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Strategies concerning ecological networks in Denmark - a review

Peder Agger, Jesper Brandt

Abstract.

The use of ecological networks as a means of mitigating the fragmentation of wildlife habitats has been a topic of discussion for the last three decades. The equilibrium theory developed by MarcArthur and Wilson explaining species richness on oceanic islands has been applied to habitat islands in cultural landscapes with little success. This has however not prevented the development and implementation of 'dispersal corridors' and 'stepping stones' in physical planning in cultural landscapes in many countries and in the European Union. The explanation for this success of an almost 'unproven' theory, must, apparently, be sought outside ecology. Other fields like recreational planning, landscape architecture, and the symbolic and ideological meaning of having member states bound together by a coherent green 'natural' network, should not be overlooked.

1. Dispersal theory

Two interdependent processes are affecting cultural landscapes in almost any part of the world. They have to do with the enhancement or inhibition of the dispersal of flora and fauna and the fragmentation of their habitats. This has serious effects on species diversity and stability of the landscapes.

The discussion concerning the problems of the dispersal of flora and fauna and the need for theoretical clarification as well as documentation and practical solutions has, in Denmark, continued for three decades. One of the first inputs was a reflection on the international discussion about the MarcArthur-Wilson Island-theory presented by Fenchel to the scientific community as being relevant for the general design of the size and pattern of the national network of protected areas (Fenchel, 1978; Biotopgruppen,1982).

Much more 'down to earth', but still presented in very general terms, was the 'Ecological Laws and Planning for Wildlife', presented by Muus at the Annual Meeting of The Hunters Association in 1980. Later this was printed as a pamphlet which provided principles for landscape design (Muus, 1981). The main message was that species richness will decrease, if an increasing isolation of local populations is not mitigated by dispersal corridors and stepping stones. This was followed up by a seminar on dispersal ecology (Lrjtnant, 1984) from which preliminary conclusions tried to translate concepts and results from research about dispersal and fragmentation into practice as a guide for nature conservation (Agger,1984).

The background for this interest was the process of specialisation and concentration of the agricultural production which started in the fifties, culminated in the seventies and continues even today. The result has been an advancing fragmentation of the habitats in the mosaic landscape. The removal of hedgerows, verges, ditches, ponds and other small biotopes as a result of the amalgamation of fields and farms came however to a nett stand still in the eighties. And a statutory regulation in 1992 suspended further reduction for the major part of the habitat types. At the same time the barriers separating the fragments have been magnified as the treatment of weeds and pests in the fields have become more efficient and road building has added to the

process of increasing isolation of local stocks of wildlife (Agger & Brandt,1988: Brandt et.al. 1998).

In practical life the relation between species richness and fragmentation has been known for a long time and has recently also studied on islands in the ocean. The central conception, in the island-theory developed by MacArthur and Wilson (1967), is the equilibrium theory. It says that species richness on a given island is controlled by two antagonistic processes: Immigration and (local) extinction. These two processes will, in the long run, tend to balance numerically. In this way the number of species will tend to be stable. The level will primarily be determined by the size of the species pool in the area, the size of the island, its composition of habitats and its degree of isolation. The smaller the island and the more remote - the lower the number of species.

The question of whether island theory is also valid in other situations than oceanic islands, (e.g. for habitat islands in a landscape), has been subject to intensive discussion (e.g. Lrjtnant 1984, Dawson 1994, Forman 1995, Kirby 1995, Novicki et al 1996, Hammershrj & Madsen 1998). Specially complicated are the agricultural landscapes where 'the ocean' is not deep and homogeneous but a heterogeneous and highly disturbed and unstable matrix that surrounds the habitat islands.

The dispersal environment and the dispersal capacity of the species might be very different in a "sea" with its varying crops, hedgerows, drainage ditches, roads, and other types of infrastructures (Agger 1984, Kirby 1995, Baudry & Burel 1998). These structures may either facilitate or inhibit or even block dispersal between still existing habitat islands to a degree that, for many species, might be far more important than the pure distance between the habitat islands.

