4a. *Areas in which the additional provincial policies are applied* (Chapter 6.6: Van der Veen & Van der Voet).

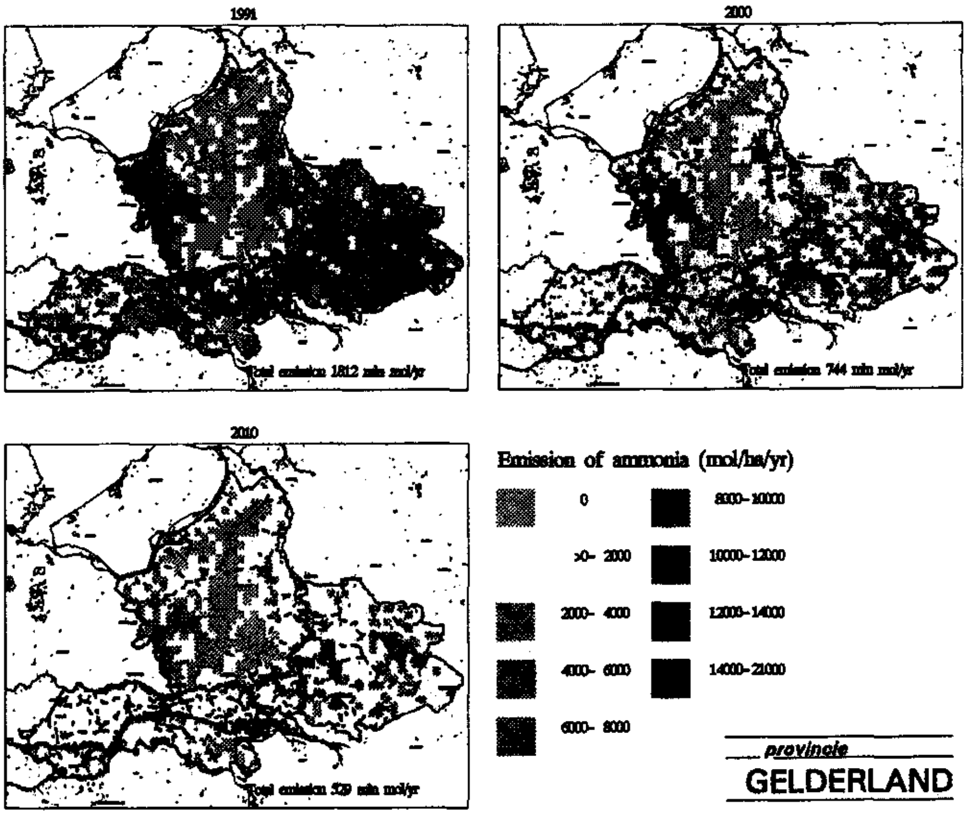


Plate 4b. *Emission of ammonia in Gelderland in 1991, 2000 ans 2010 with national policies* (Chapter 6.6: Van der Veen & Van der Voet).

