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APPLICATION OF THE THEORY OF ISLAND BIOGEOGRAPHY IN THE DESIGN OF A STUCTURAL CONCEPT OF NATURE AND LANDSCAPE CONSERVATION[1]

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ABSTRACT

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For a long term strategy on nature and landscape conservation in behalf of a revision of the regional plan for Twente, a structural concept together with a map has been composed. The theory of island biogeography has been used for the design of the nature part of the concept. The most important factor in the landscape part is the spatial structure of hedgerows, copses, clumps of trees, etc. Thoughts about improving this structure, emphasizing the contrast between hill-side open field and lowland enclosure and emphasizing landforms have been worked out for Twente. The article catches on the conception of vulnerability as a central element in the structural concept. The realization of the map of the structural concept including the mapping units is described. A major application of the map is the creation of zones within the rural area for the regional plan.

Some conclusions are:

- Segregation of nature and agriculture is proposed in areas with large extended nature areas;
- Concentration areas are most important for nature conservation; it is desired to concentrate attention and application of means on these areas;
- In case of protection conservation of characteristic ecotopes has to be pointed out;
- The importance of a structural concept is the creation of an instrument that can be used to carry out a consistent policy on nature and landscape with an eye on the future;
- Application of ideas described here seems to be possible in other landscape types;
- Regular evaluation and, if necessary, adjustment of the structural concept is proposed, running parallel with the design of a regional plan.

INTRODUCTION

During the last years the revision of the regional plan Twente of 1966 required investigation of nature and landscape. To use the results of these studies as efficiently as possible, the data have been integrated as much as possible and this led to the structural concept Nature and Landscape Conservation together with a map. The concept played an important role in designing zones in the rural area. A more comprehensive description of this subject is given in the Research note Nature and Landscape, which was written for the revision of the regional plan (ANON., 1982a).

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Description of the area

Twente is the easternmost part of the province of Overijssel (Fig. 2). The total number of inhabitants was 560,806 (1-1-1982) living in an area of 1,438 km^2. The central urban area consists of Almelo, Hengelo and Enschede. The north-western part of the area is occupied by a rather unique landscape type, the peat-moor reclamation area of Vriezenveen, within which an extensive peat-moor area is located: Engbertdijksvenen. The landscape of Twente is characterized by a large variation in relief elements. Ice-pushed ridges are alternating with low narrow ridges of cover sand deposits and rather flat spaces. The following elements belong to the rich and varied nature: brook valleys, source areas, marshy forests, oak-hornbeam forests, oak-birch forests, moist and

dry heathlands, fens, pastures in extensive use, juniper berry and bog myrtle shrubs and agricultural lands of ecological value: old farmland ('essen'), pastures with relief.

Vulnerability

Central elements in the description of the structural concept are nature and landscape properties which can be changed by human influence and which can be saved by protective measures in connection with physical planning. In this case especially changes caused by land improvement measurements, recreational land use, exploitation of resources etc. are meant; the total occupation of space at the cost of nature and landscape by, for instance, town development is not regarded here. The concept of vulnerability has to be understood in this context.

Nature. Kind and extent of human action and kind and extent of the ecosystem concerned determine the impact of the activity on the natural environment. Because the degree of vulnerability of a nature area depends on many factors, vulnerability has not been divided into categories in the map. This accords with the theory that presence of nature goes with its vulnerability with regard to external influences.

Landscape. With regard to landcape, however, it can be noticed that a subdivision in vulnerable and less vulnerable elements and structures is useful. Therefore a subdivision in two categories of landscape vulnerability has been made. The starting point of this subdivision was the supposition that for instance a large ice-pushed ridge or a large forest is less vulnerable to human activities than for instance a small ridge of cover sand deposits, or a landscape with many hedges.

Conservation of such vulnerable values is therefore a central theme in the map of the structural concept. Landscape vulnerability is a function of the land characteristics, relief and the spatial structure of hedgerows, copses, etc. and of their interrelationship.

APPLICATION OF THE THEORY OF ISLAND BIOGEOGRAPHY

The central question which has to be answered is: starting from the present situation, what is the best strategy to create a development which is benificial for nature and landscape of Twente in the long term? The choice between integration and segregation of nature conservation and agriculture and forestry plays an important role in answering this question. A choice for the last mentioned strategy leads to a concentration of nature areas as much as possible, and a removal of negative influences out of these areas.

