

CHAPTER B.II.

Green Infrastructure and Network Coherence

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II.1 Introduction

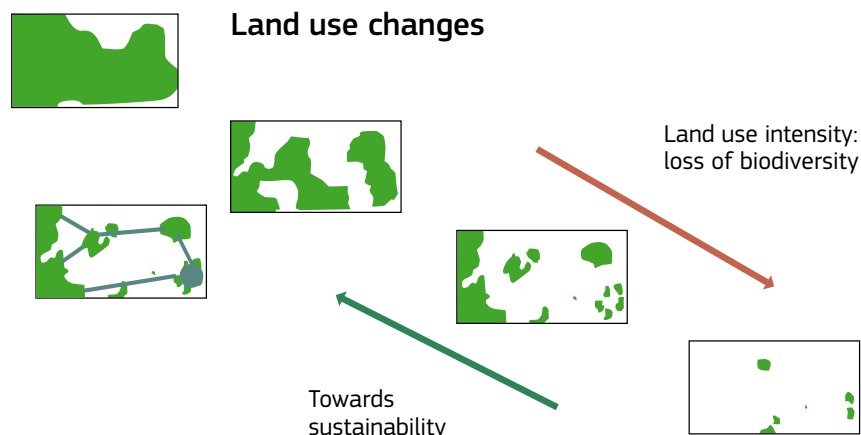
This chapter on 'network coherence' discusses the 'network of protected areas' and its physical connections in the landscape. No natural or protected area stands on its own: natural areas are always somehow connected with surrounding areas, through physical connections (corridors) and species which move between areas. This is often called an 'ecological network'.

An ecological network consists of habitat patches for a population of a particular species that exchanges individuals by dispersal.

The concept of 'network coherence' stems from landscape ecology, and is known by various terms, like landscape connectivity, a concept much used in ecological networks, and more recently the wider concept of Green Infrastructure. These aspects are briefly explained and an overview is provided of the approaches in many European countries, as well as how the concept is embedded in national or regional policies and strategies. Some inspiring examples are presented on how these strategies have been developed at a local or regional level, to improve connectivity for specific habitats and species.

II.1.1 The concept of network coherence and landscape connectivity

Biological diversity is highly dependent on the quality, quantity, and spatial cohesion of natural areas. If wildlife is spread over a large area in small numbers, and if the remaining areas are too small, sooner or later wildlife species will disappear.



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An ecological network consists of habitat patches for a population of a particular species that exchanges individuals by dispersal.

Figure II.1

The concept of landscape fragmentation: with increasing land use intensity, natural habitats are lost resulting in a fragmented landscape with very limited habitat. (Van der Sluis et al., 2011)

Due to intensive human use, Europe's habitats are 'fragmented' and sometimes lost. [Figure I.1](#) illustrates the process of fragmentation of natural areas. Extensive natural areas (upper scheme) have been changed over time by human activity such as deforestation. The suitable land surface is decreased, or broken up into small habitat patches (lower scheme "Figure I.1" on page 25). Due to the fragmentation of their habitat, many species in Western Europe have already disappeared or may disappear from several regions in the future. As natural areas are fragmented, only small populations of species can survive in the small and isolated habitat patches. Whether species survive or not, often depends on a fragile balance. For example a number of bad years, an epidemic disease or a coincidence may result in the extinction of a species*. However, good landscape connectivity will give species a better chance of survival in the long term. Moreover, the impact of climate change, which may result in species and habitats moving north in Europe, may be less severe if landscapes are well connected.

Landscape fragmentation severely affects the abundance of species. An answer to this problem is improving network coherence, that is, strengthening of the ecological network.

Network coherence is important in allowing for repopulating or restocking of small areas and habitats, which is why areas need to be connected to the remaining core areas for wildlife in the vicinity (*Jongman et al., 2011; Snep & Ottburg, 2008*). For birds, this means that the distance from source areas to their habitat is less than the normal distance they might cover when flying. For non-flying animals it might mean that a physical connection is required that functions as a corridor, e.g. woodlands, streams, rivers, natural grasslands, and so forth (*Van der Grift et al., 2013; Van der Sluis et al., 2004*).

The **connectivity of the landscape for a species depends on the mobility of a species and the type of the available habitat and its configuration in the landscape. Likewise, for habitats it depends on the natural configuration of habitats, and inherent properties of the particular habitat.** Corridors are very important for certain species. The connectivity is very much defined by species characteristics: range, habitat choice, dispersal distance, carrying capacity. These species-specific characteristics cannot be changed. The landscape itself can to some extent be adjusted. Also, each species requires a different type of corridor, and corridor types can be linear, linear with nodes, stepping stones, or landscape mosaics.

In addition to the ecological need for network coherence, there are also formal requirements in the nature directives, in particular Article 10 of the Habitats Directive. This deals with the coherence of the Natura 2000 network and the management of nature outside the network. The legal aspects are discussed in [paragraph II.1.2 Policy and legislation](#).

The various concepts have been presented in guidelines such as the 'European corridors: strategies for corridor development for target species' (*Van der Sluis et al., 2004*) but also in various brochures, papers and articles (*Opermanis et al., 2011; Vos et al., 2001*).

Options to improve landscape coherence

Basically, the options for improvement of landscape coherence or landscape connectivity are:

- » Through development or improvement of corridors
- » Improvement may entail widening, adapting the vegetation to provide more cover for species, establishing water points or stepping stones etc.
- » Enlargement of core areas, conservation areas, by enlargement and improvement of habitat
- » Improvement of the 'matrix', the surrounding landscape, e.g. through stimulation of low-intensity farming, reduced use of agro-chemicals, or more natural forest management for forest corridors, better conservation of the riverine vegetation and avoiding expansion of human settlement.

Finally, one should be aware that a corridor for one species can be a barrier for another. A forest corridor, or forest area which is a connection or habitat for a forest species, can be a barrier for certain butterfly species or meadow birds that avoid forested areas. Therefore, one cannot speak of 'an' ecological network, since it is species-specific. Development or improvement of landscape or network coherence is always a matter of choices, certain species groups that measures are aimed at or intended for.

What are ecological networks

An ecological network is a system of areas which are connected via ecological links or physical links. The ecological network usually consists of 'core areas' (protected or not), corridors, buffer zones and in some cases nature restoration areas. A pivotal role in ensuring spatial cohesion of the network is therefore played by corridors. Together with so-called 'core areas' corridors form essential components of ecological networks. The network coherence is an essential part of various strategies for ecological landscape planning.

Ecological networks can be especially beneficial for large herbivores like the red deer and gazelle, or for top predators like the wolf, leopard, lynx and otter. Corridors for large animals will also benefit many small organisms as a result of improvements in spatial cohesion and expansion of natural habitats.

What is Green Infrastructure

In the United States, the network concept was developed and referred to as 'greenways' (Ahem, 1995). Recently, the term coined in EU policies for the same concept is 'green infrastructures'.

By its nature, Green Infrastructure has a wider set of aims, or ambitions than ecological networks. Green Infrastructure (GI) is a concept, not a set of rules, and there are many interpretations of Green Infrastructure. GI is a spatial and functional structure delivering nature benefits to people. The focus is on multifunctional use, whereby natural areas can contribute to biodiversity conservation and other environmental functions.

Green Infrastructure is an approach '... that brings together both the need for strategic planning of green and open spaces and the science of ecosystem services. It promotes the multifunctional nature of space and the benefits that appropriate management approaches can deliver. It recognises the need to plan land use for specific purposes such as farming, nature protection and development but also provides the tools and methods to identify needs and opportunities to enhance the environment and its functions' (John et al., 2019).

The three key GI principles are connectivity, multifunctionality and spatial planning. A recent publication provides guidance on data, methods and tools to implement GI (Estreguil et al., 2019). How to create a strategic design of a well-connected, multi-functional, and cross-border GI.

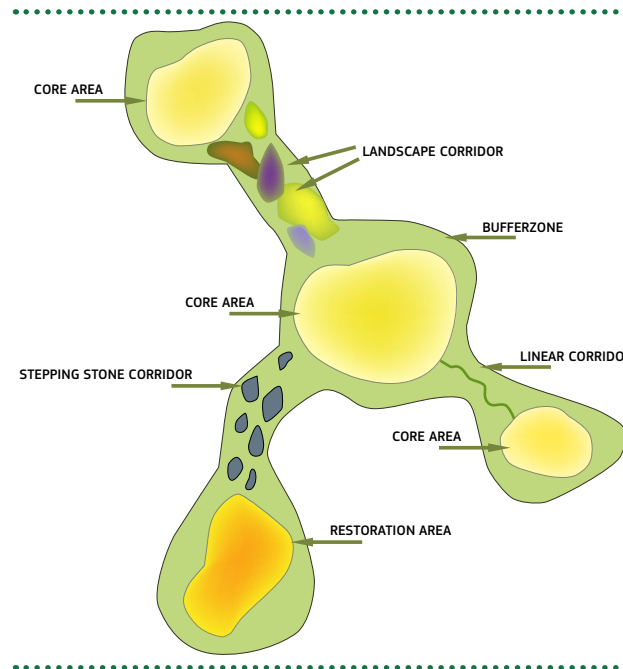


Figure II.2

Schematic overview of an ecological network. (after Bouwma, Jongman & Butovsky, 2002)

The three key GI principles are connectivity, multifunctionality and spatial planning.

GI mapping has been demonstrated to enhance nature protection and biodiversity beyond protected areas, to deliver ecosystem services such as climate change mitigation and recreation, to prioritise measures for defragmentation and restoration in the agri-environment and regional development context, and to find land allocation trade-offs and possible scenarios involving all sectors.

II.1.2 Policy and legislation

The development of ecological networks and corridors is recognized as a positive policy for promoting nature conservation both at European and global levels (*Jongman et al., 2011*).

The Bern Convention aims at conserving wild flora and fauna and their natural habitats. As part of its work under the Bern Convention the Council of Europe launched the so called Emerald Network, an ecological network of Areas of Special Conservation Interest. To fulfil its obligations arising from the Bern Convention and to realise the Emerald Network the European Union set up the Habitats Directive (Council Directive 92/43/EEC) and subsequently the Natura 2000 network.

Article 10 of the Habitats Directive is an important instrument to improve, where necessary, the ecological coherence within the context of the Directive and as a part of the national and regional ecological networks. Article 3.3 and 10 explicitly refer to connectivity in the [wider landscape](#). A long-term target for the implementation of Article 10 should be to identify the relationship between Favourable Conservation Status and connectivity. In this context species and habitats occurring outside Natura 2000 sites also need to be considered.

Green Infrastructure is of more recent date, and forms an important part of the European policy agenda. It is specifically mentioned in target 2, Action 6 of the Biodiversity strategy, *Our life insurance, our natural capital: an EU Biodiversity Strategy to 2020* (*European Commission, 2011*). Target 2 of the Strategy mentions: 'By 2020, ecosystems and their services are maintained and enhanced by establishing green infrastructure and restoring at least 15% of degraded ecosystems'. Action 6 mentions: Set priorities to restore and promote the use of green infrastructure. The Commission developed a Green Infrastructure Strategy to promote the deployment of green infrastructure in the EU in urban and rural areas, including through incentives to encourage up-front investments in green infrastructure projects and the maintenance of ecosystem services.

The EU biodiversity strategy 2030 highlights the importance of a coherent Trans-European Nature network, and the need " ...to set up ecological corridors to prevent genetic isolation, allow for species migration, and maintain and enhance healthy ecosystems" (*European Commission, 2020*). The Strategy also mentions the ambition to unlock at least 20 billion a year for investing in Natura 2000 and green infrastructure.

The following table gives an overview of the legal aspects of GI, and how it is protected in national legislation in central Europe (*John et al., 2019*).

The Birds and Habitats Directive art. 10

Article 10 of the Directive states: *Member States shall endeavour, where they consider it necessary, in their land-use planning and development policies and, in particular, with a view to improving the ecological coherence of the Natura 2000 network, to encourage the management of features of the landscape which are of major importance for wild fauna and flora.*

Such features are those which, by virtue of their linear and continuous structure (such as rivers with their banks or the traditional systems for marking field boundaries) or their function as stepping stones (such as ponds or small woods), are essential for the migration, dispersal and genetic exchange of wild species.

In addition, Article 3 mentions under 3): *Where they consider it necessary, Member States shall endeavour to improve the ecological coherence of Natura 2000 by maintaining, and where appropriate developing, features of the landscape which are of major importance for wild fauna and flora, as referred to in Article 10.*

Furthermore, Article 4 of the Birds Directive states: *Member States shall take similar measures for regularly occurring migratory species ..., bearing in mind their need for protection in the geographical sea and land area where this Directive applies, as regards their breeding, moulting and wintering areas and staging posts along their migration routes.*

Regulation Topic	Global or regional international regulations	EU	AT	AT Lower Austria	CZ	DE	DE Saxony	IT	IT Piedmont	PL
Green Infrastructure										
Green Infrastructure		GI	GI	GI	GI	GI				GI
Protection of Nature, Biodiversity and Landscape										
Nature and Biodiversity Protection (in general)				GI	GI	GI	GI			GI
Biodiversity Protection	GI	GI	GI		GI	GI	GI	GI	GI	
Species Protection	GI	GI		GI	GI	GI	GI	GI		GI
Invasive Species Management		F		F	F	F	F	F		F
Protection of areas/habitats	GI	GI		GI	GI	GI	GI	GI	GI	GI
Landscape Protection		GI		GI	GI	GI	GI	GI	GI	GI
Protection of Cultural and Natural Heritage	GI	GI					GI		GI	GI
Environmental Protection										
Prevention of harmful Effects on the Environment (in general)		F		F	F	F GI		F		F
Environmental Liability		F	F	F	F	F		F		F
Environmental Assessment (EIA/SEA)	F	F	F		F	F	F	F	F	
Water Protection	GI	GI F	GI		GI	GI F	GI F	GI F	F	GI
Air and Climate Protection		F	F		F	F	F			F
Soil Protection		F		F	F	F	F	F	F	F
Economy and Sustainable Development										
Agriculture		GI		GI	GI	GI	GI			GI
Forestry		GI	GI	GI	GI	GI	GI	GI	GI	GI
Hunting and Fishing		GI F		GI F	GI F	GI F	GI F	F	GI F	GI F
Tourism and Recreation	GI	GI		GI	GI	GI	GI	GI		
Energy		F	F		F	F	F			F
Sustainable Development		F	F		F	F	F	F		F
Spatial Planning										
Regional and Local Planning		F		F	GI F	GI F	GI F		GI F	GI F
Urban Planning		GI		F	GI	GI	GI	GI	GI	GI
Sectoral Planning		F	GI F	F	F	F	F		GI F	GI F
Access to Information on the Environment and Public Participation	F	F	F	F	F	F	F	F	F	F

Table II.1

Protection of Green Infrastructure (**GI**) or its Functionality (**F**) by regulations, laws and policies at different levels.

(John et al., 2019)

EU European Union

AT Austria

CZ Czech Republic

DE Germany

IT Italy

PL Poland

After the 1992 global summit in Rio de Janeiro, where the Convention for Biological Diversity (CBD) was agreed upon, the **Council of Europe** initiated the Pan European Biological and Landscape Diversity Strategy (PEBLDS), making the planning of the [Pan European Ecological Network](#) at European and national levels its [first objective](#). Next to the [European Birds directive](#), the [Habitats Directive](#) and PEBLDS, there are several global and European conventions that are important for Connectivity conservation. These are the [CBD](#), the [Wetlands Convention](#), the [Bonn Convention on migratory species](#) and the [Bern Convention](#), on which the Habitats Directive is based.

II.2 Ecological networks and GI at national level

II.2.1 Methods and approaches

Political support for investing in conservation of biodiversity, including connectivity, has generally increased over time in Europe. Planning landscape connectivity and ecological networks is generally accepted in Europe, but in practice carried out in different ways due to political, geographical and economic priorities. Germany, Austria, Italy and Spain are **decentralized federal countries**, while countries such as Denmark, the Netherlands, Portugal and the Czech Republic are more **centralized**.

Political support for investing in conservation of biodiversity, including connectivity, has generally increased over time in Europe. Building road- and railway crossing structures for species and habitats' connectivity depends on funding from the transport sector at European and national levels, and joint planning by transport agencies and conservation planners. **The European Commission promotes environmentally-friendly infrastructure building through its co-funding programmes so that wildlife bridges are often included in road projects.** Funding for connectivity conservation is partly provided by the European Commission, partly by national or regional governments and funds. Funding is project-driven and initiated by national and regional governments or NGOs. Cooperation depends on willingness and priorities across borders.

II.2.2 Regional approaches for Network coherence

This paragraph summarizes regional approaches. Detailed descriptions of how national policies evolved over time can be found in the detailed country descriptions, which are accessed through the links in the text.

Federal states are not all organised in the same way. In some countries (Austria, Belgium, Spain, UK) all power in the field of Nature Conservation is devolved to the lower 'regions', or 'Länder'. This can cause differences between regions within these countries. It can also be a source of complex negotiations as the national state is the point of reference for the European Union, but in some cases without power to carry out the requests from the European Union without internal coordination. In Germany the framework legislation gives the Federation (Bund) the power to make guidelines; for nature conservation, guidelines have been made in close cooperation with the member states. This means that a national approach can only be reached through negotiation and agreement between regions. In Italy tasks and responsibilities are divided between the state, the regions and provinces. In Austria the federation has no power in this field.