Another and even more important difference from the oceanic situation may be current disturbance due to human activity. The most important of which is the cultivation of the surrounding matrix. But also the deliberate or unintentional transfer and release of animals and plants will enhance immigration, and hunting may inhibit immigration.

A third reservation is that the spatio-temporal scales are different. On the one hand we are dealing with slowly colonized oceanic islands of several square kilometres, separated by up to several hundred kilometres of ocean, on the other we have a situation where many things may happen within a year around habitat islands of few hundred square meters and separated by few hundred meters.

With these reservations in mind it might be no surprise that the number of occasions, where the island theory have been used successfully as an explanation for the observed species richness in agricultural landscapes is rather modest. None of the authors mentioned above have found abundant documentation that dispersal corridors work for many species.

However the most important reservation might be that the island theory emphasises the number of species, not the kind of species. The number of species with dispersal problems may be few, but could be very important in particular situations. As pointed out by Kirby (1995) features that link up habitat patches have a conservation value in their own right whether or not they act as wildlife corridors.

So probably the use of the vocabularium from infrastructures in the human society, like ways, croosraods, and gateways, might have lead to overemphazising the amount of organisms that actually flow through these structures.

However, little experimental research on the functionality of corridors has been carried out (Hobbs & Wilson 1998), maybe because many theoretical and practical problems are facing the endeavour to set up reliable experiments in this field making expert judgements connected to practical landscape planning the most realistic alternative, at least for the near future (Brandt 1998, Sustek 1998).

2. Dispersal theory in practise

The equilibrium theory itself has been abandoned by most scientists working in agricultural landscapes, although part of its terminology is still used. In his review of corridors Dawson (1994) concluded that both the use of island biogeography and metapopulation theory (as he termed it: 'the recent fashionable bout of metapopultion work') have suffered from the problem of oversimplification and irrelevance.

The dispersal of some species will generally be welcome in the rural landscape, others are not. For some species this has, for a long time been something that has been dealt with in a very practical manner. Eelways and salmon fish ladders are century old means of improving dispersal of migrating fish. Ponds for raising ducks for shooting often have an island in the middle. This is another way of handling dispersal problems: here it is the prevention of terrestrial predators' admittance to the birds resting and nesting sites.

Although the scientific documentation for the validity of the island theory in agrricultural landscapes is sparse, it has not prevented dispersal ecology from being applied both nationally and internationally.

In Denmark dispersal ecology has e.g. been used in the management of amphibians, which is one of the taxons that recently has decreased most and which has obvious dispersal problems. E.g. on the island of Bornholm where ca. 300 new ponds have been made and 250 restored since 1983 (Hansen 1996), researchers have observed how the existence of stonewalls, live hedges, and forests edges apparently are decisive for the survival (supporting yearly movements), and for the colonization of new ponds with the tree frog (Hyla arborea).

Another very concrete way where consideration of the movements of animals have been considered is the establishing of fauna passages for terrestrial animals across infrastructure constructions such as bridges and tunnels (e.g. for otters (Lutra lutra), other small mammals and birds as described by Salvig (1991), Madsen (1993 and 1996) and Madsen et al (1998)).

