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Introduction: ecological networks and greenways

1.1 Nature conservation and landscape ecological principles

The concepts of ecological networks and greenways relate to the human environment and its development. Recent advances in environmental philosophy have shown the fragility of the concept of 'nature'. New avenues have been opened up, from the new genetic and reproductive technologies to the awareness that the continuous loss of nature is a 'foundational concept, a ground of being, a stable otherness to the human condition' (Robertson *et al*. 1996).

Yet the beginning of the third millennium reveals a moment in which changes in social, scientific and technological sectors are rapid and multiple. In a dynamic environment changes in nature too become more and more human-driven, while the landscape becomes human-dominated. The natural environment has thus been gradually fragmented and now retains sets of habitats and species that cannot survive in isolation.

Within this framework, new philosophical directions in environmental sciences have stressed the importance of moving from isolation to connection and from a concentric to a peripheral approach. Nature conservation, accordingly, is moving from local to global. If the previous focus was primarily on areas of high nature concentration, e.g. national parks, now the focus is moving towards linkages between them and linkages between nature and the human environment such as greenways, ecosystem coherence and ecological networks. These concepts have recently become familiar in ecological language at both the scientific and the public level.

The above considerations are significant for environmental conservation and sustainable development, which should in turn become priority issues for national and regional authorities. The notion of 'environment' comprises in its broadest sense all factors that are of importance for living species and living communities. Environmental conservation and management reach far

beyond technical environmental protection such as air and water purification. They also include maintaining the functioning of ecological systems in all their variety of spatial forms. Protective measures for separate environmental factors, such as emission reduction and noise protection, are not sufficient for a sustainable environment. An integrated approach based on landscape ecological principles is becoming ever more important.

The ability of humans to change landforms and land functions has made urgent the need for new avenues in planning decisions. Landscape ecological concepts have laid new foundations for basic planning ideas. In the past decades the integration of the multiple activities occurring on the land has been reconsidered in physical planning, impelled by the increasing academic interest in multidisciplinary approaches. This has important implications for the ecological functioning of the landscape.

Landscape ecological principles have been integrated into nature conservation and landscape planning. Site-based nature conservation can only be successful if the conservation sites are very large, as in Russia, but even then larger carnivores are threatened. Species have difficulty surviving in fragmented landscapes and this hampers the core objective of nature conservation. Consequently, nature conservation in Europe has changed from site protection to the conservation of ecological networks, including the wider landscape (Jongman 1995).

Plants and animals are dispersed by both wind and water, with the help of other species, or by their own movements. Migration is a special kind of dispersal, directed to a certain site; dispersal is essential in population survival and the functioning of biotopes. However, dispersal can only take place if there are means for dispersal and sites to disperse from and to. On the one hand, an animal species will leave a population if living conditions cannot support all its individuals; on the other hand, new species will fill the gaps in those sites or populations that become empty. As such, fluctuations in populations can cause changes in the species abundance and species composition of a site. Birth, death, immigration and emigration are the main processes that regulate fluctuations at the population level. Plants, like several other groups of organism, depend on other species for their dispersal. Nevertheless plant strategies for dispersal are the least known and most difficult to detect in practice, and in this book they do not play an important role. In general, restriction of species dispersal increases the chance of species extinction.

The main elements for dispersal in the landscape are the distance and the land use between sites, the presence of corridors, and the barrier effect of landscape (Opdam 1991). Area reduction causes a decrease of populations that can survive and an increasing need for species to disperse. Routes for species migration consist of zones that are accessible for the species to move from one site to

another. Migration routes moreover are manifold, from single wooded banks to small-scale landscapes, and from river shores to whole rivers and coastlines. Migration, furthermore, is a prerequisite for many species to survive the winter period. However, migration is also risky and for flying animals migration routes should have as few barriers as possible and stepping-stones should be available for feeding, rest and shelter. For fish this means that rivers should not be blocked by dams and should have good water quality. For mammals and amphibians it means that routes should be available and that man-made barriers can be crossed.

1.2 Concepts and dualities in ecological networks and greenways

The linkages between ecology and landscape, as illustrated above, show the relevance of the discipline of landscape ecology to the development of ecological networks and their integration in the planning system. They also lead to another linkage, namely between ecology and networks.

The Concise Oxford Dictionary (1995) defines *ecology* as 'the branch of biology dealing with the relations of organisms to one another and to their physical surroundings'. It also defines a *network* as (a) 'an arrangement of intersecting horizontal and vertical lines, like the structure of a net' and (b) 'a group of people who exchange information, contacts, and experience for professional or social purposes'. Hence in certain instances the two meanings of 'network' have brought about confusion over what the word actually means, whether it is ecological or human oriented.