Unitary states maintain the formal responsibilities for nature conservation at the national level, although it is also possible that part of the main executive and the implementation of tasks have been delegated to the regions. In most countries where national responsibility is dominant, the Ministry of Environment is responsible. In a number of cases, however the Ministry of Agriculture is responsible, such as in the Netherlands and Greece. In Greece the Ministry of Agriculture is responsible for the management of National Parks and all forested areas in general, species protection, the supervision of issues on fisheries, hunting, forestry, agriculture, genetic resources, ex situ plant conservation and domestic animals.

Former Soviet Union countries

National connectivity plans had already been written in Eastern Europe in former Czechoslovakia and the former Soviet Union, including the Baltic states, with the general objective of landscape ecological stability (Mander *et al.*, 1988; Bucek *et al.*, 1986; Bucek *et al.*, 1996). For all three Baltic countries, ecological networks have been developed at national, regional and local scale. They have been published together under coordination of the IUCN office for [Central Europe](#).

The approach is illustrated by the case of the conservation history for [Estonia](#). **The principles of the ecological network were first applied in Estonia in the 1960s, when it was tried to regulate the use and planning of natural resources.** In the years 1979–81 the state ordered “The outline for the protecting and sustainable use of Estonian natural resources”. The Physical Geography Department of the University of Tartu developed the idea of the ecological network of Estonia, the so-called system of ecologically compensatory areas. These areas were handled as parts of a cultural landscape that mitigated the anthropogenic influence on the landscape. The map of Estonian compensatory areas with the explanatory letter was ratified as a basis for planning and developmental action until the year 2005.

Determining the green network was one of the chapters in national planning “Estonia – vision 2010”. It suggested that core areas should be determined on the basis of at least two aspects: area and value. Natural regions comprising compact natural territories with an area of at least 100 km² were defined as core areas of international importance. ‘Compact’ regions with a ter-

Estonia 2010 Green Network

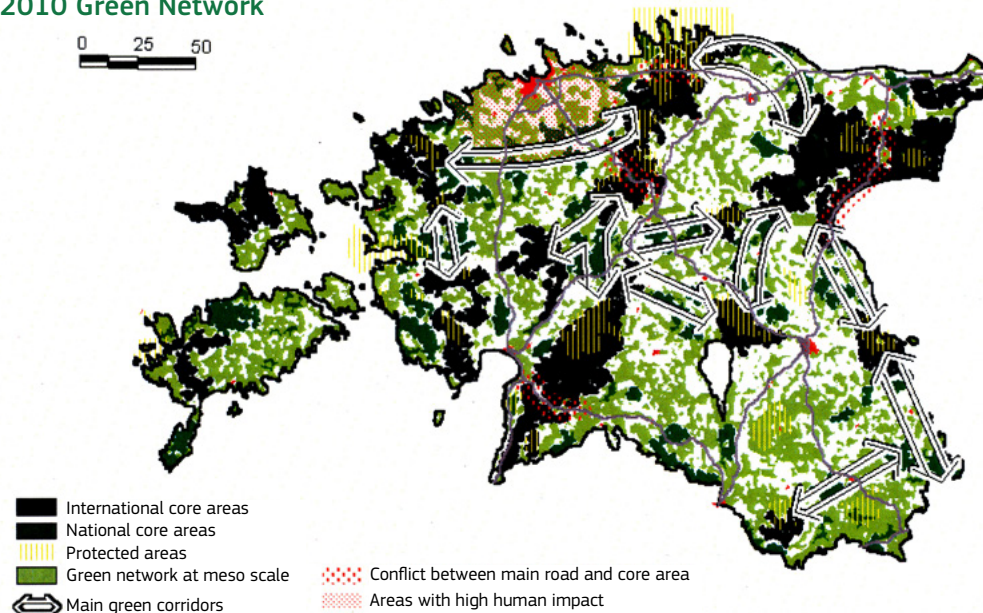


Figure II.3

Network of ecologically compensating areas of Estonia.
(Mander *et al.*, 2003)

territory of at least 15 km² are defined as core areas of national importance. As areas of national importance are situated in between the areas of international importance, it is possible to mark the most important 'green corridors' of the network, which constitute convenient dispersal routes for species between the core areas.

Networks of ecologically compensating areas should fulfil the following main ecological and socio-economic functions in landscapes: biodiversity, material and energy flows, socio-economic development (e.g. recreation) and cultural heritage.

Former Eastern Bloc countries of Central Europe

The concept of ecological networks and its application in the planning practice in former Czechoslovakia and later in [Slovakia](#) as well as in the [Czech Republic](#) was formulated as the territorial system of ecological stability TSES. The main purpose of the establishment of the ecological networks approach is the preservation of spatial ecological stability of the landscape. The concept of TSES started in 1970 and was a pioneering ecological network at national, regional and local levels. It was one of the first comprehensive concepts of this kind (*Miklos et al., 2011*). It represents a hierarchical connectivity concept of ecological core areas (biocentres) of different importance connected by biocorridors.

TSES projects in Slovakia were carried out top-down, from the General Plan of supra-regional TSES, through regional to local TSES. Following the General Plan, the National Ecological Network (NECONET) was set up based on the concept of the European Ecological Network and building on principles of the Dutch National Ecological Network. The regional TSES (RTSES) have been developed in the years 1993–1995 for all 38 regions at a scale of 1:50,000. When Slovakia joined the EU, the European system of Natura 2000 was integrated in the TSES projects.

Also in the Czech Republic, landscape fragmentation is an issue of importance and maintenance of corridors and landscape elements is an important aspect of the Czech nature conservation policy. Not having been part of the nature policy in the 1980s, they have been integrated into the TSES concept in the 1990s as Significant Elements of the Landscape (SLE) and legally recognised (Act 114/1992). They are considered to be the "skeleton of ecological stability in the landscape" and are partly legally protected.

[Bulgaria](#) has incorporated the ecological network concept in the Biological Diversity Act. This Act regulates the protection of habitats, of species of plants and animals and their biotopes. It introduces the requirements of the Habitats and the Birds Directives, focused on preservation of habitat types and biotopes of plant and animal species. The Act on the Biological Diversity envisages the establishment of National Ecological Network, consisting of three elements – protected zones, protected areas and buffer zones. The rapidly growing road network in Bulgaria, initiated by EU strategies to construct Pan-European Transport Corridors, results in increasing conflicts with biodiversity objectives and the aim of a coherent Natura 2000 network. Therefore, one of the big challenges at present is the mitigation of the fragmentation of the landscape by roads and railways.

Unitary states

In Western European countries such as Denmark and the Netherlands, spatial planning for connectivity conservation is regulated in spatial planning and nature conservation legislation (Jongman et al., 2004; Van der Sluis et al., 2012).

The national ecological network in [the Netherlands](#) stems from 1990 (Ministry of Agriculture, Nature Management and Fisheries, 1990). The Nature Policy Plan (*Natuurbeleidsplan*) presented the National Ecological Network (*Ecologische Hoofdstructuur*, NEN). The aim of NEN is to develop a coherent network of natural areas (core areas and nature development areas) that are connected by ecological corridors. With this concept of NEN, the government launched a new approach to nature conservation, replacing the traditional protection of natural areas in their original status with an active form of protection and nature development, setting clear priorities in a wider (inter)national context.

2012, during the economic crisis, re-orientation and decentralisation of the national nature policy took place. The original plan of the NEN was abandoned and aims were reduced to more or less the area that had been realised at that moment. Coordination between national and provincial authorities was needed for realizing necessary connecting measures for provincial roads for an optimal return on investments. After the crisis, a renewed effort was made to speed up the process of landscape defragmentation with the Netherlands Nature Network with extra funds.

In the Netherlands, the owner and manager of transportation infrastructure is responsible for financing and implementing all ecopassages (bridges and culverts). This is the main reason why ecoducts and culverts were not implemented in the 1990s.



Figure II.5

National Ecological Network of the Netherlands.

In 2007, the green and blue infrastructure (Trame vert et bleu, TVB) was launched in [France](#). The TVB aims to maintain and restore a green-blue network, to reduce habitat loss and fragmentation and to integrate biodiversity into urban planning, in line with the EU Nature and Water Directives. The green and blue infrastructure takes into account the ecological functioning of ecosystems and species in land use planning and focuses on '[common](#)' biodiversity. The TVB consists of five subnetworks, e.g. the wooded subnetwork and the wetland subnetwork. Based on national guidelines, regional and local networks are being developed. Regional Ecological Networks (REN) were designed with several methods freely chosen by the regions (e.g. least-cost path). Barriers to species movements (roads, dams, other infrastructure) have been identified and plans for actions formulated to preserve or restore the core areas and corridors.

Decentralized governments (federal states)

In contrast, in federal states like Spain, Germany, Italy, Austria and Belgium, regional governments are given wide latitude in spatial planning, with some guidance from federal statutes.

In 2007, the [Spanish](#) Parliament adopted a new [Nature Conservation Act](#) (Ley 42/2007) which includes ecological networks and ecological corridors. The Act defines ecological corridors as corridors connecting natural sites of special importance for wild flora and fauna, allowing genetic exchange between otherwise separated populations. Article 17 defines ecological networks as networks of sites of high natural value which allow the movement of flora and fauna species. It also specifies that nature management plans have to contribute to connectivity conservation and restoring corridors. It mentions as important corridors: river courses, drove roads (cañadas) and mountain ranges.

The different regions implement this Act in their own way, since there is regional autonomy. At present there are three regions that have developed ecological network plans: Cataluña, Basque Country and Madrid. In 1992 in Cataluña, the plan for spaces of natural interest (PEIN) was created, which was the first coherent plan that delimits and establishes a conservation system for the basic protection of representative natural spaces in accordance with their scientific,

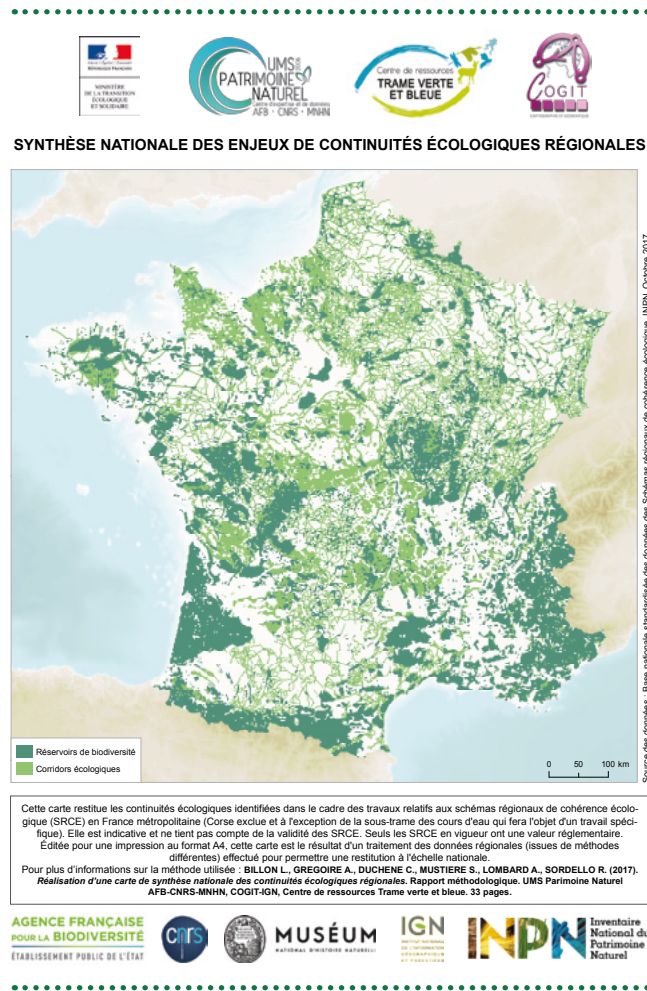


Figure II.5

French 'Trame vert-et-bleu' or green-blue network.
(source: [Romain Sordello](#))



Figure II.6

Very particular for Spain are the drove roads (cañadas) for sheep, which form part of the ecological network. Here the Cañada real de Segovia with grazing cattle. © Rob Jongman

ecological, landscape and cultural importance. Studies were done on the improvement of the ecological network, e.g. with the model LARCH (Franz *et al.*, 2011). Later in the [Basque country](#) (2005) and [Madrid](#) (2010) ecological networks were designed. However, the concept has not yet been implemented. One of the important causes of delays seems to be the lack of resources. Another problem is that regional planning is focusing on urban areas and town planning, and that land use planning for rural areas is lacking.

NGOs are very important in pushing developments in Spain. For instance the Fundación Oso Pardo which is developing with EU-Life+ funds connectivity for populations of the [brown bear](#). There are several associations involved in the use and protection of the Spanish cañadas as well as groups dedicated to specific species, such as the Spanish Ornithological Society (Sociedad Española de Ornitología).

The [German](#) federal nature conservation law, BNG, dates back to 1976 and its [last revision](#) is from 2009. One of the major tasks in a federal state like Germany with devolved responsibility for nature conservation is the integration of the state networks into a national ecological network. States and federation work together on this under coordination of the Federal Nature Conservation Agency ([BfN](#)). Through landscape planning, nature conservation criteria can be taken into account in planning and administrative procedures and the ecological network be realised.

Defragmentation is an important issue in Germany. Work on defragmentation is organised by the states in cooperation with the Federal Nature Conservation Agency, consultants and universities, such as the university of Kiel and the university of Kassel. In the planning and realisation of linear infrastructures (construction of new roads and expansion of roads, railways, canals) the existing ecological interconnect- edness is to be preserved in such a way that colonization and repopulation of habitats by naturally-occurring species can take place in sufficient numbers. Depending on the affected habitats and species, special measures can then be planned to preserve these network relationships.

In [Italy](#), there are twenty-one regions with an increasing autonomy. The state generally has a coordinating role. Each region has to produce regional legislation and often provinces and municipalities issue local regulations. State, regions, provinces, and municipalities all have responsibilities in managing parks and reserves at national, regional, provincial and municipal levels. This means that regions draft regional scale framework laws and regulations; local authorities such as provinces and municipalities define rules for application. This situation regarding task sharing allows much freedom for the different authorities to develop their own vision of nature conservation and the development of ecological networks.

Territorial fragmentation and ecological connectivity have been studied and addressed within regional authorities as well as within research institutes and universities. In 2003, ISPRA published guidelines for the management of functional [ecological connection areas](#), containing practical information on the issues of conservation, planning and management of ecological corridors. The LARCH model was used ([Estreguil et al., 2019](#)) to analyse the landscape and territory, and



Figure II.7

National important corridors and core areas for forest ecosystems.

(Fuchs et al., 2016)

with habitat modelling of target species an ecological network was proposed and partly implemented through regional initiatives and initiatives with project funding from LIFE and regional authorities. Several regional networks were developed, e.g. through the LIFE-Econet projects such as for parts of Emilia Romagna (*Van der Sluis et al., 2001; Van Rooij et al., 2003*), Abruzzo (*Van der Grift & Van der Sluis, 2003; Van der Sluis et al., 2003*) and Umbria (*Van der Sluis & Pedrolì, 2004*).

In [Austria](#), there is no federal law establishing a framework for detailed nature conservation legislation by the Länder. Most of the connectivity restoration activities are carried out jointly by the states and NGOs such as the [Alpen-Karpaten corridor](#) and initiatives for [stream restoration](#).

In [Belgium](#), the Flemish government is leading the process of developing a [Flemish Ecological Network](#). The Flemish Decree on Nature Conservation (1997) defines the Flemish Ecological Network with core areas and nature development areas (VEN) as well as Integrated Multi-functional and Supporting Network with nature corridors (IVON). A target for the VEN is to protect 125.000ha (9.3% of Flanders). The nature integration areas (IVON) are supposed to cover 150.000ha. The Flemish Decree on Physical Planning aims to incorporate nature conservation targets (VEN, IVON) into physical planning objectives. The provinces have the responsibility to realize ecological corridors. Approximately 14 years after the date that was set in the Nature Decree and eight years after the target year in the IVON, 3% (around 5,084ha) has been demarcated.

In the stage of realization of individual projects, informal cooperation with private stakeholders has to be established. This is partly done for the nature restructuring projects where landowners, farmers, hunters etc. are involved and persuaded into a 'nature-friendly' management. For the realization of the corridors, cooperation on a voluntary base is the rule. The negotiations between sectors and their legal bodies on the level of the administration in charge (nature conservation, agriculture and forestry) are time consuming.

II.3 Implementation of GI at site/regional level

II.3.1 Methods and approaches

In some cases very simple **fragmentation indices** are used to design measures for defragmentation, e.g. the use of Fragstats (*Mcgarigal et al., 2002*). These are generally not very suitable for ecological network or GI purposes, since they are too generic and the output of indices mostly says something about the map quality. Results cannot be generalized for planning.