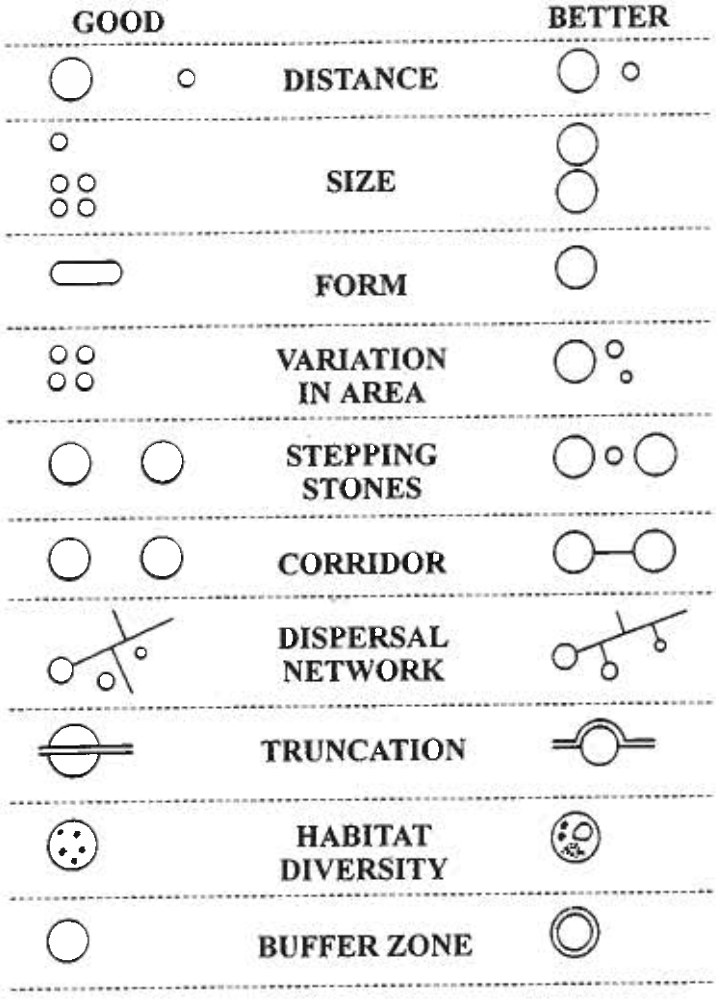
At a more general level, dispersal ecological considerations have been taken in the designation and delimitation of areas included in the Danish strategy for natural forests (Ministry of the Environment 1994).

This is in agreement with Dawson's findings that habitat corridors should be kept or created to connect nature conservation sites and to lead into the inhospitable surrounds, by Miklos (1996) called interacting landscape elements. The corridors would serve as conduits for some animals and probably plants, and 'also because we cannot await proof for which species these are.'(Dawson 1994 p 67).

3. Planning models

Biotopgruppen (1982) elaborates a set of design principles for biotope patterns based on the principles developed by Diamond (1975) for patterns of reserves.

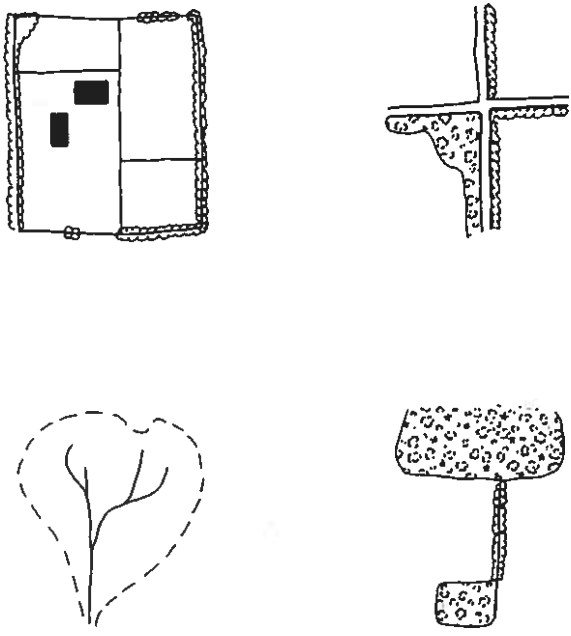
Fig.1: Design principles for consideration of dispersal of animals and plants in the landscape. (After Biotopgruppen, 1982).



At a higher level we have pointed to some practical structures or design strategies for integration considerations of dispersal ecology with other structures (Brandt & Agger,1984, Agger & Brandt 1987, Agger 1997). They are operating with structural elements comparable to the 'core areas'. 'corridors', 'nature development areas', and 'buffer zones' as described by e.g. Lammers & Zadelhoff (1996). The idea is that a future marginalization of agricultural fields, nature restoration, management etc. should be channelled or structured within, or at least considering, one or more of these structural models.

None of them should be seen as isolated from the management of the total landscape: They are all in their functionality dependant on parallel extensivation measures of the surrounding matrix of more or less intensive production areas, as well as measures to reduce the barrier effect of infrastructural constructions. There are four of them:

Fig.2: Four models for structuring of nature development areas: The Boundary -, The Road -, The Watercourse -, and The Core-corridor Model.



