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European ecological networks and greenways

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Abstract

In the context of European integration, networks are becoming increasingly important in both social and ecological sense. Since the beginning of the 1990s, societal and scientific exchanges are being restructured as the conceptual approaches towards new nature conservation strategies have been renewed. Within the framework of nature conservation, the notion of an ecological network has become increasingly important. Throughout Europe, regional and national approaches are in different phases of development, which are all based on recent landscape ecological principles. Ecological networks are interpreted in a variety of ways depending on different historical roots of nature conservation, planning and scientific traditions, different geographical and administrative levels, different land uses, and in the end the political decision-making is dependent on actors with different land use interests. This complex interaction between cultural and natural features results in quite different ways for the elaboration of ecological networks and greenways.

Keywords: Ecological network; Greenway; Europe; Environmental planning

1. Introduction

For a period of about one century, conservation movements have developed ideas of species preservation and conservation of national nature reserves on national and regional levels to mitigate the human impacts on nature caused by industrialisation (Boardman, 1981). However, in spite of the good intentions within the field of nature conservation, the industrialisation of agriculture, restructuring of land use, the building of huge transport networks and metropolitan areas has caused a serious fragmentation of natural areas, deterioration of ecosystems, loss of natural habitats and habitat structures, and extinction of species (Stanners and Bourdeau, 1995). This is especially the case in the most densely populated areas of Europe. Thus, the natural habitats can in many regions be looked upon as if they were isolated islands on the sea. The smaller and more isolated these 'habitat islands' are as a consequence of the ever-increasing land use and road networks, the more likely species are likely to decline.

Species survival is dependent on habitat quality, food availability and for most species the ability to move through the landscape. Movement is needed for daily movements for foraging and rest and shelter, as periodic migrations for reproduction and to avoid unfavourable environments and for dispersal (Hansson et al., 1992; Bennett, 1998; Van Opstal, 1999). When the environmental conditions change, either due to natural events or human activities, many species are dependent on their ability to colonise new areas. In this

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respect, we have good reasons to make the claim that a landscape's connectivity is important and physically expressed in ecological networks. Accordingly, a response from various conservationists and conservation authorities has been a shift from a strategy of conserving the existing, more and more isolated, natural 'islands' to the conservation and restoration of interconnected natural areas (Farhig and Merriam, 1985; Arts et al., 1995).

Part of the network strategy is to conserve and restore dispersal corridors and 'stepping stones' (habitat islands), which function as habitat structures between core nature areas and facilitate the biological conductivity in the landscape. The validity of the scientific theory and arguments behind this conservation strategy has been heatedly debated among ecologists and conservationists (see Simberloff, 1988; Noss, 1987; Beier and Noss, 1998; Shafer, 1990; Dawson, 1994; Jongman and Troumbis, 1995). Corridors and 'stepping stones' for species dynamics dominate the discussion on implementation in Western Europe.

In Central and Eastern Europe, a more environmentally based approach has been applied, where land use is considered to influence the interaction of the landscape elements and the stability of the landscape as a whole (Mander et al., 1988, 1995; Miklós, 1989, 1996; Kavaliauskas, 1995). Here, concepts like 'natural carrying capacity', 'self-purification capacity', 'ecological compensation' and 'ecological stability' of the landscape for human functions are the basis for the ecological networks.

Originating from terminology of American landscape architecture and planning, sometimes the ecological networks are referred to as "greenways". Greenways have been originally defined as, "linear open space established along either a natural corridor, such as a riverfront, stream valley, or ridgeline, or overland along a railroad right-of-way converted to recreational use, a canal, a scenic road, or other route" (Little, 1990; see also Flink and Searns, 1993). Furthermore, comprehensive greenway networks include ecological, recreational and cultural heritage aspects (Fabos, 1995).

Today, in many regions, the ideas about ecological networks have developed into various concepts and plans for terrestrial systems of ecological stability, or networks of linear habitats connecting habitat islands on different geographical and administrative levels. On a European level, ecological networks are proclaimed to be a leading objective in the Pan-European Biological and Landscape Diversity Strategy—*conservation, enhancement and restoration of key ecosystems, habitats species and features of the landscape through the creation and effective management of the Pan-European Ecological Network* (Council of Europe et al., 1996). The importance of wider landscape for nature conservation has been recognised in the European Union's Habitat Directive (EC 92/43), when referring to importance of landscape elements and structures for the favourable conservation status of habitats and species. In this paper, however, we discuss only the planning and implementation of the national and regional approaches.

This paper reviews the result of European efforts to develop ecological greenway networks by compiling available plans, literature and documents and by consulting different national and regional experts. The objective is to provide a comparative and up-to-date overview of different regional and national approaches to ecological networks in Europe. The approaches are reviewed and discussed concerning concepts, criteria, legislation and implementation. Variations reflect the cultural divide between East and West, between North and South but also between nations. The survey highlights common principles and differences applied in Europe. Differences and similarities are seen in the context of geographical, bio-climatic, cultural and political conditions, which again are embedded in different scientific, planning, nature conservation and policy traditions. However, we do not attempt to present a complete overview also because of the rapid development of the ecological network and greenway concept and its application.