The **functionality of the landscapes for species** is an essential aspect for species' survival. Various model approaches analyse the dynamics of species populations living in ecological networks. Such dynamics are determined by (a) the number of individuals that on average live in the network (carrying capacity), which is a function of habitat quality and network area, and (b) the spread or dispersal of individuals across the network (connectivity), which is a function of the network density and the permeability of the landscape matrix in which the network is embedded (*Opdam et al., 2002*).

To perform a landscape analysis of sustainability of (meta)populations the model LARCH was developed. The parameters were calibrated for species and ecosystems in the Netherlands (*Foppen et al., 1999; Verboom et al., 2001; Verboom & Pouwels, 2004*). The LARCH model was applied in many different countries and regions where case parameters were adjusted according to the local conditions, for example in North-West Europe, Poland, the Meuse Basin, the river Rhine, Abruzzo, Umbria and Emilia Romagna regions in Italy, Catalunya in Spain, Israel and Ukraine (*Franz et al., 2013; Franz et al., 2011; Geilen et al., 2001; Groot Bruinderink et al., 2003; Pungetti & Van der Sluis, 2002; Van der Sluis et al., 2007; Van der Sluis & Van Eupen, 2013*).

The **assessment of corridors** requires specific tools or models, which define how well-connected the landscape is. Currently, **there are no dedicated standalone tools that can be used to assess the spatial distribution of GI**. Applied GI projects are based on a compilation of spatial and analytical tools that have been developed for quantifying and analysing habitat aspects of interest to GI deployment. Instead, practitioners must be able to use standard GIS and environmental systems analysis tools (*Estreguil et al., 2019*).

Specific methods or tools exist such as [QuickScan](#) (*Van der Sluis et al., 2015; Verweij et al., 2016*), as well as free software packages, such as GuidosToolbox, Linkage Mapper, or Conefor (*Estreguil et al., 2019; Saura & Torne, 2009*). Free tools now available enable assessment at multiple scales, i.e. from local to regional, but also at European and global scales, due to increased computational capacities.

Network coherence is often addressed on the basis of:

- » assessment of landscape fragmentation, through indices
- » assessment of functionality of the landscape for particular species or ecosystems
- » assessment of corridors

II.3.2 Financial instruments

Financing of measures for Green Infrastructure is possible through the [Natural Capital Financing facility](#). This facility is in particular meant to halt the loss of biodiversity and adapt to climate change. To do so, the European Investment Bank (EIB) and the European Commission have partnered to create the Natural Capital Financing Facility (NCFF), a financial instrument that supports projects delivering on biodiversity and climate adaptation through tailored loans and investments, backed by an EU guarantee.

II.3.3 Example studies for improving network coherence

A number of examples based on LIFE or Interreg projects are presented on how measures were prepared for improvement of the coherence of habitats, as well as for specific species. The species' habitats described are selected based on their need for spatial coherence; various criteria were used to define priority habitats that are in unfavourable conservation status and require landscape coherence (*Van der Sluis & Bouwma, 2019*). The descriptions below are largely based on the examples in this study (with permission of ETC-BD). The criteria also include the potential for [habitat restoration](#). The selected species are flagship species, which may stimulate conservation and benefit the ecosystem and a wider set of species.

Habitats and network cohesion

a. Boreal Baltic coastal meadows (1630*)

Ecology and distribution

The 'Boreal Baltic coastal meadows' are characterized by low-growing plant communities. They occur in the geolittoral zone and are sometimes interspersed with salt patches. Characteristically the vegetation occurs in distinct zones, with saline vegetation closest to the sea. The salinity is low since tide hardly exists, but they can be affected by land upheaval.

The habitat is widespread along the Baltic coast of Estonia, Finland and Sweden, rare in Latvia and absent from Lithuania. Estonia reported the largest habitat area. Of the approximately 190 km² of this habitat in the Boreal region, about 78% is included in Natura 2000 sites.

Land use in this zone consisted historically mostly of grazing and mowing, which resulted in a gradual expansion of the habitat, keeping the vegetation low and open and rich in vascular plants.

Important bird species which depend on this habitat type and adjoining lagoons (Habitat 1150) are Birds Directive Annex I species Eurasian bittern (*Botaurus stellaris*), as well as several Annex II species, including Black-tailed godwit (*Limosa limosa*), Common redshank (*Tringa totanus*), Mute swan (*Cygnus olor*), Eurasian coot (*Fulica atra*), Northern lapwing (*Vanellus vanellus*) and Common snipe (*Gallinago gallinago*). Also the Dunlin (*Calidris alpina schinzii*), Ruff (*Philomachus pugnax*) and other meadow wader species breed here, and a grassland passerine community

The LIFE program



An important source of funding for improving Green Infrastructure and network coherence is the LIFE-Nature program. In the past the program has been funding activities related to improving the connectivity for large carnivores, removing barriers for raptors migration, ensuring river connectivity, transnational planning etcetera. The program will continue in the period 2021–27 with an increase of almost €2 billion from the present LIFE program.

In particular the following LIFE programs might be relevant, but check the ec.europa.eu/easme/en/life for up-to-date information:

- » **Regular LIFE+ Nature & biodiversity:** funds projects and local activities from various partner organisations and NGOs;
- » **Integrated projects:** implements e.g. the Priority Action Frameworks and River Basin Management plans. Projects are large scale; payment of complementary actions with additional co-funding; requires involvement of stakeholders;
- » **Strategic Nature Projects (SNaPs):** Mainstreaming of nature and biodiversity into other policies and programmes through coherent programmes of actions in the Member States, including institutional support. Beneficiaries are the competent nature/biodiversity authorities, in partnership with relevant stakeholders (there is also a possibility of funding for transborder SNaPs).

is present. A large number of waders of different species, as well as migrating geese and other waterfowl are present during passing migration (Rūsiņa et al, 2017). In moister areas, large sedge tussocks are preserved, which are important for birds. This also indicates that the scale of the area and variety of habitats defines the completeness of bird assemblages (Rūsiņa et al., 2017).

Coastal meadows are valuable habitats for a large diversity of invertebrate species, in particular nectar-feeding species and grassland species associated with animal excrement. One of the few endemic insects found in Estonia, *Aeschna osiliensis*, is specifically associated with coastal meadows and other coastal habitats. Seaweed mounds and salinas are home to an unconventional community of predatory beetles. Shallow water bodies that appear in coastal meadows provide habitat for the rare large white-faced darter (*Leucorrhinia pectoralis*). In coastal meadows there are various dragonflies and species of *homoptera*, *achenorrhyncha* and *heteroptera*. Areas with a long-standing grazing tradition feature sods generated by ant species of *Lasius* and *Myrmica*.



A number of examples based on LIFE or Interreg projects are presented below on how measures were prepared for improvement of the coherence of habitats, as well as for specific species:

- » Boreal Baltic coastal meadows (1630*)
- » Alpine rivers and their ligneous vegetation with *Myricaria germanica* (3230)
- » Temporary Mediterranean ponds (3170*)
- » European sturgeon/Beluga (*Huso Huso*) (HD App. V)
- » Large copper (*Lycaena dispar*) (HD App. II, IV)
- » Eurasian lynx (*Lynx lynx*) (HD App. II, IV)
- » Stag beetle (*Lucanus cervus*) (HD App. II)

The flora of Baltic coastal meadows is very rich, e.g. in Estonia a total of 390 plants species have been found, which is 26% of all Estonian species. More than 20 protected plant species grow on coastal meadows, including many orchids: *Dactylorhiza ruthei*, Frog orchid (*Coeloglossum viride*), Fen orchid (*Liparis loeselii*), Baltic orchid (*Dactylorhiza baltica*), Blood-red dactylorhiza (*Dactylorhiza incarnata ssp. cruenta*), Early marsh orchid (*Dactylorhiza incarnata*), Musk orchid (*Herminium monorchis*), Marsh helleborine (*Epipactis palustris*), Early-purple orchid (*Orchis mascula*), Common spotted orchid (*Dactylorhiza fuchsii*), Military orchid (*Orchis militaris*), Fly orchid (*Ophrys insectifera*) and Fragrant orchid (*Gymnadenia conopsea*) (Anonymous, 2011).

Figure II.8

Coastal meadows at Väinamere, Natura 2000 site EE0040002 Estonia. © Theo van der Sluis

Proposed measures for GI

Appropriate management is the main proposed measure for maintenance of grasslands. Other proposed measures include the establishment of protected areas and improvement of legislation. The 'Natureship project (2009–2013)', was financed by the EU Central Baltic Interreg IV A Programme 2007–2013 and national funding providers. The project had two focus areas: "Water protection and coastal planning" and "Biodiversity and cultural landscapes". The project activities targeted coastal areas in Finland, Sweden and Estonia. A total of eleven organisations have been involved in project implementation. Lead partner was the Centre for Economic Development, Transport and the Environment in Southwest Finland, with other partners from Finland such as Metsähallitus, the University of Turku, municipalities, from Estonia the Environmental Board of Estonia and University of Tartu, and from Sweden the County of Gotland and Norrtälje Nature Conservation Foundation.

The goal of the project was to increase cooperation in habitat management and water protection in the Central Baltic operating area. The most important objective of the Natureship project was promoting interdisciplinary coastal planning following the principles of sustainable development. The aim of integrated coastal planning is to find solutions that will benefit all users of the area over the long term, taking natural values into account. It aims at finding the best cost-efficient methods for water protection and biodiversity and rating ecosystem services.

The project has promoted conservation cooperation between these areas and the exchange of experiences in habitat and species management. Ecosystem service thinking plays a role in the planning and implementation of management measures. The project aimed at finding win-win solutions that benefit all: nature, water protection, local farmers and entrepreneurs, as well as inhabitants. Special emphasis was placed on Natura 2000 areas.

Assessment of ecosystem services

Ecosystem services related to the proposed measures, as described above, are discussed in [the chapter B.III](#) and presented in [Table III.3](#).

The Boreal Baltic coastal meadows are maintained through livestock herds which as part of agro-ecosystems have different outputs: reared animals and their resources, hay and possible other wildlife. **ES include the supply of nutrition and other renewable natural resources as well as occurrence of natural ecosystem processes, maintenance of water resources and circulation of nutrients.** The meadow ecosystem protects the coast against erosion, floods, and does some climate regulation, but the meadows also maintain pollinator populations and livestock will facilitate seed dispersal. **Ecosystem services also include recreational use of nature and the experiences obtained there**, as well as residential services, and inspirational services.



Conservation status

The conservation status of this habitat type is unfavourable–bad, based on the assessment in all Member States except Estonia which reported unfavourable–inadequate. The range is favourable in all countries, but other parameters are poor or bad for most of the region. In Sweden the bad situation is stable.

Problem

Inappropriate land use, particularly the abandonment of agricultural management (grazing and mowing) represents the major pressure to this habitat type. Abandonment of traditional management results in encroachment, which causes a decline in bird populations: grasslands smaller than 10 ha, will hold no waders and the passerine community may be incomplete. Pressures with less intensity are recreation, sport and water pollution. Finland informed that dredging/ removal of limnic sediments and dumping and depositing of dredged deposits are threats.

Figure II.9

Distribution of Baltic Coastal meadows.
(Halada, Aronsson, & Evans, 2016)

b. Alpine rivers and their ligneous vegetation with *Myricaria germanica* (3230)

Ecology and distribution

The habitat of Alpine rivers holds plant communities of low shrubby pioneers invading the herbaceous formations on gravel deposits rich in fine silt, of mountain and northern boreal streams with an alpine, summer-high flow regime. These deposits are usually dynamic, often being destroyed and recreated in floods. German tamarisk *Myricaria germanica* and Willow species *Salix spp.* are characteristic species of the '*Salici-Myricarietum*'.

The habitat type is typical for the Alpine biogeographical region, and most of the habitat is found in the Alps and Carpathians; an isolated occurrence is reported from northern Finland. The habitat usually occurs in small patches; the overall habitat area is quite small as well. In Germany, Poland, and Slovenia the entire national habitat area is located in Natura 2000 sites; in Austria and Finland a large part of the national habitat area is located in Natura 2000 sites.

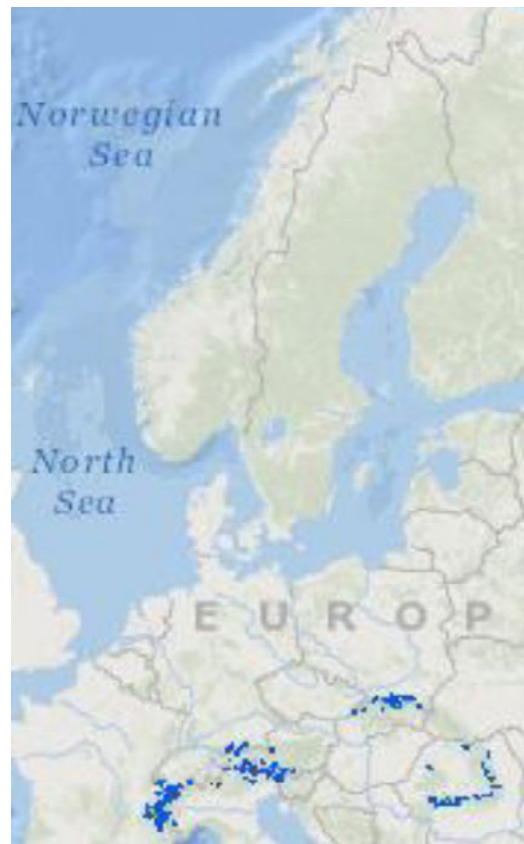
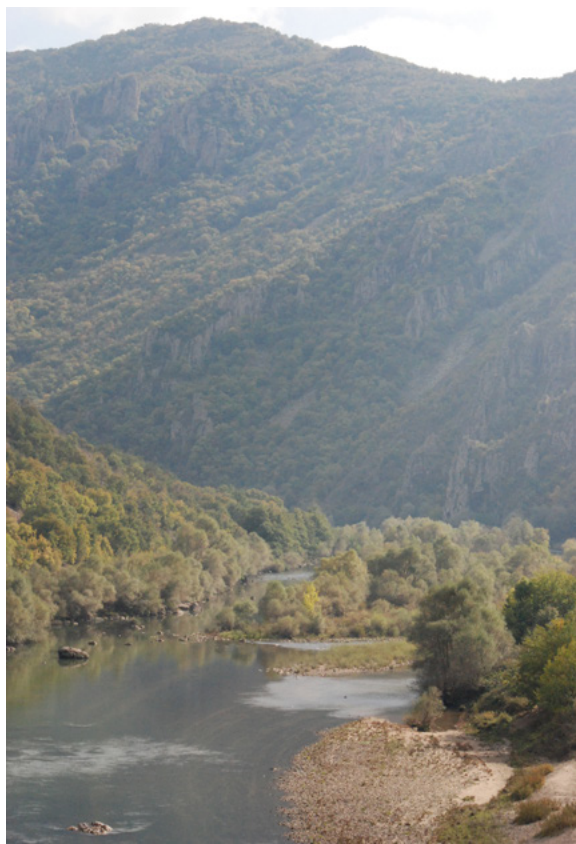


Figure II.10, left

Alpine River, Most Arda, Natura 2000 site BG0002071 Bulgaria. © Theo van der Sluis

Figure II.11, right

Distribution of Alpine Rivers (note that the 2017 report did not include Croatia at the time, so its habitats are not included in the figure).

(Halada, Aronsson, & Evans, 2017)

Proposed measures for GI

A larger project looking at the river basin as a whole, is the DRAVA LIFE – Integrated River Management (LIFE14 NAT/HR/000115), a Croatian project with involvement of WWF-Austria. The project foresees three transnational conservation actions, which involve stimulation of more natural river dynamics, decrease of human impact, increase of inter-sectoral river management and cross-border cooperation along the Drava river.

Assessment of Ecosystem Services

Ecosystem services related to the proposed measures, as described above, are discussed in chapter [Ecosystem Services](#) and presented in [Table III.3](#). The Alpine river habitat is restored through reversal of engineering works, removal of dams etc. This has limited potential for provisioning services, much more for regulating services like erosion protection, flood protection and maintenance of nursery populations and habitats (in particular fish species). Some cultural services are related to outdoor recreation, as well as inspiration.

c. Temporary Mediterranean ponds (3170*)

Ecology and distribution

Mediterranean temporary ponds are seasonal wetland habitats, subjected to extreme and unstable ecological conditions. Temporary Mediterranean shallow ponds are very shallow (a few centimetres deep) and exist only in winter or late spring. Mediterranean Temporary Ponds provide the microhabitats for crustaceans, macro-invertebrates, amphibians and reptiles. The flora is mainly composed of Mediterranean therophytic and geophytic species of the alliances *Isoetion*, *Nanocyperion flavescens*, *Preslion cervinae*, *Agrostion salmanticae*, *Heleochoion* and *Lythron tribracteati* (Janssen *et al.*, 2016).

Mediterranean temporary water bodies occur in very small stands. Temporary ponds appear in depressions during the first rain events in the hydrological year. Rainwater accumulates due to the less permeable soil layer underneath the pond, which retains the rainwater. The first flooding ends up infiltrating and/or evaporating. These ponds are hydraulically connected to the groundwater and from the moment the water reaches and surpasses the base elevation of the pond the water retention period becomes longer. Therefore, the hydroperiod of most of these ponds is higher than the one corresponding to simple accumulation of rainwater in soil depressions with low permeability.