1. The boundary model which argues that all estate boundaries ought to carry some kind of small biotopes, i.e. conbcrete sites of occurence of wildlife. It is here that they are least disturbing for daily work in the fields. In an intensively cultivated landscape as the Danish agricultural landscape this will support the existence of a minimum of habitat network for flora and fauna. Estate boundaries are further compatible with most of the other administrative boundaries such as parish -, municipality -, and county boundaries. In this way the model may also support the 'readability' of this aspect in the landscape and thus a bit of its cultural content. The advantage of the model is that estate boundaries have proved to contain especially stable biotopes. The disadvantage is that it is vulnerable to increase in farm size.

2. The road structure model proposes that the network of roads should be taken as the skeleton on which further nature development areas can be added. This will balance the loss of public accessibility that has followed in the wake of the structural changes and new production pattern within the last couple of decades. The biotopes developed along roads will often be dry grassland and other types of herb vegetation which may balance the heavy loss of permanent dry grassland that we have experienced in Denmark since the second World War. (Now only 8% of the arable land is permanent grassland). Furthermore, the road system might have historical values itself that will be supported by this model. Old road structures also reflect the geological morphology in terms of watersheds, springs, old fords, reclaimed fiords, etc.

3. The core-corridor model is a model or better, a principle, of a fractural kind i.e. is valid in the same way at many different levels of spacial scale e.g. the individual estate, the landscape, the parish, the municipality, county, nation, or continent. At any level one may ask the question: What are the 3-5 most important habitat areas (cores or biocentres) and how are they or can they be biologically interconnected? And if no habitat areas are remnant: Where should we place 3-5 nature development areas as backbone for a new network? This is the beginning of a clarification of which sites and parts of the landscape considered are prone to management and restoration in order to be included in a network of ecological infrastructure. These ideas come close to what is described from the practice in Rheinland-Pfalz (Buchardt et al, 1996).

4. The watercourse model simply prioritizes protection, management and restoration along the watercourses and watersheds. There are both very pragmatic and more theoretical arguments for this. The riparian zone is the part of the agrarian landscape where there, relatively speaking, still are rather many small biotopes and bits of semi-natural land left. The same can be said about the watersheds where woods, dry grassland and heath, now often colonised by trees, are situated. Uncultivated areas in the riparian zone and watersheds may form buffers, for the watercourse and the ground water respectively, against pesticides and nutrient coming from the adjacent fields, and the buffer zone may form a habitat itself.

An overarching argument for this model is that the watercourses and watersheds together with the coastal zone are the only parts left of the old natural landscape structures, 'the skeleton and the blood circulation of the landscape body'. In a country like Denmark where less than 1% of the area is without direct influence by man, there are good arguments for letting these structures provide guidance to the planning and nature development in the future.

By using the coastline, waterways and watersheds as the greater structure, we thereby prioritize the effort being made around three of the habitat and landscape types that are most essential and have the greatest need. The great attraction of the coastline for both production and recreation has resulted in violent fragmentation and intensification in the use of coastal

landscapes. A manifestation of this is that half the threatened species in Europe can be found in the coastal zone.

The wetland in and around waterways is equally as exploited and further polluted and encumbered with obstructions. The deterioration of moorland and dry grassland, which is often found in watersheds, is a considerable problem in many areas of the more intensely cultivated parts of Europe, is (Agger,1994).

It is important to stress that the corridors are only some of the elements determining the dispersal function for flora and fauna, i.e. the ecological network, of the landscape (see also Felton, 1996). Jongman (1996) points out that the Danish and the Slovakian interpretation of the concepts of corridor deviate from main stream definition. Therefore it might be relevant to underline forllowing points in our understanding:

a) Networks are not just a net of physical structures but a function of the landscape that

b) not only serve wildlife but also energy, matter, and people

c) in a hieracical system from the highest continental level down to the individual farm.

d) The matrix should not be forgotten either.

As we will explain, we here might find some of the more important things that have happened or might happen to the ecological network in Danish landscapes.