An *ecological network* is today recognised as a framework of ecological components, e.g. core areas, corridors and buffer zones, which provides the physical conditions necessary for ecosystems and species populations to survive in a human-dominated landscape. The goal should be considered twofold: to maintain biological and landscape diversity, but also to serve as a network assisting policy sectors in the conservation of natural ecosystems.

Again in *The Concise Oxford Dictionary* one definition of *green* reads 'concerned with or supporting protection of the environment as a political principle' and among the several definitions of *way* there is 'a place of passage; a course or route for reaching a place'. The blend of the two words produced *greenway* with an initial meaning of a passage for people and their access to the countryside, adding the function of linkage between the urban and rural American landscape (see President's Commission 1987).

A more comprehensive meaning has been proposed later by Ahern (1996) as networks of land planned, designed and managed for various purposes, but anyway compatible with sustainable land use. This definition incorporates a range of functions and possible typologies that can be set up within different

contexts, e.g. natural, cultural, spatial or political. It is actually this diversity which is, as pointed out by Ahern in chapter 3, the tool for proper communication and the key to the popularity of greenways.

Ecological networks and greenways clearly show a distinction in approach and function, but similarity in concept and structure. While greenways came initially from the need to create connections and paths for people to access the American countryside, ecological networks came from the need to conserve European species and habitats. In their later stages, however, the two concepts have come closer, having both been recently recognised as fundamental frameworks for the survival and movement of species populations, including humans.

Greenways have certainly inspired the development of ecological corridors in European nature conservation at different levels. From the European Union directives (e.g. the Habitats and Species Directive with Natura 2000) and the Council of Europe strategies (e.g. the Pan-European Biological and Landscape Diversity Strategy with Action Theme 1) the greenway concept has influenced national and regional policies throughout Europe. But whereas an ecological corridor is just a component of the ecological network, a greenway constitutes the connectivity framework itself.

1.3 A new perspective in landscape ecology

Reviewing recent developments in ecological networks, Arts *et al.* (1995) concluded that 'during the last decade, the nature conservation policies in many European countries have been based on landscape-ecological research, especially concerning the role of land use and landscape structure in the survival of species and in the protection of nature reserves'. Landscape ecology indeed provided the insight that nature is at the landscape level a dynamic system reacting to a complex of environmental and land use conditions. Land use influences the functioning of ecosystems as a whole, its self-purification capacity and the carrying capacity of the landscape (Mander *et al.* 1988; Kavaliauskas 1995). It also affects habitat quality for wild species and the potential for dispersal and migration that are vital for survival of populations especially in fragmented landscapes.

In an ecological sense isolation is an important issue. It allowed speciation on islands and led Darwin to detect this phenomenon on the Galápagos and develop his basic evolution theory. Time made it possible for species to develop. In the recent much more dynamic world, isolation is an important feature of agricultural landscapes, for example in north-west Europe. Here processes do not play a role on the timescale of speciation but on that of population dynamics.

Isolation does not only occur in places where it is evident, but also in less obvious ecosystems such as plantation forests, where management can cause isolation of the remnants of natural old growth forests within them (Harris 1984). Most natural and semi-natural habitat sites are remnants of a former natural area. Present landscapes are dominated by man-made dynamic habitats, and the less dynamic habitats are small and isolated as are the populations in them. Habitat isolation and habitat loss prevent natural species from developing viable populations or let populations survive at different equilibrium levels (Hanski *et al*. 1985). Natural interconnections have declined with the disappearance of forested and river corridors, and with the development of human infrastructures. The strategy to overcome this is the redevelopment of ecological coherence through networks.

Ecological networks and greenways have clearly brought about a new vision of landscape ecology. Previous concepts have dealt with the single elements of the network, such as patches and nodes, buffer areas, corridors and linkages; or with the dynamics of the network, such as movements, flows, migration, dispersal, fragmentation and connectivity. We now deal with the entire framework, where the single elements interact with each other in a dynamic way, and are combined to create that ideal network for conserving biological and landscape diversity and at the same time supporting sustainable land use. Planning is the key that allows these goals to be reached, since creating ecological networks or greenways requires an established planning system, be it regional or local.

