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Contributions to research, planning and management of our environment

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Both landscape ecology and landscape planning are trying to approach a whole, a synthesis. They work on a basis of many specialized scientific and practical disciplines, each producing a sea of information. The individual scientist struggles to keep pace with new developments. This task is almost hopeless where the specialized seas merge into the ocean of landscape information. Is it possible to organize a congress that does not carry more water to this ocean but endeavours to clarify the structures of its depths and surfaces, its islands and shores?

The congress organization committee has tried to meet these problems by setting up a structure of lectures with views about unifying principles and practical syntheses, workshops to discuss controversial points and a market of posters to offer a variety of new results and ideas.

The proceedings follow this scheme. Each chapter comprises lectures, posters and discussion. Lectures and posters are published as they were submitted by their authors. The workshops have been synthesized. An attempt is made to summarize discussion topics at the end of each chapter. In some cases the report written by a workshop coordinator is followed closely. More often the reports of several workshops on the same topic and relevant working papers are integrated to give one text. Sometimes it is considered elucidating to touch on some links with lectures and posters. However, the wish to publish these proceedings as soon as possible has held us back from doing this systematically. Thus the discussions reflect the differences in profoundness and comprehensiveness of the actual discussions during the congress.

In the workshop summaries, reference to lectures (articles) and poster abstracts is made by the letters (l) and (p), respectively. As these lectures and posters often form part of the same section (theme) of the proceedings, they can be found easily. If not, they can be located using the Author Index.

The chapters in this book correspond to the congress themes: theoretical concepts; rural areas; urban-rural relations, and natural areas. One theme is added, that of methods and applications. Under this heading, posters and discussions with a more general meaning, not specifically limited to one of the other themes, are brought together. These five chapters are preceded by the introductory speeches and concluded by the texts of the final session on landscape ecology and politics.

The reader may read as usual, from front to back, or backwards, or he or she may even compose a personal anthology. In any case, we hope this book will offer some help in discovering land in the ocean of information about landscapes, being the basis for changing more consciously the face of the earth. In this way these proceedings may be used as one of the stepping stones towards new perspectives in landscape ecology.
Introduction
Ladies and Gentlemen,

The chairman of our society, Dr. Thalen, was to speak to you at this moment. But due to a serious illness – from which he is, fortunately, now recovering – he can not be here personally today. As vice-chairman of the Netherlands Society for Landscape Ecology it's a pleasant task to welcome you all on this first international congress of our society.

A special welcome in the Netherlands to the participants from abroad, in particular from such far away countries as India, U.S.A., Australia, Sri Lanka, South Africa, Taiwan, Nigeria, Canada, Mozambique, the Philippines and Thailand. I must also make mention of the relatively large number of participants from nearby – Belgium. Many other European countries are also represented at this congress, so, including the 200 Dutch participants, we are together here this week with the respectable number of some 319 people, coming from 23 countries.

The Netherlands Society for Landscape Ecology (NSLE, or in Dutch WLO) was founded in 1972 to promote integrated research to gain a deeper understanding of the structure and functioning of landscapes and the patterns and processes in landscapes. The Society emphasizes the translation of this knowledge for application in nature conservation, environmental management and land use planning. We try to reach these goals by:

- Bringing together and evaluating the work of our members to deduce scientific criteria for a scientifically sound inventory, characterization and evaluation of landscapes.
- Promoting coordination of research to be undertaken to be able to set priorities, develop models and test research methods.
- Exchanging information about current research, for example by publishing a quarterly journal.
- Promoting the documentation of relevant literature sources.
- Forming working groups, dealing with aspects of the Society’s objectives already mentioned.
- And last but not least, organizing of seminars, symposia and congresses.

The Society can be joined by anyone who is in one way or another dealing with research, education or application of results in landscape ecology. There has been a steady increase in membership in the about ten years of its existence; the society has now over 550 members. Some 35 percent have a background in biology and some 20 percent in physical geography, but town planners, landscape architects, human geographers and other scientists are also members of our society, which indicates its highly diverse character.

At this moment our society is a meeting place for research workers, planners and managers from different institutions all over the country.

As mentioned in the introduction of the programme, we are faced with an increasing demand for:
- application of ecological principles in the planning and management of urban, rural and natural landscapes;
- and, partly through that, an increasing demand for a thorough theoretical basis for landscape ecology.

In spite of this growing demand for application of ecological knowledge communication of landscape ecological research at an international level leaves much to be desired at the moment.

In this context I must make mention of the symposium being organized every three years in Czechoslovakia, with Dr. Ruzicka as its stimulating initiator. This symposium, mainly attended by scientists from Central and Eastern Europe, inspired some members of our Society to organize this present congress.

We are happy that a delegation from Czechoslovakia is here now amongst us, and that they will be presenting papers and taking part in the discussions.

The programme of this new congress includes the following: plenary sessions, poster sessions, workshops, an excursion, a meeting about international co-operation and a closing session about landscape ecology and politics. The Netherlands Society for Landscape Ecology hopes that this congress in all aspects will contribute to the realization of its objective: improving international communication in the discipline of landscape ecology.

I would emphasize that your presence, your papers, your discussions and your personal contacts will be decisive for a successful congress. The Netherlands Society for Landscape Ecology has made the preparations but the Congress is yours!

We are pleased that a representative of the Ministry of Culture, Recreation and Social Welfare, one of our financial supporters, has found the time to open this congress officially. The work of this Ministry is most relevant to the research to be discussed this week. We are happy to welcome Mr. van Rijckevorsel, Head of the Directory of Nature and Landscape Conservation of the Ministry of Culture, Recreation and Social Welfare.
OPENING SPEECH

F.J.M. van Rijckevorsel, in the name of the State Secretary of the Ministry of Culture, Recreation and Social Welfare.

Ladies and Gentlemen,

It was with great pleasure that I accepted the invitation to open this international congress entitled "Perspectives in Landscape Ecology".

An opening by an official representative of the Dutch government indicates a recognition of the importance attached by that government to landscape ecological research, and this is a growing interest. I should like to underline this thesis with a short historical review.

In spite of the fact that humanity as early as the beginning of our era has put its mark on the natural landscape, the total balance of human interference until a few decades ago could not be called negative. It is true that the Netherlands changed from a woodland area (Holland originally meant wood land) into the country in Europe with the smallest area of forest, and that big wild mammals could not maintain their position as a result of the loss of biotope. On the other hand, an enrichment of the Dutch landscape took place by the creation of a considerable differentiation of environmental and landscape types, which, among other things, created chances for the development of biocenoses and the introduction of bird species which originally were not found here.

Recent developments in a wide variety of fields, however, have resulted in radical changes in the effects of human activities on the quality of nature and landscape. In general, the above-mentioned enrichment process is no longer valid. I shall not enter into details here as regards losses in terms of ecological, culturo-historical and landscape values. I suppose that this audience is sufficiently acquainted with them. It is of significance that in this day and age there is growing recognition that perceiving and experiencing a harmonious cultural landscape is of psychological importance to man.

In such a landscape he feels at ease, he derives from it his identity and it offers him aesthetical experience without which he would be impoverished in a mental and a moral way. The conservation of the landscape therefore contributes to a great extent to the mental wellbeing of the population.

Of course we do not want to freeze the landscape, that is to say to keep it as it is in a state we consider beautiful. That of course would be impossible because each landscape is by definition in a dynamic process: continuously new elements are being added, changing and moulding the landscape into its new utility functions.

Essentially no objections can be made to such additions. If however new developments in the landscape result in a sudden deterioration of natural and cultural-historical information - being collected over the centuries - then a revision of policy has to be considered and measures for conservation and management have to be taken. Such protective measures aim to control in an harmonious way the processes of the dynamics of landscape formation. In this way the continuity and development of the landscape is promoted and we and our posterity
will not be saddled with monotonous cultural landscapes which only satisfy the needs of one single generation, that is the present one. In my opinion the essential role of landscape ecological research finds its place right here in this harmonious landscape development.

After the start in the late sixties of a number of landscape ecological studies, researchers in the seventies felt the need to break the disciplinary approach: biology, hydrology, geography, landscape architecture and so on, which led to the establishment of the Netherlands Society for Landscape Ecology (NSLE, in Dutch: WLO). I do think that one of the main characteristics of the NSLE is that its members do have completely different backgrounds. For instance, they differ in their professional responsibilities. Representatives of research institutes and universities, but also private organizations and local, regional and central government, are to be found in the membership list. This brings me to a fundamental aspect of the NSLE - the task of narrowing the gap between research and policy. The different levels of government, I mentioned earlier, recognize the NSLE and take into account in their policies the results in reports published by the NSLE in recent years. Notably the experts employed in government organizations in the fields of policy preparation and implementation, through their contact with NSLE and their participation in seminars organized by NSLE, have been influenced by the developments in the discipline of landscape ecology.

In The Netherlands there is a growing consensus of opinion that agricultural and urban development and physical planning, in general, should be seen in a landscape ecological context. The day to day practice however, confronts us again and again with the limits of our scientific knowledge. This stresses the necessity to intensify landscape ecological research.

A few times already the whole country as such has been object of study, as for instance some years ago when the Ministry of Housing and Physical Planning asked for a national environmental mapping. Recently, the Ministry of Culture, Recreation and Social Welfare, which bears the responsibility in our country for nature and landscape conservation at governmental level, collected on a national scale the data on the ecological and cultural sites of interest and recorded them on a map. Apart from that, for some parts of our country integrated landscape ecological studies have been carried out. The results are to be found in governmental policy reports.

In hope to have convinced you of the fact that in the Netherlands the prospects for landscape ecological research certainly are not negative. The same does not apply, however, to the prospects for our indigenous flora and fauna. Here we do find a continuing increase in disturbance, wasteland, exotic species and ubiquists, and at the same time a decrease in species of a narrow ecological spectrum and species vulnerable to added environmental dynamics.

I realize that conservation of species is not in the forefront of landscape ecological research. However I would like to draw your attention to the danger of a landscape development which might be acceptable from an esthetic point of view but at a closer look possesses a very limited ecological diversity. I realize that I am touching upon a subject of great complexity. This introduces the problem of the relations between patterns and processes in the landscape. I sincerely hope that this congress will contribute to the study and solution of these kinds of problems.

I hope that your stay in the Netherlands, as well as your participation in this congress, will be both fruitful and pleasant.
Chairman’s Welcome

Dear audience, ladies and gentlemen,

Some years ago, I attended another international conference in the Netherlands. On the third day, one of our guests joined me in the lobby and confessed that he felt disappointed, not to say cheated (spoofed). According to him, the contents of the conference papers and discussions were not consistent with the title of the conference. The title was “integrated survey” or so, and something more, and this word apparently had quite a different meaning for my friend than it had for the conference organizers.

Therefore, I think that it will be good for me, as Chairman of this Conference, not only to say to you welcome on behalf of the whole organizing committee... welcome to our conference, welcome to Veldhoven, welcome to Brabant (the happiest province in the Netherlands)... welcome indeed—but I also have to explain what we think the title of this conference covers. We have not really started yet and, if it is not what you expected it to be, it is not too late to leave and spend your days more fruitfully, e.g., by walking through the beautiful Brabant landscapes in spring—or something else.

The main topic is “land(scape) ecology.” Indeed, I found during the 20 years I have been using the term that it does not cause identical vibrations in the heads of different people. Indeed, there is no common opinion whether the discipline indicated by this word belongs to biological or geosciences. It will be good to clarify the concept as it is used in the title of this conference. This does not mean that I will give a treatise here on what it really means, or what it originally meant. Others will probably do this in the coming hours and days.

At present, it is more important to see how the term is actually used now and especially by the conference organizers. I can tell you that there is no strict narrow definition that fits the concept in such a way that we all have exactly the same vibrations in our heads. We have seven committee members, all Dutchmen and hence with seven different types of vibrations. This difference also comes from different educations. Some of us are biologists, others are geographers, again others are educated at our famous agricultural university.

We floated together because of using the term and being members of the WLO (our “working group on land(scape) ecology”) or Netherlands Society for Land(scape) Ecology, the society that also organized this happening since it—three times three years ago—emerged from the Dutch consciousness. The present body of members (approximately 500) consists of biologists, agriculturists, conservationists, physical and social geographers, city planners, urban planners, landscape architects and foresters—working at private research and consulting institutions as well as universities and governmental institutes, for research, planning and decision and policy making and elsewhere. This variety of people—with very different scientific backgrounds and present professions—jointly rallied around the banner: “land(scape) ecology.” This, I think, expresses better than any definition what “land (scape) ecology” really means.
Nevertheless, I have half an hour to convince you that you should not run away, despite the nice spring weather—even if you agree with me that the name of our congress is wrong. If you scrutinize the titles of papers, workshops and posters, you may note that the subject is "landscape science and its application." Indeed, it would be proper use of language to call the activity of our WLO "landscape science." As with many sciences, landscape sciences can also be subdivided into a series of aspects: land morphology, landscape classification, land chorology, land chronology—dealing with, respectively, the form (description), systematics (taxonomy, classification), distribution and spatial aspects, the time aspect and development in the fourth dimension of land.

Finally, then, the study aspect of the interrelation of all components in time and space could then be called landscape ecology. Vegetation science is also subdivided in an analogous way. In that case, someone who is making landscape maps would then apply landscape chorology in combination with landscape classification to describe the legend, but not landscape ecology.

In practice, however, the common landscape scientist "in the street" is called (and calls himself) a landscape ecologist, just as most vegetation scientists (who hardly apply ecological study in the strict sense) are called "ecologists" as long as we speak English—which we do at this congress. Still, I agree that "perspective in landscape sciences" would be more correct, although less clear—as I will explain below.

I have asked various landscape ecologists what they do and think when they are working. I got approximately 20 answers, varying in length from one to several pages. I restricted myself purposely to Dutch landscape scientists (ecologists) because our guests from other countries will have the opportunity to give their opinions during this congress.

The following analysis is largely based on a personal interpretation of what those 20 answers contained and from what I already know from personal discussions in working groups and elsewhere.

It seems that the majority of our WLO members are biologists. The term ecology is considered by many of them as their own disciplinary property that may not be misused, which is opposite to certain German ideas (cf. Tienemann). Hence, according to them, landscape ecology is a special kind of ecology; hence it is biology only on a bit larger scale. We could say landscape ecology is ecology (hence biology) on landscape scale. This may be true for the zoologist and the botanist; it is also true for the phytocoenologist or vegetation scientist, who—in the Anglo-Saxon jargon—is often called "ecologist."

For many of them, landscape ecology is an "aspect science" rather than an "object science." The object of these scientists is either the individual plant or animal or the vegetation but not the landscape. They study the interrelations in the landscape between their beloved objects and their environment. The "environment" is the action from these plants and animals as well as from the abiotic part of the land. The bond with landscape scientists is that they are aware that all actions in the landscape together form a system of relations—an "ecosystem"—in which no individual action can occur without influencing—directly or indirectly—the others to a certain or even large extent.

The opposite of the "aspect ecologists" are the pure "landscape holists." They consider landscapes of a certain size as a whole. Their objects of study are not the components (elements, attributes) of the land, but the land units (ecotopes, land systems, etc.) as a whole. They are real landscape scientists in the sense that they will describe the landscape morphology and then use the forms to be used as characteristics for a classification. They will map landscape units and study their change in time. Finally, they will also study the interrelations inside their object of study on various scales, the real landscape ecology in the strict sense. For them, landscape science is an object science, even if the term landscape ecology is used for the whole.
I doubt whether pure holistic ecologists exist in the Netherlands; that is, people who consider land(scape) almost as individual entities—as organisms, rather than organizations. A much larger group, however, uses the holistic concept in a more liberal and practical and less fundamental way in the same manner soil scientists consider and classify their soil bodies and pedons. Although the latter know that soil taxa are unique locally formed products (of rock, water, climate, vegetation, fauna, relief) that in any other place may be formed in different ways and have not links of heredity whatsoever, they nevertheless classify them as “wholes,” analogous to living organisms, which are real holistic wholes. Vegetation scientists usually treat their object in the same way as soil scientists do theirs. On the contrary, soil chemists and certain plant sociologists and most other botanists will consider each soil type or vegetation type as different combinations of individual components; only the latter are of real interest to them.

Vegetation and soil surveyors, especially those from the “Edelman school of physiographic soil surveyors,” are close to—and very often are—the practical holistic land(scape) scientists. They study correlative complexes or ecosystems above a certain scale which are considered identical with land(scape). In fact, it was the soil scientist Edelman who re-introduced the land(scape) concept in the post-war Dutch scientific world. Geographers, like my brother Jan, had to fight an anti-land(scape) paradigm in the physical geographic world in the 1950s when only geomorphology was important and landscape was a dirty word. Now most biologists and geographers agree on the statement that land(scape)s are more or less complex ecosystems. Ecosystems are not always land(scape)s, since they may be too small or do not have enough “land” (e.g., ocean ecosystems).

The practical holistic land(scape) scientists and ecologists will use the hypothesis of homeostasis, learning that land(scape)s, like all organisms, have a certain self-maintaining power. The land(scape) ecosystem is supposed to have a system of positive and negative feedbacks built in the relation network that keeps it constant for a considerable time. Certain land(scape)s may easily remain constant because they are stable: that is, they have a certain resistance or resilience against external (especially human) factors. Others are much less stable; they are “labile” and can be constant only if the external environment does not change.

These are important subjects in applied land(scape) ecology. They also provide one reason why we have only one language at this conference. I once attended a congress with multilingual translation. Most interpreters mixed up both concepts—constancy and stability—in those speeches where the first was used to indicate an actual situation and the latter for a property in relation to an external attack. The other valid reason for not having multilingual translation is because we do not want to spend money for it, and our Belgian friends will agree that we are like that.

Still, everyone knows that each ecosystem changes—quicker or slower, that each individual ecosystem is a unique compilation of locally working factors that may be explained from its attributes, elements and their interaction, and that one ecosystem in time as well as in space may merge into another, and so is far from being an organism.

Not only vegetation and soil scientists but also geographers belong to our land(scape) ecologists. Some of them just continue their pure geographic activity—which they consider to be the study of the land(scape) as a relation system at the earth surface, including all features (including man). Others specialize on certain relations with emphasis on pattern and process in abiotic aspects as a counterbalance and supplement to the one-sided biological interest of biologists using the term land(scape) ecology for their work. I do not need to mention that geographers often claim land(scape) ecology as an aspect of geography. Is land not the object of geographers? Certainly not all geographers, however, are holists. Especially social geographers have a tendency to sneer at those “simple minded generalists” who too easily see wholes where in reality very complex unpredictable factors are acting.
When we look at the approach of the various scientists, we may observe that most biologists start to talk about land(scape) ecology only when they study the horizontal (better chorological) relations between land(scape) units (between individual ecosystems). The study of vertical (local, topological) relations does not, in their opinion, belong to land(scape) ecology but to biology, even if mesologic ecology (the study of abiotic environment of factors) is included. For others, certainly many geographers, both topological and chorological studies belong to land(scape) ecology.

In these concepts, the more pure and detailed studies of ecosystems—even the genesis of soil, vegetation and landform—separably belong to land(scape) ecology although no one will object to also calling these activities soil science, vegetation science or geomorphology. The more detailed the scale, the less land(scape) ecology is an appropriate term; the more global the study, the more certain soil, vegetation and geomorphology studies may be proper land(scape) science.

Another group of users of the term land(scape) ecology have a different descent. For them, ecology has to do with application, especially in the fight against deterioration of the environment. In non-scientific jargon, ecology became almost identical with conservation.

Land(scape) ecology would then be “considering the land(scape) from a conservation point of view.” The key concept here is application on behalf of the society.

Finally, there is still another very important group of land(scape) ecologists—those who often do not call themselves by this name: various kinds of agronomists, foresters and rangers dealing with the study of the land with a main aim of increasing production or achieving a sustained yield by manipulation of the land(scape) factors—water (by drainage and irrigation), vegetation (by sowing, selection or managing), climate (by shelter belts and others), soil (by fertilizing, levelling or other “improvements”). If they do it well, they are applied land(scape) scientists. In a country like Holland, however, they may be considered by some biological-conservation ecologists—and by themselves—as an opposite category of scientists counteracting “ecology” and refuse the name “land(scape) ecologist.”

I, myself, have no problems with the content and name of what we do. Perhaps this is because I did not study at a biological or geographic faculty and hence was not brainwashed by narrow scientific chauvinism. I received my ecological education from famous soil scientists, vegetation scientists and foresters, and in the practice of agriculture as well as conservation.

This conference is held to promote contacts between scientists and appliers of all these types of concepts and activities. For me, the banner—the name—does not matter. Land(scape) science, as such, can exist only if geologists, geomorphologists, social and physical and historical geographers, plant geographers, vegetation scientists and other biologists, pedologists and hydrologists, climatologists, agriculturists, foresters and landscape architects and many more disciplines work together. None of these will tackle the land(scape) completely. Each discipline has its own contribution, never mind whether the approach is holistic or more forward one disciplinary.

Each attribute may be the contact point for wide ecological study: geology as well as vegetation science, soils as well as climatology, the visual land(scape) aspect as well as hydrological cycles. There is nothing against calling activities land(scape) ecology if they are carried out in one of the disciplines focused on each of the separate attributes—as long as the study is done for, or at least as long as the mono-disciplinary scientist is aware of, contributing to the understanding of the land(scape) as a system of relations that cannot be understood fully from one discipline alone.

For those who claim that in this case “ecology” may be used only if real relations are studied, it may be noted that someone who carries out pure classification or chorology (mapping) uses ecological guidelines, and has at least ecological intentions; that is, he
does not classify or map as a game in itself but for the purpose of collecting and arranging data for the study of relations (ecology) or prediction (evaluation).

When we recapitulate the preceding statements, a sound reason emerges for preferring the term land(scape) ecology instead of land(scape) science for our congress. Those biologists studying land(scape) ecology as an aspect science (biology on landscape scale) may refuse to be called land(scape) scientists which would suggest that they are geographers and they would stay away from our congress. Still, their contribution via ecology (and also classification of vegetation and study of population and distribution or organisms) is vital for land(scape) science in all its aspects. On the contrary, most land(scape) scientists will agree that the integrating aspect of their object of study is the core of it and will not be too angry when they are called land(scape) ecologists. Similarly, most vegetation surveyors are getting used to being called ecologists. Finally, the outside world—the users and the interested laymen, the decision-makers and money-suppliers—will be less confused by the name land(scape) ecology than by land(scape) science. The first appeals to the integration and conservation aspect, more than just "science" or land or landscape. The latter word is already difficult enough. Our recent experience confirms this—when we discovered that a ministry which we approached for some funds at first refused because "landscape" is "some esthetic luxury that for developing countries should have no priority;" money should instead be spent on production or conservation of food and mineral resources. The government can hardly be blamed. Landscape is too wide—another word that must be explained every time it is used. My habit of putting "scape" between parentheses comes from this "traumatic" experience.

If we agree at this point, we should consider the consequences. These are that land (scape) ecology is a term indicating study of land(scape) as a (complex) ecosystem which ranges through an object to an aspect discipline, that belongs to bio- as well as geosciences, even including human sciences as well. Depending on the scientist, the institute he belongs to and the detailed studies done, geographers as well as biologists, soil scientists as well as any geoscientist, may claim it as their own discipline.

It is the integrated character of our earth as a complex ecosystem that leads to this non-analytical indication. There is only one serious danger. Research costs money and manpower. Traditional science of the last century was analytical. Practical boundaries to create some order in the scientific circus became separating walls so high that many scientists cannot look over them anymore. What is worse, the policy-makers have started to believe that these walls are not artificial tools for bringing some order, but are real existing items with their own value. Universities are still called universities. The universal character of sciences and their mutual gradual transitions, however, are often forgotten—or, even worse, denied.

Because of those artificial boundaries, proper allotment of manpower and material means is too often hampered. For somewhat too narrow minded people, it seems impossible that one is biologist and geographer at the same time. They think that money is spent along geographical or biological or any other subdivision and cannot be multipurpose. I am sure that in the near future, science historians will laugh about this futility, and when they read this will not understand why so much fuss is made about a name. Is it not clear that biology, geomorphology, soil science and all earth sciences and anthropological sciences should support land(scape) science and land(scape) ecology as a source of knowledge and method of study, as a means of knowledge, as a means of application of science for society?

Let us therefore look at this application. The human society "develops" in developing countries as well as in already rich countries. At one hand, man cries for changes and at the same time he longs for constancy (stability). Planning bureaus do their work, politicians and policy-makers try to steer it. Engineers try to implement the wanted change in cooperation with the common man on the land and in the street.
In land(scape) ecological terms, this means that Man (individual, society) considers himself as not occupying the proper place in the earth ecosystem—or the ecosystem does not optimally fit man. The basis for development, then, is:

1. Research about where man does stand in the ecosystem.
2. Research about where he would prefer to stand.
3. Study of where he could stand (because what he likes may not be possible).
4. Search for the means to get him there—by changing the environment and changing himself (schooling and also, e.g., its superfluous reproduction).
5. Finally, follow (monitor) the process of development or unforeseen degradation in order to see that well-meant activities do not result in the opposite—and which also provide knowledge about the fourth dimension (time).

All these steps require land(scape) ecology in one way or another. The crucial need is for an inventory of land attributes and elements as a basis for land evaluation in order to determine potentialities and carrying capacities for man, his animals, his poison-emitting factories and living quarters.

Agriculture is, for a large part, applied land(scape) ecology as an aspect science of biology. The land evaluation, treating land units as wholes with a carrying capacity or production potential, merges to application of land(scape) ecology (science) as an object science.

As mentioned above, strangely enough, many agronomists do not call themselves land (scape) ecologists or scientists. They are, however, although—as any other land(scape) ecologist—sometimes one-sided. Within land(scape) ecology, they sometimes need to be counterbalanced by more conservation-minded land ecologists (the majority of our WLO), partly merging into human-ecologist and plant and animal-ecologist. This is even more necessary the more modern mighty technology is applied in changing the land(scape) by purpose or as a side effect of reclamation, urbanization, industrialization or any other human impact on the land.

In the application of land(scape) ecology, one can distinguish four fields:

1. Promotion of production and quality of biomass (agronomy, animal production, horticulture, forestry).
2. Promotion of welfare (living environment in city and rural areas).
3. Conservation (wise use of resources, prevention of loss of resources) in the sense of (a) production and (b) natural and cultural values, national heredity (nature protection).

This conference will deal with all these applications after we have dwelled some time today with the basic theory.

I cannot end before mentioning another aspect of ecology. The oldest science is theology. Theology partly supports religion. That is, the belief of the deepest truth, the source of all that is and the way it is. Some theologians are believers, others are non-believers. Nevertheless, they use theology to study aspects of religion and so contribute to it. Among the faithful, there are the more strict ones (the purists) and there are the more flexible ones.

So it is with ecology. In addition to the science, there is faith—a faith in a natural equilibrium, which is good. We can speak about Ecologism in which land(scape) ecology
is the "theology." Among ecologists, there are believers and non-believers. Among the faithful are the more strict ones (the purists) and the more flexible ones.

The unbelievers also contribute to what the believers consider the base of their faith. For the believers, land(scape) ecology is the science that will show the way for a better life on earth for man, in harmony with all other elements and attributes—biotic and abiotic. They look for not only superficial applications, but especially for a basic theory that must supply a fundament of a new society.

Ecologism maintains the postulate that the present human society structure based on "economism," in east as well as in west, is the source of all evil. The waste economy, the technocracy, the faith in the problem solving capacity of more energy, the belief in unlimited energy, the "bigger the better" economy, the private as well as state-capitalism (as some sociologists call it), should be turned over because these sociological systems would be the main barriers to achieving optimal harmony on our planet.

One does not need to be a strict believer of such statements to agree, at least, that man and his structures and artifacts (the noösphere) is an essential part of the ecosystem—hence a subject of study of land(scape) ecologists.

Through the achievements of modern science, philosophy and science history, we know that science is not so objective and pure as 19th century scientists dreamed of. Scientific paradigm is just another word for the element of "faith" that blurs the pure "ratio." This knowledge shows that it is again impossible to draw sharp lines, in this case between ecology and ecologism. The human mind is like that.

It does not matter as long as any ecological scientist does his utmost to be as objective as possible in trying to prove his thesis about the relations in land(scape), and any ecological planner or engineer tries to implement—being conscious of what is known, what is believed and what is hoped, and aware of the fact that implementation is experimenting scale 1:1. It is a wide field that belongs to ecology and almost no scientist or scholar can be excluded from potential contributions. If geographers continuously fight about the delineation of their science against other disciplines, how shall land(scape) ecologists then be able to find a sharp boundary? And is it necessary? We as we are here know perfectly what we have to do. Or not...?

Let us include the ideas of one non-Dutchman in my speech—no one less than the man who invented the term land(scape) ecology: Carl Troll. When I asked him at our ITC symposium in Holland in 1966 about the delineation of land(scape) ecology, he said: It is not really something new. It is just an "attitude," an approach, a state of mind.

I think that is about the real answer. Any geographer, geomorphologist, geologist, soil scientist, vegetation scientist, hydrologist, climatologist, sociologist, anthropologist, economist, landscape architect, agriculturist, regional planner, civil engineer—even general, cardinal or minister president, if you like—who has the "attitude" to approach our environment—including all biotic and abiotic values—as a coherent system, as a kind of whole that cannot really be understood from its separate components only, is a land(scape) ecologist. This attitude provides a base for cooperation, national and international, even for initiating an official international association or possibly a journal as we will discuss this week.

That means, dear audience, that all of you who have responded to our invitation to come here have no reason anymore to leave. So I wish you a fruitful discussion and refreshment of your mind for your own benefit and through that for the benefit of our world—which with its present exploding population is in such a critical situation. Moreover, for those who still want to leave, the weather at the moment seems to be rather chilly.

I thank you for your attention.
Theme I: Theoretical concepts
Abstract

The author characterizes the development of landscape ecology. He distinguishes several stages while realizing the progress of methods and aims of the new concept.

In its "prehistory", which is the time before the middle of this century, C. Troll inaugurated the new concept. One couldn't rely upon a clear concept at that early time. But some fundamental problems were already discussed, which remained of interest till today. Among them are the connexion of natural and social systems in the landscape, the relation between individuals and types or other forms of abstraction and the problem of integration.

Since the time C. Troll formulated the ecological concept in landscape research, the following stages can be distinguished in the mental development of this new branch of the geosciences:

1. The stage of consolidation comprises the application of the new concept to all geographical dimensions as well as the foundation of laboratories, and the development of laboratory methods.
2. The stage of theoretical foundation;
3. the stage of structural analysis, the structural models;
4. the stage of dynamic research with dynamic models of changing landscape.

These four stages mastered have enabled landscape ecology not only to analyze each special case but they already allow it to predict the consequences of many human activities in the landscape.

The further stages in the future will be anxious to stabilize the steadily growing field of landscape ecology, to organize interdisciplinary cooperation, to elaborate on special programs for partial systems, and last but not least to create a theoretical base for synthesis. Thereby an aim, still distant may be prepared: We all know that the specialization has destroyed the unity of scientific imagination. I suppose, that landscape ecology could become one of the ways to a renewal of synthesis in science.
Introduction

Speaking about the perspectives of landscape ecology, first we must find a common base for the discussion of the problems. For no doubt this young branch of sciences has arisen within the large field of geography, but it has incorporated many elements from other disciplines, especially from biology. However, the position of landscape ecology amongst other geosciences is not yet generally acknowledged.

Landscape - this old word of German origin - has got a new dimension since it has become the subject of a new scientific discipline. Of course, it is not possible to understand the methodological problems of today and even less the perspectives in the future, if we are not aware of the problems history. The nature of landscape has been disputed for a long time.

The discussion about landscape took place only in German geography, because the equivalents of this German word in other languages do not mean the same. In other countries similar problems were discussed in the frame of regional geography. We may notice that great differences existed with regard to the points of view and also the goals of landscape research. We can say that the development of landscape studies was a process of trial and error. For this reason it is necessary to study the former literature on landscape research, in order to avoid repeating errors nowadays and also to learn from the good ideas of earlier times. Certainly we cannot expect to find a clear progressive line with different stages in the conceptual development. Because it lacked a sufficient theoretical base, this early period could not rely upon an obligatory concept. Only since 1959, when C. Troll introduced the term landscape ecology, did we have a common theoretical foundation. Therefore, we also must take into account the interesting results of former times. These findings we call the "prehistory" of our discipline.

The "prehistory" before 1950

We begin with Alexander von Humboldt. His excellent descriptions of the landscape sceneries in South-America were not only a documentation of his expedition, but they also formed the basic material for his scientific pioneerwork, especially in phytogeography and climatology. Last but not least, he gave a new interpretation of geographical regions, emphasizing their complex character and the interdependence of their elements. We learn from this famous explorer that till now critical observation and subtle description are indispensable presumptions of all landscape studies. Today we must struggle against the opinions of some young geographers who deny this old experience. Their attitudes would destroy the spiritual foundation of our ecological concept.

We meet quite another aspect in the work of Otto Schlüter. At the beginning of this century he was anxious to develop a regular method for the description of cultural elements.
in the landscape. His inquiries eminently favored the development of the historical geography of settlements. But it has not been very effective in the theory of landscape. In general, especially the analytic oriented geosciences have a greater attraction than the more complex landscape science, of which the theoretic foundations are not yet sufficiently elaborated. Several of my students have become experts in soil sciences, but not in the vague complex field of landscape research. The work of Otto Schlüter deals with cultural aspects of the landscape, and thereby it demonstrates a different central problem of landscape research. Does landscape ecology comprise only physiogeography or biogeographic items? Or does it likewise include the numerous influences of man upon the natural systems? In the first case it would be a part of physical geography; otherwise it would represent a quite new overlapping aspect of geography altogether. Originally, the first concept dominated. However, considering the program of this congress, it is obvious that the second case has been finally successfull. Human activities have such a severe impact upon all interconnections and interrelations in the landscape that a limitation of landscape ecology to merely natural facts would lead to sterility of our work. The very problem remains the same: how to find the logical context between the natural and social processes. This problem includes the transformation of statements from different kinds of causality. That is possible, because in similar way both nature and human labour deal with matter and energy. This problem of transformation must be solved in each case, if we are to find effective solutions to theoretical or practical problems.

Siegfried Passarge created a system of "Landschaftskunde", which was both descriptive and explanatory. But the preponderance of classificatory elements, the use of complex terminologies in his descriptive system, and even more the lack of a new theoretical concept inhibited a complete success. The failure of Passarge's "Landschaftskunde" shows a very important effect: Classifications might be useful in putting knowledge into an order. But they never can substitute the creative ideas of a science. The elastic mode of geographic investigations is thereby transformed into a rigid one, which is less suitable for practical applications.

In the thirties, German landscape research focused on regional divisions and on characterizations of natural units. These activities sponsored by J. Schmithüsen culminated in the great work "Handbuch der Naturräumlichen Gliederung Deutschlands", published 1953 through 1961. Certainly this standard work demonstrated the excellent cooperation and organisation of geography in Germany. However, the theoretical foundation remained the same as in the former period. It was characterized by descriptive methods and completed by causal explanations with regard to genetic and dynamic relations. The ecological concept was limited to plants as indicators. In this work more deductive statements were to be found than inductive studies, which employ
measures and quantitative characteristics. Furthermore, this concept did not consider the idea of a budget of matter and energy in the landscape.

When in the midst of our century the ecological concept was inaugurated, a new era of landscape research began and landscape ecology developed. It could rely upon a common theoretical base. Nevertheless, the unsolved problems of the "prehistory" remained difficult tasks till now. For the sake of clarity, the most important problems are summarized as follows:

1. the relations between natural and social facts and processes, including the problem of transformation;
2. the great number of possible aspects;
3. the entity of hybrid systems and the quality of integration.

Landscape ecology can only exist if it primarily acknowledges this large scope of aspects as well as methods. This acknowledgment implies a strong and obligatory concept, namely: all questions must be related to the metabolism of matter and energy in natural units. These might be in physiogeographic or biogeographic systems without the impact of man - or in very complicated systems with great human impact. In our industrialized countries this kind of metabolism will be predominantly a geotechnical one, that is a metabolism between technique and landscape.

The stages of development till 1980

The inauguration of a new concept does not implicate that the old concepts immediately cease to be valid or that all necessary new methods are available at once. For some time both the old and the new concepts will exist side by side and even occasionally they will augment one another. Eventually, the consolidation of the new concept will emerge. Three requirements must be fulfilled. Firstly, the new concept must be applicable in all geographic dimensions. Troll and later on Lauer (see the construction of Isohygromenes and their significance for the character of the vegetation cover) demonstrated the validity of the concept for the physical zones of the earth. Some geographers in Germany also verified the validity of the ecological model of landscape analysis in small regions and in a large cartographic scale. Besides this, many descriptions in former landscape literature nowadays could be ecologically re-interpreted. Consequently, each geographic dimension could be investigated employing the principles of the landscape-ecological concept. The second premise for a general application of the new concept was the problem of how to derive different types of data, which the new aim of landscape research demands. The common way to make use of the material collected by special geosciences was not practicable. These collections of data do not sufficiently meet the special requirements of our discipline, neither with regard to the peculiarities of an area, nor with regard to density of the measurements nor with regard to their distribution over the
This work is to be done by the geographers and the ecologists themselves. Therefore the geographical institutes of the universities necessarily established laboratories which made them independent from others and allowed an adequate research. A pioneer of laboratory work was Jan Pieter Bakker in Amsterdam, who was probably the first one being interested in sedimentologic analysis for the purpose of climatological geomorphology. At the beginning of the fifties laboratories in geographical institutes were unknown. Today, most likely even geography departments have such a tool for the analysis of geographical complexes. Only after these three premises were realized could landscape ecologists begin to work. This first stage of landscape ecology can be characterized as the stage of consolidation.

In this stage of consolidation the first tests of the new methods took place, accompanied by an important increase of pedological studies. Hence the second stage emerged: the development of a theoretical foundation.

This theory differs from older theoretical framework in geography. Instead of general relations with mostly stochastic or probabilistic character a greater exactness is now possible. The measurement of geographic features and the numerical values, which now are available, allow the strict application of the laws of nature. The interpretation of a good deal of these relations consequently may be understood as determined. Thus, landscape ecology could obtain a higher degree of certainty of its findings and in many cases it even could produce results of prognostic value. Hence, the main function of the topological method is to yield a more stable foundation, so that estimations of consequences also become more certain. However, further theory must prove the nature of the heterogenity of chorological units, whereas many new terms must be defined.

On such a theoretical base it was possible to erect a whole system of landscape ecology with a regular representation of individuals and types of homogenous (topic) and heterogenous (choric) units. A great number of case studies were published and cartographic documentation became quite a new line within the cartography. Indeed, this comprehensive work focused only on the structure of landscape units. We may label this epoch the stage of structural research.

Soon it was clear that the administrative and planning authorities made only small use of the knowledge. But all complaints did not help, for the information about structural features which was gathered did not correspond with the needs of these institutions. They wanted to have an answer to the popular question "what will happen, if..."? The structure itself does not give information about the impulses inducing the processes in the landscape, it only portrays the external conditions which influence the occurrences. The task of planning, however, is to know the processes leading to changes in the landscape, to predict their inevitable effects and to take actions for desirable solutions. But in this stage landscape ecology was not able to satisfy these requirements.

Thus, the ecologists were anxious to prepare dynamic models
alongside the structural models. This new step produced many curious new questions which had to be answered. Firstly, we must distinguish between dynamics in different connections. There are forces within a system which may be defined as the sum of relations of the system and cause its stability. Practically interesting, the dynamics are the sum of those special impulses that disturb the equilibrium of a system and lead to changes of the status. The clarification of these internal dynamics is one of the tasks of structure research as it explains the stability of a given structure. The external dynamics mostly result from human activities and are very diverse so that the number of possible impacts is very great. Consequently, the principles of dynamic behaviour in this case are only to be found by special and very exact case studies. Secondly, it is nearly unlikely to taylor models which illustrate very complicated examples. Therefore, additional investigations or respective field studies are necessary, whereas the dynamic model itself must be restricted to the close relation between the inducing force and its consequences. A scientific result is only to be expected, if no difficulties diminish the determinism of the statement. The complex situation in each concrete case can only be clarified by the combination of several impulses. Surely, it is a little troublesome to accomplish such an analysis, but it is the only way to efficient solutions of real world problems.

Fig. 1: Course of a process changing landscape (Neef)
Fig. 1 shows a scheme of the course of a changing process. Initiated by human actions, innovations arise through some new features which we call initiators. They are the starting points for new developments. These new elements of human work appear in nature as changes in natural conditions. Mentally, we must transform the human activity into the impulses upon nature. The impulses disturb the existing equilibrium and new processes come into being. These new processes are dependent upon the conditions of the affected area, called the field of employments events, which are not necessarily identical with the units of the ecological structure. The results of these processes are phenomena of varying kinds. Some of them may even be detrimental. In this case the observation of the disturbing situation induces feedback to the social sphere. This cognitive process subdivided into perception, evaluation, and decisionmaking results in human actions in the landscape with the purpose of avoiding greater disturbances or compensating for unpleasant effects.

This improvement on our methods by employing the dynamic type of model and the insight it gives us into the course of the events in the landscape provides us with the skills to predict the effect of human actions, planned or in progress. Especially the early prediction of any side-effects, which have a great influence on the quality of the environment, is of very great importance. This present stage in the development of our ecological thinking may be called the stage of dynamical research.

Expected stages to come

In the future the development of landscape ecology will continue. The present state of our work will decide the tasks of the next stages. Therefore it may be an advantage to determine which peculiarities of the problems are decisive and require a thorough solution.

The first look displays a very large scope of objectives and of problems and their relations. It also shows a great number of participating sciences. Unfortunately, this includes diverging interests and thereby the danger that discipline-specific tendencies could lessen the vigour of the common concept. We should not forget that single disciplines tend to overvalue their special tasks against the common ecological aspect. Originating in different sources we find that the basic suppositions of "side-by-side/or" and "and/or" are superseded by a dogmatic "either/or". This is diametrically opposed to the principles of landscape ecology. It would hinder us in recognizing the multiplicity of the interrelations and interconnections in landscape units and in respecting the admissibility of varying aspects.

It is necessary for landscape ecology to receive specific information from other sciences. Whose suppliers do not belong to the community of ecologists. However, this information is suited to the needs of the other sciences, and must be transformed as to emphasize their function within the scope of ecological relations. As one can see, the princip
les of landscape ecology can be dealt with from many different angles. Therefore, the basic ideas of our ecological concept must be exactly formulated and strictly observed. Otherwise we must fear that landscape ecology could be divided into separated parts.

Thus the most important task of the next stage will be the stabilization of our work by conceptual creative thoughts and by original field studies. This task also demands a thorough organization of the interdisciplinary work, comprising all directions which contribute to the complicated research in behalf of the new concept. Moreover, this cooperation includes the elaboration of special and detailed research programs for each single aspect. Therefore we expect, that the next level will be a stage of stabilization by organization. This may be the place to make some comments about the papers to be read in Section I: theoretical questions. Altogether they reflect the broad spectrum of the problems involved and reveal the widening of aspects. They also show us that we need a clear theoretical foundation. Moreover, the need of methodical help by experiences made in allied sciences (Biology, Information theory) is indicated. Besides this, some important desires are mentioned. There is the demand for the application of ecological experiences in landscape planning. This promises a more subtle analysis of the dynamic landscape processes and the capability of predicting the changes in the landscape.

Ecology should be developed into ecodevice. But to succeed in this direction, more exactness in the survey and a better access of the data banks on other information systems is necessary.

This high degree of complication does not only render our tasks more difficult, but it also proposes new and uncommon theoretical questions. Very complicated systems allow different methodical ways of inquiry and representation, which exclude one another, so that they cannot be combined at the same level of information. Niels Bohr, the famous physicist has created the term "complementarity" (Komplementarität) to describe the exclusiveness of the representation of nuclear phenomena, either by corpusculae or by waves. This term complementarity has been used in other sciences, too. In the field of landscape ecology analogically non-consistent approaches are to be found. But they all contribute to the understanding of landscape problems, especially if we make a synthesis of a whole "ensemble" of a landscape unit. These inevitable combinations demand special considerations of the methodological type. Some hints: Analysis and synthesis no doubt are two ways of cognition and belong to one scientific process. But the analysis destroys the complex fact in question, and only the way back to the synthetic reality gives the right understanding. In landscape ecology both methods of inference, deduction and induction are used. Scientific progress often depends upon the way the different methods are combined. In a similar manner the terms concrete and abstract, individual and typological are complementary. The theoretical development of landscape ecology must be focussed on the important problems of syntheses. This aspect, however, has been so oftentimes neglected in methodological
literature, that not even one textbook on synthetical methods in landscape ecology or geography can be supplied. With regard to these methodological problems another statement seems to be relevant. Landscape ecology primarily is the inquiry of actually existing parts of the earth’s surface. Field studies and local investigations reveal the whole variety of facts and relations, but by abstraction many useful pieces of information get lost. The intensive study of concrete cases will warrant the progress of our science, especially if it is directed upon more complicated cases or upon the balance of the geotechnical metabolism of a greater region.

Conclusion

Finally we must discuss quite another problem of the development of landscape ecology: Its position amongst the other geosciences. It is likely that landscape ecology could make an important contribution to science as a whole. It is well known, that the branches of science altogether have produced quite an immense quantity of special knowledge, which often has been characterized as atomised. In spite of all scientific progress and the widening of our knowledge, the management of the great problems of man in his environment has not yet succeeded and the research in this field has hardly begun. We might see the origin of this situation in the differences between analytical and synthetical aspects in the sciences. The clear preponderance of analytic thinking and the claim of judging other sciences and their concepts from this standpoint of view, have hindered a free and equal development of fields thinking different. These branches of science, however, focus on the great units with the highest degree of complexity and therefore deal with synthetic problems. Landscape ecology could become one of the synthetic sciences of the future, able to integrate many analytic findings into synthetical scope of general interest. I suppose that the removal of the discrepancy in the methodology will be an effective impulse for the application of our results. This will be a very long way to go, but in our minds we should get prepared for reaching that distant goal.
Science on the whole is always in search of components of the universe, which, somehow, show the extrinsic property of 'usefulness', 'suitability' or 'value'. In pure science the component involved at least has to be suitable for research purposes as such. In applied science usefulness plays a leading role again, but this time in the well-known, more technical sense: can we use it or not for this or that technical purpose.

Parts of the universe, which prove to be suitable as a topic for scientific work, are generally looked upon as 'systems', while the conceptual systems, derived from these efforts, are named 'theories'. Such theories, of cause, have to be suitable for scientific purposes too.

On the other hand, those systems or parts of systems, which are endowed with usefulness for our technical aims, are presented here together under the collective noun of 'devices'. All possible kinds of natural or artificial resources (both in the sense of 'sources' and 'sinks'), should be regarded as devices, as for example: the sun, the air, water, rocks, soils, slopes, coal layers, mineral veins, nutrients, medicines, preservatives, plants, animals and human beings, physical organs, tools, machines, furniture, statues, weapons, books, libraries, roads, bridges, airplanes, rivers, dikes, buildings, fields, meadows, hedges, parks, forests, cemeteries, nature reserves, factories, dumps, communities, social organizations, laws, and so on ad infinitum.

After all, technical suitability merely forms a type of biological or, more in particular, ecological usefulness: no organism can live within an environment which is not useful or suitable for it. Therefore we suggest to speak of 'ecodevices' whenever attention is paid to those parts of their environment, which, no matter how, show suitability for living creatures, plants, animals and humans, be it on an energetical, material or informational base.

'Usefulness', shown by a device, also and even better can be described as its 'protective power'. Now, we have to realize that this power is always related functionally to the protective power shown by some other device, which, in turn, must be related functionally to a next one and so on.

When we say that 'device A is using device B', this means the same as 'device B is serving or protecting device A, or as 'device A enjoys protection from device B'. The outcome of this protection, afforded by device B, may be one out of three sorts:
1. It keeps the protective power shown by device A on its original level. We call this 'protection sensu stricto'.
2. It brings the protective power originally shown by device A back to its former level, after a lowering. We call this 'recovery, restoration or repair'.
3. It raises the protective power originally shown by device A to an even higher level than before. We call this 'improvement or amelioration'.

On the contrary, the use of device B by device A, will lower the
protective power shown by device B, which lowering here is called 'damage' ('harm', 'deterioration') or 'worsening', as the opposite of 'improvement'. Now this very decrease of the protective power as originally shown by a device represents what in the first place has to be counteracted by using the protective power of another device.

Since in this way no protection sensu lato, so including recovery and improvement, is possible for any device without bringing about more or less damage for some other device, we will be faced with the 'law of preservation of misery' and its tricky games everywhere in ecology, including the phenomenon known as 'human technique'. In the last case the so-called 'harmful side-effects', which, in some way, always result from taking measures, only form one out of its many expressions.

Speaking about functional relations, how can it be made clear what they really are? Well, within the source-sink relations between a system and its environment we distinguish 'input relations' when the system acts as a sink, next to 'output relations' when the system acts as a source.

These two types of relations, now are brought into combination with the idea that every system, conceived as a steady-state, is ruled by two limits of tolerance, namely one of minimally required (at least necessary in order to keep up the given steady-state) next to one of maximally tolerated (at most allowed in order to keep it up). This combination then produces four and no more than four possible types of 'disturbance', or, speaking of devices, four types of 'damage'. These four basic types are:

1. **Underfeeding**. The device as an actual sink receives too little input. It cannot get enough energy, matter or information from its environment in order to keep its protective power on the given level.

2. **Stoppage** (constipation, blocking). The device as an actual source gives too little output. It cannot transfer enough of something into its environment.

3. **Overfeeding** (pollution, poisoning, etc.). The device as a potential sink receives too much input. It gets too much energy, matter or information from its environment in order to keep its protective power on the given level.

4. **Loss** (deprivation, bereavement). The device as a potential source gives too much output. It delivers too much of something to its environment.

The four possible types of damage taken together are known under several names, such as 'disease', 'evil', 'complaint', 'suffering', 'misery', and in the worst case as 'destruction' or 'total loss'. Separately considered, the number of terms, dealing with special cases, seem to be almost countless.

Against these four types of damage, four types of protective power or what represents the same, four types of 'service' or 'function' can be distinguished. These four, and no more than four, basic types are:

1. **Supply** (feeding, adding). The function directed against underfeeding.

2. **Disposal** (removal, discharge, elimination). The function directed against stoppage.

3. **Resistance** (keeping outside). The function directed against overfeeding.

4. **Retention** (memory, keeping inside). The function directed against loss.

The functions 3 and 4, named resistance and retention, are able to protect the suitability of a device against transgression of its limit of maximum tolerance. Taken together they here are called the two
'defence functions', dealing with protection sensu stricto (the first type of protection mentioned before). These two functions prove to be defensive in relation to the environment of a device. They both serve the device involved as a screen against impediment or inconvenience and represent, in terms of selection and regulation, what is called 'prohibitive or veto-regulation' (it is not allowed). As a matter of fact, resistance and retention are defending the potential protective power which the device concerned contains for its environment by prevention from the actual use of this power. In such cases we often speak of preventing 'improper or undesired use'.

The functions 1 and 2, supply and disposal, are both able to protect the suitability of a device against transgression of its limit of minimally required. We call them together the recovery functions. These two prove to be offensive regarding the environment of a device. They both serve the device involved by fulfilling its desires and represent, in terms of selection and regulation, what is called 'prescriptive regulation' ('it must be done').

The recovery functions prove to be necessary in three different cases:
1. When resistance or retention are failing to prevent improper use from the outside.
2. When the level of protective power of the device involved has been lowered by proper use from the inside.
3. When former recovery has been carried out by means of wrong devices.

The same functions, supply and disposal, are also indispensable when 'improvement' has to be obtained. In this special case of protection both offensive functions together are called the 'building functions'. In terms of functional in- and output relations every act of construction or making is carried out by supply and/or by disposal.

What has to be constructed, of course, represents some new or better device endowed with protective power of some kind. When, for example, a bird builds a nest, it improves its environmental ecodevice by adding a special subdevice, which was lacking until then. This special subdevice, which in the first place has to serve by providing resistance and retention for its eggs and chickens, furthermore will be built either by supply or disposal, or both together.

My colleague, Mr. van Wirdum, has designed a very clearcut and instructive model showing the four functions in their mutual relations, thus representing together a complete ecodevice:
Now, by means of this model, we are able to show, for example, how internal problems, raised by the four types of damage, at least partially can be solved by crossing over from the failing function to its diametrically opposed-counterpart, then called the 'saver'.

So, when the supply function is failing, the threat of underfeeding may be compensated to some degree by switching over to the retention function: energy becoming scarce and expensive we try to compensate this by a better insulation of our houses in order to lower the loss of heat.

In the same manner failing disposal may be compensated by its opposite, the resistance function, failing retention by supply and failing resistance by disposal: when a ship starts a leak, it may be saved by pumping out the water coming in.

The Van Wirdum model is also useful when we wish to show how the external functional relations between two or more devices are working. So, for example, when a given device called B succeeds in using another one, called A, as a source in order to fulfill its supply function, then device A can only afford this service to device B if it itself gets damaged by bereavement, its retention function being broken through.

When, on the other hand, device A by its retention function succeeds in keeping inside what device B is hungry for, the last one will get damaged by underfeeding.

Of course we also know the special cases in which two devices are protecting each other, or, what is the same, are using each other. An example of this type of co-operation delivers the functional relation between a device A which has something to dispose, whereas a second device B wants this disposal as a supply.

Next I would draw your attention to an important difference in the way the two defence functions, concerning resistance and retention, are fulfilled when we compare the so-called robust ecodevices with those known as fragile ones. For by introducing this difference we enter the vast and complex field of modern land-ecology, where the functional relations between robust and fragile biotic communities, represent a topic in which many of us are specially interested nowadays.

In the case of robust communities, such as, for example, found in tundras, taigas, steppes and deserts, the concerning ecodevice to a certain degree can act as a sink, without being seriously damaged itself when it has to cope with the danger of getting overfeeded by its environment. In other words it then shows a great absorbing capacity. In the same way such a device is able to provide itself with a sufficient additional source when deprivation threatens. Thus, what has to go lost is supplied with redundancy, or, what is the same, compensated by supplementation.

So, in general, robust ecodevices are able to do their own job when dealing with the two defence functions, by crossing over from resistance to disposal and from retention to supply. This ability of shifting from the two defensive functions to their offensive counterparts within the total ecodevice, means that ecodevices of this kind are mainly working by their recovery functions in order to protect themselves against overfeeding or deprivation from the outside. Working by the recovery functions in the way just mentioned now appears to be characteristic of primitive and more or less simple communities bound to high degrees of environmental dynamics.

These types of communities, in the absence of defensive barriers being continually engaged with, so to say, keeping heads above water, are unable to develop sophisticated internal regulation mechanisms and therefore are marked by poorness in species, together with richness in
individuals. Here we meet those communities, which, according to C.S. Holling, show 'resilience' as the main strategy for staying alive.

Moreover, their robustness as such gives them the ability to serve other ecodesvices with regard to all of the four thinkable functions, without the chance that they soon will collapse. This is mainly valid in the energetical and material sense.

On the contrary fragile communities, such as tropical rainforests, coral reefs and several other ones, showing a relatively high degree of species diversity, as well as a large quantity of internal regulation mechanisms, are marked by a striking variety in specialization among their organisms, next to the importance of information considering the functional relations between them and also by the recycling of nutrients and materials within the community.

In this case we are dealing with ecodesvices which enjoy the service of external protection barriers keeping outside whatever is not allowed to enter and keeping inside whatever is not allowed to leave them, a service which provides the base for their internal development of spatial complexity. The supply and disposal functions being of less importance, the accent now lies on the resistance and retention functions. Here we recognize those communities, which, in the sense of Holling are using the strategy of 'resistance'.

But where do these external protective barriers come from? Well, answering this question is rather simple when we realize that the total ecodesvice necessary for such fragile communities has to contain robust subdevices somewhere outside the locality where they are living, which subdevices can serve as their furnishers of resistance and retention. These robust subdevices may be composed from parts belonging to the cosmosphere, the atmosphere, the hydrosphere, the lithosphere and the biosphere, and in the case of nature reserves, from components of the technosphere too.

So for a first small scale example we can look at the two slopes of a dunehill, on the luffside exposed to the seawind and the other on the opposite leeside, the last one protected against the wind by the sandbody of the hill. Comparing the difference between the relatively fragile community on the landward slope and the relatively robust one on the seaside, we have to consider that the ecodesvice serving the fragile community, spatially seen, not only consists of the slope on the leeside, where the community in question is located, but that it also includes the other, on the luffside. We could say that the last one, with its robust community, has to bear all the troubles coming from the seaside, and therefore represents an indispensable part of the ecodesvice serving the fragile community on the landward slope.

Looking at a sandy dune area between the beach and the hinterland as a whole, the robust outer dunes in the same way form an indispensable component of the ecodesvice protecting the fragile communities of the inner dunes against overfeeding and deprivation.

An example on a much larger scale we find in the functional relations between the two opposite coasts of an ocean around the equator. There the main direction followed by the circular ocean current near the surface, runs from east to west, while, along the bottom it goes from west to east, upwelling near the eastcoast and descending on the westside. The seawater rather heavily loaded with nutrients, on the way taken up from the ocean bottom and carried on to the eastcoast, there provides the base for robust biotic communities, which are marked by large masses of plankton, fish, seabirds, seals and whales. These communities, on account of their robustness, can also serve man as a feeding device,
be it, of course, to a certain degree.

But the very same robustness gives it a protective power in the sense of resistance when considered as in functional relation to the coral reefs on the other side of the ocean, marked by utmost fragile communities, which, being bound to seawater poor in nutrients, could develop their astonishing world of recycling mechanisms, combined with the ample use of information flows.

On a still larger scale, it seems likely to us that the tropical rain forests are functionally related to those parts of the earth carrying tundras, taigas, steppes and deserts, all of which are located within the total ecodvice necessary to make and keep the rainforests what they are. Instead of being indispensable for the rest of the world by their protective power in a energetical or material way the rainforests themselves completely depend on that rest.

In fact the only help these fragile and, with regard to their total area, rather small communities, are able to offer their far more extensive environment, lies in the field of information: man can learn a lot of them, assumed that, as often has been said already, he does not use this library by burning its books, in order to keep his feet warm.

Man now emerging into our scenery, I would like to end my theoretical contribution to this congress by posing a thesis with regard to the functional relations between our modern, in a technical sense so highly developed western civilization, and the earth as its environment. For I suppose that this civilization, because of its striking fragility in many respects, to-day cannot subsist without the use of a very large area serving as its robust ecodvice and consisting of, what are called, man-made steppes and deserts. The question whether this necessity has to be ascribed to the explosive growth of human population moreover, however probable, will be left unanswered for this moment.
INTERACTION AMONG LANDSCAPE ELEMENTS: A CORE OF LANDSCAPE ECOLOGY

Richard T. T. Forman*
Department of Botany, Rutgers University, New Brunswick, New Jersey, USA

Abstract

A landscape is a kilometers-wide area where a cluster of interacting stands or ecosystems is repeated in similar form; landscape ecology, thus, studies the structure, function and development of landscapes. The structural components, or landscape elements, are patches of several origins, corridors of four types, and a matrix. An example is cited which illustrates the importance of large patches in a landscape.

Landscape functioning is examined with the fluxes of energy, mineral nutrients and species between landscape elements. Patch-matrix interactions are numerous in type, often highly significant, either involving the edge portions or entire landscape elements, and are driven by wind, water and locomotion. When the patch is a human habitation, fluxes are primarily from patch to matrix, and depend on people and non-native species. Interactions between two separated patches of the same community type, or between connected patch and corridor, are mainly species fluxes. Line corridors and strip corridors strongly interact with diverse fluxes in both directions. Most stream corridor-matrix interactions are unidirectional and involve water and nutrients.

Rather than being isolated, landscape elements or ecosystems are linked, indeed thoroughly entwined, by fluxes with surrounding landscape elements. This central concept of interactions demands more ecological thinking beyond the concept of a relatively-homogeneous ecosystem, and a broadening of perspective by all concerned with land/land use and landscape ecology.

The Landscape Concept

If one explores within several hundred meters of a randomly-chosen point in a landscape, a variety of contiguous plant communities or ecosystems is generally encountered. For example, in the Pine Barrens of New Jersey (USA), one of the world's ecologically best-known landscapes, an oak-pine stand (Quercus-Pinus) is commonly near a pine-oak stand, a pine lowland woods, and a swamp (Harshberger, 1916; Forman, 1979a). Movement of energy, matter or species between adjacent stands is often readily observable. If one drives several kilometers away and again explores the immediate vicinity, essentially the same cluster of ecosystems is found. Upon leaving the landscape, the cluster of ecosystems near a point generally changes abruptly. For example, to the west the cluster is usually

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corn field (Zea), oak woods and old-field, or to the east, suburban
housing, salt marsh and dune vegetation. I believe such observations are
at the heart of the landscape concept.

Thus, a landscape is a kilometers-wide area where a cluster of
interacting stands or ecosystems is repeated in similar form (Troll, 1968;
Forman and Godron, 1981). The landscape is formed by geomorphological
processes and by succession and disturbance in individual stands. The
complex of specific geomorphological processes, and the complex of
successions and disturbances within a cluster of stands, are relatively
constant throughout the landscape area.

This concept of a landscape is generally complementary to those of
artists, geographers, and the dictionary see Sauer (1963), Neef (1967),
Mikesell (1968), Hoskins (1970), Eckbo (1975), Grossman (1977) and Meinig
(1979) for other landscape definitions. A specific entity with a
structure, function, and development is delineated. Such a landscape is,
therefore, not only amenable to careful scientific scrutiny, but it must
be so studied, if mankind is to use land wisely.

The landscape concept indicates that the stands of a cluster are
interacting, which is the focus of this article. My objective is to
examine the types of interactions between landscape elements, in order to
gain insight into what are: the major fluxes, the general mechanisms
prevalent which drive these fluxes, the types of landscape elements
primarily involved in the fluxes, and the situations where the edge
effect is primarily involved. Before examining the interactions, the
structural components of landscapes (Forman, 1979b; Forman and Godron,
1981) are briefly reviewed, together with a study illustrating certain of
the structural characteristics.

Landscape Elements: The Structural Components

Ecological Mosaic

Landscapes vary from a few kilometers to several hundred kilometers in
diameter, yet may be considered to represent a single level of scale in
space. Each level of scale is, in effect, an ecological mosaic composed
of patches which vary in size, shape, origin, distinctness, number and
configuration. Most mosaics contain narrow strips or lines which may
function, in part, as corridors. Similarly, most mosaics contain a
background type in which the patches and corridors are embedded, and
which may be considered the matrix. Thus, I recognize three basic
categories of landscape elements: patches, corridors and matrix.

Although this article touches on structure, and focuses on function, the
dynamics within landscape elements are also prominent. To a large extent,
these successional dynamics are caused by the fluxes between elements.
Indeed, with landscape elements undergoing different rates of change, the
landscape presents an enormously dynamic pattern.

Patches

Four types of patches are widespread at the landscape level (ephemeral,
i.e., especially short-lived patches, are mainly important at finer levels
of scale and, hence, are not considered here). Three of the landscape
Patch types are disturbance-caused. In essence, spot disturbance patches originate from disturbance in a small area, whereas conversely, remnant patches originate from disturbance of a large area surrounding an undisturbed small area. Introduced patches originate by people planting organisms in a small area. Environmental resource patches originate from the patchy distribution of relatively-permanent environmental resources through space. The causative mechanisms of these four patch types differ sharply, but the resulting species dynamics of the patches are just as diverse.

The size and shape of patches also differ greatly and have major implications on the nature of the ecosystems within. Though many factors affect their species diversity (number of species), larger patches almost always contain more species than smaller patches. Excluding the obvious sampling factor of increasing the probability of encountering rare species in a larger area, a major reason appears to involve the edge effect (Johnston, 1947; Jakuca, 1972; Wales, 1972; Dierschke, 1974; Galli et al., 1976). Small patches are all edge (Figure 1), that is, the ambient wind and associated meteorologic effects penetrate throughout the patch.

Figure 1. Patch interior and edge proportions as landscape patches vary in size and shape.

Intermediate-sized patches may be composed of appreciable portions of both patch interior and patch edge. Large patches, though containing somewhat more edge, are mostly patch interior. The ratio of patch interior to patch edge is useful in understanding the species diversity of the patch, because typically many species are predominantly in, or limited to, either the edge or the interior environment of a patch. This same patch interior-to-edge ratio underlines the importance of the shape of patches (Figure 1). Hence, peninsulas, strip patches and ring zones (e.g., vegetation belts on a mountain) contain considerably less interior environment than the same area in isodiametric form. In short, patch area and the interior-to-edge ratio are two major characteristics of patches.
A good example of these factors in a landscape is the study of bird and tree diversity in relatively-homogeneous old oak woodlots in a corn-and-beans agricultural landscape on the Piedmont of New Jersey (USA) (Elfstrom, 1976; Forman and Elfstrom, 1975; Galli et al., 1976; Forman et al., 1976). Tree diversity increased sharply in woodlots up to about a hectare and a half, above which the increase was slight. In contrast, avian diversity increased significantly up to at least 40 hectare woodlots. No tree species was limited to a specific woodlot size range, whereas half the avifauna was woodlot size-dependent, with bird species being progressively eliminated in proceeding from large woods to small woods. Above about a hectare and a half, where the area of patch interior and patch edge is nearly equal, few edge bird species were added, whereas patch interior species continued to be added up to the largest patches (Figure 2). This illustrates the particular value of large patches in a landscape, because of the many patch interior species which would be lost if only small patches exist.

Figure 2. Diversity of interior and edge birds with increasing woodlot size. Each point is an average of eight samples. See Galli et al. (1976) and Forman et al. (1976) for methodology and species recorded in each woodlot size.

It could be argued, however, in nature conservation that maximizing species diversity, irrespective of the types of species present, is more important than protecting rare species. Since small patches are more dissimilar in community composition from one another than are large patches (Elfstrom, 1976), one might expect fewer species in a single large patch than in the same area subdivided into smaller patches. Such was not the case in these remnant oak woods surrounded by agriculture (Forman et al., 1976). Species diversity was approximately constant with area increasingly-subdivided, and indeed, in the cases which included
large patch sizes (>4 hectares), diversity was somewhat greater in a single patch than in the same area subdivided into smaller patches. The large patch contained more of the uncommon, forest-interior species, whereas the several small patches contained more edge species. Overall, therefore, this example emphasizes that species composition, and especially the uncommon, patch interior species, provide the basic evidence underlying the central importance of large patches in the landscape, not species diversity.

Corridors

Four types of corridors are recognized, based on differing structure and function. Line corridors, such as hedgerows and roadsides, are narrow and provide migration routes and habitats primarily for edge species (Pollard et al., 1974; Les Bocages, 1976). Strip corridors, such as a cut for major powerlines, are wider, with an interior environment down the center which provides migration routes and habitats for interior species (Anderson et al., 1977). Networks are anastomosing line or strip corridors, which contain loops, and thus provide alternative pathways for migration, predator avoidance, foraging and the like. Stream corridors border waterways and help control nutrient runoff, erosion, siltation and flooding. Stream corridors may double as strip corridors, if wide enough to provide a strip of interior environment on well-drained soil.

Though these corridor types differ greatly in their structural characteristics as well as their functional roles, all are major integrators of the landscape. That is, patches are linked by corridors, and the matrix is permeated and linked by corridors.

Matrix

As the background type of a landscape, the matrix is usually extensive in area, highly connected, and exerts a major influence on the successional dynamics of the landscape (M. Godron, personal communication). A matrix typology useful in the context of patches and corridors is not, as yet, evident, and therefore the general matrix concept of a relatively-homogeneous background element will be utilized for the analyses below.

Interactions Among Landscape Elements

Mechanisms and Levels

Three categories of things move through a landscape: energy, mineral nutrients and species. Energy includes the calories in heat as well as those in biomass. Nutrients include inorganic ions, water, organic and other matter. Species include taxa at any level, as well as gene flow. It should be noted that these things may move in "normal" amounts, or in greater amounts as disturbances, i.e., sudden increases in amounts of energy, nutrients or species which cause significant community or ecosystem changes within a landscape element.

Energy is required to move all of these, and this energy comes from wind, water and animal locomotion (Van der Pijl, 1969). Thus, it is convenient to speak of the primary mechanisms causing interactions among landscape elements as the following: (a) wind, (b) water (including rain, ice, tide, surface runoff, stream flow, flooding), (c) flying animals, (d) ground animals, and (e) people.
The difference in vertical structure between two adjacent landscape elements tends to accentuate the importance of the edge effect in each. Hence, a clearing in a forest or a woodlot among fields has a wide edge in the wooded portion, as well as a wide edge in the field portion. In the examples of interactions between two landscape elements presented below, one element is portrayed as wooded and the other open. In most cases, the reader may arbitrarily choose which landscape element will be considered wooded and which will be open. Many of the prominent fluxes are illustrated, though a thoughtful reader will recognize several more.

Patch-Matrix Interactions

Many energy fluxes take place between forest and field, some of which primarily involve the edge portions, while others involve each landscape element as a whole (Figure 3A). The edge of the forest primarily affects

![Diagram of Patch-Matrix Interactions]

Figure 3. Major fluxes of energy, nutrients and species between patch and matrix. The patch may be forested and the matrix open, or vice versa. The edge portion of each landscape element is indicated with a horizontal dashed line. Dashed-line arrows refer to the edge portion and solid-line arrows refer to the entire landscape element.
energy flow in the adjacent edge of the field, by casting shade (Wales, 1972; Geiger 1957) and dispersing leaf biomass (Phillipson et al., 1975; Orndorff and Lang, 1981). In the opposite direction wind usually carries heat energy horizontally across an open area into a woods, a kind of oasis-effect. For example, this advection from a shrubland into a cedar woods in the Pine Barrens accounted for over five percent of the total summer energy input driving evapotranspiration (Ballard, 1979). In drier grassland, savanna, Mediterranean and desert climates, such advection is probably several times higher, effectively controlling the forest water balance and biota therein. A familiar energy flux is cold air drainage from landscape elements upslope to downslope at night. A reverse movement of air, based on heat stored in downslope peat, is described from the upper midwestern USA (Van Arsdel, 1967; Reiners, 1979). The energy inputs of animals, pollen (Bradshaw, 1981), seeds and fruits (Barrows, 1973) between landscape elements is commonly low on a unit-area basis, but is widespread and probably critical to the maintenance of certain species.

Therefore, from an energy flow perspective, the normal levels of fluxes between landscape elements appear of major importance in both the forest edge and the edge of the open area, due to different causes. Disturbance levels of these, and the other element-wide energy fluxes, are periodically present, and cause significant changes in either the patch or the matrix.

Nutrient fluxes between landscape elements are considerably more diverse and significant (Figure 3B). A net nutrient input in dead leaves from forest to field modifies soil conditions in the field edge. Numerous sources of nutrients accumulate in the forest edge, particularly after being transported by wind across open areas. Similarly ash, dust and aerosols carried by wind at higher altitudes are deposited throughout the wooded element (Grier, 1975; Clayton, 1976; Wiman, 1981). And nutrients enter both landscape elements as a whole, through a range of wind, water and locomotion mechanisms. In short, patches and matrix are commonly strongly interrelated in a nutrient flux sense, both at normal and disturbance levels.

Species fluxes between patch and matrix similarly are diverse and widespread (Figure 3C). The edges, particularly the forest edge, appear to play major roles in these interactions. Wind and locomotion are the primary driving mechanisms behind these fluxes. In the study of air movement in the midwestern USA (Van Arsdel, 1967; Reiners, 1979), rust spores on Ribes plants in the lowlands were transported to the uplands to produce a zone of white pine (Pinus strobus) blister rust. In a study of movements of vertebrates between woods and fields in an Ontario (Canada) agricultural region, Wegner and Merriam (1979) found that avian fluxes were generally low, but relatively constant, during their six-month study period. In contrast, small mammal fluxes were almost entirely one species at one time of year. Ungulates and herons are well-known examples of animals using both wooded and open areas (e.g., Georgii, 1980; Bent 1926), and agriculture is rife with examples of weed and insect pests invading a field from the surrounding matrix (e.g., Glass and Thurston, 1978).

Overall, whether the patch is wooded and the matrix open, or vice versa, normal levels of interactive fluxes are (a) extremely diverse, (b) in some cases at a high, and in others a low level, (c) driven by wind, water and
locomotion, and (d) in some cases primarily important to the edge, and in others important throughout the landscape element. Disturbance levels of many fluxes are probably common, and further affect the nature of the patch or matrix ecosystem.

The special case where the patch is a habitation, including a dwelling, yard, outbuildings and immediate surroundings, shows a very different pattern (Figure 4). The fluxes are primarily from the patch to the matrix

HABITATION-MATRIX INTERACTIONS

INTRODUCED PLANTS COLONIZE
DOMESTIC ANIMALS FORAGE
PEOPLE HARVEST NATIVE SPECIES
PEOPLE INTRODUCE DISTURBANCES
PEOPLE STOP NATURAL DISTURBANCES

PATCH - PATCH INTERACTIONS

ANIMAL FORAGING
PLANT, ANIMAL COLONIZATION
PEST INVASIONS

PATCH - CORRIDOR INTERACTIONS

PEST INVASIONS
ANIMALS, PLANTS DISPERSING
RECOLONIZATION AFTER EXTINCTION

Corridor Patch

Figure 4. Major fluxes between habitation and matrix, between separated patches of the same community type, and between patch and connecting corridor. See legend for Figure 3.

(Elton, 1958; Salisbury, 1961; Forman and Elfstrom, 1976; Gilbert, 1980; Liberg, 1980). Overall, the mechanisms driving these fluxes are people and non-native species, and the fluxes mainly, though not exclusively, involve species, rather than energy and nutrients. Fluxes in the opposite direction are also present, particularly native species which enter and feed or germinate in the habitation area.

Patch-Patch Interactions

The interactions between two separated patches of the same community type result mainly from locomotion, and to a lesser extent the action of wind (Figure 4). The transfer of energy and nutrients, in general, appears insignificant. In contrast, the movement of species plays several roles. Animals, particularly specialists, may forage from patch to patch.
(Royama, 1970; Krebs, 1978). For example, small mammals move from woods to woods, or a bird or insect may feed in scattered clearings within a forest (Thompson and Willson, 1978). When a plant or animal species becomes locally extinct in a patch, recolonization by species fluxes from a nearby patch commonly follows. At a disturbance level, pest invasions similarly may skip from patch to patch.

In short, patch-patch interactions are mainly species fluxes, which play important roles in feeding ranges and reestablishment following local extinctions.

Patch-Corridor Interactions

Where a corridor is attached to a patch, the interactions between the two appear surprisingly similar to those just described for patch-patch interactions (Figure 4). The main fluxes are species, either moved by locomotion or wind. The corridor may facilitate recolonization following local extinction of a species in the patch. The patch, however, generally acts as a species source for the corridor. And pest invasions may move uninterruptedly between the two landscape elements. A high degree of bird and mammal movement between a woods and a connected fencerow was found in the Ontario agricultural landscape. Corridors which connect two patches are considered efficient migration routes for native species, though with few empirical data available (Pollard et al., 1974), this should be considered a hypothesis.

Corridor-Matrix Interactions

Line corridors, strip corridors and stream corridors, while differing in structure and function, also differ in their interactions with the surrounding matrix. The matrix climate exerts an overriding influence on line corridors. But beyond that, most of the interactions appear to be in the direction of corridor to matrix (Figure 5A) (Pollard et al., 1974; Les Bocages, 1976). Frequent fluxes of birds, but not mammals, between fencerows and fields were found in Ontario, and Pollard et al. (1974) cite further examples, including several insect species. From some line corridors, dust, salt, and vehicular pollutants move into the edge of the matrix. Non-native species, which often thrive in line corridors may spread into the matrix. A striking effect, though not a flux, of corridors on the matrix is to isolate populations (Schreiber and Graves, 1977), and hence limit gene flow. In short, major reciprocal interactions take place between line corridors and matrix, involving energy, nutrients and species.

Strip corridors (Figure 5B) exhibit most of the combined interactive characteristics of patch-matrix (Figure 3A, B and C) and line corridor-matrix (Figure 5A). Therefore, the fluxes between strip corridors and matrix are numerous, and the interdependence great. In a forested Tennessee (USA) landscape (Anderson et al., 1977) the bird communities in narrow powerline corridors of 12 and 30.5 m width were rather similar, but quite different from the avifauna in a wide 91.5 m corridor (Table 1). This was because the narrow corridors contained mostly forest edge species, whereas the wider corridor additionally contained many open country species. Therefore, the corridors up to about 30 m wide functioned as line corridors, whereas corridors somewhat wider than 60 m functioned as strip corridors.
Figure 5. Major fluxes between the matrix and three types of corridors. See legend for Figure 3.

Table 1. Similarity of avifaunas in forest and in four powerline corridors varying in width. Numbers are an index of overlap, $R_o$, among avian populations in a pair of communities (index varies from 0 with no species in common to 1 when the two communities are identical in proportional species composition). Study was in the oak-hickory (Quercus-Carya) region of Tennessee (USA); corridors cut through the forest landscape were dominated by mixed grass, annuals and Rubus. From Anderson et al., 1977.

<table>
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<th>Width (meters)</th>
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<th>91.5</th>
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<td>0.72</td>
<td>0.62</td>
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<tr>
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<td>Forest</td>
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Stream corridors have long been recognized as important, due specifically to their interactions with the matrix (Figure 5C). Water is the major driving force, and water and nutrients the fluxes. In this case, the fluxes are essentially unidirectional, from the matrix to the stream corridor.

All three types of corridors are, therefore, under major control by the surrounding matrix, and in turn exert some important controls on the matrix.

Conclusion

I believe landscape should be a scientifically-useful and rigorous concept, such that a landscape may be analyzed in terms of structure, function and development. The structural components, or landscape elements, are various types of patches, corridors and a matrix, and landscape functioning is the interaction among these elements, that is, the fluxes of energy, mineral nutrients and species. The scattered data and observations available suggest that landscape elements exert major controls over one another, through a wide range of fluxes. These interactions are a core of landscape ecology.

As ecologists, planners, landscape architects, geographers and conservationists, we have for too long considered a landscape element as an isolated ecosystem. The manifold fluxes linking ecosystems demand a novel way of thinking. Rather than making land-use decisions based entirely upon the characteristics of a landscape element, such decisions must be based primarily upon the specific linkages that exist with surrounding landscape elements. To accomplish this, we shall have to combat "tunnel vision" and, furthermore, noticeably broaden our own perspectives.

References


SPECIFYING THE CONCEPT OF LANDSCAPE CELL (ECOTYPE) IN TERMS OF INTER-ACTING PHYSICO-CHEMICAL PROCESSES AND EXTERNAL VEGETATION CHARACTERISTICS

Arthur W.L. Veen

Department of Physical Geogrophy and Soil Science
State University Groningen, The Netherlands

Abstract

A gap exists between landscape ecological theory and empirical landscape research. The latter has to supply not only useful information on environmental issues, but also factual background to illuminate such theoretical concepts as "dynamics". In this respect the present use of the ecotope concept, with its traditional emphasis on size, homogeneity and floristic composition is not suitable to produce the necessary data. The value of landscape maps based on ecotopes is, therefore, limited when it comes to extracting explicit and quantitative information on the functioning of the landscape ecological systems.

The situation might improve when the contribution of individual ecotopes to overall landscape dynamics is known. Such knowledge is obtained when the characteristic combination of physical, chemical and biological processes within the ecotope is studied. A convenient approach to this study is the analysis of the budgets of energy and mass.

Possible ways of stating the ecotope budgets of energy, water and sediment are briefly described. The significance of external properties of the vegetation (formation, stand architecture) in relation to physical, and therefore indirectly chemical, processes is stressed. Finally, a tentative extended definition of landscape cell (ecotope) is suggested.

Introduction

Although the roots of landscape research are to be found in the work of Alexander von Humboldt in the early nineteenth century, landscape ecology as an interdisciplinary field is less than half a century young. Despite its relative youth this new field already fosters its very own and rather involved unifying theory. Of course, I am referring to Van Leeuwen's Relation Theory (Van Leeuwen, 1966). However, a debate on its intrinsic and operational value is still continuing. Whatever the outcome of this debate may be, it seems to me that there is quite a gap between the Relation Theory and empirical landscape research.

On one hand, this gap apparently originates from the form of the theory which inhibits the derivation of empirically testable hypotheses from it. It has been stated - albeit in an embivalent manner - that the high level of abstraction hampers testing of the theory (Van der Maarel and Dauvellier, 1978). My own experiences tally with this statement. If the criticism by Peters, also discussed by Van der Maarel and Dauvellier (1978), that the Relation Theory is in fact a tautology is correct, then this would indeed explain the problems around the testibility of the theory.
On the other hand, empirical landscape research projects are usually initiated in order to supply information that is urgently needed in relation to some environmental issue. Sometimes the Relational Theory is invoked to lend respectability to the results rather than critically inspected for its merits. This custom does not decrease the gap, it just masks it.

What really is needed at the present stage is detailed and quantitative work to give a lot more factual background to such landscape ecological concepts as structure, pattern, process and dynamics. It is in this perspective that I propose to comment on the concept of ecotope and to indicate lines of empirical research that may stimulate just that kind of work.

Present status of the ecotope concept

The German school of landscape ecology (Troll, 1939; Neef, 1967 and many others) has contributed much to the present status of the ecotope (German: Okotop) concept. Most of the definitions now circulating boil down to something like "the smallest geographically relevant, ecologically homogenous landscape element". In this sense the term ecotope is synonymous with "landscape cell" (German: Landschaftszelle), which is considered to be the elementary building stone of the landscape. Landscape in this view then is considered to be a structured array of ecotopes (German: Okotop gefüge), a mosaic of cells. This approach to landscape can quickly lead to a way of looking at landscape as if it were a statical configuration of ceramic tiles. This is illustrated by the use of the term "Fliese" in the German literature. This term, put forward by Schmithüsen (1965) to indicate an element of the physical basis of the landscape (fysiotope), is sometimes used interchangeably with ecotope and landscape cell (e.g. Köllner, 1965) and indeed literally means (ceramic) tile.

This approach to landscape research has been particularly useful in preparing detailed landscape maps. In fact, most authors link the concept of ecotope closely to landscape mapping. Map scales of 1:10,000 to 1:25,000 are usually mentioned but a more realistic range of 1:5000 to 1:10,000 is indicated by Vink (1980).

Although the ecotope concept is used most frequently in relation to the legend of a landscape map, most authors emphasize the fact that the ecotope has a dynamic ecological content (ecosystem). However, this dynamic content usually is implicitly understood, rarely explicitly specified. Explicit specification generally consists of qualitative data pertaining to such attributes as floristic composition, land form, bedrock, and soil and water conditions.

Perhaps the most widely used diagnostic criterion for characterizing and mapping ecotopes is the plant community and its correlation with a few statical indicators of habitat. Another widely used criterion is the geomorphological unit with which the ecotope is associated. In landscape mapping this criterion works often quite satisfactory. Furthermore, suitable maps have been obtained on the basis of units derived from agricultural development. Lately, geomorphological processes associated with certain landscape units are mentioned (e.g. Kwakernaak et al., 1978).

Need for further development of the ecotope concept

It is commonplace to state that vegetation expresses the combined influence of climate, soil, water and land management. However, the
relationships of such vegetation parameters as species and community with environment are amazingly complex. Many aspects are still partly understood and definite quantitative knowledge is rather limited as yet. Unfortunately, the theoretical approach according to Van Leeuwen's ideas to these relationships hasn't yet resulted in a lot of basic and explicit evidence that one would like to have available. So when it comes to obtaining explicit and quantitative information on the functioning of the landscape ecological system, the value of landscape maps based on the present ecotope concept with its emphasis on floristic composition as the main ecological aspect appears to be limited.

Some years ago Van der Maarel and Stumpel (1974) have put forward a three-point programme for landscape ecological research. The points one and two of their programme imply the necessity of better vegetation surveys to serve as a basic for landscape studies and of more attention for zoological aspects. Their third point concerns the necessity of obtaining "more precise knowledge of the interactions between ecosystem behavour and human interferences". It is this third point on which the applicability of landscape ecology hinges. And, because of the reason outlined above, in this important area the contributions of landscape mapping on the basis of the present ecotope concept is limited.

I submit that this situation is unsatisfactory and that it can be improved by also describing quantitatively both the biotic and the abiotic dynamical features of ecotopes. In the first place this means that not only floristic composition has to be described but also much more information on plant and animal ecology should be gathered. This will improve the understanding of the biotic components of the landscape ecological systems (ecotopes, geotopes) and thus strengthen the basis for the study of environmental impact by man. But the abiotic components - a better phrase would perhaps be "geotic" components - should not be regarded as black boxes of which the content is sufficiently clear as soon as the vegetation has been mapped. In the second place, therefore, part of the landscape ecological research should be aimed directly at the abiotic components both at and above the ecotope level. This approach will in some cases trace human interferences more directly and in an earlier stage. And this would be valuable in environment impact studies as well.

Specifying the concept of ecotope in terms of process and structure

At any point in the landscape energy and matter are being transported as well as transformed. The physical, chemical and biological processes by means of which these transfers occur are intricately interwoven. For reasons of practical research the chain of processes has to be taken apart and the links have to be studied both separately and in connection with the chain. From this point of view an ecotope ought to be specified according to the characteristic combination of processes occurring within it and according to its contribution to the overall landscape dynamics. The former corresponds largely to vertical intra-ecotope phenomena, the latter to horizontal (lateral) inter-ecotope phenomena.

A convenient way to describe the operation of physical and chemical processes from a landscape ecological point of view is the budget approach. Biological processes may have to be treated differently and comment on this issue from biologists is invited; these processes will be largely omitted from this paper. Any ecotope can be satisfactorily defined by the values and the fluctuations (in time) of the terms of the budgets of energy and matter. In the framework of practical research it is convenient to divide energy into categories like radiation and heat, and matter into categories such as water, solutes, mineral materials.
(viz. those susceptible to erosion and sedimentation), living and dead organic matter. Qualitative assessments or semi-quantitative estimates may on occasion be helpful but of course accurate and long term measurements give much more reliable and useful information.

Energy budget

First of all, any ecotope derives the energy to maintain the functioning of its ecosystem mainly from solar energy. The diffuse and direct solar radiation that is not reflected is the most important item on the income side of the balance sheet. Energy is lost from the ecotope by its own long wave radiation. The difference between the two is the net radiation which fluctuates daily and seasonally. This net radiation is the amount of energy available for evaporation, heating soil and air within the system, photosynthesis and other processes. This statement may be summarized as follows.

\[ R = A + S + LE + P + M \]  

Where \( R \) = net radiation, received by the ecotope  
\( A \) = sensible heat lost to the atmosphere  
\( S \) = sensible heat lost to soil  
\( LE \) = latent heat lost to the atmosphere by evapotranspiration  
\( P \) = transformation of radiant into chemical energy by photosynthesis  
\( M \) = advective heat

As explained above, the net radiation \( R \) may be obtained from the radiation budget:  
\[ R = (1-r) \cdot R_{sw} + R_{lwbal} \]  

Where \( r \) = reflectivity to short wave radiation (albedo)  
\( R_{sw} \) = incoming short wave radiation  
\( R_{lwbal} \) = difference of incoming long wave atmospheric radiation and outgoing terrestrial radiation.

Each of the terms of the energy budget is influenced by the climatic conditions overhead, but also to a large extent by the nature of the vegetation and soil under consideration. \( R \) is related to the reflectivity of the vegetation stand which is in turn a function of the physical characteristics of the upper vegetation surface. Exchange of heat is related either to the physical structure of the vegetation i.e. number, vertical dimension and density of the vegetation layers \((A + LE)\) or to soil conditions \((S)\).

Water budget

In the ecotope hydrological cycle a redistribution mechanism of water operates that looks similar to the redistribution of solar radiation. Precipitation is intercepted and part of it evaporates directly. This phenomenon is analogous to reflection of radiation and is very effective when rainfall is of short duration and low intensity. Part of the precipitation may reach the soil surface as throughfall and stemflow if it is not intercepted once more by lower layers of vegetation or litter. Finally the water may enter the soil and be either returned to the atmosphere by the transpiration process or it may percolate towards a groundwater body.

Disregarding the lateral component of water transport for the moment, the ecotope hydrological budget in the vertical sense is given by
\[ G = P - \sum^{n}_{i} P_i - T \]  \hspace{1cm} (3)

Where:
- \( G \) = percolation to ground water body of ecotope precipitation
- \( P \) = precipitation on upper surface of ecotope
- \( \sum^{n}_{i} P_i \) = sum of the amounts of water successively intercepted and evaporated by \( n \) layers of vegetation (including litter layer)
- \( T \) = transpiration by plants.

The lateral transport of water to and from the ecotope over or underneath the surface is analogous to the advective heat term \( M \) in the energy budget (1). It may be specified by

\[ 0_{in} + IF_{in} + U = 0_{out} + IF_{out} + G_1 \]  \hspace{1cm} (4)

where:
- \( 0_{in} \) = input of water by overland flow
- \( IF_{in} \) = input of water by interflow
- \( U \) = welling up from ground water body, capillary rise
- \( 0_{out} \) = output of water by overland flow
- \( IF_{out} \) = output of water by interflow
- \( G_1 \) = percolation to ground water body of laterally added water.

By combining equations (3) and (4) the outline of the ecotope hydrological budget is obtained. Interception is much more important quantitatively than is sometimes suspected. In forests 10-40% of annual precipitation may be lost by interception, while up to 90% and even more is lost if rainfall duration and intensity is low (Rutter, 1975). Interception depends not only on precipitation characteristics, but also on such physical aspects of vegetation as leaf and branch area of successive intercepting strata and whether or not the dominant life forms shed their leaves seasonally. Transpiration is a function of available soil moisture, leaf resistance, atmospheric conditions and other factors. The actual transpiration of (semi-)natural vegetation is not readily determined and deserves a lot more attention.

Sediment budget

Another important means for characterizing any landscape cell is its relation to the chain of the geomorphological processes of erosion, transport and sedimentation. A simple form of the sediment budget of an ecotope is

\[ S_{in} = S_{out} + \Delta S \]  \hspace{1cm} (5)

where:
- \( S_{in} \) = input of sediment to the ecotope
- \( S_{out} \) = output of sediment from the ecotope
- \( \Delta S \) = gain or loss of sediment in the ecotope.

For example, in an ecotope where erosion is the dominant process \( S_{out} > S_{in} \) and \( \Delta S \) is negative (loss of material). When both \( S_{in} \) and \( S_{out} \) are next to zero, \( \Delta S \) is negligible; relief is stable and the soil is well developed. If, on the other hand \( S_{in} \) and \( S_{out} \) are very large as well as equal, then \( \Delta S \) is also negligible but the situation is entirely different; the relief shows indications of active transport and the soil is usually very poorly developed.

Of the numerous examples of the interactions of plant life and geomorphological process one is selected to illustrate the relevance of...
life form. In the Belgian Ardennes sequences of ecotopes are found where
the interfluve exhibits practically no gain or loss of sediment, but
where the midslope section shows both high gain and loss due to active
creep. From a description by Lotz (1979) it appears that in the trans-
portational midslope, where the soil mass with very many sharp-edged
shale fragments is being transported at a considerable rate, plants
with a geophyte life form are conspicuously rare. It may well be that
this life form with fragile subsurface hibernation organs can badly
withstand being churned over in the mass of angular soil material. This
single observation at least suggests that it could be productive to
explore apparent relationships like this one more fully.

Other budgets

Of the other budgets that could be used to specify an ecotope more
completely, the chemical budgets and the budget of organic matter are
quite significant in view of their ecological implications. Since
chemical species differ greatly in their reactions and their solubility,
it is indicated to apply the budgetting technique for single chemical
species in combination with the data provided by the analysis of the
water budget, which is in turn closely related to the energy budget
by means of the évapotranspiration term.

Significance of external vegetation characteristics

In the previous paragraph some examples have been given of links
between terms of various budgets and vegetation characteristics. The
latter had to do with the outward physical form of the stand - the stand
architecture - or with the life form of individual plants. These examples
may serve as in illustration of the significance of these two charac-
teristics. In my opinion, this significance is sufficiently great to
justify incorporating the criteria "stand architecture" and "life form
spectrum" into the definition of ecotope.

Historically, the study of the external form of groups of plants has
preceded the study of plant communities. According to Schmithüsen (1968)
Grisebach has been the first to formally define (in 1838) the concept of
plant formation as "a group of plants that has a closed physiognomic
character, like a meadow or a forest. The introduction of the idea of
life form by Raunkiaer in 1905 has been the major development in the
study of plant formations. Now, to some people the suggestion of going
back to such ancient concepts may seem to be a retrograde step. I main-
tain that it is a useful step since it will open up an interesting
field of research which is likely to produce useful results that cannot
be readily obtained if plant community is taken as the only landscape
ecologically relevant parameter of vegetation.

Apart from the advantage of having more clearly traceable links between
(abiotic) process and vegetation pattern in the landscape, there are
additional advantages. Firstly, the external form parameters of vegetation
are sometimes more readily determined, which might lower the cost
of landscape mapping. And secondly, the available classification systems
of plant formations and life forms are based on elements of plant anatomy
selected against the background of sets of environmental conditions for
plant growth. Therefore, they are very useful in quantitatively exam-
in ing the major vegetation-environment systems as they are expressed in
the landscape (Thalen, 1979).
Extended definition of landscape cell (ecotope)

In view of the arguments presented in this paper, the following extended definition of ecotope is suggested.

An ecotope or landscape cell is a homogeneous element of landscape space of geographically relevant dimensions\(^*\) that is defined

a) externally by its appearance (physiognomy), by the physical structure of its vegetation as described by plant formation and - in more detail - by stand architecture and life form spectrum, by the physical characteristics of its land surface, and by the physical and chemical properties of its soil and subsoil,

b) internally by the rates and fluctuations of the physico-chemical processes that balance the inputs and outputs of energy and mass (radiation, heat, water, chemical substances, sediment, organic matter, etc.), and by the rate of fluctuations of the biological processes, which represent the life functions of the plant and animal community comprised,

c) and by the specific set of interactions between the internal processes among themselves and between the internal processes and the external properties.

Concluding remark

The extended definition implies a multidisciplinary research programme.

References


\(^*\) As a rule of thumb it is suggested that an ecotope has to be large enough to be shown on a 1:5000 map, so a practical minimum dimension would be around 500 \(m^2\).

INFORMATION THEORY AND LANDSCAPE ANALYSIS

Michel Phipps

Department of Geography, University of Ottawa, Ontario, Canada

Abstract

As a holistic endeavour, landscape science pertains to system analysis. Some schools emphasize the study of energy-mass flows. For others, the concern for space is predominant. Information theory offers an appropriate framework to approach the landscape as a spatial information system. The abiotic and biotic complexities are equated to entropy while the level of interaction between both is tantamount to a negentropy. An analytical scheme is based on these principles. Three examples illustrate particular aspects of this approach. Some perspectives are examined in the domain of landscape development. The implications of the law of degeneracy are briefly discussed relative to two examples.

Introduction

Landscape science undoubtedly deals with a large range of aspects. There is the system of functional relationships which links non-living and living elements of the landscape (Neef, 1967; Sochava, 1970; Milkov, 1977). There is also the mosaic made up of various combinations of abiotic and biotic components which gives this science its chorologic slant (Christian, 1957; Tjallingii, 1974; Hadac, 1977). Last, but not the least, landscape must be understood as a phenomenon subject to change in time (Hills, 1974; Isachenko, 1976). Thus far, landscape research has come short of producing the universal framework that would allow for the treatment of all these aspects. Coping with landscape still requires simplifications. However, focusing on functional relationships, at a local scale, is tantamount to losing sight of space and, conversely, placing emphasis on spatial structure exposes research to confine itself in static problems (Makunina, 1975). Despite attempts at merging both streams, there is much evidence that this dilemma is still vivid and is rooted in the classical duality of process versus form. This paper aims at showing how information theory might overcome some of these methodological limitations and serve landscape science.

Methodological considerations

It is interesting to look at the ways in which the link between functional relationships--referred to by Hills (1974) as transactions--and topological structures has been addressed in landscape research. The method most commonly used to depict these structures consists in the spatial integration of hierarchical topological units. The great number of classification systems which have been proposed attests to its popularity (Hills, 1974; Tjallingii, 1974; Makunina, 1975; Hadac, 1977). Most authors following this approach, have emphasized that each level of integration is characterized by a particular feature according to which a certain unity may be achieved. No less important
is that this unity at various levels is paralleled by a similar unity
of the biotic component (Jurdant, 1977). Thus, the basic concept upon
which these systems are built is the "consistency of relationship be­
tween biotic community and its non-living environment" (Hills, 1974).
Some authors certainly made more explicit use of this concept referring
to "a recurring pattern of topography, soils and vegetation" (Christian,
1957), while others even spoke of "order and disorder in land" (Ruxton,
1968). At this point the link between transactional process and topo­
logical structure becomes clear. The process itself is not considered
but its significant inputs/outputs (abiotic and biotic features) are
accounted for in a way which gives the transaction process the key role
of a black box in the spatial system. Therefore, the notion of spatial
correlation between these inputs and outputs rests at the very core of
landscape analysis as suggested by Herz (1974). Several pieces of re­
search have led, in this direction, to the development of landscape
structural analysis based on multivariate methods (Phipps, 1968;
Mathieu & Wieber, 1973). However, besides these few developments,
the appropriate tools corresponding to these concepts have barely been used.
Further consideration can also be given to the central idea of topo­
logical organization. Obviously it must be interpreted, not merely as
a spatial co-occurrence, but rather as an ecological constraint that
one component exerts on the other. Doing so in a proper form leads us
to approach landscape in the framework of information theory. The next
section of this paper will expose several basic concepts of this theory
as applied to landscape science.

Spatial entropy: its relevance to ecological constraint

Let U be an area displaying a mosaic of biotic community-types (B)
and a variation of a particular abiotic feature (A). For convenience
U is divided into N equal size cells, homogeneous with regard to both
A and B. A map of the area shows the biotic pattern, the number m of
community-types present in the area and the number of cells n_1 , n_2 ,
... n_m where each community-type is found. If the system were
free of constraint, that is if any community-type could be located in
any of the N cells, it would be permissible to permute cells so as to
generate new patterns such as B' or B'' (Fig. 1). The total number
W(B) of permissible patterns obtainable under this assumption repre­
sents the freedom of the system and its entropy, H(B) = 1/N Log_e W(B),
measures this freedom (Pielou, 1975). This measure is important as a
theoretical value against which the ecological constraint will be
tested. In a second stage, we consider the variation of both A and B
(Fig. 2). We now assume that A exerts a constraint upon B which is
tantamount to saying that the boundary between a_1 and a_2 must not be
crossed when cells are permuted. We now evaluate the freedom of the
system by calculating the number of possible patterns W_A(B) = W_A(B) x
W_A(B) and the entropy of the system H_A(B) = 1/N W_A(B). It can be
shown that W(B) > W_A(B) and that W(B) = r x W_A(B) where r has been
interpreted as a factor of ecological order introduced by the feature A
in the pattern B. The mutual information T(A,B) = 1/N Log_e r or
T(A,B) = H(B) - H_A(B) and the redundancy R(A,B) = T(A,B)/H(B) are two
other measures of this ecological order.

It is interesting to note that, in the theory of communication, T
measures the amount of information transmitted without noise from a
source S to a receiver P by the information channel S -> P. This
suggests that our system (A,B) constitutes an information channel A -> B
Let $U$ be an area divided into $N$ homogeneous cells with $m$ community-types. Let $U$ be the same area where $B$ and $A$ are known.

If the system is free of constraints, that is if any community-type can be located in any cell of the area, by permuting cells we may imagine other arrangements (i.e., patterns) such as $B'$ and $B''$, other than the observed pattern $B$. The total number of permissible arrangements (i.e., of possible patterns) is given by $W(B) = N! 36! = 2.7867 	imes 10^{21}$.

The entropy of the system $H(B) = \frac{1}{\log}_2 W(B) = 0.86$ is a measure of the freedom of the system.

We assume now that $A$ exerts a constraint upon $B$. The boundary $a_1/a_2$ must not be crossed in rearranging the pattern. Then $W_a(B) = W_a(B) \times W_a(B)$.

$H_A(B) = \frac{1}{\log}_2 W_a(B) = 0.72$.

The freedom of the system has been lessened by the constraint $A-B$. In $B$, there is some ecological order which is measured by $T(E,B) = H(B) - H_A(B) = 0.86 - 0.72 = 0.14$.

whose efficiency is measured by $T(A,B)$ and $R(A,B)$. This makes full sense if we consider that the knowledge of $A$ improves the predictability of $B$ by lessening its uncertainty from $H(B)$ to $H_A(B)$. All these remarks go to prove that the quantity measured by $T$, $r$, and $R$ has the meaning of a negentropy, that is ecological organization.

**Extension of these concepts to landscape analysis**

It is now clear that entropy, information channel, and redundancy may be used as operational concepts to build a model of a landscape. This model would encompass the spatial structures of $A$ and $B$ and their structural relationships. However, the analysis of a real landscape differs from the previous situation because of the many abiotic features which individually and interactively exert constraints upon the biotic elements. We therefore need to shift from a mono- to a multivariate analysis. Keeping in mind the information channel model, we ought to build a new channel whereby a set of complex environmental states $E$ relates to the set of biotic community-types $B$. The set $E$ will result from a combination of the many abiotic features such as $A$, whose variation is known over the area. A stepwise procedure makes this possible by dividing progressively the initial set of cells. At each step, the division into subsets is done according to the classes of the particular abiotic feature which provides the largest amount of negentropy. As shown in Figure 3, the subsets produced at any step are taken as initial sets at the following step. The process goes on until stopping rules intervene (Phipps, 1981). The whole procedure operates as a divisive classification of spatial units and can be
FIGURE 3 - Hypothetical Dendrogram. Note that the hierarchy of features differs according to the branches 1, J, and K.

FIGURE 4 - Hypothetical Dendrogram. Note that the hierarchy of features differs according to the branches 1, J, and K.

Some major properties of the model

At this stage thorough attention is required to the properties of the channel E → B represented in Figure 4. As any information channel, E → B is stochastic in nature and rests on the probability \( p_{ij} \) of observing the \( j \)th biotic community-type \( (b_j) \) in a cell belonging to the \( i \)th complex environmental state \( (e_i) \). Each subset \( e_i \) constitutes a class of sites where all sites are homogeneous with regard to the probability of the various biotic community-types. In combining the abiotic features to build the set E, a master rule has been observed: the subdivision by the classes of a particular feature was done only if this division brought in the largest significant negentropy with regard to B. This fact bears consequences of the utmost importance.

i) the set E is not built on a pre-established combination of features but in a "reflexive" way which best accounts for the state of B and for the fact that transactions are two-way processes;

ii) Since \( T(E,B) \) has been maximized, E is the best predictor of B; however, albeit this predictive nature, the model leaves room for uncertainty usually referred to as the ambiguity of the channel; this ambiguity can be true uncertainty or lack of information;

iii) The negentropy maximization entails that the model gives the most accurate expression of the ecological order in the biotic pattern (Ruxton, 1968),

\[
R = \frac{H(B) - H_E(B)}{H(B)} = T(E,B)
\]

\[
H(E,B) = H(E) + H(B) - T(E,B)
\]

\[
H_E(B) = \text{ambiguity of the channel}
\]

\[
H_E(B) = \text{equivocation of the channel}
\]
Because of the maximization of $T(E,B)$ and of the reflexive way in which $E$ is built, the channel seems also to be the best expression of the abiotic/biotic interface or, in other words, the best expression of the transactional space previously mentioned (Hills, 1974).

Thus far, information theory has proved to be an useful framework to build a model of a landscape. The stochastic matrix – the core of the channel – constitutes a mathematical form of the model of organization underlying the "recurring pattern" often thought as the foundation of the landscape concept (Christian, 1957). The next section will provide the reader with indications regarding the application of this analysis scheme in three different cases.

Three applications

This analysis scheme has been applied to various situations. Each of them illustrate a particular aspect of this approach. The first example deals with a forest landscape located in the Laurentides of Quebec (Mont-Sainte-Marie). Ten forest community-types were first identified and mapped over an area of approximately 14 km². The set of abiotic features included 9 items: elevation, direction and steepness of slope, relative elevation, site profile, site drainage, soil parent material, soil drainage and depth of overburden material. A sample of 1231 sites was taken in the area, each site being defined with regard to the community-type and the state of each abiotic feature. The procedure ended with a set of 124 complex environmental states figuring out an environmental complexity $H(E) = 4.60$ iue. The entropy of the biotic pattern dropped from an initial value $H(B) = 2.17$ iue to a final value of $H(E,B) = 1.01$ iue thus representing a theoretical value of $R(E,B) = 0.60$ which can be considered a measure of the ecological order of the pattern (Phipps, 1981). Besides this measure of order, the most interesting point in this analysis is that it plainly shows the multiple hierarchy of abiotic features. The dominant feature in the whole landscape is elevation, but the second dominant depends upon the class of elevation. At upper elevations, the second dominant is the direction of slope whereas, at lower elevations, the depth of overburden material tends to be dominant.

The second example deals with the analysis of an agricultural landscape in southwestern France (Allaire et al., 1973). The analysis was laid on an area of about 12 km² from which a sample of 1156 sites was drawn. Each site was defined with regard to its land-use (6 types including forest, shrubs, grassland, meadows, forage crops, cereal crops and vineyards). The set of abiotic features included 5 characteristics (site profile, relative elevation, direction and steepness of slope and soil parent). The procedure yielded a set of 15 complex environmental states and showed a decrease of the land-use entropy from $H(B) = 1.331$ iue to $H(E,B) = 1.014$ iue, that is a redundancy $R(E,B) = 0.25$. Compared to the preceding one, this figure seems very low. However, one must keep in mind that this value measures the level of ecological organization of a land-use pattern which, as an anthropic phenomenon, is largely dependent on non-ecological factors. The final entropy could certainly be reduced by introducing non-ecological characteristics which display a differentiation within the area of study (the distance to the farm, for instance). However, an ultimate part of it might also be true entropy (i.e., true freedom), that is, some part of the land-use location process which cannot be reduced by any "known" factor.

The last example deals with a particular aspect of forest ecology.
The forests of Middle Atlas (Morocco) are known to offer poor conditions to cedar (Cedrus atlantica) regeneration. In this case, the analysis consisted in relating the type of regeneration to a set of features including abiotic and biotic characteristics considered as possible determinants of regeneration. Within each of the 5 areas of study, 30 different features were tested using samples of sites ranging from 1,274 to 4,744 sites. The most interesting point with regard to this example has to do with the hierarchy of features as it appears along the branches of the dendrogram. A thorough examination of these hierarchies suggested in most cases the transactional processes at work and more particularly, how their functioning was affected by the spatial variation of the abiotic features. This remark plainly confirms the idea of "black box" expressed in a previous section.

In each of the three cases above mentioned, the proposed analysis scheme has proved to be useful and efficient. It allowed for the assessment of the ecological organization of a biotic pattern with regard to the pattern of its abiotic counterparts and revealed the structure of the *transactional space*. The next phase of this research will be to examine the evolution of this structure.

**Landscape development: some perspectives**

Information theory provides an interesting model but in spite of this, the analysis remains static and structural. It is our contention, however, that the merit of this approach should be looked at in the light of general system theory. Landscape would gain perhaps for more from the "isomorphy of law in different fields" voiced by von Bertalanffy (1968, p. 48). Information systems usually develop along specific trends (Atlan, 1979; Ciplea & Ciplea, 1980) which ought to be compared to our knowledge of landscape evolution.

In Figure 4, \( H(E) \) equates the environmental complexity which, as mentioned above, best fits the biotic pattern \( B \). In turn, \( H(B) \) equates the biotic complexity which clearly refers to the mosaic of biotic types and not to the internal complexity that such types display. \( T(E, B) \) equates the ecological order of the system, that is an incomplete realization of the freedom that appeared to be permissible but which could not be achieved due to the constraint \( E \rightarrow B \).

We may now define an overall complexity of the landscape as \( H(E, B) = H(B) + H(E) - T(E, B) \) which can also be written \( H(E, B) = H(E) + H(B) - (1 - R) \). It is therefore possible to assess the landscape changes in terms of the changes undergone by the three components \( H(E), H(B) \) and \( R \) (Atlan, 1979, p. 50).

A general trend in system development is known to produce degeneracy which is defined as a decreasing redundancy, that is, disorganization of the system (Ciplea & Ciplea, 1980) unless the latter has the capability of maintaining its organization by preventing or eliminating noise in the channel.

It is interesting to look at the implications of these views with regard to the cases discussed above. In the forest landscape, a considerable portion of the final entropy \( H_F(B) \) is due to time factor. Various community-types of the pattern are seral stages while a few others may be regarded as climax communities. If we were given enough time, we would observe a progressive substitution and record a decrease of \( H_F(B) \). This replacement process has been simulated on the basis of the literature on plant succession in Southern Quebec (Grandtner, 1966) yielding a final entropy of \( H_F(B) = 0.5 \). In absolute terms, this value
represents a very low uncertainty. So far we have no measures as to the evolution of $H(B)$ and $H(E)$ during the same time, but there are general indications to the effect that maturing landscapes undergo a decrease in the biotic pattern complexity. It is also thought that this trend is paralleled by an increase in the biotic complexity within the communities. Given the procedure used to establish the set of environmental states, a decrease in $H(E)$ would certainly ensue a decrease in $H(B)$. The question as to the trend followed by the redundancy remains open. We may suppose that the upholding of the ecological constraints opposes the law of degeneracy by eliminating noise, thus keeping $R$ steady. These views are for the largest part mere hypotheses but it must be stressed that the model discussed in this paper allows for the testing of these hypotheses.

In the second example, the agricultural landscape illustrates well some major concepts regarding systems 'behaviour.' First, it is interesting to understand how, in the past, the redundancy has been maintained through time against the normal law of degeneracy. We may well admit that a societal knowledge on crops ecology, in a manner which recalls "Maxwell's devil," would influence the pattern of land use decision thus acting as a major organizational force. Recent evolution provides much evidence of system degeneracy. The emergence of a new rationale in land-use policy overruled the traditional societal controle over the landscape and lead to an obvious disruption of the ecological organization of the landscape, that is a decrease in $R$. This often occurred through so called planned operations such as "remembrement." Parallelizing this trend, more specialized farming systems tend to diminish the land-use pattern complexity $H(B)$ which, in turn, entails a decrease in environmental complexity $H(E)$. Conversely, however, there is no parallel increase in the biotic complexity of land-use types. According to general system theory, these considerations pertain to the concept of landscape resilience. The law of "requisite variety" (Ashby, 1958) suggests that these landscapes are becoming more vulnerable to external disturbances (climatic, economic) unless more energy is spent for their maintenance. Most likely, nowadays local landscape resilience rests more on the variety of larger (regional) systems including these landscapes than on the properties of their own.

Conclusion

Information theory has proved to be useful as a conceptual and operational framework for landscape analysis. It provides tools such as entropy, negentropy or information channel which make meaningful contributions toward modelization of the landscape. Furthermore, in this frame, landscape is understood as an information system and, more precisely, as an information channel between a combination of abiotic features and the pattern of biotic elements. This model may be considered a good expression of the transactional space equated to the landscape. However, the most promising perspectives opened by information theory regard the domain of landscape development. The examination of some laws controlling system development reveals meaningful comparisons and suggests new research avenues.

References

Allaire, G., M. Phipps et M. Stoupy - 1973 - Analyse écologique des
structures. L'Espace Géogr., 3, 185-197.
Tjallingii, S.P. - 1974 - Unity and Diversity in Landscape. Landscape Plann., 1, 7-34.
The concept of "landscape" has, especially in German geography, always been an important theme in the geographical disciplines. It has also had much influence in American geography (e.g. the "landscape school" of Carl Sauer). Whereas in Germany e.g. Hard criticized the ideas and methods of the "Landschaftskunde", physical geographers, biologists and country planners in the Netherlands have asked human geographers in the past ten years to pay more attention to the study of landscape. After the 1960's the study of the environment has once more made landscape a centre of interest. Geography can contribute to three types of landscape study: landscape ecological study, landscape physiognomical study and landscape genetic study.

A critical methodological examination of the concept of "landscape" and of landscape theories is required, in general as well as in geographical research. It should be accentuated that the landscape is only a part or an aspect of the environment. As a consequence of this, landscape study can only have a limited share in environmental science and in the analysis and solution of environmental problems. From a geographical point of view, we can state that landscape ecological theory and concepts in the Netherlands partly originate in the German "Landschaftskunde", with characteristics of regionalism, determinism and holism.

The environment should be studied in an interdisciplinary way. What are the contributions of geography, in particular of human geography, to environmental science? These contributions can be taken together under the heading of "environmental geography", as a parallel with environmental economy, biology, sociology etc.

Apart from the contributions of physical geography and landscape geography, in environmental geography the moment has come to develop its aim: the study of the spatial aspects of the environment and of environmental problems. Environmental problems are in general disturbances in the sphere where human and ecological processes interact. In environmental geography the analysis of man-environment relations, after the "nomothetical revolution" of the 1960's, should principally consist of the study of socio-economic spatial and ecological spatial factors in environmental problems.

Landscape ecology in this context can be conceived as the study of predominantly natural environmental systems. If landscape ecology studies man-made landscapes, the differences from landscape geography are minimal. Landscape ecology conceived as a natural science is almost identical with a broadly viewed physical geography. In both cases, however, landscape ecology can only play a significant role in environmental science by interdisciplinary research, in which attention is paid to the socio-political and spatial factors behind the changing scene of landscape.
THESES

1. Definitions and interpretations of the concept of landscape (e.g. in the report "Landschapstaal" of the Netherlands Society for Landscape Ecological Research) are often scientifically inexact and not a workable bases for environmental research.

2. Landscape is the outcome of social, political and natural processes, determined by time and place. In modern landscape horizontal relations predominate over vertical relations. Landscape ecological research therefore should more concentrate on socio-political causes than on the interrelation between the human and the natural sphere, which is mostly lost.

3. In environmental science the great attention that is paid to landscape problems in the modern world (in particular to the morphological and rural aspects) is a luxury of western civilization; it may distract the attention from the research of the causes of pollution and exploitation.

4. Historical geography is too often associated with landscape history. More attention should be paid to the historical geography of past economic-ecological systems, or in other words to the relations between population, subsistence level and natural environment in history.

5. The plea for a holistic and interdisciplinary approach in environmental science in most cases lacks a methodological backing. The heart of the matter is the difference between the properties of natural and man-made systems.

6. The study of spatial aspects of environmental problems should be developed by the geographical disciplines. The knowledge produced by environmental geography in interdisciplinary research should be applied in environmental planning, especially in the spatial (town and country) planning.
Geography is the study of the interrelations of phenomena (including man) on the earth's surface and their areal differentiation (Hartshorne). The latter part of this "definition" refers to the location, the distribution of the phenomena and the patterns and "regions" in which they appear. The first part refers to the existence of interrelations (the source of ecological considerations) and thus to the ecological aspects of geography.

A (regional) geography that wants to do justice to its ecological principles aims at a regionalisation in which as many interrelations as possible are included, regarding the natural phenomena as well as the human ones. The ultimate ideal of this approach is the "holistic" region.

A pure holistic regionalisation, however, meets with serious difficulties. These difficulties are the background of vehement discussions among geographers concerning the existence of regions as "real objects" and even the necessity of regionalisation (Report on section VIII of the Int. Geogr. Congress, London, 1964).

In practice, however, geographers are still discerning regions in the scale of the world as a whole as well as in much more detailed scales.

The elements

Distinguishing formal regions in the field and on air photos, is based on the presence of recognisable (visible) boundaries in the landscape that are related to vegetation, landforms, land use and the like. Further investigation then may yield additional information regarding other elements (hydrological situation, soils, bed rock, etc.). In some cases the boundaries bearing on all the components do coincide, or they show at least a parallelity that proves a close mutual correlation of the elements (or a strong dominance of one leading element). But in many other cases the elements concerned are not interdependent or completely subordinate to one dominating force.

As a matter of fact the elements present in a certain area are not completely interdependent, neither are they controlled by one all-dominating factor. The geosphere, the total complex of phenomena present in the earth's surface is composed of the elements (geofactors) mentioned in fig. 1.

The present-day patterns and the areal differentiation are a result of the geological evolution. The same holds true for the abiotic materials and the biological species that are available for differentiating by different processes. The two important sources of energy that kept (and keeps) this evolution going were (and are) the internal (tectonical) forces in the earth and the external (solar) energy that is unequally distributed over the spherical earth globe.
In this interplay of forces in space and time "stable" and "mobile" elements must be recognized.

- The stable elements are: the lithosphere and the landforms. It is true, that, seen in the geological time scale the earth's crust and the landforms are mobile and are subject to several kinds of variations. Seen in the scale of the geographical situation of the present (i.e. the situation of the last few thousand years), however, these variations and alterations can be neglected. The patterns and forms shown by the continents, the mountain ridges and also the individual mountains and hills are in fact inheritances from the geological past. They are independent fixed data, stable substratum.

- The air, the water, the vegetation, the fauna and also erosion and sedimentation and up to a certain degree also the soil, are much more mobile. The material concerned is "supplied" by the geological evolution as well, but their distributional patterns, and their regional properties are in principle adjusted to the distribution of the solar energy, expressed in the present-day climates.

- Apart from the geological history (especially manifest in the stable elements) and the present climatological influence the presence of mankind is an important factor. Being a representative of the mammalian fauna the species Homo sapiens is subject to the same natural laws that govern the other mammals. But during the last thousands of centuries the human kind was more and more in the position to make its own decisions. Although mankind is certainly subject to the natural laws, in some respects the work of Homo sapiens is characterised by a principle that is not extant in the extra human nature: the human ratio, the noös.

These three influences are by no means completely isolated. On the contrary, the mutual interference causes the conditions that we experience as the present geographical situation: The actual climatic conditions are basically a result of the interference of (a) the distribution over the earth's surface of the solar energy and (b) the distribution of continents and oceans and it is the experience that mankind is not able to act completely independent of the natural situation. But in the landscape ecological backdrop of regional geography these three factors can be considered the dominating and controlled principles.

The boundaries in the landscape are dependent on these three principles and the way in which the influenced elements are interfering.

### Three stamps

The geographical reality on the earth's surface can be considered a system in which three "stamps" have been printed one over the other, and whose prints and impressions are interfering. The earth's crust and its landforms forming a substratum are the "first stamp", they supply some basal patterns. The second stamp is the climate, which prints its "colours" of hydrological, biological etc. situations and processes over the basal patterns resulting in many interferences. By these interactions between substrate and climate are produced the patterns of natural regions in different scales, relating to soils, hydrological conditions, vegetational formations etc. The third stamp is that of the human noös, manifest in agricultural and engineering activities in different levels of technological development. The interferences between these "stamps" urges the regional geography to think in ecological terms.

The goal of geography is not regionalisation in itself. Regionalisation is an expedient. Geography in which ideally physical and human geography are working in close cooperation is the study of the earth as the dwelling
place of mankind and the study of man in his inhabiting the earth. Regionalisation on behalf of this kind of relational studies is most beneficial by distinguishing natural regions, representing the patterns resulting from the interference of the first mentioned two stamps and displaying in different scales. They can be used as a base for studying the effects of the human efforts, the third coining principle in the ecological interplay in the world of phenomena that is present on the earth's surface.
Topological analysis of the landscape.

In landscape ecology, the relations between abiotic, biotic and anthropic factors of the landscape are studied. These three groups of factors explain the character of ecosystems.

The abiotic factors are soil, relief, groundwater and surface water. The abiotic characteristics that are relevant to plant communities and aquatic communities are summarized into physiotopes. These units are homogeneous at the applied map scale.

The inventory of anthropic factors is restricted to those characteristics of land use that influence the communities.

The biotic factors are vegetation, birds and hydrobiology. Vegetation is the factor that most clearly expresses the abiotic conditions and land use. The presence of birds is mainly determined by the physiognomy of the vegetation. Hydrobiology is closely related to water quality.

The relations between these single factors within the ecosystems are expressed in ecotopes. An ecotope is defined as the spatial expression of an ecosystem. The integration of the single factors into ecotopes is obtained by a systematic comparison of the maps showing physiotopes, land use and the biotic factors. In this procedure, vegetation is the starting point.

An example of the topological analysis of a landscape in The Netherlands is given in Farjon et al. (in preparation).

Series of plant communities and their application in landscape planning.

A series of plant communities is defined as all plant communities occurring or able to occur under the same abiotic conditions. These plant communities are arranged in sequence. Plant communities belonging to the same series differ from each other as a result of:
- a difference in the time taken to develop; the plant community changes into another type by succession (succession series).
- a difference in anthropic influence; the plant community changes into another type as a consequence of human activities (replacement series).

The complex of abiotic conditions showing the same development of the vegetation is called a physiotope. The physiotope is characterized ecologically by a specific potential natural vegetation, i.e. the climax vegetation established after a long period of development without human influence.

Series of plant communities in connection with the abiotic conditions and the degree of human influence can be a tool to predict the way the vegetation will develop as a result of changes in land use. Examples of the application of plant communities in landscape planning of oil production (Boekhorst et al, 1977), land consolidation (Harms & Kalkhoven, 1979) and extraction of clay and sand (Vos et al, 1978) are given.
Ecological relations between ecosystems.

Ecosystems are not only formed by their factors, but also by the relations between ecosystems. Unless these spatial relations between ecosystems are described no ecosystem or landscape can be understood and no predictions of impacts of human interference in the landscape can be given.

The ecological relations between ecosystems can be defined as exchanges of matter, energy and/or organisms between various areas. Ecosystems in at least one of the areas are conditional on these exchanges. For description and classification the following simplified model can be used:

In this model the following aspects can be distinguished:
- receiving and delivering areas: the areas between which the exchange take place.
- agencies: the migrating factors that accomplish the spatial exchanges. They can be subdivided into:
  - abiotic agencies: groundwater at various depths, surface water, sea water, air, slope deposits.
  - biotic agencies: birds, mammals, amphibians, fishes, insects.
  - anthropic agencies.
- media: the environment (air, water, soil) of the agencies that enables the exchanges to take place.
- the various ways people can influence the spatial relations. Man can influence both areas and agencies.

References:
Farjon, J.M.J. et al. (in preparation) Landschapsecologische relaties in De Kampina en omgeving.
This poster introduces the research programme of the department of landscape ecology of the Research Institute for Nature Management. This programme should contribute to the study of spatial organization of landscape cells (ecotopes) and their interrelations, as a basis for planning and management of rural and natural landscapes.

Ecotopes are defined by vegetation homogeneity. Coinciding with this vegetation patch are a particular set of abiotic factors and a characteristic fauna. Through a network of within-ecotope relations these ecotope components are closely linked as a functional unit. However, an ecotope is anything but a closed ecosystem. Between ecotopes and the surrounding area (which is, in fact, an aggregation of ecotopes) another network of relations is effected by way of animals and abiotic factors. The nature of these between-ecotope relations is determined by the ecotope features and by the way the ecotopes are arranged. Through these between-ecotope relations, an assemblage of ecotopes constitute a functional system, called landscape.

A holistic study of the landscape as an ecosystem should begin with a survey of abiotic and biotic landscape patterns. On the basis of vegetation units and within-ecotope relations, ecotopes can be delimited and described. Therefore, part of our investigations is directed at relations between vegetation and abiotic factors and between vegetation and fauna. Research projects of this type are:

1. Relation between vegetation and physical and chemical properties of (ground)water, both on land (vascular plants) and in aquatic situations (diatoms).
2. Composition of fauna groups in relation to structure and composition of vegetation. Fauna groups presently studied are birds, amphibians, reptiles, and carabids.

The correlations between vegetation patterns, abiotic factors and fauna composition provide a basis for the analysis of between-ecotope relations. Current research projects are aimed at:

1. Effects of (ground)water flow and water chemistry for plant and diatom communities.
2. Significance of different types of edges as a biotope for plant and animal communities.
3. Occurrence of amphibians and reptiles as a function of landscape structure and ecotope arrangement.
4. Structure and composition of bird communities as a function of landscape structure and ecotope arrangement.

As an example, some remarks are made on the relations between birds and vegetation- and landscape structure. In different forest types it was tried to measure a number of structural features (e.g. coverage of
different layers, heterogeneity in coverage per layer and circumference of tree stems). Bird species densities were also measured and a set of bird parameters was calculated (e.g. total number of species, total density and density of ecological guilds). In a multiple regression analysis the variation in bird parameters could be explained by a set of structural features. In Oak-Beech forests the heterogeneity in the canopy-layer and plant species diversity were the main factors. In Pine forests, on the other hand, total coverage of all vegetation layers and coverage of bush-layer explained most of the variation in total number of bird species and total bird density.

Such results are used in studies at the landscape level. An area of about 10 km$^2$ is censused for bird territories. After grid transformation the area is divided into units with a more or less homogeneous bird community. The types of these units and their distribution over the area are then related to landscape pattern, e.g. vegetation type (including structural features), presence of ditches, hedgerows, isolated trees, arrangement of ecotopes and landscape heterogeneity.
DIVERSITY IN NATURE AS AN EXPRESSION OF SOCIAL AND ECONOMIC CIRCUMSTANCES

P.J. Schroevers
Research Institute for Nature Management, Leersum, The Netherlands

1. Richness in plants and animals is the main objective of the conservation of nature. It expresses the "optimalisation" of a landscape as an organic unity.

2. Richness is a scale-bound feature: one and the same distribution of organisms over a landscape can, if interpreted at different levels of scale deliver completely different results (example: the tropical rain forest seen by a walker or by an aeroplane-passenger).

3. An example of scale-levels in a Dutch landscape:
   level 1: Diatoms on the surface of a Nymphaea-leaf.
   " 2: Nymphaea-leaves in a littoral zone.
   " 3: Littoral zones in a shallow lake.
   " 4: Shallow lakes in a gradient between pleistocene and holocene
All transitions between these levels are continuous; boundaries are arbitrary, not of essential character. A distinction between "internal" and "external" after choosing an arbitrary scale.

4. If an area of low productivity is influenced by a slight eutrophication the system builds up barriers to avert the influence. Internal richness in species and communities increases. If the influence becomes too strong they will decrease. The statement that diversity increases during ologotrophication (maturation) is incorrect. A certain amount of external dynamics is favourable for the diversity within a certain area.

5. Both increase and decrease of productivity can diminish richness in species. We can speak of over- and underdevelopment of ecosystems, in analogy with economics.

6. The greatest diversity in life conditions is found, where high and low production join. Therefore richness in these regions exceeds those of other places. High diversity arises here most quickly, old structures remain here longest.

7. By influencing the energy-management of ecosystems man is able to change diversity. It may happen according to this scheme:
8. The flat country of The Netherlands is to be regarded as one large-scale gradient with dunes, sea-marshes, peatland and pleistocene sands as its elements. This large-scale and internal rather uniform picture has been changed strongly by man according to the principles given above. Regional development -respectively overdevelopment- coupled with underdevelopment elsewhere. It gave rise to the development of gradients. Hence richness of plants and animals is to be regarded as an expression of economic circumstances.

9. Alterations during history can be regarded as alterations in scale. The same basic principles can be seen on different scale levels in which roughly five stages can be distinguished:
1. First settlements and pre-feudal structures. Ephemeric and small-scaled.
2. Feudal structures of medieval times. Reclamations on village level ("es-villages", peat reclamations)
3. Renaissance and development of the towns. Large polders. First "offensive" actions from the viewpoint that nature can be mastered.
4. Industrial revolution. Differentiation on regional scale (industrial development of Brabant and Twente, origin of "Randstad").
5. Mondial system. The Netherlands as a whole as a developed country, with problems of overdevelopment.

10. Changes in the diversity of flora and fauna are connected with the macro-economic process of scale-enlarging. The process depends on the input of external energy and matter from outside (developing countries). The stages in the development mark the social structures and hence social relationships (hierarchic relations between people). Future strategies concerning maintenance and development of richness in nature have to consider these connections (separation and segregation as a guide for large-scale limitations and small-scale developments).
TERMINOLOGY

This short account of the discussions on terminology deals with the discussion theses and questions and reports of the workshops prepared by K. Bouwer and J. Gersie.

Further use is made of lectures and posters, an article by P.J. Schroevers: "The need of a language for landscape ecologists" (WLO-mededelingen 8 (1981) 4 p. 24-27) and a working paper by Th. Brossard & J.C. Wieber: "The concept of 'Visible landscape' in a systematic approach".

Pattern and process

Most landscape ecologists agree that a landscape can be distinguished by visible and functional qualities which are more coherent inside that area if compared with the surroundings. Moreover, landscapes are characterised by their natural and cultural histories. Different points of view are held about questions of size and boundaries and about dominant features of landscapes and their parts (see for example J.I.S. Zonneveld, p).

In Central and Eastern Europe a nomenclature of topic (homogeneous) and choric (heterogeneous) units was developed by geographers. These terms are not widely used by biologists and in the English speaking world, where process studies dominate, and even in mapping projects, the term landscape system is more frequently used.

Also related to cultural disciplinary tradition is the controversy about the geo- and eco-concepts. In Central and Eastern Europe the geosystem concept is used. It includes man and has a wider meaning than ecosystem. There the ecological tradition until recently used a more strict abiotic-biotic concept of ecology. The difference is not useful in Western Europe and North America, where ecology is normally used sensu lato. However, the wider meaning of ecology is becoming more common. Thus Bartkowski (1) considers the town ecosystem and the town geosystem as identical.

To the landscape ecologists the concept of landscape with its horizontal and vertical relations makes sense because it focuses attention on the pattern-process relations. In this way the "attitude" (Troll, quoted by J.I.S. Zonneveld, p) is important. Provided the interactions between form and function are described in a clear scientific way, different terms do not hinder communication.

Phipps (1) speaks about the "classical" duality of process versus form, and this is certainly - and rightly - one of the central issues in landscape ecology. Thus Neef (1) points out that only after the metabolism or process aspect of landscape was studied more thoroughly, could the spatial units of the "prehistoric stage" of this branch of science be related and adjusted to the underlying processes. A good example is given by Veen (1) in his discussion of the ecotope concept. Along these lines also Brossard and Wiebert try to develop a conceptual framework to study the way objects and processes influence the visible landscape or the "Gestalt" of the landscape.

Usefulness of the landscape concept

Is the concept of the landscape a useful one for environmental research and planning? Bouwer (p) states that the landscape theories and the concept are not a workable basis. Landscape is only a part of the environment. Dominant socio-economic factors are not limited to landscapes.
Formerly landscapes were shaped by more nature-bound, small-scale activities. These old landscapes have other boundaries now, they are more extended by the impact of modern urban and agrarian techniques. Vink (1) refers to this phenomenon as "encroachment". Landscape ecology, according to Bouwer, should concentrate more on socio-economic causes than on the interrelation between the human and natural sphere, which - he states - is mostly lost.

Tjallingii (1) expresses the view that this widening gap between the fine-grained structure of possibilities of landscape and coarse grained structures imposed by modern technology is one of the basic environmental problems. The answer then should be a reanimating of the dialogue with nature.

In his article, Schroevers states that the nearly "lost heritage" of interaction between man and landscape has to be the basis of a new conceptual framework to be used in planning, in conservation, for a critical analysis of economic theories and in education. From the discussions on environmental impacts it becomes clear, moreover, that the concept of landscape is a useful tool for impact assessment. Thus for example, the effects of urban wastes on the contamination of surface- and groundwater currents and their impacts on distant areas can be traced.

Disciplines and the holistic approach

In one of the workshops, and also by I.e.S. Zonneveld (1), landscape science was considered an object discipline, whereas landscape ecology was described as an aspect discipline. Schroevers states that landscape ecology should study first spatial-functional entities of different aggregation level and second the aspects such as the abiotic spheres, the biosphere and the noosphere. This view is more holistic but there is no disagreement between this statement and the observation that landscape ecology together with, for instance, landscape morphology and landscape history can be united in landscape science.

Holism is felt a necessity by many ecologists. Bouwer, however, points out that the plea for a holistic and interdisciplinary approach in most cases lacks a methodological backing. Nevertheless some perspectives become clear: Van Leenwan (1), Phipps (1), Van Wirdum (1), Schroevers (p) and others try to develop a holistic approach based on systems theory. In his article, Schroevers proposes the stabilizing mechanisms regulation and selection as "unifying concepts". Others, like Dijst et al. (1) attempt to work out a practical methodology for the integration of natural and social sciences in case studies.

Clearly, landscape studies have stimulated these efforts and the concept of landscape ecology as an integrated and interdisciplinary science will continue to do so.

The working paper mentioned can be obtained from: Th. Brossard & J.C. Wieber, Univ. de Franche-Comté, 25030 Besançon Cedex, France.
Theoretical aspects of ecological relations

Two workshops were devoted to the theoretical aspects of the study of relations in landscape ecology. The summary given here is partly based on the discussion points and the report prepared by R.A. Hemmer and partly on a working paper by W. Vos, J.M.J. Farjon, W.B. Harms, H. Roe-lofs and A.H.F. Stortelder: "A contribution to the classification of ecological relations between ecosystems".

Classification of horizontal relations

In their working paper, Vos et al. focus on the so-called horizontal relations in landscape: the exchange of matter, energy and organisms between ecosystems. They try to classify aspects and basic types of such relations. Among the aspects listed are: migrating factors (abiotic, biotic and anthropic), media transferring or carrying these factors, receiving and delivering areas and their interdependence, spatial characteristics of the relation system, and human influence (see also J.M.J. Farjon, et al. p). Basic types of relations identified are:
- isolation, when there is no exchange,
- one-way relations, when there is a flow from one area to the other,
- two-way relations, when there is a flow in both directions.

The last two types are subdivided to the effect of the relation on the connected areas:
- unilateral relations, when there is an effect on one of the areas,
- bilateral relations, when there is an effect on both areas.

Models are given of the classification of relation aspects of migrating animals and of the relation network of the hydrological cycle. Maps are shown of the basic types of ecological relations in phreatic groundwater and in surface water in a sample area.

In the case of interaction between two ecosystems, one could ask whether an effect on only one of the two systems is possible. The working paper does not mention this point. Most probably the case refers implicitly to a certain class of major effects.

"Relation theory", reasoning, explanation

In the chain of description - logical reasoning - explanation, Vos et al. focus mainly on description. The same can be said of the contributions of, for example, Veen (1), Forman (1) and Sharpe (1) at the congress. Van Dam et al. (p) demonstrate a program of research emphasizing a descriptive and analytical approach. As the study of horizontal relations was until recently a neglected branch of landscape ecology, this emphasis on description is understandable and useful.

Van Leeuwen's so-called "relation theory" tries to go several steps further on the difficult path of reasoning and explanation. Theory is used here as a coherent set of ideas or "conceptual system", thus in a wider sense than the concept of empirical theory commonly used in the natural sciences. "Relation theory" is the name for a logical construction based on empirical observations. Veen (1) raises the question whether this theory is not a tautology, a closed logical system like mathematics, with its axioms and deductive reasoning. Indeed the relation theory has some characteristics of a tautology, just like, for example, evolution theory and the theory of island biogeography. However, this cannot be considered a disadvantage as long as it does not turn to a self-contem-
plating sophisticated way of logical reasoning only. Van Leeuwen (1) states explicitly that the conceptual system has to be suitable for scientific purposes. Van Wirdum (1) and Tjallingii (1) demonstrate clearly that the eco-device concept and other elements of relation theory can be useful tools in the design of experiments for landscape and ecosystem management.

No doubt it is a matter of concern that logical constructs should not move too far from the real world. On the other hand, an approach focusing too much on description fails to offer the essential ideas for understanding and management of the landscape. Of course the only fruitful path to understand reality is a careful interaction between empirical research and logical reasoning. A difficulty mentioned by Veen (1) is that the high level of abstraction hampers this interaction.

"Relation theory" starts with the classical duality between process or function and pattern or form already discussed in the section on terminology. The two basic relations discerned are constancy (temporal) - variety (spatial) and change (temporal) - uniformness (spatial). This corresponds with the statement by Phipps (1) that constancy in time leads to maximum negentropy.

Clearly these concepts do not deal primarily with individual relations but with a classification of wholes.

In a system there is a class of dynamic factors essential for the steady state of the system. They may be internal or external, but they show constancy. In the discussion it was stated that all dynamic factors that show constancy are part of the system. The boundaries of a system then only exist in time. There is another class of dynamic factors that change the systems rhythm. To a certain extent the system can survive these external disturbances either by resistance or by resilience, two regulation mechanisms widely discussed in the ecological literature.

These concepts stimulated further study of the regulation processes and this again has generated a classification of regulation types. The eco-device model and its discussion by Van Leeuwen (1) and Van Wirdum (1) represent the last stage of generalization.

The next move in this logical-empirical interaction process will probably be to discover the functional relations underlying the eco-device classification of regulation types.

For example the eco-device model and its elaborations could be applied to the study of patches such as those investigated by Forman (1), Sharpe (1) or Ruthsatz (1). In that case not the relations themselves would be the central issue, but the stability and its regulation of the whole matrix-patches system.

The working paper mentioned can be obtained from: W. Vos et al., P.O. Box 23, 6700 AA Wageningen, Netherlands.

THEORY OF ISLAND BIOGEOGRAPHY

Included in this section are theses for discussion and a report by A.M.M. van Haperen, the workshop report by A.B.M. Boezeman and P.J.A.M. Smeets and two working papers: F.W.M. Vera: "The Oostvaardersplassen and the theory of island biogeography"; J.J. Barkman: "Biological minimum areas of phytocoenoses and their implication for landscape ecology".

Theoretical considerations

In the traditional landscape ecological theories and in the so-called
"relation theory", discussed in the previous section, two main complexes of ecological factors are considered responsible for species diversity:
- habitat diversity, directly or indirectly related to the abiotic differentiation of the area, including the existing gradients,
- land use, or, more precisely, the nature, constancy and diversity of management inside and outside the areas.

The theory of island biography has focussed attention on a third complex of ecological factors related to size, shape and isolation of real islands in the sea and of natural islands in a landscape dominated by man.

Generally speaking, the last complex of factors has been neglected by other theories, as is expressed in an extreme way by the dictum: "Everything is everywhere, the environment selects" quoted by Van der Maarel (1). It is the merit of the island theory that it calls our attention to the role of size, shape and isolation of islands, i.e. to the role of population dynamics in landscape ecology. However, the first two complexes mentioned above are not incorporated in a systematic way in the island theory. This was brought forward in the workshops and by Van der Maarel (1). His plea for an integration of the theories was supported by many participants in the discussion.

One of the interesting aspects of the island theory is that it tries to understand and predict the minimum areas required for the survival of species and communities. But what exactly is a minimum area? Barkman recalls an old classification of minimum areas from vegetation science literature, in which it is one of the classical problems. Three types of minima were distinguished for communities in order to determine the size of sample plots:
- the spatial minimum
- the resistance minimum (spatial minimum + buffer zone)
- the regeneration minimum i.e. the area required for all species of the community to maintain their population by self reproduction. Barkman states that if a stand is smaller than the regeneration minimum, many species eventually will disappear, unless there is a constant supply of diaspores or immigrating adults from neighbouring larger stands of the same community type.

Until recently most publications on island theory dealt mainly with birds. But is is stressed by many people during the discussion that species differ considerably in their dispersal and survival strategies. Even genetic plasticity within species can make them more adaptable to changes of environment. Generalizations therefore have to be tested for other organisms and communities.

According to Barkman in the range of one species populations - synusiae - microcommunities - phytocoenoses - complex of phytocoenoses - landscape unit - biome, each element and each sub-element has its own spatial, resistance and regeneration minimum area. So the level of integration is very important.

Another point which has to be clarified is the role of the matrix. How do standard values of size and distance vary if one is not speaking about patches in the sea but in an industrial or agricultural area? What are the barrier effects of different types of agricultural management?

One of the first steps in further research might be the formulation of useful definitions of islands. From the considerations on regeneration, or in other words the resilience type of regulation, it becomes evident that definitions can only be given within a certain time scale. In one of the workshops two definitions were proposed for the species and the community level respectively:
- A biological island for a species is a population of that species which is isolated by effective barriers from other populations so that
there is much less exchange of genes or diaspores than within a well developed community.

- A biological island for a community is a place where the potentials of a community are not realized, i.e. it does not contain all species of the community although there was time enough for all species to reach it.

The last definition seems to be more pragmatic and problem oriented but may be useful.

Practical aspects

Obviously a lot of research has to be done before reliable predictions for landscape planning can be formulated. Van der Maarel (1) presents as the main interpretation from island theory for nature conservation the idea that if you have the choice, one big reserve is better than many small ones. However, he mentions the considerations of Higgs, who made it clear that there are arguments in favour of keeping one relatively big nature reserve as well as arguments in favour of more, but smaller ones. Several authors, for example Forman (1), have pointed out that smaller patches and corridors, such as hedges, can serve as "stepping stones" for organisms to reach the larger nature reserve. Vera states that a larger reserve may act as a source of supply, from which smaller islands can be colonized. He stresses the need for research inside and connected with the Oostvaardersplassen, a recently colonized larger wetland reserve in the newly reclaimed IJsselmeerpolders in the Netherlands.

A relatively large new reserve can be considered as an experiment. This demonstrates that landscape ecology requires such experiments, which, in fact, are part of the planning process. Here the interaction between theory and empirical research, essential to the further development of theory, meets the planning practice which, to its own benefit, is made part of the interaction.

The working papers mentioned can be obtained from: F.W.M. Vera, P.O. Box 20020, 3502 LA Utrecht, Netherlands; J.J. Barkman, Kampseweg 29, 9418 PD Wijster, Netherlands.

STABILITY

The sources for this summary were a report of the workshop prepared by K.F. Wiersum, whose text is followed closely, and a working paper by K.F. Wiersum and J.H.A. Boerboom: "Erosion as a landscape ecological process". Of the working paper, only some conclusions are given here.

The concept of stability in landscape

Much of what has been said in the workshop summaries on relation theory and island theory is relevant to the problem of stability. Two forms of stability are distinguished: persistence (constancy), related to resistance regulations, and resilience (elasticity), related to resilience or regeneration regulation.

Modern human activities have resulted in an accelerated rate of environmental change. Control mechanisms to prevent greater exploitation of landscapes have been set aside and stabilizing properties have been diminished. In some cases this has resulted in landscapes being transferred from more closed systems with a "high" stability to more open systems with a "low" stability. This might result in environmental deterioration.
To counter these trends, attempts are now being made to reintroduce a certain amount of natural stabilizing mechanisms into landscape.

**Stability and scale**

The concept of stability can only be applied within a certain scale of time and space. On a spatial scale, often small scale resilience may look like constancy at a larger scale.

In several cases, local instability may even be necessary to ensure larger scale stability (e.g. gap phases in natural forest ecosystems). In his lecture Van Leeuwen draws attention for the resistance of ecosystems which use protective resilient codevices to ensure their stability. Also a disturbing force will often have less effect if it operates as a dispersed factor than as a concentrated factor.

On a temporal scale, stability can be understood as a harmonious relation between the various ecosystem components and their evolutionary speed. This makes it possible that destabilizing forces are regulated within a certain time span. Instability then is related to a differential in the speed of development of the various components, which results in a more intensive force of a destabilizing factor.

As contrasted with the human activities in old cultural landscapes the present role of man in most landscapes is characterized by large-scale energy and material inputs and outputs working on a large regional or even a global scale and in a short time span. Consequently, the relation between local instability and larger scale stability has been transferred to a regional scale and some perturbations might even have global consequences.

**Ecosystem properties related to stability**

Various efforts have been made to find a general law from which to deduce ecosystem properties which result in stability. Many general ecosystem properties that have been proposed to relate to ecosystem stability are ambiguous, especially those relating to structural properties, such as diversity. This may be partly due to the fact that there are many forms of diversity, as well as various forms of stability. The importance of a clear distinction of integration levels has already been stressed in the previous summaries. The exact properties which regulate ecosystem stability can only be ascertained in an inductive way by testing which of the general concepts are applicable.

Stability has also been related to functional aspects of ecosystems and the disturbing factors. In stable ecosystems the flow of matter and energy in the system is relatively high if compared with the dynamics of disturbing factors. Moreover such systems possess many internal compensating mechanisms, which buffer disturbances. In their working paper Wiersum and Boeboom stress the fact that the soil erosion process, which is one of the most important destabilizing forces in terrestrial ecosystems, cannot be fully understood within this framework. Inclusion of soil erosion in studies on stability focuses the attention to the potentially destabilizing abiotic factors, which occur naturally in each ecosystem, and the way these forces are mitigated. Human activities can be both destabilizing, as in the case of removal of soil litter, and stabilizing as in the example of terracing.

**Stability in natural and man-influenced landscapes**

In natural landscapes both persistent and resilient strategies to ob-
tain stability exist. They are often mainly directed towards internal disturbances. Human-influenced landscapes can be considered as more open systems where stability often must be maintained by controlling forces from outside.

In many cases in agricultural systems constancy in the form of sustained production is obtained by the elastic nature of human inputs reacting on certain unfavourable conditions (e.g. disease control). However, as the occurrence of such unfavourable conditions is mostly unpredictable, often measures are taken regardless of the real occurrence of perturbations. This overreacting might induce instability. Thus, for example, fertilizers are applied in amounts only useful in years of high precipitation and schedules of pest control are time regulated. Such overinputs of energy and matter take place in many highly developed, industrialized countries. In many cases there a lowering of input or a change to qualitative better inputs will be necessary to obtain stability. But this should not be taken as a global truth. In tropical countries presently a large proportion of products from rural ecosystems are exported to urban areas and replacement of these outputs is necessary to stabilize agricultural production and prevent malnutrition. Thus, world-wide stability can only be created by a better distribution of inputs. However it must not be assumed that inputs in the tropical zones should automatically take the same form as those in temperate zones. The latter regions have much more robust ecosystems than the former, especially with regard to the biophysical elements.

In landscapes dominated by man, stability is not only dependent on technical measures but also on its social conditions, like income opportunities, land tenure relations, etc. One of the most important social processes is the urbanization, which forces rural landscapes to become open exporting systems. In many old human-influenced landscapes stability was achieved by a resilient adaptation to the environment through social organization. The case of the Sahelian nomads is a good example. Originally this cattle-man system was stable through a resilient adaptation to an area in which large fluctuations of environmental factors are present. Under the present social conditions of increased land pressure, this strategy cannot be continued. Serious social and ecological problems are the result.

Good examples of the intimate relation between social and landscape ecological stability are also given by Dijst et al. (1) and by Banga (p).

Schroevers (p) tries to develop a theoretical model to describe social-economical underdevelopment and overdevelopment and their impact on diversity in life conditions.

The working paper mentioned can be obtained from: K.F. Wiersum & J.H.A. Boerboom, P.O. Box 342, 6700 AA Wageningen, Netherlands.
Theme II: Rural problems
ANTHROPOCENTRIC LANDSCAPE ECOLOGY IN RURAL AREAS

A.P.A.Vink

Laboratory for Physical Geography and Soil Science,
University of Amsterdam, The Netherlands

Key words: landscape ecology, land evaluation, surveys, planning

Abstract

Rural areas include all areas of the world in which the ecosystems are to a large extent directly based on the life of plants as primary producers; they contain "natural ecosystems" as well as "cultural ecosystems". Their main problem can be indicated with one word: encroachment.

Landscape ecology has to be brought to manageable proportions. This may be done by the "phytocentric approach", the "zoocentric approach" or the "anthropocentric approach". The latter approach, which is selected here, includes human needs and human responsibilities. This leads to an interdependence of landscape ecological surveys and of process studies with land evaluation. The crucial point in landscape ecological mapping is the selection of the proper differentiating characteristics within each landscape as a regional unit.

Impact assessment may be done as a direct multidisciplinary exercise, but is more comprehensively carried out within the context of land evaluation. Land evaluation includes investigations on land suitability and on land vulnerability. Given certain normative assumptions, conclusions on "allowability" or "tolerability" and on "desirability" of certain activities may be arrived at.

Eventually these investigations lead to a minimalisation of conflicts for decision makers, whose own social and political responsibilities should be clearly recognised.

1. Rural areas and their problems, an introduction

The easiest manner to define rural areas is to indicate them as all "non-urban" areas of the world (see e.g. Van der Maarel and Bauviller, 1978). Urban areas are all those areas which are covered by urban systems. For urban systems we happen to have a not too bad definition: "Urban system is any human settlement containing 20,000 or more inhabitants living in close contiguity and which exhibits a considerable degree of social, economic and political organisation" (UNESCO, 1973).

There are some improvements to be made upon this definition. As an example, there are very clear cases of small towns, for example in the Netherlands and in Switzerland (e.g. Franeker 9542 inhabitants, Bolsward 8834 inhabitants, Murten 3300 inhabitants) with a typically urban structure, which have much less than 20,000 inhabitants. A discussion on better definitions for urban and rural areas respectively might be very useful, but it would transgress too far the scope of this paper.

As it is, we have to do with a large enough surface area for the consideration as "rural areas". They include, to use a more positive approach, all areas of the world in which the ecosystems are to a large extent directly based on the life of plants as primary producers, the autotrophic organisms. This includes therefore the areas under natural vegetation as well as those under various kinds of rural land use, such as agriculture, forestry, open air recreation and fisheries.
Water areas, including oceans, seas, fresh-water lakes and streams, are just as much rural areas as are the areas covered by natural or cultural terrestrial ecosystems. If, in the following, we shall concentrate mainly on examples from terrestrial rural land use, it should still be kept in mind that:
1) rural land use in the commonly used sense (see e.g. Vink, 1975) can never be seen separate from the problems of natural areas,
2) terrestrial and aquatic ecosystems are always interrelated and mankind is equally related to both.

The problem of all rural areas in the world today can be indicated with one word: "encroachment". There is encroachment of:
- urban areas in rural areas,
- rural land use in natural areas,
- deserts in agricultural lands,
- agriculture in forestry areas,
- hothouse agriculture in agricultural areas,
- agriculture in grazing areas,
- grazing in areas susceptible to erosion,
- irrigated agriculture in grazing areas,
- to name only a few, which are mostly related to the increasing population pressure on the whole world (see e.g. FAO, 1980).

There is also, in some cases, a different kind of encroachment, for example encroachment of semi-natural vegetation in mountainous areas formerly used for grazing, such as in the Alps and in the Italian Apennines. This encroachment is due to the human wish to obtain a higher standard of living, often to be found in urban areas. It could also be seen as the reverse of the encroachment of the urban areas into the rural areas.

All these encroachments have in common that they are caused by the grave situation of human ecology in the world. They are related to the human needs at short term (food, clothing), middle term (housing, infrastructure) and long term (the needs of future generations). They are also related to human responsibilities, which finally boil down to taking the right kinds of decisions at the right time and ensuring the correct implementation, and where necessary modification, of these decisions.

A survey of previous work on these problems would include too much to even briefly summarize here. Reference is made to the literature on landscape ecology as summarized by Leser (1976) as well as to the literature on land use and on land evaluation as summarized by the present author (Vink, 1975, 1980, 1982). Recent developments in land evaluation are dealt with by Beek (1978), FAO (1980).

2. Anthropocentric landscape ecology

Odum (1963) defines ecology as "the study of the structure and function of nature" and adds "It should be thoroughly understood that mankind is a part of nature, since we are using the word nature to include the living world". Krebs (1972) writes "Ecology is the scientific study of the interactions that determine the distribution and abundance of organisms", and adds "We are interested then in where organisms are formed, how many occur there and why". Several other definitions are used, which all try to bring ecology as originally defined
by Haeckel (1869, cited by Krebs, 1972) to manageable proportions.

In consequence, there are also various, more or less different, definitions of landscape ecology. A definition which has obtained semi-official status in the Netherlands is the following (translated after Van der Maarel and Dauvellier, 1978): "Landscape ecology is the science of the relations between the biosphere and the noösphere, as they interact on the earth's surface on the one hand and the abiotic spheres (of the earth's surface) on the other hand". A definition recently put forward by the Netherlands Society for Landscape Ecology (WLO, 1979) reads: "Landscape ecology is the science which in an integrated manner studies the system of relations which is formed by biotic and abiotic factors in a part of the earth's surface which can be distinguished by its external appearance". Also here we see various attempts to bring the science of landscape ecology to a definition of manageable proportions.

It could perhaps be said that one of the main problems in the study of landscape ecology is to reduce our subject to manageable proportions. This is no wonder if one sees not only the complex definitions of ecology, but as well the various definitions of landscape and realizes the fact that the subject itself, which may also be defined as "the study of the land as carrier of ecosystems", comprises such complex systems as land and ecosystems (see also Vink, 1980, 1982).

Anybody who reduces a subject to manageable proportions for research makes a choice. This may be the choice of a limited study area, of a limited number of communities, of a limited number of variables. For the complex problem of rural areas, including the planning and execution of all kinds of projects, as well as various kinds of management of natural and cultural ecosystems, such a limited choice does not give a satisfactory general approach (see also Hempel, 1966).

A different way of making a complex system manageable is to choose a specific viewpoint, or in geographic terms, a specific projection. If one sees the diagramme of Zonneveld (1972) in which he gives the land(scape) with many "land forming factors and their interrelations" one finds a circular form, produced for convenience on a flat surface, but it is understood that more properly this should be seen as a sphere. The flat representation of a sphere is a normal projection, with which we have all been acquainted since our primary school days. In addition the factor time is brought in as a fourth dimension. This may also be indicated in a projection (see figure 1).

A viewpoint very often used in landscape ecology in order to make the actual sphere manageable, is to look at the various attributes of a landscape from the aspect of their relevance for natural plant communities. This viewpoint is a natural one for biologists. A typical example is given by Kalkhoven et al. (1976) which leads to the indication of "potential natural vegetation" in the various landscapes of the Netherlands. This approach could be called the "phytocentric approach" to landscape ecology. In a comparable manner, looking at the landscape with a view to its relevance for animal communities, a "zoöcentric approach" could, and should, be formulated much more often than has been the case until now.

The problem of rural areas, indicated as a problem of "encroachment", as has been done above, is in the first place a human problem. It is caused by human needs and it has to be decided upon by human decisions. It is therefore much more relevant to make it manageable by an "anthropocentric approach". This does not prevent us from using for specific situations a phytocentric or a zoöcentric methodology, or both. These three approaches are indicated in table 1 and in figure 1. The three
approaches should not be confused with the (old-fashioned) division into fundamental and applied sciences. Each of them has fundamental as well as applied aspects.

Table 1. Approaches to landscape ecology

<table>
<thead>
<tr>
<th>Approach</th>
<th>Description</th>
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<tbody>
<tr>
<td>Phytocentric</td>
<td>an approach which studies land(scape) and its attributes from the viewpoint of their relevance for plant communities,</td>
</tr>
<tr>
<td>Zoocentric</td>
<td>an approach which studies land(scape) and its attributes from the viewpoint of their relevance for animal communities,</td>
</tr>
<tr>
<td>Anthropocentric</td>
<td>an approach which studies land(scape) and its attributes from the viewpoint of their relevance for the short-, middle- and long-term needs of men, as well as for the impact of human interventions and the consequent human responsibilities towards other organisms and towards future human generations.</td>
</tr>
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Figure 1: Land(scape) seen in projection and in four dimensions with three different approaches.

It is absolutely necessary to consider that a large number of human needs must be fulfilled for the continuance of mankind. These are not only short-term needs of food, clothing, etc., but also middle-term needs of development. But even more important are the various long-term needs of the world community of human beings as well as of all the
various regional and local human communities. These environmental needs include abiotic, biotic and psychogenous needs, as well as the social aspects of each. They are aspects of human ecology (see e.g. Harris (Ed.), 1980). They also include the needs of subsequent human generations to make their own decisions, according to their own lives and those of their communities.

But man has not only needs. Man is a responsible animal. His extreme power to encroach on the ecosystems of other human, animal and plant communities can only be executed within the context of his responsibilities. Therefore, there is a basic difference between the phyto-centric and the zoöcentric approaches on the one hand and the anthropocentric approach to landscape ecology on the other hand (see e.g. Van Peursen, s.a.).

The anthropocentric approach puts the responsibility for any intervention squarely where it belongs. It also provides an opening for the application of several methods for solving the problems or at least of minimalising the conflicts. Many conflicts in rural areas cannot be solved solely by scientific methods. But scientific methods can bring the discussion where it belongs, in a shape in which the discussion can touch the essentials.

A large group of methods are often called "environmental impact assessment", another group is called "land evaluation". All these methods belong to "evaluation" in a broad sense. These evaluations can only be executed if sufficient basic data have been gathered of such a kind and in such a manner that their proper evaluation for a specific purpose is possible.

It should be understood that at least three different stages should be recognized (table 2). These stages are too often confused, which leads to bad manners as well as to bad decisions.

Table 2. Stages in rural planning, project execution and management

| A. Basic research: | landscape ecological surveys |
|                   | process studies |
|                   | field experiments |
|                   | laboratory experiments |
|                   | laboratory analyses |

| B. Evaluation: | land evaluation |
|               | environmental impact assessment |
|               | early warning |

| C. Decision making: | political decisions based on A + B plus several non-ecological considerations |
|                    | (social, aesthetic, ethical, financial) |

The stages A, B and C are parts of a cyclic, or repetitive, process with different aspects for the three interrelated purposes:
- planning,
- execution,
- management.

All planning has to be "process planning" because increase of information, changing circumstances and changing goals require modifications in the plans. The execution of any plan requires modifications and elaboration of details due to additional findings with regard to basic data and their evaluation. Any execution of a project, with or without
"land transformation" (SCOPE, 1979) takes place over a certain period of time. During this period processes in the landscape continue and this may lead to further findings requiring modifications. Management within any land utilization type, from pure nature conservation to hothouse horticulture and to urban land use, has to "match" its activities with internal and external processes of cyclic, continuous or irregular impacts on natural and cultural ecosystems. For all these three, planning, execution and management, the stages indicated in table 2 are parts of feedback processes.

3. Some remarks on the collection of basic data

In table 2 five different methods of basic research are mentioned. We shall only indicate some aspects of landscape ecological surveys and of process studies (see also Vink et al., 1981). Field experiments and laboratory experiments are both excellent groups of methods for collecting basic data, but the present author is not the proper person to discuss them. Laboratory analyses: chemical, physical, botanical, mineralogical, etc., are in most cases nearly indispensable tools to support all other investigations; their methodology is less relevant for the present paper. Ecology, according to Van Leeuwen (1966) is basically concerned with "pattern" (relations in space) and "process" (relations in time). Surveys and process studies may therefore be called the two central techniques for investigations in landscape ecology.

Landscape ecological surveys can be executed in several different manners and at many different scales (from 1:1000 for very detailed work in small areas to 1:5 million for world surveys). They all have in common that a complex phenomenon, a landscape, including abiotic as well as biotic attributes, has to be depicted in as realistic a model as possible. This model, a map plus additional figures and text, need not be easily readable for a lay-person. It must however be interpretable by experts with a view to land evaluation or impact assessment or both. In order to bring the survey problem to manageable proportions, differentiating characteristics have to be selected. This may be done by one expert, e.g. a botanist, selecting primarily vegetation characteristics and adding some data on relief, soils, water, etc., or vice-versa by a soil scientist or a geomorphologist, using mainly his own characteristics and adding some data on the biotic characteristics. A better solution is an integrated multidisciplinary survey, where several different experts co-operate to produce an integrated final result. The kind of solution selected for a particular case in a particular area depends on:
- the nature of the area,
- the nature of the most relevant problems,
- the availability of experts,
- the availability of time and money.
Whatever expert or team is selected, a map legend of a landscape ecological map always tries to indicate biotic and abiotic attributes of a very complicated system, a landscape, with a relatively small number of differentiating characteristics. This is possible because these differentiae, if carefully selected, represent a much larger number of associated "diagnostic characteristics" and "intrinsic properties" (see also Zonneveld, 1979). Differentiating characteristics, diagnostic characteristics and intrinsic properties together represent
the most relevant properties of the "correlative complexes" found in nature. These correlative complexes are due to the interactions of several natural processes such as soil formation and vegetation succession under given conditions of climate, geology and human activities.

In most cases some kind of map has to be produced, even if also other methods of research are used. Only the map will make it possible to interpret all data in a regionally differentiated context. This regional differentiation is essential for all practical applications. An anthropocentric approach to the survey means that from the beginning, the relevance of the characteristics is considered with a view to their eventual evaluation (see section 4; see e.g. Somasiri et al., 1979; Kwakernaak et al., 1979).

Landscape ecological survey from an anthropocentric viewpoint is not primarily meant to be studied as a pure science. It is made for people to do something with. Therefore, there is a continuous feedback from impact assessment and land evaluation to the surveys and vice versa. Expressed in other words: there is a continuous tension between what the landscape offers and what man requires. This has been described for land evaluation by Beek (1978) who even considers the surveys to be a part of land evaluation.

Process studies are an essential complement to surveys. They are a means of studying the ecological relationships within a landscape over given periods of time. These process studies may be concerned with: a) processes in the past, leading up to the actual situation, b) processes under the actual conditions occurring in the area, c) predictions of processes in the future, d) monitoring future developments. Several of these processes coincide also with the research on "land transformation", initiated by SCOPE (1979).

Processes in the past have always been, and still often are today, studied from a pure-science viewpoint of landscape genesis. Their value for the environmental conditions of the landscape of today has often been underestimated and conclusions for this purpose have been neglected. Still it is of the utmost importance for example if landscape instability leading to land slides has occurred in the past specifically under glacial, periglacial or pluvial conditions and their vegetations, or if it also occurred under conditions similar to those prevailing today. An example of studies of the changes in the more recent past, specially made for landscape ecological purposes, has recently been published for the coastal dune areas of the Netherlands (Bakker et al., 1979). A further systematic elaboration is shortly expected (Bakker et al., 1981).

Processes under the actual conditions occurring in the area are being studied by plant ecologists, zoologists (including fishery experts, see FAO, 1972), sedimentologists, soil scientists and others. Some special mention is made here of the modern school of geomorphologists who concentrate their research on "actuo-geomorphology" or "dynamic geomorphology" (Imeson and Jungerius, 1976, 1977). Their often very precise and quantitative investigations are applicable to many land conditions of the terrestrial parts of the earth (see also Vink et al., 1981).

Predictions of processes in the not too far future have to be done on certain assumptions with regard to the prevailing conditions. We have done some investigations for the prediction of landscape ecological developments due to rural land use in certain areas of Italy and of
the Netherlands, based on assumptions with regard to socio-economic and technological developments. These give a view of the fairly long-term (20 to 40 years) impact on the landscape ecological conditions (Westerveld, 1979; Verbakel, 1980; Verbakel et al., 1980; Vink et al., 1981).

Processes in the future may to some extent be predicted, but these predictions are of course always uncertain, in particular with regard to the validity of the assumptions. Quite often certain alternative sets of assumptions have to be made. It is therefore necessary to monitor these processes at periodic intervals, with special regard to the impact of human land use. An example of this is provided by the GEMS (Global Environmental Monitoring System) of UNEP. Monitoring may be done by several methods. One of these is the interpretation of sequential tele detection ("remote sensing") produced with satellite imagery. But also periodic field studies at regular intervals, are necessary for this purpose.

4. Impact assessment, land evaluation

It is a fallacy to think that landscape ecological studies as such lead to better decision-making in a man-guided, man-influenced and sometimes man-destroyed world. This has been clearly proved by experience with soil surveys, which may be seen as a specific kind of landscape ecological surveys (Vink, 1980, 1982). Basic research, even if it is carried out from an anthropocentric viewpoint, has to be explained to planners, decision-makers and managers in simple and clear terms. This needs in the first place the summarizing of often complex scientific results and secondly their translation into common language. This is not only of benefit for the people who have to handle our data; it is also of great benefit to landscape ecologists themselves with regard to anthropocentric landscape ecology and this approach is even essential for the methodology itself.

The first benefit to ourselves is, that we are free to develop our own systematics and terminology for basic research. Without this, no science can be properly developed. But this is only possible if we are prepared to summarize and translate our findings for practical purposes. It is possible, and necessary, to promote a certain general ecological awareness among all people, in particular to our representatives in democratic institutions and to technicians and policy-makers. But for each particular case, we shall have to assume a general lack of detailed knowledge of any science. To combine this approach with the development of scientific terminology hampers the application as well as the science itself.

Anthropocentric landscape ecology as indicated above concentrates its research on human needs in space and time and on human responsibilities with regard to the ecological conditions of the land. Both these aspects have to do with human management and human technology, which have in general continuous or recurrent as well as more or less large or intensive, non recurrent, impacts on the natural and/or cultural ecosystems in any given landscape. These impacts may come about gradually, for example by changes in land use (increased manuring on arable land, increased grazing on natural grazing lands, increased erosion, increased desertification, gradual waterlogging, salinization). They may also be sudden (cutting of natural forest, ploughing of natural grazing lands) or within a relatively short time (establishment of irrigation and/or drainage projects, infiltration of dunes for water purification). Most of the above-mentioned impacts are wanted and
planned with regard to their primary impacts, but they often carry with them unwanted and unforeseen impacts. Some other impacts may be due to leaving-off of the original management, e.g. the overgrowing of certain moors by other vegetation. This impact assessment needs firstly the careful study of the existing situation on different land units with different ecosystems and different vulnerability to various impacts. Secondly, it has to have prediction value with regard to the different ways and means of human technological activities. A special study of the latter, with their various variations and intensities is required.

Land evaluation as developed in the last years (Vink, 1975; FAO, 1976; Beek, 1978; Bakker et al., 1981) has several contributions to make to impact assessment as well as making its own contributions to anthropocentric landscape ecology. These may be indicated as: a) land utilization types, b) ecological land conditions or land qualities, c) land suitability and land vulnerability, d) planning procedures. Land evaluation has thus far been mainly applied to the planning of agricultural land use in rural areas. Some very similar methods have been used in fact by the Californian "Early Warning"-report (Patri et al., 1970).

The careful and detailed description of land utilization types, as quantitative as possible, is a crucial step in all planning of rural areas. Beek (1978) has developed this concept, as well as several related ideas, with particular reference to agriculture. Some initial steps have been taken in order to elaborate this concept to other kinds of rural land use, such as recreation and nature conservation. For agriculture, the following denominators are mainly used to indicate each separate land utilization type (Beek, 1978): 1) produce, 2) labour, 3) capital, 4) management, 5) technology, 6) scale of operations. With suitable modifications, these key attributes are also applicable to other rural land uses, such as recreation and nature conservation.

Ecological land conditions or land qualities have first been clearly described by Beek and Bennema (1972) and later elaborated by Beek (1978). They are attributes of the land which act largely as separate factors on the performance of a certain use, e.g. available water, available nutrients, nutritional value for animals, resistance to erosion, etc. These land qualities are the essential elements in the solution of the tension between what the land offers and what the land use requires.

Land suitability for relevant kinds of land use and land vulnerability with regard to certain land uses with certain kinds and intensities of human impact, are the crucial parts of land evaluation. Land suitability has been developed, either in this name or as land use capability, irrigability etc. in many countries and by many people. Although it is in general applied to agriculture and to forestry, it is, with modifications, applicable to all kinds of rural land uses (see e.g. Vink, 1975, 1980, 1982). Land vulnerability includes all kinds of determinations and conclusions with regard to excessive or unwarranted kinds or intensities of land use. In some cases, it correlates strongly with the land quality of resistance to erosion. But also vulnerability of (semi)natural vegetations to increasing density of recreation, is a very clear case of land vulnerability. This has been demonstrated by Van Ittersum and Kwakernaak (1977) for the Netherlands Wadden Isles.

In addition, other kinds of land evaluation for rural land uses, with special reference to recreation and nature conservation, are now being developed. The land evaluation for the coastal dune lands of the Netherlands (Bakker et al., 1979, 1981) is a case in point. In this context Van Zadelhoff (in: Bakker et al., 1981) defines the concepts of
"allowability" or "tolerability" and of "desirability". The first is developed with a view to the external management of nature reserves. It indicates the kind and intensity of human land use interventions in the surrounding area of a nature reserve, which may be allowed or tolerated without undue influence on the ecosystems within the nature reserve concerned. The second, "desirability", indicates the degree of relevance of several kinds of human interventions with regard to the internal management of a given ecosystem within a nature reserve. Both concepts have to be based on certain clearly defined normative assumptions. They promise to be useful also for other problems and rural areas. Allowability is in principle to be applied to all kinds of "encroachment" in rural areas (see section 1). Desirability is certainly a useful approach also to recreation areas, but it may be a useful concept for all kinds of land management in all other rural land uses.

Land evaluation is finally concerned with the integration of landscape ecological data with the other parts of the process of land use planning. One of its basic concepts is found in the difference between physical land evaluation and integral land evaluation (Beek, 1978). In the first, the physical or ecological aspects are considered within a general socio-economic context but without elaborating the non-physical aspects. In the second, a continuous multidisciplinary co-operation between natural sciences and socio-economics is required in order to come to a fully integrated and detailed evaluation. In solving general problems of rural areas, the former may be of more importance than the latter, but as soon as the living standard of rural populations is concerned, the latter has to be applied at least for benchmark conditions.

Another part of the planning procedure with which land evaluation is concerned, is indicated with the key words "two-stage approach" and "parallel approach" (FAO, 1976). In the two-stage approach physical, such as landscape ecological, investigations and their evaluation precede other, socio-economic and political, considerations. In the parallel approach, all various aspects are treated from the beginning of the exercise in an integrated multidisciplinary manner.

5. Minimalisation of conflicts for decision makers

The problems of rural areas are human problems. They are problems of human beings and human societies which include the problems of all other organisms which in this technological age are all dependent on man. These problems have to be investigated as fully as possible by scientific methods and the results of these problems have to be explained to all people concerned, in a manner which is at the same time scientifically balanced and easily understandable. But decisions on land use planning and on land management do not belong to science, however much we as scientists may be personally, and often emotionally, concerned with their outcome.

Decisions are taken by governments, regional administrative bodies, land owners, farmers and others who carry a direct social and political responsibility for the lands which they are concerned with. In all these, preferably democratically controlled, institutions, conflicts of opinion as well as conflicts of interests are unavoidable. In rural land use planning these conflicts are however often enhanced by a lack of knowledge of the landscape ecological facts and of their fundamental importance for all human interventions. To this is added
a reluctance, or sometimes even a lack of the will, to properly define the terms and the problems to which the decisions are applied. By contributing its general knowledge, the results of its investigations with regard to the actual situations as well as to the relations in space and time, and by explaining these findings for the benefit of the responsible people, anthropocentric landscape ecology has to help in minimizing the conflicts. In this respect it is a tool comparable to such methods as the social cost-benefit calculations made by economists, also a useful but imperfect tool (Drapers, 1980). The essential conflicts may then be seen in their true proportions. For the rest, we have to hope that there are enough responsible people of good will, not only for our time, but also with regard to the needs of future human generations and their dependent organisms.

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Methodology of Ecological Landscape Evaluation for Optimal Development of Territory

Milan Ružička and Ladislav Mikloš

Institute of Experimental Biology and Ecology, Slovak Academy of Sciences, Bratislava, Czechoslovakia

Abstract

The programme of LANDEP and EET represents a specific Czechoslovak access to solving the questions of optimal ecological utilization of the landscape for a development of society. It is a contribution to an effort for a complex attitude to the care of landscape as a part of environment. The LANDEP is a system of applied scientific methods aimed at obtaining a new quality of knowledge by means of landscape-ecological synthesis /based on typification and regionalization/ and successive evaluation of ecological value and functions of the landscape. The results obtained in a form of ecological proposition are used directly in practice, because they contain a proposal for the purposeful division of territory as well as principles of the landscape protection and creation. The LANDEP and EET of each territory contribute, with regard to their contents, not only to the development of the territory and to managing, political and production practice as well, but also to further development of theory and methodologies of complex landscape-ecological research.

Introduction

In Czechoslovakia during last two decennia the theory and methodologies of landscape-ecological planning /LANDEP/ as a specific form of the complex landscape-ecological investigation with a certain degree of application for the requirements of planning and projecting practice has been worked out. The knowledge so far obtained /Ružička, edit., 1970, 1973a,b, 1976, 1979/ opens possibilities for developing a new branch of basic research as well as for a more complete application of ecological standpoints in the process of elaboration of documentation for territorial planning and projecting / Fig. 1/. In a sphere of theoretical research the LANDEP possesses characteristics of planning the optimal utilization of ecological properties of the landscape and creating conditions for a harmony between man and landscape. In territorial planning practice the LANDEP has a simplified form of ecological evaluation of territory /EET/, which becomes a part of data on the territory and in this manner also a part of the planning and projecting processes.

Abbreviations used: LANDEP - Landscape-ecological planning, EET - Ecological evaluation of territory, LET - Type of landscape ecological complexes.
Fig. 1

Sphere of landscape research

- Complex landscape ecological investigation
- Theoretical knowledge
- Regional knowledge development

LANDEP

- EET
- Territorial planning

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<tr>
<th>Management</th>
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<td>Realization</td>
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<td>Utilization and development of territory</td>
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Scientific development

Economic planning

Sphere of landscape utilization
The LANDEP conception, namely in its EET applied form, stresses a need for the complex access to evaluation of the landscape as a territory, in which activities of man and society are developing on the basis of natural phenomena and processes. It is necessary to improve, to extend and to set in order systematically the knowledge and data on ecological factors, which have been used till now on different levels and in different ways in the territorial planning.

Theory and methodologies of the LANDEP

The LANDEP is a broadly conceived synthesis of the knowledge on potential possibilities of optimal and rational utilization of the landscape from the standpoint of intentional creation of conditions for preservation and development of healthy population of organisms and man and for development of human society as well. Methodically the LANDEP is based on the analysis of ecological properties and on their interpretation, synthesis and evaluation. The LANDEP results in a proposition of optimal ecological utilization of the landscape, which is aimed at the harmonization of social activities in the landscape including its ecological properties in time and space.

Theoretical conception of the LANDEP comes out from the presumption that the level of knowledge on components, elements, processes, and phenomena in the landscape /geobiosphere/ is approximately similar. With regard to the fact that a reverse is true, the concrete content of the LANDEP must take into consideration the aim, direction, opinion, and available information on the territory, for which it is being elaborated.

The LANDEP content crystallized gradually into the scheme of its basic items /Fig. 2/. The methodics worked out /Ruzicka, Mikloš, 1979, 1980/ ensures a harmony between a kind of the LANDEP and its content with regard to a suitability of choice of methods of differentiation of the purport in individual basic items of the LANDEP content according to the scale and timing.

The EET as a simplified method of the LANDEP

A basic methodics of the LANDEP is relatively broadly conceived and it contains a complicated method of optimalization with certain formalized processes. It can be solved also with the use of computers. However, when introducing the LANDEP into practice, all assumptions for a complete application of the methodics are not often fulfilled, namely as far as the purport and extent of the content part are concerned. It is a question of the accessibility of data and the short time limit connected with time dispositions for elaborating the documentation of territorial planning.

In the process of simplification of the LANDEP method the ecological analysis is narrowed to the most important ecological properties of the landscape and it is supported mostly by re-evaluation of already worked up data, which are supplemented by informational investigation in the field. This preserves a logic framework of the method and its basic procedures /Fig. 2/. In the most of territories investigated /Ruzička et al., 1976; Ruzička, Mikloš, 1979b,c; Ruzička et al., 1980/, the
Fig. 2

Society needs and requirements for territory

Landscape ecological properties

Determination of aims and delimitation of territory of interest

Landscape ecological analysis

Landscape ecological synthesis

Partial syntheses

LET / ECOREGION

Evaluation of ecological data

Landscape characteristics

Landscape functions / social activities /

Suitability of LET for functional elements

Ecological proposition

The primary-alternative

The secondary-functional typification

The tertiary-functional regionalization

Purposeful division of territory

Protection and creation of environment
simplified methods, mainly the partially formalized method of "decision in table" were employed.

Whereas the LANDEP is based on the broadly conceived synthesis providing the higher possibilities for a theoretically ideal ecological optimization of utilization of the landscape, the EET aims at the recognition and evaluation of selected the most significant properties of the landscape as well as at the assessment of assumptions for an optimal harmonization of landscape-ecological conditions with a functional utilization of the given territory from the standpoint of interests of development of society.

The content of EET is based on the design of LANDEP /Ruzicka, Miklós, 1979a/, and, within a range of the preparatory stages for elaborating the documentation of territorial planning, it consists from the parts as follows:

A/ Landscape-ecological data on the territory

1. Analytical part.
   1.1. The delimitation of the territory of interest, where in addition to the administrative boundaries also more or less natural boundaries must be applied.
   1.2. The geological basis from the standpoint of its resistance, carrying capacity and tectonics /engineering geology/.
   1.3. The soil-forming substratum and the soils on the basis of Quaternary sediments and of soil-ecological properties /soil and stand reconnoitring/.
   1.4. The morphometry of relief, mainly the inclination, orientation, forms, etc. /evaluation of topographic map/.
   1.5. The climatic conditions based on the climatic regions and windy conditions /atlases/ and interpretation of morphometry of relief for insolation and shading.
   1.6. The potential and real vegetation evaluated on the basis of physiognomic-ecological formations.
   1.7. The contemporary landscape structure as a result of influence of economic activity of man and natural factors. The mapping is based on the particularly elaborated units within a framework of 6 groups of elements /forests and scattered greenery, grasslands, arable lands, denuded substratum, water areas and flows, technical works and settlements/.
   1.8. The anthropic phenomena and processes from the standpoint of positive and negative effects on soil, relief, and the contemporary landscape structure.
   1.9. The environmental hygiene, mainly the pollution, the noise, radiation, the hygienic protective zones, etc.

2. Synthetic part

The aim of synthesis is to create types and regions as ecologically homogeneous units of a vital importance in the further process of EET.

2.1. The landscape-ecological typification is based on the partial typification of abiotic, biotic and anthropic factors. The characteristics of the types are expressed in the table and the spatial distribution on the map. The types, as units with a clearly defined content can be arranged into a logical scheme according to their properties /in the form of table/, which facilitates deciding the use of types to a considerable extent. The types serve as a basis for the
process of optimalization.

2.2. The landscape-ecological regionalization comes out from typification representing the spatial differentiation into territorial units with characteristic and unrepeatable composition of the landscape type. The regions serve for a total characterization of the territory and as the basis of separation of functional units.

3. Interpretation of landscape-ecological data

The main purpose of interpretation is obtaining the indices of ecological peculiarities of the landscape, which cannot be revealed directly in nature. Interpretation can be characterized as a process of transformation of basic indices into the form, which accomodate to the process of optimalization. Interpretation includes both analytical and optimalization parts, but it is applied the most at partial syntheses in the synthetic part.

Interpretation of the basic landscape-ecological properties makes it possible to obtain from analytical materials the dynamic characteristic such as carrying capacity of the substratum, insolation of relief, dynamics of material transport, anthropic changes of vegetation, degree of synanthropization of the landscape, ecological stability and resistance of the landscape, etc.

B/ Landscape-ecological optimalization of the utilization of territory

In this part are evaluated the types of landscape-ecological complexes /LET/ and landscape-ecological regions created in the process of ecological synthesis of the landscape.

4. Evaluation

This is the most significant part of the whole methodic process of elaboration of ecological data on the territory. It is divided into several closely connected parts.

4.1. The selection of indices of ecological properties of the landscape based on analysis and synthesis, which are expressed in LET /arranged into a table, see point 2.1./. It is a direct consequence of interpretation.

4.2. The selection of functional elements /social activities/ in the landscape is based on the spatial requirements of the practice for certain activities securing the development of society. Dislocation of activities in the landscape represent the spatial units, so-called functional elements. Their combination and planary requirements for working, housing and recreation are given for each territory on the basis of plans of its development. The role of EET is to arrange, re-evaluate, and classify these functional elements into basic, supplementary and special also from the ecological point of view.

4.3. The assessment of functional values of indices of ecological properties of the landscape, i.e. the assessment of suitability of LET for functional elements. It is a complicated process in which one decides according to the beforehand determined criteria based on the valid norms for individual kinds of activities. Besides that the local or commonly valid limiting factors for individual functions are determined and taken into account. For EET the so-called method of decision in table is used. For LAKDEP the functional value of an index of landscape
properties is determined by its mathematical function.

4.4. The assessment of suitability of contemporary utilization of the landscape is based on the confrontation of contemporaneous /secondary/ landscape structure with a similar and potential one, respectively, from which follows an intensity and a mode of anthropic influence on the landscape. It is determined whether contemporary utilization of the landscape is a positive, possible or negative phenomenon expressing the degree of harmony or disharmony of human activities with ecological conditions.

5. Propositions

Propositions are aimed at the harmonization of ecological properties /potential/ of the landscape with its utilization for the purpose of development of man and society.

5.1. The primary proposition is usually a projection of results of decision in table into a map, where for each LET the functions are given in an order of convenience. They provide a material for alternative solving the proposals for utilization of individual areas.

5.2. The secondary proposition represents an arranged and re-evaluated result of the primary proposition according to the spatial requirements of society for individual functions with regard to relations to adjacent areas, to the size of individual areas, etc. It is a basic result of EET called the purposeful division of territory, which has a character of functional typification.

5.3. The tertiary proposition possesses a character of regionalization, because it delineates parts of territory with a distinctive grouping of functional elements, of them one functional type prevailing. It is a creative process based on the map of functional types, in which functional regions of the territory are proposed. The results of secondary and tertiary propositions represent actually the proposal for ecologically optimal landscape structure, which serve as a basis for re-evaluation of not only contemporary, but also proposed urbanistic and productive structure of the territory.

5.4. The protection and creation of environment represent a further stage of propositions, in which the proposal of ecologically optimal landscape structure is confronted with valid or proposed documents of territorial planning /for a development of urbanization, agriculture or other complex of social activities/. We come out from the fact that in the landscape must be placed all the activities required for a social development, however, applying the principle of choice of so-called "the least evil".

5.4.1. The analysis and classification of problems of environment leads to a problematic map, which expresses a harmony, partial harmony or disharmony of ecologically optimal and territorial proposal for the purposeful division of territory. It is worked up in a close collaboration of ecologists and territory planners. The problematic map shows direct and indirect negative influences of planned interferences on the landscape, in the case that ecologically based proposals will not be respected.

5.4.2. The choice of measures for elimination or lowering the unfavourable consequences of planned interferences on the quality of environment is realized on the basis of collective expertise using the data available in this field. The measures are abiotic /of technical character/, biotic /arrangements of vegetation/ and combined.

5.4.3. The proposal of measures for elimination of existing and expected unfavourable phenomena in environment represents always a certain combination of measures /type/, which are related to a certain part of
Expression of ecologically well-founded measures in a map serves as a base for their more detailed elaboration in further stages of projecting preparation. They must represent a part of documents of territorial planning on a level of utilization and creation of territory and on a level of economy as well.

Present results and their use

The LANDEP as a part of landscape-ecological research can be developed only on the team-work basis. Composition of the team reflect needs of the LANDEP content. At the same time each member of the team must possess a skill to obtain all necessary published and unpublished data, and to elaborate his topic inventively from the standpoint of its use in the LANDEP programme. The amount and quality of data on the landscape employed in LANDEP and EoT must be modified according to their significance and usage for final theoretical and practical aims.

Theoretical and methodical principles of LANDEP were worked out and prepared for publication. They were provided to be used in Bulgaria and they are at the disposal of other countries belonging to the COMECON, which joined a common project of integration network of model territories for elaboration of the standard methodologies of EoT for territorial planning.

To verify and modify the methodologies of LANDEP for need of practice approximately 30 projects in a collaboration with projecting institutes were worked up for different purposes from small to large territories /scales from 1:1 000 to 1:100 000/. A close collaboration with territorial planning and projecting practice made it possible to elaborate simplified methodologies of LANDEP which could be used by projecting institutions. To work out and to use the EoT method a working team included into an urbanistic atelier was installed in a projecting institute /Stavoprojekt, Banska Bystrica/ in a collaboration with authors of the method. The team has successfully elaborated the EoT as a part of territorial planning documentation in the process of projects preparation.

In Czechoslovakia assumptions for incorporation of ecological standpoints into the system of territorial planning were created in the form of EoT. It can be applied as a specific preliminary step before starting the preparatory work on territorial planning, whether territorial prognoses or investigations and analyses of the territory are concerned. Besides that it can be applied directly when elaborating the documents and projects of territorial planning in accord with valid regulations, where the necessity of using the ecological documents is anchored, but its content is not specified lacking the synthetic aspect and process of evaluation and propositions from the ecological point of view.

On the level of legal regulation it is necessary to solve simultaneously a question of the calculation of costs and the mode of reckoning the costs of EoT in the process of elaboration of documentation of territorial planning. Methodic assumptions are created also for this case, and it is only the question of time, when the methodologies of EoT for optimal development of territory will become a part of obligatory documentation for territorial planning.
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SPATIO-TEMPORAL PATTERNS OF FOREST ECOSYSTEMS IN MAN-DOMINATED LANDSCAPES
OF THE EASTERN UNITED STATES

D. M. Sharpe, F. W. Stearns, R. L. Burgess, W. C. Johnson

Geography Department, Southern Illinois University, Carbondale, Ill., USA; Botany Department, University of Wisconsin, Milwaukee, Wis., USA; Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tenn., USA; Biology Department, Virginia Polytechnic Institute and State University, Blacksburg, Va., USA.

Abstract

Forest clearing in the eastern United States has created landscapes with fragmented and isolated forest stands. Theories suggest that such landscape qualities as size, shape and isolation of forest remnants, intervening land uses, habitats to which forest is relegated, and rates and location of continuing forest clearing and reforestation fundamentally affect species composition and rates and patterns of succession, local extinctions and invasions. These were investigated in several states. Original vegetation and cover type and cultural features at intervals since the 1930's, and data on topography, soils and hydrology were measured. Spatial analysis, classification techniques and diversity indices describe the underlying spatial patterns, while transition matrices describe rates of loss or creation of forest patches. Study methods, results and implications for landscape ecology are considered.

Introduction

In three centuries, European settlers and their descendents fragmented or removed most of the forest in the eastern United States. Once continuous forest has been superceded by landscapes of isolated trees, fence-rows and forest groves of varying size, shape, and levels of disturbance— islands in a sea of agricultural and urban land uses. The portions of the Eastern Deciduous Forest Biome most severely and continuously fragmented are in the Midwest where agriculture continues to be the dominant rural land use (Curtis, 1956; Auclair, 1976; Galluser, 1978). Man-dominated landscapes are exemplified by a meshing of human and natural ecological processes that create mosaics of ecologic and man-made features. A foremost concern in such landscapes is the potential extinction of plant and animal species (Curtis, 1956) which can occur even when forest tracts of several square kilometers are retained. The altered ecologic dynamics of remnant forest stands have been discussed by several researchers in Burgess & Sharpe (1981) and by Tramer & Suhrweir (1975), but these studies manifest three fundamental shortcomings. First, impacts of fragmentation have been assessed for individual forest islands, while interactions between forest islands have been neglected. Second, descriptors that integrate stand history, such as species composition are not likely to be in equilibrium with current patterns of land use. Third, a dominant attribute of these landscapes is that they continue to evolve. In contrast to the repetitive or cyclic perturbations in presettlement landscapes (Loucks, 1970; Bormann & Likens, 1979; Sprugel & Bormann, 1981), modern disturbances are often characterized more by unidirectional and
progressive sequences of types and intensities.

Surprisingly little is known about landscape dynamics of deforested regions and their ecological significance. We believe that investigation of spatio-temporal patterns is a necessary step toward understanding and managing man-dominated landscapes. This research explores the spatio-temporal patterns of selected landscapes to clarify linkages between land use and ecological processes within and among remnant forest patches.

Methods

Spatial patterns of sample landscapes were studied. In Wisconsin, Illinois, Indiana, and Georgia sample landscapes were 25 km², while in Ohio, fifteen 100 km² landscapes were examined. Samples were chosen to be representative of regions in southeastern Wisconsin, for example, along three east-west transects that extended from Lake Michigan inland for about 40 km.

Each sample landscape was gridded into 1 ha cells (i.e., 2500 cells per 25 km² grid), where locations known from the grid coordinates permit spatial analyses to a resolution of 100 m. We obtained data on historic changes in landscape pattern with emphasis on several categories of natural vegetation and on surrounding cultural features (Table 1). Physical data were obtained to determine those environments where characteristically natural vegetation had been removed.

To develop a time series extending as far back into the historic record as possible, a variety of data sources were used. Our time series extends from the presettlement landscape (Dorney, 1980) to the 1970's. Since most of this period predates high technology data such as LANDSAT, we were limited to aerial photography and maps. Most data on land use and cover types post-date the late 1930's when aerial photography became widely available for the United States.

The resulting data base is a series of digitized "maps" with information concerning the sample landscape having a resolution of 1 ha (or 100 m for linear features). The time series data were used for studying temporal changes in the spatial organization of the landscapes. We conducted our data analyses with IMGRID, a spatial data base management and analysis program (Sinton, 1977). IMGRID is useful for three classes of analysis: (1) to count the cells with a specific feature to determine totals, e.g., hectares of woodlot, or 100's of meters of fencerows; (2) to make areal associations, such as woodlot areas on particular soil types, or forest islands in the 1930's that have since been cleared; and (3) to calculate distances, as between woodlots or from forest islands to highways or other developments.

In addition to regional surveys, a field study was conducted at the University of Wisconsin-Milwaukee Field Station 50 km north of Milwaukee to estimate the dispersal distance of selected tree species. Blue jays (Cyanocitta cristata) transporting beech nuts (Fagus grandifolia) and acorns (Quercus spp.) from a large forest island to surrounding wooded areas were observed. Seedlings derived from dispersal from a fencerow of green ash (Fraxinus pennsylvanica) and basswood (Tilia americana) and from an isolated sugar maple tree (Acer saccharum) were tallied. Quadrats (1 m²) were located at 5 m intervals along transects that extended 150-200 m from the seed source.

Results

Analyses of regional surveys show the diversity of forest island patterns, the characteristic sequence of forest island development, and the
Table 1. Variables measured to evaluate spatio-temporal patterns of landscapes. Many variables include more than one parameter.

**Georgia, Illinois, Indiana, Wisconsin (data by grid cell)**

*Environmental Variables: Soils; topography*

Sources: USDA Soil Conservation Service; US Geological Survey

Topographic Maps (1:24,000)

Land Use/Cover (1937, 1963, 1975): Dominant land use (natural vegetation, agriculture, residences, etc.); Water; Linear vegetal features (fencerows, etc.); linear nonvegetal features (roads, etc.); Structures (farmsteads, residences, etc.)

Sources: aerial photographs, topographic maps

Natural Vegetation (Presettlement, 1937, 1963, 1975): Herb and shrub; natural savanna; natural forest; urban street and yard trees.

Sources: General Land Office Survey Notes; aerial photographs

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**Ohio (data by forest island)**

*Basic data: number of forest islands (per 100 km²); area (A, ha) and perimeter distance (P, m) of each forest island; distance to nearest neighbor, edge to edge (m)*

Source: Ohio Dept. Forestry 1939 maps of Ohio forests (1:63,360)

*Derived Variables: Percent landscape forested; Island Dissection Index, DI = P/(2\sqrt{nA}); Landscape Dissection Index, DL = 1/n \sum_{i=1}^{n} P/(2\sqrt{n_{i}A})*

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The agricultural Midwest has markedly diverse patterns of forest islands, evident from the series of 100 km² samples in Ohio (Fig. 1). In Ohio, the fertile plains, heavily developed for agriculture, are characterized by small numbers of widely scattered and small, basically rectangular forest islands (Fig. 1, left). Conversely, the rugged topography of unglaciated eastern Ohio supports moderate numbers of large, very irregular islands (Fig. 1, right). In between in rolling tablelands and irregular plains, large numbers of medium-sized islands are the rule.

Based on this analysis, two extremes limit the gradient of forest island landscapes. At one end are regions where forest islands exist only as dense micro-islands (of one to several trees) in intensively agricultural or urban/suburban areas. At the other, large numbers of large forest islands tend to coalesce into a regional forest system. A factor analysis, based on measures of forest island size, shape, number and spacing, shows strong correlations with soil, topography and glacial history and provides a classification into which additional landscapes can be placed.

The history of Cadiz Township in Green County, Wisconsin is instructive of how attributes of forest islands change as agricultural development progresses. Cadiz Township was 93 percent forested in 1831, just prior to settlement. By 1950, 96 percent was deforested (Curtis, 1956). In this trajectory of change, three interrelated attributes of the forest islands have also changed (Fig. 2). Initially, the total area in forest declines dramatically, as forest islands are created, then reduced in size or removed. Concurrently, each forest island becomes more isolated.
Fig. 1. Forest island patterns of selected 100 km² landscapes in Ohio. Shaded areas represent land remaining in or reverting to forest as of the late 1930's. Landscapes are arranged with increasing forest cover from left to right and increasing island density from bottom to top.

Nearest neighbor distance accelerates after about half of the original forest is removed. However, when total forest cover drops to less than ten percent, continued loss of forest islands has little effect on inter-island distances. Finally, the ratio of forest edge to forest area increases, until in an extreme case, small forest islands are dominated by environmental conditions and species composition of edge or ecotonal communities (Burgess & Sharpe, 1981).

Even the ostensibly stable modern landscapes of the Midwest are dynamic, as shown by two samples from southeastern Wisconsin (Fig. 3). One area has remained in agriculture, while the other is urbanizing as the Milwaukee metropolitan region expands. In 1937, 81 percent of the agricultural landscape was devoted directly to agriculture, and 15 percent was in natural vegetation (half of which was forested (Fig. 3, upper left). The allocation of land was virtually the same in 1975 (upper right). However, landscape dynamics that are ecologically important are concealed, as some land has reverted to natural vegetation, while other areas were cleared for agricultural and residential uses. For example, between 1937 and 1963, 2.2 ha yr⁻¹ of agricultural land reverted to old fields, marshes and savannas, while 2.9 ha yr⁻¹ of natural vegetation was cleared for agricultural uses. These dynamics continued into the 1963-1975 period when 4.4 ha yr⁻¹ of natural vegetation (primarily non-forest) were diverted to agriculture and residential uses, while 6.5 ha yr⁻¹ of agricultural land reverted to natural vegetation. The impact of these dynamics has been a shift from forest, which develops slowly on abandoned agricultural land, to herbaceous and shrub vegetation. We believe that disturbance in
these landscapes has a cyclid component, but one embedded in a general trajectory of increasingly intensive agriculture.

Urbanizing landscapes present markedly different dynamics (Fig. 3, lower). Between 1937 and 1963, urbanization reduced agricultural land use by 23 percent, but natural vegetation by only 6 percent. However, diversion to urban uses accelerated during 1963-75, when 22 percent of the agricultural land base and 3 percent of the natural vegetation was lost.

These land use dynamics (Fig. 2, 3) have created landscapes of small and dispersed forest islands with associated land in various stages of secondary succession. Of the many ecological consequences of these changes, the impacts of size and isolation are noteworthy.

Ecologists generally agree that large blocks of natural vegetation are superior refugia to similar areas of small dispersed remnants. This has been shown specifically for birds (Forman et al., 1976; Whitcomb, 1977), and generalized by Diamond (1975), inter alios. Forest islands in southeastern Wisconsin smaller than 3 ha are essentially all edge and lack the mesic interior environment that favors sugar maple and beech (Burgess & Sharpe, 1981). We counted the number of cells in woodlots that are
Fig. 3. Area in forest, nonforest natural vegetation, crops and pasture, and residential, commercial and industrial uses for rural and urbanizing landscapes near Milwaukee, Wisconsin. Numbers in rectangles are ha in each category in 1937, 1963 and 1975. Arrows are land use/cover changes, ha yr⁻¹. Each sample landscape is ~25 km² bounded by other woodlot cells (i.e., they are in the interior of woodlots) in order to ascertain how these have changed through time. In the 9800 ha of Cadiz Township, there were 1595 ha in the interiors of woodlots in 1882, compared to 160 ha in 1978. In southeastern Wisconsin the area of woodlot interiors declined from 97 ha in 1937 to 32 ha in 1975, in a total area of 2500 ha. Thus, it appears that the remnant forest tracts are increasingly dominated by edge communities that serve as poor refugia for interior-dwelling animals and the mesic forest flora.

Interisland distances have increased, especially during intermediate stages of agricultural development. In Cadiz Township average interisland distances increased from 150 m in 1882 to 340 m in 1950 (Fig. 2). In southeastern Wisconsin interisland distances averaged 226 m in 1937, but declined to 176 m in 1975, not because of establishment of new forest islands but because of fragmentation of existing stands.

The effects of isolation on interisland seed dispersal and resulting seed pools in the litter and soil (Kellman, 1974), and shifts in the species dynamics of forest stands, may be ecologically significant. Species composition should be affected by stand isolation. These effects
have been reported (Auclair & Cottam, 1971) and evaluated by simulation modelling (Burgess & Sharpe, 1981).

The effect of stand isolation may be different for wind dispersed than for animal dispersed species. Effective seed dispersal distances of green ash, basswood and sugar maple were restricted to 150, 25 and 110 m, respectively. Modelling of wind dispersal of sugar maple suggests that few seeds are carried more than 400 m in the direction of prevailing winds, and only 200 m in the direction of the less frequent and weaker counter winds. Our studies of blue jays, however, indicate that fragmentation may enhance seed dispersal of some animal dispersed species. To illustrate, several hundred thousand beechnuts and acorns are dispersed and cached annually up to 5 km from a large forest island by a large flock of blue jays. Nut caching by blue jays appears to affect the colonization of trees in a manner similar to that of the European jay (Bossema, 1979). Jays entering and leaving foraging sites often travel along wooded fence-rows, indicating that these dispersal corridors may be important.

We suggest that blue jay dispersal relative to more local dispersers, e.g., squirrels, is greater in highly fragmented landscapes. Also, fragmentation of eastern forests have caused dramatic increases in blue jay populations. Presettlement dispersal distances with low jay densities could have been considerably smaller than current distances. Thus, the effects of increased isolation have been offset by increasing populations of long-distance dispersers, illustrating that fragmentation need not be uniformly detrimental to the landscape persistence of all species.

Implications

Much research is needed on the effects of fragmentation and subsequent isolation of forest remnants. Studies of propagule dispersal distances, by both wind and animal vectors, and the subsequent establishment rates in forest islands with known distances from seed sources are required. Cross-pollination, again by both wind and insects, that has broad implications for the genetic diversity in isolated populations of plant species also needs to be studied.

In addition, recent studies have dealt with problems of population size in maintaining the viability of presently endangered species (Shaffer, 1981). As ecosystem fragmentation, a modern feature of man-dominated landscapes, continues to occur along predictable paths, some species extinctions (at least regionally) are perhaps inevitable. The implications for continued ecosystem viability are currently unknown.

Finally, land use and regional planning need to be firmly rooted in a knowledge of the historical development of landscapes. Through spatio-temporal analyses, it is possible to model vectors of change through time, and to better understand the ecological consequences of alternative plans.

Acknowledgements

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References


THE SIGNIFICANCE OF SMALL-SCALE LANDSCAPE ELEMENTS IN RURAL AREAS AS REFUGES FOR ENDANGERED PLANT SPECIES

Barbara Ruthsatz and Wolfgang Haber

Lehrstuhl f. Geobotanik, Universität Trier, and
Lehrstuhl f. Landschaftsökologie, Techn. Universität Munich
at Weihenstephan, Freising, Fed. Rep. of Germany

Abstract

Over the last decades, rural areas have suffered an alarming loss of traditionally managed grassland and woods, and even such small structures as field verges, ditch banks and forest edges are being seriously threatened by modern agricultural practices. The ecological conditions of the remaining small features have been drastically changed through input of nutrients and by isolation from their diaspore reserves. Only under certain marginal conditions they can still serve as refuges for certain endangered grassland, ruderal, reed and forest edge species characteristic of poor dry or wet sites. Nevertheless, each one of these landscape elements will enhance the survival changes of plant or animal wildlife in modern agricultural landscapes.

Introduction

In recent years, much discussion among applied ecologists, conservation experts, landscape planners and farmers has been devoted to the striking decline of natural features, of species and habitats in rural areas over the last 100-150 years (cf. Westhoff, 1976; Haeupler, 1976; Sukopp et al., 1978; Weber, 1979; Sukopp, 1980), and to the importance of small landscape elements for maintaining a maximum level of stable, self-regulating ecological conditions in rural landscapes (Haber, 1971; 1979b).

Vast cereal, maize and sugar-beet fields, pure stands of forest plantations, monotonous pastures, straightened riverbeds, new metalled farm roads, and new residential areas have replaced the traditional small-scale diversity of the cultural landscape. Food production has been substantially raised by the application of increasing amounts of fertilizers and pesticides, the drainage of wetlands, and the use of heavy machinery (Davidson & Lloyd, 1977; Haber, 1977; 1979a). In many parts of Europe, this has resulted in the nearly complete loss of small woodland areas and copses, of hedgerows, field verges, rough grazing land, small streams, river meanders, ponds, reedswamps and semi-natural wet meadows. The resting elements have undergone a radical change in their floristic and faunistic composition, caused by lowering of water tables, or by heavy nutrient inflow from adjoining fields or pastures.

These small nature-like landscape elements deserve special attention for the following four reasons:

1. They provide habitats or shelter for threatened and rare wildlife.
2. They can reduce the ecologically degrading effects of modern agricultural practices, thus even safeguarding agricultural production in the long term.
3. They maintain or improve the recreational quality of rural areas, and
provide evidence of historical land-use methods.

4. They represent obstacles to ecologically harmful large-scale intensification of agriculture and forestry.

The ecological benefits of small natural landscape elements for the promotion of an overall ecological balance in the landscape, or at least in parts of it, are not yet fully understood and are difficult to assess. However, some favourable effects can be demonstrated on several sites:

- Hedges can improve the meso- and microclimatic conditions of adjoining fields, in particular in wind-exposed areas.
- Hedges and grassy field verges can reduce soil erosion by slowing down wind-speed and surface runoff, most effectively when orientated perpendicularly to main wind and slope directions.
- Woody or perennial vegetation along streams, rivers or lakes can serve as a buffer against water pollution by nutrients or pesticides.
- All natural elements will provide shelter, food and even permanent habitats for animals, among them species useful in biological pest control.
- All less or unused elements will enhance the structural and species diversity of rural areas.

Three examples of small landscape elements

With regard to the floristic and faunistic value of small semi-natural elements in the landscape, it must be taken into account that each one has its own history and specific ecological conditions. In the following considerations we shall restrict ourselves to the herbaceous vegetation of three very common such elements in Germany: semi-natural field verges, ditch banks, and forest edges. They are mostly man-made elements, but in the given order increasingly similar to natural phenomena.

1. Semi-natural field verges on slopes (Fig. 1)

On steeper slopes in hilly areas soils are often shallow or susceptible to erosion, and therefore not suitable for cultivation. Traditionally such sites served as rough pastures. Sometimes when the soils were deep enough, field terraces were cut into the slopes, resulting in steep scrub- or grass-covered strips between terraces. There was a close ecological relationship between rough pasture land and these field verges, and both were even used and maintained by man in similar ways during long periods: especially by sheep grazing, firewood cutting, occasional burning and removing of shrubs.

Today these rough pastures have been abandoned, afforested or transformed - wherever possible and profitable - into arable land. Many of the field verges have been removed, and none are used regularly anymore. The nutrient input from the neighbouring fields into arable land. Many of the field verges have been removed, and none are used regularly anymore. The nutrient input from the neighbouring fields from fertilizer and crop residues has changed competition conditions drastically, favouring more vigorous meadow grasses and ruderal herbs. Intentional or accidental application of herbicides causes local dominance of grasses, especially couch-grass, accompanied only by a few resistant weeds. Only on broader and perhaps more recently isolated verges do some relics of the endangered dry grassland flora still occur. Many of these structures can be quite old and may have survived for several centuries. Their destruction means the loss of specific semi-natural ecosystems, with a stable vegetation cover dominated by plant species.
Fig. 1. Site conditions and vegetation mosaic of a typical semi-natural field verge on a slope

2. Ditch banks (Fig. 2)

Wetland areas are usually interlaced with small streams lined with shrubs, reed or perennial tall herb formations. The often abundant plant production of wetlands was for centuries scarcely used by man, some firewood was obtained from alder and willow, and poor quality hay and straw from meadows. But about 200 years ago systematic draining and cultivation of wetlands was started. Streams were deepened and straightened, and connected with a dense network of drainage ditches. Shrubs and trees were cleared, and the lowered water table combined with fertilizer application resulted in both a drastic change and reduction of the floristic composition of the wetland vegetation. Only ditch banks have retained a certain species richness, restricted to narrow isolated strips in the rather monotonous grassland areas that resulted from wetland cultivation.

The ditch banks are mowed every year, the beds cleared every 4-6 years to keep the water flowing. Plant growth is often luxuriant because of surface or subterranean nutrient inflow from the adjoining fertilized grassland. This input is increasing with successive drainage and change from meadows to maize fields. Thus the original plant species of the unfertilized wetlands have been suppressed by vigorous herbs of tall herb formations or even nitrophilous ruderal perennials.

The species composition of the reed vegetation of such ditches depends on the changing water level and its nutrient content, and will range from mesotrophic to eutrophic. The ditch bed vegetation is variable too. The regularly removed sludge is deposited on the banks
and contributes to the high nutrient supply. In general, wetland cultivation has been completed in most parts of Germany, however, in many areas ditches are now being cultivated thus reducing the last habitats of these wetland and aquatic plants still further.

**Fig. 2. Site conditions and vegetation mosaic of a typical ditch bank**

**3. Forest edges (Fig. 3)**

Forest edges are the landscape elements most similar to natural vegetation. Where too dry or too wet conditions or mechanical factors did not allow the development of closed forest cover, shrubs, specific herbs and some grasses could become established, forming transitional plant communities to open rock, sedge reeds or river banks. A comparable vegetation appears at the edges of man-made forests and small woodlands. These ecotones between closed forests and open formations were still quite frequent in the last century. They have since diminished for several reasons: clearing or replanting of woodland, closer approach of adjoining fields or roads, straightening of forest borders. Again nutrient input from neighbouring fields or from deposition of crop residues is changing competition conditions in the edge communities, favouring vigorous species, often nitrophilous ruderals.
Although none of the three landscape elements can be characterised on the basis of clear-cut homogeneous site conditions, the actual floristic composition (Tab. 1) allows an approximate evaluation of the nutrient level of the stands, and of the degree of external disturbance. All three are dominated by perennial species, so their floristic composition would seem to reflect past ecological conditions (due to the longevity of some species and their diaspores) rather than recent disturbances. There are few open sites, most of them the result of mechanical clearing by man, inviting establishment of additional, usually annual species.

It follows from the ecological history and actual situation of these landscape elements that they cannot, as a general rule, serve as safe refuges of severely endangered species, as these are mostly weak competitors or require specific pollination, propagation, or germination conditions. Field verges, ditch banks, and forest edges will not compensate for dry grassland, wet semi-natural meadows, mesotrophic river-banks or broad ecotones between forests and open grasslands. However, with continuing impoverishment of the rural landscape, those sites soon may offer the last refuges for grassland or even some ruderal plant species of poor dry and wet habitats.

All three landscape elements are being invaded by more or less the same nitrophilous ruderal species:

Cirsium arvense, Equisetum arvense, Artemisia vulgaris, Galium aparine, Galeopsis tetrahit, Agropyron repens, Urtica dioica, Rubus fruticosus s.l., thus demonstrating the levelling effect of the increasing external nutrient input on the originally rather different ecological conditions. However, if some habitat features favouring certain less vigorous species can be maintained or restored, we may hope to ensure their survival (Tab. 1).
Table 1. Vegetation mosaics of three small-scale landscape elements

The herbaceous layers of these elements contain plant species of the following different communities:

<table>
<thead>
<tr>
<th>Occurrence of plant communities</th>
<th>Field verges</th>
<th>Ditch banks</th>
<th>Forest edges</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>couch-grass stands</td>
<td></td>
<td>tall-herb vegetation</td>
<td>herbaceous forest edge vegetation</td>
</tr>
<tr>
<td>(Agropyretes intermediis-</td>
<td></td>
<td>(Filipendulion)*</td>
<td>(Geranium sanguineum, Trifolium medii)*</td>
</tr>
<tr>
<td>repantis)</td>
<td></td>
<td>reeds</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Phragmites, Magnocaricion, Sparganium-Glycerion)*</td>
<td></td>
</tr>
<tr>
<td><strong>Frequent</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>meadows, mesic and dry</td>
<td></td>
<td>meadows, wet (Calthion)</td>
<td>herbaceous forest vegetation</td>
</tr>
<tr>
<td>(Arrhenatherion)</td>
<td></td>
<td>flood grassland</td>
<td>(Quercus-Fagetea)</td>
</tr>
<tr>
<td>perennial ruderal veg., mesic</td>
<td></td>
<td>(Agropyro-Rumicion)</td>
<td>meadows, mesic (Arrhenatherion)</td>
</tr>
<tr>
<td>(Dauco-Meliloti)</td>
<td></td>
<td>perennial ruderal veg., fresh</td>
<td>perennial ruderal veg., fresh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Aegopodium)</td>
<td>(Aegopodium, Alliaria)</td>
</tr>
<tr>
<td><strong>Occasional</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dry grassland (Mesobromion)*</td>
<td></td>
<td>poor meadows, wet</td>
<td>poor grassland (Mesobromion, Viola caninae)*</td>
</tr>
<tr>
<td>weed vegetation (Secalineutae, Polygono-Chenopodietalia)</td>
<td></td>
<td>(Molinion)</td>
<td>heathlands (Genistia, Sapoanthasemion)</td>
</tr>
<tr>
<td>short-lived ruderal vegetation (Symbrion)</td>
<td></td>
<td>theroxyte vegetation, wet</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rare</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ruderal vegetation of villages</td>
<td></td>
<td>mires (Caricioid carrianae, Caricioid tuscae)*</td>
<td>weed vegetation</td>
</tr>
<tr>
<td>(Arctium lappa)*</td>
<td></td>
<td>(Juncion bufonii)*</td>
<td>(Secalineutae, etc.)</td>
</tr>
<tr>
<td>herbaceous forest edge vegetation</td>
<td></td>
<td>dwarf rush vegetation</td>
<td>clearing vegetation</td>
</tr>
<tr>
<td>(Trifolium medii)*</td>
<td></td>
<td>(Juncion bufonii)*</td>
<td>(Epilobietaia angustifolia)</td>
</tr>
</tbody>
</table>

* plant communities with possibly endangered species in small landscape elements.
Landscape elements and conservation planning

In order to conserve the remaining small landscape elements in rural areas, and to preserve sufficient habitats for as many plant species as possible, the following general guidelines should be followed:

- Safeguarding of the elements still existing, because the creation of new ones may result in more monotonous stands caused by initially higher nutrient levels and by a lack of diaspore pools within suitable distance.
- Establishment of a sufficiently dense network of these landscape elements, which is typical for each landscape and land-use pattern, and which should be connected to existing old woodlands, grassland and wetland areas.
- Maintenance of areas with a high structural diversity, even when of restricted size, in preference to a reduced diversity pattern in larger areas.
- Preservation of at least one example of a traditionally managed cultural landscape type in the different regions of Europe, perhaps in connection with open-air museums (cf. Schill & Schlenker, 1974 for southern Germany).

The maintenance of a species-rich vegetation in the small-scale landscape elements mentioned above requires attention to some specific properties:

- a high area: edge ratio, minimizing edge effects;
- buffer zones or strips of 2-4 m width, which are less intensively fertilized or managed, serving as protection against too much nutrient inflow or mechanical disturbances. Grassy footpaths or lanes would also be suitable;
- low original nutrient level, as indicated by the floristic composition, because once enriched with nutrients sites will retain this condition for a long period;
- adequate management in order to prevent unwanted succession to closed shrub formation.

There are still many open questions regarding an effective conservation programme for ecologically satisfying agricultural landscapes. Scientific work needed to answer these questions and to specify conservation aims might include:

- Evaluation of regional landscape studies with emphasis on small-scale elements, their flora and vegetation, and their relation to site qualities, in order to derive general rules for ecological landscape management;
- Research on the biology of ecological groups of endangered plant species in order to derive specific conservation measures from the results;
- Investigation of possible benefits (shelter or food) of small landscape elements for animals, in order to establish optimal design and management for animal wildlife conservation;
- Investigation of growth and development of newly established hedgerows, field and road verges, and plantings alongside watercourses, in order to derive specific conservation and management measures.

The most important conclusion to be drawn from these considerations of the ecological value of small-scale landscape elements is the need for an urgent appeal to farmers, land-owners, and authorities responsible...
for conservation and development to preserve as many of the remaining old elements as possible, and to stop their continuing depletion.

References


SHIFTING CULTIVATION IN THE NORTH EASTERN REGION OF INDIA - AN ECOLOGICAL PROBLEM

Majid Husain

Department of Geography, North-Eastern Hill University, Shillong, India

Abstract

Problems concerning to ecosystem have been drawing the attention of environmental experts, earth scientists and ecologists. The face of the earth is changing at a progressive rate owing to technological advancement and human response to his environment. These changes are disturbing the life support system consisting of biotic and abiotic components - men, animals, plants, micro-organism, soil, minerals, water and air. These components interact through a trophic structure, biotic diversity and material cycle.

The development planning is doing destruction to the ecosystem, creating serious ecological imbalances. The situation appears serious in the areas of isolation and relative isolations, occupied by tribals who are depending on the subsistence economy of shifting cultivation. The 'slash and burn' practice destroys the fauna and flora and creates conditions which accelerate the process of rapid soil erosion. In the present paper, an assessment of the shifting cultivation in the states of north-eastern region of India has been made to identify the socio-economic implication of the problem. An analysis of the jhuming operation in the humid region has been made to ascertain its adverse effect on the natural resources, and steps necessary for keeping a sound health of the ecosystem have been proposed. Transformation of shifting cultivation into permanent type of farming is the prerequisite for the proper management of resources and ecosystem but the problem is not a simple one as the philosophy of life of the tribals and their social structure are the products of jhuming system of economy. The problem and its prospects have been briefly analysed.

Ecosystem is a life support system consisting of biotic and abiotic components - man, animals, plants, micro-organism, soil, minerals, water and atmosphere. These components interact through a trophic structure, biotic diversity and material cycle so that the system itself is kept viable. When an artificial change in the system is introduced, the system may go off balance and there is a chain reaction of adjustment of the various components. A change in the existing ecosystem is a must in any development work as we cannot expect development without destruction. It is, therefore, pertinent before launching a development plan, to make use of the services of various experts interested in the ecological problems, to study the total spectrum of the existing ecosystem. In the past, many of the societies have vanished because of indiscriminate use of their surroundings which resulted into ecological imbalances.

In the areas of isolation and relative isolation of the north-eastern region of India, stretching over the states of Assam, Meghalaya, Manipur, Nagaland and the union territorites of Arunachal Pradesh and Mizoram,
shifting cultivation (jhuming) is a common practice of soil utilization. The diverse ethnic groups of Naga, Khasi, Garo, Jaintia, Mizo, Apatanis, Kuki and Khamias adopt the 'slash and burn' technique for their livelihood. The shifting cultivators (jhumias) are cutting and burning the forest resources for the last several centuries, resulting into serious ecological imbalances and socio-economic problems. It has been observed that the average annual rainfall in the region has decreased, much of the wild life vanished and many of the good patches of soil, rendered into barren rocks. The increasing pressure of population and the occupation of rural population is increasingly threatening to the resource health and ecosystem of the region.

An attempt, in the present paper has been made to discuss the jhum - operations, cropping patterns, jhum cycle in the north-eastern region of India, to identify the socio-economic implication of shifting cultivation and to prepare a plan for the development of jhum-land without much destruction.

Shifting cultivation has been defined as an economy of which the main characteristics are rotation of fields rather than crops, absence of draught animals, use of human labour only, application of dibble-sticks, hoe and daon, absence of irrigation, short period of occupancy alternate with long fallow periods. After one or two years the fields are abandoned, the cultivators shift to another clearing, leaving the old one for natural recuperation. It however, does not imply that the homestead are also shifted to the new site alongwith the shifting of fields.

In the tribal dominated areas of relative isolation jhuming is marked by the following stages of:
(a) selection of land, (b) clearing of vegetation, (c) burning the dried forest wood into ashes, (d) worship and sacrifice, (e) dibbling and sowing seeds, (f) weeding and protection of crops, (g) harvesting, (h) merrymaking and (i) fallowing.

The usual process of jhuming demands selection of a plot on or near the hill side of forest. Selection of land is done normally in the months of December and January by the clan leaders, who judge the fertility of land on the basis of colour and texture of the soil. Allotment of land is made normally by lottery. One who picks up number one gets the first chance for selecting a plot for his family. The area allotted varies on an average between 0.5 to 1.50 hectares. The next stage is clearing of forest trees and undergrowth. The allotted piece of land is cleared of all its trees and undergrowth. Branches of trees are lopped off and the cut and cleared growth is allowed to dry on the fields. The slashing of vegetation which takes over a month is labour intensive, being undertaking with indigenous equipments. The dried growth as well as the trees standing in the clearance are set on fire in March. Many a times the fire spreads in the neighbouring jungles causing serious damage to fauna and flora. Thereafter, the land is cleared of charred logs and branches and the ash is spread all over the field to increase the fertility of the soil.

Before sowing, the evil spirits are worshipped and cocks are sacrificed. The day of sowing is a ceremonial occassion for the whole village. It is interesting to observe that the male members of each family on reaching the field in the morning engage themselves in preparing the digging-sticks. Seeds are sown either by broadcast or by dibbling.

Harvest of leafy vegetables begins in the month of June followed by potatoes, maize, millet, yam, rice, pulses and cotton. Big feasts and festivals are celebrated after the harvest of rice in the month of November, after which the field is abandoned or left fallow to recoup its fertility during the winter season.
Jhum Cycle

Patches of land for shifting cultivation are not selected and cleared in any given sequence or order. There is always a room for choice. The period of consecutive cropping and fallowing differs from region to region and tribe to tribe. Owing to pressure of increasing population, now the jhumias are being staked to smaller areas and they do not have much choice left to shift about. Their world has become small and they have to be content in moving about in narrow circles. The jhum-cycle has shrunk which now varies between one and seventeen years in North-east India.

In Mizoram, a new patch of land is cleared every year. Among the Lushais, a plot is allowed to remain fallow for two or three years in the case of bamboo forests and seven to eight years in the case of other forests. In Arunachal Pradesh, jhum-cycle varies from two to seventeen years; in Meghalaya four to five years, in Tripura one to seven years, in Manipur five to ten years and in Nagaland six to fifteen years. In Konyaks and Rengmas (Naga) sometimes a field is left fallow for twenty to thirty years.

Intensity of Cropping

In the region of North-east India, out of the total reporting area of about 23 million hectares, nearly three million hectares are under cultivation out of which 2.69 million hectares are jhum land.

<table>
<thead>
<tr>
<th>State/Union Territory</th>
<th>Reporting area</th>
<th>Net sown area</th>
<th>Area available for jhuming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arunachal Pradesh</td>
<td>57.93</td>
<td>0.70</td>
<td>2.48</td>
</tr>
<tr>
<td>Assam</td>
<td>78.81</td>
<td>21.98</td>
<td>4.98</td>
</tr>
<tr>
<td>Manipur</td>
<td>22.11</td>
<td>0.79</td>
<td>1.00</td>
</tr>
<tr>
<td>Meghalaya</td>
<td>27.79</td>
<td>1.58</td>
<td>4.16</td>
</tr>
<tr>
<td>Mizoram</td>
<td>16.54</td>
<td>0.61</td>
<td>6.04</td>
</tr>
<tr>
<td>Nagaland</td>
<td>13.51</td>
<td>0.47</td>
<td>6.08</td>
</tr>
<tr>
<td>Tripura</td>
<td>10.66</td>
<td>2.36</td>
<td>2.21</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>227.35</strong></td>
<td><strong>29.49</strong></td>
<td><strong>26.95</strong></td>
</tr>
</tbody>
</table>

The total area available for cultivation is, however, not exclusively cropped at a given point of time. Only about 16 to 30 percent of the jhum land is cropped annually. Nagaland with 6.08 lakh hectares has the highest area under jhum, followed by Mizoram and Meghalaya. The tenurial pattern of land, whether owned by clan, community or individual influences the level of agriculture and its intensity. In the community land, there appears to be little interest on the part of individual family to improve the productivity of soil and to maintain the health of the ecosystem by efficient management. A quantified picture of jhuming in the region is given in Table 2.
Table 2. Jhumias in north-east India

<table>
<thead>
<tr>
<th>State/Union territory</th>
<th>Area affected by jhum in 10^3 ha</th>
<th>Area under jhum at one point in time in 10^3 ha</th>
<th>Number of tribal families involved</th>
<th>Percentage of population dependent on jhuming (1971-1974)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arunachal Pradesh</td>
<td>248</td>
<td>92</td>
<td>148</td>
<td>57.69</td>
</tr>
<tr>
<td>Mikir Hills (Assam)</td>
<td>415</td>
<td>54</td>
<td>45</td>
<td>-</td>
</tr>
<tr>
<td>N. Cachar Hills (Assam)</td>
<td>83</td>
<td>15</td>
<td>13</td>
<td>0.48</td>
</tr>
<tr>
<td>Manipur</td>
<td>100</td>
<td>60</td>
<td>50</td>
<td>27.95</td>
</tr>
<tr>
<td>Meghalaya</td>
<td>416</td>
<td>76</td>
<td>68</td>
<td>34.58</td>
</tr>
<tr>
<td>Mizoram</td>
<td>604</td>
<td>61</td>
<td>45</td>
<td>80.74</td>
</tr>
<tr>
<td>Nagaland</td>
<td>608</td>
<td>73</td>
<td>80</td>
<td>-</td>
</tr>
<tr>
<td>Tripura</td>
<td>220</td>
<td>22</td>
<td>43</td>
<td>6.43</td>
</tr>
<tr>
<td>Total</td>
<td>2694</td>
<td>453</td>
<td>492</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2 reveals that Manipur which has the least area under jhum, has the largest percentage of available area under jhuming at one point in time. Mizoram and Tripura states have only about 10 percent of the arable land under jhum in an agricultural year. The highest percentage of population dependent on jhuming is in Mizoram being 80.74 percent followed by Arunachal Pradesh (57.69 %). Tripura has only 6.42 percent population dependent on shifting cultivation, while in Meghalaya and Manipur this proportion is 35 and 28 percent respectively.

Prospects and Problems of Ecological Imbalances

Ecologists, botanists, zoologists, soil scientists and geographers differ in their opinion about the adverse effects of shifting cultivation on the ecosystem and resource base of the region. Some of them hold the view that it is primitive, indigenous, uneconomic and causes serious problems of soil erosion, forest depletion, wild life destruction, resulting into grave ecological imbalances. Jhuming is converting the green forest covers into barren rocks and indirectly reducing the average annual rainfall affecting the social well being of the people adversely and therefore, it needs to be stopped completely by an act of legislation.

Those who support the view of continuing shifting cultivation with necessary and effective reforms are of the opinion that it does little damage to soil health as the high temperatures, high humidity and heavy rainfall in the greater part of the year in the region do not permit the soil to remain barren for long. Some form of vegetation covers immediately the top soil which contains it from further soil erosion. In the growing of crops no ploughing and pulverization of soil is done, the soil remains compact affected by erosion very slowly. Moreover, jhumlands are generally steep slopes on which sedentary cultivation cannot be developed easily without heavy capital and labour investment. Jhuming therefore, does not have a significant adverse affect and since this is a way of life of the tribal people, in the backward states of the developing country it cannot

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be stopped altogether. Looking at the socio-economic implications of the problem and the direct dependency of over 80 percent of the population of the hill regions of the area under review, it is imperative to make the process more productive so that it may sustain the growing pressure of population at a reasonably good standard of nutrition.

The evil of shifting cultivation and the resulting ecological imbalances can be overcome by changing jhuming into sedentary agriculture. The jhumias should be provided land where he can cultivate land permanently to derive profits out of the soil. Once the retainability of soil is ensured, then the question of augmenting the soil fertility through the addition of manures and fertilizers could be meaningful. Measures need to be taken to see that the jhumias are trained in other types of occupations. They should be given training in raising trees and plant protection, cottage and small industries and indigeneous handicrafts. Moreover, they should be trained in the development of dairying, piggery, sheep-rearing, poultry and duck-keeping, fisheries, bee-keeping, sericulture etc. For the effective implementation of these programmes, extension service, co-operative and marketing facilities are essential. The establishment of forest-based cottage industry may also help in boosting up the economy of the tribes.

New varieties of crops of economic importance and scientific rotations have to be searched and their diffusion should be extended in the isolated hilly tracts under jhum. A cropping pattern with higher inputs will help in obtaining higher returns per unit area and that will help in detracting the jhumias from the uncertain way of life of shifting cultivation, provided the inputs are used for productive purposes.

One of the important measures to be adopted is the construction and development of terraces. Various types of terraces can be adopted to fit in with a particular type of ecosystem. There are, however, many techno-economic problems in the development of terraces. Terracing, apart from being a costly measure, requires adequate irrigation facilities which cannot be provided easily on the steep and undulating slopes. It therefore, may not be feasible to go for large scale terracing. The human energy input used in the jhuming, however, can be used for the development of small terraced farms. This would provide productive use of human energy for land resource development.

So far as the scope limit for the development of terraces is concerned, it is difficult to prescribe any slope limit, unless detailed evaluation of existing terrace system in the region is made and other technical details are experimentally studied. A slope upto 30 percent can be terraced. Relatively steeper slopes in the middle reaches can be given to cash-crops like pine-apple, plantain, oranges, jack-fruits, while the steep slopes of the upper reached can be reserved exclusively for forests.

Jhuming in the N.E. region of India is a way of life and there are cogent reasons for its practice by the tribal people. The climate, the terrain, their food habits, their needs, their self reliance, all have a say on shifting cultivation. The whole gamut of the primitive society is interwoven withmeans of food production. In other words their way of life, training of youths, socio-economic structure and political systems, the social ceremonies, festivals and in brief, their philosophy of life are the products of jhuming economy. This is why many of the new methods of cultivation, recently introduced in the tribal areas of the region are yet to generate the process of cultural acceptibility. Transformation of this primitive technique of soil utilization is however, necessary as further negligence in this direction will create serious ecological imbalances in the area, which may threaten the survival of the people attached to soil and forest resources. Transformation of jhuming into sedentary agriculture, however, should be gradual and smooth, causing
least disturbance in the social structure of the tribals and creating least imbalances in the ecosystem.

References

Introduction

The aim of this study is to give an analysis of the interaction between the Dogon people and their environment, especially of the cultural adaptation of the Dogon to that environment. The Dogon are a group of peasants, who settled in the area of the Falaise the Bandiagara (southern zone of the Sahel, see map on the poster) around 1500 A.D. The natural environment has been studied by mapping the whole Dogon-area according to the landsystems approach of the CSIRO (see map of landsystems and landunits on the poster). This study took place in cooperation with Dr. W. R. A. van Beek (Institute for Cultural Anthropology, Utrecht) and was subsidized by The Netherlands Foundation for the Advancement of Tropical Research.

The ecology of the Dogon

Two models of the ecosystems of respectively the villages of Sanga and Tireli, which explain the interaction between the Dogon and their environment, are presented on the poster. These two models are based on the following diagram (Fig. 1).

Fig. 1.

The term environment includes both natural and cultural environment. Regarding the interaction between man and his environment, not all aspects of the environment are equally important. This is why the term "effective environment" has been introduced. "Effective environment" comprises only those environmental aspects which are especially important for the cultural adaptation of man to his environment (Netting, 1965). In the Dogon-area aspects as for instance soil fertility, fallow vegetation, trees, quantity and distribution of precipitation, the availability of clay (for pottery) and the escarpment can be counted as "effective environment". The difference in effective environment between Sanga and Tireli forms one of the reasons of presenting the data of just these two villages.

The adaption of the Dogon to their environment may be viewed as taking place because of changes in three kinds of cultural behaviour: 1) productive technology, 2) social organization and 3) rituals (Hardesty, 1977). Productive technology and that area of social organization, which enhances the process of production, are both human instrumentalities, which are directly related to the effective environment (Netting, 1965; Bennett, 1976).

Productive technology includes not only tools and the techniques of their use, but also the understanding of such phenomena as plant potentials and faunal characteristics which allows production modification of the natural environment (Netting, 1965). For instance knowledge of the vegetation is in relation to the Dogon farming-system very important. Where land must be periodically rested the
Dogon can accurately estimate the degree of soil regeneration by means of changes in the plant cover. By reusing a field only when its fertility has been restored, the cultivator can maintain the ecological equilibrium of his environment.

This is especially important in the Sahel, where disturbance of the equilibrium by overcultivation can easily lead to desertification.

By social organization is meant the structure and function of human groups (Netting, 1965; Hardesty, 1977). In a technologically simple culture like that of the Dogon, social factors most directly related to survival of the group are: 1) population density, 2) the structure and composition of productive groups and 3) distribution of the means of production.

Apart from differences in effective environment between the villages of Sanga and Tireli, differences in population density play a role. The population density in Sanga is much higher than in Tireli, which leads to a stronger pressure on the natural resources, especially on land and wood. As a result of the high man/land ratio in Sanga, cultivation takes place in a much more intensive way, than in Tireli. In Sanga new fields are even "made". From valley-bottoms loose soil material is carried up and placed on the bare sandstone surface. On this surface normally no vegetation growth is possible, however the Dogon harvest two yields a year.

In the Dogon-ecosystem rituals take a special place. They may be viewed as a way of cultural adaption, but besides that, they can be a kind of regulation mechanism (compare Rappaport, 1969). In this way lots of female goats are offered during ritual feasts, by which the amount of goats is limited in the Dogon-area. This is of vital interest, because it prevents an overpopulation of goats, as is the case in other areas of the Sahel. They form a considerable threat to the restoration of a vegetation cover and in this way further the process of desertification.

Another example of ritual regulation concerns the shortage of wood in the Sahel. The chopping of wood is tied to very stringent rules. When these rules are broken, there will be responded by means of ritual sanctions. As a result of the high population pressure on the natural resources in Sanga, the functioning of rituals as feed back mechanism is more important than in Tireli.

References


INTRODUCTION

Dendrophthoe falcata, Ettingsh. and Elytranthe, Blume.—the two of the Loranthaceae parasites have been found to attack a number of fruit trees in the rural areas of Darbhanga (North Bihar), notably among them being Mangifera indica, L., Anona squamosa, L., Psidium guajava, Linn., Achrus zapota, Linn., Aegle marmelos, Correa., Litchi chinensis, Sonner. Artocarpus heterophyllus, Lam., Zizyphus mauritiana, Lamk. (Bamber 1916; Agrawal 1979). The parasite infected the very structure of the tree sending haustoria into the host branches, absorbing nourishment from the host starving it partially or completely. (Singh 1962).

CONTROL MEASURES

Direct control measures included two methods—(i) physical removal of infected trees or their parts by pruning, poisoning or burning and (ii) use of chemicals killing the endophytic system without causing any damage to the host. Use of quarantine measures for checking the inadvertent introduction of the parasites has been suggested. The control of vectors or pollinators has been suggested but never practised (Ali 1931; Davidson 1945) as such a step would result in disturbing the biology of forest. (Singh 1962).

Physical removal of infected parts or the pruning of the parasite though advocated by a large no. of investigators (Mathur 1949; Sarma 1952; Davidson 1945; Bagchee 1952; Tunstall & Sarmah 1947; Wyborn 1947-48) carries a great disadvantage as the latter reappears from the small stubs which are left in situ in the host. Further the ability of the haustoria to live for considerable time without benefit of the aerial parts is very well known. Flames have also been used to destroy the parasite (Anonymous 1949; Coleman 1949) but this method has its obvious limitations.

Singh (1955) pointed out that neither pruning of the parasite followed by the application of certain pastes nor injections of chemicals and hormones are successful. Chemical sprays did not affect the parasite appreciably and the effect on the hosts was variable. Sprays of 2,4-D, Sodium salt of 2,4-D, feronoxone and potassium salt of 2,4,5-T affect the parasite in most cases, but their reactions on different hosts were variable. Mangifera and Psidium were gravely injured; leaves and young branches of Zizyphus showed slight injury while Achrus remained unaffected.
2-4,5-T was even more toxic, while maleic hydrazide was not very effective to kill the parasite, but rendered the pollen sterile.

Seth (1958) stated that sprays of ammonium sulphamate, potassium dichromate, sodium salt of 2,4-D, and potassium salt of 2,4,5-T were either ineffective or caused damage to the host. Of the mineral oils tried as sprays, kerosene oil did not have any appreciable effect on the parasite or hosts. Sprays of powerine emulsion, prepared by dissolving 15-20 g. of ordinary washing soap in about 500 ml. of boiling water, adding tap water to make up one gallon followed by addition of desired concentration of oil, mixture churned briskly until powerine emulsified producing a milky white fluid proved very effective. (Singh 1957; 1958; 1962). 40 percent powerine oil emulsion sprays during summer on sunny days killed the parasite while in winter the concentration of the emulsion had to be raised to 50 percent. The spray was advantageous as it has very little or no effect on the hosts.

**KEY REFERENCES**


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WET RICELAND IN SRI LANKA

S. Somasiri and F.R. Moormann
Dept. of Agriculture, Sarasavi Mawatha, Peradeniya, Sri Lanka

Abstract

In Sri Lanka, wetland rice is grown under a wide range of agro-ecological conditions. The soil, rainfall and temperature conditions vary widely across the country. The mean annual rainfall range from 625 mm to over 5000 mm, temperature vary from 20°C to 33°C and nine out of the ten soil orders are present. Within an agro-ecological region, the topographical and hydrological conditions are not uniform, but distinct patterns are recognised. The rice lands are confined to the narrow inland valleys and hill slopes.

In a highly complex physical environment, the conventional soil survey procedures appear inadequate for evaluating lands for a specific land use type. The paper discusses a modified land system approach used in the evaluation of the ricelands in complex landscape regions in Sri Lanka. The land characteristics as defined in FAO framework for land evaluation are integrated to set limits in land qualities relevant for rice culture. The concepts, determinants of land, land classes, modifiers of these determinants and finally a system of classification are presented. The land classification system developed is a four tiered system; at the lowest category the land class is relatively narrowly defined to predict the potentials and management requirements.
CHANGES IN THE PATTERN OF INTERSTITIAL HABITATS IN RURAL DENMARK

Biotope Group (Agger, Brandt, Byrnak, Mark Jensen and Ursin)

Institute of Environment, Technology and Society, Roskilde University Centre, Roskilde, Denmark.

Scope

In Denmark agriculture takes up 70% of the total land area. Therefore agricultural changes are a major source of changes in Danish landscapes and important to study in the scope of landscape management.

Statement of the problem

Strong changes are taking place both in the structure and the way of production in Danish agriculture, in a process both of centralization and specialization of the production. The average farm has an increasing size and has an increasingly more uniform (and higher) production.

The impact of these changes on the landscape is a general pressure on the hundreds of thousands of small uncultivated areas (the interstitial habitats) situated in- and between the fields and farms. This conflicts with contemporary rural recreation and more longsighted attempts to maintain a rich and diversified flora and fauna in Denmark.

Survey of previous work

Agriculture as a landscape-forming factor with special reference to the habitats for wild species has hitherto only been studied sporadically and peripherically in Denmark. But today some relevant projects are under way. Mapping of small wetlands in Jutland has been carried out (Jørgensen, 79). Government bodies have in relation to the new nature conservation act initiated mapping of the remaining bogs (over .5 ha), ponds (over .1 ha) and small rivers (over 1.5 m width).

The present work

The interstitial habitats (drainage ditches, hedges, roadside verges, bogs and ponds) make up an important fraction of "the nature" in densely populated Denmark. The changes in area and number and an identification of the factor of changes are the objects of this study.

Funded by the university and the Danish Agricultural and Veterinary Research Council the content of all interstitial habitats (above 10 m² and below 2 ha) in ca. 15 rural areas (of 4 km²) in Eastern Denmark are being mapped, and the character of each habitat briefly described by field studies. By the use of aerial photographs and old maps the rate and quality of changes are estimated. Interviews with the owners in the chosen areas should give information on the present and previous production and structure on the farms, and information on the present and planned use of the existing habitats.
A pilot-project in two areas (total 18.9 km²) has shown:

<table>
<thead>
<tr>
<th>Changes in the number/length of the individual interstitial habitats from late nineties to 1978 in 18.9 km² agricultural areas. Zealand area.</th>
</tr>
</thead>
<tbody>
<tr>
<td>ponds+</td>
</tr>
<tr>
<td>gravel pits</td>
</tr>
<tr>
<td>plantations (&lt;2 ha)</td>
</tr>
<tr>
<td>others</td>
</tr>
<tr>
<td><strong>total++</strong></td>
</tr>
<tr>
<td>streams</td>
</tr>
<tr>
<td>hedges+++</td>
</tr>
<tr>
<td>roadsides with trees and bushes</td>
</tr>
<tr>
<td>drainage ditches with trees and bushes</td>
</tr>
<tr>
<td>roadsides without trees and bushes</td>
</tr>
<tr>
<td>drainage ditches without trees and bushes</td>
</tr>
<tr>
<td><strong>field dikes++++</strong></td>
</tr>
<tr>
<td><strong>total</strong></td>
</tr>
</tbody>
</table>

+ It was observed that 2/3 of the smaller ponds (<800 m²) were under filling with garbage, chaff, scrub, stones etc.
++ Plantations consist mainly of Abies planted for production of green twigs and whole trees for Christmas decoration. Counted as interstitial habitats the total reduction in numbers has been 30%. In total area however, there have hardly been any changes. But if plantations are categorized as "crops" the reduction in numbers has been 40% and in area 28%.
+++ The reduction in the total length of the original hedges has probably been much higher than the 18% mentioned, as the 16.4 km hedge observed in 1978 includes an unknown amount of former grass covered field dikes, that since are invaded by shrubs in varying degree.
++++Field dikes include only field divides that in the mapping period in the nineties had a height above 3/4 m, and not the field divides below. From aerial photographs it can be seen that the thin uncultivated dividing lines between fields and farms since 1960 have decreased 25% in total length. In 1978 19.6 km remained.

The general impression from the pilot project is that specially wet-areas, the smallest habitats and generally all linear habitats are under hard pressure, and the rate of reduction is increasing.

References


Dansk Orith.For., Vejle Amt.
East Yorkshire is a region of northern England comprising about 3000 km$^2$. The area is principally rural with only one city and two or three other larger urban areas. The agriculture is primarily intensive arable and this imposes severe pressures on the wildlife, both plant and animal. In the absence of a substantial base of documentation of wildlife it was necessary to devise a system of landscape biology assessment to evaluate the entire region and to identify areas of wildlife importance in addition to the existing protected areas.

Assessment was based on 1 x 1 km squares as defined by the Ordnance Survey National Grid. The region was divided up into 5 x 5 km zones (thus 25 km squares) within which five km squares were chosen for assessment. These squares were chosen primarily at random but it was necessary to confirm that collectively they were representative of the zone. In zones at the margins of the region containing less than 25 km squares, a smaller sample was chosen but still at least 20%.

Each square was then visited and assessed. A score was given on a scale of 0-5 for each of fifteen parameters including, for example, hedges, verges, wasteland, woodland. These scores reflected the ecological potential, a high score indicating a greater area and/or better habitat quality.

No attempt was made to summate scores but the average scores for each parameter could be displayed as a series of matrices which by superposition enabled areas of high value to be identified. Further information could be obtained from the full records, if required.

The method has been found to be fairly rapid and accurate. About 20 squares could be recorded in a working day without excessive effort, provided that a reasonable road and path network existed. The results given thus represent 30 man-days. Reproducibility was excellent; consistent results being obtained by technicians receiving only a minimum of briefing. It is felt that the technique is substantially better than survey by monochrome aerial photography. Whilst it is accepted that specially commissioned false-colour aerial photography could probably give the data required, on such a large scale this would be prohibitively expensive. The technique described was found to permit much better assessment of pasture, road verges and woodland than other techniques, which is of significance because of the importance of these features to the wildlife of an intensive arable area.
In Belgium, the new law of 1970 on the land consolidation process completed the previous legislation by introducing, among other things, the possibility of landscape improvement.

These new ecological preoccupations can be explained by an awareness of the multiple functions of the landscape, as well as by the emphasis put on some excesses committed in the first areas which were submitted to field clearing process.

Nowadays, every file concerning field clearing process must be accompanied by a landscape evaluation plan. The latter contains, first of all, a detailed inventory of the various elements (such as hedgerows, lines of trees, walls, wet areas, ...) which could be modified by reallocation operations and other works connected with them (road works, draining, ...).

Then, the importance of every landscape feature is evaluated from an ecological, from an agricultural (economic) and from a landscape point of view. The results of the evaluations are presented in five classes of value. These results are confronted with plans inherent in the land consolidation process, such as the plan concerning the road system as well as possible external plans such as regional plans, infrastructure plans (motorways) and the like.

A plan for redesigning of the landscape may follow the evaluation plan. In its existing form, it is generally limited to a few suggestions for complementary plantations to be realized after the end of the field clearing process.

The poster illustrates the process followed to establish the landscape evaluation plan and shows the main criteria for the evaluations made, in the French speaking part of the country, by the "Groupe d'Ecologie Appliquée" (G.E.A.) in the different studies that this group made at the request of different committees.

In spite of the interest of the existing studies, some important methodological aspects could be improved concerning mainly questions linked to:

- the choice of the criteria used for various evaluations as well as the formulation and the weighting of the results;
- the separation of the evaluations, which leads people to fail to recognize the importance of e.g. agrobiological balances in agricultural and ecological evaluation;
- the too analytical nature of the information received at the expense of functional aspects: the landscape features are still too much dreaded, as far as their structural identity is concerned, their functional nature is practically left out of the evaluation (horizontal relations).

A new methodological approach is proposed emphasizing the concept of the agro-ecosystem.
DETAILED SURVEY OF MAN'S IMPACT ON SOILS AND LAND MORPHOLOGY IN A FOREST AREA. EXAMPLE OF THE ZONIEN FOREST (BELGIUM)

Roger Langohr, Frank Beernaert, Georges Fourkiotis
Department of General Pedology, University of Ghent, Belgium

Abstract

The studied area has never been under agriculture and is a very rare remnant of landscape morphology from the last glaciation. Many soils still show traces of processes associated to a periglacial climate. The survey of man's impact on the soil surface shows that this area also contains a unique record of human activities up to before the Roman period. A detailed systematic survey of the influence of man is proposed in order to assist the future forestry management planning. The purpose is to delineate and to protect from modern disturbance those areas which have the highest value from the point of view of landscape, soils and history.

Introduction

In the Belgian loess belt (+ 8000 km²), the Zonien forest (4400 ha) is the largest area which has never been cultivated. Recent investigations made by R. Langohr have shown that the landscape is largely (> 95% of the area) stable since at least the beginning of the Tardiglacial (+ 13 - 16,000 y. B.P.). The land morphology thus is a relict of the last glaciation (the latest loess deposits date from + 20 - 22,000 y. B.P., the glaciation ended at + 10,000 y. B.P.). The same author has detected numerous clear traces of pedogenetic processes associated with a periglacial climate and this already from a depth of a few decimeters from the soil surface. These traces are still visible because of the absence of agriculture and the concomitant absence of (1) mechanical turbation, (2) erosion and aggradation processes and (3) bioturbation (very low earthworm activity in the acid forest soils).

Man's impact on the landscape and the soils

The relict soil- and landscape properties are locally disturbed by human activities. In order to have an idea of the density and the type of these disturbances, a survey has been planned. First a sample area was selected for the elaboration and the testing of a mapping legend. During this preliminary prospection a list was made of all the kinds of disturbances due to man and which are mappable at a scale of 1:5000 (systematic traverses every 50m). The following features were detected.

Artificial basic microlief: irregular pattern of mounds and depressions, covering an area of at least several ares, phases: 0-10cm, 10-25cm, 25-40cm, 40-60cm (height differen-
ces between mounds and depressions). **Superficial strongly compacted areas:** development of a continuous traffic pan. **Drained valley bottom:** intricate and dense network of drainage ditches. **Isolated drainage ditches:** mostly on the upland. **Earth walls with associated ditch:** former fences. **Pits. Quarrries. Mounds (at least 30cm high and 3 meter diameter), of charcoal:** places of charcoal furnaces, **of iron dross:** correspond to low-furnaces, **of earth:** origin variable. **Tumuli:** several meters high. **Builted area:** houses. **Monuments. Parking places. Actual roads. Actual paths. Old roads:** not used any more. **Old paths:** not used any more. **Hollow roads:** deep cuts in the landscape, where old roads cross steep slopes. **Logging traces:** deep permanent traces from the cutting and transport of trees.

**Conclusions of the preliminar survey**

From the previous list of kinds of disturbances as consequence of the presence of man, it can be concluded that the Zonien forest has not only a high value from the point of view of original landscape and virgin soils, but that it also represents a unique record of past human activity. For example, the data of the preliminar survey permit to estimate the number of mappable charcoal furnaces to several thousands; the production of charcoal existed already before the Roman invasion and lasted until the 19th century. The total number of detectable iron furnaces will be of several hundreds; they probably date from before and during the Roman occupation. Many of the upland drainage ditches, largely filled-in today, are remains of the work of the monasteries, mainly active between the 13th and the 18th century.

**Planning for the future**

Steps are made in order to make the official authorities aware of these aspects of the national patrimony. The purpose is to obtain the necessary help for a systematic survey of the whole forest on basis of the above-mentioned legend. This map, representing the density and the type of human disturbances, must permit (1) to delimit the zones with the minimal disturbance and with the highest value for landscape and soil conservation, (2) to delimit the areas which should be protected for the conservation of historical features (iron and charcoal furnaces, hollow roads, etc.), (3) to make the population conscious of the value of these remnants of the past and (4) to assist the future forestry management planning in order to find the best compromise between the various "pressure groups", namely "recreation" (the forest is situated at the limit of Brussels, a town with one million inhabitants), "wood production" and "conservation of nature". Latter should include here the landscape, the soils, and a series of features associated to the presence of man in the past.
Agriculture in the Netherlands has changed in many ways during the last few decades. Yields have been substantially increased as a result of larger farm units, mechanization, hydrogeological measures, the shedding of manpower, etc. The stagnation of farm prices (brought about by, among other things, overproduction) meant that the income of farmers increased at a slower rate than other sectors. Nevertheless, increased productivity is still considered a universal remedy for the complex problems of Dutch agriculture.

Many of the changes in farming have had a significant impact on the agricultural landscape. This is not surprising in a country where many types of landscape have been strongly influenced by a wide range of agricultural activities. In order to find correlations between changes in farming and changes in the ecological character and significance of arable and grassland, an analysis of the changes in the farming system between 1965 and 1980 was carried out in two adjacent areas on pleistocene sandy soil. In one area a land consolidation project was recently completed, and in the other a land consolidation project was planned to start within a few years. By analysing the difference between the changes in both areas the relative importance of land consolidation could be estimated.

First, a model was developed of the flows of energy and materials that were considered relevant. By means of a survey data were collected from 42 farms (21 in each area). Quantification of the parameters in the model was possible by expressing most of the data in Joules. Not all data could be transferred into Joules, of course, but it was found that a satisfactory notion of the energy flows could still be obtained. The energy efficiency of an 'average' farm was calculated and the relative ecological impact of farming in both areas in 1965 and 1980 was estimated.

Figure 1. is a quantified and simplified model of the energy flows of an average farm in Zieuwent-Harreveld, the area in which a land consolidation project has been completed. The following differences between the situation in 1965 and 1980 are notable:

- total input to the farming system had increased substantially
- total output had increased proportionately less than input
- with the higher i/o-ratio (lower efficiency of energy use) the loss of energy from the system had increased
- the farming system in 1965 was relatively more closed than in 1980. There were more internal energy cycles in 1965.

Only a few significant differences between the changes in both areas were found. The land consolidation project in Zieuwent-Harreveld had apparently not stopped the declining efficiency of the farming system.
Between 1965 and 1980, when energy efficiency and the number of internal cycles decreased, but the loss of energy increased, the ecological information value of the arable and grassland vegetation in both areas had sharply declined.

Figure 1. Quantified model of the energy flows of an average farm system in Zieuwent-Harreveld in 1965 and in 1980 (in 10^7 Joules p.a.)
The central Cardigan Bay coast is an attractive area of great environmental diversity. Although originally proposed as an Area of Outstanding Natural Beauty in the 1949 schedule of potential sites, it has failed subsequently to attract any official recognition of its scenic qualities. Bounded to the north by the Snowdonia National Park and to the south by the Pembrokeshire Coast National Park, officially, the area has been neglected. However, many holiday makers, particularly from the industrial English Midlands, are attracted to the area during the summer months, testimony to its true scenic value. In addition, sailing is an important recreational activity and has increased dramatically in recent years. Despite the area's undoubted importance, the natural resources remain largely uncatalogued.

Aberystwyth is the focus of the Central Cardigan Bay coast and in 1978, those involved with the emergent Environmental Science Degree Course at the University College of Wales, Aberystwyth, saw the potential of the coast for undergraduate inter-disciplinary project work. A long-term study was initiated in collaboration with Ceredigion District Council and the Development Board for Rural Wales, aimed not only at remedying the deficiency in information, but also at providing students with an insight into the problems faced by an authority administering areas of intense use.

A dual approach has been adopted. Small scale surveys of large coastal tracts have been made, while detailed studies of individual "honeypot" sites along the coast have been undertaken. Attention has also focussed on the present capacity of recognized sailing centres and potential for future growth based upon new marina development.

The Nature of the Area

The coastal strip can be divided into five major physiographical units. In the north the landscape is dominated by a backdrop of uplands which rise sharply from the coast. The unstable cliffs of much of the central section are composed of Silurian shale which is base poor and supports a restricted flora. Between the shale cliffs are low platforms formed by the intrusion of boulder clay into former valleys in the shale landscape. There is a marked increase in base status of the rocks in the south of the area, where the coast is dominated by spectacular cliffs of hard Ordovician rock. The soils support semi-natural vegetation rich in species. At intervals are geomorphological features of more recent origin, the most important being the Dyfi and Mawddach estuaries which are of national importance on scenic and wildlife considerations. Low intensity pastoral agriculture is an important feature of the immediate hinterland which contributes to overall visual quality. Maintenance of this use is essential for conserving the landscape.
The Problems

Even with the recent increase in recreation sailing, there is limited spare capacity in many of the small harbours. This space is likely to be allocated to a moderate increase in commercial use. Geomorphological features prevent substantial redevelopment of several harbours. Two areas for possible marina development exist in the Dyfi and Mawddach estuaries where, it is believed, there would be little adverse scenic or biological impact. The scale of individual proposals, however, would have to be reviewed carefully.

The coastal strip has limited potential for intensive recreation development. Intensive use will remain restricted to a small number of resorts with sheltered sandy beaches. For the most part, the foreshore is inaccessible at the base of dangerous cliffs. This suggests a less intensive form of use. A long distance footpath is not practicable, because of discontinuities created by areas where access is restricted (Ministry of Defence installations) or undesirable (important ornithological sites). Consequently, a number of short walks is more feasible. The rapidly eroding shale cliffs present considerable problems for footpath design and management, as each year sections of path disappear into the sea. Intensive use of individual resorts causes severe damage and detailed management proposals for a number of sites have been suggested.

Conclusions

The Cardigan Bay coastal zone has been a useful case study for teaching purposes. The problems of the local area are of concern to students and they can see the implementation of their work. Their expertise has proved invaluable in providing a multi-disciplinary team to analyze biological and scenic resources which might otherwise remain uncatalogued.
Recreation has become an inseparable part of the modern life style. This trend is further enhanced by an increasing proportion of free time, transport development and of course by the needs of people themselves, especially those living in bad environmental conditions /big towns, industrial areas etc./. Like every human activity recreation brings about changes not only in the socio-economic sphere, but also in the sphere of environmental management. The uncontrolled expanding of recreation may gradually destroy the majority of attractive places suitable for recreation.

When considering the recreational impact we must distinguish the impact resulting from building and maintenance of recreational resorts, and that caused by the people on recreation themselves. Only the latter is discussed here.

In spite of the fact that the number of recreational activities spans a wide range, so varied in time and space, according to people's numerous interests and possibilities, various kinds of impact stemming from recreational activities can be considered to fall within one of the following groups: 1. trampling, 2. eutrophisation, 3. the impact of motoring /i.e. air, water and soil pollution/, 4. direct damage to plants and plant cover /excl. trampling/, 5. plant introduction, 6. fire.

The study of the recreational impact is rather complicated for several reasons: a/ it is often hard to specify impact caused by recreation and that caused by other human activity in the area under anthropic pressure, b/ the groups of impacts given above are always complementary, c/ consequences can often be separated from their causes in time and space, d/ methods detecting these impacts /either after-the-fact analysis, or monitoring of change through time, or simulation experiments/ always have their drawbacks /inaccuracy, neglect of varying seasonable conditions, of time factor, demands on time, difficulties in determining recreational pressure etc./.

The presented poster analyses every kind of impact separately /as is usual/ with emphasis on trampling and eutrophisation. Non-quantitative models of trampling, eutrophisation and plant introduction effects are given.

For a long time trampled places have been supposed to give rise to a uniform plant community /Plantaginetea majoris Tx. et Preising in Tx. 1950 resp. Polygonion avicularis Br.-Bl. 1931/. Our work indicates that another kind of plant community can be found in rather extreme ecological conditions e.g. limestone regions.
Soil analyses on the example of the camping site Doksy at Mácha's Lake, NW of Prague illustrates the deterioration of soil in heavily used recreation areas especially the impoverishment in humus content leading to the sterility of the place thus preventing an establishment of plant cover.

A field semi-quantitative method determining the stage of eutrophisation of the area according to the nitrate quantity is presented.

As there is a lack of quantitative indices evaluating a recreational impact, an attempt at such evaluation using a method first applied to the same purpose by Kostrowicki /1970/ is given.

The aim of every landscape-ecological study dealing with recreation of a certain area should be to set some threshold of the recreational use. Although we can find ample data concerning recreational carrying capacity /RCC/, they were mostly set arbitrarily or intuitively. A solid base for setting RCC is still lacking due to the reasons mentioned above.

The solution of the problems connected with increasing recreation is above all in the sphere of proper management taken in time before the degradation occurs, including paths, tracks, cultural treatments, sanitation, maintenance of the damaged area etc. and in the sphere of education.

Preventing people from visiting a certain area or fining them is a misleading solution. It is necessary to draw attention to more resilient areas, perhaps not so attractive, by creating conditions for recreation, to encourage everyday recreation in towns the lack of opportunities and unsuitable environmental conditions lead to people being frustrated and to calamities during weekends, to promote such forms of recreation available for people with lower incomes and thus to slow down uncontrolled building of weekend houses.

Of course those are tasks of interdisciplinary approach which is an unavoidable premise for every such study.
Natural resources for recreation attract resource oriented facilities and recreational activities that may change these same natural resources or even destroy them. Analysis of sequential aerial photography may help to detect such processes and reveal their impact on the rural landscape.

Resource oriented facilities strangling the resource?

Recreational development around Lake Proserpina near Merida, southwest Spain, analysed with sequential aerial photography

Originally a Roman reservoir that provided nearby Merida with drinking water, Lake Proserpina for many centuries was just a lake in the dehesa landscape with only a few farm buildings nearby. In the 1960s, the lake was recognised as a recreational resource. A belt of eucalyptus trees was planted around the lake and one landowner started to sell plots along the lake shore for summer homes. Development during the 1970s was quite rapid. If unchecked, the resource oriented facilities may eventually obstruct access to the resource itself for most citizens of Merida. Water pollution and littering are also affecting the quality of the natural recreational resource. Careful planning and management are necessary to preserve the quality of the resource and keep it accessible for all to enjoy.
Recreational erosion of a dune landscape

Recreational activities that damage the vegetation of the dune landscape of Schiermonnikoog, The Netherlands, monitored by sequential aerial photography

The island of Schiermonnikoog, off the north coast of The Netherlands, offers a very attractive environment for weekend and holiday recreation. The island's economy is predominantly based directly or indirectly on providing goods and services to the recreationists.

The landscape, the natural resource for recreation here, is influenced by recreation in two ways.

(1) Parts of the landscape have been occupied by summer homes, hotels, restaurants, camping and other resource-oriented facilities.

(2) Recreationists—when moving around in the dunes—do not always remain on the official roads and (cycle) paths, and create "wild" paths of their own, damaging the vulnerable dune vegetation. The most seriously affected areas are the dunes between the beach—the main attraction—and a cycle path and/or the main concentration of summer homes. Numerous parallel paths cross the dunes towards the beach. High dune tops giving a good view and other promontories often become the centre of a radial system of paths. When the path network becomes too dense, areas of wind-blown sands may result.

As the process of recreational erosion is very gradual, the true impact and progress are recognizable only by comparison of sequential aerial photographs. After this problem is recognized, proper management measures can be taken to prevent further erosion and even restore some of the original qualities of the landscape. After all, this landscape is the most important natural resource for the main source of income for the islanders—recreation—and thus should be preserved. The effects of these measures can also be monitored with the aid of sequential aerial photographs.

![Diagram showing changes in the landscape between 1976 and 1979](image-url)
Abstract

Within Canada it is difficult to find an unequivocal definition of planning as many individuals and groups hold diverse views. Regardless of one’s preference for words, the measures which are taken to ensure or determine the appropriate use or conservation of land resources are undergoing increasing scrutiny. This examination is not limited to formal planning agencies but it typically entertains the perspectives of public interest groups, private companies and governmental bodies. The overall process of planning is now lengthy and seldom simple. It must weigh concerns expressed over singular or multiple combinations of particular land resources, and blend or overlap these with often conflicting issues which emerge from a legal, economic, political and socio-logical spheres. This then calls for some mechanism that would allow or assist planners in addressing biological, physical and human considerations not only on their own but in combination with each other -- as such, an ecologically based approach.

While there is neither no universally accepted nor totally perfected guiding framework in Canada, the ecological land survey (ELS) and its underlying principles affords certain opportunities. Under this approach, land is viewed holistically and as an ecosystem of which man is a part and upon which he depends for quality of life. Although natural and man-modified ecosystems are recognized, the widest application of this approach has been in relatively natural environs. However, cases in urban or rural settings are increasing. The general intent behind an ELS is to broadly characterize land and relate man’s ongoing or intended use of it, and the effects of that use. This in part reflects that human activities are affected by and exist within the context of land resources.

Since planning requires a skillful linkage to data collection, evaluation and presentation, the ELS encourages a strong dialogue at the onset of providing an information base. There should be a firm understanding that what is to be put in place is adequately comprehensive and useable for determining alternative strategies and assessing their consequences. An ELS does not presume to be “totally” comprehensive especially in practical application. Money and manpower resources are usually limitations and with such an attempt has been made to account for key components and relationships within ecosystems; from this base various evaluations concerning compatible uses or degrees of uses that can be tolerated without deleterious affects can be determined or at least estimated.
Planning is not a static or short term affair. Many of the impacts from initial planning strategies may not be determinable at the onset, and several unperceived needs or uses may emerge over the long term. The comprehensive nature of the ELS provides a future oriented flexibility. The data base is designed to be versatile and broad enough to be suitable for most planning purposes. Having characterized ecosystems in their current state also allows one the option to monitor and to provide feedback as to the consequences of initial planning actions.

Beyond the more traditionally recognized socio-economic inputs, land-use planning requires significant environmental information to ensure the longevity of the land and its ability to support life. Ecologically based planning guided via an ecosystem framework is an attempt to foster this concept.
In 1972 an intensive land-use planning program was initiated by a private developer for 13,436 acres just outside of Helena, Montana in the western United States. At the time the program was started, there were no apparent examples of similar private sector projects which could be used as role models. The planning procedure began with the general goal of developing a pattern of land-use and land management consistent with the ecological constraints and benefits of the semi-arid, mountainous land in question. Specifically, the developer wanted to 1) identify and/or critically examine environmental and spatial patterns beyond single-factor analysis and simple spatial location, 2) identify and evaluate the key elements and forces that lend quality to the natural environment, 3) incorporate the above two elements to create a viable plan, and 4) treat the environment as a resource per se rather than simply satisfying particular planning purposes. In the 10 years since project inception, there has evolved a planning process which was designed to implement these goals. The first step was the development of an integrated biophysical mapping system which would reveal the ecological characteristics of the study area (A Biophysical Study of a Selected Tract of Land Southeast of Helena, Montana). The integrated biophysical approach consisted of the identification, mapping, analysis, and description of homogeneous land units—biophysical units. Components of the units that were explicitly shown by map were soil, slope, present vegetation, and potential vegetation. Characteristics which were implicitly shown included microclimate, geology, geomorphology, and wildlife. The small biophysical units were aggregated to form biophysical regions. Through use of potential vegetation, a micro-bioclimatic map was made relating on-site ecosystems to off-site weather stations. The biophysical study was followed by a 2-part land capability study which interpreted the basic ecological data with respect to its ability to sustain structural development (Land-Use Capability: Southeast Helena Project and Land-Use Capability: Lower Holmes Gulch Project). Given the assumptions of the study, it was found that about 75 percent of the area should be eliminated from consideration for structures. Management programs were proposed for these reserved areas. In the subsequent planning phase the results of the land capability studies were reviewed by a variety of planners, architects and other professionals. This review procedure along with further analysis regarding the design, location, and political suitability of structural development led to the production of a master plan (The Crossfire Master Plan) for 4,100 acres of the initial study area. The master plan included provisions for single family and multiple family residential areas, commercial centers, work places, natural areas, commons, schools, aquatic resources, and a golf course. Each land use decision was based on an explicit interpre-
tation of the ecological constraints of the land resource. The project is now ready for specific site designing and implementation. This planning experience has demonstrated that it is economically possible for the private sector to initiate environmentally sound land-use planning.
Introduction

As a consequence of a storm disaster in 1953 the Dutch government decided to protect the south-western part of the Netherlands by executing the so called Delta Plan, a very extensive hydraulic engineering scheme, including the closure of several estuaries (Saeijs, 1979). The environmental impact of this project was at that time not fully recognized. As a consequence of changes in the public's appreciation of environmental issues the Delta Department, in charge of the project, was extended with an Environmental Division (further on E.D.) in 1971. This E.D. was given the task of assessing the environmental impacts of the project.

Advice

Since its start the E.D. has made many policy recommendations in relation to the execution of the Delta Project; these recommendations concerned all stages of the project, namely:
1. the preparation of the decisions between alternative technical solutions (early stage guidance);
2. the execution stage and its environmental impacts (short-term guidance)
3. the guidance of the developments in the influenced areas as a result of the changed environmental conditions (long-term guidance).

During the first stage decisions are prepared on the kind of activities and the technical design. The method used most in this "stage of decision-making" is the "policy-analysis strategy". In this strategy several alternative solutions are compared for many different aspects, like security, environment, costs, fishery, recreation, etc. (Goemans, 1977). The environmental contribution in this stage concerns the prediction of the environmental impacts of the alternatives.

The execution-stage comprises short-term activities, for instance sand-dredging, storage of dredged materials, construction of harbors, etc. The environmental contribution includes minimizing the damage or, if possible, improving the environment.

The third stage is concerned with the period after the project has ended and the new situation exists. This long-term guidance concerns the preparation of new schemes for management and human use of the influenced area and the new technical works (dams, locks, etc.). These new schemes have to be ready as soon as the technical works have been completed in order to prevent undesirable developments.

Research

The advice, mentioned above, requires a thorough knowledge of the following:
- the most important elements of the ecosystem (biotic, abiotic)
- the connections between these elements
- the developments expected in the ecosystems as a result of changing environmental conditions (e.g. tidal range, salinity)
- the influence of human use of the ecosystems such as fishery, water-
management, recreation, etc. (risk-analysis).

This means a lot of research has to be done, both fundamental and
applied research (Peeters & Al, 1978; Saeijs & Bannink, 1978).

Although in 1971, when the E.D. started, much was already known about
the area, due to the work of the Delta Institute for Hydrobiological
Research in Yerseke, the E.D. had to do much supplementary research,
especially applied research in the field of water- and soil-chemistry,
physical geography, hydrobiology (algal bloom), ornithology and vegeta-
tion science. At first this research was mostly descriptive but later on
most of the research gradually shifted (and is still shifting) towards
research on processes in ecosystems, including mathematical modelling.

In the E.D. many disciplines are organised nl. geomorphology, soil-
science, waterchemistry, geo-chemistry, hydrobiology, vegetation-science,
ornithology, hydrology and physical planning. The research of the E.D.
is determined primarily by the problems within the scope of the Delta
Project. Mostly the research isn’t executed in a monodisciplinary way.
When possible it’s done in integrated research-projects in which the
entire (or parts of the) ecosystem is considered in its entirety. This
integrated ecosystem approach is based on the following considerations:
- the theoretical concept of an ecosystem is a complex entity (the whole
  means more than the sum of the separate parts).
- an interference in one part of the ecosystem may have consequences for
  other parts of the ecosystem; by considering its entirety one tries to
  recognise these consequences in time.
- as a consequence of the Delta Project complete new ecosystems will
develop with new possibilities for human use; these possibilities will
  to a large extend be determined by the specific characteristics of the
  new ecosystem.
- the integrated approach can often result in an efficient working-method
  in the execution of the research.

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(* supplementary literature)
RURAL PROBLEMS IN DEVELOPING COUNTRIES WITH SPECIAL REFERENCE TO TROPICAL RAINFORESTS

The main items from the discussion points and reports by F. van der Meulen and R.F. van de Weg are summarized here, together with those prepared in connection with the workshop on the tropical rainforest by W. Bongers. Use is also made of two working papers: one by R.L. Voortman: "The role and character of landscape ecological survey for rural development planning and its adequacy towards decision making", and another paper by M.R. Moss: "Rural land development and evolving landscape ecologies in peninsular Malaysia". They all revolve about the central question of how landscape ecological research could contribute to ecologically sound land use in developing countries.

The most serious problems in developing countries are caused by increased population pressure, urbanization and growth of agricultural export production beyond the carrying capacity of both the ecological and the social systems. Traditional land use practices often were well adapted to the environment. They represented a stable interaction between man and resources. A good example is the case of the Dogon in Mali, as demonstrated by Banga (p). But in most places the old systems can no longer support the increased demands. Thus the Sahelian nomads apparently have to settle for agriculture as is indicated in the workshop summary on stability. Thus Husain (1) makes clear that the jhuming (=shifting) cultivation system in Northern India has no more space to shift to and fallows are shortened under the present population pressure. Is permanent cultivation of the fields possible from an ecological and a social point of view?

Here Adejuwon (1) points out that by intensive farming and the increased influence of fires, vital resources of natural landscape, forest products, wild life, water and soil are destroyed in West Africa.

But modern methods very often are no less destructive to the resources of tropical landscapes. Perhaps the most striking example is the case of the tropical rainforest. At the moment there are only 900 million ha left of the original 1600 million ha. Yearly 15-20 million ha are destroyed. In a country like Malaysia, according to Moss, this has serious consequence for the stability of the environment, including such problems as man-disease relationships and the maintaining of the productivity levels. Especially in mountainous areas, the deforested soils are very vulnerable to erosion, as is described by Wiersum and Boerboom in their working paper, which is mentioned in the summary on stability.

In the workshop on tropical rainforests it was stated that their preservation is not only a technical or an ecological problem, but also a political one. This would only be accepted by the Third world countries if it would become part of their socio-economic development policy. The need for sustained yield and stability should be made clear to politicians and to the local people. The rich countries have their own responsibility in reconsidering the necessity of tropical hardwood import in the present quantities and in promoting the wood processing in the producing countries. Under the present circumstances the tropical rainforests are in many cases exploited as a non-renewable resource. Can it be harvested without creating ecological imbalances? Landscape ecologists have a special task in research about such questions. There is no general recipe because landscape and social conditions differ greatly.
It was felt in the workshops that research should include especially the adjustment of technical improvements to local conditions (see for example Agrawal, p, and Somasiri & Moormann, p). Among the topics deserving special attention were mentioned agroforestry systems, improvement of small-scale agriculture and rangeland management.

Basic land inventories were considered a must. At the core of this work are aerial surveys and field investigations. Voortman described the approach chosen in Mozambique. In the discussion it was stressed that expensive and time consuming multidisciplinary surveys were only advisable in relation to specific projects. It was argued that quick and cheap land inventories were mostly needed. The limiting factors of the biophysical factors for any particular kind of land use should be given special attention during these “holistic, pragmatic land surveys”. Furthermore it was stressed that an evaluation in terms of land use ecology of indigenous land use systems should be part of landscape ecological research.

Extension was thought in all three workshops to be crucial for the application of scientific results. As a conclusion Vink formulated: local agricultural extension, continuously supported by well-equipped dispersed regional centres, provides a means of land development which as a rule will be better adopted to landscape ecological conditions than are large-scale development projects.

The working papers mentioned can be obtained from:
R.L. Voortman, FAO/MOZ/75/011, C.P. 4595 Maputo, Mozambique
M.R. Moss, Dept. of Geography, Univ. of Guelph, Guelph, Ontario N1G 2W1, Canada.

NATURE, AGRICULTURE AND RECREATION IN RURAL AREAS OF INDUSTRIALIZED COUNTRIES

The following summary is based on the workshop reports by P. Wolff & A.J. Beenhakker, P. Agger & R.H.G. Jongman and D. van der Zee. Also used in this section is a working paper by G. Poortinga: 'Panta rhei'.

Separation and/or integration of land use types

The general problem of rural areas is described by Vink (1) as "encroachment". In most cases more dynamic types of land use, with higher input and output and more intensive use of the area, are overruling the less dynamic ways of using the landscape. Consequently, in most industrialized countries a choice is made for a planned segregation of functions. However, as was stated in one of the workshops, segregation in planning is possible, segregation of effects is not.

At the congress, two contrasting approaches appeared to exist among landscape ecologists. One group stresses the need for land evaluation. A minimalization of conflicts is sought by separating, for example, agriculture, recreation and conservation. The choice of the right place for each function is considered most important, to be then followed by a careful adjustment of the management to the ecological conditions of the area (see Vink, 1). In order to mitigate mutual harmful effects, a pattern of zones or compartments is designed as demonstrated by Fabos & Hendrix (1) and Van der Maarel (1).

A second group emphasizes the need for technology evaluation. They give priority to a decrease of the dynamic level of the activities (technology,
An integration of functions in small parts of a landscape will then become feasible in more cases. Thus Poortinga in his working paper states that innovation of agricultural systems has to be directed to a technology that should not be hostile to the environment. A similar remark was mentioned in the workshop summary on stability. Further argumentation and elaboration of this approach is presented by Tjallingii (1). The interest from both sides in Environmental Impact Assessment (see workshop summary) makes clear that the two ways of looking at the problems and their solutions are not mutually exclusive. Nevertheless, the different attitudes were perceptible in many discussions.

Agriculture and nature

Most landscape ecologists receive at least part of their training in natural areas and this may explain their special concern for natural remnants in cultural landscape. More important is the weak position of smaller nature islands in a landscape dominated by agriculture and the connected problems for the planning of conservation and recreation. The vivid interest in the ecology of these forest patches, hedges and other "islands" is demonstrated by the contributions of Forman (1), Sharpe et al. (1), Ruthsatz & Haber (1), Van der Maarel (1) and by the Danish Biotope Group (Agger et al., p).

Landscape ecological surveys in rural areas mostly focus on the analysis of special qualities of natural areas and sometimes also on agriculture-nature interactions. Examples are given by Tinklin (p), Froment (p), Langohr et al. (p) and others. The results of surveys of this type are frequently used in the evaluation stages of regional planning or land consolidation schemes. A discussion of these procedures is given in the workshop summary on inventory, classification and evaluation. According to Froment (p), the influence of the surveys he discusses is generally limited to suggestions for complementary planting schemes.

In order to realize a more fundamental discussion on planning in rural areas there should be more study on problems such as agrobiological balances from an agricultural and an ecological point of view. An interesting example of ecological research on the farm system is presented by Boezeman & Meuleman (p). Their comparison of the systems in 1965 and 1980 reveals the change of a more closed to a more open system, and a notable decrease of energy efficiency in this period.

It was argued that more research should be done on the question how the same production level can be reached by more closed systems, in which more natural qualities might be maintained. At this moment it is not clear where such investigations may lead us in the future.

In any case, it was stated in one of the workshops: As far as nature and landscape values in agricultural areas are by-products of obsolete agricultural methods, they can be preserved in museum landscapes. It is difficult to hold farmers responsible for the management of landscape elements on their land if they do not consider it profitable. Even if they get paid separately for their management task, there still is a social and psychological barrier because the farmers like to be free entrepreneurs.

Recreation and nature

Among the factors that attract holiday-makers to a certain area, the following were listed:
- physical suitability (particularly referred to by the Environmental Science Group from Aberystwyth, p).
- visual, esthetic qualities (see workshop summary)
- information about the area, raising touristic or scientific curiosity.
Serious problems may rise if the number of visitors exceeds the carrying
capacity of the area. But what exactly is the limit? Certain ecosystems
give way to others; erosion in sandy areas, for example, may cause more
evident degradation. One of the workshops considered the concept of
carrying capacity for recreation basically a matter of political choice:
the level of influence that is acceptable to society.

Damaging factors discerned by the workshop on recreation include leaving
litter, trampling, cutting branches and picking flowers, and fires.
Rambousková (p) added eutrophication, water and soil pollution and the
introduction of plants. Various methods to monitor the degree of damage
were reported. Van der Zee (p) demonstrates the use of sequential series
of aerial photographs. Management measures mentioned were:
- concentrating visitors and directing them to less vulnerable places
- limiting access
- restricting or prohibiting uncontrolled building
- creating alternative attractive areas
- education on-the-spot.

The role of landscape ecology in the planning process

A general review is given by Vink (1). Some of the posters mentioned
already show landscape ecological research carried out to produce only
additional information (see also Wiken et al., p). It is encouraging that
in an increasing number of cases, landscape ecologists are called to take
part in the planning process right from the beginning. Examples were
demonstrated in regional planning by Carlson (p) and in a coastal engi­
neering project by de Jong & Visser (p).

The working paper mentioned can be obtained from:
G. Poortinga, Stichting Vrijwillig Bosbeheer, De Greeden 29, 9967 RZ
Benrurn, Netherlands.
Theme III: Urban-rural relations
REGIONAL ECOSYSTEM ASSESSMENT: AN AID FOR ECOLOGICALLY COMPATIBLE LAND USE PLANNING

Julius Gy. Fabos

Department of Landscape Architecture and Regional Planning, University of Massachusetts, Amherst, Massachusetts U.S.A.

William Hendrix

School of Natural Resources, University of Vermont, Burlington, Vermont U.S.A.

Abstract

The aim of the research which this paper describes is to present a method for incorporating ecological principles into land use planning processes for growing metropolitan regions. The research has outlined a methodological framework for regional ecosystem research which includes an ecological land classification consisting of three parts.

The first part uses a multivariate statistical technique to classify land uses based upon ecological characteristics as measured by community energetic values. The resultant classification categories are referred to as ecological function.

In the second part, the biological potential and the denudational potential of a site are determined from soil characteristics and slope. These potentials are combined to derive substrate functions that indicate which lands need to be protected, which should be used for production of food and fiber, and which can be traded off for development.

In the third part of the study, comparison of the ecological functions with the substrate function reveals where compatible and incompatible relationships exist. It also shows where land use conversions are necessary to provide for human needs can take place with minimal impact on ecological values.

The procedures for ecological classification and assessment of compatibility are applied to two communities in Massachusetts. The application is accomplished through the use of a computerized geographic information system.

Introduction

One of the most significant land use issues affecting our contemporary landscape is the conversion of millions of acres of rural land to urban uses on the fringes of urban/metropolitan areas. The costs, the negative effects and the uncertainties generated by such processes are increasingly evident. To overcome these problems, it is essential that decision makers understand the cause-effect relationships implicit in their land use decisions. Since the overwhelming majority of land use decisions are done to satisfy some kind of growth demand, the environmental impacts
of land use decisions are seldom studied or understood by planners. This
growth demand approach of planners is contrary to environmental or eco­
logical principles, which advocate the understanding of land resource
and land use potentials which are based on the capabilities of land re­
sources.

This paper presents an ecological compatibility assessment procedure
which is designed to aid planners in environmentally responsive land use
decisions. This ecological model, described here, is part of a more com­
prehensive landscape planning project, The Metropolitan Landscape Plan­
ing Model (METLAND), which includes assessment of various landscape
values and existing public services in addition to ecological compati­
bility. In contrast to the traditionally used demand models, it is ad­
vocated that this supply side approach, which composites several values
and environmental attributes, be incorporated into the land use decision­
making process at the fringe areas where urban and rural areas meet.

The philosophical notion underlying our approach is that land, like
air and water is essentially a public good whose efficient use is bene­
ficial to all citizens. In contrast, the demand side models, such as
the ones which allocate land uses based on location or economic deter­
minants are placing a greater value on the needs of the individual. En­
vironmental legislation, enacted during the past two decades expresses
an increased concern for public values. This provides sufficient reason
to include the supply side of environmental concerns in land use plan­
ing. To do so, however, models are needed, which are able to translate
the scientific findings and the diversified values of various individuals
and groups of the public in such a way that the land use planner can use
them.

To achieve the above goal, the majority of our effort was spent on the
interpretation of the wealth of pertinent scientific findings for land
use planning. Similarly, we have incorporated procedures developed by
social scientists, primarily economists and environmental psychologists
to deal with the different values of our pluralistic society. Finally,
we adopted and developed computer-aided data manipulation procedures,
which provide planners with an interactive capability, in testing out
the cause effects of alternative land use proposals on ecological com­
patibility, landscape values and public service resources.

Because the ecological compatibility procedure is part of a more com­
prehensive landscape planning model, a brief review of the larger model
is described here. A composite assessment procedure is designed to pro­
vide planners with answers to fundamental questions on: what are the
landscape resources and values of concern, e.g. visual amenity, agri­
culture productivity, biomass; where and what quantities are available,
what is the quality of each resource, how each of the resources are dis­
tributed, or possibly where and what resources are overlapping; and fin­
sally, how they are valued.

The process of determining values is complex. The values used for all
measurable and tangible resources such as agriculture productivity or
development suitability cost were determined in economic terms. Other
values such as aesthetic/visual qualities were based on environmental
perception studies in addition to some attempt of placing dollar values
on them. Ecological compatibility was rated on a relative scale from -3
(very incompatible) to +3 (very compatible).
When assessment procedures are applied, the results are three value profiles. The landscape value profile expresses all initial/special value resources, the negative values of hazards and various development suitability costs. The public service value profile composites seven public resources of concern such as public water supply. Finally, the ecological compatibility value profile shows the degree to which the various uses satisfy ecological principles.

The second phase of the model is the plan formulation phase, which can be generated by using a supply (landscape sensitive) approach or a demand (status quo) approach. The results of each land use can be shown spatially by a computer CRT or by statistics. In the final phase, or plan evaluation phase each of the alternatives are evaluated against two sets of criteria. One is the traditional cost/benefit or efficiency criteria. The second is a goal-oriented of effectiveness criteria. It is this second set of criteria where the ecological compatibility is meaningful. Since it is difficult to measure ecological compatibility in terms of dollar loss or gain, we evaluate each alternative against goals expressed by ecological values. This approach is appropriate, because economic values are dealing only with the present and values which may project only ten to twenty years into the future, while ecological values have an infinite time span. The rest of this paper will discuss the ecological compatibility model in greater detail.

The Methodological Framework

The study of ecology, and particularly the study of regional ecology, is of such a complex nature that no single research effort can hope to address the entire scope of the problem. For this reason it is desirable to define a conceptual framework within which a particular research effort will fit. An extensive survey was made of the literature in: (1) ecological theory dealing with the dynamics of human interaction with the environment (Vernadsky, 1949; Odum, 1969 and Dansereau, 1973), (2) quantitative ecosystem analysis (Patten, 1966; Dale, 1970; Watt, 1968; and Walters, 1971), and (3) resource-based regional planning (MacKaye, 1928; Zube and Carlozzi, 1967; McHarg, 1969; and Rodiek, 1974).

The conceptual framework presented by Odum in his 1969 paper entitled "The Strategy of Ecosystem Development" was selected as the most suitable basis for generating a regional ecosystem analysis. There were several reasons for this. First, it considers the human use of land in terms of the general ecologic function that use performs. The model proposed four categories. These are: (i) "production" (e.g., agricultural lands and productive forests), (ii) "protection", so-called because they protect established characteristics valuable for ecosystem maintenance (e.g., mature forests), (iii) nonvital or urban, so-called because they contribute little or nothing to the functioning of natural processes (e.g., heavy industry) and (iv) "compromise". These uses include all those which exhibit characteristics of both non-vitality and production or protection (e.g., low density suburban residential areas under the forest canopy).

Secondly, Odum's compartment model incorporates the influence of human activity on ecosystems and addresses the potential conflicts between natural and cultural processes.
Thirdly, there is in this model a recognition that interactions between compartments influence the ecological characteristics of the compartments. Odum suggests that these interactions can take the form of energy flows or material flows, and, although they are essential to his ecosystem model, he is quick to mention that little rigorous definition or measurement of them has yet been carried out on a regional scale.

The Odum ecosystem compartment model, then, provides the basic conceptual framework for the METLAND regional ecosystem analysis. The only significant modification that was found to be necessary was the consideration of "closure" in the model. Closure, in ecology, defines the condition in which all processes and materials required for the successful maintenance of the system are contained within or controlled by the system. Odum's model assumes a closed condition, and thus can properly be applied only to the biosphere in its entirety. It is obvious that metropolitan regions are far from closed, due to the large quantities of energy, food, fiber and other materials regularly imported into the region. To accommodate this situation, an additional element is proposed for the model, namely the degree of relative closure exhibited by a given regional ecosystem.

In summary, a three-level regional ecosystem model has been proposed. The model is graphically presented in Figure 1. The first level is a classification of the landscape into system compartments by an ecological interpretation of land use. The second level is an assessment and evaluation of transactions between compartments. The third is an analysis of the degree of regional ecosystem closure. Since all three of these levels are dependent upon land use characteristics, proposed or impending land use changes can be evaluated in terms of the resultant effects on any part of the regional ecosystem.

Ecological Land Use Classification

The model of regional ecosystems proposed by Odum characterizes superficial landscape attributes into classes of ecological function. Some land uses such as farm land and growing forests play a productive role, which is beneficial to human life by providing food and fiber. Other land uses such as mature forests play a protective role by reducing erosion from steep slopes and accumulating large quantities of nutrients which would otherwise be lost through leaching and runoff. Still other land uses, such as residential land play non-vital and compromise roles in the ecosystem. The objective of this component of the ecological compatibility assessment is to determine which of these compartments appropriately describes the ecological function of each land use.

It should be noted that in the course of this study an expansion of Odum's model to five compartments was deemed necessary. This was in order to distinguish the production of agricultural land uses from that of natural systems, such as forests and wetlands. Agricultural systems are characterized by a much lower standing crop (or biomass) and a much higher yield than natural systems. In addition, farmed land has many more inputs and outputs as a result of cultivation, fertilization, pest control and frequent harvesting.

Odum, in his paper "The Strategy of Ecosystem Development" (1969) lists some twenty-four distinguishing attributes of ecosystems which could form
Research Levels: I. Ecological Functions  II. Transaction Functions III. Regional Closure

Figure 1........Conceptual framework for the regional ecosystem model

No actual field measurement of these parameters of ecologic energetics was carried out in this research. Rather, the results of previous research were surveyed. Two problems became evident in the search of the literature for findings on productivity, biomass or yield assessment. First, several techniques for the measurement of productivity have been utilized including: (i) harvesting (ii) forest dimension analysis and (iii) gas-exchange analysis. (See Whittaker and Marks, 1975). These techniques vary considerably and their results are somewhat difficult to compare.

The second problem stemmed from the fact that, while these parameters were to be used to classify as many of the land use types as possible, most of the studies dealt with either of three types of ecologic community: (i) forested, (ii) "early successional" or (iii) agricultural.
It became clear that prior to applying an ecological land use classification procedure to the METLAND study area, the few land uses whose ecologic function had already been quantified, and thus could be classified into a compartment, would need somehow to be analyzed to extrapolate the function of the unknown, unmeasured land uses.

**Discriminant Analysis of the Ecological Function of Land Uses**

In order to distinguish among the five compartments of the modified Odum ecosystem model, the three parameters discussed above were used as "discriminating variables," for the multivariate statistical technique of discriminant analysis.

The first step in the discriminant analysis was to generate data on each of the discriminating variables for as many of the land use types as possible. Values for production/respiration (P/R) ratio, yield and biomass were generated by: (i) interpreting results for some land uses which were found in the literature and (ii) extrapolating from those results to analogous land uses.

Secondly, 25 of the evaluated land uses were designated as "known cases." Five each were assigned to each of the five compartments: protection, production (natural), production (agriculture), compromise and urban. These assignments were based on the distinctiveness of the energetic characteristics of the uses and on professional judgement. The remaining uses became "unknown cases."

Thirdly, a stepwise discriminant analysis was run on the 25 known cases to determine the respective contribution of the variables to the classification. Overall, it was found that 88% of the known cases were correctly classified by the discriminant analysis using the parameters discussed above. Finally, the "unknown cases" using the discriminant functions derived from the analysis of the "known cases" were classified. Table 1 shows the results of the classification.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Compartments</th>
</tr>
</thead>
<tbody>
<tr>
<td>All forest &gt;40' tall</td>
<td>Protection</td>
</tr>
<tr>
<td>Tilled land, orchard, nursery, cranberry bog</td>
<td>Production (Agricultural)</td>
</tr>
<tr>
<td>All forest&lt;40' tall (or of uneven height), all wetlands water, unused tilled land, pasture, abandoned field, abandoned orchard, heath, sand dunes, power line, golf course, Production driving range, ski slope, urban park, cemetery, urban open land.</td>
<td>Production (natural)</td>
</tr>
<tr>
<td>All residential land* densities&lt;1 d.u./ac., airport, marina, beach, swimming pool complex, tennis courts, playground, race track, athletic field, amusement park, fairground, drive-in theater.</td>
<td>Compromise</td>
</tr>
<tr>
<td>All residential land* densities&gt;1 d.u./ac., all industry, all commercial, public institutional land, docks, railyards, truckyards, highways.</td>
<td>Urban (non-vital)</td>
</tr>
</tbody>
</table>

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d.u. = dwelling unit
Substrate Function Assessment

This component of ecological compatibility assessment deals with the characteristics of the land which underlies land use. These "substrate" characteristics are evaluated in terms of their ability to support ecological processes. They are analyzed from two points of view. First, the inherent "biologic function" of the land is assessed, which is seen as a function of soil productivity and exposure to solar energy. Secondly, the inherent "denudational potential" is assessed. Denudation is ordinarily a geological term describing weathering or breakdown of rock and the transportation of debris. It is used here to describe the loss from a given piece of land of biogeochemical material necessary to the maintenance of an ecological system. The procedure for substrate function assessment as diagnosed below in Figure 2.

![Figure 2. Substrate Function Assessment Procedure]

Biological Potential Assessment

This procedure is based on the concept that differences in solar radiation significantly affect the productivity of an ecological system (see Reifsnyder and Lull, 1965), in addition to the effect of inherent soil fertility. It also recognizes the fundamental differences between agricultural and natural production and therefore measures each separately.

In each case the biological potential is first assessed by interpretation of Soil Conservation Service data. In the case of crop potential the assessment is based upon the estimated production of tons of corn silage for each soil type. The forest potential is assessed using an estimate of the volume of timber that can be produced. These estimates of biological potential are then modified by an assessment of solar radiation receipts which are derived from a model using geographic locators, and topographic parameters as inputs. The result of these procedures is the classification of all lands into eight categories of biological potential. (See Figure 3)

Denudational Potential Assessment

This procedure uses information on soils and topography (i.e. slope) to generate estimates of the inherent potential of the substrate to erode and to permit run-off. Each of these processes is seen to degrade the overall ecological potential of a site. Both the run-off potential and the erosion potential are determined by a combination of soil characteristics and slope. Values are derived from Soil Conservation Service data for run-off and erosion, and from slope analyses prepared from topographic maps. The denudational potential is determined by comparing run-off potential with erosion potential and is classified into four categories from low to very high.
Substrate Function

The substrate functions are derived from a comparison of the biological potential with the denudational potential. Figure 3 below diagrams these comparisons.

### Biological Potential

<table>
<thead>
<tr>
<th>Denudational Potential</th>
<th>Very High</th>
<th>High</th>
<th>Moderate</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIGH PROD. AGRI. Nat.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>HIGH PROD. AGRIC.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>HIGH PROD. NATURAL</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>HIGH PROD. NATURAL</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>LOW PROD.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>NON PROD. NATURAL</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 3: Substrate Function 1) Protective, 2) High Production, 3) Production, 4) High Production Agriculture, 5) High Production Natural, 6) Production Agriculture, 7) Production Natural, 8) Trade off

As can be seen, those lands that have a very high denudational potential are classified as protection. On the other hand, those lands which have no productive value and which have low denudational potential can be traded off for a variety of cultural uses, with little concern for loss of ecological value. The other substrate functions (values 2-7 in the matrix) of course suggest a range of cultural uses of the landscape that span these two extremes.

Ecological Compatibility

Ecological compatibility can be seen as a measure of the "goodness of fit" between the ecological characteristics of the cultural landscape, and the physical characteristics of the substrate. Figure 4 shows the procedure that has been used to determine the ecological compatibility values. The values assigned to many of the relationships in the matrix are easily understood. Where agricultural uses appear on lands that are determined to be highly productive, compatibility is very high. Likewise, when urban land uses appear on land designated as trade-off, compatibility is very high. However, where urban uses appear on very productive lands, incompatibility is very high.

Many of the other relationships are not as obvious. In assigning the other values, attention was given to the needs of man in the regional ecosystem. In this regard, while productive forest lands are not found to be incompatible with highly productive agricultural lands, the latter might be most appropriately used for production of crops, while forests are grown in areas unsuitable for cultivation. Urban and compromise uses are shown to be at least somewhat incompatible with all lands except those designated as trade-off. The degree of incompatibility does vary, however, depending upon the protective or productive value of the land. In areas of low productivity, the incompatibility would be slight.

It will be noted that the values in the matrix for protective land uses compared with all lands other than those designated protective are 0, indicating neutral relationships. This is explained by the fact that the "strategy of ecosystem development" (Odum, 1969) is to move towards a
mature or protective condition. It is a condition that maintains the land in a state that does not preclude its conversion to another use. If a protective use that was occupying land suitable for agricultural production were converted to farmland, no incompatibility would result.

<table>
<thead>
<tr>
<th>ECOLOGICAL FUNCTIONS</th>
<th>PROT.</th>
<th>HIGH PROD.</th>
<th>MEDIUM PROD.</th>
<th>AGRIC.</th>
<th>HIGH PROD. AG.</th>
<th>MEDIUM PROD. AG.</th>
<th>AGRIC. PROD.</th>
<th>HIGH PROD. NAT.</th>
<th>MEDIUM PROD. NAT.</th>
<th>AGRIC. NAT.</th>
<th>COMP.</th>
<th>HIGH PROD. NAT.</th>
<th>MEDIUM PROD. NAT.</th>
<th>AGRIC. NAT.</th>
<th>URBAN</th>
<th>HIGH PROD. NAT.</th>
<th>MEDIUM PROD. NAT.</th>
<th>AGRIC. NAT.</th>
<th>PROD. AG.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROT.</td>
<td>+3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>PROD. AG.</td>
<td>-2</td>
<td>+3</td>
<td>+2</td>
<td>+3</td>
<td>-1</td>
<td>+1</td>
<td>-1</td>
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</tr>
<tr>
<td>PROD. NAT.</td>
<td>-1</td>
<td>+2</td>
<td>+2</td>
<td>-1</td>
<td>+3</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>+3</td>
<td>-3</td>
<td></td>
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</tr>
<tr>
<td>COMP.</td>
<td>-2</td>
<td>-3</td>
<td>-2</td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>+3</td>
<td>-3</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>URBAN</td>
<td>-3</td>
<td>-3</td>
<td>-2</td>
<td>-3</td>
<td>-2</td>
<td>-2</td>
<td>-1</td>
<td>+3</td>
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</tbody>
</table>

Figure 4: Ecological Compatibility +3 Very compatible; +2 Moderately compatible; +1 Slightly compatible; 0 Neutral; -1 Slightly incompatible; -2 Moderately incompatible; -3 Very incompatible.

Application

The ecological assessment procedures described above have been applied to the communities of Bernardston and Greenfield, Mass. of the Connecticut River Valley. Interstate Route I-91 runs north and south through both towns, providing good access. Bernardston is a rural community of 23.5 square miles with a population of 1,659 (1970 U.S. Census). The economy of the community primarily centers around agriculture and related services. There is also some lumbering activity since the town and county is 77% forested. Topographically the town is varied, with a total relief of 1,000 feet.

Greenfield is a more urbanized community of 23 square miles with a population of 18,116 (1970 U.S. Census). The economy of the community is based upon light industry, agriculture, and related services. Greenfield is the commercial center of Franklin County and it has a relatively large retail commercial section. It has a varied topography with a total relief of 700 feet. The town enjoys considerable frontage on the Deerfield and Connecticut Rivers. Interstate 91 and State Route 2 intersect in Greenfield, providing good access to the Boston area as well as to Springfield and Hartford.

The procedures that have been described were performed with the aid of a computerized geographic information system at the University Computing Center, University of Massachusetts in Amherst. Mapped information is stored in the computer in digital form and can be manipulated. The output of the system includes line printer maps, plotted maps, and statistical information. The procedure can also be used interactively through the use of a graphic display terminal.

The application of the procedure for determining ecological function is easily accomplished by aggregating the land uses of the existing classification systems into the five ecological compartments. The distribution of ecological functions in these two communities is quite
different. Greenfield is much more urbanized than Bernardston, although both have large acreages in protective and productive forests.

The application of the substrate function procedure to the two communities was more complicated than that described above for the ecological functions. The computer system was required to make several aggregations and overlays. The communities are also quite different in terms of substrate functions. Greenfield is characterized by large acreages of productive lands, and considerable acreages of lands in the trade-off category. Bernardston, on the other hand, is characterized by very large acreage in the protective category with only limited productive lands or opportunities for development.

The two communities are also significantly different in terms of ecological compatibility. Nearly 45% of the lands in Greenfield fall into the three incompatibility classes compared with only 26% in Bernardston. Over 55% of the lands in Bernardston fall into the higher compatibility class compared with only 27% in Greenfield.

Conclusion

As was noted, the two communities where the procedure was applied are distinctly different. Economically, socially, and physiographically they are quite dissimilar. These dissimilarities should be reflected in the outputs of the regional ecosystem analysis procedure. The analysis results, which can be looked at as an ecological profile of the two communities, shows that the procedure is indeed sensitive to differing ecological characteristics. The profile of substrate functions shows that Greenfield has much more productive land and much more land that can be traded off for development than does Bernardston. These landscape characteristics along with cultural factors such as access to transportation, are reflected in the way the two communities have developed.

Greenfield has clearly developed beyond the limits that would be imposed by a strict ecological interpretation. These limits, however, have been exceeded in terms of distribution rather than total area. As the profile shows, there are about 2700 acres of land in the last two substrate function categories. One thousand (1000) acres of this is designated as trade-off, with an additional 1700 acres as having only low productivity. These areas could have very nearly accommodated all of the development of compromise and urban land uses which total to 3100 acres. The ecological compatibility profile, however, shows that this is not the case, as nearly 2000 acres or 20% of the town lands are in the two highest incompatibility classes. Bernardston, on the other hand, exhibits quite different characteristics. Little of the land falls into the highest incompatibility categories. There has been less opportunity for development there due to physical and cultural constraints with the community remaining quite small and rural in character.

The above discussion demonstrates that the procedure is sensitive to land use changes which result in modification of ecological characteristics.

The utility of the procedure derives from the ability to project alternative land use changes which produce new ecological function profiles, which when compared to the unchanging substrate function, produce ecological compatibility profiles. In this way, any number of alternative
land use proposals can be evaluated and compared to existing conditions and to each other. This type of an evaluation, along with others that are economically and socially founded, can be used to select alternative development proposals that best meet the needs of a region, of a community.

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ENVIRONMENTAL STRATEGY AND RESEARCH IN AN URBANIZED AREA

Sybrand P. Tjallingii

Department of Landscape science and ecology, Delft University of Technology

Abstract

Ecologists often have an uneasy feeling about the way the results of their investigations are used in the planning practice. For the planners and to the public it very often appears that ecological proposals say no to plans in which there seems to be "no choice".

In order to bridge this gap a strategy for environmental planning is discussed.

First some general conditions are formulated for alternative plans, designed to promote public and specialist discussion on facts and values of the relation between society and the environment.

Then two basic principles are proposed for such alternative plans:
1. It is necessary to reduce the dynamics of the socio-ecological systems.
2. The dialogue with nature should be re-animated.

Next, three further guidelines are given in order to make it possible to work with the principles in planning practice; notably in urbanised areas:
1. Study the ways in which systems can be made less dependent on input and output.
2. It is desirable to integrate activities rather than concentrating them separately.
3. Planning of integration should start with the weakest link.

To demonstrate how the strategy can generate planning alternatives and the corresponding research priorities, two examples are given: surface water management and agriculture, both in an urban fringe situation.

Introduction

Discussing the plan to construct a new road one could ask three basic questions. 1. Whether to build a road or not. 2. Where should it be located. And 3. How can it be constructed. These questions can be considered relevant to activities with environmental impacts in general.

The time I worked with the Kromme Rijn Project (Kromme Rijn Projekt 1974, Tjallingii, 1974) we prepared a landscape ecological evaluation map. This map was meant to serve for the regional planning in the rural area subject to urbanisation near Utrecht. The question of the planners was essentially where? This attitude and the corresponding behaviour of the planning agencies left us with severe doubts. Our intention was primarily to let the map work as a warning, showing the impact of many expansive plans and trying to urge a new discussion on the whether or not question. Apart from a few exceptions our idea did not work, first because, as the planners and authorities told the public and us, there was "no choice" and secondly because we were just treated as one of the groups engaged in the conflict of interests.

Later I went to work at the Delft University of Technology, where the ecological training of townplanners and architects is my task. Here the main question to deal with in most study projects is how. Mostly the question whether to build or not is left out of discussion but sometimes it becomes possible to touch on more fundamental questions such as private or
public transport or preventing much transport by planning living quarters and working places integrated or very close to each other. But in the real town planning, alternatives based on for instance a reduced consumption of water and energy, usually are held back in an early stage because "it is necessary to supply what is needed". The question whether or not is left out of discussion as "there is no choice".

In this paper I will start with the assumption that the public and the planners cannot judge whether they have a choice or not, unless practical alternative designs or plans are worked out and then discussed. The alternatives I have in mind generally speaking at a more balanced interaction between society and nature. The question investigated in this paper is: Is it possible to design a strategy useful in generating planning alternatives relevant to fundamental environmental problems?

First some general considerations and conditions are given, then a possible strategy is formulated which is worked out into some guidelines for regional physical planning. Finally two examples are briefly dealt with: water management and agriculture in an urban fringe situation.

The paper is an attempt to bring some structure in the practical and theoretical ideas emerging from the experience of ecological guidance of training projects in architecture, town- and regional planning (i.e. mainly on the how-whether or not interaction line).

General considerations, the alternative activity approach

Some critical observations are made first, primarily in order to obtain a set of conditions to be realised in "alternative activities", i.e. other ways of town building, agriculture, water management, transport etc.

There are at least three reasons to concentrate on activities rather than on landscape evaluation.
1. In the interaction between society and nature the activities are the true variables which can be influenced by planning.
2. Only a more fundamental change in human activity will create conditions essential to the preservation of natural areas.
3. Increasing exploitation of nature, increasing energy consumption leads to more rules in industrialised societies which means less freedom for people and less chances for a dialogue with nature (see for instance Marcuse, 1968; Habermas, 1968, Illich, 1973).

This means there are cultural and social reasons to criticize the human actions threatening nature, and not only economical and ecological arguments. The word activities is used here and not needs. It may be possible to meet basic needs with other activities and adapting activities to a more balanced interaction with nature may also cause us to revise our standards about real needs.

As a consequence of this, value statements are involved. They are introduced here explicitly because a public discussion about environmental problems in my opinion should include facts and values. Alternative plans cannot be made dependent wholly on political or technocratic apriori's. If they are, "no choice" arguments frequently make it impossible to escape from the real problems.

This means that for instance a landscape ecologist, taking part in preparing planning alternatives, can take the side of a group of environmentalists and become an "advocacy planner". Another possibility is that the scientist holds the point of view that comparison of fundamental alternatives is essential for public discussion and therefore he prepares several alternatives based on different sets of values. Habermas (1968) -speaking about the relation between politicians and scientists- distinguishes be-
tween a decisionistic model (power for the politicians, scientists only to provide them with facts) a technocratic model (technocrats have the power, values considered less important) and a pragmatic model in which facts and values belong to the competence of politicians and of scientists. The approach proposed here is an attempt to elaborate the pragmatic model.

To be realistic one should admit that it is impossible to deny the ruling power structure within which possible alternatives should be designed. However just as you can make yourself more or less independent of the automotive power structure by selling your car, so I will demonstrate that it is possible to start small-scale experiments less dependent of systems in which they legally exist.

Such experiments can influence public opinion and with these the decisionmaking process, serving as "building stones" for new approaches (Tjallingii, 1978). Substantial alternative designs in planning are becoming very important if they can be evaluated within the framework of an Environmental Impact Statement. Thus they could become an important tool for the so called "offensive school" in Dutch applied landscape ecology (v.d. Weijden and v.d. Zande, 1980). Emphasising alternative activities more than nature protection, this approach differs from the "defensive" landscape evaluations as those, reviewed by v.d. Ploeg and Vlijm (1978). Both approaches consider landscape-analysis essential.

The General Ecological Model (GEM, v.d. Maarel & Dauvellier, 1978) can be considered "defensive" too, as it tries to support the role of natural areas in physical planning by elaborating the information- and regulation functions of these areas for society. The production and carrying functions of landscape however are neglected and it is exactly with these functions that an alternative activity approach should start.

The GEM procedure fits in the competition model philosophy as found for instance in the Third Report on National Physical Planning, part III: Rural Areas (Derde Nota, 3a, 1977). The competition of conflicting interests seems to lead to a planning of compromises and eventually to a compartment policy in regional planning. Instead new ways of integration should be looked for on the basis of other activities.

Summarizing the following conditions to be realised in our alternatives can be listed.

1. In order to promote a fundamental public discussion about possible solutions to environmental problems political, economical and technocratic values should not be taken as facts.
2. A realistic approach however should first concentrate on small-scale projects, if necessary as independent as possible. These projects should be able to serve as examples.
3. The possible use as alternatives in an EIS procedure should be kept in mind.
4. Special attention should be given to the possibilities of integrating alternative activities on a regional scale.

A possible strategy towards environmental problems, basic principles

We live on a spaceship with many non-renewable resources. Our productive management is limited by the fact that the earth is an ecosystem. Overpopulation, affluence and wasting technology are considered the most serious threats of the ecosphere (Commoner, 1971; Commoner et.al., 1972; Hardin, 1972 for example). This complex of problems may be called the material problem, characterized by the increasing exploitation of resources (input) and increasing production and pollution (output), in short: the increasing dynamics of the system as a whole.
But there are also immaterial problems: reduced landscape differentiation, less wildlife and fewer natural areas, more noise and annoyance by pollution, more health risks, more stress. These problems, showing aspects of alienation, may be referred to as the immaterial problem. But both sides of the environmental crises are intimately linked with each other. Two views on these interactions are worth noting in this context. First the relation between very dynamic conditions of processes and coarse-grained spatial patterns as stressed by van Leeuwen, (1966, 1980). According to this point of view, increasing the dynamics of human action in our environment necessarily leads to a loss of differentiation, which is in fact part of the immaterial problem. A second interesting view on interaction, mentioned already, is represented by for example Marcuse (1968), Habermas (1968) and Illich (1973): increasing the exploitation, losing the dialogue with nature out of sight, means that inevitably a complicated technocratic structure becomes necessary. As a result people become more alienated from nature and from each other. The "no choice" dilemma is only one aspect of this immaterial problem. It is impossible to discuss more details and backgrounds of this interpretation of environmental problems here. Important at this moment is to stress the view that they are a complex of socio-economic and ecological events, connected with the development of industrial societies in the east and west and in the north and south.

Two basis principles are chosen for a strategy designed to re-establish a more balanced relation between society and nature:
1. Reducing dynamics. In ecological terms, this means reducing input and output of ecosystems, in socio-economic terms the principle of self-reliance comes very close.
2. Re-animating the dialogue with nature. This does not only refer to conservation but even more to human activities like water management, agriculture and town planning.

The "principles" seem to be trivial and self-evident. The most relevant question is of course whether they are useful or not, and this largely depends on the possibility to find new practical approaches to daily planning problems. A first direction is indicated. Some further guidelines now have to be formulated.

**Further guidelines in the urbanized landscape**

It should be realized that working out more details necessarily means taking into account more regional and local conditions both landscape-ecological and socio-economic. The following considerations may have a more general meaning but they are based on the Dutch, notably the Randstad situation. The usefulness for this situation is open to discussion. For other conditions this holds even more.

Let us first take the process aspect of the systems on a regional level. Industrial or agricultural areas, living-quarters but also the individual factory, firm or dwelling can be taken as examples of such systems. Such a system can be represented by an ecodevice model as is given in figure 1. For the background of this model I refer to van Wirdum (1979) and van Leeuwen (1980). This model illustrates the four regulation principles which enables us to focus on the regulation inside the system and on it's relation with other systems.

Figure 1.
For a factory generally speaking industrialisation means increasing the input and output levels. The availability of cheap energy has facilitated the increase of the energy flow which is used to produce more (output) with less labour (less labour retention). The disposal of wastes is also increased. The system is highly dependent on capital investment and on transport which has developed rapidly causing considerable extra energy-consumption. Resistance to external perturbations as rising energy prices and problems on the export market is relatively low, it is a vulnerable system. Dynamics are high and there is only a very weak dialogue with local conditions, not to speak about a dialogue with local natural resources and the local landscape. Of course this very schematic picture is not applicable in the same way to every factory or every industrial area. But the tendencies can be observed in many cases and can be analysed mutatis mutandis in agriculture and in urban dwellings as well.

A first strategy guideline can be formulated from this analysis: an attempt should be made to change the overemphasis on input and output into more attention to the retention and resistance regulation principles. (In fact this is a practical translation of the reducing dynamics principle.) Practical elaboration of this idea can be found in the intermediate technology initiatives, highly stimulated by the works of Schumacher (1973, 1980) and also in the further development of the idea of self-reliance, for example in Anderson (1978) and Tinbergen et.al. (1977). Self-reliance and intermediate technology should not only be applied as a guideline for underdeveloped but also for overdeveloped countries.

The question rises whether the model can be relevant to sites for extensive outdoor recreation and nature reserves. I doubt the usefulness of that interpretation but it is clear that also in these areas the capital investment is increasing. And certainly the vulnerability of these areas is very high because the proper management is endangered by the output of other systems and because the price we pay is high and it is uncertain how long we can afford to pay it under difficult economic conditions. Natural areas are no longer supported by a living landscape but they are tolerated at a high price.

Herewith we are already in the field where procedures affect the functional structure and the pattern of activities in the landscape. It is clear that activities at a high dynamic level cause much nuisance to each other. Activities are concentrated separately therefore, as can be observed in our urbanised areas where industry, recreation, living, agriculture and nature get their own, monofunctional territory. Once this spatial structure is established with high capital investment and supported by a strong infrastructure it fixates the landscape and, what is worse, it acts as a stimulus for further accelerated growth especially of the productive activities.

In view of these tendencies a second guideline can be formulated: it is desirable to integrate activities rather than concentrating them separately (in this way essential elements of the "reducing dynamics" and of the "dialogue with nature" principle are more operational).

Evidently integration is only possible in a satisfactory way in case the dynamic level of (productive) activities is reduced (first guideline). Only then will it be possible to prevent mutual nuisance by subtle selection devices such as fences, hedges, ditches or walls and screens as they are found in town and country. In the Third Report on National Physical Planning (Derde Nota, 3a, 1977) it is tried to plan spatial integration, disregarding actually the functional ecological and economical basis, and this cannot be considered a fruitful approach. In fact this is one of the dilemmas of physical planning in general as has been clearly demonstra-
Planning the integration of activities has to deal with the problem caused by the dominance of activities with many external effects over the more vulnerable systems. The case of agriculture and nature is a good example. Even if we are successful in reducing the dynamic level of agriculture activities surrounding a natural area it will be necessary to protect the natural area effectively. The size of the area is important but, provided a minimal area exists, subtle selection devices as mentioned before, can play an important role. In a densely populated area a good use of selectors is more realistic than trying to oversize the area.

As an integration chain is as strong as its weakest link the third guideline is: planning integration of activities should start with the weakest link, and should study the possibilities of an active role of the weakest parts in the whole of the living landscape (though this is primarily a practical translation of the "dialogue with nature" principle it can set a standard for the dynamic level of the whole system).

Consequently the planning of a water management system for example, should start with the sources of unpolluted clean water, not by trying to isolate them as is done in swimming pools, but by studying the way they can play a role for the benefit of the whole landscape. This implies landscape mapping and a careful analysis of "horizontal" relations.

Surface water management and the urban-rural relationship

Quality and quantity of surface water in the urbanised area of Rotterdam and Delft changed considerably during the last decades. Examples of quantitative change are the increased use, extension of irrigated surface in combination with a low phreatic level in the new urban areas and in rural areas the lowering of the groundwater table. In terms of the hydrological cycle, the time the water rests in the land part of it became much shorter, because there is more consumption and less storage. In practice this means that rainwater of relatively good quality is quickly pumped out. In summer however, when there is a precipitation deficit, much water is needed and this can only be supplied then by pumping in new surface water, indirectly derived from the river Rhine. As a result serious quality problems rose notably in dry summers as in 1976.

The general strategy proposed to meet these problems is to try to increase the storage capacity for good quality water, notably rainwater. In this context a number of alternative plans seem to be relevant (Tjallingii, 1981):

1. More efficient systems of catching, use and re-use of water inside the house are studied. Considering the matter technically savings up to 50% are not beyond reality. The consequences for regional and even national infrastructure planning are not easily overestimated.

2. Designs are made for parks with more water storage capacity where the effects on water management and the possibilities for public use can be studied. Temporarily inundated park areas for example can be used for skating in winter.

3. Recreation lakes in the urban fringe can be designed as independent systems storing the water in winter which is evaporated in summer. The precipitation surplus can flow into the urban water system. An interesting study is carried out to determine the carrying capacity for recreational use of an existing lake with this watersystem near Delft (den Blanken, 1975). In the northern fringe of Rotterdam a new park design for an existing area is made, based upon these ideas and in close concert with the
inhabitants concerned.
4. Plans are designed for new urban areas with a water system which takes more advantage of good-quality water sources, has more storage capacity and hence less necessity of flushing regularly the whole system.
5. A study is set up now for a wetland area in the countryside between Delft and Rotterdam to discover the water management possibilities based on these ideas and the functions of the area for conservation, fishery, agriculture and recreation.

The purpose of all these studies is to use the method of designing alternative plans first to analyse the possibilities of lowering dynamics by increasing the storage capacity for good quality surface water (retention) and thus making the systems less dependent on input of other usually polluted water. Secondly the functions such systems can have, are studied, possibly with participation of the people concerned. Special attention is given to the possibilities to integrate activities by using simple and subtle selectors. Thus operating in dialogue with nature was tried and this includes the functional and form qualities existing in the studied areas.

Agriculture in the urban fringe

The problem with agriculture in the urban fringe is that it is neglected by official agricultural policy and by the authorities of the urban concentrations. The fringe situation poses a number of difficulties to modern agriculture with a high input of energy, fertiliser and cattlefood and a high output of products for the (European) market.

Yet recently there is a new interest in part-time agriculture (OECD, 1978) and also in the role of allotment gardens. There are studies in which more attention is paid to the possibilities of linking agriculture production more directly to urban consumption in the same region and the resulting effects on transport, employment and the differentiated urban fringe environment (Tomasek, 1979).

Research projects should concentrate for example on:
1. The possible regional production - consumption structures in terms of food. For some farms for instance it is possible to shift from milkproduction to the manufacturing of cheese that can be sold directly to urban people.
2. The possibilities to use urban wastes as manure and for cattlefood.
3. The possibilities of creating production - consumption cooperations, operating independently of the official market.
4. The effects of part-time and small-scale agriculture on the local employment situations.
5. The relation between recreation and agriculture.
6. The possibilities of interaction of natural areas in the fringe with the help of "subtle selectors".

Only some of these problems can be dealt with by landscape ecologists and probably the best idea for scientific and practical integration is the starting of experimental farms where all questions can be studied. More important even is the fact that farmers can go there and look how it works. Such a proposal we made in the context of a bufferzone and re-allotment scheme planned for the area between Delft and Rotterdam (van Oord en Tjallingii, 1979). The proposal was discussed with farmers and planners, who used examples from other parts of the country as arguments. So far no practical project resulted, but discussions go on. For this moment we try to make study designs of practical situations, the function of which is both illustrative to the discussion and useful to focus on the research priorities. In some cases the ecodevice model is a useful tool to formu-
late more precise questions that can be investigated.

Conclusion

Returning to the question of facts and values it is clear that values before all are involved in the choice of priorities for research and in the way the results are applied. In the example given here, with the aid of the strategy developed, experiments are selected which themselves should be carried out according to the scientific and practical standards of truth and usefulness.

There is no doubt that the strategic-condition principles and guidelines as indicated in this paper, need a more sound theoretical basis. But more important is the fact that they seem to work as a set of ideas useful in generating alternative plans dealing with fundamental environmental problems.

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TOWNS ECO-GEOSYSTEM VersUS RURAL GEOCOMPLEX
CASE-STUDY OF THE POZNAÑ AGGLOMERATION.

Tadeusz Bartkowski

Department of Complex Physical Geography, Institute of Geography, Adam Mickiewicz University in Poznañ, Poland.

Abstract

Towns are conceived as ecosystems with matter and energy subsides from outside the producing system and devoid of ability to selfregulation. The necessity for the town to receive subsides from outside the town focus our attention on spatial relations of the town to its surroundings and lets way open to apply the notion of towns conceived as geosystems. These geosystems are composed of two types of terrains: 1/ this of the s.c. skeleton or urban infrastructure (build up terrains, factories, roads, airports) and 2/ this of rural geocomplex in the suburban zone (surfaces of primary production, immediate food supply zone). Towns geosystems develop spatially and are studied in horizontal dimension because the process of the growth of towns body occurs horizontally too. This process of spatial growth that takes place in the immediate surroundings of the skeleton lets "devour" the suburban zone by this skeleton; the surfaces of primary production, that is mainly agrarland becomes buildingsland. This agrarland acquires very high productivity level and it becomes very precious. There arises ecological and economical conflict. How to manage the use of land in the suburban zone? The solution of the dilemma lies in the concept of the s.c. linear or rosary's like urbanization that is in development of small settlement units along communication lines interspaced by free surfaces of primary production (of recreational use too!). Such "rosary's" like urbanization in the urbanization strings along railways and motorways of high transport effectivity is meant to bring solution. The problem is exemplified by the Poznañ agglomeration (main town and satellite towns = 0,9mill. inhab. on 3600km²). The agglomeration lies amidst highly productive agrarland.

Towns ecosystem = towns geosystem

The notion of towns ecosystem constitutes an example of an extension of a biological concept upon a socio-economicographical one (of urban geography). Like biological ecosystem towns ecosystem concerns a flow of matter and energy (and information) through a physical structure encompassing towns population, the towns infrastructure and towns surroundings. Unlike the biological ecosystem towns ecosystem is devoid of ability to selfregulation of its homeostasy.

The second particularity of towns ecosystem lies in the circumstance that towns ecosystem exists only with the help of matter and energy subsides from outside the town and that it must dispose with imported raw materials (and food) in the form of urban production and of wastes. The fact that there are always imports and exports of matter and energy in towns lets focus our attention upon the spatial relations of towns ecosystem. The material substratum of this ecosystem —
a section of Earth's surface can and must be studied with the methods of physical geography and it is here that enters the notion of towns geosystem.

Geosystem is known to be a concept of complex physical geography, developed in diverse countries as for example in the Soviet Union (Sochava 1975, 1978, Dyakonov 1975, Retyum 1977), England (Chorley-Kennedy 1971), Czechoslovakia (Demek 1974). In spite of some differences in approaches the generally accepted version consists in discerning two elements of the geosystem: the structural frame (a section of Earth's surface) and a flow of matter and energy (the functional setting). Some of the geographers have drawn an equation sign between the notion of geocomplex and the notion of geosystem but as it was clearly indicated by Armand (1975) geosystem reaches far beyond the limits of the geocomplex and this constatation has its importance in respect to the notion of towns geosystem. It is the horizontal dimension of spatial relations in the town - the matter and energy subsides from outside the town that leaves the way open to apply this concept in the study of the relations of the towns material structure (the urban infrastructure) with its immediate surroundings (the suburban zone) commonly named a rural area.

**Towns geosystem versus surrounding rural area**

The importance of rural area surrounding the town consists in this fact that it is the immediate food supply zone of the town. Of course town can procure its food resources outside the immediate suburban zone or (the inner suburban zone). The greater is the town the wider is its food supply zone and town can procure its food subsides equally from the more distant places but nevertheless the existence of the inner food supply zone cannot be denied and it is here that the town comes in immediate contact with the surfaces of primary production. It is here that arises the primordial, the fundamental conflict between the spatial development of the town and the subsistence of the surfaces of primary production round the urban infrastructure.

In order to substantiate more the formal development of the theory of this ecological conflict we must firstly visualize the general structure of the territorial extension of the geosystem of the town and secondly its place in relation to topic, choronic and land use surface units that occur in this territory. In a town we must firstly discern:

1/ the core, the "skeleton" of the geosystem, consisting of terrains with buildings (residential, factorial), streets, motorways, railways, railway stations, airports, etc. that constitute the structure "constringeant" the place of a town into a territorial system.

2/ the immediate sub-town zone, the towns surroundings (falling mostly with the immediate food supply zone) that is the zone of predominant primary production oriented towards the food needs of the town. It is the area that is being "constrigned" (not only by the food supply functions but equally by other services of the suburban territory as for example recreational, water supply) into towns geosystem.

Secondly we must discern in the territory of this geosystem...
three superposing systems of surfaces that form the complex of towns geosystem as exemplified by the more detailed study of the eastern fringe of the city of Poznań represented on Figs.1, A, B, C.

1/system of natural topic and choric units (nano- and microchores see P. i. Haase-Schlüter 1980) subdivided into varieties of vekctoral and nonvectoral geosystems (of autochtonous and allochtonous types) and this territorial system constitutes the substratum of the expanding city of Poznań (on Fig. 1A the geotope units were not represented for the sake of clarity of the image!)

2/system of land use units (see Fig. 1B) generalized into the main types of productional surfaces, that crosses, that dissects the units of the first system (see equally Fig. 1C).

3/system of human settlements that is superposed upon the units of the two prior units. It changes, it transforms and constrings these units by forming a dynamic whole (as well in functional as in developmental respect) — see the arrows that indicate the impact of transurbation on the productional surfaces of the immediate food supply zone. The respective relations of these three systems are demonstrated on Fig. 1C.

City of Poznań and its impact upon productional surfaces

Provided with the above formulated principles the reader will have the opportunity to confront them with the concrete example of the city of Poznań and of its agglomeration (the already presented Figs. 1ABC concern even this case study). It is a mononodal agglomeration centre that counted in 1980 already 546 000 inhabitants. The approximative extension of the agglomeration is marked by the 1-hour isochrone. In these limits there were at the end of the year 1974 the following settlements units (see Table 1). As we see the area of the geosystem of the city of Poznań and of its agglomeration occupies a huge territory of 3 648 km² of which only 428 km² (12%) are occupied by the "skeleton" system while the remaining area (88%) counts only 13% of the population. The peculiarity of geosystems limits consists in that its boundaries are expressed by the extent of areas of diverse "services" of the towns surroundings such ones as the already mentioned immediate food supply zone (after the study of W. Deya 1973), of short term recreation (Bartkowski 1970), of external territories of protected nature and landscape (Bartkowski 1977, 1979). The areas of these "services" overlap one upon another, thus forming this kind of limit (or better "fringe", "belt") of the geosystem.

Fig. 1. The urban-ecological conflicts on the eastern fringe of the city of Poznań - expansion of urban infrastructure (transurbation) into the suburban zone.

1A. System of physical space: of natural topic and choric units that constitute the physical substratum of the city in its expanding fringe.

1-Geosystems of vectoral type:
1-nanochores of the slopes of morainic plateaus, of terraces (allochtonous, geone), 2-nanochores of the small valleys (allochtonous, geone), 3-nanochores of the valley
bottom of larger valleys (mixed regime: allochtonous -
allochtonous, geone - geide), 4 - nanochores of the open waters
bodies (river, lakes) - allochtonous, geone, 5 - nanochore of the
valley bottom with thick cover of artificial heaped up
material (build up terrains of the "old core") - allochtonous,
geone (of special type), 6 - nanochore of valley bottom with
artificial irrigation (for waterworks) - allochtonous, geone,
7 - contours of land use units, 8 - nanochore of the near water-
course valley bottom with lateral water supply (allochtonous,
geone).

II. Geosystems of nonvectoral type:
1 - nanochores of flat morainic plateau - mostly arable land
(autochtonous, geide).
10 - administrative boundaries of the city of Poznań.
Designations of microchore: M - morainic plateau, O - outwash
plain, T - river terraces, V - valleys of the tunnel type,
VB - valley bottom.

1B. System of land use surface units with indication of the
process of transurbation.
1 - forests, mostly pine forests, 2 - other trees associations
(parks, orchards, cemeteries, etc.), 3 - permanent meadows,
4 - open water (lakes, river), 5 - arable land, 6 - areas of
good productive soils (classes II - V of soil value), 7 -
build up terrains, 8 - communication lines (railways with
stations, motorways), 9 - indication of an urbanization
string, 10 - direction of expansion of build up terrains
PR - station Franowo, ST - station Staroieka.
1C. Model of spatial interrelations of subsystems in the megasystem "geosystem of the city of Poznañ" (in its eastern fringe).

1-subsystem of natural tectonic units represented by nanochores, 2-subsystem of natural choronic units represented by microchores, 3-subsystem of land use units, 4-subsystem of build up terraines (system of the skeleton) = settlements units.

Table 1. The Poznañ agglomeration at the end of 1974.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Number of units</th>
<th>Surface in $\text{km}^2$</th>
<th>Number of inhabitants in thousands</th>
<th>Density of population on km$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Poznañ</td>
<td>1</td>
<td>228</td>
<td>506</td>
<td>2 192</td>
</tr>
<tr>
<td>Other town commons</td>
<td>19</td>
<td>200</td>
<td>224</td>
<td>1 120</td>
</tr>
<tr>
<td>Rural commons or in 3/4</td>
<td>19</td>
<td>2 320</td>
<td>133</td>
<td></td>
</tr>
<tr>
<td>Parts of rural commons</td>
<td>12</td>
<td>880</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Rural commons tot.</td>
<td></td>
<td>3 200</td>
<td>178</td>
<td>56</td>
</tr>
<tr>
<td>Area of 1-h.isochrone in totality</td>
<td>3 648</td>
<td>908</td>
<td>252</td>
<td></td>
</tr>
<tr>
<td>All towns</td>
<td>20</td>
<td>428</td>
<td>730</td>
<td>1 453</td>
</tr>
</tbody>
</table>

On Fig. 1B the large arrows indicate directions of urbanization strings developed along communication lines where occurs "transurbation" (term used by Zimowski 1979) that is "the conquest of new territories by the town" (see transurbation on fertile soils on Fig. 2 indicated by small, black arrows).

This last phenomenon deserves our greatest attention. In the very interesting study of Komorowski (1977) there were measured spatial changes in land use within administrative limits of the city of Poznañ in the period 1960-1970, as demonstrated by the table below.

Table 2. Changes in the fundamental functional surfaces of the land use within the limits of the city of Poznañ during the period 1960-1970 after J. Komorowski 1977.

<table>
<thead>
<tr>
<th>Specification</th>
<th>% of area in 1960</th>
<th>% of area in 1970</th>
</tr>
</thead>
<tbody>
<tr>
<td>System of build up terrains &quot;skeleton&quot;</td>
<td>28.1</td>
<td>33.9</td>
</tr>
<tr>
<td>System of surfaces of primary production</td>
<td>41.6</td>
<td>37.3</td>
</tr>
</tbody>
</table>

As we see the skeleton system has increased by 5.8% and the primary production system has decreased by 4.3%. More detailed data of this study inform that the greatest increase show areas of industry (by 47.2%), of residence of great intensity (by 73.3%) and of services (by 73.0%) while the greatest
decrease showed areas of arable land (by 23.8%) and of residence of low intensity (15.9%). Another study of J. Komorowski (1978) informs that in the urban commons of the voivodship of Poznań (that belong mostly to the system of satellite towns of Poznań) there were excluded during the period 1974-1977 from rural land use in total 1,469 ha and that in this area 200 ha (14%) belonged to the II-III soil value classes, 752 ha (52%) to the classes IV-V and only 496 ha (34%) belonged to the classes VI-VIa. It follows from these findings that when we consider the soil classes IV-V as good productive land, equally worth of conservation as the soils of classes II-III we do find that 66% of good productive soils in these commons were converted in buildingsland while only the remaining 34% of surface were converted either in buildingsland or afforested. It follows from these data that in the towns themselves and of course in much the same way in the suburban zone good productive soils are being constantly converted in buildingsland and that it is the very fate of the agrarland round the urban structure. One special circumstance must be revealed: the soils of the immediate food supply zone, as they are cultivated very intensively, change in the course of time into excellent productive soils and this loss in the resources of primary production surfaces has its peculiar importance in the surfaces balance of the surrounding territory of the choronic units system.

Fig. 2. Explanations see next page.

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Fig. 2 Model of linear urbanization of the Poznań agglomeration.

1-blocking of development of the central city, 2-territory of the Wielkopolska National Park: "O" – the "old" (from 1957) Park, "N" – the "new" Park (propositions from 1978), "E" – the envelope (as proposed in 1978), 3-urbanization strings in the form of separate settlements along communication lines, 4-urbanization strings that pass the territory of the W.N.P. where all expansion of building shall be banished, 5-the projected international motorways with indication of the extent of zone of prohibition of building, 6-towns within the limits of the W.N.P. whose further territorial growth shall be stopped (residential settlements), 7-promotion of urbanization along communication line, 8-prohibition of compact building up of terrains along communication lines.

The announced problem is best to be seen on the example presented by the study area in the eastern part of the city of Poznań (see Fig. 1B) where one can observe the very process of "devouring" good productive soils (II-V soil value classes) by the expanding new residential quarters – especially their transurbanization along railways (the stations St and Fr) and along the main motorway towards South (to Silesia). And here we come to the problem of solving this dilemma.

Linear rosary's like urbanization as the solution of the dilemma.

The last constatations have led to the concept of the s.c. belt-nodal (see Malisz-Zaremba 1971) or linear (Bartkowski 1976) urbanization. The Fig. 2 visualizes the concept as applied to the city of Poznań and to its agglomeration. As we see the central city of the agglomeration is supposed to be stopped in its further spatial development in order to save the suburban zone with its fertile and cultivated soils. The urbanization strings that are spreading out from Poznań are provided either with signs that indicate prohibition of compact building up of terrain along communication lines or its promotion. Of course these indications influence the development of the already existing satellite settlements (mostly towns) and of urbanization processes. In the case of the urbanization string "S", that crosses the territory of the Wielkopolska National Park, the towns that lie in this territory are provided with prohibition signs (challenge to transform the towns in only residential places).

As we see, by this strategem one can hinder the "devouring" of fertile, cultivated soils of the suburban immediate food supply zone as the effect of the expansion of the skeleton system of the town. The further growth of the city is diverted into development of settlements along communication lines by means of seeking and choosing places where are feeble soils that can be converted into buildingsland. It is understandable that the terrains between the urbanization strings where urbanization should either be restrained or banished would be free from endangering by urbanization - they should be managed as areas of primary production (with eventual recreational use of the geocomplex). It is this urbanization pattern that shall be applied in order to protect rural geocomplex. This picking
out of areas with feeble soils with their predestination to settlement and this isolating of fertile soils with their predestination to primary production and finally the optimal disposing of them will surely spare space of the society resources and help to their proper management. Of course one should take into consideration another side of urbanization. Urbanization means not only "transurbation" that is expansion of urban infrastructure but equally the expansion of "urban way of life" what do not necessarily involve such expansion. This other solution of the dilemma involves not more the horizontal dimension of investigation but the vertical one but this dimension of investigation would not imply the use of the notion of geosystem though it could be as it was tried in the study of Neef (1979) a new area of studies of the complex physical geography (comp. equally Haase 1978, Jäger 1978).

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LONG TERM PROBLEMS OF THE RESTORATION OF DERELICT LAND

M.J. Chadwick

Derelict Land Reclamation Research Unit, University of York, York, UK

Abstract

A number of problems need to be solved in relation to the planning, establishment and maintenance of restored derelict and waste land. These problems are interrelated and concern: i) restoration strategies in which trade-offs are made between speed of restoration and land-form acceptability; ii) ultimate land-use objectives and vegetation establishment; iii) the subsequent management capability. Plant nutrient supply and phytotoxicity problems need to be dealt with on a long-term basis. This will involve the use of suitable fertilizers, the establishment of legumes and the use of amendments such as lime and organic materials. The choice of appropriate plant species and cultivars is important and consideration of a wider range of plant material than that normally employed in agriculture or forestry should be made. Management procedures may have to be more imaginative than those conventionally employed.

Introduction

Derelict and waste land restoration is an appropriate topic for consideration in the context of urban-rural relationships. The term 'derelict land' is commonly used to describe land which has been degraded by some use or process and then left untended—a combination of the heavy hand of man (characteristic of urban areas) and the interplay of natural forces (more in evidence in rural environments). Indeed, it is not uncommon for derelict and waste land to be concentrated at the urban fringe.

In the United Kingdom, the official definition of derelict land is: land so damaged by industrial or other development that it is incapable of beneficial use without further treatment. It arises mainly as a result of the activities of the mineral working and processing industries, rail and military closures and urban decay. Table 1 gives the official estimates of derelict land in England, Wales and Scotland up to 1974.

A recent survey (Dennington & Chadwick 1979a) has tried to estimate the extent of other derelict and waste land that is known to exist but is not so easily defined and not included in the Government surveys. Much of this dereliction is often associated with urban development, which may give rise to neglected farmland and woodland, and also includes abandoned allotments, neglected public open space, demolition sites, disused industrial installations and public utilities and derelict buildings. Estimates of this associated derelict and waste land have been made from the Second Land Utilization Survey of Britain, aerial photographs and Local Authority Planning Department expertise. They are also given in Table 1.
Table 1. Estimates of the total area (ha) of derelict and waste land in Britain

<table>
<thead>
<tr>
<th>Country</th>
<th>Area of derelict land(^a)</th>
<th>Area of derelict and waste land(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>43 273</td>
<td>200 000</td>
</tr>
<tr>
<td>Wales</td>
<td>14 478</td>
<td>59 000</td>
</tr>
<tr>
<td>Scotland</td>
<td>13 404</td>
<td>72 000</td>
</tr>
<tr>
<td>Total</td>
<td>71 155</td>
<td>331 000</td>
</tr>
</tbody>
</table>

Source: \(^a\)Department of the Environment (1974); Scottish Development Department (1973); Welsh Office (1975). \(^b\)Dennington & Chadwick (1979a, 1979b, 1979c, 1979d).

Reclamation Strategies

The overall strategies for dealing with the return of derelict and waste land to biological productivity, or reclamation with some other appropriate objective in mind, have varied considerably. One strategy is to minimise the time period between the degradation of the land by industrial use and the reclamation activities to restore it. This strategy is seen in its most advanced form in the Ruhr, Federal Republic of Germany where a multi-land-use approach results in the basal layer of a colliery spoil tip being reclaimed for forestry purposes whilst, at the same time, tipping is proceeding to form further waste disposal layers above the basal one, subsequently to be planted also.

A strategy at the other end of the spectrum has been seen in past practice in Great Britain and the United States of America. Here, some colliery spoil tips have remained derelict for many years after the final cessation of tipping. The pay-off for this approach has been that greater freedom is available in creating acceptable landforms and allowing a range of land uses than is possible where there is a need to combine a number of land uses within a tight operational schedule.

These two extreme approaches can be fused to allow rapid reclamation and dual land use in a way that keeps eventual land use objectives more open. In fact, recently, the range of opportunities that derelict land restoration gives to refashion the landscape, introduce new uses, and 'recycle' land has been more widely appreciated (Bradshaw & Chadwick 1980).

Reclamation Objectives

Although there is much to recommend derelict land restoration strategies that maintain a range of possible reclamation objectives, it is important that a stage is reached where a clear objective of the restoration work is identified. From this will follow a whole sequence of design decisions, site appraisals and the formulation of site preparation plans, planting and amelioration regimes. The
stages involved are summarized in Fig. 1. They include a programme
of monitoring, on a continuing basis, the results of which will
enable correct maintenance procedures to be undertaken.

Much derelict and waste land consists of substrates on which it is
difficult to establish vegetation because of physical characteristics,
phytotoxicity and poor nutrient supply features. These need to be
improved to establish vegetation, by appropriate substrate ameliora-
tion and the choice of suitable plant species and cultivars. However,
as Fig. 1 emphasizes, the reclamation procedure has not been completed
once vegetation establishment has been attained. Many derelict and
waste land substrates, even in an ameliorated condition, are poorly
buffered and subject to changes that result in vegetational
regression and plant death. A continued programme of maintenance
procedures is essential to the successful biological restoration of
most derelict and waste land sites and still presents a problem in many
situations.

Vegetation Establishment and Maintenance

Initial site assessment

It is now generally appreciated that detailed site investigations
must precede full-scale biological reclamation work. A complete
series of investigations might progress from site inspection,
laboratory analyses, pot experiments and on-site experimental field /
trials. Such investigations need not always be complicated and
time consuming. A simple experiment on colliery spoil in West
Yorkshire, UK (Newmarket Silkstone), indicated the initial major
nutrient limitation of the substrate. The results and details are
given in Table 2.

Variability in time

Most derelict and waste land substrates are not the well-buffered
medium represented by soil. Fig. 2 records the change in colliery
spoil pH, at Cefn Pennar in Wales, following an initial application

Table 2. Yield (kg ha\(^{-1}\)) of two grass mixtures sown on
colliey spoil with different fertilizer additions

<table>
<thead>
<tr>
<th>Grass mixture</th>
<th>Fertilizer treatment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N(_0) P(_0) K(_0)</td>
<td>N(_75) P(_0) K(_0)</td>
</tr>
<tr>
<td>Festuca rubra +</td>
<td>222</td>
<td>229</td>
</tr>
<tr>
<td>Agrostic tenuis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lolium perenne</td>
<td>363</td>
<td>179</td>
</tr>
</tbody>
</table>

Subscript numbers refer to kg ha\(^{-1}\) of the applied nutrient
Fig. 1. Land restoration flow diagram (Bradshaw & Chadwick 1980).

Fig. 2. Changes in colliery spoil pH at Cefn Fennar.

Fig. 3. Changes in phosphate intensity following different rates of fertilization (Palmer et al. 1979).
of 32-15 tonnes ha$^{-1}$ of ground limestone, to correct a prevailing substrate pH of 2.7. The failure of this application to buffer the spoil reaction is clearly seen. It is not only pH values that are subject to such change. Table 3 gives mean values of chemical characteristics for another colliery spoil site (Thorne, South Yorkshire).

Table 3. Spoil chemical characteristics (mean values ± standard deviation) at Thorne, South Yorkshire

<table>
<thead>
<tr>
<th></th>
<th>1975</th>
<th>1978</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.8 ± 0.3</td>
<td>6.6 ± 0.4</td>
</tr>
<tr>
<td>Ec (mS cm$^{-1}$)</td>
<td>7.1 ± 3.5</td>
<td>0.4 ± 0.1</td>
</tr>
<tr>
<td>NH$_4^+$ + NO$_3^-$ ($\mu$g g$^{-1}$)</td>
<td>9 ± 4</td>
<td>5 ± 5</td>
</tr>
<tr>
<td>P ($\mu$g g$^{-1}$)</td>
<td>12.6 ± 10.8</td>
<td>3.5 ± 3.1</td>
</tr>
<tr>
<td>K ($\mu$g g$^{-1}$)</td>
<td>173 ± 82</td>
<td>12 ± 3</td>
</tr>
<tr>
<td>Ca ($\mu$g g$^{-1}$)</td>
<td>857 ± 478</td>
<td>23 ± 11</td>
</tr>
<tr>
<td>Mg ($\mu$g g$^{-1}$)</td>
<td>3.5 ± 0.4</td>
<td>0.04 ± 0.04</td>
</tr>
<tr>
<td>Na ($\mu$g g$^{-1}$)</td>
<td>4.0 ± 0.6</td>
<td>0.02 ± 0.02</td>
</tr>
<tr>
<td>Zn ($\mu$g g$^{-1}$)</td>
<td>6.6 ± 0.4</td>
<td>0.04 ± 0.04</td>
</tr>
<tr>
<td>Mn ($\mu$g g$^{-1}$)</td>
<td>5 ± 2.8</td>
<td>5 ± 2.5</td>
</tr>
</tbody>
</table>

Source: Palmer et al. (1979)

The fate of applied fertilizer is such that attempts to maintain levels of major nutrients over long time periods are seldom successful, resulting in very low percentage recovery values of applied fertilizer. Spoil mineral nitrogen levels have been shown to be only subject to short-term improvement after applications of up to 250 kg N ha$^{-1}$ (Palmer et al. 1979).

Fig. 3 shows the way in which phosphate depletion occurs following P-fertilizer additions. To these difficulties in maintaining non-limiting levels of major nutrients may be added the problems arising from seasonal fluctuations in other elements, some resulting in increased availability of Al, Mn and Zn at the time of active plant growth (Williams & Chadwick 1977).

Maintenance procedures

Attempts to deal with the maintenance of vegetation on restored derelict and waste land usually make use of one, or a combination, of the following: substrate amelioration programmes (supplying nutrient ions or correcting toxicities); choice of tolerant or specifically adapted plant material; specifically designed management techniques that limit disturbance, nutrient removal or meet other site susceptibilities. One example of each of these approaches will be given.

The provision of an adequate supply of nitrogen on a continuing basis could be secured by repeated dressings of nitrogen fertilizer, use of slow-release fertilizer (Gold-N, IBDU or an organic manure)
or the use of legumes. The dry weight yields of the second cut of grass swards on two colliery spoils, where form of nitrogen supply varied, are given in Table 4. It is clear that slow-release fertilizers may result in yields equally as good as two or four applications of ammonium sulphate and also that legume-N can give relatively good levels of sward dry matter.

Table 4. Dry weight yield (g m⁻²) of the second cut of grass swards growing on two colliery spoil sites when given different forms of nitrogen supply

<table>
<thead>
<tr>
<th>Spoil</th>
<th>Nitrogen supply</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thorne</td>
<td>Trifolium repens (S100)</td>
<td>44.8</td>
</tr>
<tr>
<td></td>
<td>Gold N</td>
<td>35.1</td>
</tr>
<tr>
<td></td>
<td>IBDU</td>
<td>35.1</td>
</tr>
<tr>
<td></td>
<td>Ammonium sulphate</td>
<td>32.2</td>
</tr>
<tr>
<td></td>
<td>Calcium nitrate</td>
<td>26.0</td>
</tr>
<tr>
<td></td>
<td>Organic manure</td>
<td>14.3</td>
</tr>
<tr>
<td>Cefn Pennar</td>
<td>Gold N</td>
<td>35.9</td>
</tr>
<tr>
<td></td>
<td>Ammonium sulphate:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 applications</td>
<td>31.9</td>
</tr>
<tr>
<td></td>
<td>2 applications</td>
<td>30.7</td>
</tr>
<tr>
<td></td>
<td>IBDU</td>
<td>13.9</td>
</tr>
<tr>
<td></td>
<td>Ammonium sulphate:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 application</td>
<td>7.3</td>
</tr>
</tbody>
</table>

Source: Palmer et al. (1979)

The establishment of legumes on derelict and waste land substrates can give rise to some difficulties. If sufficient seed-bed nitrogen is supplied to enable satisfactory grass growth to be attained, clover establishment is suppressed. This has led to attempts to introduce clover into an established grass sward once the initial supply of nitrogen to foster grass growth has fallen (Fig. 4). Considerable nitrogen fixation by legumes has been measured on colliery spoil (Fig. 5).

Most of the derelict and waste land restoration work that has involved establishing swards has, of necessity, had to make use of grass species and cultivars bred for agricultural use on high fertility soils. However, results of trials on colliery spoil suggest that certain non-agricultural species and cultivars, particularly at low fertilizer supply levels, will be of use for some derelict and waste land substrates (Fig. 6).

The adaptation of management techniques to derelict and waste land situations can be illustrated by reference to tree planting and harvesting. In a trial at Water Haigh in West Yorkshire, the establishment of twelve tree species was tested under conditions of high phosphate supply or none, and with undersowing of a grass-legume sward or leaving the spoil bare, in combination. Fig. 7 illustrates the adverse effect on tree height of undersown grass.
Fig. 4. Contribution to dry matter by S100 clover at four N levels and weeks grass before clover.

Fig. 5. N fixation by Trifolium repens (S100) on colliery spoil in 1980.

Fig. 6. Dry weight yield of nine grass cultivars at low nitrogen.

Fig. 7. Tree growth on colliery spoil.
The tree species were not managed for timber but for overall biomass production, as an energy crop. By sacrificing the 10-28% of dry matter represented by the leaves of deciduous trees, from 50-85% of the N, 85-95% of the P and 50-75% of the K in the crop could be left behind on the relatively nutrient-poor site. Coppicing appeared to be a suitable method of obtaining biomass material without the disturbance involved in clear-felling and replanting. The potential for a coppicing-management regime is illustrated in the data given in Table 5.

Table 5. Coppice regeneration (mean number of shoots from cut stumps) in twelve tree species growing on colliery spoil

<table>
<thead>
<tr>
<th>Species</th>
<th>No grass + lime</th>
<th>No grass + basic slag</th>
<th>Grass + lime</th>
<th>Grass + basic slag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Betula pendula</td>
<td>8.07</td>
<td>7.14</td>
<td>6.52</td>
<td>5.45</td>
</tr>
<tr>
<td>Alnus glutinosa</td>
<td>7.75</td>
<td>7.70</td>
<td>10.99</td>
<td>-</td>
</tr>
<tr>
<td>A. incana</td>
<td>7.29</td>
<td>5.44</td>
<td>7.75</td>
<td>-</td>
</tr>
<tr>
<td>Robinia pseudoacacia</td>
<td>2.57</td>
<td>5.89</td>
<td>3.63</td>
<td>4.5</td>
</tr>
<tr>
<td>Quercus borealis</td>
<td>-</td>
<td>2.0</td>
<td>7.0</td>
<td>-</td>
</tr>
<tr>
<td>Populus alba</td>
<td>11.38</td>
<td>13.02</td>
<td>13.89</td>
<td>12.8</td>
</tr>
<tr>
<td>Sorbus intermedia</td>
<td>11.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Acer platanoides</td>
<td>-</td>
<td>6.78</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>A. pseudoplatanus</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7.0</td>
</tr>
<tr>
<td>Salix caprea</td>
<td>9.21</td>
<td>8.48</td>
<td>8.45</td>
<td>9.0</td>
</tr>
<tr>
<td>Pinus nigra</td>
<td>7.46</td>
<td>10.45</td>
<td>5.49</td>
<td>3.5</td>
</tr>
<tr>
<td>Larix leptolepis</td>
<td>8.56</td>
<td>11.34</td>
<td>9.32</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Source: Dennington & Chadwick (1981)

Conclusions

Maintenance is the major factor contributing to the long-term success of restored derelict and waste land. Monitoring site performance must be coupled with the correct interpretation of results to produce appropriate maintenance and management techniques.

Acknowledgments

I wish to acknowledge the continued cooperation and assistance of my colleagues in the Derelict Land Reclamation Research Unit.

References


Abstract

At any given moment the landscape of the Netherlands is an expression of a continuous interaction of geological, biological and socio-cultural processes. The human factor has become more and more important, if not dominant. However, it is not self-contained; man is part of society with its increasingly intricate and changeful pattern of relations and organizations.

Until today, landscape ecologists in the Netherlands have been mainly concerned with the management of natural elements in the landscape. Landscape ecologists may analyse the human impact on environmental processes. Usually man is considered to be an external factor, without regard for the complexity and dynamics of society.

Social scientists, on the other hand, have tried to develop comprehensive approaches to the complex of socio-cultural and natural processes.

In order to enable planners to get a grasp on the interaction of society and environment, confrontation and integration of landscape-ecological and socio-cultural information are essential.

The results of a case-study of the willow-coppices in Vijfheerenlanden will substantiate the benefits of the integration of social sciences and landscape ecology.

Landscape Ecology and the Social Sciences

The landscape in the Netherlands expresses the relationships between human groups and their surroundings. Landscape ecologists and anthropologists share an interest in this kind of relationship. Their interest, however, is traditionally due to different reasons.

There is a rich background to the study of interrelations in human groups and their surroundings in the social sciences (and particularly in cultural anthropology). Two familiar though obsolete approaches are environmental determinism and environmental possibilism. In environmental determinism, the way humans live is actively shaped by their surroundings. Environmental possibilism, on the other hand, merely assigns the surroundings a "limiting or selective role". A more recent approach (cultural ecology, based on Steward's work in the thirties) attempted a synthesis. To a greater extent than the possibilists and the determinists, cultural ecologists were aware of the complex nature of the relationships between human groups and their surroundings. At the same time the cultural ecologists had in common with the determinists and the possibilists an overriding concern for the consequences of such relationships for the way people live.

Landscape ecologists have the very opposite approach. They are chiefly interested in this kind of relationship because of the
consequences such relationships have for the environment. Many ecologists work with models in which man is merely an external factor.

Planners and researchers are becoming increasingly aware of the necessity to pool their resources if they are to cope with the shortcomings of the individual methods. With this in mind, ecological anthropologists have adopted terms and theories from biological ecologists. They try, for instance, to regard societies as components of eco-systems. One of the snags, however, is that the adopted terms and theories do not adequately express the socio-cultural processes' own nature.

Landscape ecologists, too, aim at a more holistic approach. They reduce socio-cultural processes to needs, desires and motives of individuals and aggregates of individuals, thus doing insufficient justice to the nature of human society. The relationships between people and their environment affect and are affected by the mutual relationships among people and human groups.

We do not claim to have found a holistic approach. What we are trying to do is to apply the two approaches to an example. By combining the two approaches we can formulate problems more clearly, and lucid formulation is the first step towards finding solutions. We have chosen the development of willow cultivation in a region of the Netherlands as a case-study.

Willow Cultivation

Plantations of willows grown for periodical cutting were known long before the Christian era. We do not know from when the first willow-coppices in the Netherlands date. In any case, in the second half of the nineteenth century the growth of industry and trade in the Netherlands and surrounding countries caused a growing demand for packing materials (barrels and baskets), resulting in a substantial variety of willow-coppices. A lively wood trade flourished, particularly in the Great River Lowlands, where coppices can be found outside the dikes or in the heart of the polders. Since the requisite length, thickness and quality of the shoots varied according to their use, a rich variety of species was grown.

Willow plantations resulted from the reciprocal action of natural and social conditions which together determine how the plantations should be managed. Changes in social conditions, and to a lesser extent in natural conditions, are responsible for changes in the management of willow-coppices and consequently in the coppices themselves. An analysis of the changes in the natural and social conditions of willow cultivation within the dikes in the Vijfheerenlanden region is used to examine the consequences for management and the conclusions to be drawn regarding future development of willow cultivation.

Willow Cultivation in Vijfheerenlanden

In Vijfheerenlanden both natural and social conditions were extremely favourable for the development of willow planting. The soil of the region forms a transition from river clay in the east to peat in the west. It was difficult to drain or even gain access to large areas of this land, which meant that it was ill-suited to other kinds of agriculture, although quite adequate for planting willow. There was not much work in the area, particularly in the winter months, and hardly any social services. Sheer poverty therefore forced many people to do the hard work in the willow-coppices for low wages.
The rising demand for willow in the second half of the nineteenth century inspired absentee landlords (often living in towns outside the area) to convert their marginal land into willow-coppices, despite the considerable investment involved and the uncertainty of annual variations in prices on the wood market. The landlords were able to take such risks, though, because their incomes only partly depended on their land, and so the acreage of willow-coppices greatly increased.

Locations of willow-coppices were determined by a complex of factors. Not only was the river close by (important for transporting the bulky product), but there were other conditions such as the soil-type, drainage, accessibility, land-ownership and the availability of a large, cheap work-force. Another factor was that the area already possessed willow-coppices and their social infra-structure of skilled woodcutters, contractors, merchants and entrepreneurs with their hoop and basket workshops.

During the willow boom there was great demand for a wide variety of kinds and sizes of wood. This demand, together with the high quality required, the ample, cheap manpower and the extremely strict, labour-intensive management, led to an eco-system of willow-coppices with their own flora and fauna. The willow-coppice flora and fauna are not in themselves specific - the species also occur in woods. In the traditionally unwooded river-clay area the willow-coppices are a substitute for woods, introducing a greater ecological variety to the area. The location of the coppices in relation to one another and in their alternation with meadowland is particularly important for the fauna; the stage of growth a coppice has reached causes variations. Recently-cut coppices accommodate different species than coppices in a later phase of growth; older coppices with several different environments provide a refuge for different species than newly-planted coppices. This mosaic of coppices also brings about a constantly changing picture in the landscape, both in the seasonal or harvest cycle (one to four years) and in the life cycle of the plantations (twenty to fifty years). The low blocks of willow-coppices look different every year, shifting, as it were, through the landscape with the passing years, the shift being caused by digging up old plantations and planting new willows somewhere else, and also by variations in the total willow acreage depending on the market situation.

As already stated, most plantations were in the hands of absentee landlords, farmers in Vijfheerenlanden only owning a few coppices due to the investment costs and the uncertain market. Besides, in order to reduce the risk they would have had to manage and cut the willow themselves. Managing and cutting willow-coppices was however something they did not do for various socio-cultural reasons: willow-cutting was for casual labourers and their families, synonymous with poverty.

The landlords' agents sold the harvesting rights to contractors at annual auctions. The contractors hired "polderboys" to cut the wood (polderboys were occasional labourers who worked elsewhere in the summer and looked for work in Vijfheerenlanden in the winter). Women, children and elderly people did easier jobs such as weeding and stripping bark off the shorter twigs. The contractors would sell the wood to wood merchants who in their turn sold shoots and branches to the entrepreneurs. The latter employed the many hoopers and basket-weavers working in larger centres in the Vijfheerenlanden area. In practise one person could combine a number of functions in willow cultivation, trading and processing, an obvious example being the big
bosses who were plantation-owners, contractors, wood merchants and entrepreneurs all in one.

Developing trade and industry not only stimulated willow cultivation but also formed an increasing threat to it. Technical innovation and economical development produced more and more substitutes for willow and willow products. This caused the variety of willow products to diminish, and was responsible for a number of crises in willow-planting. There was a serious crisis at the time of the first world war, when the demand for hoops dropped, and another one during the second world war when baskets became less popular.

With the diminishing demand for different kinds of willow products, one of them - in fact one which used to be regarded as a waste-product - became more and more important, and eventually the main reason for cutting willow: the bundles of stems used for making willow-matting for water engineering. This had direct consequences for the maintenance and management of willow plantations. Since not much is required of willow-shoots in the way of size, shape and quality, maintenance and management did not need to be so strict or labour-intensive. Besides this, the employment situation in Vijfheerenlanden changed during the 20th century. Better means of transport (with daily shuttles), more employment in the area and improved social services have resulted in the disappearance of the kind of labourer who sought work in winter and was ready to toil for poor pay in order to survive the winter. Improved socio-economical circumstances have also put a stop to the necessity for children, old people and women to work in the willow-coppices and practise the crafts associated with willow cultivation. In other words, higher wages and a reduced labour force have caused management to change. New technology (improved drainage techniques and artificial fertilizers, for example) has also made it possible to convert land which was formerly only suitable for willow cultivation into grassland.

These reasons have been responsible for a considerable decrease in willow acreage since the first war. Many landowners converted their willow-coppices into grassland or poplar woods; occasionally they simply left willow-coppices to their own devices. When maintenance and management cease entirely, willow goes on growing, but a plantation will not survive for very long. Clearings develop, offering less shelter for animals. Owners using their plantations as hunting-grounds therefore benefit by regular cutting, even if shooting is their principle motive for keeping up the plantations. They continue to auction off their willow, but the returns are so poor that in order to minimize costs they have to reduce maintenance and management practically to nil. The result is that the relatively rich variety of species in the herbiferous layer occurring in regularly maintained willow plantations makes way for a rough vegetation dominated by a few species. What is more, willow plantations age rapidly when old stumps are not replaced by new plantings.

Just as town-dwellers were the owners of the willow plantations in Vijfheerenlanden, town-dwellers were the first to point out, during the slump in willow cultivation, that the coppices were a historical, structural element of the landscape, constituting a specific eco-system. The first willow-coppices in Vijfheerenlanden were acquired at the initiative of private conservation organizations back in the thirties. Most of the willow-coppices in the area are owned by such an organization these days.
Since willow-coppices can only be maintained by regular cutting, the ones owned by conservation groups are cut too, not just for the sake of the wood, but mainly due to scenic, scientific and cultural-historical "conservation" arguments.

Like the private owners, conservation groups are faced with high maintenance and management costs compared to what they earn with the wood. Government subsidies, however, enable them to have managers (woodcutters, for example) on the payroll, thus basically separating management from willow profits. The subsidies are insufficient for the conservation groups to manage all the plantations they have acquired, and also insufficient for managing them in the traditional manner, which is highly labour-intensive. In order to keep up some kind of traditional management for the plantations not managed by the groups themselves, they do not auction off the woodcutting concession, but prefer to sell it to contractors who carry on the old traditional skills. In this way the largest willow plantation owner in Vijfheerenlanden operates outside the marginally existing wood market in which the contractors operate, thus collaborating in reducing the economical significance of that market.

The government's part in all this is somewhat ambiguous. Government policy has always been mainly involved with willow-planting outside the dikes, most of the wood being used for water engineering. Nowadays this function (the production of stems) has been mainly taken over by the inland plantations. In other words, the government practically has a monopoly with regard to the inland plantations. It pays so poorly, however, that it is barely possible to manage or maintain the plantations by selling the wood, and so the government subsidizes the conservation organizations in order to preserve the plantations. These subsidies are of course too small to maintain and manage the plantations in the traditional manner.

This double-dealing on the part of the government results in further decay. The appearance of the plantations managed by the conservation groups changes greatly. To facilitate ditch maintenance by machine, the edges of the plantations have been replaced by broad strips of grass, destroying the original rectangular shape. The herbiferous layer is sprayed with herbicides instead of weeded. In other words, management activities are changing greatly, and with them the appearance of the willow-coppices.

The social structure of willow cultivation in Vijfheerenlanden has changed drastically in the course of time. The absentee landlords and their agents have made way for the conservation organizations with their full-time managers, and for a few smaller plantation-owners. The entrepreneurs and their workers (hoopers and basket-weavers) have disappeared. The same goes for the big wood merchants and contractors. A few small wood merchants are left; they are contractors as well, and in this function employ a few woodcutters. As small wood merchants they buy wood from a few former plantation workers who have since become self-employed. In other words the economical significance of the willow plantations no longer exists for the inhabitants of the region.

The development of willow cultivation in Vijfheerenlanden shows how the natural and social conditions prevailing there favoured a type of cultivation with a highly labour-intensive management. Changes in social conditions, with the changes in the influence of natural conditions they involved (artificial fertilizers, drainage techniques etc.), also
involved changes in management. The relevant literature, presenting a case for preserving the plantations, mentions their economical, ecological, scenic and cultural-historical functions. The problem here is that the terms "function" and "valuation" are confused, both explicitly and implicitly. Functions distinguished by people are involved, however, and valuations are a concomitant of that distinction.

Literature has a second problem in assigning functions to the willow plantations. The functions are put in such general terms that practically each individual plantation fulfills a number of functions. What is more, those functions, described in such general terms, are positively valued and endorsed by nearly everybody. The question ought therefore to be as to the content of the functions of willow plantations, and how to value that specific content. It is not enough, for example, to label plantations as having "cultural-historical significance", as is done in literature in the sense of "a small country's great achievements" (water engineering). To the inhabitants of Vijfheerenlanden the willow plantations are rather a symbol of an age when people were forced to work under extremely poverty-stricken circumstances.

Conservation organizations provide the diverse functions with a content of their own, making implicit use of an ideal model of the plantations as they were in the second half of the nineteenth century. The non-economical functions which they had in those days are valued, and in order to live up to that model, the management of that period is imitated as faithfully as possible. In fact, though, management has changed since then, and continues to change, and with it the specific content of the non-economical functions. For example, the appearance of many plantations has altered for the sake of more efficient management, and the variation of the herbiferous layer has greatly diminished. With regard to the cultural-historical aspect, the function of the plantations outside the dikes which used to produce willow-stems has been largely assumed by the inland plantations, which traditionally produced branches and twigs for hoop and basket-making.

In other words, the criteria are not lived up to in fact. This is not surprising. In order to retrieve the traditional content of the non-economical functions, traditional management would have to be re-introduced completely. However, this is a more costly business than it seems to be at a first glance. Even in the heyday of willow planting, this highly labour-intensive form of management was only possible because marginal groups were involved in actual cultivation. Seasonal labourers, women, children and the elderly worked in the plantations for very poor wages. The plantation-owners were never completely dependent on the willows, because they had sources of income other than from agriculture; their reasons for planting willow-coppices were not only economical - the function as shooting-grounds also played a part.

If the complex of traditional functions cannot be retrieved, since traditional management cannot be retrieved, it is better not to adapt management to the model of the past, because this only erodes the functions still further.

Choices

Now new policies are to be considered. The choice is whether to keep up willow plantations, in which case the general functions will have to be given a different content, or to clear them because they can no longer, under present social conditions, provide any content for these general functions. In the former case a choice must be made as to which
function is to be given new content, putting up with changes in other functions as being necessary. Experiments can be made, for instance, with other markets for willow, and investigation be carried out into whether a modern, less labour-intensive form of management could preserve the willow-coppices as a visual element of the landscape.

In the latter case one can conclude that filling in the functions of willow-coppices in a new way by means of a less labour-intensive management is not feasible. This can also lead to the conclusion that the functions can be better fulfilled by making different use of the land.

It is important when making such choices that the aforesaid general, ecological, scenic and cultural-historical functions be fulfilled not so much by the individual plantations but in fact by plantations situated in complexes. This is yet another aspect to be considered.

At present the acreage of willow-coppices is still dwindling. This is partly planned by the government, partly unplanned. What is actually happening is a continuous economical clearance. The question is whether this clearance process will stop short at the coppices now protected by the conservation organizations. If they persist in imitating former management, it will gradually become impossible to afford these coppices; management will have to become less labour-intensive, or the willow acreage will shrink still further.

The present tendency makes it look as though willow acreage will be reduced to a level at which the demand for willow-stems can be met. This need not be disastrous in itself. The danger of such a process is however that ad hoc choices must constantly be made (whether a coppice is preserved or not depends, for instance, on whether someone in the district is able to start up an action group for the preservation of the coppices).

A national plan for willow cultivation might be able to control the process in such a way that complexes remain in areas chosen for the evaluated functions which the coppices fulfil, or can fulfil, in a particular region. The functions which the coppices can fulfil depend on the prevalent conditions in a region, such as its social structure (the availability of labourers and processors) and factors such as accessibility on the one hand. On the other hand the genesis of the landscape in a region can be a basis for evaluating the visual functions of willow-coppices.

These conditions are combined in Vijfheerenlanden, which might be a point in favour of preserving the willow complexes there either from the viewpoint of economical functions, or from non-economical considerations. Seen on a national scale, one could then proceed to preserve coppices in areas where social and functional conditions are relatively good. Each region would have to be examined in such a way to find out whether other forms of land use could replace the valued functions of the willow-coppices. An effort could thus be made at a national level to give content to one or more of the valued functions in an area of willow cultivation which can be feasibly managed in complexes with suitable conditions. Such a plan might compel the authorities to come up at last with estimates and market guarantees for the inland plantations. What makes planning so difficult again and again is that no estimates are forthcoming from the authorities of the amount of willow required in the coming years. The government has always bought the willow cheaply up to now, first as a waste product, it now being a product which due to the plantations' potential surplus capacity is still relatively cheap.

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The willow plantations exemplify the problems of conservation in the Netherlands. By idealizing nature and landscape in the form they had at the end of the nineteenth century, one implicitly idealizes the social structure that went with them. By combining approaches from landscape-ecological and cultural-anthropological angles, we wanted to demonstrate how inextricably they are intermingled, and how, with regard to willow cultivation, changes in the valuation of social functions result in changes in the willow-coppices themselves, and vice versa.

An insight into this entwinement might lead to new solutions no longer concerned with the sheer preservation of relics whose function, as in the case of the willow-coppices, has become hollow, but with giving content to (new) functions, and with making choices.
INTERSTITIAL HABITATS AND THE URBAN-RURAL RELATIONSHIP IN EASTERN DENMARK

Biotope Group (Agger, Brandt, Byrnak, Mark Jensen and Ursin)

Institute of Environment, Technology and Society, Roskilde University Centre, Roskilde, Denmark.

Statement of the problem

In Denmark the urban areas take up an increasing part of the total land area - today about 10%. At the same time the total rural area - about 70% - is decreasing, and this causes a number of rural-urban-con­flicts. The effects of these conflicts on the interstitial habitats sit­uated in and between the fields on the urban fringe are discussed in this paper. Furthermore it will be shown how urban development results in establishment of new types of small, more-or-less uncultivated areas.

Survey of previous work

The rural-urban conflicts and their effect on production and farm­structure has been studied in Denmark (Jensen 1976, Jørgensen 1978). The fate of the interstitial habitats in the rural environment has been studied by the authors of this paper (Agger et al, 1981). The urbanization process, as a landscape-forming factor with special reference to inter­stitial habitats, has not yet been thoroughly studied in Denmark.

The present work

The interstitial habitats (drainage ditches, hedges, pits and ponds, etc.) make up an important fraction of "Nature" in Denmark. This fact and their potential use as areas for outdoor recreation close to the city, are the main reasons for this study.

The study of the changes in area, number and character and the identi­fication of the urbanization process in this context, constitute a part of the undergoing work and is funded by the university and the Danish Agricultural and Veterinary Research Council.

In 13, 1 km² areas - located in the immediate vicinity of the city of Odense on Fyn - the interstitial habitats are being mapped. Type, content and status of each individual habitat are briefly described in field studies. We are using aerial photographs to map the changes in the amount and character of habitats together with the urbanization of their envi­ronment. Interviews with the owners or tenants give information on the present and previous production, farmstructure and on the recreational use of the habitats. The city authorities dealing with planning and con­servation are also being consulted. Odense (about 140,000 inhabitants), has been chosen because the city authorities here perform advanced landscape-planning for recreational purposes, and this must be expected to become more common in the future around other Danish cities.
The consequences of urbanization

It is possible to point out a number of tendencies that influence farm-structure and production which must be expected to cause a change in the pattern of habitats. The most important are mentioned below:

- Increasing landvalues and ground-rents (due to planned or expected urban development)
- Increasing proportion of tenancy (often short-termed)
- A growing number of elderly farmers
- Decreasing animal husbandry
- Fewer and smaller investments in production.

Normally the high taxes force the farmers to utilize their land to the greatest extent. This can lead to the removal of interstitial habitats, which otherwise would have remained, e.g. for hunting purposes. The coming urban development and the short-termed tenancies may result in less maintenance of hedges. Fewer livestock causes many pits and ponds to lose their function as watering-places which again can lead to their filling. Likewise, the fall in livestock production results in a smaller number of crops, which tends to reduce the number of necessary field divides, such as hedges and dikes.

On the other hand the normally smaller investments of elderly farmers is a factor which may result in a prolonged existence of some habitats.

The new types of habitats which emerge as a result of urban development, consist mainly of recreational areas and footpaths. Around Odense many plantations of different sizes, consisting mainly of deciduous trees, are being established. Besides these, the following habitats can be found in a higher proportion nearest to the city: Ponds for drainage overflow, ruderal areas (i.e. areas which are left un-utilized due to forthcoming urban development), shelter plantings around industrial and residential areas, plus small farms (owned by nonfarmers) which are wholly or partly planted with trees. Many of the tendencies mentioned above can work both ways, but it is our hope that we, at the symposium, can throw more light on the primary trends in the habitat pattern on the urban fringe.

References


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Introduction

Within the Ministry of Agriculture and Fisheries the State Forest Service is responsible for forest, nature and landscape in the Netherlands.

In order to coordinate its own policies and to solve the problems confronting it in the field of physical planning, the Service has had to develop a new form of integral landscape planning. The Regional Landscape Plan (RLP) aims to outline possible solutions to a number of physical planning developments occurring in an area often at inter-municipal level or at the higher, more abstract level of regional plans. In general the RLP is aimed at creating guarantees for lasting preservation of existing qualities and development of new qualities in rural areas.

The first experiment with a plan of this kind has been completed by the State Forest Service and is summarized in the following.

Explorative phase

The area studied covers some 40,000 ha, lies north-west of Amsterdam in the province of Noord-Holland, and belongs to the northernmost part of the West-Holland conurbation.

The area in question borders on the sea and contains a large number of totally different types of landscape at relatively small distances from each other, such as the beach and the dunes, the old landscape of coastal barriers and beach plains along the inland side of the dunes, the open fenland around the Alkmaar lake and the large inland polders such as the Schermer, Heerhugowaard and the Geestmerambacht. The central problem in this area is the relation between excessive urbanization and clearly existing scenic and natural qualities.

In connection with the choice of building sites for a minimum of 28,000 and a maximum of 39,000 houses until the year 2000, and with the growing need for recreational facilities near the town the layout of the outskirts of the towns and the adjoining rural areas demands attention.

In this context work is in progress to improve facilities for extensive forms of recreation in the countryside and to establish new forests together with new urban areas. A view of developments within agriculture (ever-increasing intensification), as they affect existing natural qualities, for example those of the meadow bird areas, is needed too.

The chosen method of attempting to gain an integral view of the issues, was to set the physical and ecological facets of nature and landscape as long-term interests against the sector interests, such as those of housing, farming and recreation.

Analytical phase

In the study the various types of landscape were extensively analysed. In the description of the natural environment particular emphasis was laid on the relation between soil flora and fauna. In the description of the structure of the landscape man was the focus of attention in
the search for relations between soil, vegetation, land use and occupation patterns.

A survey was made of the soil situation, cultural monuments, old dikes and pacellation patterns existing gradient situations, vegetation, fauna and the visual structure of the area.

The knowledge and insight obtained by this method resulted in a diagrammatic, simplified representation of the structure of the area. This representation reflects the existing zoning in anthropogenic dynamics which is clearly distinguishable in the area. This means that a distinction has been made between areas where many changes in land use take and took place and areas where the type of land use has remained fairly constant over the years. It is particularly these differences of stability and dynamic which are - at this highest level of abstraction - regarded as preconditions for the conservation and development of ecological and scenic qualities in the area. This does not imply that the changes and differences in the intensity of agricultural utilization within the so-called stable zones have been overlooked. These differences, which are of such significance to the ecological and scenic qualities of the countryside, have been worked out on the final chart in a less abstract form.

The diagrammatic zoning model in anthropogenic dynamics, developed for 1980 in the way described above, constitutes the result of a continuous process in the past and at the same time the basis for a view of future developments.

Planning

As this study aims to develop as concretely as possible a concept of the main structure of the landscape desired in future, the various developments within the different sectors have been dealt with quite extensively. As explained above, the results (sector claims) were placed at right angles to the desired theoretical landscape-ecological model and to the detailed claims for nature and landscape, per type of landscape. By means of a confrontation diagram the choices regarding where and how sector activities should take place, were elucidated. In this selection process the choices were directed particularly by the principles of the zoning model.

The Regional Landscape plan chart as the end result of this process presents an integrated picture. This chart does not show use zoning as is customary in physical planning but the direction of developments (action chart), indicating where and how certain developments need stimulating and/or adjusting. Only those places requiring attention are spotlighted. Proposed measures leave sufficient space for adjustment. They point to sites for houses and industries for the next 10-15 years.

As regards farming the developments proposed are aimed at strengthening the present agricultural function without limiting conditions; strengthening the agricultural function with nature and landscape as limiting conditions, and at improving the natural and scenic qualities of an agricultural area.

Where the principle of interweaving different functions in the countryside has led to imbalance, measures have been incorporated in the plan to restore this balance, depending on the strength of the environment in that area.

Thus we have tried to develop a form of landscape planning viewed as an important complement to more city-oriented views of planning.
FOREST ENERGY CROPS FROM DERELICT AND WASTE LAND

V.N. Dennington & M.J. Chadwick
(Derelict Land Reclamation Research Unit, University of York,
York Y01 5DD, and Imperial College Centre for Environmental
Technology, University of London, London SW7 2AZ)

Competition for land use in Great Britain makes the
possibility of devoting large areas to forest energy crops
an extremely remote one. However, there exists 71,000 ha
of derelict land. A recent study (Dennington & Chadwick
1979) has shown that to this can be added a further
260,000 ha of associated waste land. Much of this area
of 330,000 ha has a potential for forest energy crop
plantations although substrate type and area of the
individual sites are highly variable.

Considerable expertise exists in the reclamation of
derelict land and the establishment and growth of a wide
range of woody and herbaceous species. Often the reclaimed
land, although having an amenity value, provides little
economic return and therefore the growth of energy crops
represents an attractive associated activity.

A study has identified the extent, distribution and
categories of derelict and waste land. Representatives
of each have been sampled for tree species composition,
standing crop, mean annual dry weight production and
elemental composition of leaves and wood. Standing crop
varied between 135 t.ha\(^{-1}\) for Alnus glutinosa on pulverized
fuel ash to 3.5 t.ha\(^{-1}\) for the same species on colliery
spoil.

Harvesting a total crop of 4 t.ha\(^{-1}\) could result in the
removal, for example, of 3.2-6.5 kg.ha\(^{-1}\) of potassium from
the site (and equivalent amounts of nitrogen, phosphorus
and calcium). However, if the crop were to be taken after
leaf fall this could be significantly reduced. Even so
the removal of nutrients involved can represent a consider­
able proportion of the nutrient reserve from these low
fertility sites.

The level of productivity can be improved considerably by
appropriate management techniques and coppicing represents
one of the most promising methods of short rotation cropping.

Dennington, V.N. & Chadwick, M.J. (1979). An Assessment of
the Potential of Derelict and Industrial Wasteland
Energy and Technology Support Unit, Harwell, U.K.

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In the G.D.R. the lignite mining provides a fast amount of the raw material requirements for power plants and the chemical industry. Large and superficial deposits offer best conditions to open pits of high economy. On the other hand narrow connected areas changed by mining demand a high quality of recultivation. This is regulated by law (Law of Landeskultur, Law of mining purposes of the G.D.R., e.a.). Prognosis and planning for fixing extraction and redeposition of overlying strata as well as continuous recultivation are possible only by exact cooperation of several disciplines. Landscape ecology is contributing a distinct part for it. The period, when mining is finished after complete extraction of a large region, is of special interest.

The poster deals with an area to the south of Leipzig. At 2010 A.C. this district of 300 km² will be divided into small stripes of coal pillars undisturbed by mining and occupied by settlements, big plants of the chemical industry, main traffic lines, channels a.s.o., and very large dumps, reconstructed for agriculture, forestry and other purposes, but also deep, waterfilled residual pits. Most important problems are connected with the rejuvenation of the groundwater table and water balance in the dumps of different type, age and deep, but also in the coal pillars. The rising groundwater table influences the quality of the dump soils, the stability of slopes and the foundations of buildings and traffic lines. Other questions are to be answered for the complex development of the region, f.i. for the residual pit lakes, used for flood control, waste deposition, fishery, recreation a.s.o.
THE INFLUENCE OF LANDSCAPE ON TRAFFIC NOISE

L.A.M. van der Heijden and M.J.M. Martens
Department of Botany, Section Experimental Ecology,
Catholic University, Nijmegen, the Netherlands

Abstract

Nowadays the traffic and industrial noise have become an increasing factor in the disturbance of the acoustic climate of rural and natural areas and this noise should therefore be counteracted. One of the means of achieving this consists of a rational use of vegetation alongside noise sources such as motorways. It has become evident that the two components of vegetation, the soil formed by the vegetation and the vegetation itself, each act on sound in their own specific manner. The soil reflects to some degree the sound and an interference pattern is built up above the soil. The acoustical properties of soils are best described by their impedances. Measurements of soils of woods and grasslands have shown that a significant difference exists between soils, formed by different vegetation. The living plant material absorbs sound energy too, as could be confirmed in sound propagation experiments with different plant species in an anechoic chamber and with a laser-Doppler-vibrometer system. It is also shown that when using vegetation to influence the acoustic climate of the environment some facts should be taken into account as there are: rows of planted trees should be parallel to the source, small paths should wind through the vegetation and not be perpendicular to the sound source, and the vegetation must be as dense as possible.

Introduction

Since some years attention is paid to the acoustical aspects of landscape design. Because of the hindrance by noise, endured by both man and animal, the aim has become to reduce the noise levels by measures such as: reduction of emitted noise levels, isolation of houses against noise, screening by earthen walls or artificial screens. In rural areas it is most practical and aesthetical to apply belts of vegetation as a screen. The influence of vegetation on sound propagation can be divided into two mechanisms: the sound reduction by the living plant parts such as leaves, branches and trunks and the absorption of sound by the soft soil resulting from root activities and decaying plant materials. In the existing noise forecasting models the variables accounting for the influences of vegetation are based on insufficient data and we therefore suggest further research to permit more accurate planning.

Results

From outdoor sound propagation measurements the sound reflection coefficient was calculated from the interference pattern of sound. Because of destructive interference some frequencies were absorbed up to 15 dB. The acoustical soft soils in woods shift the absorbed
frequencies from 500 Hz (above grasslands) to 125-250 Hz (Martens, 1981). This is caused by the larger phase shift of the sound at reflection to the surface.

The high frequencies of sound are best absorbed by the living plant parts. This was concluded from measurements in plant monocultures (Martens, 1981), from measurements with model-forests in an anechoic chamber (Martens, 1980) and from direct measurements of sound induced vibrations of plant leaves (Martens & Michelsen, 1981) by means of a laser-Doppler-vibrometer.

The influence of vegetation on traffic noise is best illustrated by the following figure (from Martens, 1981). A comparison is made between: a typical traffic noise spectrum (a); a traffic noise spectrum after filtering over 100 m grassland (b), showing the net effect of the grass after correction for air absorption and 1/r doubling distance law; (c) as (b) but over 100 m beech tree monoculture; (d) as (b) but over 100 m spruce-fir forest.

References


SUMMARIES OF WORKSHOPS ON THEME III: URBAN-RURAL RELATIONS

URBAN-RURAL RELATIONS

This workshop summary presented here is based on discussions points con­ceived by J.F. Jonkhof, P.H. van Gessel and P.L. Dauvellier and workshop reports made by G. Johnson & J.F. Jonkhof and C. van de Watering.

Urbanizing areas and their problems

Town-country relations are of various natures: urban holiday-makers going out to the countryside; the conservation societies and action groups started by urban citizens; the intensification of agriculture to feed the increasing urban population; drinking water supply and use and the corresponding pumping stations, reservoirs and pipelines. All these are true urban-rural relations, although they have been discussed primarily in the workshops on rural problems. The items dealt with in this summary focus on highly urbanized areas and particularly the urban fringe, where the urban pressure on rural functions is felt more directly and violently.

In suburban zones it is very hard to maintain the ecological conditions conducive for nature areas. Equally difficult is the position of agricultural land use. Both direct impacts of the urban way of life and the uncertainty about future land use are at the root of these problems. The Danish Biotope Group (Agger et al., p) describes the urban influences on nearby farming and the resulting impacts on small natural habitats. Both workshops expressed a special concern for more vulnerable, weaker "functions" like natural areas, small farms, clean water, fresh air and quietness. Proper (p) demonstrates a special regional landscape plan, designed to set long-term conditions for the survival of these weaker functions in the process of regional development.

In search of an integrated approach to the urban-rural zone

The two contrasting views on segregation and integration outlined in the workshop summary on rural problems became equally manifest in the discussions about the urban-rural zone. Some speakers argued that the dynamics of socio-ecological systems should be reduced to a lower level in order to harmonize with natural systems. The flow of energy and matter through the systems should be slowed down, by means of recycling for example, so there would be less dependence on input and output. This view gets near the priority for reconsidering societies activities, an approach further elaborated by Tjallingii(1). Whether this is considered a priority or not, all participants in the discussions shared the view that there should be an incorporation of ecological thinking in socio-economic research and planning. The need for this integration becomes clear from the historical analysis of social structures carrying the willow-coppice landscape by Dijst et al.(1). Here the point made is actually that social and economic thinking should be incorporated in landscape ecology.

A related point of view expressed in the workshops is that man should be included as an internal factor in landscape. Although man has disturbed and destroyed his environment in many ways, it was stated that basically society should be regarded as a constructive force in landscape development. Some went as far as stating that in the urban fringe priority should be given to potential values rather than to actual nature qual-
ities. This view was not shared by every conservationist. But there was general agreement on the necessity of ecological field data on poten-
tialities to be incorporated in the multifunctional land-use planning of areas under increasing urban influence. An ecological land classification was considered an essential base for this work. Fabos & Hendrix (1) demonstrate an operational example of such a classification. Methods of this type can provide the planners with maps which can be used - they state - in a supply-side approach. A policy towards a balance between activities and ecological possibilities is more likely to be fruitful in this way than in the traditionally used demand models.

Landscape ecology does not only produce maps indicating site qualities. "Horizontal relations" also between town and country are carefully inves-
tigated. Such studies, and some by other disciplines, clearly reveal that urban and rural problems are intimately interrelated. Unfortunately, town planning and country planning are carried out separately in many cases. The urban fringe is neglected by both. It was stressed that its special qualities should be studied as a basis for detailed land use planning, including the so-called fringe activities.

Finally some more practical proposals and approaches are worth men-
tioning. At the planning and main line design level it was argued that urbanization should concentrate along communication lines. This approach is demonstrated for the city of Poznan by Bartkowski (1). In this way at-
ttempts are made to reconcile urban concentration and the special function of "open space". At the management and maintenance level, Chadwick (1), Dennington & Chadwick (1) and Richter (1) demonstrate ecological aspects of derelict and wasteland restoration. Van der Eelde & Martens (1) re-
port on their investigation on the role of vegetation in absorbing traffic and industrial noise. Conclusions can be drawn about the detailed design and management of noise barriers. These can be considered as examples of "selectors". They mitigate disturbing influences of one function on another and therefore can be important instruments in the design of an integrated land use plan. In the urban-rural zone some participants in the discussion consider these selectors more important for conservation than the size and distance variables proposed by island theory considera-
tions.

POLLUTION AND DEGRADATION

One workshop was devoted to problems of pollution and degradation. This short summary is based on the discussion points and report, both written by H. van Dam.

Pollution and energy

An attempt was made to formulate the general concept of pollution by stating that it occurs when energy from outside the landscape is intro-
duced into it by man or his activities. This input of external energy (e.g. fuels, fertilisers) and the resulting output of pollution was con-
sidered as a problem intrinsic to and unavoidable in modern society. A view like this can be illustrated by the ecodevice model, developed by Van Wirdum (1) and Van Leeuwen (11), as shown by Tjallingii (1). The model developed by Schroevers (p), which is referred to in the workshop summary on stability, is also worth mentioning in this context.

It was argued that recycling of materials and the restoration of dere-
licit land are remedial measures, difficult to realize in an economy of
growth. However, several approaches to introduce more ecological feed­
back in economics can be mentioned. First, internalising the costs of
recycling and restoration by incorporating them in the price of products.
Second, the supply-side models as proposed by Fabos & Hendrix (1). Third,
technology assessment procedures as discussed during the workshop summary
on Environmental Impact Assessment. Sometimes one has to learn just by
experience. The case of the technical waste dumps discovered recently in
the Netherlands was given as an example. A new housing estate situated on
one of them had to be cleaned up and rebuilt - a very costly affair.

It was argued that recycling, restoration and even management for con­
servation also costs energy. In the discussion, some participants stated
that this was acceptable only within the framework of a general strategy
of saving energy. Dennington & Chadwick (p) demonstrate an interesting
possibility in this context: the establishment of forest energy crops on
derelict land. Restoration problems of these areas are discussed further
by Chadwick (1) and Richter (p).

Pollution, degradation and diversity

In most cases pollution and degradation cause a decrease of the species
diversity of communities. Therefore this diversity is used as a parameter
to measure the impact of pollution. However there are situations in which
a moderate degree of pollution enhances the number of species. Hence this
type of diversity is no reliable overall parameter in this connection.

But on the scale of landscape, most types of pollution certainly do
result in a decrease of abiotic and biotic diversity. Thus it is very
important to describe accurately the type of diversity and the scale
level of the investigation.

As with other environmental problems, pollution requires study and
action both on the site and in a wider area, on the short and long term.

The following working papers were present at the Congress, but no spe­
cial reference was made to them in the workshop report: "Nitrogen cycling
and the creation of functioning ecosystems on nutrient deficient materials" (R.H. Marrs) and "Interception and retention of particles by vegetation:
a seasonal change" (P. Kovár). These papers can be obtained from
- Dr. R.H. Marrs, I.T.E. Monxwood Exp. Station Abbots Ripton Huntingdon
Cambridgeshire U.K.
- Dr. P. Kovár, Inst. of Landscape ecology Uke Cxav, 25243 Prahonice, CSSR.
Theme IV: Natural areas

Eddy van der Maarel

Division of Geobotany, University of Nijmegen, The Netherlands, and Institute of Ecological Botany, University of Uppsala, Box 559, 75122 Uppsala, Sweden.

Abstract

The significance of nature reserves is considered here from the general viewpoint of optimal land use. Our conceptual framework is a system of functions of the natural environment, a function being defined as a potential way of using the environment to fulfill a need in society. There are four main groups of functions: production, carrier, information and regulation functions.

In this system nature reserves are considered necessary sources of information and/or regulation within larger landscape units to provide an ecological balance with production and carrier functions. To achieve an effective balance we need:

1. A network of nature reserves
2. A zoning system to integrate highly susceptible natural with pluri-functional semi-natural, agricultural, and urban-industrial landscape units
3. A strategy for the internal and external management of nature reserves.

This contribution will concentrate on the planning of optimal networks of nature reserves. Biogeographical considerations on this planning include first of all the comparison of nature reserves in a "cultural desert" with islands in the sea.

The theory of island biogeography is explained and Preston's species-area relation demonstrated. The example makes clear how habitat diversity is also governing species richness on islands. Both the spatial diversity and the temporal diversity due to continuous disturbance and regeneration processes should be included in the island theory.

From a conservation point-of-view the interest is in the total number of species maintained in a group of islands (reserves) rather than in the largest possible island (reserve) to be maintained. This is explained formally. Some differences between plants and animals are discussed in this context.

Finally some landscape ecological views on the vulnerability of nature reserves are made and some ideas presented on an elaborated system of environmental compartments. Nature reserves should be included in zoning systems surrounded by buffering compartments.

Introduction

Nature reserves are both inevitable and invaluable elements in the system of land use as it has been developed by our urban-industrial society. Even if we would agree upon a drastic change in our basic attitude from careless exploitation and pollution to careful management of natural and cultural environments, we would still face for a long time oceans of the urban and industrialized rural with small islands of the natural.

What Norbert Wiener, the father of cybernetics, once said about life in
general seems to have an even more oppressing significance in our days: "Life is an island here and now in a dying world".

In any attempt to improve the quality of our natural environment, be it the maintenance and further diversification of the remaining natural ecosystems or the restoration of derelict land, we badly need our nature reserves.

Stressing the significance of our nature reserves is not just an ethical and emotional attitude. It can also be emphasized more rationally in the framework of what we may call optimal land use (e.g. Zonneveld 1972, Vink 1975). Such a rational approach is found in various models for physical planning and land use planning, e.g. the General ecological model for the physical planning of the Netherlands (van der Maarel & Dauvellier 1978, van der Maarel 1978, Anon. 1977).

The various ways in which we can use nature are called functions and we may distinguish four main groups of functions:

- **Production functions**, regarding the supply of matter and energy from natural resources, both abiotic and biotic ones.
- **Carrier functions**, regarding the provision of space and surface for human activities (urban-industrial, rural, waste producing, and recreational activities).
- **Information functions**, regarding the supply of information for orientation, aesthetic appreciation and philosophic identification, scientific research, education, and signalling of environmental changes.
- **Regulation functions**, regarding purification through waste assimilation and absorption, and environmental stabilization through atmospheric filtration of cosmic rays, biospheral damping of climatic fluctuations, retention of water and soil, and biotic regulation.

Clearly in such a system of functions the nature reserves are necessary sources, concentrations of information and regulation which contribute to an ecological balance within larger landscape units (cf. Dasmann 1972, Anon. 1973). One may recognize a parallel here with the protective compartment in Eugene Odum's (1969) well-known model of environmental compartments.

To achieve such a balance between natural sources and human needs we can think of a threefold plan for nature management:

1. A network of nature reserves; 2. A system of zoning in which the highly susceptible natural landscapes can be integrated with the semi-natural, agricultural, urban, industrial landscapes; 3. A strategy for internal and external management of nature reserves.

Networks of biosphere reserves; the situation in the Netherlands

Network planning is becoming an important approach in nature conservation, notably within IUCN and UNESCO (Anon. 1974). A system of biosphere reserves is equally important for countries with a high amount of natural ecosystems and densely populated countries such as the Netherlands. May be for such countries a good network of reserves is all the more urgent (cf. Westhoff 1977, van der Maarel 1980).

In the Netherlands the nature reserves are of great importance for the maintenance of our flora, fauna and biotic communities. Due to the reduction in natural areas, pollution and other factors 50 of the ca. 1400 native vascular plant species (to mention one example) have become extinct during this century, while another 700 are rare to almost extinct. Almost all of these rare species are dependent on our nature reserves for their survival in this country (cf. Westhoff et al. 1970, Westhoff 1976).

Sukopp (1976) listed percentages of extinct and threatened species in various parts of the world: for smaller European nations and provinces
the figures are between 35 and 55%!

To illustrate the island character of Dutch nature reserves I present some statistics. More-or-less natural areas make up only 5% of the Dutch territory, while another 8% is "woodland" (Anon. 1974b). From the handbook of Dutch nature reserves and recreation areas (Anon. 1980) I derived the astonishingly high number of 1300 nature reserves, covering still only 210,000 ha, which is 6% of the territory and roughly half of all natural and woodland areas. Table 1 shows the distribution of their sizes.

Table 1.

<table>
<thead>
<tr>
<th>Size of reserve in ha (x 2 classes)</th>
<th>number of reserves</th>
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<tr>
<td>&lt;1 ha</td>
<td>40</td>
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<tr>
<td>-2 ha</td>
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<tr>
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<td>7</td>
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<td>&gt;8192 ha</td>
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A more or less regular distribution appears from these data, be it skewed to the smaller size-classes. Not more than 9 reserves reach a size of 4000 ha, while on the other hand no less than 275 reserves are smaller than 4 ha.

The theory of island biogeography in brief

Since around 1975 ecologists and biogeographers are treating nature reserves as islands. We may mention here Diamond (1975, 1978), May (1975), Diamond & May (1976, 1977) and Terborgh (1976). They were all influenced by Robert MacArthur and his theory of island biogeography. One should realize that they are all zoologists and the model developed by MacArthur & Wilson (1967) is largely inspired and supported by data for birds and mammals. To present straight away the main interpretation from this island theory for nature conservation (cf. Gorman 1979): if you have the possibility to save a certain area of natural ecosystems; then one big reserve is better than many small ones. This theory has received favourable attention from many conservationists, and also from Dutch "critical biologists", who usually criticize traditional Dutch nature conservation (Brussaard & van der Weyden 1980).

Let us first briefly review the theory with reference to MacArthur & Wilson (1967) and Gorman (1979). Any species population on any island will be subjected to two counteracting processes: immigration of new individuals and death of existing individuals. If we look at the total species composition of an island the two processes may lead to the immigration of new species and the extinction of existing species.

Both the immigration and the extinction rates vary with the number of species present. The immigration rate falls, since as more species become established fewer immigrants will belong to a new species. The extinction rate must rise because the more species there are present, the more species will become extinct due to the smaller average population size in connection with increasing interferences (competition!) between species. Obviously there is something like an equilibrium number of species.
For immigration we need a source, and that is of course either another nearby island or a continent. It will be clear that the immigration will be lower at larger distances. As to extinction it will be higher on smaller islands.

Finally it will be clear that the species composition will change, not only during the colonization or recolonization of islands but also at the point of equilibrium. This change is usually called turnover and the rate at which it occurs is the turnover rate. MacArthur and Wilson carry on with some mathematics to calculate such rates, and then indicate a link with a slightly older model of Preston (1962) which expresses the relation between the total number of species, $S$, on an island and the size of its area, $A$: $S = cA^z$.

This model has been confirmed in many studies of floras and faunas of series of islands. There are two parameters in this model, the average species number on unit area, $c$, and the more important index, $z$, indicating the rate of increase. Preston tried to make clear that in a series of islands which are more or less homogeneous in climate and topography the population sizes of the occurring species form a lognormal distribution and for that situation the $z$-value is calculated to be ca.0.27. In situations with areas of various size within a mainland, i.e. where the accessibility of species to all areas is high, the $z$-values tend to be lower, usually between 0.12 and 0.17. For series of remote islands or with a large variation in habitats $z$-values can be higher.

I prepared an example regarding the Dutch, German and Danish Wadden islands based on data from Abrahamse et al. (1976), in which we observe a clear deviation from the expected relation, i.e. only part of the islands fit the Preston relation. To explain this we have to go back to an earlier application of the theory of Preston to the entire Dutch flora, which aimed at evaluating one outstanding dune area, the Voorne dunes W. of Rotterdam, as to their species richness (Adriani & van der Maarel, 1968, van der Maarel, 1971). On the basis of systematic species counts for 5x4 km squares derived from the ordnance survey maps a Preston-type relation was found for species number and area in the Netherlands with a $z$-value of 0.28. Although the species counts date from 1910 and may not have been complete on the smallest areas the general relation seems to be valid. (The average number of species on one sq.km. as deducted from the relation is 70 while a recent estimate is near to 120; this would cause a decrease in the $z$-value to 0.23).

The line expressing the Preston relation for the Netherlands was used as a standard line and parallel lines indicating richness values 2x, 3x and 4x average are drawn (van der Maarel 1971). Species numbers for smaller areas were then compared with the average number for that area. In this way the Voorne dunes appeared extremely rich with a richness of more than 4 x average. Most of our Wadden islands are situated between the 2x and 3x parallels, which mean that they obey Preston's law with a $z$-value of ca. 0.28, and that their species richness is between 2 and 3 times the average for this part of the world.

Species richness and habitat diversity

It appears, that some islands, all smaller ones, are situated clearly below the others, i.e. around the standard line itself. A simple explanation would be, that the habitat-variation is smaller on these islands. Abrahamse et al. (1976) present information on the distribution of 10 major landscape types, such as low salt marsh, high marsh, beach, fore dunes, middle dunes and dune heath. Most species-rich islands contain 7-8 landscape types, but the poor ones have much less, down to 2. On the other
hand the Voorne dunes, which are also taken up in the figure would have at least 11 types when described in the same way, with own landscape types, such as dune scrubs, primary dune slacks, dune lakes and inner dune woodlands.

We now touch upon a weak spot in the island biogeography theory: it does not take habitat diversity into account in a systematic way. For a landscape ecologist the first source for species diversity would be habitat diversity. Such studies of island series are still rather rare. A botanical example is provided by Nilsson and Nilsson (1978) who studied 41 islands in a South Swedish lake. Now these islands are small and rather uniform. So we can understand that in this case the best predictor for species richness is still the size of the island. Abbott (1978) however, summarized studies by G.E. Watson and himself in which habitat diversity is the better predictor for species richness (notably birds) on islands. He also concludes that this aspect is neglected in island theory. Goeden (1979) comes to the same conclusion regarding habitat diversity in coral reef islands and the number of fish species living around them.

It is not yet clear how MacArthur's model can be adapted to cope with within-island habitat variation. And the same is true for a second type of habitat diversity: the temporal differentiation which results from the continuous disturbance or death and subsequent regeneration in any ecosystem (cf. Grubb 1977, Huston 1979). The island theory has not been modified either to cope with this source of diversity.

Species richness and island diversity

In relation to the foregoing I have to mention a further criticism of the island theory, or better of its blind application in nature conservation. From a conservation point-of-view we are interested in the total number of species (or comm.types) which can be maintained on a group of "islands", i.e. in a group of nearby reserves. If such related islands or reserves have a low floristic or faunistic similarity the total number of species will be greater in the ensemble than in any one of the individual islands if extended to the size of the ensemble.

Higgs & Usher (1980, Higgs 1981) have presented a formal analysis of this effect. If two subareas with relative sizes p and (1-p) have V species in common the total number of species $S_t$ as compared with $S_1$, the number of species on one area of the same size, is given by

$$S_t = c(pA)^z + c(1-p)A^z - V$$

while $S_1 = cA^z$

If we take for simplicity $p = 1/2$, we get

$$S_t = 2c(1/2A)^z - V$$

If the nr. of species on each of the half areas is called $S_g$ we can say:

$$S_t = 2S_g - V$$

We take the proportion

$$P_V = V/(2S_g - V)$$

which is in fact the well-known Jaccard-formula for the similarity between the two subareas, we obtain

$$S_t/S_1 = 2^{1-z} \cdot (1-P_V) / (1 + P_V)$$

We observe that the relation between $S_t$ en $S_1$ depends both on Preston's $z$ and the similarity between the two parts (cf. Higgs 1981 for the derivation). Clearly if $S_t/S_1$ is >1 the situation with two half-size areas gives more species than the situation with one full-size area. To mention just one example: for $z = 0.27$ Preston's theoretical value the two half area situation give more species as soon as the Jaccard similarity is lower than 0.66. This is easily reached. Higgs also makes clear that if we compare two very small areas they will contain only a fraction of the...
total species pool available in the wider surroundings. And that means a low Jaccard-value. On the other hand very small areas will have less stable floras. Higgs summarized effectively how various considerations from both biogeographical and conservational viewpoints can have arguments involved in favour of keeping one relatively big nature reserves as well as in favour of keeping more but smaller ones.

We cannot discuss all arguments here but the overall conclusion is far from unidirectional in favour of either strategy.

Extinction and immigration for various groups of organisms

As to the extinction it is clear that for each species there is a minimal area required to retain a minimal population of the species (Moore & Hooper 1975, Diamond 1978). Obviously the critical areas for most plant species are very small, whereas for large mammals and birds at the top of the food pyramid the critical areas might be in the order of sq.km.

There is another striking difference between plants, even between various groups of plants and animals and that is their capacity of dispersal. Without giving any detail now I may conclude that in general the dispersal capacities are not big, certainly not as big as we usually assume. I remind you to the so called Law of Beyerinck-Baas Becking "Everything is everywhere, the environment selects". It seems that this law has to be changed into: "Noting is everywhere and moreover the environment selects". This leads to a plea for the maintenance or even the creation of stepping stones and land bridges (cf. Helliwell 1976).

The vulnerability of nature reserves

One related problem here, which was also touched upon by Higgs (1981) is the fact of the ever-increasing negative impacts of environmental changes in the surroundings of nature reserves. We all know how fertilizers and biocides can enter nature reserves, even through deliberate disposal. We all know that recreation around and within nature reserves creates damage. And finally we know how urban-industrial activities have far-reaching side-effects, far-reaching even in a literal sense.

This all makes nature reserves rather different from islands in the sea. Thus from a landscape-ecological point-of-view we must again further modify the theory of island biogeography.

Environmental compartments and zones

The obvious solution to the safeguarding of island reserves from negative influence from the surrounding urban and agro-industrial sea is to create buffer zones. And more generally we should adopt a zoning system. First we come back to the division into environmental compartments. On the basis of the functions I mentioned we suggested 8 environmental compartments. They are presented in Fig. 1 in relation to the degree of naturalness and the degree of complexity (van der Maarel 1979). At the same time the four compartments of Odum (1969) are indicated.

1. Information - regulation INRG: This is the nucleus of Odum's protective compartment;
2. Information - biotic production INBP: This comprises natural ecosystems with a dynamic character and semi-natural types with extensive exploitation;
3. Information - landscape recreation INLR: Here mosaics of natural and semi-natural ecosystems with agricultural systems are characteristic and quiet forms of recreation are tolerated;
4. Rural RU: This compartment comprises "green" areas which are used for functions such as water catchment, purification, military training, extensive recreation and agriculture;

5. Agricultural AC: This is Odum's productive compartment with intensive forms of agriculture;

6. Urban UR: Although this compartment uses the natural environment intensively it is a non-vital compartment. It is a very vital, though dependent compartment with a high degree of complexity;

7. Substrate-bound recreation SR: This compartment is small in size but special in character, it comprises areas in which intensive forms of recreation are organized: sport fields, campings, parks in urban regions etc.;

8. Abiotic production and industry AP: Here areas arranged for mining, energy "production" and industrial activities are dominating.

According to the ideas on function interaction we can judge the compatibility of environmental compartments, i.e. the possibility or impossibility to combine compartments in spatial complexes.

Fig. 1. Environmental compartments in relation to naturalness and complexity.

Environmental zoning can be based on the compatibility of such compartments. Clearly our nature reserves, representing the INRG and INBP compartments should be embedded in a buffering sea of extensively agricultural and rural compartments (cf. van der Maarel 1979 for some examples).

Conclusion

The planning of nature reserves can be based on island biogeographical theory, but it should not be based entirely on that. Clearly landscape ecological theory, including habitat diversity theory should play a major part as well.

Acknowledgements

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References


Blackwell, Oxford.


ENVIRONMENTAL DEGRADATION IN SAVANNA DERIVATION

J. Oladipo Adejuwon

Department of Geography, University of Ife, Ile-Ife, Nigeria

Abstract

Savanna, a major vegetation of the humid tropical land has now become widely accepted as anthropogenic, existing because of the activities of man. The natural vegetation replaced by the savanna is tree rather than grass dominated. The process of savanna derivation is a process of resource degradation affecting forest products, wild life, water and soil. The restoration of the resource status of savanna areas calls for judicious utilization of land for agricultural practice and the control of forest fires.

Introduction

The dynamics of tropical vegetation revolves around questions relating to the existence of savanna as alternative to forests. Forest, as used here, is a type of vegetation consisting predominantly of woody plants and from which grasses are virtually absent, (Hopkins, 1965). On the other hand, the distinguishing feature of the savanna is a herb layer dominated by tall grasses, although shrub and tree elements are almost invariably present.

The 1964 ICU/UNESCO symposium held in Venezuela on the ecology of savanna/forest boundary reached a number of conclusions which are pertinent to the understanding of the ecological status of the tropical savannas. The participants at the symposium were reported by Denevan (1964) to be in general agreement on the following:-

(i) That there is probably no savanna in the humid tropics which can be primarily explained by climatic conditions.

(ii) That the majority of tropical savannas are anthropogenic, existing because of the activities of man.

(iii) That there are also natural savannas which can be considered as edaphic climaxes.

One very important question which arises from the above relates to the climax or matured vegetation from which the anthropogenic savannas were derived. Adejuwon (1976), reviewing earlier works, concluded that the natural vegetation replaced by savanna is tree-rather than grass-dominated and include, in the humid areas, the Tropical Rain Forests, and in the sub-humid areas, the Tropical Deciduous Forests.

Processes of Savanna Derivation

The hypothesis that the savanna is anthropogenic - occurring because of human activities - can be substantiated by referring to two aspects of
the dynamics of the vegetation of Nigeria. These include:

(i) The tendancy for savannas to occur in areas liable to cultivation because of good soils and topography while inaccessible and areas otherwise unsuitable for cultivation are under woody and or non-savanna vegetation.

(ii) The close areal correlation between the stature and foliage density of trees in savanna areas on the one hand, and distance from centres of population concentration on the other. Woodland savannas exist in areas with low density of population while park and shrub savannas dominate areas of high density of population.

An area, long and intensively used for agriculture is characterised by a process of vegetation degradation, the end product of which is the savanna. Under the prevalent rotation bush-fallow system of cultivation, a farmer clears a small plot from forest and crops it for a year or two after which it is allowed to revert to a bush fallow. The plot replenishes its soil fertility during the period of fallow which may last from four to ten years. The process of savanna derivation can be noticed in the regrowth after cultivation which gradually changes from woody fallows to grassy fallows and ultimately to savanna. Grass becomes progressively more important as a result of necessary elimination of trees to reduce the shade on growing crops. Moreover, grasses and other annuals are better adapted to survive because of a relatively short life-cycle.

At the advanced stages of the process, a completely new ecosystem is created in which grass can flourish, and only the hardest trees can be tolerated. Grass elements such as Andropogon tectorum Schmach, Imperata cylindrica Beauv., Panicum maximum Jacq., Pennisetum purpureum Schum dominate the wetter areas, while in the drier zones Pennisetum ramosum Schweinf., Sorghum aethiopium Stapf., Sporobolus spicatus Kunth, Phragmites communis Trin and Hyperhenia newtonii Stapf are dominant. Once established, these grassy fallows are liable to be burned, and the fierce fires further contribute to the elimination of the trees and shrubs. The rate and the degree of degradation appear to vary not only with the intensity of human activities, but as well with biological productivity. Thus area of Deciduous forests (with lower biological productivity) tend to be more widely converted to savanna than the areas of Tropical Rain forest.

Resource Degradation

It would be easy to appreciate that the derivation and maintenance of the savanna as the dominant vegetation type in the sub-humid parts of the tropics constitute a degradation of environmental resources. This can be substantiated in Nigeria with reference to natural landscape, forest products, wild life, water and soil resources.

Natural landscape:

A complete elimination of natural landscapes including their mature plant and animal communities, their soils and terrain represents an ecological degradation of the first order. This would be difficult to appreciate in view of the fact that the large human population on the earth's surface could not be maintained without converting areas of...
wilderness into farmland. There is no other way of obtaining the large amount of food required in feeding the world population today than by agriculture. One needs therefore to point out that it is not the removal of the natural biological community of a particular area but the complete elimination of a regional type.

The environment is impoverished in two respects if the occupation of a region is complete without leaving any patch to nature. Firstly, from the scientist's point of view, the wilderness can be regarded as reference point in explaining the dynamics of environmental systems. It would be difficult, for example, to assess the biological potential of any surface unless the climax vegetation for the area is known. In the absence of relic areas, it would be difficult to reconstruct the climax vegetation in the region. According to Greenwoods and Edwards (1973), it is through the study of such climax communities that one can tap the knowledge needed for managing man-made ecosystems. Secondly, as sanctuaries for endangered plant and animal species, the natural landscape acts as a genetic bank contributing in no small way to the maintenance of ecological balance and stability. The more complex a biological community is in terms of its multiplicity of species and life forms, the more stable it will be. As human activities tend to replace complexity with simplicity, the existence of wildernesses in a given region protects the environment against catastrophic genetic degradation and susceptibility to other forms of environmental damage.

Forest Products:

As a result of the widespread replacement of the natural forests by savanna, vital vegetal resources have been destroyed. At present, the savanna areas are virtually written off as sources of timber. Practically all of Nigeria's current production of timber comes from the rain forest areas. The reason for this is not because the savanna areas are not capable of yielding good crops of timber, but mainly because the processes leading to the derivation and the maintenance of the savanna are not conducive to the existence of good timber trees.

Some of the dominant tree species of the savanna zones have been adjudged capable of yielding high quality woods. These include Anogeissus leiocarpus Guill & Perr., Daniellia oliveri Hutch & Dalz., Diospyros mespiloformis Hochst., Isoberlinia doka Craib & Strapf., I. tomentosa Gaib & Strapf., Khaya senegalensis Juss. and Pterocarpus erinaceous Poir. (Comben, 1964). Isoberlinia is the most abundant and characteristic tree of the Northern Guinea zones. Khaya is widely distributed in the savanna regions especially in the Guinea and Sudan zones. Anogeissus occurs in all savanna zones from the driest margins to the forest border. Diospyros and Pterocarpus are also widely distributed. Diospyros is however relatively prominent in the Sudan zone. Daniellia is especially abundant in the Southern Guinea zone and the Derived Savanna.

The timber produced from each of these trees has been rated fair to fairly good. Khaya senegalensis is classified among the light timbers. It provides the best surfacing of all mahoganies. It is very useful in furniture, construction of railway carriages and prefabricated buildings.

Daniellia and Isoberlinia belong to the medium hard timbers. They are reputed to work easily by hand and machine tools. A good clean finish is usually obtained. In most operations of cutting, sharp edges are
maintained. Daniellia is recommended for building while Isoberlinia can be used and in fact is being used for railway sleepers, high class joinery, door and window frames.

Pterocarpus and Anogeissus are the hard, strong and heavy timbers. Anogeissus is recommended for fence posts, pit props, bridge work, tool handles and industrial flooring. Pterocarpus is very strong and yet easy to work. It sands well and finishes smoothly. It is reputed to be a very decorative wood suitable for all purposes for which an attractive appearance is desired. It is also suitable for heavy construction.

The luxury category of timber is represented in the savanna by Diospyros. It provides not only the dark ebony in the centre of the log, but also the very hard, close textured wavy and interlocking grains of light pinkish to pinkish brown wood also suitable as timber for tool handles, gun butts, vehicle bodies, joinery and flooring blocks.

In addition to these, there are exotics which can be profitably introduced into the savanna areas (Iyamabo, 1971). These include Azadirachta indica Juss extensively planted in the Sudan zone, Eucalyptus species (recommended for the Northern Guinea and Sudan zones), Gymelina arborea Roxb and Tectona grandis Linn, both of which are widely planted in the wetter savanna zones.

Destruction of valuable timber is affected chiefly by annual fires. First, seedlings are destroyed, thus limiting the population of tree species. Second, the seedlings that survive suffer great deformity as a result of exposure to the lethal heat of the annual fires. Third, the scotched parts of the boles usually form the points of entry of pests and diseases which limit severely the quality of the wood. Thus in the processes of the derivation and maintenance of the savanna, valuable environmental resources are lost.

It is true that the needs of Nigeria is served at present by the rain forest zone. With the present rate of development however, it will surely not be long before timber may have to be imported. The vast potentialities of the savanna therefore need to be carefully managed to ensure adequate timber supply in perpetuity.

Wild Life:

The processes of savanna derivation have also led to the destruction of the habitats of several wild animals with the result that their numbers have been drastically reduced. Some have even become extinct. Elephant, manatees, giraffe, rhinoceros, hippopotamus, buffalo, lion, leopard, cheetah, hyena, jackal, chimpanzee, colobus monkey, baboons and a variety of other monkeys together with birds, crocodiles have once been widely distributed in the Benue/Plateau States (Sikes, 1973). However, as of now, most of them including elephants, lions, cheetah, hippos are now restricted to a few areas. The rhinoceros is extinct.

Jia (1964) recognises farming and bush fires as the main causes of habitat destruction. These also are the chief factors of savanna derivation. It cannot be contended that hunting plays a significant role in the process of decimation of wild life. However, with the large areas of low density of population especially in the Middle Belt area of the country, one would have expected the animals to migrate and concentrate in
such areas. Except for baboons which occur in large numbers, few species seem to have made use of the advantage of such migration. Wild-life in the frontier zones is not particularly richer in species than in the other more densely populated parts. This can only be interpreted to mean that such factors as fire with a general effect throughout the savanna zones are more important than farming and hunting in bringing wild life population to its present level.

Annual burning does not only destroy habitat, it destroys food and even the animals themselves. During the dry season, some of the fires are started by people in search of meat. After the fire in each area the people go about collecting the carcasses of those that have been killed. Over large areas however, there are not many people around and the dead animals are left to rot. The younger animals are particularly susceptible to fire destruction. Also land animals are more vulnerable than those that can climb trees and rocks in order to avoid the fire.

Limited protection offered by the Yankari game reserve of Bauchi State since 1956 has resulted in a rapid multiplication of population of a large number of species.

Water:

Horne (1964) has rightly observed that the single factor limiting development in the Nigerian savanna is water. Yet Northern Nigeria is not a dry country in terms of the mean annual rainfall. Over the larger part of the savanna zones mean annual rainfall is more than 1,000 mm. A good proportion of the water falling as rain, apart from that which is lost through evapotranspiration, is not available because of (i) the concentration of the rain in a few months of the year and (ii) the heavy nature of each downpour. Thus there is high intensity of both single falls and seasonal rainfall. All that is required to make the water falling as rain effective is a technique of management that would save water during the rainy season for use during the drier period. Under natural conditions, a thick vegetal cover helps in many ways to conserve water.

The widespread destruction of forests and their replacement by savanna has therefore been instrumental in aggravating the water problems. First, the degraded vegetation increases runoff. This could be expected to increase flood peaks and streamflows at the beginning of the rainy season. Thus a large proportion of water that would have gone to recharge ground and soil water is lost. Second, there is increased soil erosion which leads to increased silt load in streams and the silting up of dams and reservoirs. Third, degraded vegetation also leads to reduced infiltration resulting in reduced ground water supplies and shortened period of streamflow. Thick forest cover usually acts as a sponge breaking the fall of heavy rains and therefore affording good time for the water to soak gradually into the ground. Instead of rain drops striking the soil surface directly, it comes down along the leaves, branches and trunks taking several hours.

Conservation leading to the re-establishment of forests should therefore be expected to have beneficial effects on water availability in the savanna zones.

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Soil Erosion:

Evidence of accelerated erosion have been found in some locations in the Nigerian savanna belt.

Ologe (1972), de Swardt (1946), Grove (1952) and Lewes (1962) have conducted studies on erosional problems in the savanna region of Nigeria. The recurring conclusion in these studies is that man, through his activities - cultivation, grazing and bush burning, is capable of increasing rates of erosion and sediment yield. The magnitude of erosion seems to depend on the extent to which cultivation and grazing practices affect run-off, soil stability and the tendency of the soil to cap.

The undesirable consequences of soil erosion in relation to forestry and agricultural practice are too well known to deserve anything than a passing reference here. Suffice to comment that soil erosion constitutes a serious problem in water resource management and agriculture. As a result of the removal of the top soil layer, infiltration capacity is reduced leading to increased run-off and flooding; and reduced ground water storage and period of stream flow. Also the large amount of suspended and bed load carried by the rivers increase problems of sedimentation and eutrophication in lakes and reservoirs downstream.

Again, it must be realised that the problems of increasing soil loss is related to the removal of the original forests and their replacement by the more open park and shrub savanna.

Conclusions

The two aspects of human activities leading to the derivation of the savanna are agricultural practice and the introduction of fire. Agricultural practice as it is done in these areas cannot be regarded as mis-use of the environment for two reasons. First, the dominant method of agricultural production is the rotation bush fallow system. This has been widely accepted as a most reasonable system from the conservationists point of view. The soil is protected and allowed to be renewed under fallow vegetation. Continuous good growth of crops and wild life is therefore ensured. Second, agriculture in these areas provide a set of human needs which cannot be otherwise procured. The savanna areas are probably better off with these products than would have otherwise been the case. The products sustain local exchange and as well provide a considerable part of the production for export.

Savanna will therefore form part of the best managed agricultural ecosystems in the zones they now occupy. However, the occurrence of savanna in areas not being used for agriculture indicates mis-use of environmental resources. Such savannas are in the main, results of bush fires. The resource management innovation that needs to be introduced in the complete control of fire.

To many, a complete control of fire is almost impossible to achieve. There are very good reasons for holding such an opinion. A number of such fires occur accidentally or through carelessness. Other fires are set deliberately to the bush as a means of procuring meat of wild animals. It is considered a rather herculean task to attempt dissuading people from such practice. Also bush fires are used with good effect in encouraging early growth of grass at the end of dry season for the
benefit of cattle and other life stock. Moreover, it has been suggested in highly respected circles that the replacement of forests and woodlands by open savanna should be encouraged as a way of eliminating tsetse flies and thereby controlling trypanosomiasis.

However, it appears that the balance of advantages is on the side of a control of bush fires and a reestablishment of forests especially in areas not likely to be put to agricultural use in the immediate future. It is believed that through a programme of education, the people in these areas could be made to realise the gravity of the destruction which annual fires cause and cooperate with government agencies concerned with fire control. The time is ripe for the government to institute a range fire fighting organization with adequate equipment and training facilities. Apart from these, legislative action is required to give legal backing to the measures designed to control bush fires. The task ahead certainly is not an easy one, but it is not impossible. All that is needed is determination and commitment to the programme of conserving our wild vegetal resources for posterity.

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Abstract

In connection with nature protection, land ecology primarily deals with geographical forces ruling the suitability of any place on earth for nature, i.e. for any of its organisms. These geographical forces differ basically from the bio-physiologically operational stimuli organisms respond to. Physically, the latter are fluxes, resulting from driving forces and transmissivity factors in the surroundings of the organisms.

In planning of surveys as well as policy, macroscopic models of the deducted system may show useful. The above tripartition of environmental factors has been explored as a possible basis for such a macroscopic systems model. For shortness of future communication, several words have been introduced. Fundamental concepts are the ecodevice and ecological field ones. Reference has been made to other publications using this model or some or more of its elements or forbears. This paper can be regarded an addendum to these publications and a call for broadened discussion.

Examples of application have not been given in the paper. Some studies are mentioned, however, which more or less explicitely do so.

Introduction

Nature protection aims at regulation of the environment to have certain organisms survive. In The Netherlands, mainly biological effort is put forward to combat the deterioration of habitats, suited for several organisms of nature. The processes involved in this deterioration continuing, widely available bio-ecological knowledge is confirmed daily: many human activities are far 'more' anyhow than most organisms can stand in their habitats. A change of species composition is noticed: obviously, common species become more common and rare ones still more rare, they become threatened with extinction from a region at least.

If it is agreed biological species fit a specific environmental template, which may be coproduced by other species, the interest is not primarily in the specification of this template or the way species get around with it, but in the question whether it will be affected by human activities or not. So the problem appears to be one of transfer of change in the environment. If change is transmitted as a result of transports of clearly defined physical quantities (including chemical or biological matter), key points will be linking the organisms sense of change to physical quantities and routing these change agents through the system.

A maior step in the technique of nature protection in The Netherlands has been the introduction of the concept 'milieudynamiek' or environmental inconstancy by van Leeuwen (1966) in his Theory of Relations (see also: Bakker, 1979 and Westhoff et al., 1970-1973). As their is uncertainty about the analytical nature of this deductive quantity, it will be kept vague in this paper by referring to it as 'midy' shortly.
According to this theory now, every place is said to have a certain amount of midy of its own, to which a supplementary amount is added by the continued human use of the site. Organisms that tend to become rarer as their stations become more intensively used by Man, apparently hate high amounts of midy, whereas those, becoming commoner, love it. Thus, organisms can be used as midy indicators, by just monitoring their occurrence in areas influenced by midy import. This is virtually all of The Netherlands today, as only some isolated nature reserves seem to escape from the processes involved. Yet, in the early stages of human occupation, use of the environment is by regionally redistributing midy, for instance by mowing and grazing large and remote areas of the region in favour of having arable fields close to the settlements. As many species endangered with extinction in The Netherlands now, showed an apparent increase in the past in the remote areas just mentioned, we cannot but conclude the natural amount of midy of those areas was negatively influenced by the addition of some operational human midy. With respect to this, it is convenient to suppose there are latent or inactive forms of midy, next to active forms. Biomass would represent an inactive form of midy, which can be transported by applying a relatively small amount of active midy. If, in a more or less equilibriated geobiocoenose, the mean annual storage rate equals or only slightly exceeds the mean annual activation rate, disposal of stored midy will eventually lead to a decrease of active midy.

Van Leeuwen has derived some rules for guessing midy from physically known aspects of the environment. For instance, several aspects of energy and mass represent midy positively: warm > cold, rich in nutrients > poor in nutrients, wet > dry, moving > calm. In the application of these rules, it is necessary to have some knowledge of the interaction of these midy-components. If an area is made drier, for instance, this may lead to an increase of midy. Physically, this can be understood by assuming nutrient supply has increased by diminishing wetness impact on soil mineralization processes. A relatively high degree of movement of groundwater may, in other cases, be important to maintain high calcium-levels in a soil, thus effectively controlling phosphorus uptake by plants and resulting in the presence of apparent midy-haters. Users of the midy concept in The Netherlands know a lot of these things by experience from a wide range of types of land. They are therefore regarded a kind of sorcerers by those trying to translate randomly gathered ecological data into midy. The latter category even tends to ban the whole subject from official science. In an attempt to bridge this gap between expert judgment and formal science, Van Leeuwen and I have worked together from 1975 onwards, developing descriptive tools in order to enable more formal scientists to reconstruct the lines of thought. The present paper is, in addition to that by Van Leeuwen (1981), meant to draw attention to some of those tools.

The main points combine into design requirements for landecological survey for nature protection, organized in some macroscopic systems model. Some parts of this model will be loosely discussed below, with emphasis on their description, relation to published concepts, and use. Tools for the execution of a real survey will not be given: they can be found in several textbooks on such fields of knowledge as soil science, hydrology, water chemistry and others. The macroscopic systems model just helps in the design of the survey; it is made to learn what available tools should be used at what instances in the execution of a survey. Or: if important things are found by chance, this model should help to increase the chance to find important things, but it does not change the rules for scientific proof.
The organism to be protected is invariable

Accept, for the moment, nature protection aims at regulation of the environment to have certain organisms (those, otherwise threatened with extinction) survive in acceptable numbers.

Suppose, now, all individuals of a biological taxon react with their environment according to the same predetermined main part of their, say, biological program. At the lower hierarchical levels of taxonomy, and typically in species, this main part is nearly all of the biological program available. Noisy behaviour of individuals is neglectable. Exchange of biological program is controlled by heredity and can usually be considered without any alterations. In Homo sapiens, however, the biological program contains a routine, capable of generating technological program interactively with the environment and the prevailing contents of the continually growing technological program bank. Technological program exchange between individuals does not use heredity control and is not by exact duplication. Predictable trends have been detected by the social sciences. Yet, in land (systems) ecology, technological program is safely dealt with as (alternative) constraints, to be defined in scenarios. Requirements to have scenarios realized or probabilities of scenarios to become reality should be afforded by social scientists.

Consequently, an organism's biological program determines the environmental template it needs to feed on and discharge into: the habitat it fits. Saying the habitat is surrounding concentrations, the milieu of its inhabitant is the feeding and discharging fluxes it is subject to in the habitat. If, with irreversible thermodynamics, the complex of concentration gradients in the habitat-organism interface is the generalized driving force in producing the organism's milieu, the milieu is generalized fluxes, the organism's envelope representing transmissivity factors or phenomenological coefficients. Strictly speaking, habitat and milieu are only there, once the organism is in. If an organism moves around, it is supposed to carry both along with it. Measuring milieu will therefore be limited to large and homogeneous habitats, surrounding more or less spherical organisms (microcosms with free-floating algae) or to the use of dummy inhabitants. (Most measuring tools are not too realistic as dummies). In nature protection, habitat and milieu must be considered inaccessible for operational regulation. The organism as a subject of protective regulation may thus be replaced by a lump of universe which contains it and which is equal to or greater than the organism plus its milieu plus its habitat. This lump of universe, in a systems approach, is an ecologically 'working' black box.

Note that, with regard to this, nature protection differs from, for instance, agriculture. In agriculture, it is possible to develop new organisms, provided with biological programs making them more suited for breeding purposes. Moreover, in addition to protective regulation as nature protection uses it, agricultural regulation may be executed in the habitat itself. Examples are the supply of water and nutrients or the removal of 'natural enemies'. In doing so, agricultural Man as it were by himself partly replaces the lump of soil which he would use in nature protection. The organisms concerned will presumably die back when Man does. For this reason, even when it would seem possible to do so, nature protection should not use regulation within the habitat. Here is the main difference between culturing and protection.
Ecodevices in an ecological field yield suitable habitats

Apparently, organism and remoter environment coproduce habitat and milieu in a supply and demand system. The organism part in this system is, by its biological program, invariable. If a certain habitat continues to exist, in spite of the organism feeding on and discharging into it, this is most likely caused by an upkeeping or protective machinery in the remoter environment. In the design of a survey for nature protection, this machinery is the black box lump of soil mentioned in the earlier paragraph. At the same time, this machinery may be able to stabilize the driving forces in spite of environmental oscillations or trends. Destruction or generation of habitats can thus be attributed to variations in the performance of this machinery, and, the other way round, man can improve it to deliberately protect habitats. The most typical example of such an improved habitat protecting device, is the human house. The type of machinery meant is therefore called ecodevices (Both & van Wirdum 1979, van Leeuwen 1981, van Wirdum 1979a), and, from the point of view of nature protection, classified according to the immediate user organism. Ecodevices, driven to produce or improve or protect the habitat of Homo sapiens are called humecs (houses, towns, arable fields, meadows, recreational areas, water purification plants, rubbish-dumps, etc.), whereas those for the protection of nature (against the side effects of humec driving!) are called natecs (van Wirdum, 1981). There is some discussion about the use of the combination nature reserve today, but, typically, natecs are nature reserves and, anyhow, all nature reserves are natecs.

To safeguard minimum and maximum concentrations in the habitat to be protected, an ecodevice must be able to enlarge or diminish both the incoming and the outgoing flows. This combines into four basic functions: supply, disposal, resistance and retention (compare also van Leeuwen, 1979). It is convenient to use the generalized driving forces — phenomenological coefficients — generalized fluxes idea again, the phenomenological coefficients being represented by the ecodevice this time. As the driving forces show geographical gradients, they are described by an ecological field. The type of relation of the field, the device and the habitat (more precisely still: the milieu) with the organism is intuitively talked about as positional, conditional and operational respectively (van Wirdum, 1979b). Bad performance of an ecodevice can have two main causes: device failures or field failures. Organisms, however, do not fail. Main trends in environmental and nature protection are: striving at constancy in the ecological field; adapting otherwise unsuited local field properties; and reconstruct ecodevices. Examples of these respective trends are: emission control by law; surrounding a natec with buffer zones; and digging down a natec soil. It is possible to have a single grain of sand as an ecodevice, as well as the whole earth. Most applications however will concern devices of a degree of complexity somewhere inbetween. Smaller devices will be dealt with in practice as ecodevice components.

Ecosystems can serve to understand the use of ecodevices

Destruction or generation of habitats has been attributed to variations in the performance of ecodevices, and, the other way round, it has been said, man can improve ecodevices and drive them to deliberately protect habitats. It would have been convenient to name the human conception of real devices, in advance of their deliberate use, ecosystems. The system, thus, is a mental abstraction which helps man to understand the use of ecodevices.
stand things of nature. The device would be the realization of a modified system, helping man to have nature do things he wants it to. For this reason, van Wirdum (1979a) tried: 'An ecosystem is an explanatory system of extra-individual relations between a particular phenomenon of living nature and its environment'. The mentioned phenomenon, or 'ecotopic', should itself be considered a dependent factor. The ecotopic can be an individual organism (marginal case), a species, a population, a set of such things, or, probably, the occurrence of certain soil types, (un)polluted waters, etc., which can be regarded phenomena due to living nature. Sloep (1980) hit at an apparent lack of formal rigidity in this definition and made a pro parte reconstruction, which should be accepted as a typical case: 'An ecosystem is a system of formal non-trivial relations of properties of a biological species and properties of its environment'. He argues this typical case is a very unusual one, as it allows for a species to be the subject. Is the present ecosystem the same logical entity other authors on ecosystems seek to talk about? Three points can be made with respect to this question.

At first, many authors say you can walk in an ecosystem, photograph it and identify it with an identification key (Ellenberg, 1973). Straightforwardly, Odum (1975) makes it a synonym of the biogeocoenose (compare also Fortescue, 1980). Yet, Tansley (1935), claimed the ecosystem is the fundamental concept appropriate to a biome considered together with all the effective inorganic factors of its environment. Effectiveness, now, might be slightly different from just being there! Moreover, Odum stresses the holistic idea with the wellknown example of the water molecule, the properties of which are supposed to be different from what can be expected from the properties of both elements present. Exactly this key point of systems is lost in the way biogeocoenoses are recognized: a biogeocoenose is determined by saying, to put it that way, two H plus one O is water. It might well be that the only property that can be ascribed to what is conceived as a system in the whole thing, is just the occurrence of certain species. So, if a particular phenomenon of living nature (which may be a biological species) is the emerging property of a certain biogeocoenose as a system, it is all perfectly in order. If, however, the local presence of the biogeocoenose is the emerging property, the abiotic factors considered effective, will only rarely be confined to the same horizontal area where the biogeocoenose can be recognized and so the whole system will.

At second, many authors mix up their holistic views with the idea of superorganisms. To be operational, my definition requires the user to state how much explanation is desired. Otherwise, the ecosystem concept would converge with the universe one. Here, Margalef (1968) is found paving my way: "Any ecosystem under study has to be delimited by arbitrary decision, but one has to remember always that the imposed boundaries are open, and that the sort of interaction going on across such boundaries is dependent on the properties of the two systems on either side of the boundary. With this proviso, all the problems of defining closed ecosystems, limiting superorganisms, etc., happily vanish. The open ecosystem is also suggested by Jenny (1958). The arbitrary decision in defining the extent of a system is indicated in many more or less fundamental systems texts. The point probably is, studying a moorland pool algae vegetation as a microcosm, differs from being a conservationist involved in the protection of species bound to land gradient belts. Consequently, however, also the recognizability of biomes and biogeocoenoses is doubtful, unless it is done by systems analysis as defended herein.

At third, there is discussion whether a system is some concrete part
of reality (like with Margalef and also like a biogeocoenose), or an abstraction of it. In physical sciences, such definitions as (just an example is quoted): "The part of the universe under study in thermodynamics is called the system" (Levine, 1978), can be found. Obviously, however, the students of those systems have a very abstract picture of the universe, provided with frictionless axes, adiabatic walls and more of this type of phantasy things (see textbooks, e.g. Kronig, 1966) and they seem to hate too open systems. In Systems Theory, much emphasis is on the abstraction to be made (compare Pask, 1961), and Sachs (1976), dividing between a teleological and a structural-relational approach in systems science, is clear about the latter: "... this approach fails to capture the essence of the notion of system, as that term is generally understood among systems scientists". If we accept that the reality of those physicists mentioned is just their mental image of reality, having more or less closed systems justifies the fact they do not always confine their systems according to definite would-be emerging properties. Land ecological reality however probably does not afford this type of systems. As it has been stated in the second point, ecosystems are fundamentally open. Now, effort in finding boundaries in reality is no longer mainly to limit the system, but to limit what one is going to study the system of. Thus proceeding, systems will gradually build up ones operational image of reality.

In the setting of nature protection, the ecosystem concept tells there is more than just directly operational influences of man on populations of threatened species. Protection is to be done by improving their 'houses', which we conceive as ecosystems. The systems idea should guide inquiries of real devices of unknown internal composition and handling instructions. In the whole process of inquiry, the internal composition may stay unknown, but knowledge of the handling instructions must be gained to enable the draft of a user's manual, referring to the organization of the device. This organization is the system.

Organisms are used in driving ecodevices

The ecodevice is deliberately used by bringing the most damageable elements of reality in the regulatory part of the ecosystem under human protective control. Thus, the beneficiary will be made less sensitive to undesired environmental influences. The organism is the typical beneficiary of ecodevices, but it is also used as part in the devices themselves. The internal structure of an organism is only considered by saying it is provided with a fixed biological program. If there is no organism available which has the biological program desired, it can sometimes be made e.g. by a process of adaptation to a standard available ecodevice: domestication. Of course, this does not apply to an organism which has to be protected.

According to their type, organisms are applied in driving ecodevices, either as working or as sensory parts, or they are the goal of the whole thing. In the use of organisms, no stochastic behaviour of any importance should be allowed.

Apparently, three types of organisms can be distinguished:

a) Goal organisms (goals), their presence being the emergent property of an ecosystem and the goal of an ecodevice. Examples: Homo sapiens is the goal in all humec driving. In the independent use of specialized partial humecs, as in agriculture, e.g. cow is used as a substitute goal. Carex dioica is a goal in nature protection in The Netherlands. If more eatable or less demanding stuff or species can be made or found, agriculture will drop cow; if Carex dioica is no longer threatened in
The Netherlands, it will be dropped by nature protection. Man will presumably never be dropped as a goalo.

b) Working ecodevice component organisms (wecos), doing physical labour within the ecodevice. Examples: cow can be an important weco in nature protection. Horse formerly was in agriculture and urban technique. Now, it has been replaced by tractor and car respectively.

c) Sensory ecodevice component organisms or indicatory organisms (indos), sensing changes of ecodevice performance and informing the ecodevice driver about this. Examples: lichen species are indos in the atmospheric branch of environmental hygiénics, like Escherichia coli is in the water branch. Dirkse (1977) gives an interlocking series of indos, composed of Carex species, each of which is most useful once the next is goalo in nature protection. If improvement is aimed at, as it basically is in techniques, the first missing species in the series should be goalo until it is there and indicates moving on to a next goalo is opportune.

References


PLANNING FOR THE MANAGEMENT OF NATIONAL PARKS

M D Hooper
Institute of Terrestrial Ecology, Monks Wood Experimental Station, Huntingdon, Cambs, UK

1 Introduction

In 1976 the Nature Conservancy Council commissioned the University College London (UCL) Conservation Course to develop a format and system for planning nature reserve management. Having reviewed existing formats and systems the UCL Course tested their ideas on five nature reserves and published a format and system. (Anon, 1976; Wood & Heaton, 1976). In subsequent years the UCL Course tested this format and system on areas much larger than the usual British Nature Reserve:- the National Park of Garraet el Ichkeul in Tunisia in 1977, The Covadonga National Park in Spain in 1978, and the Burren in County Clare, Ireland in 1979. As I was on secondment, from the Institute of Terrestrial Ecology, (ITE) to the staff of UCL from 1976 to 1979, I was fortunate enough to take part in all three exercises. In this paper I describe briefly the format and system; for which the UCL staff should have the credit. I will also describe some of the developments and my own impressions; for these I will accept partial and full responsibility respectively.

2 The UCL System

2.1 The UCL Format

Management plans contain three categories of information. In the UCL format they are allocated to distinct parts of the management plan:-

| Part 1 Description | see next page |
| Part 2 Policy and Prediction | |
| Part 3 Prescription | |

The prescriptive section, stating what must be done, may be regarded as the most important because it directly relates to management of the reserve. Nevertheless, Part 3 can only be authoritative if it is based on the background knowledge contained in Part 1 and follows policy decisions made in Part 2. However, preparation of an interim Part 3 document should not be delayed until these other parts are available, although subsequent preparation of these will almost certainly mean a revision of Part 3 is necessary.

Alternatively Part 2 may be regarded as the core of the plan as it contains the original reasons for the establishment of the Reserve or National Park, and an up to date evaluation of the area plus a statement of the policy for management.

Part 1, in contrast, is apparently simple: a description of the area and what is to be found there. In many ways this too, may be regarded as the most significant part of the plan as it is impossible to
proceed to the evaluation and policy of Part 2, and proposals for the implementation of that policy in Part 3, without having an inventory of what is present.

For me the major points of interest in the format concern subsections of Part 2 - Chapter 2.2 on Evaluation is divided into 2.2.1 Evaluation of Important Features and 2.2.2 Assessment of the Potential of the Site. But it is not the fact that UCL have included potential development which I find most significant here, but that they have produced a simple method of evaluation by tabular comparison. To an extent this is still dependent upon subjective valuations but does make clear both the origin of the judgement and the relative importance of physical, biological or cultural features for preservation.

Chapter 2.5 is also of interest in that UCL have thought it worthwhile to provide guidance to the reserve manager in the form of limits, below or above which, action is imperative. The limits are in the form of area for habitats or vegetation types, or numbers for populations of individual species of interest.
Many will feel that giving limits can only be arbitrary, but although, subject to later revision, they can be valuable in clarifying the objectives and difficulties of management. They are also useful as indicating thresholds beyond which positive action may be necessary; they act as criteria in a programme monitoring the effects of management.

2.2 The Planning Process

The usual sequence of events has been: first a period gathering basic information; second a site visit or visits to verify and extend that information; third a period of evaluation and discussion of the information; and finally a period of writing the formal plan.

2.2.1 For smaller areas, the Nature Reserves in Britain, one person assumes responsibility. Others may be involved at various stages. Indeed their assistance may be essential to complete certain parts but final responsibility rests with one person.

2.2.2 For the larger areas, the National Parks, the final plan has been a group effort of some fifteen to eighteen people; composed of five or six staff and eight to twelve postgraduate students. For the purpose of gathering information and site visits the group has been subdivided: for example botanical, zoological, geological subgroups. For evaluation and discussion all are equally involved and, for the final writing of the formal plan, individual responsibility for separate sections was given to one person with help from members of one of the old, or even a new, subgroup.

The involvement of a large number of people has been of considerable benefit in modifying or developing particular areas of interest within each Park plan. Indeed the group interaction could be regarded as the most important single factor leading to a successful plan.

3 The Planning Process in Action

3.1 Descriptions of the three areas

3.1.1 Ichkeul

Ichkeul National Park occupies the northern half of the plain of Mateur in the Gouvernorat de Bizerte, northern Tunisia. It lies 20 km south west of the town of Bizerte, and 60 km to the north west of Tunis.

Garaet el Ichkeul is probably the only large, shallow, water body remaining in North Africa that has not been drained and reclaimed for agriculture. It probably remains un-reclaimed because the bed of the lake lies some 1.5 m below mean sea level, so that it receives a considerable inflow of salt water from Lac De Bizerte, through the Oued Tindja, during the summer months. Despite this, the edges of the basin, chiefly to the south of the lake, have been reclaimed, and the lake and marsh system now occupies only about 40% of its extent during historical time.

Garaet el Ichkeul is fed by the Oued Djourmine, Oued el Malah, Oued Sedjenane and Oued Doumis, and several other small seasonal rivers. A prominent dolomitic mountain, Djebel Ichkeul, rises from the centre of the basin to a height of 511 m. This must formerly have been an
island in the lake, but now forms the central part of its south shore.

The shallowness of the lake, its inundation of surrounding areas in winter, the high densities of aquatic plants and invertebrates, and its location on the north of the African continent, make it an internationally important wintering area for a very large number and variety of waterfowl. In summer the fringing reedbeds and surrounding grazing marshes are attractive as a breeding area for many other bird species.

The grazing animals of the marshes include a small, half wild herd of buffalo, and domestic goats, sheep and cattle. The Djebel is also grazed by domestic stock, principally in the winter. The several warm water springs (hammams) around the foot of the Djebel, are renowned for their healing properties and are much visited during the months of February to May, and to a lesser extent throughout the remainder of the year.

3.1.2 Covadonga

The Parque Nacional de la Montana de Covadonga is situated on the western flank of the Picos de Europa - the highest part of the Cantabrian Cordillera, which runs parallel with the northern coast of Spain. The range lies between Oviedo and Santander 30 km from the coast, with maximum altitudes from between 1600 and 2000 m.

The Park extends from Covadonga in Oviedo province eastwards to the Rio Cares in Leon province. The western boundary follows the Rio Dobra. At the broadest point the park is approximately 19 km by 14 km, from San Vicente on the Rio Dobra east to Cain, and from the peak of Cabezo Llorosos south to Picos El Abedular.

Thus it covers 16,925 ha of spectacular mountain country of hard carboniferous limestone: Pena Santa (2596 m) is the highest peak. Much of the original woodland cover has been degraded and replaced by grassland or Ulex communities. Woodland remnants occurring on steep slopes are representative of the north-west European temperate forest. The tree line extends to a maximum of 1800 m but is often much lower; beechwoods replace mixed oakwoods with increasing altitude.

Pre-alpine grassland communities up to 2300 m are locally very rich floristically and support several regional endemic species. The area has attracted much botanical attention. True alpine communities are of limited extent above 2300 m.

The mammalian fauna is varied and includes several species which are now declining in numbers in Europe. Similarly there is a wide variety of breeding birds including several threatened raptors.

Pastoralism is a long established activity throughout the Park; it involves cattle, horses, goats and sheep.

Access by car for tourists is primarily via the Covadonga road to Lago Enol and Lago Ercina. These attract large numbers of visitors in summer. The main alternative access to the Park is through the valley of Valdeon. Many mountain tracks cross the Park and the area is well provided with simple shelters (refugios) for walkers and climbers.
3.1.3 The Burren

The Burren covers some 600 km$^2$ of north-western County Clare. Most of the area is a high limestone plateau of terraced pavement. Because of the high permeability of the limestone, most streams flow underground for much of their length. After periods of heavy rain temporary lakes or turloughs are formed. These features are of outstanding interest in the context of the British Isles.

The Burren has long been known as an area of great botanical interest. The most outstanding features of the flora are the unusual combination of plants with widely differing geographical distributions, and the close association of calcicole and calcifuge species. Botanists are also attracted by species which are rare in the British Isles.

The interesting species include the arctic-alpine Dryas octopetala, the alpine Gentiana verna, Saxifraga hypnoides (which has an oceanic northern distribution), and other species of generally northern affinities, such as Potentilla fruticosa and Antennaria dioica. The occurrence at sea level of some of these species, which are found elsewhere only at high altitudes, adds further to their interest. Species with a usually more southern distribution, for example the Mediterranean Neotinia intacta and Rubia peregrina and the southern continental Helianthemum canum are also found in the Burren. The reasons behind this unusual assemblage of species are not well understood, but probably include mild winters, low summer temperatures and considerable exposure.

3.2 The questions posed

For each of these tree areas the basic remit was to produce a management plan for the National Park. There were also similarities in that for example, all three areas were on limestone rock or all three had problems caused by grazing of domestic stock.

There were also major differences in the questions posed.

3.2.1 At Ichkeul the major question was posed by the proposals to dam the inflow streams to provide water in a dry country. These dams would reduce the overall rate of inflow and tend to smooth irregularities in flow: there would be fewer floods. In turn these could reduce the volume of the lake, causing a flow of salt water in through the Oued Tindja, and cause a reduction in the area of marshland. Thus the case of Ichkeul could be regarded as an Environmental Impact Assessment of the dams on the Oueds Djoumine and Sedjenane (Warren et al, 1979).

3.2.2 At Covadonga the major questions are all posed by people. In complete contrast to Ichkeul where virtually the whole area is owned by the Tunisian Nation Park authority (the Direction des Forets) most of Covadonga is in corporate ownership of the local town councils in respect of grazing rights. Five municipio's have grazing rights within the park. The Spanish National Park Authority, ICONA, has the legal right to determine stocking densities and timing of transhumance but these decisions are taken by a meeting of local shepherds, the Consejo de Pastores.

In addition the Covadonga is fully open to public access. There are
no limits on the number of visitors and no zones within the Park from which the public are excluded, even temporarily.

3.2.3 In the Burren the Office of Public Works has become interested in establishing a National Park at Mullach Mor to preserve its special characteristics. It has made a more tentative proposal to extend the Park in an area to the west. Clare County Council are also concerned, and both bodies are considering positive strategies for conservation over the Burren as a whole.

Our purpose was therefore to examine the projected Park and its extension to see (a) whether they appear to be big enough, (b) whether they have the best boundaries and (c) what kinds of management are most appropriate. We also looked at the Burren as a whole to see whether an alternative regional policy for conservation might be feasible.

3.3 Development of the format and system

In 1977 the format and system (Anon, 1976) was first applied to a Park. As a result a revision appeared (Wood & Warren, 1978). Apart from renumbering the sections the changes include three which I regard as significant. First suggestions for monitoring the effects of management are emphasised. Second a photograph collection and catalogue are suggested. Third, and most important, a new section on Ecological Relationships has been introduced. It is particularly important in two respects. Ecological interactions are of very considerable impact upon Part 2 of the plan. They are also often an area of ignorance on the part of reserve managers. Not necessarily the managers of the ground responsible for day to day management, but those in power above them do need clear statements about the complex inter-relationships that exist. No less than 10 pages of the Ichkeul plan were devoted to this section.

3.4 Costs

As all three of these exercises were run, at least partially, to contribute to the training of postgraduates, the actual costs were not recorded carefully. Some estimate of the probable costs should, however, be available to anyone thinking of using the system.

For a Nature Reserve in Britain, where basic data is often reasonably accessible, it is possible for one competent person to write a management plan in three to four months intensive work. A possible maximum would be 100 man days. Hence I would estimate the cost to be of the order of £4,000 to £5,000 with a maximum of £7,000. This would include a substantial allowance for various items such as travel and secretarial costs. Given that the average British National Nature Reserve is 800 ha this comes to an expenditure of about £6 per hectare on preparing the plan. The Nature Conservancy Council is using the UCL format and system. They may be able to effect some saving by minor modifications to the plan and spreading the overheads. But this must surely mean that a major responsible authority is willing to spend, say, £4 per hectare.

What would be the costs for a National Park Plan? In the three cases I have described we had a large party working intensively for a short time. Assuming that every member of each party worked for similar periods and similar intensities, I estimate that each plan took between
200 and 400 man days. Therefore total costs are likely to be in the range of £15,000 to £25,000. Taking the highest figure and the plan for Ichkeul (which I regard as the most complete example) this works out at £0.28 per hectare. Even if my admittedly crude estimate is out by a factor of ten the application of this planning system to large National Parks is a much better financial proposition than the application to the smaller, British Nature Reserves. And, as we have seen, that latter application is accepted by the NCC.

4 Conclusions

My conclusion is that this is a useful format and system. I am confirmed in this by the NCC having adopted it. I believe it succeeds for two reasons. First it is comprehensive but it is so comprehensive that I cannot demonstrate that in a short paper. Second within the wealth of detail, giving it clarity and coherence is a strong logical structure. We start with taking stock, making an inventory, not only of what species are present and how they are arranged but also of the factors controlling their presence and the trends of change. Then we evaluate these things and determine the objectives of management. Thirdly, taking into account the possible constraints, we prescribe courses of action and finally, hopefully, see that action executed.

In doing so we are using a range of disciplines:-

- Inventory: Biogeography
- Trends & Controls: Ecology
- Evaluation: Politics & Ethics
- Management Prescription: Ecology & Economics
- Execution: Applied Ecology

The major salutary lesson that this should teach us is that in planning for the management of a National Park we are acting not only as relatively objective ecologists but are also making some ethical and political judgements which are entirely subjective.

For myself I’d like to express this in colloquial English and say that there are four questions to answer:

- What is where?
- Why is it there?
- What happens if?
- and
- So what?

As an ecologist only the first three questions are mine to answer. As a human being I may have my own answer to the last question but should not think that, because I am an ecologist, my answer is better than that of anyone else.

References


Abstract

After the closing of the Brouwersdam in 1971 new possibilities for the development of nature and recreation in particular arose in the Grevelingen-area. For an optimal utilisation of the potential value of this area for nature and recreation, planning of the development is necessary. To obtain a good final result this planning has to be based on the results of landscape ecological research into the potencies of the area. This research started already long before the closure by a rough mapping of the soil of the areas, that would emerge after the closure, by the IJsselmeerpolders Development Authority (R.I.J.P., Rijksdienst voor de IJsselmeerpolders).

The closure created a totally new situation, that was incomparable with the situation in the estuarine Grevelingen. To get a clear insight into this new situation and into the possibilities for nature and recreation, various fields of research were explored.

Similar to this research-program, the planning procedure also pursues a course from a rough plan for the Grevelingen-area as a whole to detailed plans for the various parts of the area. Owing to this it is possible that the results of the research play a part at the various stages of the planning procedure. This makes it possible to adjust the plans, if necessary.

Consultation between the authorities concerned in research and planning, is necessary to guarantee a balanced weight of interests. For this purpose contacts take place between institutions and departments, concerned with research in the Grevelingen-area. Also a consultation-structure of planners is realized, that guarantees a contribution of government, provincial and municipal authorities.

Introduction

In the southwestern part of the Netherlands the rivers Rhine, Meuse and Scheldt flow into the Northsea. This region, which is known as the Delta-area, is formed by a great number of islands, surrounded by rivers and estuaries. Already since the Middle Ages man has tried to control the destructive forces of the water by the construction of dikes and land reclamation. After the disastrous storm-surge of February 1953 the studies into the possibilities to shorten the coastline by damming off the sea-arms in the Delta-area were pressed forward. This so-called Delta-plan included the Grevelingen, part of the common system of estuaries of the rivers Rhine, Meuse and Scheldt. In 1965 the Grevelingen changed from an estuary into a sea-arm by the closing of the Grevelingendam, that excluded the influence of the rivers. The closing of the Brouwersdam in 1971 excluded the influence of the tides and caused the salt, stagnant Lake Grevelingen. By establishing a fixed water-level of 0.20 m minus N.A.P. (Amsterdam ordnance datum), an area of land of approx. 3,000 ha emerged, consisting of sand- and mudflats along the former sea-dikes.
and a number of banks. The total area of water of Lake Grevelingen is approx. 11,000 ha.

In 1967 a land-use plan for the Grevelingen-area was published, in which much attention was paid to the recreational development. In 1973 this plan was considered obsolete, due to changes in planned infrastructure and in the ideas about outdoor recreation and natural environment. A new land-use plan was completed in 1975 (Werkgroep Herziening Inrichtingsschets Grevelingenbekken, 1975). This plan was submitted to the government of the provinces of Zeeland and Zuid-Holland and of the adjacent municipalities. Also individual citizens and organizations could put forward their opinions about the plan. In 1977 this plan was accepted by the Dutch Government as the basic plan for the development of the Grevelingen-area for nature and recreation (fig. 1).

![Diagram of the land-use plan Grevelingen.](image)

Figure 1. The land-use plan Grevelingen.

The research into the possibilities of the in 1971 emerged parts of the Grevelingen-area already started soon after the storm-surge of 1953. This research was broad and concerned especially the suitability of these parts for agriculture and forestry. After the emerging the research was extended and nowadays it includes pedological, hydrological, geomorphological, botanical and zoological research.

Both research and planning pursue the same course from broad to detailed subjects. Besides that, the Grevelingen-area is to be developed in several stages, so that it is possible to use the most recent results of the research for the detailed plans.
Planning

Organization

The land and water of the Grevelingen-area are part of the adjacent municipalities and provinces. These municipalities and provinces each have their own responsibility for the development of the Grevelingen-area. They can lay down their policy in regional and local plans. In 1971 the Dutch government decided, that the state was to take care of the further development of the Grevelingen-area. For this decision the following reasons were mentioned:
- the state owns the land and water
- the state carries out the management of the water regime
- the state is responsible for the water-infrastructure
- the development of a new nature- and recreation-area like the Grevelingen-area is of superlocal and superregional interest.

Until 1975 the Department of Transport and Public Works had the first responsibility, after that the Department of C.R.M. (Cultuur, Recreatie en Maatschappelijk Werk: Culture, recreation and social work). By order and under the responsibility of this Department the R.I.J.P. takes care of making plans, research and execution of plans for the emerged areas. The Department of C.R.M. charged the State forestry-department (S.B.B.: Staatsbosbeheer) with the management of these areas.

In 1971 the Projectbureau Inrichting Grevelingenbekken was established as an interdepartmental official consultation-group and the Stuurgroep Inrichting Grevelingenbekken as a governmental consultation-group. In future the governmental responsibilities will be delegated to the lower authorities (municipalities and provinces) by creating a so-called "Recreaties- en natuurschap Grevelingen", in which also the state will participate.

Figure 2. Planning-procedure.
Planning-procedure

As a basic plan, the N.I.S.G. (Nieuwe Inrichtingsschets Grevelingen-bekken: New Land-use Plan Grevelingen-area) gives an integrated view on the desired development and management of the emerged areas. The working out of the possibilities for development, as indicated in the basic plan, is made per area. This is done like the Department of C.R.M. has prescribed (Anonymus, 1973). The prescribed procedure implies a proceeding course of decisions, which starts with an idea about the future of a planning-area and ends when the management-stage starts (fig. 2). In that course six stages can be discerned:

1. Preliminary study (Voorstudie)
2. Basic plan (Basisplan)
3. Set of conditions (Programma van eisen)
4. Partial plan (Deelplan)
5. Detailed plan (Objectplan)
6. Specification (Bestek)

At 1/2. The N.I.S.G. functions as the preliminary study/basic plan and contains a motivated, quantified and phased proposal at long notice for the development of the emerged areas in Lake Grevelingen into nature- and recreation-areas, considering the conditions for zoning and location as given in this basic plan. The basic plan states which parts of the total project can be developed as more or less independent units and can function as such (deelprojecten).

At 3. For each "deelproject" a Set of conditions is made. This Set of conditions contains information about the functions of the "deelproject" and comprises the conditions and limits, which are to be paid attention to in the design of partial plans. The Set of conditions a.o. contains statements about zoning, desired traffic structure, environmental demands, desired character of the area, location of provisions, natural values, financial restrictions and exploitation form. The Set of conditions is a provisional end of the decision-making action and can be the start of outlining designing by making a (or a set of) partial plan(s).

At 4. A partial plan is a design for a "deelproject" and is made within the conditions of the approved Set of conditions. After the approval of the partial plan the preparation of the implementation can be started.

At 5/6. An object is a construction of provisions with a limited execution-time, that is designed, calculated and executed as a unit. In general an object will contain a number of parts, made by different executors. From a detailed plan in general some specifications can be extracted for the activities that take place.

Procedure of judgement of plans

The R.I.J.P. makes Sets of conditions for each "deelproject", based on the N.I.S.G.. The Stuurgroep Inrichting Grevelingenbekken establishes for each "deelproject" a working-group, that reviews the Sets of conditions, that are made by the R.I.J.P.. In these working-groups officials of the authorities, concerned with the "deelproject", take part. After consultation of the working-groups, the Sets of conditions are submitted for approval to the Projectbureau Inrichting Grevelingenbekken and the Stuurgroep Inrichting Grevelingenbekken.

The partial plans and detailed plans, based on approved Sets of conditions, are also made by the R.I.J.P. by order of the Department of C.R.M., as far as it concerns projects, that are financed by the state.
Partial plans and detailed plans for provisions and accommodations, that are to be made and/or exploited by private persons, are made by these persons, according the conditions given by the government. The Department of C.R.M. approves the partial plans and detailed plans after consultation of the Stuurgroep Inrichting Grevelingenbekken.

Research

Both before and especially after the damming of the Grevelingen research has been done in many fields. As far as it concerns the emerged areas, most of this research is coordinated in a project called L.O.O. (Landschapsocologisch Onderzoek: Landscape Ecological Research), a project in which the Deltadienst of the Department for Maintenance of Ways and Waterworks and the R.I.J.P. cooperate. Also the Delta Institute for Hydrobiological Research investigates the consequences for nature of the Delta-plan. This research contains a.o. the study of the development of the vegetation of the former saltmarshes and the study of the carbon-cycle in the aquatic ecosystem.

Landscape Ecological Research

The landscape ecological research is concentrated on the Slikken van Flakkee (fig. 1), the largest land-area of the Grevelingen (approx. 1,500 ha). The conservation and increase of variation and diversity, both spatial and temporal, are central points of the research. This research must provide the basis for a development, that is adjusted to the present and the expected spatial and temporal variation and diversity. The landscape ecological research can be divided into a number of stages. First of all it contains an inventarisation of the components that form the landscape, presented as descriptions and maps. This stage is followed by an integration of the components into landscape-units and a mapping of these units. Finally an evaluation of the landscape takes place.

Simultaneously research was done into the following components: soil, ground water regime, salt regime, geomorphology, topography, microclimatology, vegetation, mammals, birds, caribid beetles. These inventories started in 1972 (Anonymus 1972, 1975). In 1973 an interim report was published (Anonymus, 1973).

At this moment the integration- and evaluation-report, concerning these aspects, is in preparation. This final report will be published in 1981.

An example of the way the landscape ecological research is carried out, is the publication of Drost & Visser (1980). In their report Drost & Visser put forward relations between the patterns and processes of the abiotic environment (like composition of the soil, desalination, ground water regime) and the patterns and processes of the vegetation (like species composition and succession).

By making a good typology of the abiotic environment it is possible to compare the discerned environment types in the Grevelingen-area with similar, older areas elsewhere in the Netherlands. This comparison makes it possible to make statements about the future development of the vegetation. These expectations of the succession in their turn form the basis for the management of the emerged areas.

Other research in behalf of the planning

Soon after the damming of the Grevelingen plans were made (Anonymus,
1973\(^c\) in order to increase the variation of the abiotic environment by means of habitat construction. In connection with this especially the creation of gradients in water supply by means of lowering the ground surface was thought of. To study the effect of this kind of measures upon the hydrological situation on the spot, two experimental pools were digged out on one of the emerged banks. On account of theoretical calculations (Polman, 1978) and the results of the research at the experimental pools conditions and directives are formulated for habitat construction by lowering the ground surface (Polman et al, 1978). The results of this research also can be used for other projects of habitat construction.

Apart from research for the development of the Grevelingen-area as a nature-area also research is done for the development as a recreation-area. Counts are made of the various categories of tourists (c.q. anglers, holiday-makers, yachtsmen), that visit the Grevelingen-area. Also inquiries are set up among them. The recreational research is done in order to get insight into the way, that tourists make use of the area (spatial and temporal) and into the wishes they have with regard to the development of the Grevelingen-area.

A.o. this research made clear that there is an increasing demand for landing stages outside the marinas. This increasing demand could cause an increasing pressure upon the nature-areas, unless special provisions are made. For that reason the N.I.S.G. mentions a number of man-made islands, to be made especially in behalf of tourists and to lead them away from the nature-areas.

Relation between planning and research

The N.I.S.G. gives in broad outline the possible development of the Grevelingen-area and the necessary management. It is not a detailed land-use or management plan, but a basic plan. The development, outlined in this basic plan, will take place in several stages during a period of approximately ten years. The execution of the development started in 1978. It is rather useless (and also hardly possible) to make a detailed plan at this moment, that will not be realised until 1990. Yet there must be such a management during the period until 1990, that the development plans can and will fit into an integrated total-view. For that reason the basic plan already contains the main lines of the management.

Only when the development of a certain area is completed, it is useful to make a detailed and definite management-plan. For this reason the planning of the N.I.S.G. takes place in several stages. For each area the plans are made from great to small, from broad outlines to detailed plans. This gives the opportunity to use the most recent results of research for the working out of the detailed plans for the various areas.

After the damming of the Grevelingen a totally new situation arose, especially for the emerged areas. After the quick changes, caused by the suddenly changed environment (shock effect) the remaining ecosystems slowly adapted to the new circumstances. Also the development of new ecosystems started slowly. When the N.I.S.G. was written, predictions were made about these developments. As the ecosystems are developing and more results of the research are obtained, the insight in the course of the processes improves. This enables an adjustment of plans, if necessary.
Conclusion

The foregoing shows, that planning in stages in the way it takes place during the development of the Grevelingen-area as a nature- and recreation-area, gives the opportunity to couple theory and practice, research and planning during the whole planning-period. The risk of an interim adjustment of parts of a plan is, that this influences the plan as a whole. This risk is decreased by the integrated planning, for which a basis is made in the N.I.S.G. and that is continued in the present proces of detailing plans. This way of planning prevents nature and recreation to become competitors, prevents a polarisation between development and management and prevents a domination of the detail above the total plan. Such a link between planning and research offers fruitful perspectives for the development of new nature-areas, not only in the Grevelingen-area, but also elsewhere in the Netherlands.

References

Abstract

In North America, natural areas generally are remnants of earlier ecosystems little affected by Amerinds or Caucasians. Less commonly they are developed on disturbed mining or agricultural sites. Combining concepts from island biogeography, biophysical or ecological landscape inventory procedures, as well as genetic behaviour and mobility of animal populations, a selection process for nature reserves is proposed.

The integrated system proposed for Ontario, Canada includes five scales: the Ecoregion, Ecodistrict, Ecosite, Ecoelement. It integrates geological, botanical and zoological components, as well as the rural and urban landscape. From a jurisdictional point of view it requires cooperation of and collaboration from four levels of government.

On the next page a scheme is given for natural area planning in Ontario.
CHANGES IN THE NATURAL CONDITIONS OF LANDSCAPE AND LIVING ORGANISMS

Milan Kminiak
Department of Systematic and Ecological Zoology, Comenius University, Bratislava, Czechoslovakia

Registration of stabilizing and destabilizing phenomena in faunal populations, to which also man contributes in the long run, is an indispensable demand of biological research. Changes in the natural conditions of the landscape may also be characterized indirectly /by mediation/ through a knowledge of changes in the life habits of selected groups of animals. In this sense, the complex of ecological factors of the natural environment become manifest: A/ in changes that negatively alter the structure and stability of the faunal populations; B/ in such as, on the contrary, aid the growth and development of the populations.

The negative effects /A/ manifest themselves in direct interventions by man /catch/, i.e. a purposeful reduction of the abundance of numerous animal species; or indirect, i.e. man, thorough his activity in the economic, industrial and construction work initiates destabilizing shifts in the natural ecosystems /e.g. extension and changes of agricultural areas, chemization, changes in plant associations, development of industry, traffic, etc./. Man's activity is also associated with the resulting changes of topical, trophic and climatic conditions. Population stability is also intensively affected by natural enemies, parasitic and viral infections and disorders in individual's defense mechanisms.

Man's activity in natural conditions /B/ permits the creation of new habitats and of new qualities in the ecological relations which further determine the development of other associations. In this manner, man cooperates e.g. in the spread of species /indirectly/ and also in their progressive synanthropization. A knowledge of the degree of man's intervention into the environment also through changes in
the biology and ecology of living species is indispensable for the formation and control of the landscape. It helps to ensure the basic informations for biological prognoses in the creation, managing and protection of nature.
Trying to examine the influence of ground water extraction for drinking water-supply, a hydrogeological, pedological and ecological study of the "Kalmthoutse Heide" was carried out. Near this heathland reserve, 4 pumping stations are situated (fig.1). The tapped aquifer is the thick Neogene sand layer above the Boom Clay (Rupel Formation) and below the Kempen Formation. The latter consists of a complex of clay and sand lenses.

The goals of the hydrogeological study concerned the location of the clay banks in the Kempen Formation and the reconstruction of the main flow of the water above and underneath these banks. Fig.2 illustrates the variation in thickness and depth of occurrence of the first clay layers (10m under surface), as well as the discontinuity of the bank. From the maps of piezometric contours it can be learned that the flow of the unconfined, freatic water mainly follows the overall relief (fig.2). Some dune complexes however obscure this trend. Ground water of the semi-confined aquifer flows to the NW. The fall of the freatic water doesn't occur simultaneous or uniform. The lowering is very quick in the NW, the N and some places near the center of the reserve (fig.2).

The vegetation study resulted in a vegetation map, from which fig.3 is drawn. Comparison with data from 1955 showed hardly change in pattern or composition of the vegetation. From the analyses of aerial photographs, it became clear that in some cases Molinia caerulea had spread widely in the Genisto anglicae-Callunetum. Field work pointed out that part of the Ericetum tetralici shows some degradation, probably caused by desiccation. Freatophytes (Erica tetralix, Scirpus caspitoceus) decrease in abundance and presence, the lichen Cladonia impexa extends over large areas.

Impoverished plant communities of moorland pools were located. In them only Juncus bulbosus was found. Molinia hummocks indicate the normal expansion of the pools. Most of these pools are found in the NW and the center of the reserve. A classification and ordination of relevés made at the same places in 1955 and 1979 showed a modification of the diversified communities of the lower and upper shore (Lycopodio-Rhynchosporetum albo-fuscae, Eleocharitetum multicaulis) to a monotonous and species-poor Molinia stand.

From the vegetation study we conclude the presence of some restricted areas where the hydrological conditions has changed (fig.3). In the center they coincide with places where the clay layer is absent. As an explanation of the quick fall of the water table and the presence of influenced plant communities in the NW, we have to think of a quickened surface drainage, probably caused by the near pumping station. The influence of the pumping station in the N is obscured by the presence of large ditches and an extensive dune ridge. Finally we have to take into account a considerable decrease in precipitation for the past 10 years.
fig. 1 situation of the survey area

fig. 2 hydrogeological survey
- piezometric contours of the
- Ceasnic water level 01.05.80
- fall of frostic water level in
- spring: April - May 1980
  - 3.0 - 2.1 cm/da
  - 2.0 - 1.6
  - 1.5 - 1.1
  - 1.0 - 0.6
  - 0.5 - 0.1
  - 0.0 -

fig. 3 vegetation survey
- ecosystems mainly composed
  by freestyles
- types of woodland pools
  - strongly impoverished
  - vegetation
  - un impoverished vegetation
  - spodosols
  - ornamental
  - dried up in dry years
  - always filled with water
  - diminishing number and
  - abundance of freestyles
The central Dutch 'Gelderse Vallei', formerly established by fluvioglacial influences, has been filled up with cover sands in the postglacial period. In spite of this the region still is a valley and mainly consists of soils characterized by upward flowing seepage water. This groundwater, originally being raimwater, infiltrated the surrounding highlands of the 'Veluwe' massif on the eastern and the ice-pushed sand ridges on the western flank of the valley. The general flow direction of the groundwater is towards the central valley's main channel, which flows northward to the IJssel lake.

In the aeolian valley landscape the presence of sand dunes causes infiltration of groundwater which results in an alternating pattern of soils characterized by downward and upward flowing groundwater and an establishment of local stream patterns of groundwater superimposed on the regional stream pattern.

The nature reserve 'Groot Zandbrink', situated on the side of the valley which receives its seepage water from the 'Veluwe' massif, derives its character from its position on two interfering stream patterns, called hydrological fields.

Hydrological field properties between source (infiltration site) and sink (seepage site) are reflected in the hydrochemical characteristics of the groundwater. From the source, the calcium part of total major cations is growing to about 80% near the sink. Parallel with it the hydrocarbonate part of total major anions is growing (alkaline type of water). This phenomenon manifests itself in the hydrological field within the nature reserve on a very local scale.

In the presence of organic deposits in the subsoil, however, a predominance of the sulfate-ion (saline type of water) might occur. This saline groundwater can be considered to be the prevailing type of shallow groundwater in the region, as a consequence of the presence of large organic deposits of manure and sods resulting from age-old farming practices.

In the zone where the alkaline pole of the reserve's hydrological field interferes with the saline pole of the regional hydrological field, gradient rich vegetation types of the Caricion davallianae and Cirsio-Molinietum are present.

These differences in hydrochemical composition have an indirect significance rather than a direct operational one, as the saline/alkaline ratio regulates soil acidity, mineralization processes, nutrient availability, etc., which can result in a very differentiated operational environment.

Despite a drawdown of the mean groundwater level in the reserve of about 30 cm during the last 30 years, vegetational composition altered only slightly. It was concluded that this drawdown resulted in a change of the hydrological field interference, rather than in a lowered physiological availability of groundwater for the plant communities concerned.
A complex of moorland pools near Oisterwijk (Fig. 1) is originally oligotrophic, because it is situated in an area with nutrient poor sandy soil. The original vegetation belongs to the Isoeto-Lobelietum.

About 1870 a series of pools (Groot Kolkven, Voorste Goorven, Witven, Van Esschenven) was connected by ditches with a mesotrophic marshy area. Because of the extensive agricultural use of the area the moorland pools were manured slightly. In the gradual transition from oligotrophic to eutrophic conditions mesotrophic conditions were present, which were optimally suited for the development of desmid communities. To prevent eutrophication of these so-called central pools after reclamation of the marsh in the thirties, the ditches were dammed. In 1916 a tea garden was built near the central pools. The waste water was discharged in the central pools, which were overgrown by a saprobic flora. The characteristic desmids disappeared. The pools were cleaned by dredging in 1950, when the discharge was stopped.

From the data, obtained by studying diatom samples of 1920 and 1975, the central pools proved to be more acid in 1975 than in 1920, which is in accordance with the results of Coesel et al. (1978). Also a number of other pools, strictly isolated from external influences are acidified since 1920 (e.g. Achterste Goorven). These pools are very acid now (pH 3.1-4.7), while the former pH was between 5 and 6. The Isoeto-Lobelietum decreases in these pools. These changes are, at least for a part, caused by the acidification of precipitation (Van Dam et al., in the press).

Some pools are changed by the influx of agricultural drainwater (Allemansven, Hildsven). The original diatom communities and macrophytes of acid, oligotrophic environment disappear and are replaced by species of alkaline and saprobic environment.

Other pools are used as a swimming pool (Staalbergven) or as a fish pond (Groot Aderven). These moorland pools may be called metatrophic, i.e. species of oligotrophic and eutrophic environment are present, but mesotrophic species do not occur. However, the most sensitive oligotrophic organisms disappear (e.g. Lobelia dortmanns, Isoetes lacustris, Tabellaria bifilis). The pH fluctuates seriously in these pools (3.1-7.0).

The variety within and between the moorland pools has decreased since 1920. Before 1900 man enriched the variety of the landscape, because gradual transitions were made between the (dominating) oligotrophic areas and the (subordinate) eutrophic areas. Owing to the use of fertilizers the eutrophic areas are dominating now. The trophic pattern of the landscape has reversed. Trophic gradients cannot be maintained any more. Therefore only two types of moorland pools will survive: an extremely acid type in the remaining oligotrophic areas and a hypertrophic type in the other areas.

Full details are to be found in Van Dam & Kooyman-van Blokland (1978) and Van Dam (1980).
Figure 1. The trophic patterns about 1920 and 1975.

References


Problem: Methods used to improve agricultural profits have, in general, negative effects upon (semi)natural landscape elements. In the Netherlands one of the most important effects is eutrophication. This eutrophication can be caused by high levels of fertilization of the neighbouring agricultural land, from which nutrient transport by water flow can occur. Lowering of the groundwater level is another agricultural method that causes, by acceleration of mineralisation in the soil, an increased availability of mineral nutrients.

The aim of this study is first to understand the interactions between agricultural and (semi)natural landscape elements. Special attention will be given to:

- transport of water and the dissolved nutrients;
- nutrient cycling in aquatic as well as terrestrial ecosystems;
- the relationships between the availability of mineral nutrients and biomass production and species density of the vegetation;
- the mechanisms, responsible for the coexistence of plant species.

In future the results of this research will form the base for the development of a simulation model, that might make it possible to predict the effects of the mentioned agricultural methods on (semi)natural landscape elements and to develop a well-based management plan.

The study areas comprise polders in the "Vechtplassen" area that are intensively used for cattle feeding; small mesotrophic fens in the polders are the main research stations. Areas of moist heather and mesotrophic grasslands in the "Gelderse Vallei" form another study area.

- Transport of water and nutrients in an agricultural landscape.

Cycling of nutrients in aquatic ecosystems.

Weekly or twice a month samples have been taken in drainage ditches for chemical analyses of groundwater, surface water and precipitation to study the cycle of nutrients in the aquatic ecosystem and trace the influence of manuring at meadows upon these nutrient cycles and the influence of the ditch water upon the surrounding fens. The quality and quantity of the uptake by plankton, epiphytes and waterplants are a part of the research, as well as the discharge through the ditches.

Analysis of groundwater and precipitation shows a considerable input of \( \text{NH}_4^+ \).

Decomposition of water plants in ditches takes place at least twice as fast as decomposition in land plants.

- Transport and cycling of nutrients in an agricultural landscape; contact between cultural and natural landscape components.

The annual cycle of biomass was followed in two stands in a mesotro-
phic fen (dominated by Juncus subnodulosus and Carex rostrata) and in a more nutrient-rich grassland. N. P. and K. in plant material and in soil water were regularly determined. The fen was cut in July, the grassland in November.

The biomass maximum of Juncus subnodulosus is close to that of the grassland, and much larger than that of Carex rostrata. Both fen species show only moderate regrowth after cutting. The deeper groundwater in the sand layer contains high NH$_4^+$ levels and low PO$_4^{3-}$ levels.

The nutrient levels in the soil water under Juncus subnodulosus are consistently lower than under Carex rostrata. This agrees with the negative correlation between biomass and nutrient availability found in fens in this area.

The K$^+$ level in the soil water increases sharply after cutting.

The nutrient contents of the vegetation indicate N- and P- limitations in the fens and only weak N- limitation in the grassland.

Relations between nutrient availability in the soil and biomass production and species density of the vegetation.

Samples of the vegetation and the soil have been taken on the same spots in two different ecotypes: the floating fen and grassland, on ridges of uncut peat.

Comparison of the results found for the two ecotypes shows that the correlations found for the fen are opposite to the correlations found in the grassland.

Under stressed conditions in the fen (water stress, low pH) low nutrient levels are limiting and biomass is not negatively correlated with species density, as should be expected, but positively correlated.

The opposite is found in the grassland under more optimal conditions (drier, better O$_2$- and nutrient supply).
SPONTANEOUS VEGETATION AND GROUNDWATER WITHDRAWAL

IN A RURAL AREA OF 370 km²

M.J.S.M. Reynen & J. Wiertz
Research Institute for Nature Management, Leersum, the Netherlands

Introduction

The authorities of the province Noord Brabant concerned with an increasing drinking water demand are willing to know the impact on nature conservation of alternative winning plans. The Research Institute for Nature Management being contracted with this purpose started an one year research program. The poster gives a preliminary report of the study outlining the method used. The study area covers about 37,000 ha mainly rural area with sandy and loamy soils and several brooks. The study concerned groundwaterbound spontaneous vegetation only, 20,000 ha remained to be actually studied.

The study covers:
- a vegetation map on scale 1:25,000 with a legend based on ca. 900 vegetation samples.
- a statement of the vulnerability of the spontaneous vegetation for groundwater withdrawal.

Mapping method

To arrive at the vulnerability statement a combined map of soil types and groundwater level classes (map 1) was derived from maps of the Netherlands Soil Survey Institute (STIBOKA). The actual vegetation structure of each mapped element (+ 2-20 ha) was described using panchromatic aerial photographs 1:20,000. In 20% of all mapped elements having characteristic combinations of soil type, groundwater table and vegetation, vegetation was sampled in the field summing up to 900 relevés. The samples were classified at two levels, at first using Ward's clustering method as derived from the CLUSTAN-package (Wishart 1978), followed by a more elaborated classification using the program TABORD (Van der Maarel e.a. 1978) leading to 81 classes of vegetation characterized by average species composition. The legend of the vegetation map drawn (map 2) was based on this classification.

Method for assessing vulnerability

Using STIBOKA calculations watersupply to the rooted soil zone was known for each element of the soil map (map 1) simulating a drawdown of the watertable of 0, 10, 25, 50, 75, and 100 cm respectively. Putting in the frequency of vegetation types by superposing the vegetation map (map 2) vulnerability analysis was based on average species composition of the mapped elements using Ellenberg (1979) and Londo (1975) ecological indicator figures. Seven dose-effect formulas were postulated; moreover, one formula (8) was added for mapped elements rich in easily decomposable organic matter;
### D.E.F. Soil Type

<table>
<thead>
<tr>
<th>D.E.F.</th>
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<th>Dosis</th>
<th>Process</th>
<th>Effect</th>
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<td>msl</td>
<td>% opt. w.deliv.</td>
<td>'milieudynamiek' increases</td>
<td>disappearing of: midy haters</td>
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<td>&gt; 2</td>
<td>-</td>
<td>-</td>
<td>F9-species</td>
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<td>2</td>
<td>&gt; 10</td>
<td>&gt; 30</td>
<td>-</td>
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<td>-</td>
<td>increases F7-species</td>
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<td>-</td>
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<td>&gt; 10</td>
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<td>-</td>
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<td>F4-species</td>
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<tr>
<td>7</td>
<td>&gt; 10</td>
<td>&lt; 30</td>
<td>-</td>
<td>N-mineralisation increases N1,2,3-species</td>
</tr>
</tbody>
</table>

**D.E.F.** = Dosis-effect formula number

0 = rich in easily decomposable organic matter

wldd = waterlevel drawdown

msl = mean spring level

% opt. w.deliv. = % of optimal water deliverance

midy haters = 'milieudynamiek' haters are often rare species disappearing by slight changes of phosphate availability (Londo 1975, Van Wirdum 1981)

F4 t/m 9 = moisture figures (Ellenberg 1979)

N1,2,3 = nitrogen figures (Ellenberg 1979)

### References


ESTABLISHMENT AND MANAGEMENT OF NON AGRICULTURAL LAND AS A REFUGE FOR WILD PLANTS

Janice Rosalind Scott

Department of Biology, University of Essex, Wivenhoe Park, Colchester, Essex, CO4 3SQ, UK

Roadside verges cover an area of 220,000 hectares in Great Britain, more than three times the area of National Nature Reserve controlled by the Nature Conservancy Council, (65,000 Ha). Five of the nine major British habitats regularly occur on roadside verges; 870 species of higher plants are found on verges including 35 of the 257 nationally rare species.

Pressures on land and the need for agricultural improvement of marginal lands have reduced the variety of habitats for wildlife, especially in lowland Britain. The rate of extinction of rare plants is increasing, thirteen species were lost between 1900 and 1970 compared with only seven during the previous three hundred years. In the light of these changes the value of roadside verges as a conservation resource is now generally accepted and new methods of management are required to make the best use of the land by increasing species diversity and the variety of habitat and species associations.

Vegetation on roadside verges must be managed in such a way as to satisfy the engineering and safety requirements. However local authorities are also responsible for wildlife conservation under DoE circular 108/77, 'Nature Conservation and Planning', where special mention is made of the need to manage verges sympathetically to enhance their wildlife value.

Present management, in line with specifications by the Ministry of Transport, involves spreading of topsoil, addition of fertilizer, and seeding with a mixture of agricultural grass and legume species. Subsequent management involves grass cutting at various times of the year, and, in special circumstances, herbicide applications may also be carried out. Unless regularly mown this practice tends to produce a dense, tall, species poor and monotonous grass cover due to the rapid growth of Lolium perenne or Festuca rubra. With the present economic cuts, mowing is taking place less frequently in many local authority areas, and this may lead to excessive growth of these grass species and to troublesome scrub invasion.

In view of the competitive nature of vegetation cover produced by standard practices on roadside verges, most studies on increasing species diversity have concentrated on the effect of competition and rate of seed recruitment. Seeds have been sown into undisturbed vegetation, but with very low rates of successful germination. Gaps have been made in the vegetation cover by techniques such as slot seeding and ripping and new species added as seed, mature individuals, or turves. All these methods have proved expensive and have, in general, had a high failure rate.
Results of recent research at Essex University suggest that continued sward diversity may also be dependent upon the accumulation of adequate seed pools. Thus, on established swards which have been bared by rotoverting and on newly spread verges, establishment and survival of herbaceous species was markedly influenced by the presence of viable seed reserves. The trial plots are relatively young and the full effects of competition, especially from nurse crops sown to ensure initial greening and soil stability, may not yet be evident. Furthermore the choice of wild species to be introduced must take soil type into account. But the effects of various management regimes appear to be small in contrast to the effects of seed availability. It may be necessary therefore to consider maintenance of species diversity in terms of seed pools and cycling processes.
CONSERVATION: AIMS AND MANAGEMENT

This summary of the discussion on conservation and related subjects is based on workshop reports by A. Vreugdenhil, R.H. Kemmers, H.E. van de Veen, A.J. Beenhakker & P. Townsend, J.H. Smittenberg and M. Loenen; discussion points by H.E. van de Veen & P. Townsend; and working papers by H.E. van de Veen: "On the use of large herbivorous mammals for development and maintenance of natural values" and by J.H. Smittenberg: "Ecology and waterrecreation in the Friesian lake district".

The aims of conservation

There is no general consensus about the priorities for conservation among landscape ecologists. At least three approaches can be discerned.

In the species-oriented approach the survival of the remaining wild species comes first. This does not necessarily imply a phytocentric or zoöcentric view. Man has not only needs, he is a responsible animal as Vink (1) states in his anthropocentric approach. But why should we concentrate on species, rather than systems or landscapes? Species come and species go, it was argued. An answer to this statement was the observation that the rate of extinction is rapidly increasing and by far surpassing the rate of species generation. But even if species are the final aim, one cannot look at them as isolated individuals or populations. In the words of Van Wirdum (1), the aim of nature protection is the regulation of the environment to allow certain organisms to survive. Protection entails improving the "houses" of the species, which we conceive as ecosystems.

Some expressed the view that the species-oriented management fits into a "museum-concept". And a museum-type reserve could not be considered suitable for species preservation because of genetic impoverishment. Others argued that several ways of planning and management are developed to cope with this and similar problems. These methods will be discussed in the second paragraph of this summary.

The reserve-oriented approach focuses on areas. These may be patches or greater natural or semi-natural reserves, or even national parks or landscape parks, where traditional and diverse landscapes are preserved. Planning may include the investigation of potential natural developments and then the choice of the desired successional stages. Species diversity is appreciated as a result, but the priority is given to a diversity of ecosystems or landscapes including scenic and historical values. In most cases there is a multipurpose aim of conservation. National parks and landscape parks are considered as areas with a combination of natural, recreational and agricultural values. Consequently, it was argued that national parks should not be seen as isolated islands but as parts of an integrated regional plan. From a practical point of view tourism may add to the income of the parks' administration, and even the national economy, thus contributing to the financial basis of the management of national parks. Van der Maarel (1) expresses the fundamental view that nature reserves are sources of information and regulation necessary to provide an ecological balance with production and carrier functions. To achieve such a balance a system of compartments and zoning is proposed as a way of integration on a regional scale. (See also Fabos & Hendrix, 1)

However, conflicts rise particularly with dominating and growing activities such as urbanization, modern agriculture, traffic and mining. An
example of the latter was given by Townsend for the cement works in the Peak National Park in England. Tjallingii (1) argues that a zoning approach even can stimulate the growth of dominating dynamic activities (see also workshop summary: Nature, agriculture and recreation in rural areas of industrialized countries).

Problems of this type have generated a third view on priorities in conservation: the resource-oriented approach. A definition given in one of the workshops is: conservation is the wise use of resources. Practical examples of this approach are demonstrated by Adejuwon (1) for the savanna belt of Nigeria. Restoration of resources is the most important aim. In this context the relation between economy and ecology was discussed. "Ecology is long-term economy" it was stated (see also the workshop summary: "Pollution and degradation" and the final discussion). Although the resource orientation naturally tends to stress long-term effects, there are also important consequences for short-term objectives, notably concerning the productive functions. A good example is the case of a plan in Botswana for the introduction of cattle grazing in a large area. The proposed change of bush land into grazing land would probably result in a distorted water-balance, because evaporation in grasslands is considerably higher. This project can be considered as a model for many similar plans all over Africa, where the FAO experts aim to increase the number of cattle to about 120 million. The water balance problems in tropical grasslands are also discussed by Adejuwon (1). In the discussion it was stressed that a wise use of resources would in this case imply further investigations on the regional possibilities of game-farming.

It should be stated clearly that the different approaches described here are not mutually exclusive, but they may lead to different priorities in the formulation of general aims and practical objectives in conservation.

Planning and management of nature reserves

Any practical conservation has to be based on a sound management plan. Hooper (1) demonstrates a procedure to draw up management plans for national parks, developed at the University College of London.

In the discussion several guidelines for planning and management were mentioned:
- The need for the planning of a network of greater reserves and smaller stepping stones, based on island theory considerations.
- The essential constancy of management.
- The safeguarding of the internal biotic and abiotic conditions for the desirable communities.
- The necessity to resist or buffer external disturbances.

Priorities given to one of these guidelines or to certain combinations of them vary with the local situation, but also with the view of the ecologists. Arguments are discussed by Van der Maarel (1) and in the workshop summary: "Theory of island biogeography". Some prefer an approach based on the actual situation, others advocate the upgrading or reactivation of ecosystems. Thus Van de Veen in his working paper proposed to reintroduce larger predators and herbivorous mammals in some greater reserves where they have become extinct. He stressed the fact that, particularly in Europe, functional ecological relations are often disrupted due to human influence on the larger wild animals. Hence they should be reintroduced in appropriate nature reserves in order to reestablish the original natural selection. He added that large and medium-sized herbivorous mammals can be a dominant factor in shaping the natural environment, particularly the pattern of forests, bushlands and grasslands. Man and
domestic stock are no functional equivalents, he argued, because they lack the specific feeding strategies of the wild animals. In the discussion, the importance of grazing in management schemes was stressed. In some cases a delicate system of both grazing and mowing is essential for the floristic diversity of an area. However, as a rule, grazing is much cheaper.

Recreation by visitors, a major second aim of many nature reserves and national parks, also poses serious problems to management, as is discussed in the workshop summary: "Nature, agriculture and recreation in rural areas of industrialized countries". Not only the number of visitors is important, even more so are the conditions of transport and access. It was stated that the looking at wild animals from four-wheel driven vehicles has little to do with the feeling to be in a natural environment. The experience of risk also is a vital part of a preferred type of outdoor experience. "Over protection" of the visitor, some argued, might degrade a reserve to a zoo or a botanical garden. Therefore areas like national parks were not only to offer a scenic environment but should also include at least modest challenges for those visitors who want to go off the paved roads. Applying this view to local conditions and objectives would certainly have implications for the design of roads and paths, for the management plan and for the way visitors are informed or educated. Several examples were discussed of the zoning of recreation in nature reserves and national parks. In his working paper, Smittenberg demonstrated a case of water recreation in a lake district in the northern part of the Netherlands. Special attention was paid to the vulnerability of lake-border ecosystems. He proposed a differentiated way of planning facilities for the mooring of boats.

The problems of the nature-agriculture relation were an important item in the conservation workshops. The main issues are covered by the workshop summaries: "Stability" and "Nature, agriculture and recreation in rural areas of industrialized countries". Farmers are an important group in the resident population of many larger nature reserves. It was stated that the management of a national park is impossible if the residents do not cooperate. Therefore they should be consulted and involved in all phases of planning. Problems may arise, it was argued, because of the psychological and cultural gap between conservationists and the local people. Hence education to promote mutual understanding is an essential task.

There was a general agreement of the vital importance of conservation-education. National parks and their educational centres can play an important role, but education should not be restricted to the qualities of nature reserves. The wider aim is a general consciousness of the delicate balance between man and nature. See also the workshop summary: "Landscape ecology and environmental education".

The working papers mentioned can be obtained from: H.E. van de Veen, Instituut voor Milieuvaagstukken, Postbox 7161, 1007 MC Amsterdam, the Netherlands; J.H. Smittenberg, Prov. Planologische Dienst, Postbox 115, 8900 AC Leeuwarden, the Netherlands.

NEW MAN-MADE NATURE

A special workshop was devoted to the discussion of objectives and possibilities of newly-created natural areas. This summary is based on discussion theses and the report, both written by D. van der Heek, and a working paper by P. Wathern: "The case for 'Natuurbouw'."

The creation of new man-made natural areas or, as it is called in the
Dutch language, "Natuurbouw", is a relatively new issue. At first sight the approach seems contradictory. Although it is hard to think of an aspect of nature not influenced by man, as a rule the areas we call natural are not created so deliberately. In many cases they are the by-products of agricultural practices now considered obsolete, or they survive in corners of the world where human pressure is still low.

However, some consider it justified to speak about "creating" nature in those cases where man establishes conditions for the self-regulating processes in nature. In his article, mentioned in the workshop summary on terminology, Schroevers states that these processes are essential if one wants to call a successional development natural. Creating conditions or habitat building includes a careful choice of size and pattern of the new areas, but also the abiotic diversity is of importance. Van der Hoek referred to Van Leeuwen's view on the optimal gradient situation, which favours the development of a differentiated vegetation: dry, low pH and oligotrophic should dominate wet, high pH and eutrophic conditions, as in the case of a higher sandy and a lower river clay area connected by groundwater flow.

The building of a new habitat, it was stated in the workshop, should be followed by management practices that steer the natural processes towards more stability and decreasing human influence. The importance was stressed of a removal of nutrient surpluses by mowing and haying or by grazing. In his working paper Wathern stressed that many species are confined to a decreasing number of refugia and therefore only species with efficient dispersal mechanisms will invade newly-created habitat, where invasion rates will decline with increasing isolation. Thus, he argued, in future it will be inappropriate to leave vegetation to develop naturally. In the workshop, some participants also proposed the introduction of species as an instrument for creating nature. Others disagreed with this view, which indeed may lead easily to a practical approach that does not offer much room for self-regulation.

Decisions at this practical level at least partly depend on the choices made about land use in the region. Will the new natural area be a wildlife resource created to "compensate" for the loss of nature in the region, or will it be designed as a multiple-use recreation area, where the "creation" of nature is a secondary objective? Here also the different approaches mentioned in the workshop summary "Conservation" may be decisive.

There was a general agreement that the idea that man's activities, as Wathern formulates it, should not be viewed as purely deleterious. Man has immense creative possibilities to stimulate natural developments in public open space, along road verges (see also Scott, p) and on areas of derelict and reclaimed land. Planning and research aspects of a big project in the Delta area of the Netherlands are discussed by Loenen (1). An important function of these new habitats, Wathern stated, can be to reduce recreational and educational demands on our prime sites for nature conservation.

The working paper mentioned can be obtained from: P. Wathern, University College of Wales, Dept. of Botany, Aberystwyth, U.K.

THE ROLE OF WATER IN LANDSCAPE

This summary is based on discussion points and reports by W. Bleuten and B. Beltman. A further source was a working paper by D. van der Hoek: "The significance of water bodies (including groundwater) in landscape ecological analyses".
The study of water relations in landscape

Both Van der Hoek, in his working paper, and the workshop discerned two levels of integration in the study water relations. First, the topological level, i.e. the role of water inside an ecotope, or landscape cell as Veen (1) describes it. The main field of research is concerned with the water-soil-vegetation system. The second level of research is the chorological or landscape level. Here the "horizontal" connections between ecotopes and the role of climate (precipitation), surface and groundwater are investigated.

It was argued that at both levels quantities and qualities should be studied. Therefore the simultaneous collection of data on hydrobiology, chemical and physical properties was considered essential. Many participants in the discussions stressed the key role of water studies in discovering the long-term and long-distance effects of human activities on landscape.

Van der Hoek mentioned three important recent developments in water research that, according to him, should be evaluated as tools for landscape ecological research:

- An assessment system for running surface water based on quality index and a stream character index. By means of these indices maps of the qualitative and quantitative aspects could be made.
- A method developed by Niemann to elaborate data of groundwater levels to cumulative frequency diagrams. In this way groundwater conditions relevant to ecological differences in landscape can be characterized. This approach was further detailed recently by the Research Institute for Forestry and Landscape Planning "De Dorschkamp" at Wageningen, the Netherlands.
- Van Wirdum proposed to link chemical data on groundwater with its flow patterns between infiltration and seepage areas. Diagrams presenting the ratios of major ions can be used to map groundwater conditions and connections.

Some research cases

Mrs. H. Mochnacka-Lawacz from the Institute of Ecology of the Polish Academy of Sciences reported on research of pollution input by precipitation in Poland. Near the industrial centres of Silesia, values of dissolved N, Ca, P, K, S, as well as pH and electrical conductivity, were considerably higher than the corresponding values found in the precipitation in an agricultural area north of Warsaw. However, particulate-matter input was considerably higher in the agricultural area as a result of wind erosion of the arable land.

The acidification of precipitation is at least partially responsible for a decrease of the variety within and between moorland pools studied by Van Dam & Kooyman-Van Blokland (p). The decrease is further aggravated by nutrient input from the surrounding agricultural area. Research on the interference of nutrient cycles of land and water systems is also reported by Beltman & Verhoeven (p).

Lowering of the groundwater table can influence the delicate balance between qualitatively different hydrological fields. Changes in vegetation are linked to this process by Kemmers (p). Impoverishment of plant communities of moorland pools is reported by De Blust & Van Dyck (p) as a result of groundwater withdrawal for drinking-water supply.
Research and application

Many of the studies mentioned above provide useful data for the internal maintenance of natural areas. More important even are the implications of their results for the management of the interactions between different land-use types in the landscapes concerned. The poster presented by Reynen & Wiertz, demonstrates a method for the assessment of impacts in spontaneous vegetation of alternative drinking-water supply plans. In one of the workshops Van Dyck demonstrated some aspects of his study on the assessment of drinking-water infiltration projects in the Dutch coastal dunes. Finally, it is worth mentioning the proposals by Tjallingii (1) for the more efficient use of drinking-water inside individual dwellings. To a certain extent, new infiltration projects or more and bigger pumping stations can be made superfluous in this way. He also calls attention to the need of increasing storage capacity for good-quality precipitation in towns and the countryside. It becomes clear that water and water management constitute one of the major urban-rural relationships.

The working paper mentioned can be obtained from: D. van der Hoek, Vakgroep Natuurbeheer, LH, Ritzema Boschweg 32, 6703 AZ Wageningen, the Netherlands.
Theme V: Methods & Applications
On the basis of the generalized maps (1: 600,000) of geology, geomorphology and soils of the Netherlands, presented in the Atlas of the Netherlands (1963-1977), a physical geographical subdivision of the Netherlands is proposed.

The subdivision has three levels. The first subdivision is based on the geogenesis, resulting in six districts. The two other levels are determined by a combination of geological, geomorphological and/or soil properties, which can be various in different regions and subregions. Sometimes, the regional position can also be important in the subdivision. A total of 16 regions and 54 subregions are distinguished (Table 1). On the lowest level, the characteristic abiotic composition of each subregion will be given both qualitatively and quantitatively.

It is tried to link up the names given to the districts, regions and subregions with their characteristics. Some examples are:

<table>
<thead>
<tr>
<th>Name</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terraces of the Meuse landscape</td>
<td>geomorphology</td>
</tr>
<tr>
<td>Late tidal-inlet landscape</td>
<td>historical condition</td>
</tr>
<tr>
<td>IJsselmeer polder landscape</td>
<td>human activity</td>
</tr>
<tr>
<td>Peat district</td>
<td>soil</td>
</tr>
</tbody>
</table>

Table 1: Maps used for drawing the boundaries between districts, regions and subregions
a= geological map, b= geomorphological map, c= soil map, d= regional position, N= number

<table>
<thead>
<tr>
<th>Name of district</th>
<th>District</th>
<th>Region</th>
<th>Subregion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>abc d</td>
<td>abc d</td>
<td>abc d</td>
</tr>
<tr>
<td>marine</td>
<td>XX 1</td>
<td>X 3</td>
<td>XX 10</td>
</tr>
<tr>
<td>glacial</td>
<td>XX 1</td>
<td>XXX 4</td>
<td>X X 16</td>
</tr>
<tr>
<td>eolian</td>
<td>X 1</td>
<td>X 2</td>
<td>XXX 14</td>
</tr>
<tr>
<td>fluvial</td>
<td>XX 1</td>
<td>XX 4</td>
<td>X 6</td>
</tr>
<tr>
<td>marine/fluvial</td>
<td>XX 1</td>
<td>XXX 3</td>
<td>XXX 8</td>
</tr>
<tr>
<td>peat</td>
<td>X 1</td>
<td>XXX 3</td>
<td>XXX 8</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>16</td>
<td>54</td>
</tr>
</tbody>
</table>
ENVIRONMENTAL INVENTORY TECHNIQUES FOR PROVINCIAL PUBLIC MANAGEMENT

Bart Korf & Henriet Metz
Provinciale Waterstaat van Noord-Holland, Haarlem, Netherlands.

Abstract

In most provinces of the Netherlands mappings or inventories of one form or another of the natural environment are drawn up by the provincial authorities. These mappings aim at providing information regarding ecological conditions in behalf of the provincial public policy, particularly where the field of environmental planning and management is concerned.

It has been found necessary, to facilitate adequate ecological advising, to have at one's disposal a compilation of data (databank), that is useful for the more frequently occurring problems, owing to the shortage of time available for field research at the moment of a problem arising. Furthermore field research can only be carried out in the specific season.

For practical reasons such an environmental inventory will have to restrict itself to some factors of the ecosystem only, such as soil, geomorphology, flora, vegetation, avifauna, hydrobiology, etcetera. Circumstances of the landscape as well as the aims at which it is directed determine which factors will come under research. In inter-provincial official consultation, agreements are made upon the methods of recording data, to enable mutual comparability.

The framework of the environmental inventory in the province of Noord-Holland will be explained. In this province the following factors are involved:

- flora and vegetation
- breeding birds
- amphibians and reptiles
- aquatic macrofauna
- physico-chemical factors of the aquatic environment

The environmental inventory here has a multi-purpose intention, that is to say it is not specifically aimed at one field of public management. Between 1979 and 1985 a systematic inventory of this entire province will be performed. For each factor involved it must be determined in which method the investigation will be carried out (e.g. partitioning of area to be inventoried into workable units, working season, number of visits, method of recording, etcetera). Particularly important in this respect is the relation between the intensity of the investigation and the amount of relevant information obtained.

It was found necessary to computerize data regarding the factors flora and aquatic macrofauna, thereby providing more usefulness. In particular distribution maps of individual species can be made in a quick and efficient way. These maps often provide important information on the ecological factors involved.

In this way information is gathered on the ecological "Status Quo" of the rural areas in the Province. Assuming the presence of sufficient ecological skill, and insight into the relevant ecological processes, this produces workable information for advising on the ecological
aspects of environmental planning and management.

The distribution of Achillea millefolium L. in grasslands.
Legend: 3 = rare, 4 = local, 5 = occasional, 6 = frequent, 7 = abundant; a dot means that grassland is surveyed in the km-square, but the species is not found.
ANALYSIS AND MAPPING OF LANDSCAPES BASED ON SATELLITE-IMAGES AND

COMPLEX LANDSCAPE-CLASSIFICATION

Rasmus Ole Rasmussen and Sten Folving
Institute of Geography, Socio-Economic Analysis and Computer Science.
Roskilde University Centre, Roskilde, Denmark

Abstract

The purpose is to illustrate
1. the value of using principal component-analysis as a tool in detecting structures/processes in the landscape which determines the appearance of the landscape, and
2. the possibility of expanding the usability of multispectral satellite images by introducing the principal structures/processes as "bands" in the image, and using this extended multispectral image as a basis for classification and mapping.

Test areas have been chosen in Greenland to simplify the analysis by avoiding disturbance from atmospheric interaction and human impacts on/in the landscape.

Introduction

The most common way to use satellite images as a tool in landscape-mapping has been the classification of image-data in accordance to selected ground-truth-localities. This way of using satellite-images has shown rather limited results while the landscapes are always submitted to temporary changes, i.e. humidity, plant-growth, plant-cover etc., whereby the calibration of one image is seldom transferable to others. A change in a single parameter (structure/process) may alter the response completely, and thereby give rise to mal-classification. On the other hand, the basic informations in each pixel still consists of an integrated respond, and therefore it should be possible to expand the usability of the images by adding knowledge of single structures/processes to the integrated respond detected by the satellite.

Principal-component-analysis in complex landscape-classification

The possibility of selecting the most important features by means of multivariate statistics is due to the fact, that the appearance of a landscape is a function of a complex of structures and processes. But often single features will be able to describe the appearance, either by determining it, or by showing the same variations as it shows. A principal component analysis reveals such features or sets of features.

In a test-area in SW-Greenland, various data concerning basic edaphic conditions (pH, Humus, N,P,K,Ca,Mg,Na etc.), topography and vegetation (coverage, species) has been collected. A principal-component-analysis has been used to determine structures and complexes in the data, and some clear connections between plant-communities and various components has been revealed. Especially a component describing topography has turned out to be important.
Landscape classification and landscape mapping based on satellite images

Principal-component-analysis has been used for some time to derive important features from multispectral images, e.g. a "structure"-component, a vegetation-component and a noise-component. But furthermore it is possible to use the principal structures and processes derived from the principal-component-analysis as "new bands" in the multispectral image. This new multispectral image gives a much better accuracy and goodness-of-fit compared to classifications based on the original multispectral image.

By combining available informations concerning the principal structures and processes with multispectral data in this manner, it is possible both to classify and map large areas in an accurate way, and at the same time to provide a homogenous basis for the results.

An area near Sdr. Strømfjord, Greenland, has been classified and mapped by means of a normal multispectral Landsat-image. The same area has been classified and mapped as outlined above. The expanded multispectral images as a basis for classification and mapping shows considerable better goodness-of-fit than the classification based on a normal multispectral image.
Some contributions of physical geography to landscape ecology
by A.P.A. Vink, P. van Hooff, C. Kwakernaak and B. Pedrol

Four examples of landscape-ecological investigations are presented. These were made by the staff and students of the Subfaculty for Physical Geography and Soil Science of the University of Amsterdam. The studies show much difference in scale and scope, but all of them describe ecological relationships between abiotic and biotic landscape factors, the human influence explicitly included. In some cases, the knowledge about the existing relationships in the landscape is used for regional landscape planning on an ecological basis.

Processes on slopes in two catchment areas (Luxembourg)

The role of soil animals in slope processes is the object of this study. In two oak-beech forested catchments in Luxembourg the activity of two different species of earthworms was studied. In several ways these earthworms influence the exposure of forest soil to erosion:
- by removing litter from the surface and pulling the leaves into their burrows (Lumbricus terrestris)
- by bringing soil material to the surface as casts upon the litter layer (Allolobophora caliginosa).
As a result parts of the once litter-covered surface become exposed to splash erosion. In the month of May at some sites the percentage of bare soil is 30%; it reaches a maximum of 90% in September. Splash erosion occurs when rain is intercepted by the tree canopies and large drops are formed with high kinetic energies. The erodibility of the surface material determines the amount of material transported downslope by splash erosion. Because of the large number of earthworms (up to 30 large active earthworms per m²) their influence may be greater than might be expected. Their number is influenced by forest type, understory cover and soil properties.

Voorne-Putten, a landscape ecological survey

A landscape-ecological survey of Voorne-Putten is presented, based on existing maps (soils, hydrology, vegetation) and aerial photographs, as well as on systematic field investigations.
Part of the landscape-ecological map, scale 1:25,000, is reproduced. Several landscapes are recognized as main ecological units. Within each landscape various attributes of the land have been used as differentiating characteristics according to their relative ecological importance. Special attention is paid to the processes in the forelands, former tidal areas which have been strongly changed by the construction of several dikes, separating the tidal areas from the sea.
A land evaluation was made with regard to problems of nature conservation. The encroaching townships of the area
endanger small conservation areas as well as the habitats of migrating birds.

Landscape-ecological research in the Pre-Alpine Region, Switzerland

A detailed landscape-ecological study has been made in four sample areas, selected in the Pre-Alpine mountain area of Switzerland, in order to investigate the relationships between pedological, geomorphological, vegetational and economic variables as "correlative complexes". By frequency analyses and correlation tests the indicator values of plant species according to ecological factors were first calculated. This was followed by an ecological classification of data by means of cluster analysis.

Key variables were selected from insight acquired in the field, supported by the results of correlation tests. The landscape factors were divided into classes, which were analysed for significant correlations, leading to a matrix, with the key variables as column variables, and the other variables as row variables, as a quantified model of the abiotic correlative complexes. Together with the indicator values of plant species according to the ecological factors, an overall model can be presented of the correlative complexes with regard to the landscape ecology.

Simulation study based on quantitative field information and landscape ecological survey (scale 1:100,000) of a part of the province of Arezzo (Italy)

A quantitative procedure is demonstrated to evaluate simulated trends in the development of land use, including its environmental impacts, in a predominantly rural area of 500 km² in Tuscany (Italy). Landscape ecological survey resulted in a map 1:100,000 of the area, the units of which were delineated according to the mapping criteria: physiography, slope class and parent material. The field information of over 3000 sample points was coded and computer-stored and represented in tables with relative frequencies. The frequency countings also make it possible to describe the land units by means of all inventoried variables, and to check the differences between the mapped land units for each variable. This basic data can be used for the computing of a number of different models; some examples are given.

A first model is based on the simulated continuation of the present trends in the development of land use in the next approx. 40 years. A second model proposes an alternative, i.e. a better adjusted ecological development of land use. The change in the land use situation is illustrated by a derived land use map for each model.

The resulting impacts presented as the simulated changes in the field data, are given in tables and can be illustrated with maps, thus forming a basis on which the consequences of a simulated land use planning can be evaluated.

*Lab. for Physical Geography and Soil Science, University of Amsterdam
Introduction

In 1974 a research group called Physical Geographical Landscape-ecology "Fysisch Geografische Landschapskunde" has started to work within the Physical Geography of the State University in Utrecht (The Netherlands). In different projects in France (Vosges, Ardèche and the Alpes) and the Netherlands (i.a. Delta-area, Kromme Rijn area) research is and has been done on "structure/pattern" (landscape morphology, landscapechorology); dynamics/development (landscapechronology, landscapeprognosis) and processes with spatial consequences (landscape-ecology sensu stricto) of both more natural and more cultivated landscape-types, on various scales.

Most of the field research has been carried out with the help of students.

Landscape mapping

Landscape-ecological process research (see below) is preceded by the inventory of different landscape component variables of which the synthesis results in a landscape map.

Dependent on the nature of the studied area and the objectives of the project a choice can be made between different kinds of landscape maps.

The map units can be distinguished on the specific spatial arrangement of the basic units (or units of a higher scale level) after their structural and/or functional relationships.

Formal landscape maps

The units distinguished in the map are defined in terms of the separate landscape components like relieftype, soiltype, groundwater characteristics and landuse or vegetationtype.

These so-called formal landscape maps are made almost exclusively if the area, which has to be mapped, lacks the necessary information, or when only a short fieldperiod is available. In case of the latter, already existing aspect-maps (e.g. geomorphology map/soil map etc.) have to be used.

Functional landscape map

The units distinguished in the map are defined in clusters of abiotic and/or biotic variables which coincide spatially.

Premises are the specific relationship and interaction between the landscape components and -factors according to the cybernatic system concept.

In confronting these various variables (testing their critical values; limiting conditions; distinguishing landscape system-types, etc.) it is apparent that these so-called functional landscape maps can only be made after intensive fieldobservations.

Depending on the kind of variables which have been used in the analysis and synthesis as described above the following types of landscape maps...
can be distinguished:

a. Biosystem map

- Based on pattern and structure of, and relations between living organisms.
- Structural characteristics: Vertical structure; kinds of organisms/species, biomass ...
- Process characters: Trophic structure, population dynamics, evapotranspiration, etc.

b. Fysiosystem map

- Based on the specific connection between the abiotic components and factors (relief, soil, waterhousehold, micro-climate).
- Structural characters: Stability of the substratum, topoclimate, soil chemistry, etc.
- Process characters: Groundwater/soil moisture regime, geochemical cycles, waterstorage capacity and drainage.

c. Geosystem map

- Based on the specific interaction system of abiotic and biotic components and factors.
- Structural characters: Development, stability, complexity, open/closed system character.

Applications of landscape maps

Landscape ecological maps can be used for many practical purposes in the field of physical planning, nature conservation and management, soil conservation and improvement, land evaluation and so on.

Aim and resultant scale determine which aspects of a research should be accentuated. The results are usually expressed in special maps, which have been derived from the landscape maps.

In some cases, however, a problem is considered directly, and this results in criteria and maps which are not supported by the outcome of a landscape study. By way of example two specimen are treated.

- Relative erodibility map of a limestone/marl area under (sub) mediterranean conditions (Ardèche, France).

In the area concerned soil erosion is a common phenomenon. It is mainly determined by three factors, namely: the slope angle, the permeability of the underlying rock and the degree of vegetation cover.

Three soil stability classes have been distinguished, based on the combination of rocktype and slope angle. They have been subdivided into five levels of erosive activity, depending on the degree of vegetation cover.

The relative erodibility map shows where and to which extent the actual vegetation protects the area against soil erosion. It is now possible to deduce the consequences of changes which are coupled to a decrease of the the vegetation cover.
Landscape roughness has an influence on the windprofile at the earth-surface. The presence of obstacles in the field causes turbulence in the lower air layer.

The amount and manner in which the windprofile is influenced depends on the extent, height, stiffness and windoporosity of the obstacles, and on their distribution along the line of the winddirection. Vegetation e.g. exerts different kinds of influence on wind, depending on structure, such as deciduousness or crown height kinds of species, etc.

Information concerning landscape roughness is important for a comparison of windvelocity measurements of different meteorological stations, the measurements in fact are influenced by the particular roughness of the environment.

Landscape roughness is also an important parameter in the estimation of the evaporation of the total landscape.

Landscape-ecological process research

Since 1974 a part of the "Kromme Rijn" area, southeast of the city Utrecht, has been the object of a study directed towards the interactions by flowing water, between land- and waterecosystems.

The research program is based on the notion that water, supplied by precipitation - which exceeds evapotranspiration in the Netherlands - moves from one ecosystem to another. During these movements the waterproperties e.g. content of nutrients, are being changed. This process influences the functioning of the receiving ecosystem.

On behalf of the study the processes are divided into overland-, groundwater- and channelflow. In order to study the mentioned interactions, the ecosystem of the studied drainage area must be split into land- and water ecosystems. Each land-ecosystem provides water and dissolved matter by the above mentioned processes to a water-ecosystem. The land-ecosystem can be divided into various "basic-ecosystem-units". Each unit, determined by a specific soil type, vegetation and human influence level (e.g. agricultural input of manure), produces its own groundwater type with specific physical and chemical properties, as has been shown on the poster session. For analyses of the spatial influences, we stressed the nutrients. As groundwater and overland flow (which, if present, has also basic unit depending properties) feed the water-ecosystem the water biocoenosis shows also spatial differences.

It has been tried to compose a model of these spatial hydro-ecological processes. In this purpose, precipitation quantities, groundwater fluctuations and channel discharge were measured. These three watertypes were frequently sampled for analysis. The phytoplankton and macrofauna was sampled simultaneously in order to find relations between biocoenoses and physical and chemical properties within the water-ecosystem (the last aspects are worked out by the department for Nature preservation and landscape-ecology of the State University of Utrecht).

Main purpose of this modelling is to try to determine relations between variations of physical and chemical properties of surface water through the seasons and land use. By this model it will be possible to forecast the effects of changes in the spatial arrangement and or land use (planning activities) on the water-ecosystem. From this model it is also possible to determine the standards for "natural" waterquality and to calculate the side effects resulting from groundwater withdrawal and lowering the freatic level in winter (for agricultural purpose).
Introduction

The increasing needs of a growing population for food, fuel, fibre and shelter generally lead to changes in rural land use. Some of these land use changes preserve the inherent qualities of the landscape. Others provide benefits in the short run but lead to a progressive degradation of the landscape on a longer term.

Monitoring involves the detection and continued observation of changes (processes) in the course of time. Monitoring land use changes that have either undesired or beneficial effects on the environment deserves special attention. Information on such changes, their underlying causes and their impact on the environment is necessary for planning and executing measures that control, adjust or stimulate the processes that take place.

Means of change detection and monitoring

The detection and monitoring of land use changes can be done by (1) comparison of existing data and maps of different dates; (2) sequential ground observations; and/or (3) the application of remote sensing techniques.

Most existing data and maps are inadequate for this purpose. Systematic ground observations at regular time intervals have either a limited areal coverage or very high manpower requirements. On the other hand, remote sensing -- with only a limited amount of supplementary ground data -- generally allows the coverage of large areas at regular times at relatively low costs.

Change detection and monitoring using satellite imagery

With satellite imagery, a frequent sequential coverage of large areas can be obtained at low costs (provided local cloud cover is slight). A disadvantage is the small scale of the standard products. Digital processing, however, makes it possible to produce imagery at scales of 1 : 50 000 and allows the application of image enhancement techniques that facilitate monitoring changes.

Two examples of the use of satellite imagery were shown on the poster:

A. False colour images of June and September, 1976, of an area in Zaragoza province, Spain. The pronounced difference between the two images is caused mainly by the degree of cover of different crops at the time of imagery. This demonstrates the importance of understanding seasonal changes for the selection of properly timed imagery for monitoring longer term land use changes.

B. The use of satellite imagery for monitoring deforestation on a part of Luzon island, Philippines. In this illustration, forest boundaries as interpreted from a Landsat image of 1972 are compared with the forest boundaries shown on maps of the Bureau of Forestry (soil cover data of
and topographic maps (based on aerial photography of 1946-1952). The comparison shows that a zone 10 to 30 km wide has been deforested in the last 20 to 25 years. Field observations show that most recently deforested land is subject to severe erosion and, where used for crop growing, is often abandoned after a few years of cultivation.

Change detection and monitoring using aerial photography

Sequential aerial photography can provide accurate information on medium and long term changes of land use and landscape. Compared with satellite imagery, however, the sequential coverage of large areas at short time intervals is almost impossible because of prohibitive costs.

Two examples of the use of aerial photography were shown on the poster:
A. Aerial photographs of an area in Gambia of 1956 and 1972. The traditional system of cultivation in this area is a bush fallow system: land is rested after some years of cultivation so that it can regain its natural fertility. The photographs show the expansion of cultivated areas during the 16 year period and the reduced land areas left fallow for regeneration. Continuation of the process indicated by the photographs will lead to declining soil fertility and declining crop yield unless adequate fertilizers are applied.

B. Aerial photographs of 1973 and 1978 of an area in Badajoz province, Spain. The photographs show the progressive clearing of "dehesa" areas (traditional grazing land with stone oaks) for cereal cultivation. The process indicated by the photographs is enhanced by the government's favourable price policy with respect to cereal production. The process is irreversible: a return to the traditional dehesa management system which provides feed and shade for grazing animals and charcoal from pruned stone oaks will be impossible, at least in the short term.

Conclusion

Satellite imagery and aerial photography enable the detection and monitoring of land use changes with only a limited amount of supplementary data.

The impact of land use on the landscape depends on the type of change and on environmental factors such as climate, relief and soils. Predicting and monitoring the effects of land use changes on the environment is, therefore, preferably done on the basis of natural landscapes or ecological units which are homogeneous with respect to these environmental factors. Aerial photography is required for the identification and delineation of these landscape or ecological units.
AN INTEGRATED APPROACH TO LANDSCAPE ECOLOGY

R. G. H. Bunce
Institute of Terrestrial Ecology, Merlewood Research Station, Grange-over-Sands, Cumbria.

Abstract

A system of land classification appropriate for landscape ecology should not only provide a framework to identify actual and potential land uses but also enable interactions between them to be examined. However, the available classifications do not provide a sufficiently broad framework since they are designed to answer specific, limited objectives. The approach described is a unified system for Britain, in which subjective judgement is reduced to a minimum. Firstly environmental strata (termed land classes) are defined through multivariate analysis of data recorded from maps using a grid of 1 Km squares as a sampling frame. Secondly random squares are drawn from each land class and surveyed for ecological factors in the field. Thirdly these data have been correlated with the initial strata and have been shown to have sufficiently high correlations to enable predictions of ecological factors to be made for areas where the land class composition only is known. Comparisons with independently derived statistics have provided an external test of validity that justifies the approach. The system therefore enables potential changes to be studied and converted to national figures and for interactions to be modelled.

Introduction

One of the major problems in examining the components of landscapes over a large area is the lack of a common frame of reference within which to examine the interactions between the various relevant parameters. In Britain the various sources of statistics concerning ecological features comprising the landscape have either been compiled at different scales, in both time and space, or are not available because it has not been feasible to carry out the necessary surveys. It is therefore difficult to develop an adequate data base at a strategic level to carry out numerical analyses with sufficiently reliable data to give confidence in the results. The project described in this contribution was set up to provide a sampling framework for Britain.

The Approach

The principle is that if strata determined on the analysis of environment can be shown to have sufficiently high correlations with ecological parameters observed in the field, then they can be used for predictive purposes. The original study was carried out in a small test area before being extended first to the Lake District National Park (Bunce, Morell and Stel (1975)) to Shetland, and then to the whole of Cumbria (Bunce and Smith 1978)). In the latter study high correlations were shown between the map stratification and the vegetation of the county. The method has now been extended to Britain and includes soils and land use, as well as vegetation. The project (Bunce 1980)) is in 3 phases:

Phase I. Analysis. Environmental data were recorded from maps using a grid of 1 Km squares as a sampling frame. These data were analysed by a multivariate technique to produce 32 strata (termed land classes) which reflect arbitrary but reproducible separations of the land surface.

Phase II. Survey. 8 squares were drawn at random from each of the 32 land classes and field records made of vegetation, soils, land use and
ecological features.

Phase III. Prediction. The field data have been correlated with the land classes and show a high degree of correlation. The proportions of the land classes in Britain can therefore be used to derive national land use data which have been shown to be comparable with independently derived statistics, suggesting that the method can be used with some confidence to estimate parameters for which independent figures are not available. The extent and distribution of native species, vegetation soils, and land use can also be predicted for Britain.

Applications

(a) The ability to assign the squares of any region to the appropriate land classes enables the composition of that region to be predicted in terms of its vegetation, soils and land use. The region can then be set in a local and national context as a basic input into structure plans or as the descriptive contribution to environmental impact assessment.

(b) The small number of sample squares required to obtain a representative sample of Britain means that detailed studies at a few localities can be related to Britain as a whole and can therefore be used to carry out regular monitoring studies of factors such as pollution levels or loss of agricultural land to urbanisation.

(c) The distribution of the land classes can be used at a strategic level to delineate zones within which common planning policies can be developed, particularly in rural areas.

(d) The sampling framework is being used as a basis for examining the potential of land in Britain for wood energy crops in order to develop an optimal use of land for production, having accounted for specified constraints. Comparable studies are also being carried out to examine the impact of forestry, improvable agricultural land and other potential land uses.

(e) The land classes provide a convenient basis for modelling studies of various types, including linear programming and Markov chains, which rely upon an integrated system of data collection to enable the strength of the mathematical techniques to be fully employed.

References


APPLICATIONS OF A LANDSCAPE INFORMATION SYSTEM IN THE NETHERLANDS

P.A. Burrough and A.A. de Veer
Netherlands Soil Survey Institute (Stiboka), Wageningen, The Netherlands

Introduction

In 1976 a comparative investigation conducted into the methods of landscape mapping used in the Netherlands concluded that no single method was suitable for a national mapping programme. Therefore, a Landscape Information System for elementary landscape data was set up so that maps, tables etc. could be prepared with the content and scale to match any planning project.

The landscape Information System

Three main aspects are considered - the landscape content of the system, the automatic manipulation of the data and the production of the required high quality end-products.

The list of landscape elements eligible for survey (e.g. hedge, solitary tree, farm) was compiled from earlier research into eight Dutch landscape mapping methods. Gaps in this list were filled by elements from the legend for the Topographic map 1:25 000 of the Netherlands, and with elements mentioned by respondents to a user-enquiry. Because of the degree of detail of the list, the decision was taken to collect all elements by field survey. A proforma has been developed that comprises a field sheet together with a set of rows and columns for noting the attributes of the landscape elements recorded. This proforma was developed jointly with the needs of the automatic system.

For the automatic manipulation of the landscape data a Computervision C system is used. The basic software is supplied by Computervision. Programs for input, data quality control and manipulation were specially written for the needs of landscape mapping. Important development aspects are the input of landscape data concerning the graphic (locational) and non-graphic (descriptive) attributes of landscape elements, Boolean selection and classification facilities and the creation of end-products (maps, tables, magnetic tapes). Special attention has been paid to the cartographic quality of the maps.

The landscape Information System can deliver information about simple or combined data at any desired map scale. Maps can be supplemented by tables showing the number and lengths or areas of the elements on the map. If interpretation norms are available (e.g. a landscape evaluation scheme) the data can also be presented in the interpreted form. A special program was written to trace visual influences of striking elements (present or planned) in the landscape e.g. high buildings. Naturally, the combination of map scale and detail of landscape data defines the lowest planning level at which the system can be used. It is possible to select (or combine) data for applications at higher planning levels.

Projects

The landscape Information System has or is being used in a variety of planning projects, study or by contract. The table gives an overview.
### Table: Planning level and Scale Type of planning | Project name | Area Project (km²) | Stage
---|---|---|---
Local | 10,000 | Municipal development/ Landscape management | Ede | 110 | Delivered
District | 25,000 | Municipal structure | Overbetuwe | 60 | In press
          |          | Recreation planning | Gravenwoude | 52 | Delivered
          |          | Reallocation planning | Aalten | 37 | In press
          |          | Reallocation | De Hilver | 90 | Ongoing
Provincial | 50,000 | Provincial development | Twente | 1400 | Ongoing
          |          | Provincial development | E-Gelderland | 37 | In press
          |          | Provincial development/ Green belt planning | IJsselmonde/ Hoekse Waard | 91 | Ongoing

The figure gives an example from the Twente project (scale 1:25,000). It forms part of the map "Spatial size and type of edges" and it is used, in combination with other data, in order to map areas of high landscape value yet that at the same time have problems in agricultural management.

Descriptive legend: Cross-hatched areas: Mass (forest) and Association Mass-Space; Numbers: Area of space in hectares; -o-o-o- Tree Line; ——— Line with buildings; vvvvv Low escarpment; R Association of lines.

**Future developments**

Some of the future developments of the Landscape Information System will be the following: integration of the system with other data bases, e.g. of soil, geomorphology, vegetation and cultural history, incorporation of the results of perception studies, more precise understanding and fulfillment of user's map requirements.

**References**

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ANTHROPOGENIC HABITATS IN RURAL AREAS AND THEIR TYPORIZATION

Pavol Eliáš
Institute of Experimental Biology and Ecology, Slovak Academy of Sciences, Bratislava, Czechoslovakia

Summary

The ecological typization of anthropogenic habitats has been made for use in synanthropic biology, landscape ecology and planning /e.g. for mapping of secondary structure of landscape, for evaluation of degree and character of synanthropization of landscape, etc./. It will be also important for comparison studies of vegetation in rural areas and settlements in different regions of the world.

Anthropogenic habitats are considered as habitats for biota. They have been formed by anthropic factors and are permanently influenced by them. The man-made habitats /ecotopes or "sociotopes"/ were grouped into several habitats types differing by the effects of both anthropic and natural factors. The following typization units were used: ecotopotype /ET/, group of ecotopotypes /GET/ and complex of groups of ecotopotypes /CGET/. ET is certain, homogeneous /mainly ecologically/ habitat type offering environment for characteristic combination of species of plants and animals /biocenoses/ and repeating in landscape. CGET is heterogeneous unit which grouped different GET into cultural components of landscape. The typization has been made on the principle of unifying ecological factor which determined main ecological features of the group and represented equal or similar possibilities for colonization by certain type of synanthropic vegetation. The effects of anthropic factors were used as fundamental ones /e.g. trampling, enriching, etc./. The following main GET have been distinguished: trampled /trodden/ habitats, arable-area habitats, ruderal habitats, railway-yard habitats, embankment habitats, ruined-area habitats and abandoned-area habitats.

Anthropogenic habitats occur in cultural landscape in the forms of several sets /complexes/ which are considered by landscape ecologist as structural landscape units. The occurrence has different character: it has forms of lines, areas and mosaic. Frequency of ecotopotypes within a complex is different and complexes are differentiated by type /character/ of occurrence and distribution as well as by ecotopotypes dominated. The following main CGET have been distinguished: settlements, communication ways, agricultural areas and industrial objects. The agricultural lands predominate in rural landscapes. Villages, towns, cities and other man-made ecosystems are represented by complexes of several many different kinds of anthropogenic habitats.
The viewshed includes the area seen from a viewing point. The extent of the area seen from each point is a typical index of intervisibility, but gives little information about the complex visual relationships of the land. Plotting visible areas may be a good way to analyse the visual relationship between the viewing point and its environment. The plot allows to identify every point seen and connect it with the observation point and its adjoining ones. But, usually, the viewshed has many holes or non visible areas and an irregular shape and it is hard to make use of it.

An approach that may be useful is to replace the viewshed by an equivalent area of known shape. For handling irregular and fragmented surfaces is helpful to use the second moment of area. For each visual beam, we compute the axial moment \( I_\alpha \) about the perpendicular by the centre of gravity. We compute also the radius of gyration \( i_\alpha = \sqrt{I_\alpha / A} \), \((A=\text{Area})\), and plot the second inertia ellipse, or Culman ellipse, marking \( i_\alpha \) in each direction from the center of gravity. We obtain a visual ellipse of correlated size, dimensions and orientation with the viewshed.

Three parameters are enough to plot this visual ellipse: two half axis, corresponding to principal moments, and the major axis direction. The relation between axis mark the roundness (approaching to unit) or the ellipticity (approaching zero) of the viewshed. This is a shape index. The product of axis is related to the viewshed area. It is a quantity index. The major axis direction makes the viewshed topographical orientation compatible with environment observed morphology. It links each viewshed with the immediate ones.

We have found a sound relationship between the topographic situation of every viewpoint and these shape, quantity and orientation indices.
Viewpoints located at the bottom of a valley provide elliptic viewsheds and narrow visual boundaries, and correspond to low shape and quantity indices. Their topographical orientation corresponds to the valley main one. Likewise, viewpoints on the mountain heights provide almost circular viewsheds, with high indices, without definite orientation. It corresponds to panoramic views.

The sequence of visual ellipses derived by following a path provides parameter series closely connected to the topographical orientation sense. Parameter series with slight changes enable a sharp comprehension of environment morphology. Parameter unexpected variations reveal situations of hypothetical disorientation.
General characteristics

Coastal sand dunes occur in all climatic zones as dynamic landscapes with specific vegetation and fauna. Ecological factors are instability of surface, permeability of substrate, leaching, strong winds, salt spray, high air humidity, buffering of extreme temperatures. Many species have large coastal areas or are introduced from other continents. Landscapes have a small-scale mosaic character because of extreme variation in spatial and temporal patterns. On the other hand, there is often much similarity between areas that are geographically far apart. Change of sea level has always been an important world-wide phenomenon influencing the geomorphology of coastal dunes.

Practical importance

Major importance for recreation, conservation, coastal protection. These are often incompatible because of vulnerability of the landscape, heavy losses or complete destruction being common in all parts of the world. Multi-purpose uses are only possible with careful management based on landscape ecological research. Additional problems are created by the use and infiltration of drinking water (Netherlands), sand mining (Australia) or afforestation (France). Technical as well as biological means are available to stimulate the formation of new sand dunes in certain areas, or to slow down natural erosion in others.

Methods

A method of holistic "landscape" mapping, with emphasis on vegetation, has been worked out for coastal areas in the Netherlands. Topographical maps scale 1:25000 were used for the field survey. Experience leads to the following theses (also applicable in other than sand dune areas):

1. Integration of disciplines should not be postponed until monothematic maps are produced. Instead, "geosystems" (= the sedentary parts of ecosystems) should be described in the field and classified at an early stage.

2. Single geosystems cannot be used as mapping units. Landscape mapping units on most scales should be complexes of geographically correlated geosystems. Thus, landscape units may be described in the form of lists of dominant, differential and characteristic geosystems. Spatial patterns of geosystems may be mapped in key areas. Such landscape maps do not lose their validity as quickly as traditional vegetation maps (e.g. because of successional processes).

3. Delimitation of landscape units is also determined by boundaries in geomorphology, land use and local climatic (e.g. altitudinal) zones. No fixed order of criteria should be established beforehand.

4. Landscape units should have a functional background, based on a study on their origin, land use, hydrology, erosional processes etc. The main
lines of succession must be derived from historical data, old maps and photographs, interviews etc.

Results

The main result is a map of all Dutch coastal sand dune areas, including conterminous salt marshes. Some parts of this map have been published on scale 1:25000. A simplified map 1:50000 of the whole area is being prepared for publication.

Units are landscape types or zones, indicated by a hierarchical letter and number system. These correspond with dune complexes which are homogeneous in respect to their age and origin, geomorphology, composition of the substrate (e.g. lime content in the C-horizon), land use history, vegetation and soil complexes, flora etc. The system can be adapted to various scales, e.g. the use of false colour aerial photographs 1:5000.

Field reconnaissance was carried out in various sand dune areas around the world, e.g. France, Poland, U.S.A., Japan, New South Wales and tropical Africa. From these, some general principles concerning the landscape ecology of coastal dunes could be derived. For comparative purposes, a number of general "habitat types" (mostly landscape zones) could be distinguished. These are listed below.

1. Tide mark zone on sandy beaches a. annual b. perennial communities
2. Embryonic dunes (beach dunes) a. monospecific b. mixed communities
3. "Yellow" dunes with sand accretion a. and b. as in 2
4. Sheltered zone immediately behind foredunes
5. Sandy flats created by "overwash" during storm tides
6. Specific salt spray ecosystems (e.g. on dune cliffs)
7. Open pioneer dune shrub or woodland zone (N-fixation in rhizosphere)
8. Dry, short, open dune grassland on calcareous sand
9. "Gray" dunes (e.g. blowout communities) on sterile sand
10. Slack with pioneer communities (often brackish)
11. Wet slack with fresh open water or closed herbaceous communities on mineral soil
12. Ecosystems with increased mineralisation of organic matter in the topsoil a. Young, calcareous dunes with herbaceous vegetation (e.g. on bluffs or hummocks) b. Older dunes with woody vegetation
13. Dense shrub in mature dunes (species rich)
14. Maritime forest on relatively fertile soils
15. Maritime forest on poor, acid soils (e.g. on older dunes)
16. Swamp forest, shrub or herbaceous vegetation in old slack on peat
17. Dune heath ("black dunes")

Applications

Because of the close interaction between land use and all components of the landscape, an optimal applicability is to be expected from an approach as presented above. Our landscape maps of dune areas are used for
a. Regional planning + management instructions for conservation, recreation, technical works for water extraction and infiltration, coastal protection etc.

b. Training of students. The dunes are the largest semi-natural area in the Netherlands, ideally suited for training in ecology, field botany, landscape architecture, use of aerial photographs etc. Methods of survey, e.g. those suitable for work in developing countries, are taught in this way.
The utility of aerial photographs in landscape studies is widely recognized. The bird's eye view gives the field investigation the essential information about the spatial distribution of the landscape attributes and the relations between them. Although aerial photographs contain an evident holistic view of the landscape, most interpretation work has been focused upon the thematic mapping of separate landscape attributes. This thematic-analytical approach can be understood easily, considering the fact large-scale photographs allow an easy and detailed recognition of the separate landscape attributes. In some cases this analytical phase is followed by an synthesis which attempts an integration of these separate aspects. Regional geography, landscape ecology and land classification have developed methods, based upon photo-interpretation, to divide the landscape continuity into distinct land units, which are described and classified in a hierarchical system.

On the other hand, the recent explosive growth of remote sensing, makes that images become available which can not be interpreted that easily. Valuable information beyond our visual experiences is collected too and most documents have small scales, which makes the recognition of the separate attributes impossible. The pixel is considered as the spatial unit of information and gives the result of the combined radiation characteristics of ALL features it contains. The unique base for interpretation are the image characteristics. The collection and production of remote sensing images becomes really more and more "remote" to user in the field.

Image interpretation means a fundamental extension of the traditional photo-interpretation. Two trends can be distinguished: the pattern recognition, which aims at an automatic interpretation, and the visual interpretation, which has to be done by the specialist in the field. Both trends show two approaches referred to as supervised and unsupervised interpretation. The supervised approach aims at thematic interpretation as for example recognition based upon spectral signatures and visual interpretation by means of interpretation-keys. The unsupervised approach looks at the image as a "Gestalt". The images characteristics have to be analysed and described in such way that photomorphic units can be delineated. The main goal is to connect these units with aspects of the structure of the landscape. No attempt is made to identify single attributes, but the attention is focused upon the characteristics of the holistic meaning contained in the image.

In important element in the visual interpretation is the psychology of the interpreter. The "Gestalt"-psychology is seen as a base for learning. Therefore, the method is based upon the theory of learning known as field theory.
The original image is experienced as a diffuse complex which can be understood through continuous differentiation of the image elements. This understanding means that links can be made between the structure of the image and the structure of the landscape, even without recognition of individual landscape attributes. A final step in this process is the restructurization where aspects of the structure of the landscape are synthetized again.

This methodology is illustrated by some examples of visual image interpretation of Landsat images. Landsat offers images with an original scale of about $1 : 1,000,000$, registered in visual and infrared bands. Temporal registrations are available too. The individual landscape attributes can hardly be recognized with a pixel size of about $80 \, \text{m}^2$ and stereovision is still not widely possible. Nevertheless, the images contain an amount of information of the holistic nature of the landscape. Examples are landscape diversity, complexity, temporal changes, contrast between landscape units and spatial frequency.
LANDSCAPE MODEL-RESEARCH PROJECT IN THE REGION OF INGOLSTADT (BAVARIA)

Wolfgang Haber and Jörg Schaller
Lehrstuhl für Landschaftsökologie, TU München-Weihenstephan

Abstract

The research project in the region of Ingolstadt (a typical mixed industrial/rural environment with strong human impacts on the natural resources) is an integrated environmental Systems Research project involving 16 single special disciplines. The goal of the project is to develop new methods of assessment of human impact on natural resources on a regional scale, especially in rural areas, for regional landscape planning.

The special disciplines are involved with data collection, evaluation and impact assessment. They are expected to indicate solutions for problems and issues around the capability, suitability and sensitivity of the natural resources in the region.

For the project an issue-based information system was developed, focusing the issues on two mapping scales (M 1:5,000, M 1:25,000). The data collection of the vegetation, zoology, soil etc. scientists was made on 1:5,000 maps where each piece of land was covered, and the special data were collected as exactly as possible. For this mapping, representative sectors of the research area were chosen.

1:25,000 maps were drawn from data in soil maps, topographic maps, etc. A land-use map was developed from interpretations of remote-sensing data and ground-truth controls. This data-base is evaluated and assessed with relatively simple assessment models which are in use for planning purposes, and which give area-related answers to the issues.

These answers are compared with the results of the evaluation and assessment of the gained data in the scale of 1:5,000 where the issues are answered on a more quantitative basis. The goal of this feedback and comparison is to get practicable assessment methods in form of indicators for most existing or easy-to-get data for the regional landscape planning.
In the Netherlands, as in large parts of Western Europe, in most areas the potential natural vegetation is some type of deciduous forest. As a result of man's activities, only relicts of these forest types remain, and usually the original forest sites have been irreversibly changed.

In present-day forests, the various plant communities are described in terms of all the species present including the indigenous trees and shrubs. In landscape planning, management and design, proposals should be ecologically suited to the soil conditions and it is important to know which combination of indigenous trees and shrubs is best suited to a particular site. Therefore, we drew up a classification of potential forest types, describing 21 potential forest types and their matching sites.

We derived the site qualities from the soil map, using the following assessment factors: water supply; drainage status; fertility status; whether the soil is light textured and peaty or heavy textured.

The second sheet of the poster shows the maps of potential forest types obtained by 'translating' three soil maps.
THE VISUAL LANDSCAPE
INVENTORY AND EVALUATION FROM THE VISUAL/AESTHETIC PERSPECTIVE

Roland Baumgartner
Institute of Arctic and Alpine Research, Boulder, Colorado, USA
Geographical Institute, Bern University, Bern, Switzerland
Swiss League for Nature Protection, Basel, Switzerland

Abstract

Discussed is the visual aspect of landscape as an essential environmental resource of a scenic mountain area. Presented data, based on landscape analysis in the "Indian Peaks", Colorado Front Range, USA, and evaluation for dispersed recreation, enables researchers as well as planners to specify the potential for different modes of this specific type of land use from the visual/aesthetic point of view. The relevance of characteristic landscape elements and composites is determined together with assessment of the carrying capacity of the visual environment. Guidelines for the preparation of landscape development plans are suggested.

Introduction to the Visual Landscape Analyses

In 1978 the "Indian Peaks Wilderness" was established. For the past four years the Institute of Arctic and Alpine Research (Boulder, Colorado, USA), through its Mountain Research Station, has been involved in the production of an "Environmental Atlas" of this scenic mountain area. This work is part of a team study supported by a research grant from the National Aeronautics and Space Administration (NASA) to J.D. Ives (Principal Investigator).

Before any questions about management decisions concerning the visual resource of our environment can be answered, it is necessary to conduct a detailed analysis to compile an integrated visual inventory of a certain landscape. In a second step, based on the first landscape analysis, the actual perception of landscape is assessed through public surveys. This motivation research enables us to determine the scenic value of any region and of single landscape elements.

Through a sophisticated map-legend it is possible to suggest specific solutions for the management of the visual resource in this area, and to formulate guidelines for the preparation of landscape development plans. This procedure highlights the elements of the environment which are especially sensitive from the visual standpoint and must be protected in order to conserve landscape as an essential natural resource.

The Visual Landscape - A Natural Resource

Using a first, preliminary landscape inventory to survey users of the mapped area, responses to landscape elements depicted on the map were generated. Such responses are related to the impression individuals gain from the actual natural and man-made environment. The motivation research has taken into account the following variables in order to obtain proper data: -- Different user categories
-- Mode of questionning: open-ended interview system, using color prints of each landscape unit
The approach to landscape aesthetics from the user's point of view is an important input for management policy-making. Motivation research addresses specific questions about differences in visual value of a mountain area for an individual tourist. It allows consideration of the elements which are especially sensitive and of those under them which must be protected to preserve an unmodified scenic mountain landscape. The planners' attention has to be directed to those factors which are highlighted as most important to classify the region as an estimable living and recreation place. Vigilant and careful preservation is then the only means by which high classification values of and in a region can be retained in future.

Further information concerning individuals' perceptions and reactions particularly with reference to changes considered "acceptable" or "unwelcome" in an environment, was elaborated to give the map (see following section) more significance.

"The Visual Landscape" Map of the Indian Peaks Region

This landscape types map of a Front Range section in the Colorado Rocky Mountains (USA) is based on the landscape analyses above. It is a combination therefore of either abiotic or dominant vegetation aspects or an association of both, man-made or -influenced features, and data generated from the motivation research. Each unit is additionally typified through the three main geographical approaches (formal/descriptive, genetic/historical and functional), which reinforce the attempt to obtain an integrated characterization of the visual environment.

The dominance of the units has been determined by a simple matrix method: abiotic versus vegetation features with less dominant, man-made or -influenced aspects represented by symbols. Many of the matrix possibilities are non-existent and others can be combined. The final question of dominance was examined through public surveys: Motivation research justifies, modifies or changes the preliminary selection of dominant units in the first landscape inventory (above).

The confrontation of landscape inventory, ecological stability data, perceived actual value as well as assessment of the carrying capacity of the visual resource in one map (with one legend) evidences conflicts caused by certain recreation uses directly on this map sheet.

It is ventured here to say that too often political administrations plan and manage entire regions with economic considerations a top or with high priority. Environmentalists and scientists on the other hand convey concerns about natural ecosystems only. It is highly recommended here, that the visual aspect of our environment is established as a basic resource, to be "treated as an essential part of and receive equal consideration with the other basic resources of the land" (U.S. Department of Agriculture, Landscape Management, Forest Service Manual 2380). "It has become necessary to both inventory the visual resource and provide measurable standards for the management of it" (U.S. Department of Agriculture, Forest Service, 1974. The Visual Management System. National Forest Landscape Management, Volume 2, Chapter 1. Agriculture Handbook No. 462).
Abstract

An inventory of the range and game resources of the Kalahari in Botswana, approximately 240,000 km², was carried out during 1978-1979 by a DHV/ITC team.

The range was mapped at scale 1:1,500,000 by combining LANDSAT- and B&W aerial photography (1:40,000 - 1:70,000) interpretation with field sampling according to ITC procedures. The rangeland map legend includes the following range characteristics: landform, vegetation structure, soil, floristic vegetation type, functional land use and nutritive value of forage.

The distributions of the large game animals (Hartebeeste, Wildebeeste, Gemsbok, Springbok, Eland, Ostrich, Giraffe) and domestic livestock were mapped at the same scale by systematic reconnaissance with low flying aircraft; populations estimates were produced.

The observed animal distributions were linked with the range characteristics on the basis of the known animal behaviour characteristics: mobility, habitat selection and food habits.
Three workshops were held on the subject methods for inventory and classification, one on indicator organisms and two on evaluation. Discussion points and reports on these workshops by their secretaries, B. Korf, A. Littel, R.M. Mooij, J.C. Pape, F.J.A. Saris, E.E.J. Weiss and J. Wiertz, are reworked and presented here together with data from two working papers, one by M. Ruzicka and H. Ruzicková ("Inventory and mapping techniques of the landscape structure") and one by M.D. Hooper ("Landscape ecological evaluation"). In addition, twelve different poster summaries, which the workshop participants had at their disposal, are referred to. An article about "Evaluation of ecological data for planning" by A.N. van der Zande, F.J.A. Saris, W. Tips, R. Deneef & P. van der Brent is quoted (WLO-meded. 8, 1981, pp. 16-23).

The methods chosen for landscape ecological inventory and classification depend on several factors. The most important of these are: 1) aims of the research, 2) time and money available and 3) scientific tradition and ecological skill. Because of the first point, discussions concerned also the use of landscape ecological data, especially in planning. There is therefore a certain overlap with the theme of the workshops on environmental planning.

If one puts the "things to be done" in sequence, the outcome would be: observation, inventory, storage, classification, evaluation, use. Some steps can be combined and, as has been said before, it is only useful to collect data with the purpose in mind these data must serve. Later steps also influence the content of former steps, and, therefore, the sequence given is not a chronological one.

It was found advisable to collect as many relevant data as possible in the field by instrument. The most sensitive, mobile field instrument for landscape ecological research was called the scientist's eye. The lowest level of research depends on that kind of perception.

For inventory a (mapping) scale must be chosen. The scale largely depends on the purpose of the project. Hof (p) gives an example of a small-scale research project: a nation-wide physical geographical subdivision of the Netherlands, scale 1 : 600 000. Especially in developing countries, small-scale projects on large areas can be useful. Among others, Korf & Metz (p) give examples of middle-scale inventories for provincial planning purposes. Lists of mapping parameters are given in different papers. A compilation of these parameters is: geology, geomorphology, soil, ground and surface water, flora and vegetation, birds, amphibians and reptiles, aquatic macrofauna, (macro) wildlife, climate, land use, visual and genetic landscape characteristics. To reduce the amount of work, often only some key factors are used, as is illustrated by Rasmussen & Polving (p).

Many landscape ecologists are familiar with the use of indicator organisms in preparing inventories and maps of key characteristics. A special workshop agreed on the necessity of careful analysis of ecological relations and a clear statement of the information required before choosing the appropriate organisms. In a way in this case an evaluation is performed prior to the inventory or mapping stage. Once adjusted the method can work quickly and may be well suited for monitoring or for the prediction of effects.
A more complex part of the inventory is the study of relations and processes in the landscape. Horizontal as well as vertical relations are discussed. It was said that we know more about the vertical relations (see, for example, Veen (1), Vink et al. (p), van Dam et al., p) than the horizontal ones (Farjon et al., p). One can distinguish between short-term and long-term processes. On one of the workshops Haase elucidated short-term processes in nanochores (smallest heterogeneous landscape units) in the Lusatier Bergland. The Department of Physical Geography, Utrecht (p), gives an example of short-term processes (water movements), whereas both Huizing (p), in his proposal for monitoring with help of remote-sensing techniques and Vink et al. (p), in their simulation of changing land uses in Italy, elucidate long-term processes.

The point of data storage and the use of grids were discussed in two workshops. Grids form a good basis for comparing data concerning different parameters and coming from different sources. Attention was drawn to the fact coincidence of data does not necessarily mean that a relation exists between them. A databank, in which data can be handled in grids (Bunce, p, Korf & Metz, p) or using a vector system (Burrough & De Veer, p), gives the possibility for easy updating parts of the data collected. The choice of a general grid size, say 1 km², was rejected. The appropriate grid size again depends on the project purpose. See also the Workshop summary about Databanks.

Classification, the next step, often means reduction and combination of data, which means information loss. Rusicka and Rusickova illustrated this process in their working paper about ecological interpretation of topographical data (primary and secondary landscape structure; see also Rusicka, 1). Elias (p) comes to a grouping of "ecotypotypes". Aguillo & Ramos (p) give an example of reduction of information concerning the visual landscape: from "viewshed" to visual ellipse as an expression of surrounding visible landscape. Other contributions stress the danger of classification as a mere reduction process. The approach should be more holistic, landscape should be considered as a whole, in German a "Gestalt". Doing (p) describes such a procedure for dune landscapes and Antrop (p) presents a holistic interpretation of Landsat images.

Evaluation seems to be the most difficult and controversial item in the sequence given. In every-day practice, many landscape ecologists participate in the evaluation of our environment. Froment (p), for example, offers an example of landscape evaluation in the Belgian land consolidation projects. First of all, such evaluations are only appropriate in connection with concrete problems, e.g. the designation and management of elements or areas for nature conservation. Methods of evaluation vary a lot, depending on the purpose. Whatever the method chosen, it should be described carefully, and the results presented clearly to the users. Hooper, in his working paper, mentioned four operations that form part of the evaluation procedure: (1) selection of criteria; (2) weighting and (3) scaling of those criteria, and (4) calculus of the value. Well-known criteria are rarity, diversity, maturity, soundness, and naturalness. Their use differs depending on the scale as has often been made clear for rarity. Criteria, Hooper stated, should be relevant and precise, and they should not overlap. Weighting and scaling used often demonstrate arithmetic operation on ordinal data, which is not permitted. The resulting "value" can be then considered as the result of a mathematical construction without "reality value". Hooper proposed to avoid this problem by using species richness as the only criterion in judging reserve sites. Apart from critical remarks on
this "solution" from the conservation point of view (see workshop summary on pollution and Schroevers, p), there are objections to using this approach at the landscape level. Using species richness cannot be called a useful criterion for landscape ecological evaluation because it does not deal with the functioning of landscapes. Stability within ecosystems and the balance between different types of land use require a more functional evaluation, not expressed by species diversity. Van der Zande et al. in their article object to ecological evaluation, especially at the landscape level, "because it does not qualify as a scientific activity, for it is not repeatable by independent researchers". They suggest scientists to confine themselves to description, analysis and prediction, i.e. more or less the stages in our sequence from observation up to classification, and to leave evaluation to the public, politicians and conservation organizations. However in one of the workshops evaluation, especially in terms of potentials of sites for functions, was mentioned as a legal activity for landscape ecologists. That evaluation is later followed by another, i.e. political weighting between environmental and other, for example economic, interests (cf. workshop summaries on Environmental planning and Politics).

Finally, several examples of the use of the results of landscape ecological research were discussed. One of them was for plotting new roads: the Netherlands (General Traffic and Transport Scheme), West Germany (corridor finding) and USA (public assessment to find zones "without objection"). Haber & Schaller (p) propose a system for impact assessment in regional planning problems. As to nature conservancy, in USA so called red flag areas are pointed out because of their special qualities and vulnerability; later these areas are investigated more in detail.

The working papers mentioned can be obtained from:
M. Ruzicka, Institute of Experimental Biology and Ecology SAV, Obrancov Mieru 3, 885 34 Bratislava, Czechoslovakia
M.D. Hooper, Institute of Terrestrial Ecology, Monks Wood Stn., Abbots Ripton, Huntingdon, U.K.

DATABANKS

This summary about the workshop 'Databanks' is based on a report of that workshop by G. Hof. No working papers were presented at this workshop.

Databanks are collections of (environmental) data which can be handled automatically with help of computer programs. They can contain geographical (localized) as well as attributive data (soils, vegetation characteristics, etc.). Handling and delivery of data is quicker than for manual procedures. Programs can be written to test ecological models, to find interrelations between different variables, etc. In the workshop the following subjects were discussed: centralization of databanks, openness and use, and reliability.

On the topic centralization, it was stated that both options have their advantages and disadvantages. A centralized databank offers difficult access for users, whereas with decentralized banks it can be difficult to exchange data with each other because these banks are strongly diversified in their development. An example from Denmark was mentioned, where a lot of databanks exist, and where at the same time a committee deals with standardization of different classifications to make exchange
of data possible.

Most Databanks are open in principle to all sorts of users. However, to work with the data presupposes the availability of a computer system and the knowledge to be able to use it. These create a high threshold to potential users. From the databank owner's point of view there is the problem of using the data in a correct way. How do you check on this? Often it is better to restrict the role of the user to formulating clear questions. The owner of the databank then must try to answer these questions by delivering adequate products from the databank.

In principle, the reliability of data from a databank is the same as those gathered by hand. Of course, a databank can never use extra data, that is only present in the human mind and that is impossible to be put in the databank system. Computer programs for extracting data from a bank must be logical. If a user discovers unexpected things or peculiarities, he should ask the original collector of the data.

See for information about databanks also the workshop summary Inventory, classification and evaluation, Burrough & De Veer (p) and Korf & Metz (p).

STRATIFICATION AND SAMPLING PROCEDURES

This report of a spontaneously organized workshop is based on a report of the workshop by R.G.H. Bunce.

Stratification means subdividing a quantity of data (a population) into classes (strata) in order to take samples that are representative for their classes and for the population as a whole. A stratification and sampling procedure will be pursued to reduce the amount of inventory work. This procedure can be important in landscape ecological research.

The members of the workshop described problems that they had encountered in stratification and sampling environmental data. The discussion concentrated on the way in which different classes can be discriminated from each other and the number of samples required for a given level of definition (description of a class). An example from Mozambique was given, where a major problem is how to determine whether the units defined from aerial photographs or satellites cover the variation within the area to be sampled.

It was stated that, although the approach has to be pragmatic, statistical methods of analysis can be proposed to help solve specific problems.

As to the criteria, it was recognized that diversity is an inherent feature of landscape ecological data which should be used as a separate parameter. Classes determined by one criterion should always be validated by other factors. For a given series of objectives it is essential to consider data at the appropriate scale.

A statistical analysis in the way mentioned can prolong a project. However, such an analysis is essential if one wants to provide reliable research results. Programs should be carefully designed to ensure statistical validity.
MODELLING

The problems and possible applications of quantified models are discussed in some lectures. Veen (1) for instance, elaborates the basic formulae to quantify the energy, water and sediments budgets of the ecotope. Discussion in the workshop focussed on energy flow models as presented by Boezeman and Meuleman (p). Here a short report of the workshop written by L. Braat is given:

The merits and problems of dynamic models, in general, and energy flow modelling, in particular, with respect to landscape ecological research and landscape planning, were discussed. A conclusion was reached that two lines of modelling should be stimulated, one line concentrating on development and improvement of models for landscape subsystems and the other concentrating on integrated landscape models for planning purposes.

In order to facilitate the integration of the subsystem and models for planning, the workshop group suggested more contact between the various disciplinary model builders, for instance by forming a working group within each national landscape ecology organization.

THE VISUAL LANDSCAPE

A spontaneous workshop on the theme "The visual landscape", reported upon by A.A. de Veer, came to the conclusion that the visible aspects of landscape were underestimated during the Congress. It was said that the visual landscape is a basic environmental resource in itself, e.g. soil, vegetation and fauna, and that it deserves its own inventory.

Some participants even claimed the landscape in its visible form as a starting point for landscape ecological research - the many different ideas about landscapes as "ecological entities" exposed during the Congress were said to justify that claim.

Striking in this workshop was, on the one hand, the common language the participants appeared to use, and on the other, the diversity in approach of description and evaluation of visual landscape aspects mentioned. Four posters were examined, explained and discussed intensively by the group (see also the poster abstracts).

Aguiló and Ramos elucidated their "viewshed" model. The viewshed is the area seen by an observer from a specific viewing point. According to the model, this viewshed is expressed in an ellipse of which size, axes and orientation correlate to the amount and direction of visible information the observer receives. Topographic situation (e.g. in a valley or on a mountain) and afforestation are important determining factors of the viewshed. The poster authors mentioned recreation and landscape fragility studies as applications.

Antrop argued that due to the changing position of the observer in the terrain, it is difficult to find an objective way of describing landscapes in visual terms. In his poster about visual interpretation of Landsat images (scale 1 : 1 000 000), with an example from Greece, he adopted a vertical, objective way of viewing the landscape. The pixel used, i.e. the spatial information unit, has a size of 90 m²; individual attributes cannot be seen. Landscape is described in photomorphic units which contain information on the "holistic nature" of the landscape and correlate with landscape structures in the field.
Baumgartner shows a Visual Landscape Map of part of the Indian Peaks Wilderness National Park in the USA. It is a combination of abiotic and vegetation aspects of the area, man-made or influenced features and data from perception research, which was gained by public surveys (questionaires). The legend shows conflicts between recreational uses and the carrying capacity of the visual resource.

Much more analytical is the Landscape Information System developed in the Netherlands, which was described by Burrough and De Veer. The system is based on a complete inventory of individual, visible landscape elements (hedgerows, solitary trees, farms, etc.), which are put into an automatic cartographic system. Many different maps, simple or complex, without or with use of evaluation parameters, can be drawn depending on the application level and purpose (mostly planning).

It seems useful to mention also a paper, written by Th. Brossard and J.C. Wieber, called 'The concept of "visible landscape" in a systemic approach', that was discussed in the workshop on terminology. The authors provide a descriptive instrument as neutral as possible to study how (landscape) objects form (landscape) pictures. It is striking that they consider perception research, the study of the way landscape is looked at by many people, as a separate issue. The organization of their visible landscape depends on points, lines and patches in (below), as well as on, the earth's surface. As an application, analysis of landscape sensibility for different "controlled variations" (i.e. plans) is mentioned.

Finally, we mention some other papers in these proceedings that in one or another way deal with the visual aspects of landscape (ecology): the workshop summary Landscape architecture/design, Environmental Science Group (p), Proper (p), Hooper (1).

The working paper mentioned can be obtained from:
Th. Brossard & J.C. Wieber, Université de Franche-Comté, 25030 Besançon Cedex, France.

LANDSCAPE ARCHITECTURE/DESIGN AND LANDSCAPE ECOLOGY

This report is based on a working paper by Grontmij ("Reflections on the Dutch landscape and on ecological planning in general") and discussion points and reports by the coördinators N. Streefkerk and H.O. Faassen.

In a schema, landscape was presented as the visible result of interacting abiotic, biotic and anthropogenic processes. The landscape is perceived by the observer; his perception is "adapted to" personal factors such as education, experience and ethic attitude. The landscape architect designs landscapes.

The following theses were put forward in one of the workshops.
1. If the design is based on ecological concepts, it will meet the aesthetic standards "automatically".
2. Vice versa, if design is based on esthetical concepts it will meet ecological fringe conditions "automatically".
3. Landscape architecture is in our world often described as "the management (of the beauty) of the landscape". If management of the landscape is only based on personally or generally accepted ideas about beauty, other interests, such as agriculture, nature, industry and recreation, are not involved.
4. In the Third World, landscape as described above is rarely considered
in planning. This is acceptable provided that an ecological planning approach is followed. "There are more important things there to be handled than to consider the beauty of the landscape".

In the other workshop about the same subject two main questions were formulated.

5. Which design criteria can be formulated, and by whom?

Six criteria are given as examples. The first three fit well into the concept of ecological design along the lines of Thesis 1 above:

a. Form follows function
b. Coherence in physiographic, biologic and socio-cultural patterns
c. Increasing and strengthening of the variety of landscapes

The next three, however, start more-or-less from an architectural point of view.

d. Simplicity in the main structure, complexity and surprise in the details

e. "Style"

f. The visibility of the modern city in the surrounding rural landscape: yes or no?

6. How to obtain information on wishes and needs of actual and potential user groups about form, design and architecture of the landscape?

It was stated that Theses 1 and 2 are not necessarily contradictory: Large-scale design (large area) can be based mainly on ecological criteria, whereas small-scale design (small area) is based much more on architectural concepts. Paradoxically, ecologists tend to start looking at "small things", whereas architects do the opposite. The choice of plant species the landscape architect adopts must be related to the variety in soil, climate, etc. He also must know about forestry and vegetation (management) techniques, cf. Bannink & Pape (p).

It is striking that in neither workshop a pure architectural starting point for design (see These 2) has been set forth. Landscape was described as an interest of different users, such as recreationists and farmers.

Although a discussion landscape architecture - ecology is necessary, it was stated that many mondial problems occur, like local lack of energy and inflow of cattle food products. These problems seem to be ecological in the first place (These 4).

In both workshops the necessity of perception research was stressed. Too little is known about what landscape means for people. The information landscape gives us nowadays drastically changes, especially in urban fringe areas (see Thesis 5 f). The results of perception research can be used after ecological research has been done (cf. Theses 1 and 5 a). Maybe the small influence of designing criteria in decision-making processes is due to the lack of validated social - psychological background data.

In one of the workshops, somewhat aside of the main subject, a discussion occurred about planning in urban-rural fringe areas with a high landscape diversity. A possibility to maintain or create diversity in landscape, was described as "supporting extreme environments" (whether strongly man or nature dominated), as well as landscape types inbetween where man and nature are in balance.

The working paper mentioned can be obtained from:
Dept. of Landscape architecture Grontmij N.V., P.O. Box 203, 3730 AE De Bilt, Netherlands.
This summary of the discussions held in the two workshops about environmental planning is based on points in question and reports by P.H. Veen and R.J.V. Nys and a number of working papers and a poster, the titles of which are quoted in the text below.

Harms and Kalkhoven, in their working paper "Ecological contribution to the Central Brabant Land Use Project", gave a clear subdivision of physical planning in facet and sector planning. Both can be tackled from the viewpoint of ecology; together they might be called environmental planning. Ecological sector planning deals with suitability for nature conservation (e.g. well known from the USA), whereas ecological facet planning provides an ecological framework for landscape planning or physical planning in general. As an implication, landscape ecologists should not only put emphasis on nature conservation, but also on other types of land use. The authors' structure plan for Central Brabant gives some conditions for ecological planning:
- aiming for more extensive farming on less fertile agricultural land;
- adapting land development techniques to the physical landscape;
- varying the management according to the natural diversity.

Ecological diversity as a basis for optimalization of rural landscape use was also the subject of the working paper by Zigrai and Kozová ("Changes of the Landscape Ecological Diversity of the Model Territory Léaky in Northern Slovakia by Human Activities from 1769 to 1979 and their Importance in Landscape Planning").

Is it correct to place environmental planning besides economic and social planning? In other words, to consider it as a separate planning facet? Almost all participants agreed on the fact that environmental planning deserves its own place in planning procedures. However, what is "its own place"? Martis, in his working paper "Programme of ecological optimization of land use", described the Ekoprogram 1981-85 in Czechoslovakia, in which he stressed that the aim is not isolated and oppositional ecological planning, but operational, theoretically well-founded help for the existing systems of planning. Carrying capacity, ecological load and, derived from that, ecological stability, are estimated according to the Ekoprogram in order to suggest ecological management systems. Gross, in a working paper called "The Significance of Landscape Ecology in Regional Planning: The Case of Major Facility Siting", pleaded an equal weighing of engineering, socio-economic and environmental considerations. In one of the workshops it was said that, looking at the future, the economy of the growth and the increase of population seem to be major problems. Landscape ecologists should contribute to spatial planning by suggesting limits to socio-economic developments. In that case, environmental planning forms the base for other facets of planning.

The theoretical basis of environmental planning is weak. Different options were exposed during the workshops and in the working papers. One option is the use of "suitability for ecological functions". However, this issue is considered by some people to be too anthropocentric; instead, the term allowability of functions was proposed. "Fulfillment of functions" as a criterion for ecological quality is used in different papers: by Van der Maarel (1), and by Niemann in his working paper "Contribution to the management of Landscape Elements and Landscapes". Niemann excerts an analysis of features and functions in the landscape, and derives a matrix from it in which for every type and management variant of a landscape element (pond, meadow, hedge etc.)
the degree of fulfilling significant functions can be established. Use of the theory of island ecology was mentioned as a means to maintain rare types and a sufficient number of plants and animals; islands should be connected by corridors (see Forman (1), Sharpe et al., (1), Van der Maarel (1) and the Workshop summary on Island biogeography).

Some problems about inventories and evaluation were discussed, see also Workshop summary Inventory, classification and evaluation. For technical and financial reasons landscape ecological research for planning purposes is often restricted to the components water, soil, vegetation and birds. However, other components, such as geomorphology, land use, other zoological groups and visual landscape, should also be taken into account. Information should be valid and realistic; for planners data must be given in 'translated' form. The cooperation of biologists, geographers and other discipliners both in research and planning teams is essential. Haber and Schaller (p) even mention 16 disciplines involved in a regional project for impact assessment, with mapping scales of 1:5 000 and 1:25 000. The use of mathematical techniques in environmental planning, especially introduction of weighting factors, was criticized.

The working papers mentioned can be obtained from:
M. Gross, University of Massachusetts, 109 Hills North, Amherst, MA 01003, USA
W.B. Harms & J.T.R. Kalkhoven, Research Institute for Forestry and Landscape Planning, P.O. Box 23, 6700 AA Wageningen, Netherlands
M. Martis, Federal Ministry for Technical Development and Investments, Slezska 9, 120 29 Prague, Czechoslovakia
E. Niemann, Institut für Geographie und Geoökologie, Dimitroffplatz 1, 7010 Leipzig, DDR
F. Zigrai & M. Kozová, Institute of Experimental Biology and Ecology SAV, Obrancov mieru 3, 885 34 Bratislava, Czechoslovakia.

ENVIRONMENTAL IMPACT ASSESSMENT

This account on the workshops about Environmental Impact Assessment (EIA) is based on the discussion points and reports by the secretaries P.E. de Jongh and W. de Herder, and a working paper by C.M. Madduma Bandara titled "Does an Environmental Impact Statement (EIS) make sense on the landscape level? Significance of landscape ecology in EIS".

EIA is a process whereby an assessment is made of the environmental impacts of alternatives of an activity to be undertaken. EIA includes:

- identifying the alternatives for an activity;
- identification of impacts;
- prediction of the size of impacts;
- evaluation of the significance of impacts;
- comparison of alternatives;
- preparation and approval of EIS (the statement itself).

An EIS will be a public document. According to the new Dutch law on EIA, there will be a preliminary discussion before an EIA study in which everybody can give his opinion on important issues. An independent check of an EIS afterwards will be obligatory. The political decision-maker on the activity has to justify his decision by describing how he used the EIS in the decision-making process.

The main objectives of making EISs can be described as to inform the
parties involved (especially the decision-makers) about the environmental effects of the planned activity, and, through that, to improve planning. In one of the workshops it was stated that up till now the environmental aspect of planning is badly served, mainly because of lack of public participation in the planning process. EIS, then, might be a solution.

What can be the contribution of landscape ecology to EIA and making EISs? Two types of landscape ecological research can be distinguished:

1. Basic landscape ecological research for supporting EIA in general
   a. Theoretical research: development of a landscape ecological model to be used whenever EIS is obligatory;
   b. Studies on the methodology of impact research;
   c. Pilot studies on certain activity-impact combinations;
2. Applied landscape ecological research for a particular EIS.

All sorts of research were proposed by (groups of) workshops participants, however for Point la. no suggestions were made. As to Point lb, it was stressed that many data about the quality of the (existing) environment are available, but that knowledge of impacts is (almost) lacking. Impact research should be undertaken in the form of defining doses-effect relationships. Bandara, in his working paper mentioned above, considered the use of EIS in a development country (Sri Lanka). Concerning Point le, he suggested that EIS does not make sense at a local level, but that it can be helpful regarding disturbances of stable ecosystems by large scale irrigation, land development and settlement projects. In general, pilot studies were mentioned as a good starting point for theoretical research, i.e. Point le influences Point la. In one of the discussion notes a good description of the content of research for Point 2 was given. "Only an active attitude of the landscape ecologist can contribute to the formulation of alternatives; he should participate in planning instead of confining himself to predicting effects of alternatives generated by planners from technical fields". Only in that way can alternatives be found that do less harm to nature and the environment.

In both workshops attention was paid to the way of presentation landscape ecological data for an EIS; qualitative and quantitative description and/or aggregation of data. EIA should be based on facts. A certain subjectivity in the choice of impacts to be predicted is inevitable. In most cases a quantitative description is desirable, but often it is not (yet) possible to quantify impacts. The landscape ecologist cannot give the "hard information" the decision maker wants. When two alternatives differ very much, a qualitative description is sufficient. The level of aggregation of data was mentioned as a problem in the discussion points: a low level, e.g. data on soil and flora might be more clear for the decision makers, but it cannot be considered as a landscape ecological contribution. A high level of aggregation, e.g. on eutrofication and diversity of ecosystems, does not allow interpretation by the decision maker.

Evaluation also forms part of the EIA procedure. Here the point subjectivity was discussed. For whom is the landscape ecologist evaluating effects? It was said that the landscape ecologist's customer is society and in that case he will take all members interests concerning environment equally into account. Others said that the quality of an EIS and the way it can be used will be strongly influenced by the attitude of the landscape ecological expert. He will always have a personal notion of good and bad in impacts, based on ideas about the most desirable state of nature.
LANDSCAPE ECOLOGY AND ENVIRONMENTAL EDUCATION

This summary is based on a working paper of the same title written by P.J. Schroevers and a discussion report written by E. Jongejan.

The main points from the working paper are:

1. Since about 1850 nature has become a toy for technocratic development. Educative processes, directed towards a fight against this approach, can be taken together as "environmental education".

2. Science and technology provide the means with which our system is able to maintain itself. Solution of problems is only possible from a reductionistic point of view, where nature is considered as a sum of certain processes. If one knows these processes, one can also solve the problems. This approach means at the same time alienation from nature.

3. Fighting against alienation of nature demands an integrated, holistic picture of nature. This can be found in an historical landscape ecology, which describes the development of the landscape, the course of self-arrangement in living systems with or without interference.

4. Landscape ecology is no environmental education, but interpretation of history by a combination of social, economic and ecological criteria can be regarded as the objective of that education.

The workshop members first discussed the objective of environmental education and the changes in the last decades. About 20 years ago education was theoretical. Nowadays "everyone has a green feeling in his heart" and children go into the landscape with their teacher. In this education it is important to synthesize and to practice holistic thinking. It is wrong to speak only about one object in the landscape and even worse to emphasize certain negative processes such as pollution. Step by step education can go from feeling, knowledge and integration to society.

Some topics in education discussed were:

- Problems can be introduced in a sort of drama simulation, e.g. of farmers and town-inhabitants.
- Most ecology books miss information about man; they should include "society models".
- Development on earth went in the direction of less entropy (chaos) and more order. Mankind can now choose to continue along this path or return to a certain degree of entropy.
- Children must be made aware of their environment by letting them use all their sensory organs.

Integration of disciplines in order to reach a holistic approach of nature and landscape was discussed. In the primary school all subjects can be combined in one landscape project supervised by one teacher. In the secondary school problems arise because different teachers teach different subjects. At some universities environmental education is raised to a higher level by combining the disciplines geography, biology and planning. Two examples of education projects were mentioned: an energy project for secondary schools (see Schroevers, p) and a landscape project of Jongejan at tertiary levels.

The working paper mentioned can be obtained from:
P.J. Schroevers, Research Institute for Nature Management, P.O. Box 46,
LANDSCAPE ECOLOGY AND POLITICS

This account is based on the discussion points and report on the first workshop on "Landscape ecology and politics" by T.E.M. Van Leeuwen and two working papers, one called 'Significance of landscape ecology in political decision-making processes' by R.J.V. Nys and another called 'Research on landscape ecology and its use in policy' by R.H.G. Jongman & A.C. Bertoen. It was complimented by some of the questions formulated for a second workshop and data from the plenary discussion following the lecture of J.C. Terlouw (referred to in this summary as 'Discussion').

Fundamental aspects

Is landscape ecology a separate science, and if so, is it a basic science or an applied one? Nys, in his working paper, discerned two branches of landscape ecology: as a basic science it wants to describe, generalize and explain its object (the landscape system), whereas as an applied or action science, it wants to change, manage and restore the environment. In these branches there is a different way of thinking and a divergence in methodology. However, it is desirable that landscape ecology remains a unified science and that a bridge between its theoretical and its action foundations be developed. In one of the discussion points landscape ecology was called an applied science by definition, based on ecological science and making use of other sciences. Apart from the implicitly denying the theoretical framework, the latter thesis reveals a different use of "application": landscape ecology applies other sciences, whereas Nys speaks about the application of landscape ecology in planning and politics. To reach that type of application he sees theoretical justification, usefulness for action research and reproducibility as essential claims.

According to some workshop participants, landscape ecology is not a science but an attitude. If an attitude only means vague considerations about a holistic approach of landscape, of course no fundamental contribution to the solution of environmental problems is given. However, a consistent attitude can influence decisions on each level, and it can support ecologically justified long-term planning instead of short-term, mainly economically-based, plans. This is illustrated by some examples in the workshop summaries on urban-rural relations, rural problems of industrialized countries and pollution.

Ethical aspects

There is a dilemma between the social and the scientific responsibilities of the landscape ecologist. Can his contribution to planning and politics be objective? According to Nys, it will always be subjective, although individualistic subjectivity must be rejected. He proposed a representative subjectivity, one in science by a collective agreement on intrinsic (ecological) factors, and one in society by making the values of landscape ecology commensurable with other (extrinsic) values. In this respect, Jongman & Bertoen, in their working paper, stressed the fact that up till now the weight attached to the quality of nature
and environment is often inferior to that of other interests.

Different groups in society have different interests and think in different values concerning environment. Landscape ecologists have their own sympathies and so, they cannot exclude ideological presuppositions. This is no drawback provided the values chosen by the investigators have been made clear.

The choice of priorities is often made by governmental institutions. However, at some Dutch universities, science shops have been started, which lower the threshold for ordinary people to ask for research they cannot pay for.

Tactical and practical aspects

Should priority be given to the information and education of the public or should scientists (landscape ecologists) concentrate on getting the right report on the right desk on the right moment and leave it to the politicians to sell it to the public? Both directions of "landscape ecological information flow" were mentioned as useful. Landscape ecologists should have a feedback on the goals of societal groups, e.g. have their input into political parties (cf. Discussion). But they should also provide the planner and, indirectly, the political decision-maker, with relevant landscape ecological data. Jongman & Bertoen gave a clear idea of how inventory and interpretation can make an important contribution to policy-making. Indeed, clear presentation of data is an important point. Prediction of effects are asked for and must be given with a directness as much as possible. Other predictions (e.g. demographic) have also to be corrected from time to time; why should landscape ecologists be so prudent? Translation of ecological research results into feasible planning alternatives can give an extra dimension to the participation of landscape ecologists in Environmental Impact Assessment (see workshop summary on this subject, and Discussion).

In these ways landscape ecology might become a basic part of the planning process, guiding and influencing environmental goals and decisions.

In the workshops, as well as in the discussion points, people were worried about the use of environmental data in time of economic recession. In the plenary discussion too, this point was mentioned, with special reference to the problems of the Third World.

The working papers mentioned can be obtained from:

R.J.V. Nys, Research Institute for Landscape Ecology and Environmental Planning, Coupure 160, 6000 Gent, Belgium
R.H.G. Jongman, Dienst Landinrichting en Landbouw Prov. Gelderland, P.O. Box 9090, 6800 GX Arnhem, Netherlands.
Closing Session
I do not intend to add any scientific content to what has been said during this congress, Perspectives in Landscape Ecology. Now the work done by landscape ecologists will be approached from the political side. I will discuss three decision-making tools used in physical planning. But first I will mention some general problems concerning decision-making in our bureaucratic and technocratic world.

A black-white contradiction between science and politics is: science tries to find the truth; politics makes choices, sets priorities. However, priorities (of research) also exist in science, and politicians use facts. The question is whether these facts are objectively compiled, or are they a selection from the truth?

A political party’s programme should be based on an evaluation of all facts, and it should be democratically compiled and voted on. A weak spot in our parliamentary democracy is the fact that elections are never far away, so many political decisions are short-term ones. However, from a landscape-ecology point of view we need to make long-term decisions and it is the politician’s task to teach people what long-term policy is. The new law for making Environmental Impact Statements (EIS) will give us the possibility of avoiding irreversible short-term decisions.

Sometimes we do not know where, when and by whom decisions are made. An example could be the development of microprocessors (chips) that give people the opportunity to do their work at home. But if people do not want that opportunity, how can we stop that development when it seems to be an autonomous process?

Another problem in decision-making is the co-ordination of activities by different government departments. They all have their own interests. This is illustrated by the new Waddenzee Law, concerning the shallow tidal area along the northern coast of the Netherlands. It is difficult to achieve co-operation between the various departments that are responsible for defense, recreation, economics, foreign affairs, and the like.

In spite of these points, we have made progress in planning and in acquiring the tools we need for it. Three of them will now be discussed.

1. OTA. Some countries have an Office of Technology Assessment (OTA). Such an assessment describes what a decision is going to mean for people. In a way, we can compare OTA to EIS (see above).

Already in the late sixties, the public in the Netherlands did its own technology assessment concerning the sea arm Oosterschelde. According to the Delta Law of 1957, made after the flood of 1953, all Dutch sea arms except two were to be dammed. An action group of private persons affirmed that of all official advantages of the damming up, only that of safety was a valid one. Facts had to be stripped of their political colouring. In 1972, a State commission concluded that a half-open dam with holes, that could be closed during storms, was the only solution to guarantee the natural quality of the Oosterschelde and, at the same time, the safety for the people living on the islands. At first no majority for such a solution could be found in Parliament nor in the governing Cabinet. Only after heavy political pressure was brought to bear was the decision taken to build the half-open dam. It was the result of the strong feelings of an originally small group of people against an irre-
versible decision.

2. **PKB** is the Dutch abbreviation of Planological Main Decision. It is a national procedure to be followed in main planning questions. The procedure consists of: initial decision by the government; publication of the decision; consultation with local authorities, individuals and experts; discussion in parliament; final decision; execution. The "inpoldering" (land reclamation) of the Markermeer, part of the former Zuiderzee, will follow along the lines of a PKB. An initial decision was taken to reclaim almost the whole Markermeer to Markerwaard, in order to create farmland, a new airport and residential areas. Many people, also from the Democrats '66 party, are against this, arguing that things must be kept flexible by planning step by step, among other reasons to safeguard the Netherlands' largest freshwater body and its natural qualities. When all the experts have spoken and the discussions are finished, a political decision will be taken.

3. 'Broad social discussion' is a new political tool. Its first case, the nuclear energy issue, has much to do with landscape ecology. The discussion, starting in 1981, is likely to shift from the siting of nuclear power stations to the general question of "whether to or not". An important aspect will be the free exchange of ideas without any instruction or governmental scenario. Maybe an advisory referendum can bring the definite choice when everybody has been informed.

In conclusion, it must be said that the process of political decision-making in our technocratic society can be improved. Humanity seems in level to be behind science and technology, which is not good. The new tools for decision-making discussed can be used profitably in landscape ecological issues.
between J.C. Terlouw, a panel consisting of the congress participants Gjessing (N), Golley (USA), Kuyken (B), Roberts (UK), Schroevers (NL), Vink (NL), I.e.S. Zonneveld (NL) and J.I.S. Zonneveld (NL), and an audience consisting of other congress participants. The discussion is given in a condensed form, mainly in chronological order. Remarks and questions not answered (literally) are given as well. Central discussion themes are underlined.

Schroevers asks how a long-term strategy can be practised in short-time views. He wonders whether it is possible to indicate a strategy to create a broader scope of alternative solutions to environmental problems. Gjessing asks if there is a legal framework for channelling landscape ecological information in the Netherlands.

Terlouw answers that politicians must try to prevent that short-term decisions are in discord with long-term strategies. Sometimes this relation is difficult to find. To reach his voters, a politician cannot neglect their daily problems. The legislative framework meant by Gjessing is being built up. There are new laws against air, water and soil pollution. Special laws for decision-making concerning the environment have also been passed (see EIS and PKB in Terlouw's lecture).

Van der Maarel says that there is one good way to integrate long-term and short-term planning, by "doing nothing" or veto-planning. One could also put this in positive terms: instead of saying "don't inpolder the Markerwaard" say rather "save the valuable water area". Kuyken mentions the Dutch Oostvaardersplassen as a very good example of the result of doing nothing: a high qualified nature area. Golley adds that "doing nothing" sounds negative in an economic sense.

Terlouw does not see objections in the choice of doing nothing. Too often we have said "let's do it", in spite of insufficient knowledge about the consequences. The positive formulation proposed by Van der Maarel does not make much difference.

Schroevers says that the possibilities nature offers and the things man wants always give a result for which man is responsible. He sees another point where long-term strategy could be practiced in short-term policy: a new way-of-life by using more handicraft in this time of unemployment instead of importing energy.

Terlouw does not see such simple solutions. His party pleads the creation of more part-time jobs and the placing of a general ecological interest above personal interests.

Mrs. Broekhuizen asks about reconsideration of the national Dutch motorway plan; Terlouw affirms that the plan will be reconsidered. She also puts a question about the quality of the Markermeer water after possible inpoldering of the Markerwaard. Schroevers points out that experts gave contradictory research results, and, of course, this gives politicians the opportunity to colour the facts in the way they want.

The next discussion point is the usefulness of a special ecological political party. Zonneveld raises the question whether the ecological philosophy is strong enough to build such a party on. Streefkerk stresses that there is a big distance between such a philosophy and the programme of a political party. The philosophy should debouch into practical concepts -not bound to time or place- usable in political decision-making. Adejuwon discerns two types of politicians: leaders and organizers. Leaders are retreating and organizers are coming up. Is it possible to organize the people in an ecologically desirable way, e.g. by teaching them about conservation? Habor sees a short-term function for an ecologically-
oriented party, namely in convincing existing parties of the interest of ecological viewpoints, cf. "Die Grünen" in Western Germany. Smittenberg sees only possibilities for such a party if an ecological view on all problems of our society can be given. Golley thinks an ecological party is a typical solution for West-European political systems. Van der Maarel, at last, suggests in certain cases the replacement of the term economic by ecologic, in order to use ecology as a good planning tool (e.g. ecologic development aid).

In Terlouw's opinion an ecological party that does not consider anything other than ecological problems (which exist) has only a short-term function. Maybe ecology is a philosophy, but in politics it is (or should be) a priority. Essential is that the people are convinced of this priority. Vink adds to this point that, to reach balance between economy and ecology, ecology should be dealt with in the Constitution or at least in a sort of 'frame work' law.

Kayken points to the dilemma of every ecologist: should he be a researcher serving politicians or an educator reaching a large public?

Golley likes to focus on international problems; what can be the ecological contribution to the solution of world-wide problems such as atmospheric pollution, population growth and nuclear armament? Also he pleads consistency between life-style and scientific activity by ecologists.

Schroevers sees 'ecologism' as a way of life and a philosophy besides well known political movements like communism, socialism and liberalism. The latter "isms" fit into the existing system of 'econonism', which means alienation from nature and, in that, they are one-sided. Has not ecologism the right to be one-sided too?

According to Bennett there is no principle reason to remove environmental factors from economy. Van de Veen says that the problem arises because of reduction of the notion of economy to "all taking pieces of a growing cake". If we speak of economy in terms of scarceness of goods, it is very close to ecology.

On Third World Problems, Voortman argues that economy without ecology destroys natural sources, whereas ecology without economy is a luxury that can be afforded only by developed countries. Economy is ecology, and vice versa. It is essential that no development projects be undertaken that mean a disaster for the developing country. Vera pleads for economy to be ecologically adjusted; this is especially important in the "closed systems" still present in developing countries. Husain gives an example from India, where an oil refinery in Bihar only brought employment for people from elsewhere. To the ecological values of Bihar the project meant only damage. With development projects it is more and more important to take ecological viewpoints into consideration. Ecological models from developed countries can help in this.

Terlouw, in his final comments, says that every ecologist who wants to bear his responsibilities, should be member of a political party. On the relation economy-ecology, he repeats that ecology is a priority and as a consequence plans have to fit in economically. Referring to the recently published OECD report about structure, growth and values, he mentions the tension between existing structures and ecological needs, pointing to the example of industrial meat production. Ecological values in developing countries have been and are still being destroyed. It is important not to introduce our technical mistakes into those countries.
In a short final speech, the Chairman of the Congress Organizing Committee, I.E.S. Zonneveld, gave a review of the Congress. He stressed the importance of the meeting about international co-operation in the field of Landscape Ecology (not separately reported on in these Proceedings). By contacts in the years to come between landscape ecologists from all participating countries the foundation of an international society for landscape ecology will be prepared. Personal contacts, meetings and maybe a special bulletin then will lead to intensive communication between landscape ecologists. Finally, the Chairman thanked the participants for their co-operation during the Congress.
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