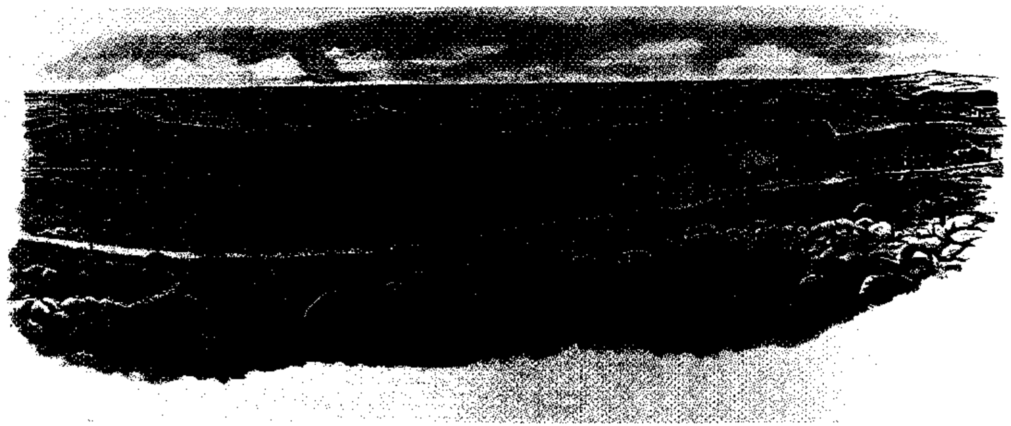


Plate 5a. *A landscape in Time, Jæren, as it appeared in 1966, reconstructed on the basis of air photographs and topographical maps. Characteristic for the landscape were the many stone walls, stone-covered pastures, bogs and wetlands* (Chapter 10.2: Jones & Emmelin).

Plate 5b. *The landscape in May 1988. Agricultural rationalization and land reclamation have led to substantial changes since 1966, although stone walls and stony pasture still characterize parts of the area* (Chapter 10.2: Jones & Emmelin).

Plate 6a. *A physical extrapolation of recent trends. If rationalization and land reclamation had continued, the landscape could be expected to look as it does in this picture. The landscape here has lost many of its distinctive features and has a poorer fauna and flora than in 1988* (Chapter 10.2: Jones & Emmelin).

Plate 6b. *The possible impact on the landscape of a manure-spreading area requirement of 0.4 ha per livestock unit, introduced in 1989. The requirement was reduced for grazing animals according to the length of the grazing season. This is expected to lessen the pressure for land reclamation* (Chapter 10.2: Jones & Emmelin).

Plate 7a. *The possible impact on the landscape of a stricter manure-spreading area requirement. A hypothetical requirement of 0.7 ha per livestock unit would force small farms to reduce livestock numbers. They could be expected to cut out labour-demanding dairy cattle. Greenhouse production and non-farm activities would be ways of compensating lost income. Pasture would be ploughed up* (Chapter 10.2: Jones & Emmelin).

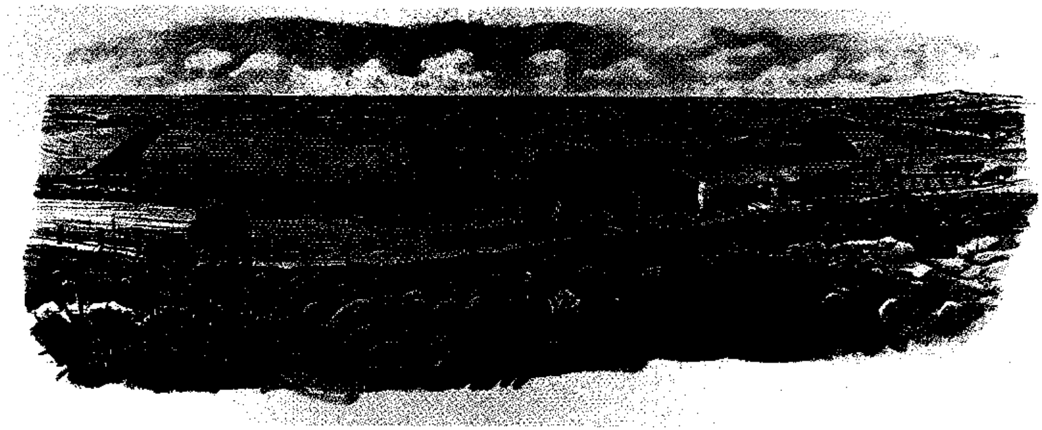


Plate 7b. *The possible impact on the landscape of more environmentally conscious farming. Wetlands have been restored in order to reduce the pollution problem. A biotope network has been created to stimulate ecological diversity. Characteristic features of the landscape are retained* (Chapter 10.2: Jones & Emmelin).

Plate 8. *A scenario of an unexpected future. This picture illustrates possible ways in which farmers might react to forces outside agricultural policy. Alternative sources of income might be derived from a riding centre or the cultivation of Christmas trees* (Chapter 10.2: Jones & Emmelin).