2. Development of ideas and practice

The idea of green networks was already developed in urban planning in the beginning of the 20th century. In the great metropolitan areas in both the Eastern and Western Europe, ideas were created to develop green-belt systems that interconnected the city and the nature areas or forest zones. Plans were developed in London as well as Moscow. Similar systems were also created elsewhere, e.g. in Berlin, Prague and Budapest (Kavaliauskas, 1995). In Copenhagen, a plan

for a network of green paths was approved in 1936 (Forchammer, 1939). Such city plans of green belts or networks of green paths were mainly constructed to satisfy recreational needs of people crowded together in polluted cities. Although their function may be defined as recreational, they most probably made the way for what we know as ecological networks and greenways today, they facilitated the concepts (Jongman and Pungetti, in press).

What has characterised our concept of nature in both East and West, at least since the 1920s has been the institutionalisation of nature, and planning ideas like segregation and functionalism developed from scientific concepts. However, their implementation in planning is as well rooted in social life: growing urbanism and territorial demands from an increasing population. The scientific ideas harmonised well with the centrally planned economies in Eastern Europe, as well as with the Western development of capitalism and the ideals of private property of the land. They were extended to their limits in planning, including conservation planning, and provided the shaky ground for preservation of beautiful natural sceneries as a reaction to further increase in production, population size, and wealth.

For the last decades, the ideas about integration have been restored to favour in planning and an increasing academic interest in multidisciplinary approaches can be observed. This has also facilitated the development and acceptance of such ideas as ecological networks and greenways. Moreover, the recreational functions, which might be embedded in all the networks, other different functions of ecological networks can easily be identified. These are the ecostabilising functions and the ecological (population dynamic) functions.

3. Environmental planning concepts

3.1. The ecostabilisation principle

Russian and East European landscape sciences have to a higher degree been based on geographical sciences: geomorphology, hydrology and climatology. In addition, soil data has been a most characteristic product of the Soviet era. American and English landscape science did not really develop as in continental Europe; the major issue has been landscape ecology as a landscape systems approach and it has mainly been based on ecosystem ecology, population ecology, and its new branch of conservation biology. Generally speaking, the Anglo-American tradition has concentrated on the vertical (chorological) processes in the landscape, whereas the German and Eastern tradition has concentrated more on the horizontal (topological) and regional aspects for physical planning. East European countries and Baltic states have been influenced by both traditions. Estonian geographers have, e.g. due to both Swedish and Russian occupations, a long tradition in investigating landscape regions and the dynamic relationships of small landscape units (Roosaare, 1994).

Another condition that has been decisive for the Eastern European approach is that spatial and environmental planning in the Soviet era has not existed by itself but only as subordinated to the rules of the planned economy. This kind of planning initiated large-scale technocratic projects and a functional simplification of the collectivised agricultural landscape. Destruction of landscape systems and ecological destabilisation were visible results of this process.

In contrast to this economic planning, concepts like '*territorial systems supporting landscape ecological stability*' were introduced in the early 1980s (Miklós, 1989; Buček et al., 1986, 1996). Theoretically, the approach has been described in the concept of a *polarised landscape*, suggested in 1974 by the Russian geographer, Rodoman. This idea was a logical consequence of the development of planning and the knowledge available. His principle is a functional zoning of the landscape elements into natural zones that antagonises the poles of intensive land use. The fundamental principle of the concept is strict delimitation of natural zones and zones for restoration as antagonistic poles from zones with intensive land use (agriculture, industry, urban areas), and uniting all natural zones into one coherent network. However, the influence of Rodoman to Buček, as well as to Ružicka and Miklós is not at all clear.

The concept accepts intensive land use, but proposes a functional zoning of the landscape, including areas and elements for natural zones as and antagonism for the centres of intensive land use. These natural zones and the zones selected for agriculture, industry and urban development were the poles of this planning concept. Rodoman's concept was dialectic and holistic, developed within a deductive scientific tradition.

It resulted in concepts such as '*nature frame*', '*natural backbone*', '*ecological compensative areas*' and '*ecostabilising functions*'. Essential in these concepts is:

1. The designation of territories to function as an ecological compensation to the territories that are heavily exploited.
2. The linkage of these compensative territories by zones with coherent land management.
3. Sufficient space to create compensation and linkages.

The important principle behind the ecostabilisation concept for spatial planning is acknowledgement of the importance of processes on the landscape scale, the presence of flows, the transmission role of ecotones and the use of the ability of nature to purify and restore.

3.2. Ecological principles: dispersal and migration, connectivity and connectedness

Movement is itself the product of evolutionary pressures contributing in many ways to the survival and the reproduction of the animal. Animals move through their home range, but may also move long distances from where they were born and their kin remain. Three kinds of movements can be distinguished (Caughley and Sinclair, 1994):

- *Local movements*—These are movements within a home range and are on smaller scales.
- *Dispersal*—Movement from the place of birth to the site of reproduction, often away from its family group and usually without return to place of birth.
- *Migration*—This is movement back and forth on a regular basis, usually seasonally, e.g. from summer range to winter range to summer range.