A theoretical concept which was important in determining the strategy is the theory of island biogeography, developed by MAC ARTHUR & WILSON (1967). Ecologically very important buffer areas around nature areas which have to buffer and muffle negative influences, are not presented on the map. This is not done, because the width of this zone is largely dependent on the kind of area, a function of the adjacent area, and on the kind of negative influence. An explanation of this theory and its possibilities for application can be found in DIAMOND (1975), OPDAM (1978), GORMAN (1979), BRUSSAARD & VAN DER WEIJDEN (1980), MADER (1980), BALSER ET AL. (1981), VAN DER MAAREL (1982) and ANON. (1982a).

Islands – surrounded by seawater – form areas where terrestrial and fresh water organisms can exist, whereas their direct surroundings, i.c. the sea, is an environment where these kinds of species can hardly survive or not at all. In other words, the sea is a barrier for movement and reproduction of species living on the island.

This situation is comparable with a mountain top surrounded by lowland with different ecological conditions, where alpine species can not survive or only for a short time. Forest species are restricted in the same way if forest is surrounded by farmland or pasture.

An island situation will develop at places where the environment of organisms is enclosed and where crossing over to another specific ecotope is hindered or even impossible. For animals such a barrier of their ecotope for instance is the transition of a forest to arable land in intensive use. A water body or a road are other examples of barriers (MADER, 1980). Immigration and emigration of organisms from or to isolated small landscape elements such as a hedge, a pool or a solitary tree can be reduced by an isolated location. The specific ability of distribution of organisms or diaspores, together with environmental factors such as climate and physical geographical conditions, determines the presence or absence of organisms on an island respectively.

Compared with the original situation when the total area of Twente was one large nature area, nature has been driven back gradually. Fig. 1 shows the change of land-use between 1900 and 1978.

Applying the island theory to nature areas in Twente, it is evident that the islands are becoming smaller and that large islands have been broken up in archipelagos of small islands. The conclusion is that the process of reclamation of the original nature areas, followed by land use types as agriculture, town development etc., has resulted in loss and isolation of ecotopes, and, by the disappearence of the so-called ecological infrastructure, to a decrease of structure.

Landscape elements and small nature reserves which are linking larger natural areas are aspects of the ecological infrastructure. Hedges and brook systems form the most important links, next to verges of roads and banks of canals. The effects of the break-up on the remaining ecotopes will generally become evident in the long term and the actual gravity of these problems is therefore blurred.

In spite of the fact that some critics consider the application of the theory of island biogeography as premature, many people plead for the application of this theory in nature conservation planning (see BALSER ET AL., 1981, p. 342). The