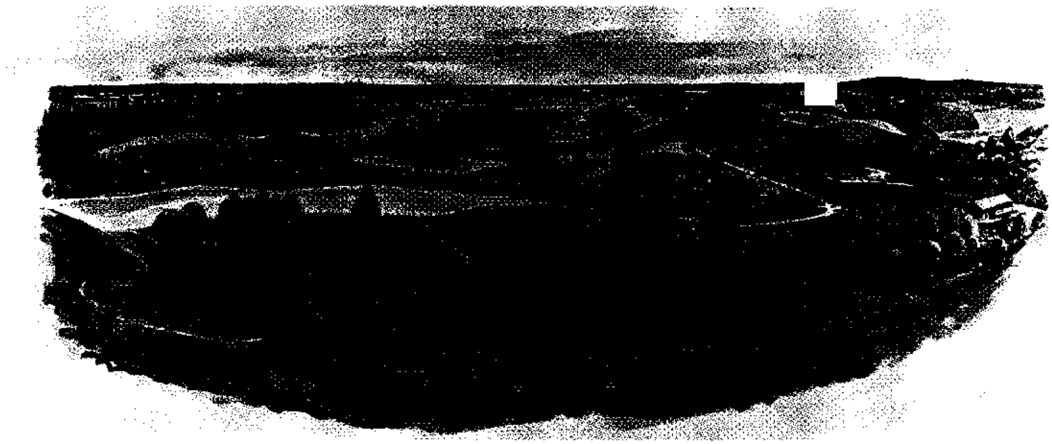


Plate 9a. *A landscape in Nannestad and Ullensaker, Romerike, as it appeared in 1969. Characteristic for the area are ravines and undulating terrain. The main income was provided by dairy farming* (Chapter 10.2: Jones & Emmelin).

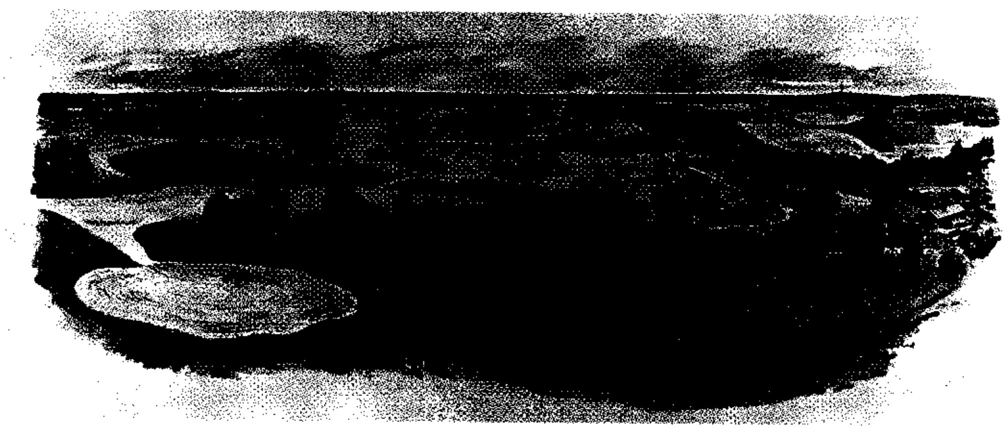


Plate 9b. *The landscape in May 1989. Most farms have made a transition to grain monoculture since 1969. Mechanized farming has been facilitated by land grading (cut-and-fill). Ungrazed ravines have become overgrown by scrub* (Chapter 10.2: Jones & Emmelin).

Plate 10a. *A physical extrapolation of recent trends. If land grading had continued, the landscape could be expected to look as in this picture. The lowering of the terrain reveals the Leira river. This is shown canalized* (Chapter 10.2: Jones & Emmelin).