Local movements are within the home range of a species. They are movements for foraging hiding for enemies and optimising living conditions. Ricklefs (1990) defines dispersal as the one-way permanent movement away from established home range or natal area. In contrast, migration is the two-way movement between two distinct areas. Dispersal is often associated with what it is referred to as emigration and immigration. That is movement from one population to another population or habitat site. It is usually one-way movement (Caughley and Sinclair, 1994). Stenseth and Lidicker (1992) claim that dispersal or movement from one home site to another is a phenomenon of potentially great importance to the demographic and evolutionary dynamics of populations. However, it is also one of the less understood features of ecology and evolution. It determines the probability that individual currently "here" will later be "there", and as a consequence be exposed to different opportunities and risks. It gives populations, communities, and ecosystems their characteristic texture in space and time (Clobert et al., 2001).

Migration can be defined both as a population's periodic, or seasonal movement, typically of relatively long distance, from one area or climate to another. Migration is characterised by the periodicity and regularity of the movement. The term of migration is generally reserved for mass directional movements of individuals of a species from one locality to another. The individuals engaged in migration mostly move between two locations and return to the same home ranges and often with the same mates.

Plants and animals both disperse by wind, water, with help of other species or by own movements. Migration is a specification of dispersal, while it is directed to a certain site. Dispersal is essential in population survival and the functioning of biotopes. However, dispersal can only function if there are sites to disperse from and to and means for dispersal. Dispersal is important for survival of populations. On the one hand, animal species will leave a population if living conditions cannot support all individuals, and on the other hand, species will fill in gaps in populations or sites that became empty. Fluctuations in populations can cause changes in species abundance and species composition of a site. Birth, death, immigration and emigration are the main processes to regulate fluctuations at the population level. Plants, but also several other groups of species, depend on other species for their dispersal. However, plant strategies for dispersal are the least known and difficult to detect in practice. Restriction of species dispersal increases the chance of species extinction.

The main functional aspects of the landscape that are of importance for dispersal and persistence of populations are connectivity and connectedness. According to Baudry and Merriam (1988), connectivity is a parameter of landscape function, which measures the processes by which sub-populations of organisms

are interconnected into a functional demographic unit. Connectedness refers to the structural links between elements of the spatial structure of a landscape and can be described from mappable elements. Sometimes biological connectivity (e.g. functional patterns) and landscape connectedness (e.g. physical connection of similar landscape elements) match, as in the movements of small forest mammals which move along wooded fencerows from one woodlot to another (Henein and Merriam, 1990). Sometimes, they do not match as in ballooning spiders (Asselin and Baudry, 1989).

Structural elements are different from functional parameters. For some species, connectivity is measured in the distance between sites, for other species the structure of the landscape, the connectedness through hedgerows represents the presence of corridors and barriers. Area reduction will cause a reduction of the populations that can survive and in this way an increased risk of extinction. It also will increase the need for species to disperse between sites through a more or less hostile landscape.

3.3. Principles for river systems: a continuum and spatial–temporal diversity

Rivers do play a crucial role in the structure of ecological networks, mainly as a connecting landscape feature. A river itself is more than the sum of its parts and it is not a static body of water, but rather a continuum with a changing ecological structure and function. The concept dominating the river studies for the last decades was the river continuum concept, which was the first unified hypothesis about how streams and their watersheds work. The river continuum concept (Vannote et al., 1980) is based on macro-invertebrates and it states that from the headwaters to the river mouth a continuous change in macro-invertebrate community take place. The headwaters are likely to be narrow, fast flowing, and shaded by trees and other vegetation, therefore all the energy that virtually enters, is in the form of leaves, twigs and other debris. Detrivores and filter feeders dominate the fauna. Energy in the form of biomass and detritus is constantly flowing downstream, hence the energetics of any particular section of the river are influenced by events upstream. The result is a longitudinal continuum of ecosystem structure with a number of predictable properties. Vannote et al. (1980) argue that the river's biological and chemical processes correspond to its physical attributes and that the nature of biological communities changes in a downstream direction just as the river itself does. This also means that from all the catchment energy, food and water is collected in the river streambed. Rivers are the core of the catchments, the places where food is abundant and where migration is easy.

Rivers are also far more than just longitudinal river corridors and according to Jungwirth et al. (1998), modern ecology recognises them as complex ecosystems. According to Townsend and Riley (1999), the science of river ecology has reached a stage where explanations for patterns rely on links at a variety of spatial and temporal scales, both within the river and between the river and its landscape. The links according to Townsend and Riley (1999) operate in three spatial dimensions:

1. Longitudinal links along the length of the river system, such as the river continuum (Vannote et al., 1980), downstream barriers to migration.
2. Lateral links with the adjacent terrestrial system, such as the flood pulse concept (Junk et al., 1989).
3. Vertical links with and through the riverbed.

Many linkages occur between the river and its environment, therefore it is suggested to consider the river continuum to be considered within broad spatial and temporal scale (Roux et al., 1989). The lateral and vertical dimensions of the ecosystems need to be associated with running water. In the flood pulse concept (Junk et al., 1989), it is stated that the pulsing of the river discharge, the flood pulse that extends the river onto the floodplain is the major force controlling biota in rivers with floodplains. The flood pulses control biota in three ways: directly by facilitating migration of animals, indirectly by enhancing primary production and thirdly by habitats structuring. During floods, biota migrate both actively and passively between different habitats in the river–floodplain system. The lateral exchanges between main channel and floodplain, and nutrient recycling within the floodplain has according to Grift (2001) more direct impact on biota that the nutrient spiralling discussed in the river continuum concept. The floodplains provide besides important factors for driving ecological processes in the riverine ecosystem mainly the habitat complexity and habitat quality in the river ecosystem.