4. Dispersal considerations in Danish planning

Generally, the need for ecological connections has been considered in the regional planning in most of the Danish counties since the beginning of the eighties. But it has been documented that although many plans for ecological networks have been made around 1980, hardly any were implemented 15 years later (Brandt 1996a). It can, however, be argued that the manifestation in the field of e.g. dispersal corridors laid out as wide bands in the landscape, will take time. This is because it is more a restrictive administration within a designated strip of land than it is a plan for massive nature development that has been the intention behind the first generation of networks in Danish counties.

It has also been claimed by Brandt (1996b) that the plans lack a formal link with physical planning in general and with nature conservation policy in particular. This has been true in so far as it has not been an obligation for the counties, and not all have, in first stage included these considerations in their regional plans. Although some of them have, in general terms, have indicated such consideratains in the introductory chapter of the plans, these are general and still not administratively binding for the county administration. But in recent years more weight has been placed on considerations of ecological dispersal.

In 1995 a national strategy for the protection and sustainable exploitation of biodiversity was made. In accordance with Article 6 of The Convention on Biological Diversity one of the target areas for rural planning is:

> *'Promoting the development of true ecological networks, by integrating efforts and coordinating measures between the Ministry of Environment and Energy, Ministry of Agriculture and Fisheries and the counties.'(Prip et al. 1995 p 91).*

In the instructions given by the Minister of Environment for the revision of the physical planning in the counties in 1997 this has been strengthened by underlining that:

'It is a precondition for the revision of the regional plans 1997 that in all counties there are designated ecological connections, and that the guidelines for their protection are elaborated'.(Miljø og Energiministeriet 1997a,p.24).

Further in the same instruction it is underlined that

building and construction works should, as far as possible, be avoided on low laying areas i.e. reclaimed wetland, so that the future restoration of the area as a natural one is not prevented. These types of areas cover 6,700 sq.km. or 15% of the national territory (Miljø- og Energiministeriet 1997,p.25).

These instructions are aimed at the fulfilment of the obligations in relation to the implementation of the EU-Habitat Directive. The 175 designated Habitat areas (11,000 sq.km. of which 31% is land i.e. almost 8% of the national land area) should, as far as possible, be interconnected. To the network of Habitat areas one should also add what remains of designated 'Biological Areas of Interest' that not are designated as Habitat Areas (Fredningsstyrelsen 1983).

Another important thing, that has happened, is that the protection of the coastal zone was strengthened in 1994. The 100 m general prohibition against altering beaches was widened to 300 m. And a 3 km. coastal proximity zone was amended in the Planning Act. The idea is that new areas for urban development and constructions in the rural areas should be located as far as possible from the coastline (Prip et al,1995).

It is however important that networking is not restricted to the national level. It should also be undertaken at other levels of spatial scales. In every landscape and every estate there is a need for improvements and the maintenance of ecological networks. These are not suited to centralized designation, but can best be negotiated and implemented in a discussion with the landowners at the municipality or village level if not on the individual farm.

One obvious possibility is to use the schemes for agricultural subsidies. In a cross-compliance scheme one of the criteria for subsidies could be that all estate boundaries carry some kind of biotope e.g. a one meter broad strip of uncultivated land if nothing better. Such schemes are in wide use elsewhere e.g. in Ireland and Sweden. But in Denmark where the schemes for environmentally friendly agriculture are not used to full capacity, we are obviously only at the beginning of considering such means (Miljø og Energiministeriet,1997b).

Recently networking in Denmark has been strongly stimulated by the so called "The Aquatic Environmental Action Plan II". This is a strengthened edition of a first action plan. Both aim at a reduction of nitrate and phosphate in the environment. As the first plan has not had the expected effect on the aquatic environment and as abundant nitrate pollution of drinking water wells (over half of which now have more more than 0.25 mg/l og Nitrate and traces of pesticides) stronger countermeasures have been taken. One of these is the restoration of 16,000 ha. of wet meadows along watercourses in the years 1998-2003.

Another unexpected, but fundamental, support in favour of a general easing of the dispersal problems may come from diminishing the load of sprays on Danish soils. A Parliamentary Commission is evaluating the national consequences of diminishing or ceasing the use of pesticides or a swich to organic farming throughout Denmark. The Commission will come up with its report in May 1999. To anticipate what will come, all municipal authorities are now negotiating a total ban of all use of pesticides on all land owned by the municipalities. And the state forestry, which covers 4 % of the country, decided already two years ago in principle to phase out the use of pesticides.