Plate 10b. *The possible impact of a more environmentally conscious farming. Mixed farming and reduced intensity characterize this alternative. Pasture and grass production occur on the areas most susceptible to erosion* (Chapter 10.2: Jones & Emmelin).

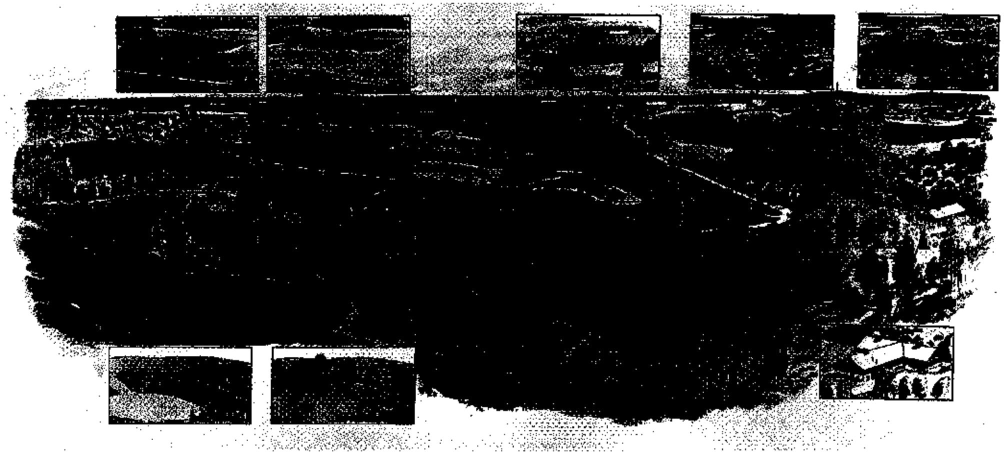


Plate 11a. *The possible impact of a policy reversing regional specialization. This scenario illustrates a variety of possible results of an attempt to reverse Norway's specialization into grain districts and livestock districts. A prohibition of autumn ploughing to reduce erosion in an area of heavy marine clays would encourage grass cultivation and animal husbandry. The boxes show alternatives with scrub growth, afforestation and grazing in ravines, as well as new farm buildings, and contour ploughing to reduce erosion* (Chapter 10.2: Jones & Emmelin).

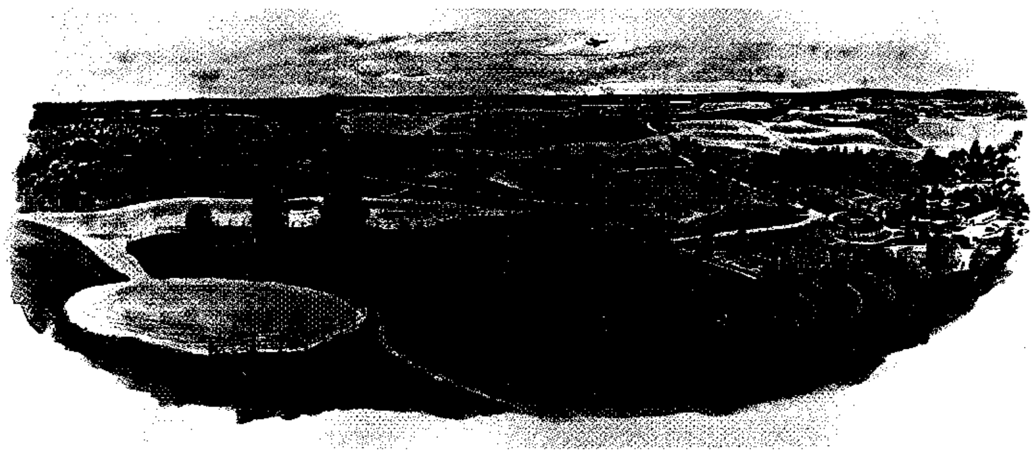


Plate 11b. *A surprising future. The picture shows the possible impacts of new development resulting from the siting of a new airport for Oslo in the vicinity. Developments might include a hotel, golf course, new dwellings and industry* (Chapter 10.2: Jones & Emmelin).