In general, running waters constitute a vector for the transfer of material from elevated reaches to the bottom of a drainage basin. Fish, mammals and plants move along their corridor in different speed and with different steps. The strong interaction between the stream and its riparian ecosystems in its ecotone provide a huge exchange of energy, matter and nutrients that attracts all kind of natural species. The transport of matter and nutrients is restrained by all kind of natural and retention devices and in this way the river is an important mechanism for reconstruction of landscapes and for species, linking reproduction sites and populations. The way matter, energy and species move through a river system can be well described with the spiralling concept, based on the recurrent use of matter in ecosystems along the river. Although this concept has been developed for nutrients, it can also be a valuable concept for considering the behaviour of species.

Rivers are in principle dynamic systems and in relation to other parts of the landscape important pathways. Downstream they have higher diversity and are less dynamic than upstream. This also means that interactions with other ecosystems are more complex in the downstream stretch than upstream. Human use of rivers as a transport route or recreation pathway will also be different, because of differences in accessibility, the diversity of the landscape and the potential use of the system. It varies from water provider to the most intensively inhabited areas in the world, where conflicts for space are common.

4. Environmental planning criteria

In most European countries, the mapping of biotic and abiotic resources and conditions has been carried out and the results have been used in different ways and different scales as criteria for location of the network. The Central Eastern European territorial planning in the 1970s came up with complex schemes of environmental management, where research was related to intensive agricultural production. Since the 1980s, interdisciplinary studies focusing on cycling of matter in catchment areas based on computer modelling have been carried out by physical geographers. Thus, a large amount of data from geology, geomorphology, geography, hydrology, soil physics, etc. has formed the main basis for design of the ecological network, where the basic criteria have been related to the existence of ecostabilising functions. The focus on ecostabilising functions is most clearly expressed in the Lithuanian and Slovakian cases (Table 1).

In Lithuania, the hierarchical structure in the nature frame means that areas of biological importance is seen as a subsystem of geo-ecological functions and systems (Kavaliauskas, 1995). One principle in getting the Lithuanian nature frame active is the principle of location ‘where the need is’. The territorial system of urban frame with its centres and axes of economic and technical activity polarises the territorial system of nature frame with its centres and axes of ‘ecological stability’ compensation functions, which is defined as: groundwater cleaning, air cleaning, recreational resource protection, aesthetic improvements, etc. The concept includes a geo-ecological approach, a core structure of natural landscapes. Beside this approach the concept includes natural and semi-natural land use patterns, and ecological network of habitats.

In Slovakia, three types of criteria for the creation of Territorial System of Ecological Stability (TSES) were developed (Miklós, 1996):

- Selection criteria (to answer the question what?).
- Location criteria (to answer the question where?).
- Realisation criteria (to answer the question how?).

Selection criteria are based on representativity, ecological significance and internal ecological stability and size and shape.

Location criteria are based on position and spatial arrangement of geo-ecosystems, requirements of soil and water protection, anti-erosion measures, filtration, micro-climatic, hygienic, aesthetic functions and ecostabilising measures.

Realisation criteria are used to determine the possibility of TSES realisation in an area, especially evaluating if the current structure of the landscape provides existing elements for TSES (including the structure of the settlements). The main realisation criteria are ecological quality of the current landscape structure, existing legal protection of the elements of TSES.

In contrast to the countries of Central Eastern Europe’s focus on ecostabilising functions, the development of ecological networks in Western Europe have focused more on the protection of valuable sites and threatened species with long dispersal ranges. Different values of biodiversity are embedded in a