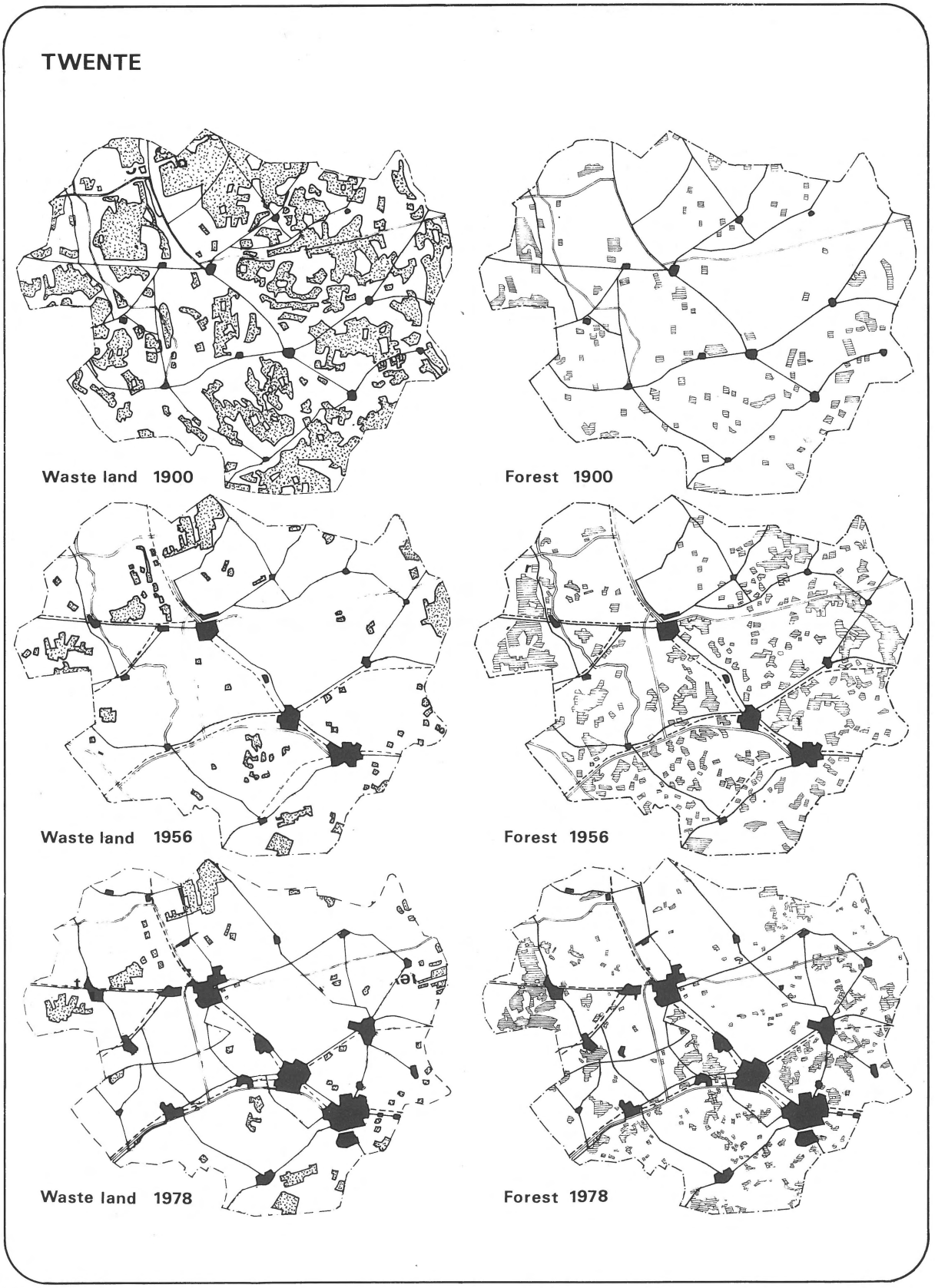

Fig. 1
The land use development of heathlands, peat-moors and forested areas between 1900-1978.

present knowledge is however insufficient for an indication of all groups of organisms in Twente for which the island theory will be applicable. Factual results of investigations with regard to testing of the biogeographical island theory are absent.

It can, however, be stated that the habitats of large mammals such as pine marten (*Martes martes*), beech marten (*Martes foina*) and badger (*Meles meles*) have been severely curtailed by an intensification of infrastructure, recreation, urban extension, etc. For the badger the situation in Twente has grown so bad that this species already has disappeared. It has been proved that the island theory can be applied with regard to some groups of non-flying lower animals (cf. MADER, 1980).

Practical significance

The following suppositions can be formulated that are relevant for physical planning on the basis of the general ecological theory and the theory of island biogeography (see also BRUSSAARD & VAN DER WEIJDEN, 1980):
- increase (decrease) of surface area implicates increase (decrease) of species diversity;
- increase (decrease) of ecotope diversity implicates increase (decrease) of species diversity;
- increase of distance between island and genetic source (continent) implicates decrease of species diversity.

What are relevant conclusions that can be drawn with respect to the aspect nature in regional planning?
- Increase of surface area of nature areas, for instance by acquisition of enclaves with disturbing effects, will lead to an increase in the number of species. There are also possibilities by an increase of surface area of forest.
- There is also an advantage in enlargement of nature areas with respect to management practices. External influences (external management) can be repelled more easily, and management efficiency will be improved.
- Conservation and increase of ecotope diversity will also implicate an increase of species diversity.
- Isolation of a nature area will in the long term reduce the number of species. The duration of this process is dependent on the group of organisms and varies from a climatologically extreme season to centuries or possibly more.
- Especially species, which have a small distribution ability and/or live in populations with large fluctuations in size and/or are restricted to a rather specific environment are likely to become extinct in an isolated nature area.

In the introduction of this section the choice between integration and segregation has been mentioned. Taken the preceding conclusions into account a segregation is proposed between nature areas and agricultural areas in intensive use in the part of Twente where large nature reserves are located.