Plate 12a. *Geographic distribution of dominant values for the pH in deciduous forest at the bottom of the rooting zone in 1990 (left) and 2050 (right)* (Chapter 11.4: Kros *et al.*)

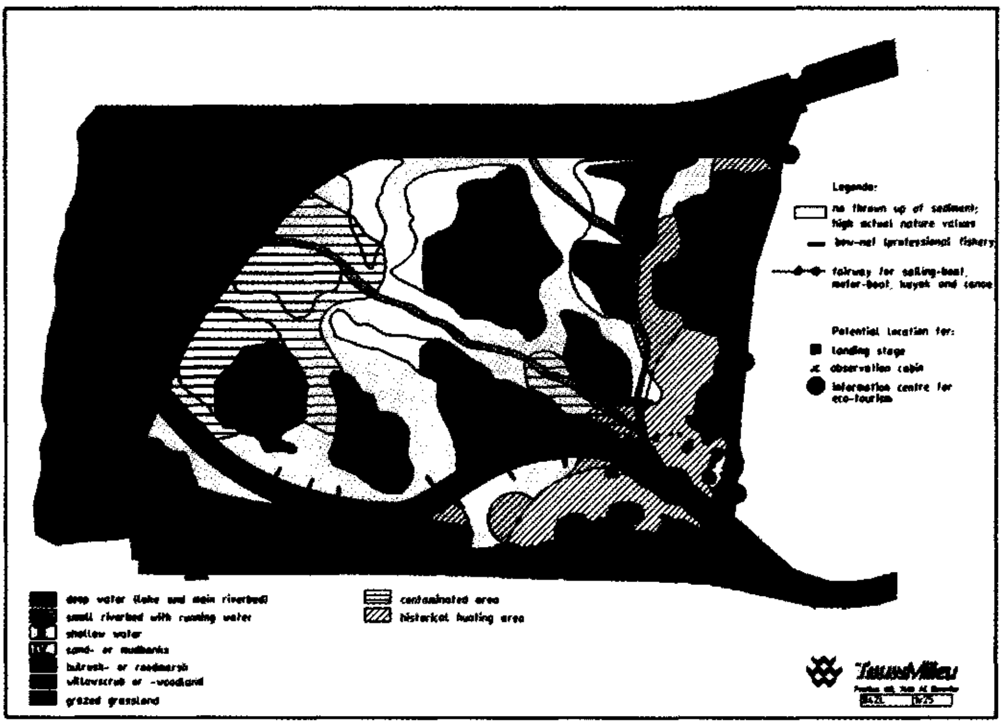
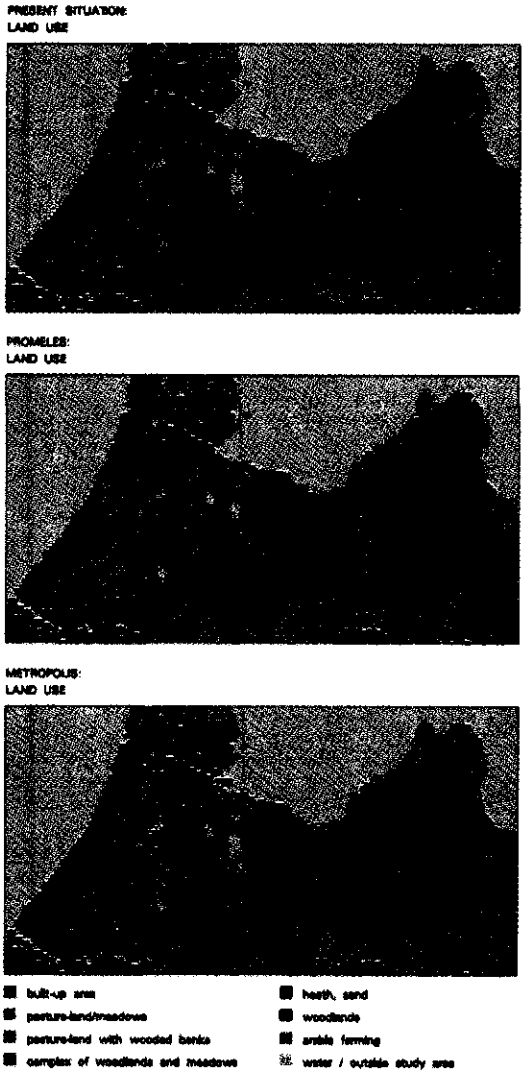
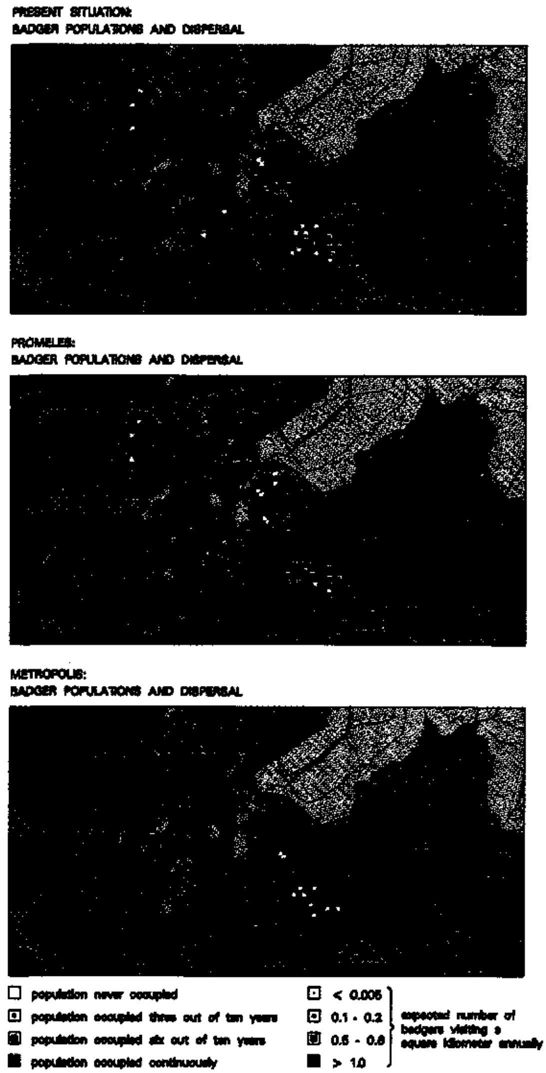