Table 1
Approaches for ecological networks and greenways in Europe

Name of the network	Main functions	Approaches, concepts and aims
Belgium: Ecological Network of Flanders (VEN/IVON)	Ecological	Coherent structure of areas in which nature conservation policy is the main objective to be developed in the network and in its supporting network
Belgium: Ecological Networks of Walloon	Ecological	Local plans at community level based on regional guidelines, scale 1:25,000
Czech Republic: Territorial System of Landscape Ecological Stability	Ecostabilisation, ecological	Network of ecologically important landscape segments based on functional spatial criteria aiming at the preservation of biodiversity, conservation of nature and supporting multi-functional land use
Denmark: Ecological Networks/Naturverbindsele	Ecological, river systems	Core areas and ecological corridors developed as part of the counties multifunctional planning. Aiming at the creation of a coherent structure to facilitate dispersal of species
Estonia: Network of Compensative Areas	Ecostabilisation	Planning and management of rural areas aiming at optimal diversity of landscape pattern and ecological infrastructure within regional spatial planning.
Germany: Vernetzter Biotopsysteme, Rheinland Pfalz	Ecological, river systems	Planning concept for conservation of nature and natural communities, development of core areas and corridors and to conserve species
Italy: Reti Ecologiche	Ecological	Projects at provincial level for establishing ecological networks under development; partly as part of an EU-Life project
Lithuania: Nature Frame of Lithuania	Ecostabilisation, river systems	System for land management to preserve and create an environment for both conservation and restoration of nature
The Netherlands: National Ecological Network	Ecological, river systems	Policy document aiming at the conservation of species in a coherent area structure at the regional level. The national plan is worked out by the 12 provinces co-ordinating its implementation through provincial plans
Poland: National Econet	Ecostabilisation, ecological, river systems	Network of core areas connected by landscape linkages mainly along rivers. The project is an IUCN initiative and under discussion with the national authorities
Portugal: Greenways System for the Lisbon and Porto Metropolitan Areas	Ecological, recreational, river systems	Gap analysis of protected areas and areas to be protected for both biodiversity conservation and cultural and recreational values, initiated by universities and NGOs in co-operation with urban authorities
Russia: Protected Nature Area Systems	Ecological	Different systems for designations of protected areas (state natural Zapovedniks, national parks, Zakazniks, etc.) form several independent subsystems under supervision of different ministries and a variety of regional bodies
Russia: Green Belt of Russian Karelia, Karelia, Heart of Russia, Orembourg, Volga–Ural Russia	Ecostabilisation, ecological	Zonation of area in policy plan created beyond influence of authorities by Scandinavian companies (Karelia) and national as well as international NGOs by applying the PNA systems, a functional polarised zoning of natural areas. Objective to interconnect areas of mainly fragmented parts of forest and forest areas
Ukraine: Ecological Network	Ecostabilisation	Network based on the law on nature protection prepared by the Ministry of Environment including existing protected areas, buffer zones and ecological corridors as a legally binding strategy plan
Slovakia: Territorial System of Ecological Stability	Ecostabilisation, ecological	Network of ecologically important landscape segments based on functional spatial criteria aiming at the preservation of biodiversity, conservation of nature and supporting multi-functional land use
Spain: Catalonian 'Network' of Natural Protected Areas (PEIN)	Ecological	As a product of the Catalan strategy for biodiversity some projects try to connect the PEIN natural protected areas by rural areas into what might be considered an ecological network
United Kingdom Ecological Network, Cheshire County	Ecological	Regional project aiming at implementation. The project is a mapping of network of core areas, corridor and buffer zones and is carried out as a EU-Life project with Italian partners

Source: Developed from Jongman (1995), Jongman and Kristiansen (2001) and Bennett and Wit (2001). *Main functions*: The networks have been created with the purpose of different functions in the landscape. *Ecological* means the main purpose of creating the network plans has been species dispersal and survival in the landscape. *Ecostabilisation* means, the main purpose is to stabilise the whole landscape by a functional zoning of landscape elements into ecological compensative areas, that compensates zones of intensive land use. *River systems* means that rivers are the core of the ecological network.

variety of ways in different approaches of nature conservation. Biodiversity is an extensive concept that among other things means that biodiversity can be landscape diversity, ecosystem diversity, habitat diversity, biotope diversity, populations diversity, species diversity, species richness, taxic diversity, or genetic diversity, which often can result in conflicting views (Agger and Sandøe, 1997).

There is obviously a lack of knowledge, and a lack of time and funding for creating such knowledge on species behaviour in landscapes. Since species dispersal and survival is uncertain, and the facilitation of one species dispersal might be a barrier to dispersal of another, dispersal considerations are difficult and include a lot of uncertainties. What species are protected in the respective ecological networks depends on the size of the habitats and core areas, and the length and width of the corridor (Dawson, 1994). A differentiation of a variety of species used as indicator species having different human values could be listed: *focal*, *target*, *keystone*, *exotic*, *indicator*, *threatened*, *umbrella*, *flagship*, *typical* and *endemic* species. Species traditionally focused on in nature conservation like endangered, umbrella, and flagship species are used in most cases.

The actual criteria for developing EECONET-Poland are the status and distribution and sites of certain target species (vanishing, threatened, rare, endemic species) in combination with analysis of geomorphological structures, hydrological conditions, biotic conditions and landscape structure.

In Russia, criteria for developing the system of protected nature areas has primarily been based on valuable plants and animal species. However, a variety of methods for selecting the areas suitable for protection are used by a variety of scientific institutes in different regions (Sobolev and Simonov, personal communication). One of the used criteria are the rates of anthropogenic disturbance and of indigenous biodiversity presence. An indicator of low rate of anthropogenic disturbance is the absence of non-native plants and animals. To designate core areas of ecological network, basing on the criteria of presence of rare and diverse species is useful when there is a lack of time or resources for exhaustive decision-making (Sobolev et al., 1995), which in situations of nature conservation often seem to be the case, not just in Russia.

In Walloon (Belgium), criteria for nature areas are waters, shores and different semi-natural habitats in the landscape and different types of forest vegetation including forests especially with box (*Buxus sempervirens*), xerophilic forests, alluvial forests and pollards. Criteria for corridor zones are small biotopes and cultural and natural linear features in the landscape, e.g. hedgerows, ditches, field margins, footpaths, small streams, and narrow valleys.

In the Czech Republic, criteria for TSES are based on hydrology and climate, species composition, species diversity and edge composition. Data of actual vegetation have been compared with natural vegetation composition and the gene-pool. Historical documents (historical maps, air photographs, cadastral data) have been used as a tool to confirm the consistency of the landscape structure and for planning of ecological corridors for both fauna and flora (Lipsky, 1992).