The salinity and hydroperiod are probably the most important community structuring factors, in particular for the active and dormant crustacean communities. **The aridification as a result of climate change may lead to a loss of species that come late in the succession, while salinisation may lead to the loss of already fragile freshwater species.** Although resting egg banks can temporarily buffer against unfavorable conditions, persisting bad conditions may lead to their extinction.

Conservation status

The overall conservation status of this habitat type in the Alpine biogeographical region is unfavourable-bad (and deteriorating). There has been no change in conservation status since 2001–2006.

Problem

The habitat has become rare due to river engineering. All countries reported a broad range of pressures, the most important being sand and gravel extraction, canalisation, water deviation, modification of hydrographic functioning, and modification of structures on inland water courses (e.g. small hydropower projects and weirs). Other important pressures are vegetation succession, waste disposal, water pollution, invasive non-native species, removal of sediments, flooding modifications, lack of flooding, surface water abstraction, and construction of dykes and embankments.

Proposed measures for GI

The most important conservation measure reported in the Art. 17 reporting is the establishment of protected areas/sites and legal protection of habitats and species. Additional measures might be to set out management rules for maintaining a favourable conservation status of temporary ponds; also the demonstration of ecological restoration techniques and measures could inspire countries and managers to take action. Another measure is creating a seeds bank specifically for this habitat, which can be used in restoration actions and for the safekeeping of genetic reference for the flora of the habitat.

We must consider these habitats as 'communicating' networks, whereby regular exchange takes place. The habitats are particularly vulnerable because they are small, dynamic and ephemeral. It is therefore important to maintain or improve the connectivity between these habitats. This requires the protection of existing ponds against destruction, restoration of destroyed or overgrown habitats and the creation of new habitats in particular where this would support the network of ponds.

The Project LIFE+ 'Conservation of Temporary Ponds on the Southwest Coast of Portugal' (LIFE12NAT/PT/997), LIFE CHARCOS, coordinated by the 'Nature Protection League (LPN), promotes the conservation of the Mediterranean Temporary Ponds. Among the practical activities that were carried out, the following might be relevant for replication elsewhere:

- » Construction of temporary ponds, planting shrubs on the margins of ponds and creating shelters from stone and wood to promote habitat connectivity for amphibians, mammals, reptiles and other biological groups in the pond complex.
- » Eradication of exotic plants, shrub control.
- » Rehabilitation of ponds with replacement of the natural relief with slight sinking and replacement of the upper organic horizon to ensure the safeguard of the seeds and cysts of the species of the temporary ponds.
- » Re-introduction of species.
- » Removal of drainage ditches.

The Life PRIMed (LIFE17 NAT/GR/000511) promotes restoration of temporary ponds in the Greek Nestos Delta. Restoring the habitat includes the clearing of the vegetation that covers and falls into the temporary ponds. The shrub removal is necessary for the survival of the species *Emys orbicularis*, *Testudo hermanni* and *Callimorpha quadripunctaria*, present in these habitats. Enlargement of the habitat 3170* area is necessary due to the reduction of the total pond surface area that has occurred during the last 20 years.

Conservation status

Temporary Mediterranean ponds are assessed as unfavourable-inadequate in three regions, as stable in the Mediterranean and Macaronesia and improving in the Atlantic together with unfavourable-bad (deteriorating) in the Continental region and unknown in the Alpine region (Apennines).

Problem

Most important pressures and threats mentioned in the article 17 reporting are changes in hydrology and pollution. Over the last two decades, also changed land use such as modern industrialised agriculture and tourism have caused a steep decline in the condition of this habitat type. Temporary ponds are subjected to strong anthropogenic pressures, such as deep soil turning, accelerated drainage, change of the surface topography or transformation of ponds into permanent reservoirs for irrigation.

Not featuring much in the Art 17 reporting (yet) but increasingly important in the near future will be climate change. Increased temperatures combined with more irregular precipitation will probably result in a shorter hydroperiod, loss of species and fragmentation of habitat and dependent communities. Urgent action is needed in order to assure their long-term protection.

New pond sites should be identified based on the proximity to other ponds and accessibility for plants and animals, as well as on the hydrographic system of the area. A GIS-topographic analysis may help to identify suitable areas where the flow of the rainfall converges optimally, allowing natural filling of the ponds during the wet season. A soil survey may assist to identify areas featuring a waterproof clay substrate, which is indispensable for the persistence of ponds. Based on this site identification approach, a maximum 50cm excavation is required to excavate the temporary ponds.

An additional habitat restoration measure may be the planting of shrubs on the margins of ponds. Also, **the creation of shelters from stone and wood can be important to create additional habitat and improve connectivity for amphibians, mammals, reptiles and other biological groups** in the pond complex. If ponds are too isolated, keystone or target species might be introduced in the pond for those species which are not mobile. Specifically in new sites it might be worthwhile to ‘transplant’ water with e.g. crustaceans to ensure a fast establishment of temporary pond communities, improve water stability, and spread the risks of loss of species over a larger number of ponds.

Assessment of ecosystem services

Ecosystem services related to the proposed measures, as described above, are discussed in paragraph [II.3.3 Example studies for improving network coherence](#). Conservation, restoration or creation of Mediterranean temporary ponds will have positive effects with relation to erosion protection and climate regulation. In particular the microclimate around ponds will be positively affected, providing some shade and water in an otherwise dry and harsh habitat. The ponds may to some extent positively affect flood protection due to buffering peak rainstorm events. Of particular importance are the maintenance of nursery populations and habitats, as indicated for amphibians, reptiles, crustaceans etc.

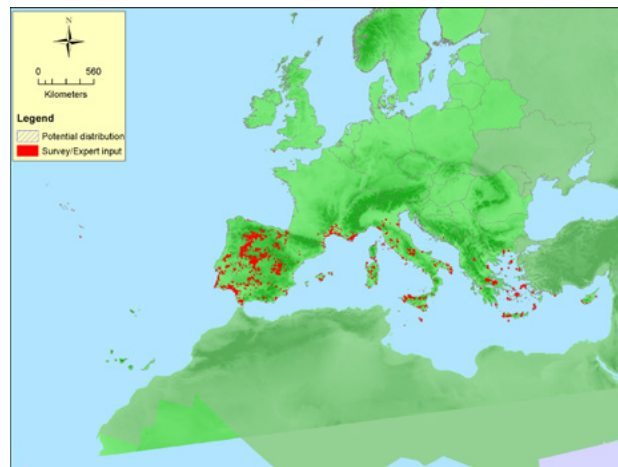


Figure II.12, left

Mediterranean temporary pond, on Komat island, site HR4000001 Croatia. © Theo van der Sluis

Figure II.13, right

Distribution of Mediterranean temporary ponds, Red List of Habitats (Jansen et al., 2016)

Example species and network cohesion

a. Eurasian lynx (*Lynx lynx*)

Ecology and distribution

The Eurasian lynx (*Lynx lynx*) used to occur throughout Europe, but currently the European distribution is associated with a rather scattered pattern of large continuous forest regions. Important core areas are: East Poland, the Carpathians, the Alps and the Jura Mountains. The species occurs in many biogeographical regions: Boreal, Alpine, Continental, Pannonian, and a small part of the Mediterranean region.

The Czech Sumava and German Bavarian Forest hold recently-established populations. In some Western European regions the species has been reintroduced very recently. The home-range size within these regions varies according to the season, prey density, sex and age. Dense populations are mainly found where prey availability of roe deer and chamois is high. Human activity and intensive land use is tolerated as long as there is enough vegetation cover.

Proposed measures for GI

To strengthen the European lynx population it is essential to improve the connectivity of the landscape, the peripheral areas where small populations face the threat of extinction. Recent lynx observations in Northern Belgium, the southern parts of the Netherlands and the Dutch Veluwe indicate the potential for colonisation of small isolated areas. Spontaneous recolonisation of potential habitat (forest) may be facilitated by incorporating corridors with stepping stones into the ecological network for the lynx.

With the [LARCH model*](#) the potential habitat and the connectivity of the landscape were evaluated for the Eurasian lynx. The analysis confirmed that the potential habitat has a patchy distribution. The most effective corridors comprise the area between North-eastern and North-western Poland, the area of Western Poland, the corridor south of Berlin, towards the Harz area and the area between South-eastern Belgium and the French-Swiss Vosges and Jura area.

Transboundary migration occurs in almost all countries in Central and Eastern Europe (e.g. Hungary, Bulgaria, Romania, Czech Republic, Greece, Baltic states). There are specific proposed measures, as described above, that aim at improving the landscape connectivity:

- » [Life Lynx](#), a consortium of mostly Slovenian partners, with Croatia and Italy
- » the [INTERREG](#) project 3Lynx
- » [LIFE Luchs Pfälzerwald](#) - Reintroduction of lynxes (*Lynx lynx carpathicus*) in the Palatinate Forest Biosphere Reserve (LIFE13 NAT/DE/000755)

* LARCH (Landscape Analysis and Rules for Configuration of Habitat) is a landscape ecological model to assess species' habitat and viability of populations.

Conservation status

The Eurasian lynx is protected under the Bern Convention (appendix III), EU Habitats Directive (appendix II and IV, for some Eastern European countries annex V), CITES (Appendix II) and IUCN Red list (Least Concern status). The species seems stable throughout most of its territory (*Adamec et al., 2012*). The last article 17 reporting indicated that the species has a favourable conservation status in the Alpine and Boreal region, an unfavourable-inadequate status in the Continental region whilst it has an unfavourable bad conservation status in the Mediterranean, Pannonian and Black Sea region.

Problem

The habitat of the lynx mostly has a patchy distribution; suitable habitat is often destroyed by deforestation and agriculture. As a result, most smaller populations have limited genetic variation or are even inbred. Other problems are related to persecution, low acceptance due to conflict with hunters and shepherds, and vehicle collision.

The landscape is fragmented for the lynx: potential suitable habitat is badly connected with core areas, and peripheral areas are especially badly connected with already occupied areas. The latter is problematic for the species, because relatively small populations of the Eurasian lynx may easily become extinct as a result of environmental stochasticity (random fluctuations), such as prey availability, poaching (nowadays), hunting (in the past) or road kills.

LIFE Lynx project's primary objective is rescuing the Dinaric-SE Alpine lynx population from extinction and to preserve it in the long term. The Dinaric-SE Alpine lynx population went extinct at the beginning of 20th century due to hunting and persecution, habitat loss and lack of prey species. It was successfully reintroduced in 1973 by translocating animals from the Carpathians and Slovenia. The animals spread, but after a few decades the population started declining, mainly due to genetic deterioration.

Currently, the population is small, isolated, and extremely inbred. It urgently needs reinforcement by introducing additional, healthy animals from another population. The Dinaric-SE Alpine population is now reinforced with lynx from populations in the Carpathians. This work is done in close cooperation with stakeholders to ensure broad public acceptance of lynx conservation. Scientific information is incorporated into management plans and other strategic documents.

Improved population connectivity for lynx will improve natural gene flow within this population. Such a metapopulation will help reduce negative impacts of habitat fragmentation and will reverse genetic deterioration across the entire Dinaric-SE Alpine population.

The INTERREG 3Lynx project has set itself quite a different aim: to integrate lynx monitoring, conservation and management into a common strategy on a transnational level. The project does so **by improving lynx conservation capacities of responsible stakeholders through experience, data and tool sharing** and by implementing a harmonised lynx monitoring at the population level. The project is also an instrument to achieve active involvement of key stakeholders (hunters and foresters) into lynx conservation issues. These are only a small sample of projects, many more initiatives have been listed in *Estreguil et al. (2018)*.



Figure II.14, left

Release of the Lynx 'Bell'. © Martin Greve, Stiftung Natur und Umwelt Rheinland-Pfalz

Figure II.15, right

Eurasian lynx (*Lynx lynx*) distribution in Europe 2006–2011. Dark cells: permanent occurrence, Grey cells: sporadic occurrence. Red borders mark countries for which information was available.

(Kaczensky et al., 2013)

The [LIFE Pfälzerwald program](#)'s main aim is to re-establish a lynx population in the Palatinate Forest, the transboundary biosphere reserve Pfälzerwald/Vosges du Nord. This is achieved through a reintroduction programme involving the release of 20 lynx (10 coming from Switzerland and 10 from Slovakia). This should result in a reproducing population of lynx in Rheinland Pfalz. The project is also monitoring lynx; it aims to increase public acceptance, cooperation with stakeholders (it is all on public land) and improved spatial connectivity.

Assessment of ecosystem services

Ecosystem services related to the proposed measures, as described above, are discussed in the chapter [Ecosystem Services](#) and presented in the [Table III.4](#). Ecosystem services related to interventions for the Eurasian lynx are mostly related to forest habitats that are promoted. The European lynx is very much dependent on extensive and continuous forest habitats. This demands the conversion from cropland to forest, which may reduce some of the provisioning services such as crop and livestock. The development of Green Infrastructure for the lynx will however also benefit a range of mammals through habitat provision, such as red deer, roe deer, wolf, brown bear, badger, wild cat and pine marten. The increased cultural services include outdoor recreation services as well as inspirational services.

b. Stag beetle (*Lucanus cervus*)

Ecology and distribution

The stag beetle (*Lucanus cervus*) is one of the largest insect species in Europe. The larval development in dead wood takes five to eight years. Although females are able to fly and need to do so in order to search for stumps for mating and laying eggs, they tend to stay in the neighbourhood of the stump they emerged from. Chances for colonisation of new habitats are therefore limited. A wide range of woods are used, especially oak, but also ash, elm, sycamore, lime, hornbeam, apple, cherry and even some garden tree varieties.



Figure II.16

Stag beetle, *Lucanus cervus*. © Chris van Swaay, De Vlinderstichting/Dutch Butterfly Conservation

The stag beetle is common only in Northern and Central Spain and Northern Italy and is rather stable. In [France](#) the short-term trend is stable, although the long-term trend is unknown. In [South-eastern England](#) its populations are surviving well in several core areas. **Distribution patterns of the stag beetle have been shrinking since 1900 in the remaining countries, leaving only small isolated populations.** The stag beetle is one of several rare and threatened saproxylic (woodboring) beetles in Europe, like *Rosalia alpina*, or *Monochamus scutellatus* (white-spotted sawyer).

Proposed measures for GI

To create more breeding possibilities for the stag beetle, old and moribund deciduous trees as well as large stumps of these trees are required. At the local level connectivity can be enhanced by the **introduction of natural and artificial breeding facilities**, such as dead wood pyramids, loggeries and large wooden boxes filled with wood chips and sawdust. The location of these breeding habitats should be based on the core areas already present. The corridors connecting the breeding places should be of the 'nodal type' with nodes every 2km.

The European Red List ([Cálix et al., 2018](#)) recommends that at the landscape level connectivity can be enhanced with the maintenance of ancient woods, conservation of forest remnants, hedgerows and old deciduous trees. The exchange of individuals between isolated patches of old deciduous woodland can be facilitated with plant schemes for deciduous trees in the vicinity of forest remnants, single trees, open areas and coniferous woodland. These corridors should be constructed away from roads, as stag beetles are very vulnerable to traffic.

Little evidence is found of larger, transboundary projects aimed at the stag beetle: the project LIFE for insects – Conservation of selected Natura 2000 insect species in transboundary area (CZ-SK) of Western Carpathian Mts. LIFE16 NAT/CZ/000731 is focused on the regional scale, and partly on meadows for butterflies. The LIFE description notes, however, that the most threatened habitats in Central Europe are open-canopy middle forests home to valuable Habitats Directive-listed species such as the stag beetle (*Lucanus cervus*) or clouded Apollo (*Parnassius Mnemosyne*) butterfly. With the disappearance of traditional coppicing of woodlands and forest grazing (and changes in forestry practices and legislation), the best way to support this habitat is through the restoration of open-canopy forests.

In South Sweden, a LIFE project aims at restoring saproxylic beetle species (LIFE15 NAT/SE/000772). One of the project aims is to initiate the creation of decaying wood habitats which in the longer term can bridge gaps in space and time for the *Annex I habitats* (9070, 6530*, 9160, 9020 and 9190) and *Annex II species* *Osmoderma eremita*, *Cerambyx cerdo*, *Lucanus cervus* and *Anthrenochernes stellae* within the Natura 2000 sites.



Conservation status

The stag beetle is listed in appendix III of the Bern Convention and in appendix II of the EU Habitats Directive. In many European countries the European stag beetle also occurs on the national Red Lists, but it does not occur on the IUCN Red List since the species is not endangered on a global scale. The last article 17 reporting indicated that the species has a favourable conservation status in the Black Sea and Pannonian region whilst it has an unfavourable-inadequate status in the other regions where it occurs. [In general saproxylic insects are threatened and in decline.](#)

Animal species associated with old-growth forest and dead wood are among those most threatened in European forest ecosystems. Many studies have demonstrated the susceptibility of forest species to intensive forest management practices and forest fragmentation ([Bosso et al., 2018](#)). Saproxylic insects comprise a disproportionately large percentage of nationally rare and threatened species ([Grove, 2002](#)). An assessment of the Red List status of saproxylic beetles in Europe was made: saproxylic insects stood out as a highly threatened group ([Cálix et al., 2018](#)). At the same time it has been demonstrated that Natura 2000 so far may not have been effective in the protection of rare saproxylic beetles ([D'Amen et al., 2013](#)).