Plate 12b. *Optimized scenario* (Chapter 14.1: Van Wezel *et al.*)



a.



b.

Plate 13a. *Land use in the present situation and after realization of the scenarios Metropolis and Promeles* (Chapter 14.2: Knaapen *et al.*).

Plate 13b. *Expected size of badger populations and intensity of dispersal after 50 years when the present situation is continued and after realization of the scenarios Metropolis and Promeles* (Chapter 14.2: Knaapen *et al.*).

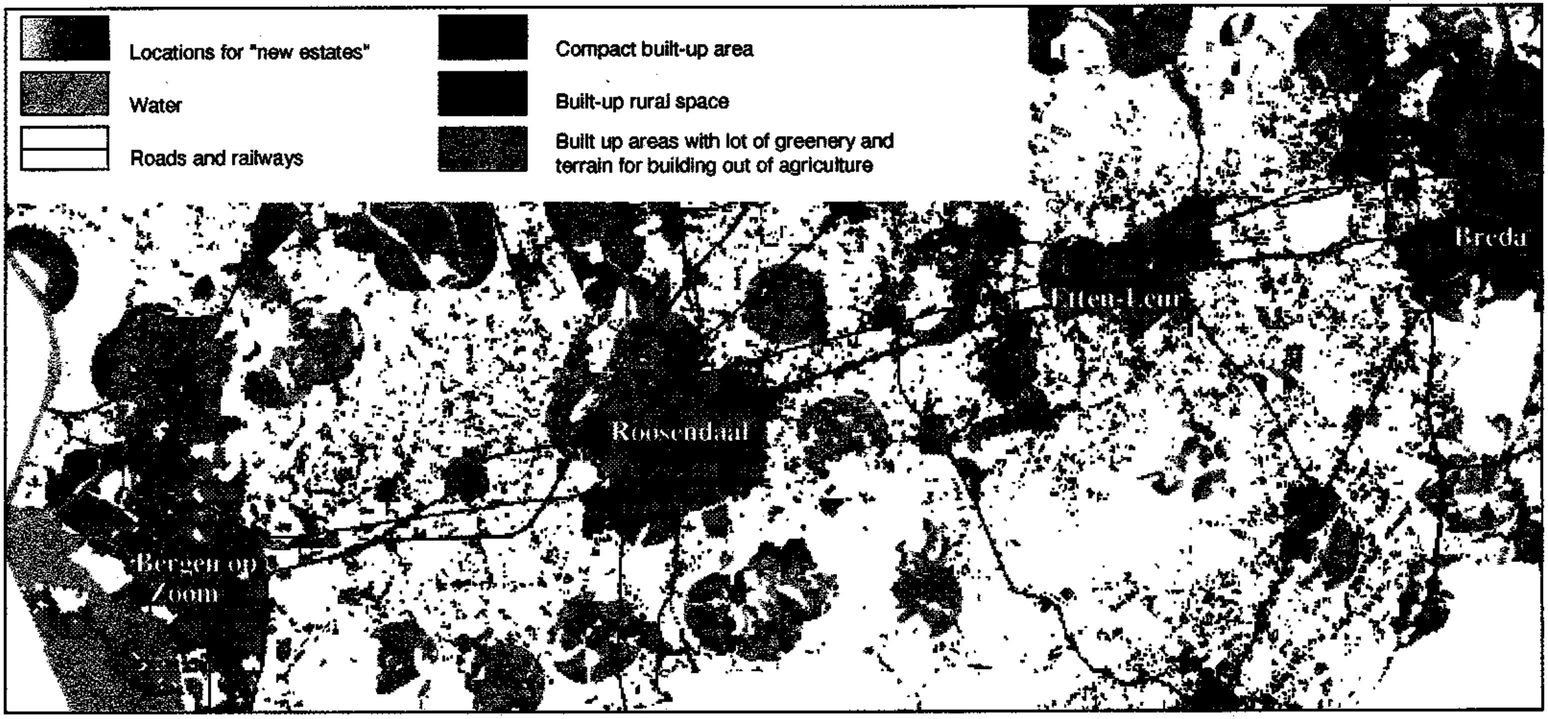


Plate 14. *West Brabant with the network of locations for the "new estates"* (Chapter 16.6: Tisma).

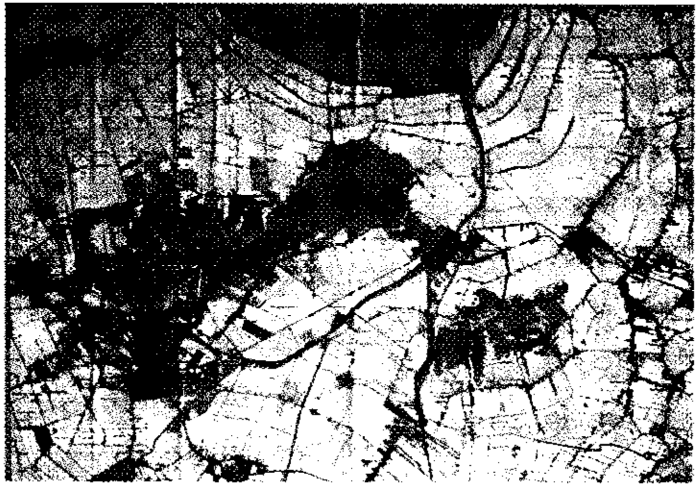


Plate 15a. *The new lake in the Oldambt* (Chapter 18.3: Beukema).