The protection of habitat and species, however, is affected by many factors interrelated with each other and with the human world. From the latter, variations to the environment can be triggered not only by planning, but also by administrative skills, community values, sense of place, environmental attitudes, political and economic situations. After all the final goal of ecological network and greenway development is nature conservation; the former is only a tool to reach the latter. Ecological networks, as suggested by Bouwma *et al*. in chapter 6, are one of the possible measures in tackling species and habitat conservation. A combination of several measures is hence the best practice for ensuring alternative solutions to the problem of environmental fragmentation. Moreover, since ecological networks consist of both ecological and human components, the interaction between nature and culture is a priority to consider in both nature conservation and sustainable development.

All this leads to the further perspective on landscape ecology envisaged in this book, namely the indispensable link between nature and culture in the implementation of future econets and greenways. In this new scenario the full ecosystems are the actors, nature the scenery and the human species

the director. The last has great responsibility towards future generations and therefore has to accept a role that truly respects nature. From this standpoint one may see how econets and greenways have to be MULTI-functional, -cultural, -organisational, -national, being in turn part of the above-mentioned planning, social, economic, political and continental sectors. This book is an attempt to illustrate such a multi-sectorial dimension within the context of different countries.

ROB H. G. JONGMAN

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The context and concept of ecological networks

2.1 Introduction

Niels Holgerson travelled on the back of his goose with the wild geese to the north to the breeding areas and he saw the land beneath him. Geese fly north and south for breeding and wintering. When walking in a forest or through agricultural land you may suddenly meet a deer, a badger, a hare or a rabbit. Looking carefully in the grasslands in the wintertime you can detect mouse tracks. Salmon migrate from the ocean up the rivers for spawning. Humans used to walk or drive horses to travel for business and religious purposes. In the modern western world, humans walk mainly to enjoy a tour on a grande randonnée or a old pilgrims' path. However, in general connection and exchange are important for all species to survive, to forage, to reproduce or establish new communities. On all scales and for most species pathways do exist to link individuals and populations.

Land use and nature changed dramatically in the nineteenth century. The land has been developed, parcels enlarged and land use intensified. Since the end of the nineteenth century nature conservation through national parks and nature reserves has been the prime tool to counteract decline of species and natural ecosystems. This was very important to preserve species and natural ecosystems. In that period the linkage between protected sites did not seem to be crucial. The increasing pressure of land use in combination with the insights from landscape ecology on the role of landscape flows and the functioning of metapopulations of species has changed that idea. Nowadays the idea is accepted that reserves alone cannot maintain biological diversity in the long term (Beier and Noss 1998; Bennett 1999). Networks and landscape linkages are needed for long-term survival.

This chapter introduces the reader to the development of concepts of ecological networks in general and the European approach to ecological networks

in particular. In the last decades of the twentieth century ecological networks have been developed by authorities and scientific institutions in Europe, America and Australia (Bennett and Wit 2001). In Europe this has been partly a Europe-wide approach as a reaction to the Convention on Biological Diversity or as newly developed European policy, such as NATURA 2000 (Habitat and Species Directive, EC 92/34), the Emerald Network and the Pan-European Biological and Landscape Diversity Strategy (Council of Europe *et al*. 1996). These have been scientific studies and national initiatives varying from strategies for adaptation of conservation policies to development of ecological networks as a scientifically based approach. Nowadays most of the ecological networks in Europe are part of national and regional nature conservation policies.

This chapter does not intend to present a complete picture of these developments, but to present common denominators, concepts to highlight common developments between countries and regions, and indicate where and when differences between countries and regions have to be taken into account when developing ecological networks. This chapter emphasises the development in Europe and it shows trends in decline of landscapes and the diversity of approaches to biodiversity conservation and nature conservation planning. Understanding these differences and common issues is of the utmost importance to find common principles and approaches and to know when differences are important enough to be maintained or when they can be abolished.

2.2 A short nature conservation history

Throughout the centuries, land use was adapted to the restricted technical ability of people to change the land. In Europe this led to a rather stable pattern of landscapes until the second half of the nineteenth century. Then around 1850 the industrial revolution started. It meant a revolution not only in the urban environment, but also in the rural environment. Machines were introduced as well as fertilisers and wire fencing. Semi-natural areas were converted into agricultural land and the scale of agricultural holdings increased. In the same period people began to regulate the main European rivers, such as the Rhine, the Danube, the Elbe, the Meuse, the Po, the Rhone and the Tisza. That meant better transport facilities and a safer and better-drained land. This process started on a small scale, but has continued until the present day.

