THE ECOHYDROLOGICAL APPROACH TO NATURE PROTECTION

G. VAN WIRDUM
Research Institute for Nature Management, Leersum
(The Netherlands)

Reprint from:
Research Institute for Nature Management, 1982 -
Annual Report 1981
RIN, Arnhem, Leersum and Texel, p. 60 - 74

The ecohydrological approach to nature protection

G. van Wirdum

Introduction

The Ecohydrology Section of the Botany Department of the RIN has been involved in several external projects concerning the investigation and schematization of the relationships between spontaneous vegetation and hydrological factors. Both technical and theoretical problems were encountered, and it appeared necessary to find a new approach to existing knowledge to arrive at the desired solutions. The application of these solutions to concrete questions has revealed the shortcomings of specialization and the need for refinement of the matrix. The Section's research projects aim to illustrate and develop some of these items far enough for others to take them further, as in the present cooperation with the Department of Advisory Services on the effects of withdrawal of drinking water (cf. Reijnen & Wiertz 1981). At present, research is being done on the interactions of the hydraulic cycle with the unsmoothness of the land surface and with the water management as well as on the response of spontaneous vegetation to the resulting geographical pattern of soil and water types. This response seems highly sensitive to strategies applied for water use or water management.
This report is intended to serve as an introduction to the present activities of the Section and some recent publications. More detailed references will be found in the publications themselves. A leading topic not covered by this report is the role of remote sensing in the detection and evaluation of several aspects of patterns. The theoretical contribution is, needless to say, part of the project of the Theory Section. Obviously, biological laws and theory do not suffice to cover the field of application, i.e., nature protection. Hence, identification of the technical problem is not a superfluous matter. Readers with an interest in applied science may appreciate our effort to produce technical descriptions of instruments, methods, and calculator and computer programs.

Threatened organisms need protective devices

Nature protection cares about environment. In our attempts to set standards for water-related environmental factors, it became necessary to define a technological frame work for nature protection. For this purpose, the basic question to be answered was: what is this particular environment and what is it used for? It is often suggested that it is used for the physiological performance of species, but that appeared to be a different environment! A systems approach may remove some ambiguity from the ecosystem and environment concepts. In the biological literature, the word ecosystem is generally defined as a collection of organisms and environmental factors in a certain area. This collection is claimed to form a whole which is more than the sum of parts involved. Research is done on the identification of this 'more', on the detection of relationships between parts, and on the physiological basis of the functioning of the parts. This 'microscopic', structural-relational approach has unlocked vast fields for new research and has yielded a wealth of data without which we would probably underestimate the deterioration of nature. Nevertheless, the picture is very incomplete and the why of the system is not really understood.
The original definition of an ecosystem, given by Tansley, can be interpreted teleologically as

well. This other-way-round approach, formulated in systems theory, defines any supposed system in terms of an emerging property or *goal*. Effectiveness or functionality is a prerequisite for inclusion of any element. Questions as to how they are able to function as they do, what they look like, and what their real names are, have less importance. The approach of teleological systems is therefore macroscopic, reducing many divergent causal questions to a single final problem. However, this involves the risk that some less conspicuous elements that might in the long run prove to be essential, will be overlooked in early exercises. Nevertheless, careful application of technology has convincingly proven able to give man the power to reach hitherto remote goals. In these applications, the system is merely a mental concept, the approximate realization of which is a machine, apparatus, or device. Accordingly, in the applied theory of teleological ecosystems, one of the main issues will be the *ecodevice*. Where the application of ecodevices for agricultural and industrial production threatens spontaneous fauna and flora, other ecodevices may help to protect the habitats of these organisms. If man is the goal organism, ecodevices may be called *humecs*. When threatened spontaneous organisms are involved, we have *natecs*. The goal organism will be seen here as an emerging property of an ecosystem. In nature protection, the relevant part of reality will be sought and driven as a natec towards the continued existence of this emerging property. This approach has been recently discussed by van Leeuwen (1981) and van Wirdum (1981b). After all, the question will not be whether reality is a whole with emerging properties or whether its elements are exactly what we think them to be. What must be asked is whether the organization of the relevant part of reality can be represented by the devices and functional elements to be discussed: it should behave more or less similarly.

Tasks and functions of ecodevices

The performance of its tasks by an ecodevice is evaluated on the basis of the emerging properties, which must be measured. Typical devices have their most sensitive parts locked against unqualified use and will obey driver instructions. Analysis of the response of ecodevices to external events shows four categories of *functions*.

These functions can be activated via the *gates* of the ecodevices. The most frequent problem of natecs is probably overfeeding (eutrophication). In this case the actual environment obviously does not meet the design specifications of the device: functions do not properly match tasks. If it must work under such conditions, the input *resistance* must be improved. In natecs, reasonable results are sometimes obtained by increased mowing or grazing, i.e., by disposing of produced biomass. It should be stressed that this is a marginal solution that can only be used if the supply does not lie too far outside the specified limits. The most common problem associated with the *disposal* function, i.e., constipation, is seen in cast-off agricultural humecs, now used for nature protection. Such practices as sod-cutting, sheep grazing, litter collection, and hay-making (not with heavy machines!) have been abandoned in these ecodevices, for financial reasons, but should be reinstituted. Improvement of water management for agriculture often leads to leakage of water for natecs. Sometimes, this problem can be cured by improving the *retention* in the natec by enlarging the resistance in the water-output gate. Underfeeding occurs when – for instance, due to canalization of rivulets – *supply*ing flows are diverted. Drinking-water withdrawal may similarly cause what were originally receiving soils to become shedding and leached soils. Van Leeuwen (1981) gives several examples of applications of the four apparent functions of ecodevices. The functions of the ecodevice model are shown in Fig. 1.