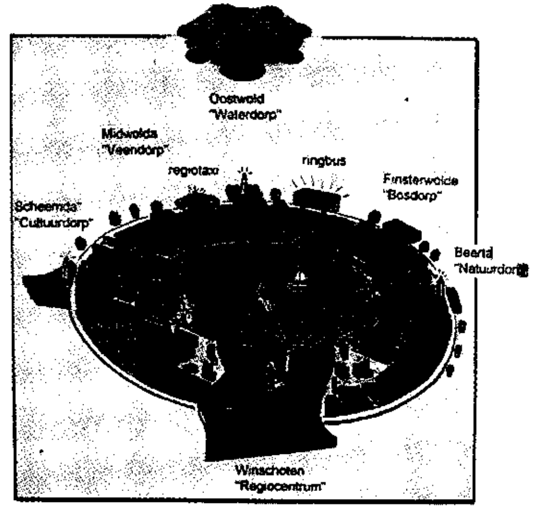


Plate 15b. *The Blue City concept* (Chapter 18.3: Beukema).

Plate 15c. *The Blue City design by Hamhuis, Van Nieuwenhuyse and Sijmons Consultancy* (Chapter 18.3: Beukema).

Plate 16a. *The Blue City design by Hagenbeek and Yap* (Chapter 18.3: Beukema).

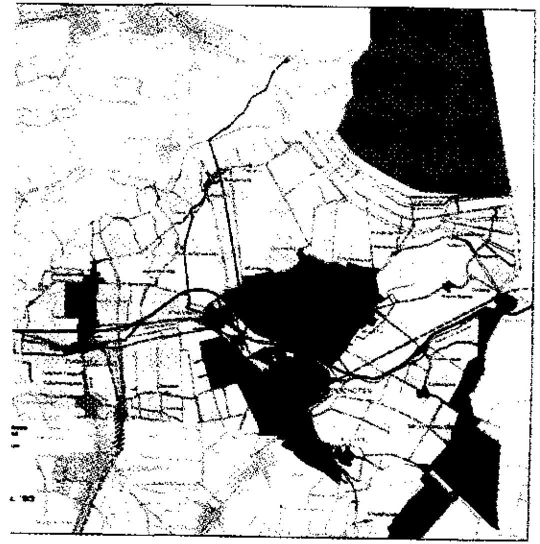


Plate 16b. *The Blue City design elaborated in detail* (Chapter 18.3: Beukema).

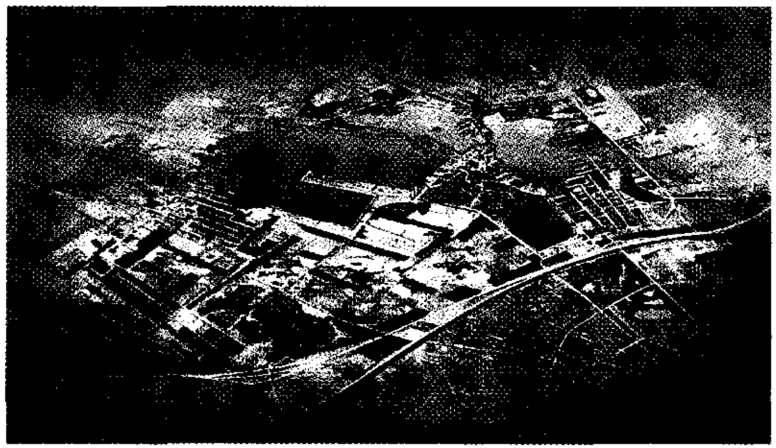


Plate 16c. *Metamorphosis of the area, an artist's impression* (Chapter 18.3: Beukema).