Integration of agriculture and nature and landscape conservation was preferred in other parts of Twente. This will be worked out in the map of the structural concept.

MAP OF THE STRUCTURAL CONCEPT NATURE AND LANDSCAPE CONSERVATION, OUTLINE AND EXPLANATION

For the design of the map a large number of nature and landscape data bearing on aspects such as vegetation, avifauna, geomorphology and scenery, have been generalized on a scale 1:50 000. The map of the structural concept has to be regarded as a line of action for a long term development of nature and landscape.

Firstly the plane-sized nature areas have been subdivided into three classes:
- areas with a small (0-40%) coverage of nature areas;
- areas with a moderate (40-75%) coverage of nature areas;
- areas with a large (75-100%) coverage of nature areas.

For small nature areas a combination with enclosed cultural land[3] has been made. A map of vegetation types has been used as reference for this subdivision[4].

The subdivision into 3 classes (0-40, 40-75 and 75-100% coverage) has been estimated and the ultimate values 40 and 75% proved to be satisfactory in practice. By allowing only small surface areas of cultural land as enclaves within nature areas a rather small number of areas occur with a coverage between 25% and 40%. Instead of combining a number of small nature areas into one area with a small coverage, two areas with a moderate cover have been mapped, excluding enclosed cultural land.

The theory of island biogeography has been applied explicitly in the development of the structural concept 'Nature'. In the structural concept 'Landscape' an improvement of the spatial structure of hedges, etc. has been emphasized; this leads to improvement of the ecological infrastructure, and is thus connected with the structural concept 'Nature'.

The mapping units of the map of the structural concept will be described successively. Anticipating the following section, where a view of the application of instruments is given, this matter is already mentioned at this place. The scale of the map of the structural concept from which a representative part has been lifted out as Fig. 2, is about 1:175 000 and is a reduction of the map that belongs to the regional plan.

NATURE

Concentration area

As concentration areas are indicated areas with a high coverage (75-100%) of nature areas with a minimal surface

[3] Cultural land in the meaning of farmland (arable land) or pasture.

[4] If such a map is not available, a topographic map can be used. On such a map nature areas can however be indicated as cultural land, e.g. meadows in extensive use.