5. Other countries

In other countries, like The Netherlands (Ministry of Agriculture 1990), and at the supra national European level dispersal ecological considerations have been taken up as a foundation for framing future nature conservation. The idea of a European ecological network, EECONET, origin from 1991 as a network of EU-Habitat areas (Benett & Wolters, 1996).

In 1993 Germany suggested that NATURA 2000 should be enlarged so that other European states (other than the EU member states) could also be included (Bennett 1994). On behalf of Netherlands Scientific Council for Government Policy Bischoff and Jongmann (1993) made a background study by devising a map of existing and potential areas of high nature conservation status for the EC. This was in preparation for the meeting of European Environmental Ministers in Sofia 1995 where 'The Pan-European Biological and Landscape Diversity Strategy' was adopted (Council of Europe, 1996). This strategy has four main goals:

1. Substatially to reduce and, if possible, eliminate current threats to Europe's biological and landscape diversity.

2. To increase the resilience of Europe's biological and landscape diversity.

3. To strengthen the ecological coherence of Europe as a whole.

4. To ensure full public involvement in conservation of the various aspects of biological and landscape diversity.

(Council of Europe, 1996, p.5).

The establishment of a pan-European ecological network is mentioned as number two of the twelve points for the action plan of the strategy for the period 1996-2000.

Also the IUCN, in its action plan for protected areas in Europe, places decisive importance on the dispersal ecological conditions, and it uses the island-theory terminology in the description of goals for the action plan:

> *The protected areas would form an interconnected network - this will requires corridors and stepping stones between them. Representative samples of all the ecosystems will be included* (IUCN 1993,p.4).

6. Concluding discussion

Nothing is as practical as a good theory: We are facing a situation where scientists (MacArthur and Wilson) have elaborated a theory related to a situation (islands in the ocean) from where some others have tried to transfer it to another situations (habitat islands at land) about which an intense scientific discussion has taken place. Because of sparse documentation, the discussion went on among biologists for years, while practitioners, planners and politicians already are using the theories and apparently they are determined to continue doing so.

The practitioners (e.g. hunters and managers) position was explainable, because they do not distinguish between daily and yearly movements and dispersal. Rather they have seen that a bettering of the possibilities for movements works. And they have seen that it often is possible to combine these considerations with other purposes also for example shelter belts and foot paths for ramblers.

The planners position was explainable too. They are used to work with vague ideas and undocumented theories. Many other aspects, than dispersal ecology, within physical planning (not at least when it has to do with far sighted considerations) are at least as much, or even more

unpredictable. And barriers and corridors for wildlife may also be barriers and corridors for people (Kaae,1998).

But *the biologists* had problems. On many occasions the island theory provides the best explanation of the distribution of species in others not. The theory is not good at supplying us with precise predictions. But it has sharpened our general understanding of the importance of dispersion in a fragmented landscape and thus the interdependency among the habitat islands in the context of the landscape. In Denmark, there might be a fading trust in the importance of dispersal corridors for all species. On the other hand, there is an increasing effort to consider the dispersal of concrete species or group of species.

The politicians could, besides being influenced by the same insight and experience as the three other groups already mentioned, utilise the island theory and dispersal ecology in general in propagation also of other aims than nature conservation in senso stricto.

Kristiansen (1997) has analyzed the interface between politics and science. He focus on how an ecological theory - the theory of island biogeography - could be implemented as part of nature conservation in Denmark and used in the promotion for protection of nature. And he draw the following conslusion:

> *'Although it is of questionable status, the reductionism and the largely hypothetical character of the 'island theory' gave it great heuristic value and the appearance that it could have obvious applications in Danish nature conservation.*
>
> *The wide acceptance of the theory sheds light on the Foucaudian claim that whatever gives power attains the status of knowledge and that neither accuracy or completeness in the ecological theory determines its status - nor the question of truth.'*

This quotation may contain the clue to our understanding. The easy 'dispersal' and acceptance of the theory among biologists and planners (that all like other human beings also have a political life more or less integrated with their professional life) might have to do with a wish to attain influence for the nature conservation in the agrarian landscapes from where they formerly have been almost excluded.