Problem

The main risks for the stag beetle are its vulnerability – due to its long life cycle which requires large stumps in an undisturbed environment- and the relatively small dispersal range of the females. It appears that the main condition for survival and gradual dispersal forms a rather dense network of undisturbed patches with old large stumps of deciduous trees and sap trees for adult feeding as well. At the landscape ...

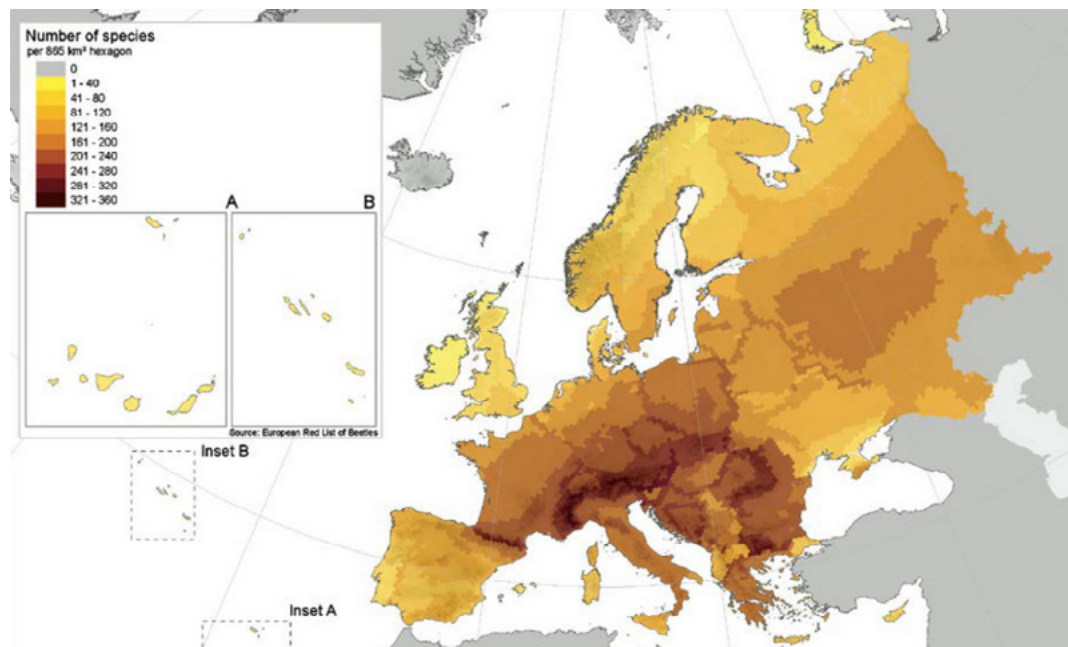
Figure II.17

Observations of Stag beetle in Europe. ([Harvey et al, 2011](#))

One of the methods used is ‘veteranisation’ of trees: a method to create old tree structures in younger trees, carried out using a chainsaw by arborists. The veteranisation methods aim to mimic effects on trees due to naturally occurring disturbances like storm felling, lightning, browsing animals and woodpeckers. It increases the number of available dead-wood-habitats for threatened species, such as hollow trees, trees with partially dead trunks, and sap flows. So far no results have been reported at lifebridgingthegap.se.

Assessment of ecosystem services

Ecosystem services related to the proposed measures, as described above, are discussed in [par. III.5](#) and presented in [Table III.4](#) (chapter [Ecosystem Services](#)). The stag beetle is exemplary for the strongly declining group of large woodboring (saproxylic) beetles, such as the black tinder fungus beetle. If ancient woods are maintained, then ancient woodland indicator plants will also benefit. These old forests have limited provisioning services, and may in fact require reduced timber harvesting. The regulation services may be high though, in particular climate regulation, pollinator functions, seed dispersal and maintenance of nursery populations and habitats. Lastly, the habitat may facilitate some recreational services, as well as inspirational services (*Plieninger et al., 2015*).



... level the beetle is affected by the disappearance and fragmentation of old deciduous forests, leading to smaller and more isolated habitat patches. As a result, the distribution of the beetle is scattered (Figure II.17). Dispersal distances are reportedly up to 3 km (Rink & Sinsch, 2007). At the local level, forestry activities also minimize the remaining suitable habitat because they consist of the removal and disturbance of large pieces of dead wood from the forests and the cutting of deciduous trees for forest regeneration purposes. Consequently, only small stumps are left behind which are too small for proper larval development of the beetle. In addition, the use of herbicides and insecticides threatens the beetle.

The decline and fragmentation of habitat of the stag beetle also affects other saproxylic (woodboring) insects; Figure II.18 shows the richness of forests containing habitats of rare woodboring invertebrates (Cálix et al., 2018). Some forests are of respectable size, but others are as small as 40 ha. The highest richness occurs within mountainous parts of the continent. The distribution pattern demonstrates that forests important for saproxylics are either isolated relicts in unforested regions or – although embedded in large woodland regions – isolated from similar forests.

Figure II.18

Species richness of European saproxylic beetles. (Cálix et al., 2018)

c. European sturgeon/Beluga (*Huso huso*)

Ecology and distribution

Sturgeons are excellent flagship species for ecologically healthy rivers and seas due to their size, longevity, diverse habitat utilization and their migratory life cycle that connects coastal waters to the upper reaches of riverine ecosystems. **Sturgeon species, together with migratory fish, are useful indicators of the ecological status of a river, especially when considering the river's function as an ecological corridor.** The beluga or European sturgeon (*Huso huso*) is endemic to the Ponto-Caspian Sea region that includes the Caspian Sea (the largest inland body of water in the world) as well as the Sea of Azov and the Black Sea. The current native wild distribution within the EU is restricted to the Black Sea (in the Danube only), but it does occur in the Caspian Sea and Volga as well. As it is a long-lived species (has a long life expectancy), individuals can still be caught in areas where their spawning sites have been cut off. The beluga have reached 100 years of age and more than 1,000kg weight. The last wild population in the Black Sea basin migrates up the Danube river. All other Black Sea stocks are almost extirpated due to overfishing and impoundment of spawning rivers.

Proposed measures for GI

The protection of sturgeon needs a holistic approach, connecting international waters, coastal areas, and often multi-national river systems. A [Pan-European action plan](#) was prepared for this species. This plan makes it clear that saving sturgeon from extinction is really a cross-sectoral and trans-national issue: it requires that transboundary networks of people work together to overcome complex problems. In the immediate future, **survival depends on restocking, effective fisheries management, and combating illegal fishing.** Range states are also encouraged to provide protection to the species spawning and feeding grounds. Protective measures include fishing regulation, habitat restoration, juvenile stocking, and the CITES listing of all sturgeon products including caviar. The most important measures are habitat protection, restoration or enforcement of fisheries regulations. These are however in conflict with economic interests, and implementation therefore has proven to be particularly difficult (*Friedrich et al, 2018*).

In the future, sturgeon farming may resolve some pressure on the wild populations (due to illegal fishing), presently farming yields more than 2,000t per year (equivalent to wild sturgeon landings) and about 15t of caviar. This artificial production may contribute to a reduction of fishing pressure and lead to the rehabilitation of wild stocks.

One of the approaches is the MEASURES project developed under the [INTERREG Danube Trans-national program](#). MEASURES stands for “Managing and restoring aquatic ecological corridors for migratory fish species in the Danube River Basin”. This project is a partnership with many other institutions from across 10 countries.

Conservation status

The European sturgeon is critically endangered, following the IUCN criteria and included in the EU Habitats Directive Annex V, the Bern Convention Annex II & III. Based on catch data, and number of recorded spawning individuals it is estimated that the species have seen a wild native population decline of over 90% in the past three generations (a minimum of 60 years) and overfishing for meat and caviar may cause global extinction of the remaining natural wild populations. Stocks of sturgeons are dramatically decreasing, particularly in Eurasia; the world sturgeon catch was nearly 28,000 tons in 1982 and less than 2,000 tons by 1999 (Billard & Lecointre, 2000). The last article 17 reporting indicated that the species has an unfavourable bad conservation status in the regions where it occurs.

Problem

The decline of Sturgeon resulted from overfishing and environmental degradation such as: accumulation of pollutants in sediments, damming of rivers, and restricting water flows, which become unfavourable to migration and reproduction.

MEASURES aims to create ecological corridors by identifying key habitats and initiating protection measures along the Danube and its main tributaries. The sturgeons and other migratory fish species act as flagship species in support of these goals. It will achieve this by identifying key habitats and initiating protection measures along the Danube. A combination of measures is required to restore **the landscape connectivity for the European sturgeon. These measures comprise the bypassing of obstructions such as dams, weirs and culverts, the restoration of spawning areas by restoration of the morphology of rivers and streams, and in some cases young fish have been reintroduced in tributaries of big rivers.**

In 2019, project partners in Hungary began work to build a sturgeon hatchery whilst also undertaking two pilot restocking actions. Thus, 5,000 sterlets fitted with yellow identifier tags have been released into the Danube. From April 2020, the released population's growth rates and travel routes will be assessed.

The corridor required for migration and dispersal is of the 'linear type'. A coordinated approach is required though; the connectivity may be a major problem, a chain of measures is required for sturgeon to reach its spawning areas.

Assessment of Ecosystem Services

Ecosystem services related to the proposed measures, as described above, are discussed in [par. III.5](#) and presented in [Table III.4](#) (chapter [Ecosystem Services](#)). The sturgeon populations can be restored through reversal of engineering works, removal of dams etc. This has some potential for provisioning services, in particular for fisheries. More important are the regulating services like erosion protection, flood protection and maintenance of nursery populations and habitats. The habitat finally may facilitate some recreational services (fishing), as well as large inspirational services.



Figure II.19, left

Sterlet *Acipenser ruthenus*. © Hans Braxmeier ([Pixabay.com](#))

Figure II.20, right

Fish hatchery for Danube sturgeons. (www.interreg-danube.eu/approved-projects/measures/gallery)

d. Large copper (*Lycaena dispar*)

Ecology and distribution

The Large copper (*Lycaena dispar*) usually occurs in natural marsh vegetation along water courses, rivers and marshes, but may also be found in unimproved, semi-natural grasslands. The male defends his territory, whilst the female wanders over large wetlands looking for a male or – after mating – for a plant to deposit eggs. The females are quite mobile and can colonise suitable habitats relatively quickly up to a distance of ten km. This means that the butterfly functions very well in mosaics of habitat patches. The large copper has declined significantly in Western Europe, whereas Eastern European populations are mostly stable. At the northern limit of its range in Estonia and more recently in Finland, the butterfly is expanding, probably caused by global warming in the last decades.



Proposed measures for GI

To increase the connectivity for the Large copper two types of corridors are required. Firstly corridors connecting different networks and secondly corridors which link smaller local populations within a particular network. The landscape matrix is very important for the development of such network corridors, but also linear corridors with attached nodes are needed to link the smaller local populations. This is illustrated in [Figure I.22](#).

In the North-western part of Germany wetlands are small and isolated. This means that the Large copper population occurring in the Netherlands is isolated from populations in Eastern Germany. Only a large scale creation of wetlands could be a solution to this problem.

It is important that existing wetlands with *Lycaena dispar* populations are maintained and the area is connected to the east with the Biebrza valley and Kaliningrad.

The Large copper is an umbrella species for many other wetland insects. But also other species of large wetlands, such as the Otter and many birds will profit from action taken to favour this butterfly.

Assessment of ecosystem services

The habitat for the large copper is much related to large wetlands and meadow systems, which should be restored. This has limited potential for provisioning services, some wild animals, but much more important are plant-based resources, reed used for roofing, for biomass, pellets etc. (*Van der Sluis et al., 2013*). These wetlands also provide important regulating services, in particular climate regulation, flood protection and maintenance of nursery populations and habitats (in particular fish species). The areas also form important recreation areas for hikers, canoers, fisherman or hunters. Also, inspirational services are associated with large wetland areas ([Table III.2](#)).

Figure II.21

Large copper *Lycaena dispar*. © Chris van Swaay, De Vlinderstichting/Dutch Butterfly Conservation

Conservation status

The Large copper is listed on appendix II and revised Annex I (requiring specific conservation measures) of the Bern Convention. It is on appendix II and IV of the EU Habitats Directive. The butterfly is listed as 'Least Concern' on the European Red List (*Van Swaay et al., 2010*). The last article 17 reporting indicated that the species has an 'unfavourable-inadequate' status in most biogeographical regions (Atlantic, Boreal, Pannonic, Steppic region) and favourable conservation status in the Alpine, Black Sea and Continental region. At the national level it is reported as 'unfavourable-bad' in The Netherlands and Germany.

Problem

The biggest threat to the Large copper is a decline in habitat quality, in intensively farmed regions by lowering of the groundwater level and nitrogen deposition. In abandoned areas the threat is by succession turning open habitats into secondary forest. Smaller and degraded habitat patches suffer under fragmentation of their habitat.

By means of a LARCH analysis potential habitat of the Large copper was identified and compared with the actual distribution pattern of the species ([Fig. I.22](#)). In many areas (1, 2, 3) large core populations exist whereas in other regions populations are smaller, but still well connected (4, 5). In areas such as North-western Germany (6) however the wetlands are too small, scattered and isolated. Although the ecology differs slightly for this species, the model also predicts reasonably well the potential distribution of the Large copper in the Netherlands. In reality this subspecies is restricted to the Dutch regions of North-west Overijssel and Southern Friesland.

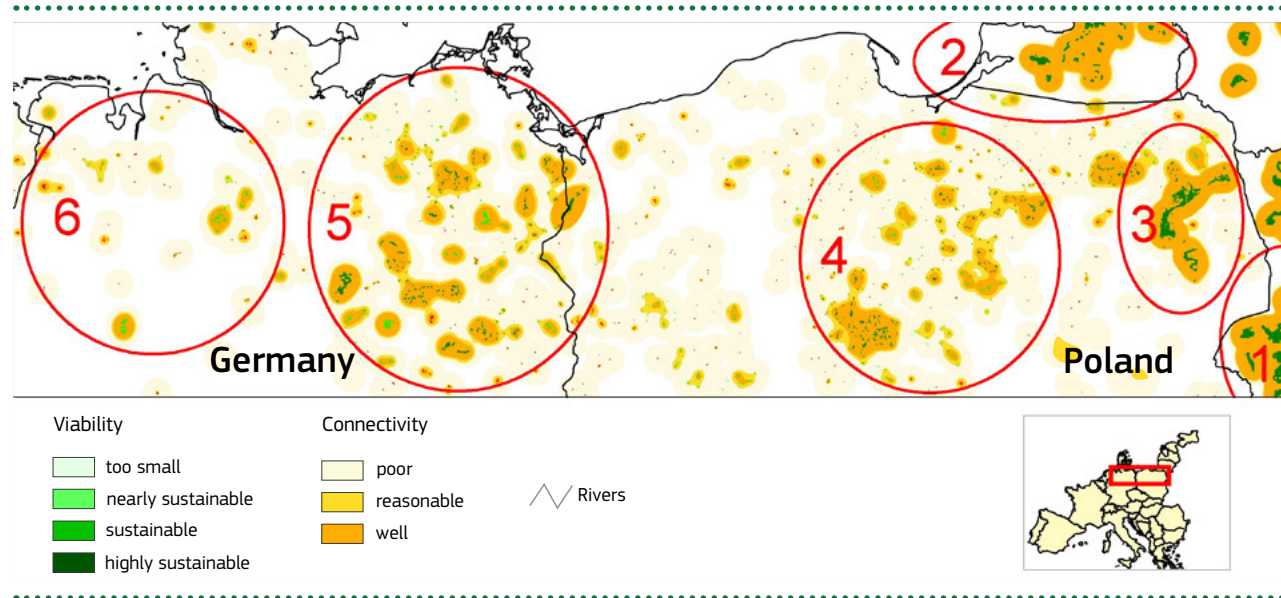


Figure II.22

Ecological core areas for the Large Copper.
(Van der Sluis et al., 2004)

II.4 Key findings and recommendations

II.4.1 Key findings

We may conclude that the **various concepts used (ecological networks, corridors, green infrastructure, network coherence) vary**, which can be explained by changes in priorities and policy targets over time. In the end, most boil down to the same concepts, whether it is called Green Infrastructure or ecological network.

The policies and approaches vary a lot in the different Member States. Also here policy plays an important role, as well as cultural differences and approaches adopted in planning: strong central planning, or decentralized approaches, bottom-up or top-down.

Important is the involvement of stakeholders in planning for improved network coherence, stakeholders can contribute, can add to planning processes. This is very much in line with the various directives and implementation guidelines, as well experiences gained in various projects.

II.4.2 Guidance, recommendations; practical information for practitioners

What is happening in the EU-countries?

The situation with regard to biodiversity and Green Infrastructure is available on [BISE Biodiversity Information System for Europe](#). This site has a link to every country, biodiversity fact sheets, but also information on MAES reporting and Green Infrastructure per country. This report provides a brief overview of the history and initiatives in Europe. A review of initiatives worldwide is presented by *Keeley et al., 2019*.

What tools exist for improvement of Network Coherence?

Network coherence or Green Infrastructure can be improved through a variety of measures. The landscape cohesion is very much defined by species characteristics: range, habitat choice, dispersal distance, carrying capacity. These are species specific characteristics which cannot be changed. The landscape itself can to some extent be adjusted.

There are various reports that provide guidance on ecological network development and the relevance of corridors, such as the handbook from IUCN (*Hilty et al., 2020*). Also the guidance for Green Infrastructure, prepared by JRC is very relevant (*Estreguil et al., 2019*).

In this report also practical GIS-based tools and knowledge systems are presented. One is the [LARCH model](#). This model was used in several examples in this chapter, e.g. for the [Large copper](#), but also various regional studies (in Italy, Catalunya, Poland).

It is recommended that a working group be established to adequately help the implementation of Article 10 to support achieving Favourable Conservation status.

Targeted materials should be developed for different stakeholders (government authorities at national, regional and local levels, NGOs, the public etc.) to clearly demonstrate and explain the network coherence in terms of reaching Favourable Conservation Status, thus showing the functional aspects of the raised attention for Article 10.

Which projects might be relevant?

The MaGICLandscapes Interreg project (2017–2020) focuses on Green Infrastructure implementation. The website introduces the Green Infrastructure concept and its benefits. In close cooperation with local stakeholders, project partners elaborate strategies and action plans to enhance the existing Green Infrastructure in Central Europe. The project promotes sustainable land use by providing land managers, policy makers and communities with tools and knowledge.

The website also provides a link to the output of the project, with the '[Green Infrastructure Handbook – Conceptual & Theoretical Background, Terms and Definitions](#)' (*John et al., 2019*). The Handbook provides a table with the countries of Central Europe, and what they are doing on GI. In addition, fact sheets are provided on GI, currently in 5 different languages.

Basically, the options for improvement of landscape coherence or connectivity are:

- » Through development or improvement of corridors
- » Improvement may entail widening, adapting the vegetation to provide more cover for species, establishing water points or stepping stones etc.
- » Enlargement of core areas, conservation areas, by enlargement and improvement of habitat
- » Improvement of the 'matrix', the surrounding landscape, e.g. through stimulation of low-intensity farming, reduced use of agro-chemicals, or more natural forest managements for forest corridors, better conservation of the riverine vegetation and avoiding expansion of human settlement.

Financial instruments

As demonstrated in [par. II.3.2](#), the LIFE program is and has been of major importance to develop, restore or improve Green Infrastructure and network coherence.

Financing of measures for Green Infrastructure is possible through the Natural Capital Financing facility. This facility is in particular meant to halt the loss of biodiversity and adapting to climate change. To do so, the European Investment Bank (EIB) and the European Commission have partnered to create the Natural Capital Financing Facility (NCFF), a financial instrument that supports projects delivering on biodiversity and climate adaptation through tailored loans and investments, backed by an EU guarantee.

The NCFF also provides a '[seven-step guidance](#)' on financing, a 40-page document describing the ways of financing conservation and nature-based solutions measures. Except for financing measures related to Green Infrastructure, they also provide loans for pro-biodiversity and adaptation of businesses (e.g. forestry, farming, ecotourism, energy), payment for ecosystem services. Also, several [examples of funded projects](#) are provided.

Recommendations should be developed on the use of other legal and policy instruments, that could or do support ecological coherence, financial instruments, planning instruments and specific programmes (e.g. Water Framework Directive, Agricultural Policy (CAP), Fisheries Policy (CFP), Cohesion Policy and Structural Funds, spatial planning, wildlife conservation programmes).

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Annex I: Country descriptions

Austria

The **Federal Republic of Austria** consists of 9 independent states (*Länder*). The competence of the Länder includes all areas that are not explicitly attributed to the federation by the Federal Constitution (*Bundesverfassungsgesetz*). Within this federal system, nature conservation, hunting and fishing are domains of the Länder, whereas agriculture, water and forestry are domains of the federation. There is no federal law establishing a framework for detailed nature conservation legislation by the Länder. The basic protection of species and landscapes is regulated by the nature protection acts (*Naturschutzgesetze*) of the [Länder](#). Details are determined by ordinances. Parliament Acts (*Gesetze*) are promulgated in the official gazettes of the Länder as well as ordinances (*Verordnungen*). The nature conservation laws of the Länder that are currently in force stipulate a general obligation to protect and care for nature as the basis of life for mankind, fauna and flora. They also have special regulations with regard to the protection of species, areas and licensing certain activities. The states in the federation are also responsible for the international agreements concerning nature and landscape conservation such as the identification of Natura 2000. National environmental information coordination such as the State-of-the-Environment Report is carried out by the [Umweltbundesamt](#). Since 1998 the Umweltbundesamt is as a Limited Liability Company. It acts as the expert authority of the federal government for environmental protection

Most of the connectivity restoration activities are carried out jointly by the states and NGOs such as the [Alpen-Karpaten corridor](#) and [stream restoration](#).



Figure II.23, left
Alpen-Karpatenkorridor

Figure II.24, right
March Auen project

Belgium

Belgium is a federal country and has three regions (Flanders, Brussels and Walloon) and three communities (Dutch, French and German). Nature conservation and biodiversity conservation is regionalised and Brussels, Walloon and Flanders have different approaches. There is a national strategy on biodiversity for the period of 2006–2016, agreed upon in 2006 by the Interministerial Conference of the Environment consisting of the ministers of the Federal Government, of the three regions (Flemish Region, Brussels Capital Region and Walloon Region) and the three communities (Flemish, French and German). This is a National Policy Document on biodiversity, which summarizes the responsibilities of different governments in Belgium with a view to comply with the commitments made by Belgium on the European and international plans. This [strategy has been updated in 2014 for the 2020 targets](#). It outlines a framework for the policy to be followed and implementation measures to be developed.

Through state reforms, the regions in Belgium gained full competence and responsibility for environment and conservation issues. Supporting research is the responsibility of the three communities. On the [French website](#) the ecological network is indicated as "all habitats that can provide a temporary or permanent living environment for plant and animal species, in accordance with their vital requirements, and to ensure their long-term survival". For Walloon and Brussels this is not further spatially elaborated.

The Flemish government is leading the process of developing a [Flemish Ecological Network](#). In the Flemish Decree on Nature Conservation (1997) there are articles concerning:

- » Adoption and translation of European regulation and categories in appropriate articles. However, there is no explicit relationship with [Natura 2000](#).
- » Definition of the Flemish Ecological Network with core areas and nature development areas (VEN).
- » Definition of the Integrated Multifunctional and Supporting Network with nature integration areas (a kind of stewardship areas) and nature corridors (IVON).

A target for the VEN is to protect 125.000 ha (9.3% of Flanders). According to the Nature Decree, this must be demarcated by the beginning of 2003. In 2009, the Flemish Parliament added an explanation to the decree stating that this is a [target date](#) as the process is slow. The nature integration areas (IVON) are supposed to cover 150.000 ha. The Flemish Decree on Physical Planning aims to incorporate nature conservation targets (VEN, IVON) into physical planning objectives. The provinces have the responsibility to realize ecological corridors. In the stage of realization of individual projects, informal cooperation with private stakeholders has to be established. This is partly done for the nature restructuring projects where landowners, farmers, hunters etc. are involved and persuaded into a 'nature-friendly' management. For the realisation of the corridors cooperation on a voluntary base is the rule. The negotiations between

sectors and their legal bodies on the level of the competent administration (nature conservation, agriculture and forestry) are time consuming. Constraints arise at the regional as well as at the local level. Conservation ecology experts deliver information to the officials at the regional level e.g. the Institute of Nature Conservation maintains the databases on habitats and species and prepares the preliminary maps of habitats for the designation process.

In the desired VEN scenario and additional existing green regional plan designations, there would be a significant decrease in the fragmentation until 2011, since that is when the process stopped. Fragmentation remains an important issue in [Flanders](#). Approximately 14 years after the expiry of the date that has been set in the Nature Decree and eight years after the target year in the IVON, 3% (around 5,084ha) has been demarcated.

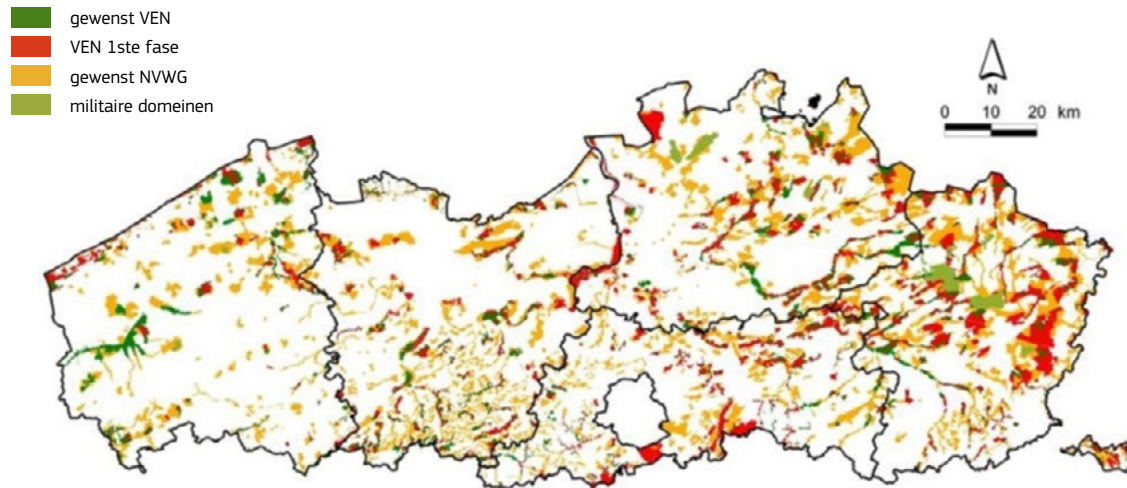


Figure II.25

VEN and IVON in Flanders

Germany

Germany is a federal republic, consisting of 16 member states. The states (*Bundesländer*) are relatively autonomous regions; many have been self-governing kingdoms in the past. In total, Germany identifies six layers of government: the Federal Authority (*Bund*), States (*Länder*), physical planning regions (*Regierungsbezirke*), Counties (*Bezirke*), Districts (*Kreise*), non-district cities (*kreisfreie Städte*) and Municipalities (*Gemeinden*). The Bundesnaturschutzgesetz is a framework legislation: the Bund has the right to enact general laws that are worked out by the Länder (*Rahmengesetzgebungskompetenz*) and the Bundesländer determine the precise institutional forms of enforcement. The present [federal nature conservation law](#), BNG dates from 1976 and its last revision is from 2009. In the revision of 2003 the obligation has been included for the Bundesländer to develop an [Ecological Network for the state](#).

One of the major tasks in a federal state like Germany with devolved responsibility for nature conservation is the integration of the state networks into a German ecological network. States and federation work together on this under coordination of the [Federal Nature Conservation Agency \(BfN\)](#) (Fuchs *et al.*, 2010). Also, the protection of NATURA 2000 sites is included in this the national nature conservation legislation. In Germany, landscape planning is an important instrument for nature and landscape conservation as well, and enshrined in the 1976 [Nature Conservation Law](#). Landscape planning is, besides a control instrument for nature conservation, a sectoral planning system for all other fields of interest that have to take account of nature conservation interests. Through landscape planning, nature conservation criteria can be taken into account in planning and administrative procedures and the ecological network be realised. The NGO BUND (Friends of the earth Germany) has prepared a [handbook for implementation of ecological networks](#) (in German). It relates in general to the physical planning area, but it also contains measures without physical objectives, such as regulations for the protection of animal- and plant species. The second important principle introduced in planning is the Intervention regulation (*Eingriffsregelung*): it is of major importance for species and biotope protection outside the protected areas. It is meant to prevent avoidable impact and to compensate unavoidable measures that damage nature and landscape processes. The objective of the intervention regulation is to preserve the functionality of the natural environment and the landscape also outside the special protected areas. The most common types of intervention are building of housing areas and traffic infrastructure. Interventions in nature and landscape should be avoided according to the nature conservation intervention regulation. If this is not possible, landscaping measures (so-called compensation and mitigation measures) must be taken. With this procedure, a comprehensive approach based on all protected nature areas and the landscape is pursued nationwide. The intervention regulation is of fundamental importance for the achievement of the objectives of nature conservation and landscape management in general.

Defragmentation is an important issue in Germany. Work on defragmentation is organised by the states in cooperation with the federal office for nature conservation, consultants and universities, such as the university of Kiel and the university of Kassel.

In the planning and realisation of linear infrastructures (construction of new roads and expansion of roads, railways, canals) is the existing ecological interconnectedness to be preserved in such a way that colonization and repopulation of habitats by naturally occurring species can take place in sufficient numbers. For this purpose, both the networking relationships and the necessity of measures must be demonstrated and sufficiently justified at various planning

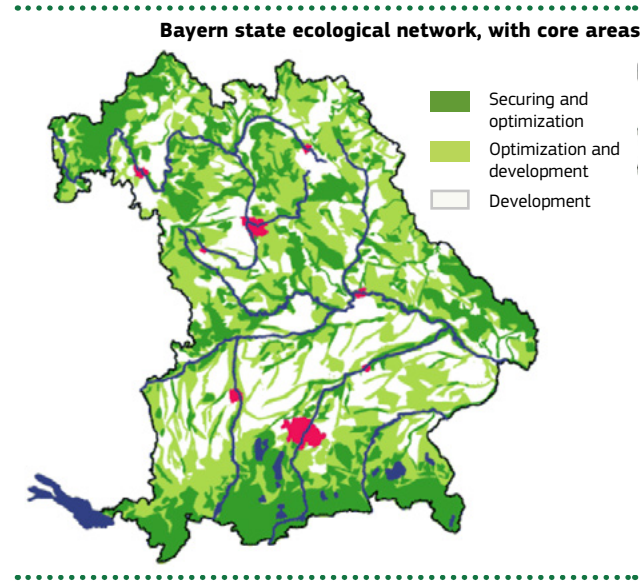


Figure II.25

The Bavarian Ecological Network

levels. An important planning aid for assessing the need for reintegration measures are the habitat networks for dry habitats, wet habitats, near-natural forest habitats and the habitat networks for larger mammalian forest dwellers (Hänel & Reck, 2011). Depending on the affected habitats and species, special measures can then be planned to preserve these network relationships. These include a variety of technical options for road crossing such as green bridges and underpasses. There is an important road defragmentation programme, as is formulated in the national strategy on biological diversity (Vision B2.8): In 2020, the existing roads are generally not hindering the [connectivity in ecological networks](#).

These technical structures are measures with which, if successfully integrated into the landscape, habitat networks can be maintained or restored. With appropriate structural design and e.g. fences the frequency of accidents with larger vertebrates such as red deer are reduced, which contributes to traffic safety. Depending on the affected species, it may be necessary to carry out additional measures in the vicinity of road crossings with which their habitats are improved. The aim is to stabilize remaining populations and to promote their dispersal ability.

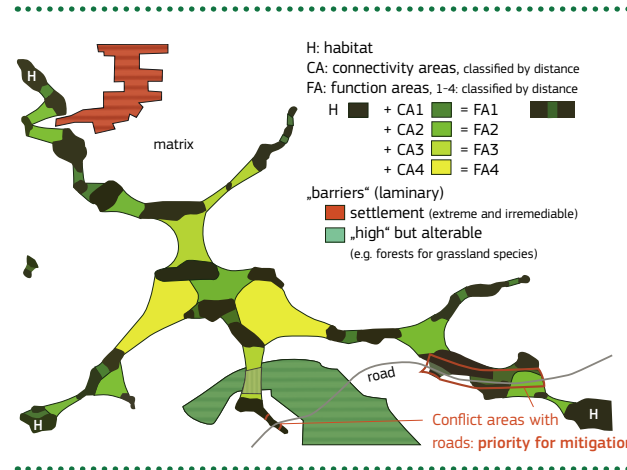


Figure II.26

Identification process of barriers and corridors for mitigation measures

Spain

Spain is a federal country; within the period that it is a member of the European Union, regionalization has taken place as well as strong economic developments. Both have an impact on nature conservation. Spain consists of 17 autonomous regions. The regional governments carry the responsibilities for environmental protection and nature conservation. There are a number of national protection categories and Spain has a large territory with protected areas. However, each autonomous region has its own approach to nature protecting, with different priorities towards nature conservation. At present the area covered by Natura 2000 is 134.150km². There are fifteen National Parks divided over eleven autonomous regions. The National Park is the highest protection category for areas of high natural and cultural value and only scarcely inhabited. In all of Spain the cañadas or routes, originally for merano sheep used to be important for livestock movement from the summer pastures (*puertos*) in the [Pyrenean and Cantabrian mountains](#) through even major cities such as Madrid, to the winter grasslands in [Extremadura and Andalucía](#). They have a legal protection status that is differently organised in each region, but they form the largest network of natural areas covering a large part of Spain.

This network of drove roads has been recognised by the national government. In December 2007, the Spanish Parliament adopted a new [Nature Conservation Act](#) (Ley 42/2007) which includes ecological networks and ecological corridors. Article 3 defines ecological corridors, connecting natural sites of special importance for wild flora and fauna, allowing genetic exchange

between otherwise separated populations. Article 17 defines ecological networks as a network of sites of high natural value which allows the movement of flora and fauna species. It also specifies that nature management plans have to contribute to connectivity conservation and restoring corridors (Art 21). It mentions as important corridors: river courses, drove roads (*cañadas*) and mountain ranges.

At present there are three regions that have developed ecological network plans; Catalunya, the Basque Country and Madrid. In 1992, in Cataluña the plan for spaces of natural interest (PEIN) was created, which was the first coherent plan that delimits and establishes a conservation system for basic protection of representative natural spaces in accordance with their scientific, ecological, landscape and cultural importance. They represent approximately one third of the whole of the Catalan territory and within them it is [forbidden to build and hunt](#). Studies were done on improvement of the ecological network, e.g. with the model LARCH ([Franz et al., 2011](#)). Later in the [Basque country](#) (2005) and [Madrid](#) (2010) ecological networks have been designed. For both it is not yet clear how implementation is taking place. In Navarra the first concept of an ecological network has been established in 1997, but then further elaboration has been stopped. In Extremadura the law on Nature Conservation (Ley8/1998) includes ecological and biodiversity corridors. However, the concept has not yet been implemented. One of the important causes of delays seems to be the lack of resources. Another problem is the fact that regional planning is focusing on urban areas and town planning and that land use planning for rural areas is lacking.

NGOs are very important in pushing developments in Spain. For instance in 2013 the Fundación Oso Pardo has been set up that is including the governments of Asturias and Castilla y Leon several municipalities in the Cantabrian Mountains. It is developing with EU-Life+ funds connectivity between the [western and eastern populations of the brown bear](#). There are several associations involved in the use and protection of the Spanish cañadas as well as with single species and species groups, such as the [Spanish Ornithological Society \(Sociedad Española de Ornitología\)](#), that is campaigning to get all areas currently designated as Important Bird Areas (IBA) to be given Special Protection Area (SPA) status.



Figure II.27, left

The Cañadas reales of Spain

Figure II.28, right

Cañada real de Segovia with grazing cattle

Italy

Italy is rich in biodiversity with its long north-south gradient. In the 1970s, part of the competences for area protection has been devolved from the State Government to the 21 regional administrations. Many natural parks came under the jurisdiction of the regions and new ones were created. The result of these experiences was not only a notable growth of protected areas surface but also the beginning of the discussion that led to the new law n. 394 of 6 December 1991 that proposed protected areas, parks and reserves network to actively protect the ecological system of the country. This law aims to establish a shared distribution of responsibility among the State, the regional administrations and local administrations and to ensure adequate sector planning which enables significant parts of the country to be placed under special protection. This legislation is still valid and in accordance with its general principles the present Regional Act lays down rules for the creation and the management of protected nature areas in order to guarantee and encourage the conservation and improvement of regional natural and environmental resources. The central government is responsible for the implementation of international and national policies.

The authorities involved in nature conservation in a strict sense (habitats, ecosystems, species, sustainable planning, etc.) at the national level are the Ministry of Environment; the Ministry of Agriculture, the Ministry of Public Works and the Ministry of Cultural and Environmental Heritage (landscape protection). The Ministry of Environment has frequent relations with Regional bodies in official works for protected areas and the safeguard of species and habitat.

In Italy there are twenty one regions with an increasing autonomy, 103 institutional bodies of second level, which includes 80 provinces, two autonomous provinces, six free municipal consortia, 14 metropolitan cities and 7954 municipalities (2018). The State generally has a coordination role. Each Region has to produce a regional legislation and often Provinces and Municipalities issue local regulations. In management of protected areas state, regions, provinces, and municipalities all have responsibilities in managing parks and reserves at national, regional, provincial and municipal level. This means that regions draft regional scale framework laws and regulations; local authorities such Provinces and Municipalities define rules for application.

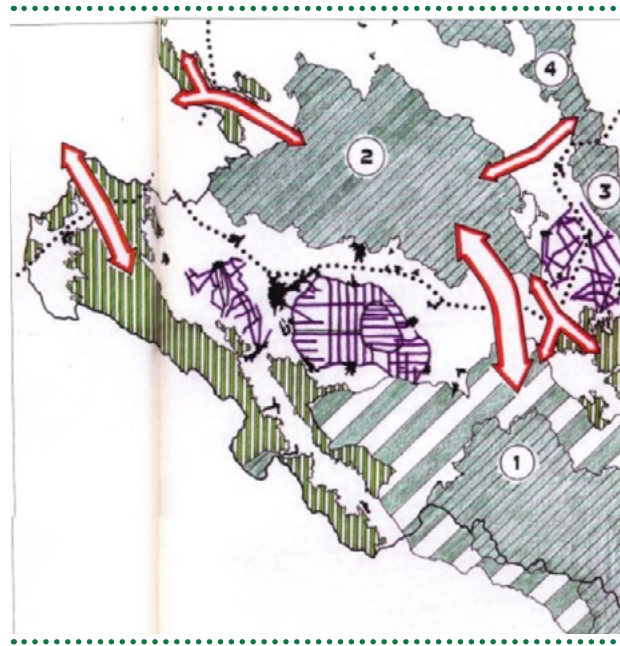


Figure II.29

The connectivity between national and regional parks in the Central Apennines (*Romano, 1996*)

This situation regarding task sharing allows much freedom for the different authorities to develop their own vision of nature conservation and the development of ecological networks.

Territorial fragmentation and ecological connectivity have been studied and addressed within regional authorities as well as within research institutes and universities. ISPRA published in 2003 [guidelines for the management of functional ecological connection areas](#), containing practical information on the issues of conservation, planning and management of ecological corridors. Several regional networks were developed, e.g. through the LIFE-Econet projects such as for parts of Emilia Romagna (Van der Sluis et al., 2001; Van Rooij et al., 2003), Abruzzo (Van der Grift & Van der Sluis, 2003; Van der Sluis et al., 2003) and Umbria (Van der Sluis & Pedrolì, 2004). The LARCH model was used to analyse the landscape and territory, and with habitat modelling of target species an ecological network was proposed and partly implemented through regional initiatives and with project funding from LIFE and regional authorities.

In Italy, ecological connectivity has been elaborated at all levels, between national and regional parks, such as in the central Apennines, around towns such as around Milano and in rural areas such as the water network in the province of Bologna.

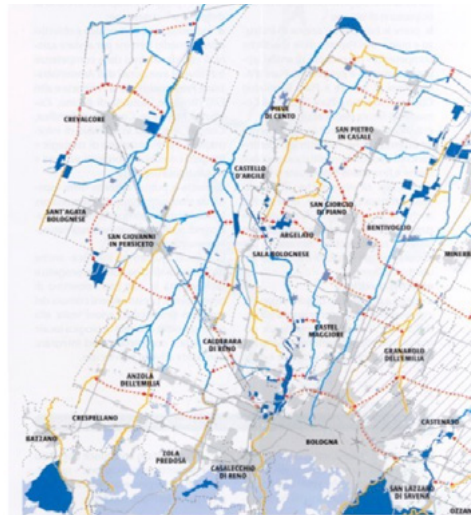
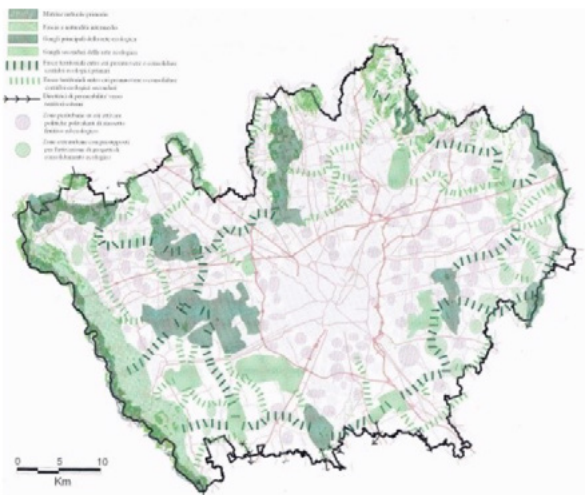


Figure II.30, left

Ecological network of Milano
(Dimaggio & Ghiringhelli, 1999)

Figure II.31, right

Aquatic ecological network in the region Bologna (Emilia Romagna). The dark blue areas represent core area, the streams the corridors. The arrows are smaller corridors connecting the streams.
(Bolck et al., 2004)

Bulgaria

In **Bulgaria**, nature conservation dates from the beginning of the twentieth century when acts on forests management, hunting and fishing that included some protective measures, were adopted. The first Act, the Nature Protection Act adopted in 1967, had a clearer focus on the international legal norms. It envisaged measures for preservation and sustainable use of the natural resources. In 1992, the Environmental Protection Act, which sets up the contemporary framework of the state policy and management, has been approved. In the same period the Ministry of Environment was established and Bulgaria signed the Bern Convention and the Convention on Biological Diversity. In 1998, the Protected Areas Act was adopted and this is the first specialized nature conservation law. It introduces contemporary, adequate to the international norms, a [system of protected areas categories and defines the hierarchy between the institutions responsible for their management](#). This law has also imposed the elaboration of management plans, determining the concrete regimes for each protected area. The [description and management plans for NATURA 2000](#) are publicly available. In 2002, the relations between the state and municipalities as well as between juridical and real persons have been regulated concerning the protection and the sustainable use of the biological diversity. This Biological Diversity Act regulates the protection of habitats, of species of plants and animals and their biotopes. It introduces the requirements of the Habitats and the Birds Directives, focused on preservation of habitat types and biotopes of plant and animal species. The Act on the Biological Diversity envisages the establishment of National Ecological Network, consisting of three elements – protected zones, protected areas and buffer zones. This National Ecological Network has to include with priority identified SCI sites, Ramsar sites and Important Bird Areas.

Bulgaria is currently in a phase of political and socio-economic transition and faces many challenges in balancing economic and environmental interests. One of these challenges is the development of a sustainable road and railroad network that facilitates the needs for efficient transport of goods and people but does not threaten areas that are especially valuable for nature conservation. At present this is a field where important conflicts occur and decisions have to be taken such as the [motorway to Greece that is planned through the Kresna Gorge](#). The rapidly growing road network in Bulgaria, initiated by EU strategies to construct Pan-European Transport Corridors, results in increasing conflicts with biodiversity objectives and the aim of establishing a NATURA 2000 network. Therefore, one of the big challenges at present is the mitigation of fragmentation of the landscape by roads and railways. The implementation of a plan for road and railroad mitigation will significantly improve the population viability of most threatened wildlife species. This is an indispensable first step in preserving Bulgaria's biodiversity and developing a coherent and sustainable ecological network across the country. A [first inventory has already been made in 2008](#), but the process is slow.



Figure II.32

Bottlenecks in the Bulgarian road and railroad network. Blue bullets indicate existing bottlenecks road and railroad network for wild species. Red: main roads, yellow: regional roads. The bigger the bullets the more species are involved.

Slovakia

The concept of ecological networks was formulated in the 1970s as the Territorial System of Ecological Stability (TSES) and it has been applied in the planning practice in former Czechoslovakia and still now in **Slovakia** as well as in the Czech Republic. The main purpose of the establishment of ecological networks in the Slovak approach is the preserving of spatial ecological stability of the landscape. The concept of TSES was a pioneering ecological network at national, regional and local levels. It was one of the first comprehensive concepts of this kind (Miklós *et al.*, 2019). It represents a hierarchical connectivity concept of ecological core areas (biocentres) of different importance connected by biocorridors. Biocentres maintain the food chain as well as the conditions for reproduction, protection, resting place and shelter. The main principle was that a set of valuable nature reserves does not automatically constitute an ecological network: it becomes one only after interconnectivity of the reserves has been established.

TSES is incorporated into the legislation for territorial planning and nature conservation (Buček & Lacina, 1984). TSES developed in Slovakia as a part of the so-called General Ecological Model of the Slovak Socialist Republic and later incorporated into first official environmental policy issued by the Slovak Commission for the Environment (Miklós, 1991). TSES projects in Slovakia were carried out top-down, from the General Plan of supra-regional TSES, through regional to local TSES. Following the General Plan, the National Ecological Network (NECONET) was set up based on the concept of the European Ecological Network and building on principles of the Dutch National Ecological Network. The regional TSES (RTSES) have been developed in the years 1993–1995 for all 38 regions at a scale of 1:50,000. Local TSES projects were in general made as a part of spatial planning procedures.

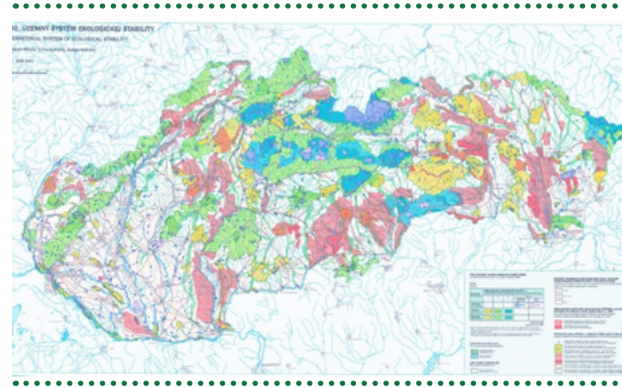


Figure II.33

TSES Slovakia (*Landscape Atlas of the Slovak Republic, map 92, Ministry of the Environment, 2002*)



Figure II.34, left

Floodplain restoration as compensation for the Gabčíkovo–Nagymaros Dams.

Figure II.35, right

Special Protection Areas in Slovakia

When Slovakia joined the EU, the European system of NATURA 2000 was integrated in the TSES projects. The establishment of biocentres and biocorridors is the best-developed part of the TSES system. Also “ecostabilising measures” are a part of the TSES especially in agricultural areas. In the first decade these aspects were less elaborated and used; nevertheless, the concept of the TSES is considered as one of the most notable and evident successes of incorporating landscape-ecological principles into the legislation and spatial planning. In 1990, spatial planning came under the Ministry of Environment. As a consequence, the law “turned greener” through amendments which define that:

- » A landscape-ecological plan is an obligatory regulation for utilisation and spatial arrangement of territory.
- » TSES or its elements (biocentres, biocorridors, interactive elements, and ‘ecostabilising’ measures) are defined as an obligatory designation.
- » The purpose of the act is, inter alia, preserving the diversity of conditions and life forms on earth, as well as achieving and maintaining ecological stability of TSES and its whole-territory structure.
- » Establishing and maintaining of TSES is a public interest.
- » New “networks” are integrated: the national network of protected areas and the European protected areas network NATURA 2000.

Czech Republic

In the **Czech Republic** nature conservation has a long tradition as the first forest reserve (the Hojná Voda Virgin Forest) was created in southern Bohemia in 1838. The concept of ecological networks and its application in the planning practice in former Czechoslovakia and later in Slovakia as well as in the Czech Republic was formulated as the territorial system of ecological stability TSES. The Czech National Council Act No. 114/1992 (Gazette on Protection of Nature and the Landscape, 1992) is based on an integrated approach. Its main idea is that not only specially protected parts of nature should be conserved for the future but that it is also important to maintain natural processes in ecosystems and landscapes, stressing diversity and importance of life-supporting processes in various biological systems. The purpose of the law is to contribute towards the preservation and restoration of the natural equilibrium in the landscape. The present legislation based on a holistic or integrated approach has also tried to deal with unprotected agricultural and forest lands, using a national concept of TSES (Territorial System of Ecological Stability) at various levels. The concept of TSES started in the 1970s as a pioneering ecological network at national, regional and local levels in Europe. The Ministry of Agriculture is responsible for forest management (except in the three national parks) which is expressed in the Forest Act (Act. No. 289/1995 Gazette). Therefore, the program defines more than 40 priorities

in medium- and long-term scale for nature conservation and landscape protection in the Czech Republic and is explicitly based on cross-sectoral approach, incorporating nature management issues in various sectors (agriculture, forestry, regional development, physical planning, transport, tourism, education, etc.). In 1994, the Ministry of the Environment of the Czech Republic implemented the [National Biodiversity Conservation Strategy in the Czech Republic](#) dealing with biological diversity at all three levels (genes, populations/species, and habitats/ecosystems) as a basis for its holistic approach.

Additionally, in the Czech Republic landscape fragmentation is an issue of importance and maintenance of corridors and landscape elements is an important aspect of the Czech nature conservation policy. Not being a part of the nature policy in the 1980s, they have been integrated into the TSES concept in the 1990s as Significant Elements of the Landscape (SLE) and legally recognised (Act 114/1992). They are considered as the “skeleton of ecological stability in the landscape” and are partly legally protected. The non-legally protected elements can change and disappear or be renewed, depending on human intervention or natural processes. Part of the landscape elements support fish and mammal movements.