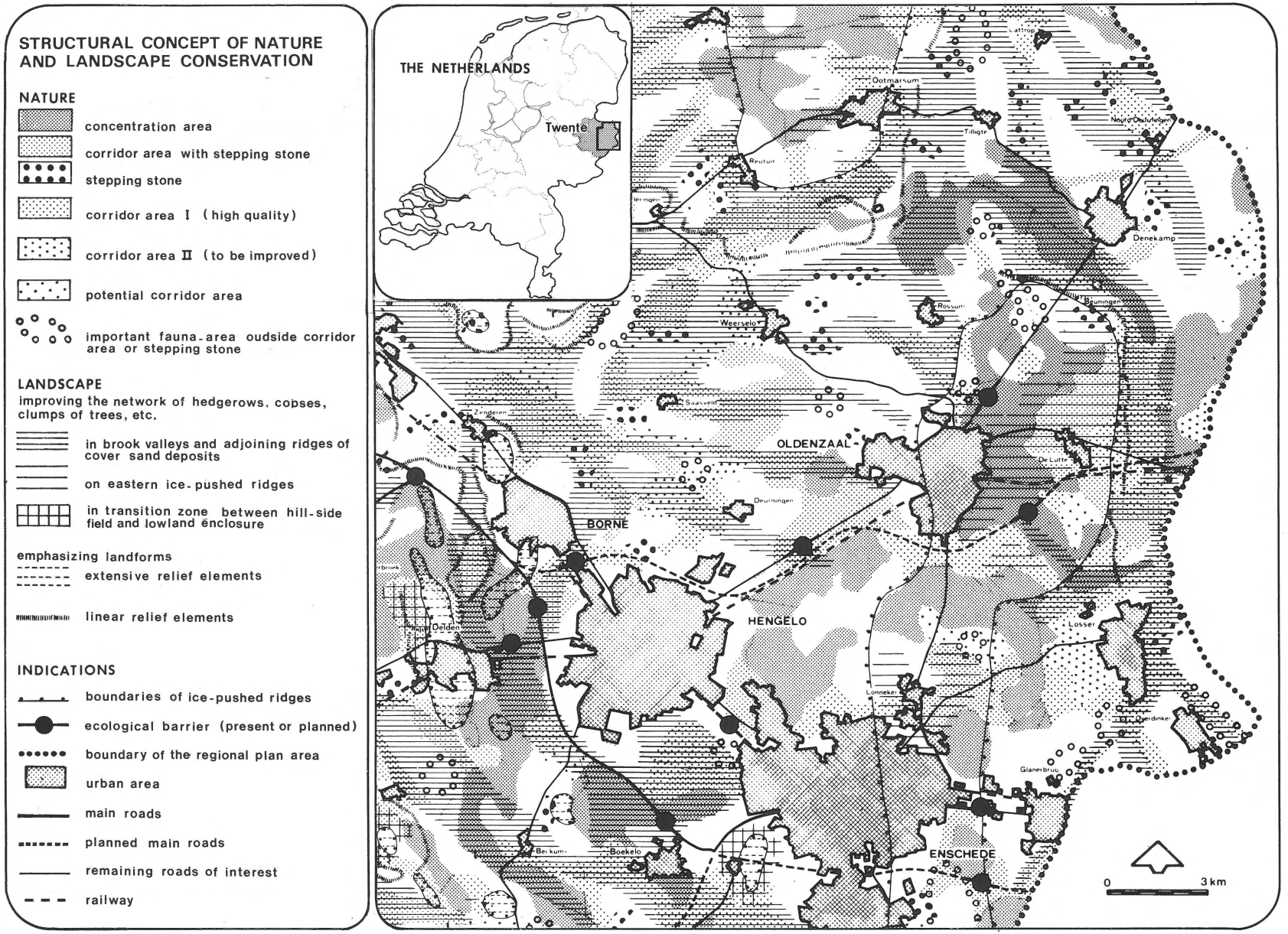

Fig. 2.
Structural concept of nature and landscape conservation.

area of 100 ha. This value has been determined on theoretical arguments and also by the actual situation in Twente.

With respect to nature conservations, concentration areas are the most important units. It is therefore desired to focus attention and expenses, i.e. acquisition as well as management on these areas, with an eye on their potential possibilities. This may include that an area will be destined to an undisturbed natural development, finally resulting into primeval forest. In the case of such a destination centuries can be gained by selecting a centuries old forest complex for this purpose (see for the latter CAPEL & MOBACH, 1979). Another possibility to increase the value of naturalness is the transformation of production forest into heathland. The change of intensive to extensive management of agricultural enclaves yields also profit after some time.

Conservation of the characteristic ecotopes of Twente (e.g. spring forest, natural brooks, moist heathlands and oak-hornbeam forest) has to take a central place in the safeguarding process. It has to be taken into account that vulnerable ecotopes have to be considered sooner for acquisition or another measure of safeguarding than less vulnerable ecotopes.

Stepping stone

An area has been indicated as stepping stone if the surface of the area is less than 100 ha, covered for a large percentage (75-100%) by nature areas. Also areas with a moderate coverage of nature areas (40-75%) belong to this mapping unit.

The ecological significance of a stepping stone is less than that of a concentration area, but more than that of a corridor area. Size, quality and location are the most important factors for the determination of importance of the stepping stone.

Corridor area I and II

A corridor or communication area is characterized by a dense network of single or multiple lines of trees; in Twente, these are especially hedgerows and brook valleys. In these areas plane nature areas cover less than 40% of the total area.

Corridor areas have been subdivided into two classes:
Class I: areas with single or multiple lines of trees of quality class 1[5], and brook valleys carrying a natural or a potentially natural brook.
Class II: areas with single or multiple lines of trees of quality class 2[5] and remaining brook valleys. According to nature and landscape conservation options these structures should be improved (restored).

The corridor II class carries out a communication function between concentration areas, although to a lesser extent than the corridor I class.

[5] Quality classes have been determined by the properties of stand: density, height, width and location. See for more information: Buitenhuis et al. (1982).

Vegetation elements which are rich in structure and apart from a communicative function they also have an important function as a habitat for birds (see GERRITSEN, 1979) and other fauna species. Of course these elements have also botanical qualities which vary with their soil, management, age and other characteristics.

Corridor area with stepping stone

Mapping unit 'corridor area with stepping stone' is placed in the legend after 'concentration area'. This place illustrates the large ecological importance of this category.

Potential corridor area

Corridor areas which potentially can be developed have to be considered with respect to possibilities for ecological and landscape engineering. This unit includes plantations of hedges and trees, plantings of farm-yards, etc. This mapping unit incorporates the areas with low coverage of woodland and lines of trees. Planting an ecological infrastructure may implicate that in the future these areas will have a function with respect to the migration of fauna and diaspores. Cultural land which of old has been open does not belong to this mapping unit.

Important fauna area outside concentration area or stepping stone

To this unit belongs cultural land with a high ornithological or herpetological value. The contribution of avifauna concerns meadow birds and other species of cultural land such as: quail *(Coturnix coturnix)*, little owl *(Athene noctua)*, whinchat *(Saxicola rubetra)*, curlew *(Numenius arquata)*, etc. Especially the presence of a population of tree-frogs -a threatened species in The Netherlands – was a decisive factor with respect to the contribution of herpetology. For the conservation of natural elements in cultural land only faunistic data and no botanical data are used. This can be explained by the fact that vulnerable (semi-)natural vegetations in cultural areas already partly have been regarded as stepping stones. Extensively used agricultural land of a high botanical quality is however rare in Twente.

Ecological barrier

This symbol has been used to indicate situations where important barriers disturb the relationship between areas with high natural values. This concerns highways which already exist or which will be constructed according final governmental decision.

A large open area located between large natural areas acts also as a barrier with respect to certain plant or animal species; for this kind of area the mapping unit 'potential corridor area' has been utilized in order to remove this barrier.

LANDSCAPE

In landscape management the structure of the network of hedgerows, copses, etc. is the factor which deserves most attention. It is the only reasonable landscape factor that not only can be conserved but also repaired (restored) and improved. Relief and historical landscape elements are factors for which conservation is the only possible type of management.

Starting point for the structural concept of landscape is the present landscape differentiation, whereas suggestions about construction of structures are also involved. Old, closed and small-scale cultural landscapes (enclosures), together with physiographic main structures constitute the key areas for landscape management.

The mapping units will now be described successively.

The physiographic main structure is, among other things, determined by high and low ice-pushed ridges, ridges of cover sand deposits and vast plains (e.g. Vriezenveen and surroundings). In the structural concept three aims have been formulated with respect to these key areas, which are determined by presence and/or absence of a structure of hedgerows, copses, etc., that are or are not related to relief and to cultural-historical aspects.

These three aims are:

- improving the network of hedgerows, copses, etc.;
- emphasizing landforms;
- conservation of openess of yet vast cultural land.

Improving the network of hedgerows, copses, etc.

In these areas an improvement of the present hedgerows is proposed, including restoration as well as planting of enclosures (Fig. 3). A subdivision into three types has been made: along brooks, in the fringe of higher ice-pushed ridges in eastern Twente, and around large old arable lands ('essen').

Enclosures predominantly along brooks. This concerns the originally small-scale landscapes which occur along brooks ('akkerkampenlandschap' and 'matenlandschap'). Also included in this unit are enclosures that occur locally at the fringe of ice-pushed ridges.

Enclosures at the eastern ice-pushed ridges. The ice-pushed ridges of Ootmarsum and of Enschede-Oldenzaal are different from the other ice-pushed ridges in Twente by the presence of enclosures up to the highest parts of the ridge. Ice-pushed ridges elsewhere are covered by vast forests and large old arable lands.

Enclosures around large old arable lands. A third category which is fit for improvement is a narrow zone of enclosures around large old arable land. The contrast will be enhanced by planting in the transition zone between the hill-side open field and lowland enclosure.

Emphasizing landforms

Until now the structure of a network of hedgerows, etc. was the most important factor; with respect to this mapping unit relief is also a determining factor. Accentuating the present relief by adaptive planting is recommended here.

Extensive relief elements. Only the lower ice-pushed ridges belong to this unit. The higher ice-pushed ridges, however, are also determining factors with respect to landscape structure, but the presence of these ridges need no additional enhancement, because of their striking elevation and surface area.

Linear relief elements. This indication concerns accentuating the relief of ridges of cover sand deposits ('gordeldekzandruggen').

Conservation of openess of yet open vast cultural land

In the foregoing the characteristic enclosure of a landscape has been emphasized. In this category the aim is conservation of the openess of yet (almost) open and vast cultural land. This concerns old cultural land and the peat-moor reclamation area of Vriezenveen. For reasons of visibility on the map of the structural concept, this unit has not been mapped.

Remaining area

Although the map has been covered for the most part by one or more mapping units, a part of the map remained blank. The structural concept does not indicate an explicite development in the future for these areas, except for the cultural land that has to be kept open. At the scale of a regional plan the nature and landscape values of these areas have not been considered. In the development of plans with a larger scale, such as local plans and reallotment plans, those values can be taken into account, however. In these areas there are posibilities for ecological and landscape engineering.

STRUCTURAL CONCEPT AND INSTRUMENTS

The available means for management and maintenance are scarce. Therefore they have to be applied carefully. In relation to the supposed categories in the structural concept the following scheme may be considered:

– in concentration areas:	concentrated application of acquisition stimulating request for the appropriate law (Natuurschoonwet)

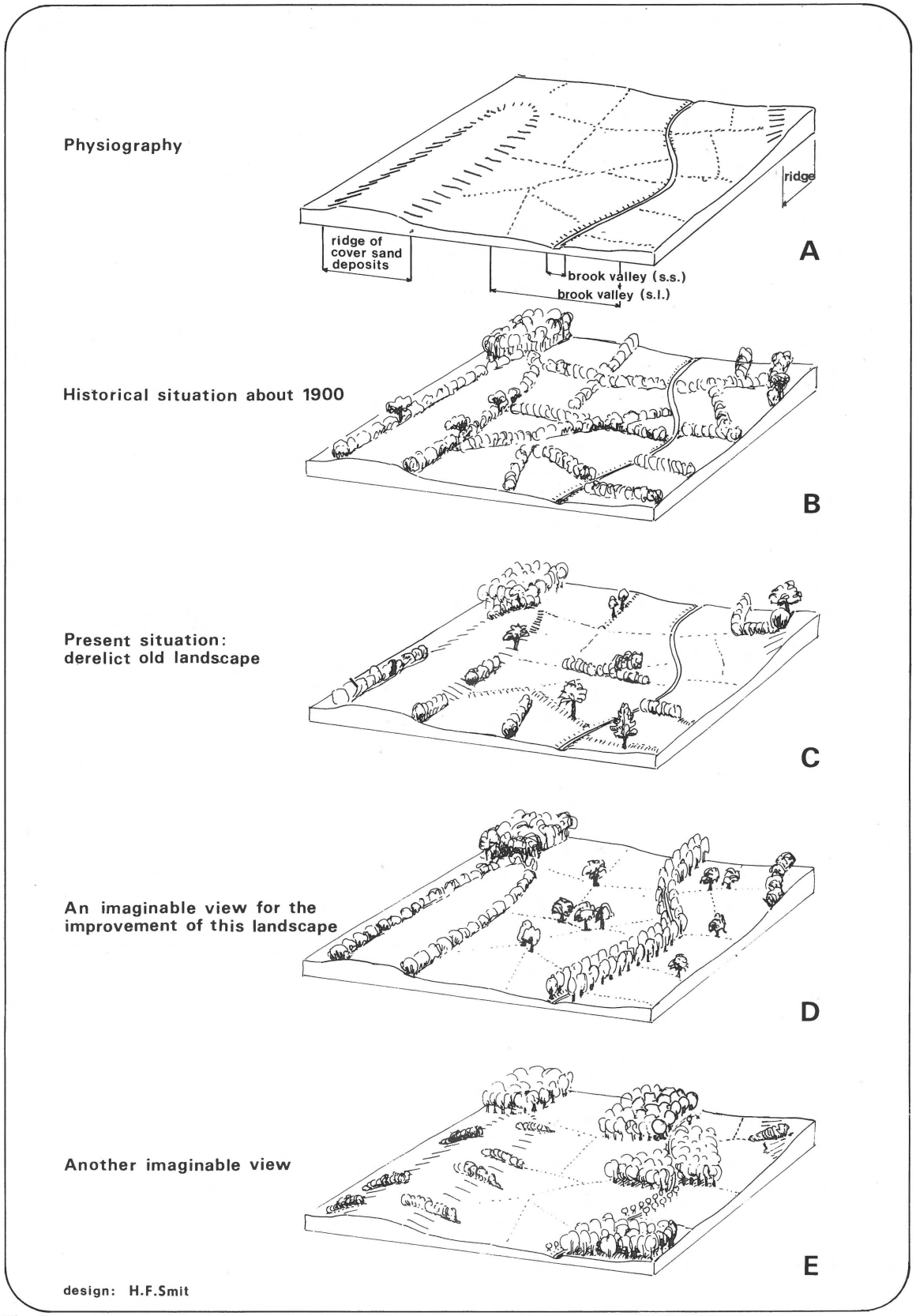

Fig. 3.
Improvement of the network of hedgerows, copses, etc.

– if also enclaves of cultural land are present:	concentrated application of means as expressed in the so-called 'Relatienota'
– in stepping stones:	secondary application of means for management or development
– in corridor areas and in zones where improvement of the network of hedgerows, copses, clumps of trees is proposed:	concentrated application of BOL[6] stimulating reallotment stimulating subsidy for landscape care
– emphasizing landforms:	stimulating reallotment stimulating subsidy for landscape care
– in case of overlapping zones:	also application of means as expressed in the so-called 'Relatienota'.

APPLICATION OF THE STRUCTURAL CONCEPT IN THE DESIGN OF A REGIONAL PLAN

Within the rural area four zones have been formulated broadly which are taken up in the pre-concept regional plan (ANON., 1982b).

Rural area zone I. Areas where development of agriculture is emphasized.

Rural area zone II. Areas where development of agriculture is emphasized, but where more important nature and landscape values are present than in zone I.

Rural area zone III. Areas with important nature and/or landscape qualities, generally utilized by agriculture.

Rural area zone IV. Areas with for the most part very important nature and/or landscape qualities.

Rural area zones have been created firstly by a subdivision of segregation and integration of the functions 'nature and landscape' and 'agriculture'. Segregation of functions implicated the indication of zones I and IV, dependent on the present land utilization: principally cultural land with limited nature and landscape qualities in zone I; areas with high nature and landscape qualities and limited agricultural development in zone IV.

In the case of integration of functions, hydrological control, the division of land in larger lots and the improvement of the infrastructure belong to environmental measures at a regional planning level, where nature and landscape conservation interests often disagree with agricultural desires. During this investigation infrastructure proved to be less relevant and was not considered any more. Maps which contain agricultural desires with respect to hydrology and the subdivision of lots have been compared with maps containing desires with respect to nature and landscape, before indicating an area in zone II or III. With respect to the latter the importance of conservation of the present surface area of nature and landscape elements has been regarded as a restricting factor. Loss of nature and landscape qualities anywhere may be compensated by enlargement of the nature and landscape area elsewhere.

Those areas where desired developments of an agricultural aspect disagree with the desires of nature and landscape are considered to be problem areas. For example, an agricultural desire may be a lowering of the watertable, whereas this means a loss of ecosystems that are determined by a high groundwater level. Another example is hedge cutting for the benefit of agricultural management efficiency, which means a decrease of nature and landscape values. The remaining rural area (excluding zones I and IV), the no-problem areas, have been subdivided into zone II and zone III respectively, dependent on the presence of moderate or high actual nature and landscape qualities respectively. The map of the structural concept involves this subdivision. This map and the land qualities have also been taken into account for the designation of problem areas.

Also the internal spatial coherence of areas has played an important role, for instance the negative impact of one area on another by a hydrological relationship. The impact of drainage followed by intensification of agriculture is generally not limited by the boundaries of the area concerned and this is especially relevant for wet and oligotrophic natural areas.

Other possibilities for application

The map of the structural concept has played not only an important role in the design of the regional plan, it is also useful with respect to activities following the conception of the regional plan, such as acquisition of nature areas, recreation plans, reallotment plans. The great advantage of a structural concept is the possibility of a consistent policy of nature and landscape planning with a long term view.

Although there is no experience with a structural concept like this one in aberrant landscapes, application of these ideas seems to be possible.

Evaluation and adaptation of the structural concept

It is recommended to evaluate and adapt the structural concept regularly, synchronous with the realization of a new regional plan. This structural concept is a start for future activities, into which new empirical and theoretical knowledge and insights have to be involved.

[6] BOL: management decree for maintenance of landscape elements (Beschikking Onderhoudsovereenkomsten Landschapselementen).

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