According to Machado et al. (1995), in the greenway plan for Lisbon the planning criteria have been protected areas (protected land set); biotic, abiotic, cultural recreational resources, that should be protected (greenway resource set). Using gap analysis methods, gaps are identified and proposed to be eliminated; patches are linked and barriers are removed.

5. Tools for implementation

A lot of legislative changes concerning nature conservation in the European countries have been made during the last decade. All countries have included biodiversity conservation in their legislation and most of them have prepared or are developing biodiversity strategies and action plans (Külvik, 1996). The Biodiversity Convention of Rio is mentioned by most countries as a decisive factor for new initiatives in nature conservation legislation.

Most countries and regions have developed policy documents, agreed on by political and planning institutions, in which the plans and the instruments for ecological networks development have been worked out. Ten of the 15 countries in this survey have developed nature policy plans, which means nature conservation is the main objective of the plan (Table 2).

Many countries in Europe are in a state of transition, however, its impact and intensity varies between different regions. In the Eastern Europe, the economic and political transition has both created

Table 2
Status of implementation tools of ecological networks and greenways

Name of the network	Implementation tools in use		
	Legislation[a]	Planning policy[b]	Nature conservation policy[c]
Belgium: Ecological Network of Flanders (VEN/IVON)	X	PP	NP
Belgium: Ecological Networks of Walloon	–	PP	NP
Czech Republic: Territorial System of Landscape Ecological Stability	X	PP	NP
Denmark: Ecological Networks/Naturverbindsele	–	PP	NP
Estonia: Network of Compensative Areas/Green Network		PP	
Germany: Vernetzter Biotopsysteme, Rheinland Pfalz	–	PP	NP
Italy: Reti Ecologiche	–		NP
Lithuania: Nature Frame of Lithuania	X	PP	
The Netherlands: National Ecological Network	–	PP	NP
Poland: National Econet	–	PP	NP
Portugal: Greenways System for the Lisbon and Porto Metropolitan Areas	–		
Russia: Moscow City, Moscow Region, Orenbourg	X	PP	NP
Russia: Heart of Russia (Central Russian Plain), Volga–Ural Region, Volga–Viatka Region, Lower Volga Region		PP	NP
Russia: Altay-Sayany, Central Chernozem Zone, Volga Basin, South Ural			NP
Ukraine: Ecological Network	X	PP	NP
Slovakia: Territorial System of Ecological Stability	X	PP	
Spain: Catalonian 'Network' of Natural Protected Areas (PEIN)	–	PP	NP
United Kingdom Ecological Network, Cheshire County	–	PP	NP

Source: Developed from Jongman (1995), Jongman and Kamphorst (1999), Jongman and Kristiansen (2001) and Bennett and Wit (2001).

[a] *Legislation*: Ecological network is the core of nature conservation legislation. In addition, many countries have legislative support potentially applicable to the establishment of ecological networks.

[b] *Planning policy*: Ecological network document agreed upon by political and planning institutions.

[c] *Nature conservation policy*: The main objective of the ecological network is nature conservation.

great challenges, and simultaneously opened new opportunities for economic, institutional, legislative, administrative and management changes. In this phase of transition, ecological networks in the Czech Republic, Slovakia, Lithuania and Estonia have become a powerful strategy to mitigate both the former constructed mono-functional simplification of the agricultural landscapes, and to help shaping the future economic changes. The networks of these countries are integrated in the sense that they are carrying more functions than just nature conservation (Table 2). The strategies differ from the traditional defensive strategies by employing a plan for building new nature elements into a fragmented and monotone landscape. This more pro-active character is also demonstrated in the nature conservation legislation of Lithuania, Slovakia, and Czech Republic, which are countries that explicitly have put ecological networks into national legislation. In Flanders, the ecological networks are also part of the regional legislation. In these countries, it might be harder to take ecological networks off the policy agenda than in countries where ecological networks are only part of a policy plan. The legislative status may also influence the order of priority in the daily practices of nature conservation and nature restoration.

In The Netherlands, ecological networks are as well a pro-active strategy and the core of national nature conservation management. This is due to the intensive interaction with nature, which has provided the country with a both long and unique planning tradition. Then, the Dutch strategy is quite different from the

decentralised Danish model, although both countries' land use is dominated by intensive agricultural production. The Danish strategy is more defensive and less pro-active, based on restrictive nature conservation legislation.

The Slovak, the Czech, the Polish, and the Dutch plans show approaches that are similar in the sense that they are elaborated in hierarchical levels, the national, provincial, municipal, and across the borders. The planning approaches are a centralised and top-down and are at the general level decided upon by national and regional governments. Emphasis is given to regional implementation of ecological networks. Nearly all plans (Table 3) have instruments at the regional level and they have linkages with the local level where implementation has to take place. Regional is linked with regional authorities between national and local. Local is the level of municipalities. A development is ongoing in which top-down meets bottom-up in different phases of the implementation process.