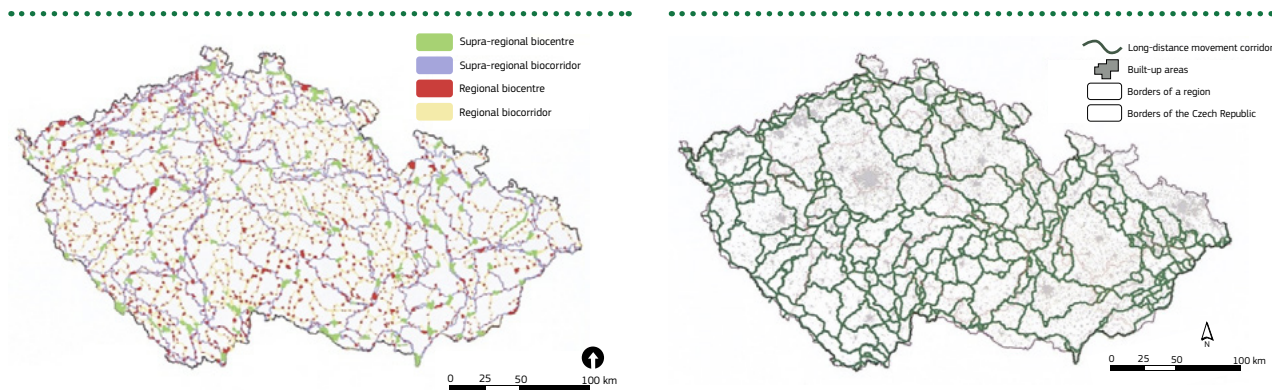


Figure II.36, left

Terrestrial System of Ecological Stability (TSES) for the Czech Republic

Figure II.37, right

Large distance mammal corridors in the Czech Republic

Estonia

In **Estonia**, the roots of nature conservation lie in folk religion. The harsh environment created a strong respect for nature and preservation of the living environment. The nature conservation function of folk religion derived from the closely connected ideas of sacredness and taboo. Because of the vitality of prohibitions and the great number of sacred natural objects, this heritage has been preserved over the centuries. In 1297, the Danish King Erik Menved issued a strict order to prohibit cutting of coastal woods on four islands near Tallinn. The Swedish forest regulations of 1647 and 1664 contained several provisions on forest conservation: ban on cutting of oak, wild apple, rowan and bird-cherry trees. In the beginning of the twentieth century the

main focus of activities turned on preservation of natural areas and strengthening of the nature protection movement. The first protected area in Estonia was established in 1910 – a bird sanctuary on the Vaika islands of the West-coast of Saaremaa. The first Nature Conservation Act was passed in 1935.

At present, the basic frame for nature conservation is set in the Estonian Constitution (1992) stating in Article 5 that: "... natural resources are of national value and they should be used sustainably". Article 53 states, that "...every person shall be obliged to preserve the human and natural environment and to compensate for damages caused by him or her to the environment." In June 1994 the Act on the Nature Conservation Objects (SH 1994, 46, 773) was passed, being one of the main instruments concerning nature conservation. The act is elaborated in several regulations. On March 12, 1997, the Parliament adopted the Estonian Environmental Strategy, which contains following aims on Maintenance of Landscapes and Biodiversity. Tasks set for the year 2010 were among others "to establish a network of nature reserves corresponding to EU recommendations where zones of strict protection (strict nature reserves and special management zones) would cover up to 5% of the terrestrial area of Estonia". The Nature Protection Department of the Ministry of Environment is responsible for national tasks in nature conservation and sustainable use of the earth's surface, environmental management and environmental impact assessment.

The green network is treated both in the Estonian Environmental Strategy (1997) and Environmental Development Plan (1998) and represents the spatial structure of natural areas in the most reasonable way from an ecological, natural, environmental protection and social standpoint. It is also used, in the broader sense as a term of planning, which functionally completes the network of protected areas, connecting them into a complete system with natural areas. In the given areas network communities develop in a natural way, which enhances biodiversity and guarantees environmental stability and social acceptance.

The principles of the ecological network were first applied in Estonia in the 1960s, when it was tried to regulate the use and planning of natural resources. In the years 1979–81 the state ordered "The outline for the protecting and sustainable use of Estonian natural resources" (mapped in a scale 1 : 200 000). The Physical Geography Department of the University of Tartu developed the idea of the ecological network of Estonia, the so-called system of ecologically compensatory areas. These areas were handled as parts of cultural landscape that mitigated the anthropogenic influence on the landscape. The map of Estonian compensatory areas with the explanatory letter was ratified as a basis for planning and developmental action until the year 2005.

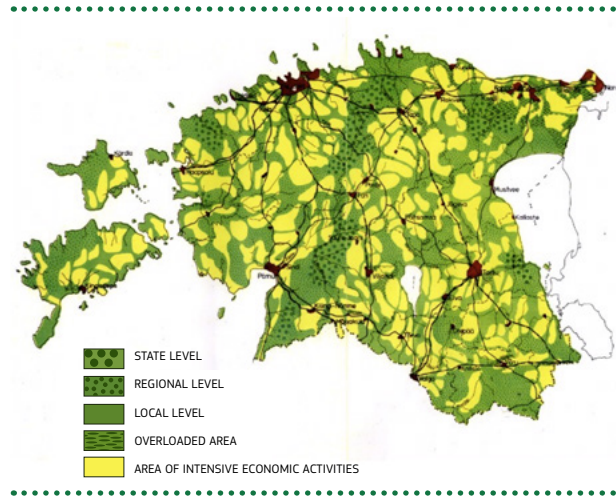


Figure II.38

Network of ecologically compensating areas of Estonia
(Mander et al., 2003)

Determining the green network was one of the chapters in national planning “Estonia — vision 2010”. It suggested that core areas should be determined on the basis of at least two aspects, area and value. ‘Area’ shows the resistance to anthropogenic influence, and the ‘value’ of the given territory is assessed from the natural and environmental protection point of view (landscapes, prioritised associations and protected species of international importance). Natural regions comprising compact natural territories with the area of at least 100 km² were defined as core areas of international importance. Cartographic generalisation shows that such territories form the 12 biggest core areas in Estonia.

‘Compact’ regions with a territory of at least 15 km² are defined as core areas of national importance. As areas of national importance are situated in between the areas of international importance, it makes it possible to mark the most important ‘green corridors’ of the network, which constitute convenient dispersal routes for species between the core areas.

Networks of ecologically compensating areas should fulfil the following main ecological and socio-economical functions in landscapes:

- » **Biodiversity.** Refuges for species (incl. genetic variability). Migration and dispersal tracts for biota.
- » **Material and energy flows.** Material accumulation, recycling and regeneration of resources. Barrier, filter and buffer for nutrient fluxes. Dispersal of human-induced energy.
- » **Socio-economic development and cultural heritage.** Supporting framework (e.g., recreation area) for settlements. Compensation and balancing of inevitable outputs of human society (e.g., supporting traditional rural development).

For all three Baltic countries Ecological networks have been developed at the national, regional and local scale. They have been published together under the name [coordination of the IUCN office for Central Europe](#).

France

France has a long history of habitat protection for hunting purposes. Already in 1791, the status of the national forests has been regulated by law. The law of 1922 on production forests also had the aim of protecting soil against erosion. One of the first modern laws with relevance to the protection of areas was the 1930 law relating to the protection of natural monuments and sites of artistic, historical, scientific, romantic or scenic interest. This law was inspired by a previous law of 1913 on historic monuments. The green and blue frame policy in France is a response to the implementation of the pan-European ecological network and is in line with the objectives of the European

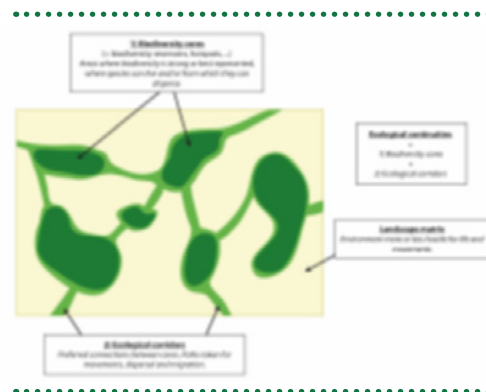


Figure II.39

The French concept the Trame verte et bleu (TVB)

Union biodiversity strategy. Even before the implementation of this policy at the national level, a certain number of communities (regions, departments, natural parks, regional, intercommunal, municipalities) have identified ecological 'continuities' and integrated them into their territorial policies and their planning documents. Since 2007, the green and blue infrastructure is one of the major national projects supported by the 'Ministère de Transition écologique et solidaire'. The main legislative milestones are the law n° 2009-967 on the implementation of the 'Grenelle de l'environnement', or the environmental Round Table that brings together state and civil society in order to define new actions for sustainable development. The second law n° 2010-788 on national commitment for the environment proposes and specifies a set of measures intended to preserve biological diversity. It provides, inter alia the basis for the green and blue infrastructure (Trame vert et blue, TVB), an approach that aims to maintain and restore a green-blue network. It aims to halt the loss of biodiversity by preserving and restoring networks of natural environments that allow species to migrate, disperse and interact.

The TVB policy has been launched in 2007 to reduce habitat loss and fragmentation and to integrate biodiversity into urban planning, to support existing EU Nature and Water Directives (Natura2000 and WFD) as a response to the current biodiversity crisis and a way to encourage ecosystem services. The green and blue framework aims to include the preservation of biodiversity in planning decisions, contributing to the improvement of the living environment and the residential and tourist attractiveness. The national parks, nature reserves, biotope protection decrees, Natura 2000 network, regional natural parks focused on the presence of remarkable or endangered species and habitats are essential. However, they have resulted in the creation of islands of unspoilt nature in increasingly artificialized and fragmented territories.



Figure II.40, left

Wooded habitat network at national level.

Figure II.41, right

The 'Trame vert et bleu' of Lorraine.

The green and blue infrastructure complements these policies by taking into account the ecological functioning of ecosystems and species in land use planning and relying on ordinary biodiversity. The trame vert et blue consists of five subnetworks, the wooded subnetwork, the open land subnetwork, the wetland subnetwork, the littoral subnetwork and the aquatic subnetwork constituting together the French ecological networks. Based on national guidelines regional and local networks are being developed. Regional ecological networks (REN) were designed with several methods freely chosen by the Regions (e.g. least-cost path). They are mapped at 1:100 000 and accessible in an atlas. Barriers to species movements (roads, dams, other infrastructure) have been identified and plans for actions formulated to preserve or restore the core areas and corridors.

The Netherlands

In **the Netherlands**, the parliament approved in 1990 the Nature Policy Plan (*Natuurbeleidsplan*), in which the long-term nature policy of the government was presented. This policy principally aims at the sustainable conservation, rehabilitation and development of nature and landscape. The government introduced in this policy plan the National Ecological Network (*Ecologische Hoofdstructuur, NEN*). The aim of NEN is to develop a coherent network of natural areas (core areas and nature development areas) that are connected by ecological corridors. With this concept of NEN, the government launched a new approach to nature conservation, replacing the traditional protection of natural areas in their original status, with an active form of protection and nature development, setting clear priorities in a wider (inter)national context.

Per 2015, the Netherlands had 66 ecoducts or green bridges. The concept of 'robust corridors' was added. The realisation is coordinated by the Multi-year Defragmentation Program (MJPO) which ran from 2005 until 2018. It was decentralised and further planning implementation was handed over to the provinces.

In 2012, during the economic crisis, re-orientation and decentralisation of the national Nature policy took place. The original plan of the NEN was abandoned and aims were reduced to more or less the area that had been realised at that moment. The national agency responsible for land acquisition and the realisation of the NEN through land acquisition was shut down. Also, the realisation of those robust ecological corridors that were not finished was stopped and nature policy was passed over by the national government to the provinces. Most national green bridges were already realised, those plans for corridors and bridges



Figure II.42

National Ecological Network of the Netherlands.

not yet realised were terminated. The NEN changed its name to the Netherlands Nature Network consisting of twelve provincial ecological networks. The provinces continued the national policy with different ambitions and intensities.

Due to it being a strongly urbanised country, nature faces severe pressures in the Netherlands from urban expansion, infrastructure, intensive agriculture and recreation. The Utrecht Hills (Utrechtse Heuvelrug) stretch from north-west to south-east in the centre of the country and consist of several important nature reserves and a national park. This area is dissected by urbanised areas, several motorways and railroad lines, which were making it nearly impossible for fauna to move through the landscape. However, the area is part of the Netherlands Nature Network, and therefore the province of Utrecht and the responsible nature management agencies were mandated to restore connectivity for wildlife.

Therefore, the owner and manager of transportation infrastructure is responsible for financing and implementing all ecopassages (bridges and culverts); the funds do not come out of the nature conservation budget. This is the main reason why ecoducts and culverts were not implemented in the 1990s. The province's mandate to restore connectivity and lack of actions by the national road authorities (which had an implementation budget) created tensions. Coordination between national and provincial authorities was needed for realizing necessary connecting measures for provincial roads for an optimal return on investments.

A renewed effort was made to speed up the process of landscape defragmentation with the Netherlands Nature Network with extra funds. The province of Utrecht planned priority measures for the Utrecht Hills to improve wildlife movement across national motorways and railroad



Figure II.43

The oldest green bridge in the Netherlands over motorway A50 in 1988

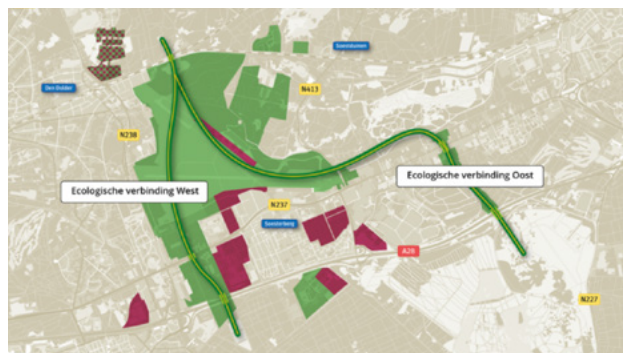


Figure II.44, left

Areas of Connectivity Conservation west and east in the Utrecht hills. The numbers indicate motorways (red) and link roads (yellow). The blue names indicate built-up areas, purple: heathland, green: forest.

Figure II.45, right

Ecoduct Op de Hees, crossing the railroad Utrecht-Amersfoort. A recreational cycle path is situated at the left side of the bridge.

lines. Both the state and the province contributed to the plan by [implementing defragmentation measures for the roads under their responsibility](#). The project “Hart van de Heuvelrug” consists of two main corridors that merge in the north. Whereas the western part is a forest corridor, the eastern ecological part is a heathland corridor. Both corridors contain many small tunnels to cross roads in the area. To realize connectivity, five additional ecoducts have been built in these two areas of connectivity conservation, including the Ecoduct Op Hees, which was completed in 2013 and crosses a busy railroad line between the cities of Amersfoort and Utrecht. In addition to facilitating wildlife movements, it also serves as a recreation corridor, the ecoduct has been made wider to allow cyclists and pedestrians to cross the railway via the ecoduct. This Area of Connectivity Conservation acts as movement routes for mammals (such as roe deer, badger and tree marten) and as a temporary living and breeding area for smaller mammal species.

Annex II: Definitions of used terms

Connectivity: a measure which defines how easily species can move to other habitat patches.

Carrying capacity: the maximum population of a species that a specific ecosystem can support indefinitely without deterioration of the character and quality of the resource, i.e., vegetation or soil.

Dispersal distance: the capacity of most individuals of a species to bridge distances to new potential habitat.

Ecological network: a network constituted of physically separated habitat patches, for a population of a particular species or a set of species with similar requirements that exchanges individuals by dispersal.

Green Infrastructure: GI brings together both the need for strategic planning of green and open spaces and the science of ecosystem services. It promotes the multifunctional nature of space and the benefits that appropriate management approaches can deliver. It recognises the need to plan land use for specific purposes such as farming, nature protection and development but also provides the tool and methods to identify needs and opportunities to enhance the environment and its functions (*John, Neubert, & Marrs, 2019*).

Habitat: an area which can support living organisms for at least part of their life cycle.

LARCH: a landscape-ecological model (acronym for: Landscape ecological Analysis and Rules for the Configuration of Habitat) used to visualise the persistence of metapopulations in a fragmented environment.

Local population: a small population of at least one pair, in one or more habitat patches within the home range of a species. A local population on its own is not large enough to be sustainable.

Local distance: the local distance is the distance covered by a species in its daily movements. This is sometimes called the home range, but home range is usually the area utilized by the species from which you can calculate the local distance.

Metapopulation: a set of local populations in an ecological network, connected by inter-patch dispersal.

Minimum Viable Population (MVP): a population with a probability of exactly 95% to survive 100 years under the assumption of zero immigration.

Network coherence: the spatial coherence of habitat, the network of a species

Network distance (or network gap-closing distance): maximum dispersal distance of a species within non-habitat (e.g., farmland).

Spatial cohesion (landscape connectivity): a relative measure that can visualise the weakest and strongest parts in the ecological network of a certain species.

Viable population: a viable (or persistent) population has a probability of at least 95% to survive 100 years.