The history of nature conservation and of urban ecological networks started as a reaction to the industrial revolution. Already in the last half of the nineteenth century and the first period of the twentieth century nature was integrated into urban planning, for instance when the main axes of towns were developed into green boulevards, such as the Champs Elysées and the footpaths along the Seine in Paris (Searns 1995). In the USA Frederick Law Olmsted

proposed in 1860 a plan for Brooklyn and later for Boston to link the urban parks and quarters by green corridors, the 'parkways'. These are routes to and from the urban parks surrounded by trees and with an aesthetic and recreational function. These parkways were between 65 and 150 m wide. The Boston plan is still partly extant and known as the 'Emerald Necklace', and also has a drainage function for the town. Drainage remained an important function of plans for green corridors through the whole century. In chapter 3 the historic developments in the USA are described in detail.

In England in the same period Ebenezer Howard (1898) developed the greenbelt concept, meant to regulate the urban sprawl of London and other urbanising areas in England by surrounding the inner city with parks about 8 km wide. Behind this belt commercial and industrial areas should develop. London is the clearest example of this approach. The difference between the two approaches is the linking function of the parkways and the dividing function of the green belts.

In other countries, such as the Netherlands, developments took place comparable to those in the USA and England. The industrial revolution had a heavy impact on the cities and a need for urban green developed: the Amsterdam Vondelpark was one of the first urban parks, established in 1870. The Dutch housing law of 1901 allowed town authorities to designate areas as open space for public use. The city of Arnhem was, around that period, the first town that officially designated a park as 'public green space' and there the park system still reaches from outside town into its city centre.

Nature conservation and urban development joined forces in the 1920s. At the international congress on housing and urban development in Amsterdam in 1924 the statement was made that nature is important for outdoor recreation, for its scenic beauty and its intrinsic value. Urban planners and architects pleaded for the development of parkways and in this period several were constructed, such as those in Rotterdam and Utrecht (van Langevelde, 1994).

After the Second World War nature conservation focused more on the preservation of values within semi-natural landscapes. This was especially important in the northern states of Europe, where the decline of nature was alarming. After the first nature conservation year, 1970, changes took place in nature conservation in western Europe; nature conservation acts were revisited in many western European states, in some cases by amending existing legislation and in other cases by formulating a new and more integrated nature conservation policy relating issues such as recreation, urbanisation, regional planning and agriculture. In this period nature conservation obtained a more or less accepted position in policy. The same process took place in central and eastern Europe after 1989; since then some central and eastern European countries have introduced the most progressive legislation based on the latest scientific knowledge.

2.3 The driving force: land use change

Under the influence of changes in food demand, caused by demographic trends, the cultivated area of Northern America and Europe has shown considerable fluctuations. Agricultural areas are moving from one region to another, forests are removed in one part of the world and forests of exotic species are planted elsewhere. Agricultural productivity in Canada, USA and the European Union (EU), measured in kilograms of dry matter per unit of area, continues to rise thanks to ongoing advancements in agronomic knowledge. Through the consequent changes in agriculture and forestry practices, landscapes have suffered rapid and often irreversible changes. These changes consist of two groups (Fry and Gustavsson 1996):

- changes resulting from the marginalisation of farmland and forests and consequent abandonment of earlier practices
- changes arising from the more intensive use of highly productive land, resulting in less land being farmed, but farming and forestry becoming more intensive, more specialised, and at larger scales

The result of these two opposite trends is a polarisation between intensively used land and natural or abandoned land. Intensifying agriculture makes land monofunctional and takes away both cultural and natural diversity. Intensification by one farmer – reducing production costs – will improve his position on the market. We also have to realise that the farming market is an international market. The farmers in the Paramó of the Andes have to compete with the large-scale potato farmers in Canada, and Greek farmers have to compete with Dutch and Danish farmers on the cheese market. Also the trade in animal stock is international or continent-wide. If the market is not regulated the farmers in the less favoured regions will marginalise and eventually abandon their land. Both intensive and extensive land use are expressed in the landscape: the structure of the land, the size of the parcels and the area of natural and semi-natural vegetation that is still present.

The pressure of economic competition in farming, forestry and urbanisation makes the land partly homogenised through the disappearance of regional differences in (semi-) natural features. This is not a new process but its features become more and more recognisable. We develop towards a homogenised world. As a consequence, the multi-functionality of the landscape is disappearing and outdoor recreation and nature conservation have fewer opportunities in the wider countryside. According to research by van Rabenswaaij *et al.* (1991) the optimum for the presence of critical meadow birds turned out to be the range between 50 and 150 kg N ha^{-1}. If this is applied to the practice of present day farming it appears that this regime can only lead to marginalisation (De Wit, 1992). Economically sustainable agriculture is being driven either