Some countries and regions in this analysis are in the phase of developing plans to be implemented in the next decades. Many are in the phase of pilot projects; not all are mentioned here. Eight are in the phase of real implementation that means that delineation of core areas takes place, that subsidies are given for management and that the idea is communicated with the public. Actually around the world many more are developed or under development (Jongman and Pungetti, in press). In some countries, the idea of ecological network is in a slow develop process, or the idea of ecological network has been given another meaning. This can vary from bringing nature conservation policy up-to-date to on the one hand protecting major core areas for biodiversity in open areas and on the other the development of greenway-systems in mainly urbanised areas.

Table 3
Status of implementation of ecological networks and greenways

Name of the network	S	N	R	L	D	P	I
Belgium: Ecological Network of Flanders (VEN/IVON)			R	L		P	I
Belgium: Ecological Networks of Walloon				L		P	
Czech Republic: Territorial System of Landscape Ecological Stability	S	N	R	L		P	I
Denmark: Ecological Networks/Naturverbindsele			R			P	I
Estonia: Network of Compensative Areas		N	R	L		P	
Germany: Vernetzter Biotopsysteme, Rheinland Pfalz			R	L		P	I
Italy: Reti Ecologiche (Bologna, Milano, Modena, l'Aquila)			R		D		
Lithuania: Nature Frame of Lithuania		N	R	L			I
The Netherlands: National Ecological Network	S	N	R			P	I
Poland: National Econet	S	N	R	L	D		
Portugal: Greenways System for the Lisbon and Porto Metropolitan Areas				L	D	P	
Russia: Altay-Sayany	S				D		
Russia: Heart of Russia (Central Russian Plain), Moscow Region, Volga–Ural Region, Orenbourg, Volga–Viatka Region, Lower Volga Region			R			P	I
Russia: Central Chernozem Zone, Volga Basin, South Ural			R		D		
Russia: Moscow City				L			I
Ukraine: Ecological Network		N	R		D	P	I
Slovakia: Territorial System of Ecological Stability	S	N	R	L		P	I
Spain: Catalonian 'Network' of Natural Protected Areas (PEIN)			R			P	
United Kingdom Ecological Network, Cheshire County			R	L	D		

S: supranational level; N: national level; R: regional level; L: local level; D: developing phase where plans and criteria are in a process of being elaborated; P: progressing implementation where plans are being made or (still) being developed; I: implemented, plans are being carried out in practice.

6. Discussion

Across the different concepts, it is easy to find similarities. There is a different vocabulary, but a great resemblance between the Dutch and the Czech/Slovak approaches: biocentres–core areas; biocorridors–ecological corridors, etc. This similarity is probably created by the same needs—to restore degraded agricultural land. In Eastern Europe, the former planning system has both contributed to a severe degradation of certain areas, but at the same time to a well conserved natural heritage. Therefore, the concern in the Czech Republic and Slovakia is more with the conservation of the existing natural and semi-natural habitats as well as the revitalisation of abandoned agricultural areas.

In the Central Russian Plain, like the other East European countries, the goal of the network is based on Rodoman's socio-ecological concept of a polarised landscape (Sobolev et al., 1995; Shvarts, 1998). 'The largest natural and semi-natural complexes' in the network are located in the zones of economic inactivity on the borders between administrative units (Sobolev et al., 1995). Reduced to this essence the outlook towards the natural world seems remarkably similar. In addition, the West European networks are mostly located in the zones of economic inactivity, where they will not disturb the private ownership and the agricultural or forestry development. In Denmark, one of the models, developed in response to expected marginalisation of agricultural land, was the 'boundary model'. A limited version of this principle is implemented in the Nature Conservation Law (1992). The argument in the boundary model is that all estate boundaries and (for example) all the old boundaries between the parishes should carry some kind of biotopes (Agger, 1997). This leads to a system of fine-scaled natural networks, combined with the protection system for small biotopes. However, networks of such boundary zones might have quite different mesh size all over Europe and would not function in most cases. In the intensively used agricultural regions of Western and Eastern Europe, many boundaries have disappeared or they are diminishing invisible thin lines on the map. They may form a potential basis for network restoration the mesh size is very wide and the structure unstable.

Ecological networks as well as greenways are all designed based on certain concepts, within certain scientific and planning traditions, mediating specific values, traditions, and relations of power. Specific concepts are selective and will usually only be valid under the specific circumstances they were created. The elaborated ideas of a national ecological network or a state-wide greenway system have little sense on a national scale in Russia and would not within the time limits of next generation be given the large amounts of funding needed. The comprehensive ecological networks of the relative sparsely populated and small in area Estonia and Lithuania will certainly be easier to implement, than it would in densely populated Denmark or large in area Poland. Although such comprehensive network would make sense also in these countries, temporary relations of power have not given political or public support.

The fact that in Europe most of plans are in an early phase of development means, that it could be important to exchange knowledge on different methods, technology, and development of instruments. Differences are among others:

- To some extent national spatial planning traditions in Southern Europe have not been very strong, but this is a very general statement, because in some fields planning traditions have been based on a regional level. This is indicated by the cases in Italy (provinces), and Portugal (metropolitan areas). Here, regional and local governments are mainly responsible for nature conservation.
- In Poland, the protected areas system was introduced in 1977 (Liro, 1995), and received political and legal support. Consequently, Poland has enlarged its nature-protected areas from 1 to 26% the last 20 years. But, it has been difficult to get support for developing this system into an ecological network. This can be due to political traditions, but also the fact that agricultural collectivisation process has not been as far completed in Poland compared with other East European countries. At least it has not been possible to elaborate detailed working maps below 1:500,000, which is required to define nature development areas and to start an implementation.
- In the Catalonian 'Network' of Natural Protected Areas (PEIN) covering 20.3% of the territory of Catalunya, emphasis is given to biological connectivity and physical continuity. As an instrument for regional planning, PEIN constitutes a reserve of

land of outstanding natural value, that remains excluded from important changes. However, it is not a real network, but rather a creation of buffer zones around the different protected nature areas.

- In larger urban areas (Lisbon, Porto, Milan, Barcelona, Berlin, The Hague–Rotterdam) initiatives have been taken to design greenway systems to combine ecological networks and outdoor recreation concepts. Academic studies are carried out to support these plans.
- In UK, the development of ecological network has been given a late priority. This can possibly be interpreted due to a political reluctance against direct control of farming and landowner interests. This reluctance has been expressed through an ideological discourse anchored in a long historical tradition with slow adaptation of new conservation schemes (Cox, 1988; Bishop et al., 1995). At the moment, an important regional pilot project is ongoing in Cheshire County with support of the EU-Life fund.
- The Russian situation at present is better explained by the interaction of huge natural areas and the diversity of administration in different regions. That Russian nature conservation, although early developed, has been suppressed for some decades (Weiner, 1988) could probably also mean that nature conservation thinking is rendered within planning institutions.

This diversity also implies that exchanges are needed on the variety of contexts in which the ecological greenway networks are developed: the diversity of socio-economic contexts, different cultures, and perceptions of nature. To develop implementation of ecological networks across European boundaries (the Carpathians, the Danube, Central Eastern Europe, the Wadden Sea, etc.) implies a variety of interactions on a variety of levels to which the actors involved might try to adapt. This does not only imply a variety of kinds of communication to develop mutual understanding in sense of vocabulary and terminology. The variations in concepts and planning traditions implies the development of a mutual cultural understanding beyond these variations. In some countries, objectives of ‘core areas’ and nature conservation have mainly been public access to nature, in other countries the main objectives have been the exclusion of people from certain areas. This also reflects quite different interactions with nature and perceptions of nature plus different conditions for raising awareness towards nature. Some corridors are designed to prevent isolation of certain selected species, other corridors are designed to compensate polarising areas of intensive human activity. The national and regional ecological networks are always defined and constructed within a complex interaction of specific political, social, economic, and natural conditions resulting in specific cultural traditions. Thus, perceptions of nature and interpretations of the same words differ across boundaries of different regions. The key then is to downplay centrism and focus instead on the kinds of interactions that might occur across a variety of boundaries between regions, levels, hierarchies, organisations, NGOs, departments, etc. It must be considered of great importance to turn target groups and land users into active co-producers in the social process of creating and protecting ecological networks. Such a process includes reflections about the public involvement on different levels, and analyses of public perception of the applied sciences (Beck, 1992).

7. Conclusions

Ecological greenway networks have huge potentials in ecological perspectives but also to unite Europe. Among the most important potentials is their function as both an ecological and social network on different levels. The network has a potential to increase co-ordination across the human borders of administrations, countries, regions and local spots and to increase co-operation between administrative sectors, local people and NGOs. The strategy of making ecological networks as the core in nature conservation can also be very powerful, in the sense that it can raise awareness and funding for nature conservation. The real potential of the ecological networks as well as of greenways is, however, that they might potentially widen our understanding of interaction with nature in a socio-economic context. Such a potential might be revealed in the discussions on ecological networks approaches in future years of implementation.

Development of plans for ecological networks and greenways have been rapid for the last decade. This development can be seen as a response to fragmentation of land, and restructuring and intensification of

land use. Inside the framework of nature conservation, there is generally an awareness of a need to implement considerations about ecological connections in the landscape into spatial planning. There is also a reported need to broaden the perspectives of ecological networks to make co-operation possible with the actors in the field.

There are two main approaches to ecological network, the ecostabilisation and the bio-ecological. These two do not exclude each other, but could be applied in a more comprehensive approach. However, in many countries and regions it will be difficult to gain the necessary political, administrative and public support for such an approach. The criteria for designation of the networks express the specific and characteristic natural and cultural features of the region or the country. They are developed within the traditions and framework of national and regional institutions of planning and science. NGOs in most countries and regions have a decisive influence.

Cross-border co-operation is not yet well developed. Most plans are being or have been developed at the regional, sub-national level. The national plans are also being (or will in the future be) developed at the lower levels within the regional and local frameworks for their implementation. This has the implication, that for future European co-operation on ecological networks, the projects has to take off at the local and regional levels.

For the future development of ecological greenway networks as a strategy within nature conservation the conclusion is:

- to make implementation of ecological networks possible through the integration of nature conservation objectives into the economic sectors of agriculture, forestry and tourism;
- to develop instruments for implementation especially at the local levels;
- to develop cross-border projects;
- to exchange and share experiences and disseminate results;
- to support multi-disciplinary research programs concerning public involvement, and mutual understanding of the diversity of nature conservation and perception of nature in the context of socio-economic development within the wider Europe as part of European co-operation.

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