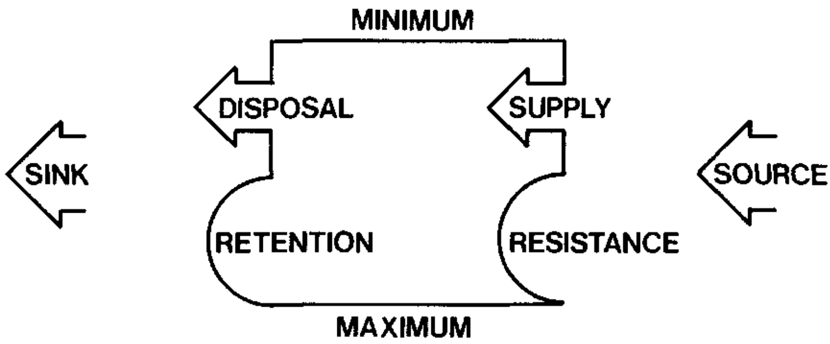


Fig. 1. Ecodevice to control the operational environment of organisms.

In actual applications it will be seen that the reaction of ecodevices is not as straightforward as suggested above. Retardation and chain reactions are common phenomena for which the devices seem to have certain *programs*. We think of these programs as contained in retained matter formed into a structural code organ within the ecodevices, the memory organ. The memory organ is said to have four main compartments, the *geomneme*, *pedomneme*, *biomneme*, and *techno-* (or *noo-*)*mneme*, which have been introduced by van Wirdum (1981a). These are accessible for *in situ* inspection and will aid tracing programs. Some aspects are dealt with below. The maturation of ecosystems, as described in ecological texts, parallels the growth of the memory organ. Historical events are thus reflected in response programs, as in a learning process. Retention makes ecodevices intelligent devices.

The environment of ecodevices

It has been shown that the functioning of ecodevices depends on the resistance in the input gates and the retention in the output gates, relative to the supply and disposal 'tensions' in the environment of the devices. Up to this point, it has been a question of inaccessibility. In the design of devices, it is a good idea to specify the required 'tension' and the tolerated deviation. This should, in the case of natecs, meet the expected range of environmental properties. The use of certain 'heavy' humecs may change the environment outside this expected range, rendering any application of natecs useless. Of course, humecs too might suffer, and some humecs are designed for application in an environment that cannot support the use of certain natecs in their vicinity. The problem recently created by Dutch cormorants which started to take their food from a fish farm is just one example of the latter. The technique developed to prevent and deal with this type of problem is called environmental management or protection of the environment. One of its methods is regulation by law (as a strategy of, e.g., emission control). Another is the use of specialized devices for purification of air and water.

These devices work for humec users as well as natec users and should be considered to belong to a separate class of ecodevices, the *envec* class. The ecological significance of envecs arises from the availability of humecs and natecs. This way of defining environmental management removes some of the confusion caused by the question as to which organisms should be specified as the beneficiaries of environment. Now that these have appeared to be not organisms but whole devices, it is immediately clear that autecological data and physiological backgrounds are of very restricted suitability for the specification of standards that environmental management should meet. The relation between any threatened organism in a natec and this 'general' environment is brought about by the programmed functioning of individual natecs. Although the same species with the same autecological requirements may be the goal organism in different natecs, those natecs may differ greatly in their response to the same environment and the same environmental change, since they were probably built for different environments.

It seems useful to have separate names for the different environments. The *operational environment* of organisms, met by their physiological properties, is found in the habitat, i.e., in a very thin envelope surrounding the organism. A *conditional environment* is identified in the ecodevice. The spatially extended concept appropriate to the *positional environment*, the environment of the ecodevice, is the *ecological field*. The tripartite environment of organisms has been described by van Wirdum (1979).

A scheme of relations in teleological land (systems) ecology

The technological framework sketched thus far permits the routing of change agents from humecs through the ecological field into natecs, straight to the organisms to be protected. This may be seen as a layered model, as illustrated in Fig. 2. In each layer, a physical set of laws appropriate to the propagation of a particular agent can be formulated mathematically. In the devices, transfer of information between the layers can be postulated to explain reactions and complex formation. In this case, a change agent can be traced in several layers, thus forming an indirect *channel* through the model. If necessary, the ecological field should be represented by an additional system of devices.

Until recently, three alternative or complementary mechanisms have been mentioned to explain effects of humec water use, as illustrated in Fig. 2. They are:

a) The direct channel of water: lowering of water levels in the template of the humec causes lowering of hydraulic head in the natecs template of the ecological field, which may alter the capillary water transport to the rooted zone of the natec soil and thus, in critical periods, interfere with physiological water demand. This channel is a headliner in agrohydrology.

b) In the natec, information transfer from the direct channel via the depth of aeration of the soil and, via physico-chemical and microbial reactions, into the nutrient layers, may cause enlarged mineral-nutrient availability (eutrophication). These processes, summarized under the term enhanced mineralization, may dominate the effects of the direct channel if the latter is not critical and the soil contains a considerable nutrient stock. Probably, enough of the elements needed for mathematical treatment are available to allow simulation of simple cases. In actual studies, however, the matter has been kept very vague.

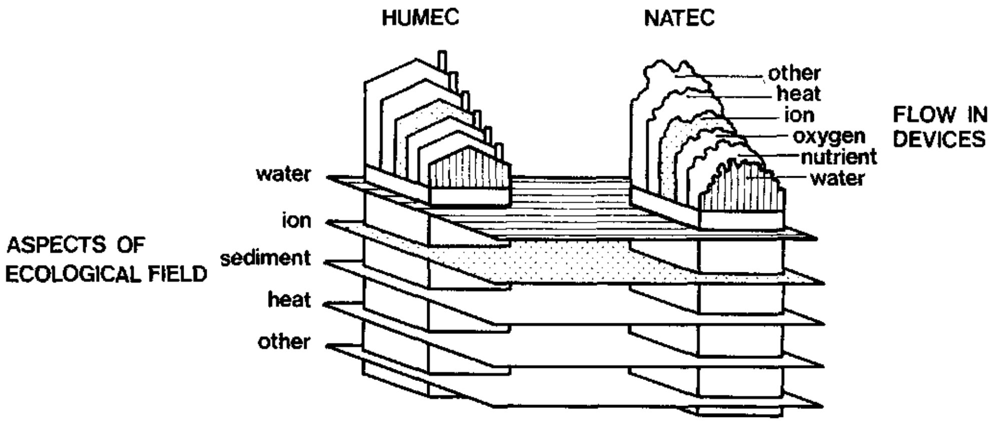


Fig. 2. The direct channel of water (hatched) through an ecological field from man in a humec to nature in a natec. The dotted area respresents the direct ion channel.

c) Several plant species (called 'midy-haters') are said to be extremely sensitive to something called *milieudynamiek*, which can be translated as changeability of the environment. In relation to water management, the principle is most often interpreted as a statistical dependence of plant performance on the frequency distribution of hydraulic head at the plant's station. Thus, it could be seen as a direct-channel effect. So far, results have been rather poor. Yet, the existence of extreme sensitivity is known to most experienced botanists and has led to the statement that effects of lowered water-tables may be seen where the actual lowering is hydrologically negligible.

It may be remarked that there are several reasons to consider the frequency distribution of hydraulic head. Biologically, the dispersal of propagules and their germination may be related to this distribution. Physically, the supply of solute, and, in some cases, soil particles to the natec might well be correlated with it. The same probably holds for the complex balance between peat formation and humification processes versus mineralization processes.

Nevertheless, we have obtained indications that the pattern and reaction of goal organisms belonging to this midy-hater category coincides with differences and changes in the macro-ionic composition of ground-water. In typical inland natecs, a divergence is found between, on the one hand, elevated places with predominantly rain-water infiltration, pronounced fluctuations of the water-table, and a highly dilute solution, and, on the other hand, places that have a low elevation with respect to the regional drainage base, less fluctuation of water levels, and a somewhat stronger solution in which calcium is the dominant kation. The influence of the ionic composition seems to be related to the buffering of fluxes of physiologically active substances by the chemical equilibrium in the porous soil, but is known to be of direct physiological importance too, because it has effect on the transmissivity of biological membranes. Van Wirdum (1981a) has dealt with the layered relational model and its macro-ionic field aspect in somewhat more detail. H. Houweling has undertaken the collection of elements for the mathematical formulation of the indirect channel.

Gradients of macro-ionic water composition

One important aspect of the ecological field is the associated gravitational force which owes its gradient to the unsmoothness of the land surface. This goes far to explain a complex of partially derived factors, because of its bearing upon the flow of water, the quality of the solution it carries, and the formation of soil. The soil gradient was – in older work – already recognized by C. G. van Leeuwen as one of the main causes of the patterned distribution of plant species. In particular, rare species in the midy-hater category correlate very well with a few more or less narrow zones, which in plant ecology are sometimes called gradient zones. The significance of an ecological field for biological species in a natec can be schematically attributed to source-sink relationships, which often occur in transitional zones of the land surface. This idea basically means that ecological stimuli are processes and not states. Interested by this fact, T. Reijnders has for many years directed his investigations to detailed analysis of vegetation patterns in relation to the microrelief. The dynamic interpretation of pattern in these studies is concerned with long-term fluctuations of ground-water levels. These investigations will be reported in the near future. Concerning the results mentioned in the preceding section, it seems relevant to study the dependence of soil gradients on water management. It might be worthwhile to assess the macro-ionic aspect of the ecological field as a driver of natec responses in these gradient zones, and thus as a way to derive water-quality requirements.

In the hydraulic cycle, water consecutively passes through the atmosphere, the lithosphere, and the ocean. During its stay in these spheres, its chemical properties are changed; it is, as it were, fed by these spheres. It has proved possible to recognize the changed chemical water compositions at several places in ground and surface waters, where water becomes mixed at different stages in the hydraulic cycle. Reference compositions of *atmotrophic*, *lithotrophic*, and *thalassotrophic* water have been determined for water, changed by a stay in the atmosphere, lithosphere, and ocean, respectively. The terms rain- or meteoric-water, ground-water, and sea-water are reserved for water found in the respective compartments of the hydraulic cycle. Indeed, many analysed water samples form connecting links between the reference samples. Numerically, several analytical factors can be used to determine the degree to which a water sample is related to a reference standard. So far, a normalized nine-factor nomograph correlation coefficient has been used most frequently, in addition to a graphical representation of electrical conductivity (EC) and a weighted calcium concentration. The graphical procedure has the advantages of requiring only a few analytical factors and ease of calculation and visualization of results. For the weighted calcium concentration, use has been made of the ionic ratio $IR = (\frac{1}{2}Ca)/((\frac{1}{2}Ca) + (Cl))$ (molar concentrations). This combination has been shown to be very important, not only theoretically but also empirically and statistically. Theoretical and empirical results have been given by van Wirdum (1980). Fig. 3 shows an example of an EC-IR diagram. The samples in question are discussed below. Related material can also be found in van Wirdum (1981a) and van Dam, Suurmond & ter Braak (1981). The involved factors can be measured by on the spot titration, for which purpose field sets are made available by the Chemical Analysis Section of the Institute.

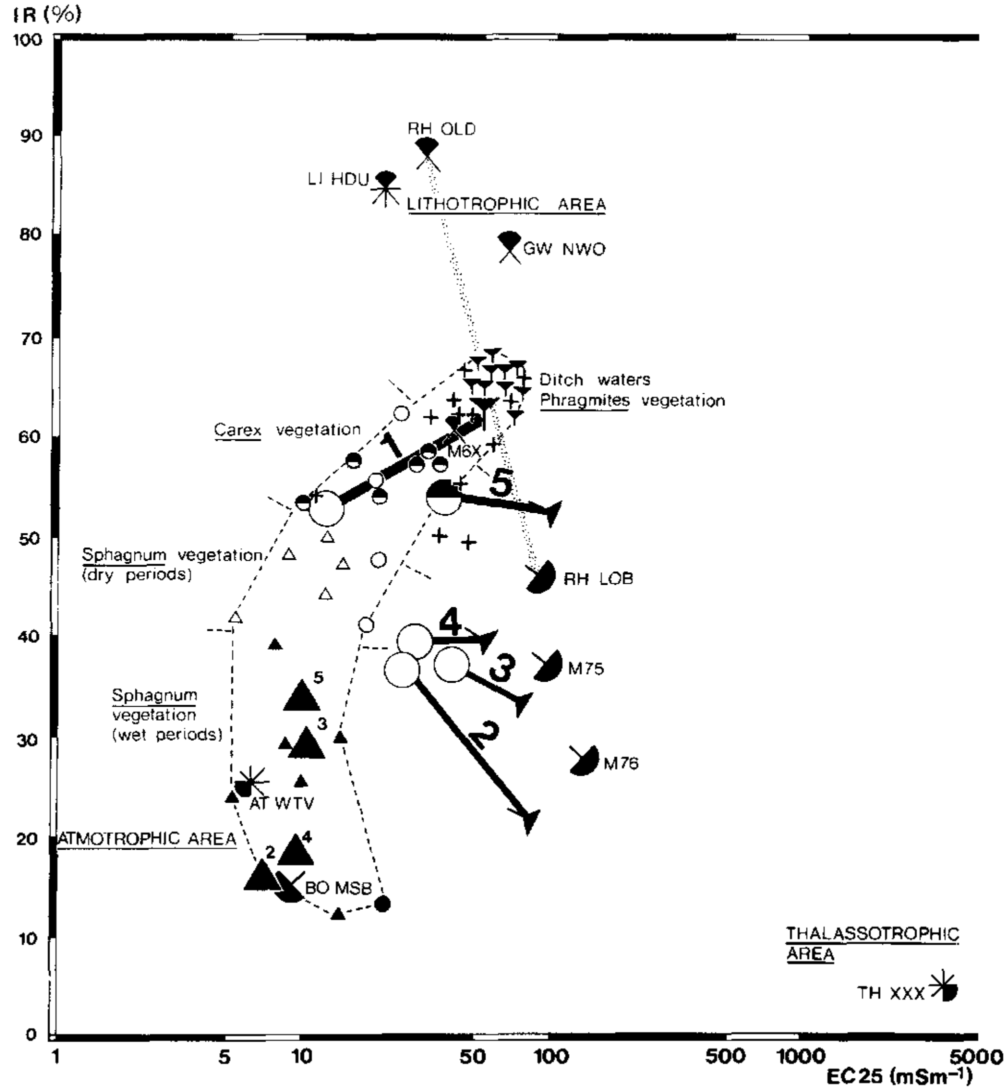


Fig. 3. EC-IR diagram for water samples of the Stobbenribben natec. Some sampling stations are indicated in Fig. 4. Sampling days in the 1970–1974 period are numbered 1–5 (701118, 730724, 730920, 731125, and 740403, respectively). For symbols and inscriptions, see legend.

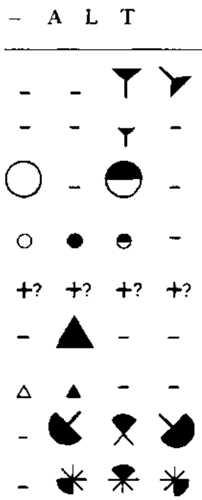
LEGEND TO FIG. 3

Symbols reflect a typology based on the coefficient of correlation with AT WTV (rA), LI HDU (rL), and TH XXX (rT), respectively, concerning:
$(EC_{25})^2/1000$, (H_3O^+), $(\frac{1}{2}Ca^{++})$, $(\frac{1}{2}Mg^{++})$, (Na^+), (K^+), alkalinity, (Cl^-), and $(\frac{1}{2}SO^{--}_4)$, derived from values referring to mS/m and mmol/l units. The type assignments are:

– rA, rL, and rT, all lower than the limits stated below
A rA greater than or equal to 70%
L rL greater than or equal to 70%
T rT greater than or equal to 55%

Samples indicated by + could not be classified because several factors were not determined.

Symbols according to water type



– A L T	Station of origin	Sampling period
	Ditch (period 1)	1970–1974
	Ditch (period 2)	1980–1982
	Carex vegetation	1970–1974
	Carex vegetation	1980–1982
+? +? +? +?	*Carex* vegetation?? (Archives)	1961–1966
	Sphagnum vegetation	1970–1974
	Sphagnum vegetation	1980–1982
	See code below (included for comparison)	
	See code below (standards of reference)	

Code	Origin
AT WTV	Precipitation Witteveen (Drenthe), 1973–1974. Source: KNMI
LI HDU	Ground-water Hoge Duvel (Veluwe), 1969. Source RID
TH XXX	World oceans. Source: hypothetical
BO MSB	Meerstalblok bog (Drenthe), 1981
GW NWO	Ground-water Meenthebrug (study area), 1980. Source: RWS/RIN
M6X	Mean of 106 analyses, surface water study area, 1961–1969
M75	Mean of 18 analyses, surface water study area, August 1975
M76	Mean of 18 analyses, surface water study area, August 1976
RH LOB	River-water, Rhine (Lobith), 1975 (mean). Source: RIZA
RH OLD	River-water, Rhine (Arnhem), before 1863. Source: Zinreck-Gunning

If not specified, the source of the data is UvA/RIN.

The success of individual species: on demand

Another important aspect of ecological fields, which seems to have been misunderstood to some degree in many applications, is Jenny's potential flora, or flora and fauna. This appears to be a crucial point in problem identification for nature protection. Should a certain species be regarded, for example, as a competitive invader (or a predestined looser), or is it an indicator of natec performance? Should protectors of nature cut back particularly 'nasty' species or should they take ecodevice-driving measures? For instance, the age-old farmers' battle against creeping thistles is determined by the fact that this plant belongs to the above-mentioned potential flora, and that humecs abound in particularly suitable habitats for it. Thus, in contrast to the cormorant problem also referred to above, natec drivers are not culpable in this case, nor should they themselves fight thistles. Indeed, good natecs will not be favourable for creeping thistle, whereas the cormorant would become extinct in The Netherlands without natecs. The activation of members of the potential flora and fauna, and so of their fixed *biological program* (and thus their competitive peculiarities), is governed by natec demand, more precisely by the prevailing state of the memory organ. The state of the memory organ is, in turn, determined by the interaction of the ecodevice with its environment, according to the relational scheme dealt with above. Although the potential flora is roughly the same everywhere in The Netherlands, specific applications require distinction between different propagule frequency distributions. The latter are partially linked with geographic features of the ecological field that determine its transmissivity for propagules according to the relevant dispersal mechanisms. These factors are combined into an often overestimated parameter of the ecological field called accessibility of the site. If species are imported in less critical stages of their life cycle, access and success may be forced. Once there, new species will themselves become working parts of the ecodevice in question and change its memory organ's state, whether they have come in spontaneously or by forced access. Their functioning may, in turn, change other components of the ecodevice and related parts of the memory organ. The process involved is called *succession*. Succession and related problems of ecologically and technologically indicative species are being studied now against the described background. Initially, somewhat contradictory theories seem to be reconcilable if the boundary conditions for their validity are correctly stated. If, for instance, a prevailing state of memory of a natec is sufficiently indicated by its present vegetation, the demand for species of the potential flora may be statistically treated by a table of replacement probabilities having at least local validity. If several ecodevices have exactly the same state of memory, the appropriate tables of replacement probabilities will differ only with respect to the potential flora. This may be the case if a causal event of change deletes part of the contents of the memory organ of those devices, leaving the less variable 'hardware' basis of the geomneme. An extreme case is the supply of raw environment for spontaneous settling of organisms. In such cases, succession appears to be entirely determined by the individual properties of species. Within a confined region, odd conditions may explain low transmissivity of the environment for propagules of species and therefore (in)accessibility-determined local differences of the potential flora. This situation has been profitably explored in island biogeography. In the application to natec design, nature reserves have been looked upon as virtual islands in an ocean of humecs. In The Netherlands at least, the initial state of memory varies

Vertical view of the Stobbenribben natec: black and white rendition of a color-infrared image. Remote sensing can be used to detect ecohydrological properties of natecs and the resulting pattern of the vegetation.

mainly as a consequence of the (in)accessibility of the geomneme and pedomneme. The abiotic environmental gradients referred to above will therefore determine successional trends more than will differences of the inaccessibility to species of organisms. Thus, the individual properties of organisms will only become active on demand. In rare cases of rather undisturbed development, climatological aspects of the ecological field may become dominant, and thus give rise to the development of zonal vegetation or climax systems. However, it seems rather imprudent to argue that in the absence of local disturbances, each ecodevice would develop toward this climax system state. Even providing for geomnemic differences only, as in the potential-vegetation concept of phytosociologists, will not suffice to cope with further differences between devices in a very complex ecological field.
All in all, it seems justified to use technological indicators for evaluation and goal setting in nature protection and to use the appropriate ecological indication for detailed realization where empirical knowledge of management does not suffice. In any case, neglect of the non-biological layers of the ecological field may lead to underestimation of the significance of natec driving as a technical occupation.

Introduction to a case study of the Stobbenribben natec

On the basis of the foregoing theoretical considerations, the Ecohydrology Section is now concentrating on mesological aspects of ecology in case studies and in particular on the significance of the ecological field for natec performance. One of the natecs studied is the Stobbenribben, part of the Weerribben Nature Reserve in the northwestern part of the province of Overijssel. Particularities on the area have been given by van Wirdum (1979). The Stobbenribben natec consists of four rectangular peat holes each measuring approximately 180 × 30 × 2 m. The species composition of the vegetation growing on a floating mat of root systems in these holes is characterized by several fairly rare algae, mosses, and phanerogams. The zonation shows a *Sphagnum*-dominated belt near the dead ends of the peat holes, a *Calliergonella*-dominated reed belt near the dissecting ditch, and in between a Parvocaricetea vegetation with a moss layer of *Scorpidium*. The floating mat, called a *kragge* in Dutch, hangs on the baulks left between the peat holes created when peat was extracted at the beginning of this century. A schematic representation is given in Fig. 4. Most of the rare species involved are said to be indicators of upwelling water, and this ecological relation seems to have been proven in the Stobbenribben peat holes, which supports Segal's discussion (1966). His approach may be characterized as a synecological approach to individual sites: the supposed operational environment of species in a sociological group is measured where the species occur. Van Wirdum (1972) obtained strong indications of downward seepage of water in the same area when he studied it as a conditional device. In this case, chemical and physical measurements were performed as suggested by the abiotic structure of the device and its probable input and output gates.
In the autumn of 1972, the authorities responsible for natec management were extremely concerned about eutrophicating influences in the above-mentioned ditch. It was decided to block the ditch to keep the preferred upwelling water inside the natec, but this experiment led to such a dramatic drop of the water that shortly afterward it had to be terminated abruptly. Similar blocking strategies were nevertheless planned at other places in the same

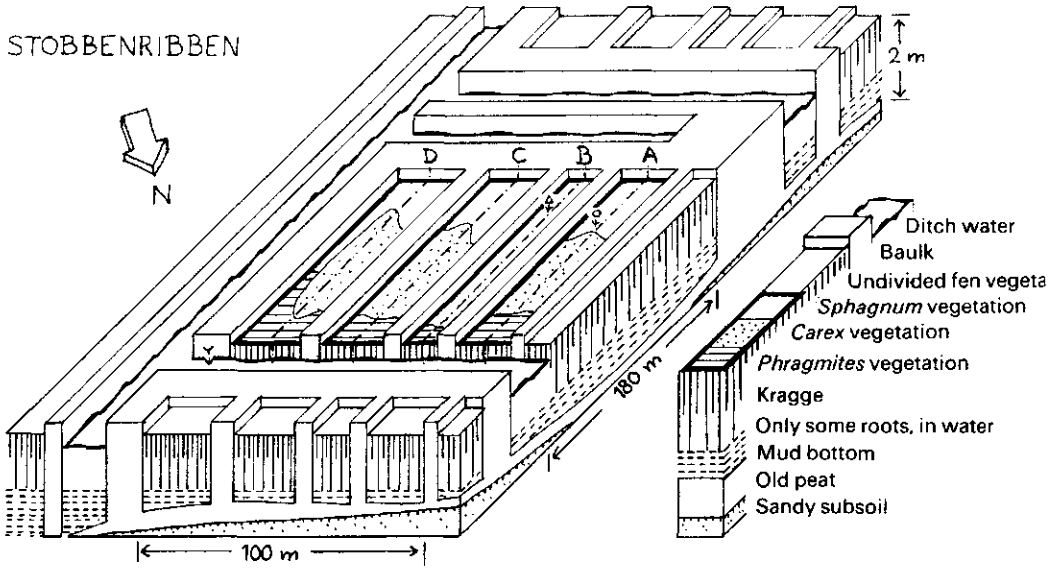


Fig. 4. Schematic representation of the Stobbenribben natec (relative width of baulks and ditches exaggerated). A-D refer to sections giving electrical conductivity in Fig. 5. Three sampling stations for chemical analysis of water (compare Fig. 3) are indicated by the symbols Y (ditch), o (*Carex* vegetation), and △ (*Sphagnum* vegetation), respectively.

fenland area. It was disputed whether the Stobbenribben debacle was due to the disappearance of springs after the realization of several polders or to their 'intermittent and surprisingly localized' occurrence, as reported by Segal. Alternatively, it was thought, vegetation lagged considerably behind and might reflect lost conditions, or springs might still occur locally, although – on average for the natec as a whole – water moves downward. In due course, preference was given to the latter hypothesis, because the indicative species (and other phenomena) persisted. Further investigations into the problem, financed by a grant from the Netherlands Organization for the Advancement of Pure Research (ZWO), were started by the present author in the Hugo de Vries Laboratory (University of Amsterdam), and continued at the RIN from 1975 on. The results indicate that the synecological and the device-oriented data may acquire convincing strength if they are properly combined. Effectively, Stobbenribben species cope with an environment characterized by a lithotrophic type of water. This is not caused by upwards seepage of ground-water, but by a leakage-compensation supply from the retention basin, via the ditch. Safely driven, the Stobbenribben natec provides a stable gradient from atmotrophic to lithotrophic water quality in a constantly water-saturated *kragge*. One of the main tasks for environmental management in this area will be to maintain the lithotrophic character of the water in the retention basin.
The most convincing data on the flow paths of water through the Stobbenribben area came from an analysis of frequent temperature readings and conductivity soundings at several

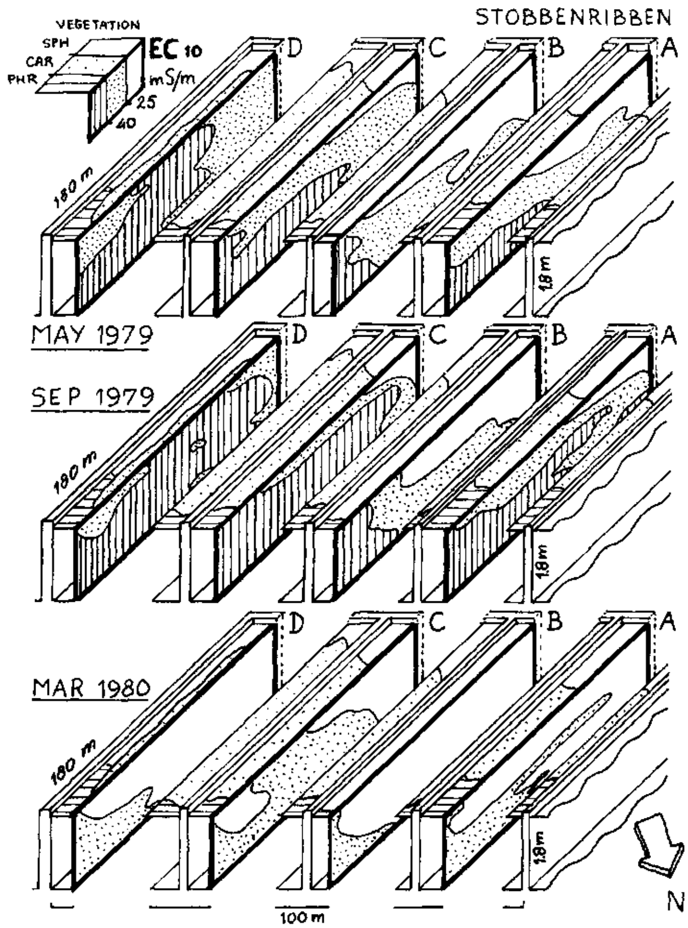


Fig. 5. Change of electrical conductivity (at 10°C) in sections A-D through the Stobbenribben natec. Viewed from the same angle as in Fig. 4.

places in the peat profiles. The high accuracy required was made possible by the Section's specialization in instrumental research. C.H. van Leeuwen is particularly involved in the design, adaptation, and functional control of instruments, as well as the transformation of measured values into reliable physical data and their presentation (for instance, on computer-drawn isopleth maps). Calculation of the conduction and convection of heat, as driven by the annual temperature variation at the surface, indicated a downward movement of water with an average velocity of a few millimeter per day. Horizontally, the flow paths could be traced by the electrical conductivity of the water on several dates at several places. Some examples are shown in Fig. 5. Whenever the ditch was blocked in periods of heavy precipitation, the conductivity values dropped sharply for the peat holes without supply of

ditch-water. In view of the goal organisms, the change reflected by this reduced conductivity is probably not desirable. The very open part of the profile between the *kragge* and the bottom of the peat holes probably serves as a main vein. The conductivity values correspond to a section of the atmo-lithotrophic gradient, as shown by chemical analysis of critical water samples.* Some of the results are indicated in Fig. 3, which also gives some representative values of the nomograph correlation already mentioned. Compared with other natecs in The Netherlands, the pattern is very rich. The more thalassotrophic samples dating from the mid-Seventies represent a period of artificially governed water supply, the same pattern, but even stronger, having been seen for other stretches of the retention basin area. Simplification and intensification of humec application in the northern part of The Netherlands in the Sixties and Seventies involved regional adaptation of the ecological field by strategies of water management. As a consequence of these adaptations, the intake of lithotrophic water from the province of Drenthe has become impossible in dry periods. The more thalassotrophic water supplied via the province of Friesland is largely derived from the lake IJsselmeer and thus from the river Rhine, and is sometimes also influenced by water from the Wadden Sea. This change in the quality of the water supplied is reflected in the vein under the Stobbenribben *kragge*s and also in the water superficially sampled in the *kragge*s, where it mixes with stored water and rain-water and where it is modified by internal processes of the natec. Since 1978, the initial situation is being more or less restored, thanks to the diminished artificial water supply to the area. Probably, however, dry years will show a reversal again.
Although there have been certain gradual changes in the composition of the vegetation, the interpretation of these changes, which is not free from ambiguities, lies outside the scope of this report. The cause of these ambiguities is the intermediating effect of the pedomneme of the Stobbenribben natec. Elsewhere in the retention basin, however, there seems to be a striking relation between increases and declines of the water soldier (*Stratiotes aloides*) and the degree of lithotrophy of the water, which is well in line with van Wirdum's discussion (1979). Since that publication, both lithotrophy and *Stratiotes* have increased remarkably in the area. Studies requested by the local water-quality board showed a very obvious lithotrophic dominance in most of the area of the retention basin, at least from 1960 to 1970. In the Weerribben Nature Reserve the replacement by thalassotrophic water could be easily observed and explained during the period from 1972 to 1978 (compare samples M6X, M75, and M76 in Fig. 3). It should be underlined that in this case the data yielded by natec-oriented research are much more convincing than the results of simultaneously made observations of physiologically operational factors in the immediate vicinity of goal organisms. Indeed, even lithotrophic patterns become obscured between the *Stratiotes* plants.
It can be concluded that the present efforts to protect nature in the fenland reserves of the northwestern part of the province of Overijssel as a national landscape reserve with a legal status should include the restoration of the hydrological aspects of the ecological field since, as is clear from the above discussion, this is not a local task. Unless this is done, this 'supernatec' will not function, despite the charm of the landscape of reeds and broads.

* The current financial problems made it impossible to perform sampling of water for chemical analysis in the first half of 1980. Regrettably, too, the reorganisation of the RIN's computer facilities has delayed processing of temperature and conductivity data from that date on. For this reason, different dates are concerned in Figs. 3 and 5.

REFERENCES

Dam, H. van, G. Suurmond & C. J. F. ter Braak 1981. Impact of acidification on diatoms and chemistry of Dutch moorland pools. *Hydrobiologia* 83. 3: 425–459.

Leeuwen, C. G. van 1981. From ecosystem to ecodevice. In: S. P. Tjallingii & A. A. de Veer (eds.), *Perspectives in Landscape Ecology;* contributions to research, planning and management of our environment. Pudoc, Wageningen, 29–34.

Reijnen, M. J. S. M. & J. Wiertz 1981. Spontaneous vegetation and ground-water withdrawal in a rural area of 370 km^2. In: S. P. Tjallingii & A. A. de Veer (eds.), *Perspectives in Landscape Ecology;* contributions to research, planning and management of our environment. Pudoc, Wageningen, 280–281.

Segal, S. 1966. Ecological studies of peat-bog vegetation in the northwestern part of the province of Overijssel. *Wentia* 15, 109–141.

Wirdum, G. van 1972. Beknopt verlag over de eerste fase van een onderzoek naar de waterhuishouding in het kraggelandschap van De Weerribben en de betekenis daarvan voor de vegetatie. Unpublished report, Hugo de Vries Laboratory (UvA).

Wirdum, G. van 1979. Dynamic aspects of trophic gradients in a mire complex. In: Committee for Hydrological Research TNO. *The relation between water quantity and water quality in studies of surface waters.* Proceedings of Technical Meeting 35 (October, 1978). Proceedings and Informations 25, The Hague, 66–82.

Wirdum, G. van 1980. Eenvoudige beschrijving van de waterkwaliteitsverandering gedurende de hydrologische kringloop ten behoeve van de natuurbescherming. In: Commissie voor Hydrologisch Onderzoek TNO, *Waterkwaliteit in grondwaterstromingsstelsels.* Rapporten en nota's 5, Den Haag, 118–143.

Wirdum, G. van 1981a. Linking up the natec subsystem in models for the water management. In: Committee for Hydrological Research TNO, *Water Resources Management on a Regional Scale.* Proceedings of Technical Meeting 37 (November, 1980). Proceedings and Informations 27, The Hague, 108–128.

Wirdum, G. van 1981b. Design for a land ecological survey of nature protection. In: S. P. Tjallingii & A. A. de Veer (eds.), *Perspectives in Landscape Ecology;* contributions to research, planning and management of our environment. Pudoc, Wageningen, 245–251.