In a EU and Pan-European context it is likely that the ideas of conserving and strengthening a coherent network of nature areas for the benefit of the European flora and fauna, are welcome to politicians who have ambitions of conserving and developing European coherence in other ways for example economical and cultural, as they say, for the benefit of the people.

The president of ECNC almost touch this where he in the preface to the book on perspectives on ecological networks (Nowicki et al, 1996) express the hope that besides of providing a coordinating framework for regional initiatives they will also stimulate new projects 'so that in twenty years time migrating wildlife too will have the benefit of a unified Europe without frontiers'(Nowicki et al, 1996, p.5).

There is, however, a danger which the very cantralized directive that mainly is based on 'ecocentric' natural scientific thinking inspired by professional elites, we may call this a discourse of biomodernity, may alienate the local inhabitants. They would have been better off with a broader and more democratic bottom-up-oriented approach. Thus the whole project may fail as the identity and active acceptance among the local people in the end is crucial. The importance of having all the stakeholders involved is thus also emphasized by Sidaway and Philipsen (1996).

Zev Naveh (1998) comprehend the cultural landscapes as the tangible meeting points between nature and mind. And if we want to understand the structure and processes of the these,

landscape ecology should deal with what he calls the total human environment which consists of the geosphere, the biosphere, the technosphere (man with all his things and actions) and the noosphere (the realm of our minds). Studies of ecological networks, their theory, structure, function, and abundance have to draw on elements from all these four spheres. Therefore network studies fits nicely into the definition as landscape ecology.

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Landscape Units and Protected Areas - Elements of Ecological Network. Some Experiences in Eastern Central Germany.

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Abstract.

To create an ecological network (ECONET) can be seen as an important aim of both environmental protection and spatial planning in Germany as a whole, but also in the Federal states, the so-called Laender as such as in Saxony, Saxony-Anhalt and Thuringia constituting Eastern Central Germany. A portion of 15 % of the open landscape of all land must have settled for that aim: to fullfil the protected function of landscape structure as geoenvironment for people, social life, commerce and industry. The way to reach that goal can be quite different. An inventarisation of the landscape structure and classification of landscape spatial units as one of its result of the whole country is on the agenda in Saxony. Results can be used as foundation to set up plans for creating and designing an ecological cross-link network or web structure within the cultural landscape. Another approach is to use the widespread system of big protected areas as such as nature reserves (NSG), national parks (NaP), biosphere reserves (BR) landscape protection areas (LSG), nature parks (NP), nature monuments (ND), protected landscape components (GLB) and other protected areas oriented on different natural resources as such as water, wilderness, wood, and others. Nature parks they are one of the interesting elements to create a ecological network. They consist of different protected areas and various status. Nature parks can be seen as real cultural landscapes characterised by traditional settlement structures and agricultural land use, as result of history, and they can be also used as environmental oriented Foundation for recreation and leisure and last but not least as protection areas for both species and biotopes or habitats. Examples of such nature parks are shown.

1. Introduction

Ecological network (ECONET) can be seen - with the biocentric viewpoint - as a mosaic of paths, islands and nodes of habitats for species or of barriers for that. Green spaces, important parts of the open landscape, can also be seen as an effective instrument of spatial planning to save the open landscape against the human settlements and to fullfil all target functions of landscape in both a wider sense on regional level outside of settlements and a stronger sense at local level within built up area of any settlement too. There are settlements of different types extending as such as from small rural village up to big agglomeration area. This is the viewpoint of the humans, social groups and societies of man. Therefore it should be named better the social or sociocentric approach than the anthropocentric.

The first greenspace-policy of spatial planning in Germany was elaborated and applied during the 1920ies in the Rhine-Ruhr-Emscher-Region (SVR, later KVR) and than in the Greather Berlin but also in Central Germany, in the surroundings of Halle and Leipzig (Weißenfels, Altenburg, Dessau). The regional planning organizations have had created concepts learning from the green-belt and garden-city ideas of the English.

Nowadays in the states of the eastern part of Germany they will bound both concepts: