A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfilment of the Degree of Master of Science

Connecting science, policy and practice: the challenges to protecting ecological connectivity in Poland

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July, 2014

Budapest

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ABSTRACT OF THESIS submitted by:

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for the degree of Master of Science and entitled: Connecting science, policy and practice: the challenges to protecting ecological connectivity in Poland

Month and Year of submission: July, 2014.

Ecological connectivity has been on the environmental agenda in Poland since the 1990s with many unfulfilled commitments and unachieved goals. In order to analyse the implementation of ecological connectivity protection measures in Poland, research was conducted on the state of connectivity discourse in Poland. In addition to a literature review of ecological and sociological studies and practical reports, interviews with 20 professionals dealing with ecological corridors were conducted and important planning documents were analysed (2030 Spatial Planning Conception for Poland, EIA of National Road Construction Program 2011-2015 and 40 so far completed Natura 2000 management plans). The research found many methodological problems in corridor designation (divergent habitat requirements of different species, issues of scale, deficient data and lack of consideration for social constraints) and implementation (weak and uncoordinated system of spatial planning, lack of political support, lack of legal protection and low public participation and support). Document review found that concepts of ecological connectivity, despite not being implemented on the ground, have infiltrated into policy documents but are more present at the higher level of governance. At lower levels (such as county spatial plans and Natura 2000 management plans) inclusion of connectivity issues is still unsatisfactory. The research found that the main obstacle to successful corridor protection is lack of support at the local level and the perceived inconsistency between environmental protection and economic development. Results of this study have been used to propose policy recommendations in order to help advance the implementation of connectivity protection measures. (247 words)

Keywords: ecological corridors, ecological connectivity, ecological network, spatial planning, landscape, Natura 2000, green infrastructure, policy, implementation, Poland

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Acknowledgements

The author of this thesis wishes to thank everyone whose contribution, guidance or support has made this thesis what it is. Firstly, I wish to thank my research participants – without your good will and readiness to share your knowledge, experience and time this research would not have been possible. Special thanks must go to the supervisor of present thesis, Prof. Ruben Mnatsakanian – for his guidance throughout this research – and to the staff of the Environmental Sciences and Policy Department at Central European University – for devoting their work to our education. Last but not least, thank you to my family and friends – for believing in my thesis writing and other abilities.

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List of Abbreviations

ASCI	Area of Special Conservation Interest
BD	Birds Directive
CBD	Convention on Biological Diversity
EC	European Commission
ECNC	European Centre for Nature Conservation
ECONET	Ecological Network
EEA	European Environmental Agency
EEC	European Economic Community
EIA	Environmental Impact Assessment
EU	European Union
FOEN	Federal Office for the Environment
GI	Green Infrastructure
GIS	Geographic Information System
HD	Habitats Directive
HNV	High Nature Value
IALE	International Association for Landscape Ecology
IUCN	International Union for the Conservation of Nature
NEN	National Ecological Network
NGO	Non-Governmental Organisation
NLPA	Nature and Landscape Protection Agency
PAS	Polish Academy of Sciences
PEBLDS	Pan-European Biological and Landscape Diversity Strategy
PEEN	Pan-European Ecological Network
SAC	Special Area of Conservation
SCI	Site of Community Importance
SEA	Strategic Environmental Assessment
SPA	Special Protection Area
TSES	Territorial System of Ecological Stability
UK	United Kingdom
USES	Územní Systém Ekologické Stability
WWF	Worldwide Fund for Nature

"Science may be described as the art of systematic over-simplification" (Karl Popper).

1. Introduction

Intensity and diversity of life forms depend on the spatial and temporal distribution of materials (both organisms and organic matter) as well as energy (Puth and Wilson 2001). These, however, are seldom spread out evenly, rather, they are concentrated in patches across the landscape matrix due to the patchy and discontinuous distribution of soils, bedrock, topography, hydrography and natural landscape dynamics (Forman 1995). While in in a permeable landscape such a model works well, human appropriation of the vast majority of landscape has created numerous barriers to the exchange and flow of biological materials and energy.

Present ecosystems are highly fragmented, a phenomenon that is especially severe in the developed world. Strips of forested land and other natural habitats valuable for the remaining wildlife are isolated and surrounded by cities, residential and commercial areas, industrial sites and cut into parcels by roads, highways, railways and power lines. High human population density, urbanization and urban sprawl, development of linear infrastructure, agricultural intensification, unsustainable tourist use, intensive forestry activities, damming and channelization of rivers as well as natural phenomena such as forest diebacks are causing a rapid decrease in landscape permeability.

Habitat fragmentation has been found to lead to the isolation of populations and their habitats, restraining of animals' home ranges and thus restricting their chances to find food, mates and shelter, halting dispersal and expansion of species and lowering colonisation rates, creating a barrier to genetic exchange between

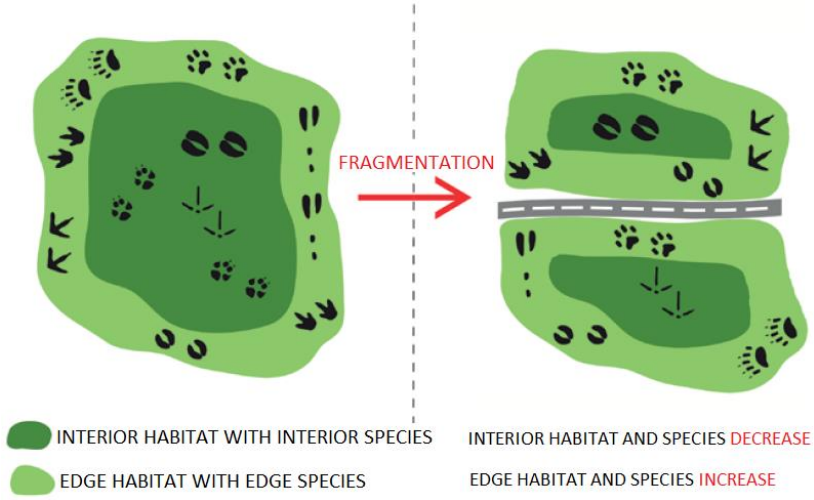


Figure 1 Fragmentation causing core habitat loss (EEA 2011)

populations and lowering genetic diversity within populations and finally leading to extinction of local populations and decreasing local and global biodiversity. Biological modeling research (Lefkovitch and Fahrig 1985; Fahrig and Meriam 1985) has shown that populations in isolated patches have much lower chances of survival, while connectedness to other patches increases the probability of survival proportionately to the size of the interconnected area. Unfortunately, protected areas are usually too small to support viable populations of vulnerable wide-ranged low-density species such as the grey wolf *Canis lupus*.

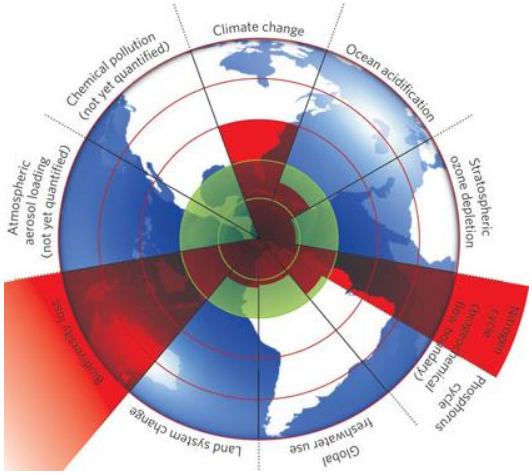


Figure 2 Planetary boundaries (Rockstrom et al. 2009)

Habitat loss is the single largest threat to biodiversity and was reported by Rockstrom *et al.* (2009) to be the most exceeded planetary boundary. The current extinction crisis has been classified by many as the largest mass extinction of species in the Earth's history (Barnosky *et al.* 2011).

Thus, conserving habitat in order to preserve biodiversity should be our greatest environmental priority. The ability to disperse freely and exchange genetic material becomes even more important in the face of climate change, where animal and plant species' ranges are expected to shift in response to changing conditions, temperatures and precipitation patterns (McLaughlin *et al.* 2002).

Thus far, safeguarding ecological connectivity has proven more difficult than the traditional protected area approach, as it necessitates a broader and more holistic approach to land use and spatial planning. Questions regarding the correct designation of corridors and challenges in the implementation of corridor protection have not yet been overcome in many countries, including Poland.

1.1 Aims

The author of this thesis wishes to contribute to solving the problem by investigating the issues around ecological corridor implementation and operationalisation in Poland as well as proposing policy recommendations for better management and incorporation of connectivity into policy, law and spatial planning. Thus the main aim of this thesis can be summarized as: **to investigate the state of implementation of**

ecological connectivity protection measures in Poland and the associated problems and challenges. Within that aim, the author sees it useful to carry out the following objectives:

- Investigate the scientific grounds for establishing ecological corridors
- Research types and examples of ecological corridors and networks
- Learn about policy, legal and implementation solutions
- Explore the current situation of connectivity protection in Poland and investigate the challenges to its effective implementation
- Propose policy recommendations to advance the discussion

1.2 Contribution

Although much research has been conducted on the science behind ecological corridors, developing effective policy, legal and planning tools and implementing protective measures remains problematic. Thus, focusing on ways to implement connectivity policies is seen as a priority over discussing various approaches to corridor designation and ecological network conceptions. Although some policy research has been carried out, a more holistic approach is necessary to further the understanding of the situation and the obstacles to successful connectivity protection in Poland.

1.3 Outline

Firstly, the state of current literature on the science behind ecological connectivity, underlying theories and concepts, corridor criticism and concrete examples of ecological networks, including the situation around ecological connectivity in Poland, are discussed. *Results* section presents findings from qualitative interviews as well as the more quantitative document review data. *Discussion* critically explores both the designation and implementation problems for ecological corridors as well as dissecting the available legal and planning protection tools and their potential. The thesis concludes with policy recommendations and final conclusions.

2. Literature Review

2.1 Theory

As ecological corridors deal with migration, it is important to first look at the biology of species movement and the scientific theories that explain it.

2.1.1 Species migration

Animal and plant populations exist in space and time, which shape and constrain them (McArthur and Wilson 1967). Species movement can be divided into two kinds: migration which is cyclical and dispersion which is not. Reasons for movement include finding fodder, escaping predators and competitors, looking for partners, comfortable reproduction, shelter and resting areas, accessing seasonal or ephemeric resources and increasing one's home range (through colonisation or re-colonisation) (Bouwma *et al.* 2002). In terms of scale, movement can be local (within a species home range), migratory (regular or seasonal) or dispersive (from the place of birth to the place of reproduction) (Caughley and Sinclair 1994; Ims 1995). The possibility of movement is especially important in dealing with environmental stochasticity such as natural catastrophes and disease outbreaks as well as to avoid inbreeding, facilitate genetic exchange and preserve genetic variability (Deodatus *et al.* 2013).

Figure 3 Lynx crossing the street in Żegiestów village, Poland, 16.11.2012

2.1.2 Island biogeography theory

Island biogeography theory describes how ecosystem patchiness affects species richness. Originally applied to islands, the term *island* has come to mean any habitat (suitable for a given species) which is surrounded by another habitat (unsuitable from the given species point of view). It states that species richness in any given ecosystem depends on the rates of immigration and extinction, which are further dependent on the distance of the habitat patch from the source of colonisation (the patch producing surplus individuals). The further the habitat patch is located from the source, the less likely it is that it will be colonised. The probability of extinction of the local population, on the other hand, is inversely proportionate to habitat size. Larger habitats are less

prone to stochastic extinctions and they also attract more immigrants who can prevent local extinction (MacArthur and Wilson 1967).

2.1.3 Meta-population theory

Similarly to the island biogeography theory, the meta-population theory deals with source – sink dynamics. The theory states that any population will eventually become extinct due to unfavourable stochastic events (Hanski and Gilpin 1997). The smaller the population, the sooner extinction will occur. However, a meta-population which is a set of interconnected populations of which some are sources (they produce a surplus of individuals who emigrate) and others are sinks (they accept immigrating individuals) is thought to be more stable than the sub-populations composing it. A healthy meta-population can often save a sub-population from extinction, thus proving that movement possibility between populations is crucial to long-term survival (Keymer *et al.* 2000).

2.1.4 Theory of landscape polarization

Proposed by Boris Rodoman, the theory of landscape polarization states that biosphere should be categorized into functional zones and managed according to land use intensity (Rodoman 1974). Heavily modified areas should be adjacent to natural or moderately used terrain to compensate for the habitat loss and ensure overall ecological stability thus creating a balanced self-regulating environment (Bennett *et al.* 2006).

2.1.5 Application to nature conservation

All three theories are very relevant for nature protection, as protected areas, especially in largely urbanized countries, constitute *islands* in the middle of highly modified anthropogenic landscape. Many studies, including that by Newmark (1987) confirmed that larger and better interconnected protected areas display higher species richness. Ecological corridors are thus understood to be important for the successful functioning of protected areas.

2.2 Ecological connectivity: theory and terms

Having established the importance of retaining/restoring ecological connectivity for biodiversity protection, it is now important to further explore the different associated approaches and terms.

2.2.1 Ecological corridors

Ecological corridors are structures that facilitate the movement of organisms, genes, information, nutrients, energy and water as well as disturbances. Although usually discussed in relation to large mammals, corridors are important for animals of all sizes, plants (functioning animal corridors are necessary for the dispersal of zoochorous plants), fungi, protists and diaspores. Puth and Wilson (2001) mention the two fundamental aspects of ecological corridors to be *'movement'* and *'channelization'.* Ecological corridors are most commonly thought of as strips of forest; however, they can also be comprised of open-space grasslands, wetlands or watercourses depending on the target species habitat preferences. As different species often have radically different requirements, what constitutes a corridor for one can constitute a barrier for another (Fraser 1999). For organisms with narrow habitat specialization, it is best when the corridor consists of the same vegetation as the patches that it connects (Pchałek *et al.* 2011). When creating corridors the concept of an *umbrella species* is often used to mean a species whose habitat requirements, when fulfilled, satisfy the needs of many other organisms. As species differ greatly in size and range, the choice of an appropriate scale for a corridor can also be tricky. While underground passages connecting two sides of a highway might restore habitat connectivity for amphibians, sizeable wildlife overpasses and migratory corridors designated across an entire country or continent are needed to ensure connectivity for large mammals. The question of scale applies equally to obstacles. While to a snail a forest brook is an impassable boundary, it is easily passable to a bear who in addition will find it a valuable feeding ground (Puth and Wilson 2001). Related to scale, optimal corridor width also depends on the target species. Studies have shown that large mammals prefer wide corridors (Gustafsson and Hansson 1997) while rodents, birds and invertebrates use smaller scale migratory passages. Although in general, the wider the corridor, the better, some scholars have suggested that unnecessarily wide corridors may compromise the overall migratory direction (Soule and Gilpin 1991).The travel mode of the animal constitutes another important characteristic that influences what corridor it will use. Animals crawl, walk, run, jump, swim, fly or travel by a vector (Puth and Wilson 2001). While organisms with low mobility or low tolerance to ecotones or mosaic habitats require continuous corridors, others are satisfied with so called *stepping stones* (Hilty *et al.* 2006). The latter are understood as habitat patches

too small to support a population but large enough to support occasional migrants (Pchałek *et al* 2011). Interestingly, *stepping stone* corridors may be dynamic and do not need to be temporarily continuous, as long as when one stepping stone is lost, another one appears. Similar temporary corridors may also be created by seasonal floods or forest fires (Puth and Wilson 2001).

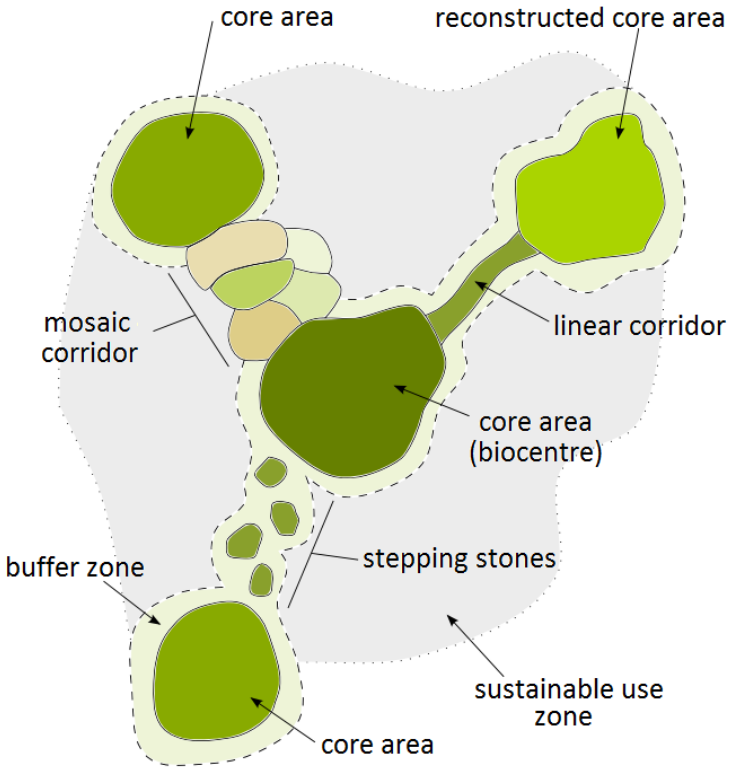


Figure 4 Corridor types (by structure) and accompanying concepts (Bennett et al 2006)

Corridors can be defined by their function (connectivity) or structure (connectedness) (Gustafsson and Hansson 1997). The former ecological approach understands corridors as routs that allow for dispersal and migration, while the latter physiographic approach sees corridors as physical structures that maintain landscape connectivity, narrower than the patches that they connect, according to the patch-corridor-matrix model (Forman 1995). Such structural corridors are necessarily linear, they connect separate patches, are uniform in terms of habitat and are systematically different from the surrounding landscape matrix (Pchałek *et al.* 2011). Thus, the physiographic definition encompasses unutilized corridors while excluding mosaic landscapes (such as mountains, river valleys etc.) that are ecologically permeable. Finally, the two definitions can be merged to form a new definition where a corridor is understood to be any spatial structure that allows for animal and plant dispersal (Hilty *et al.* 2006). Thus, in addition to facilitating species' movement, corridors also have the function of maintaining visual and aesthetic landscape connectivity (Haaren and Reich 2006).

2.2.2 Boundaries

The idea that corridors constitute permeable landscape by definition require the existence of impervious landscape features. Puth and Wilson (2001:22) define boundaries as "area[s] of sharp gradients in ecological flows that slow (…) or redirect (…) flows of organisms, matter, or energy between patches". Boundaries and ecotones are a natural occurrence; however, human alteration has increased their severity and frequency. Roads, paths, power lines or dams act as barriers to natural flows between systems and populations. Puth and Wilson (2001:22) believe that any discussion on corridors cannot be discussed without mentioning boundaries, as they are located at "opposite ends of a gradient of permeability". Despite the fact that most boundaries are man-made, the concept itself is not limited to anthropogenic factors. Winter ice sheet on top of a lake or a tree that has fallen into a brook can constitute significant natural boundaries to biological flows. "By modifying ecological flows as they move across the landscape, boundaries function to delimit populations, communities, and ecosystems" (Puth and Wilson 2001:22). An interesting example of how the definition of an ecological corridor can be widened is provided by the snow geese *Chen caerulescens* who transport phosphorus and nitrogen from agricultural areas to wetlands, thus channelling the flow of nutrients across an otherwise impervious boundary (Post *et al.* 1998).

2.2.3 Rivers as corridors

In the past, rivers were thought to be structures separate from their surroundings that transported matter and nutrients in a single direction (Forman 1995). However, it is now widely understood that water bodies have flexible boundaries and thus strongly affect the surrounding ecosystems. Rivers constitute both corridors and boundaries, e.g. they aid plant seed dispersal, but restrict the movement of rodents or fires redirecting them to other habitats (Parendes and Jones 2000). Nevertheless, boundaries between aquatic and terrestrial systems are not impervious. With the help of floods and animals such as beavers (Naiman *et al.* 1994) or water birds (Post *et al.* 1998) that occupy both types of habitats, matter and nutrients flow between the two. Within water flows natural structures such as waterfalls and man-made obstacles such as dams and culverts can block movement. Physical and ecological properties of a river such as the level of oxygen, temperature, speed of the flow or resident predators can also limit its permeability (Puth and Wilson 2001). Again, boundaries

are not universal; waterfalls constitute an obstacle for most fish but not their larvae (Radtke and Kinzie 1996). A beaver's dam which constitutes a barrier for in-river flow, may constitute a stepping stone that helps terrestrial animals to cross what is a barrier to them – the river itself (Puth and Wilson 2001). Habitats along boundaries such as riparian zones are now also considered important biodiversity corridors (Galle *et al.* 1995, Naiman *et al.* 1993). In a study by Rouget *et al.* (2006) buffer zones along rivers scored higher in terms of conservation value than forested land corridors, in seven out of eight categories. Thus, it can be seen that rivers themselves and ecotone habitats along their banks both constitute important migratory corridors.

2.2.4 Corridor typology

Based on the above variables the following typology of ecological corridors can be helpful in understanding the complexity of the concept. The lists under each category are indicative of the possibilities rather than exclusive. Furthermore, correlations exist between the various categories, i.e. selecting a certain option under one category may determine the outcome in several others.

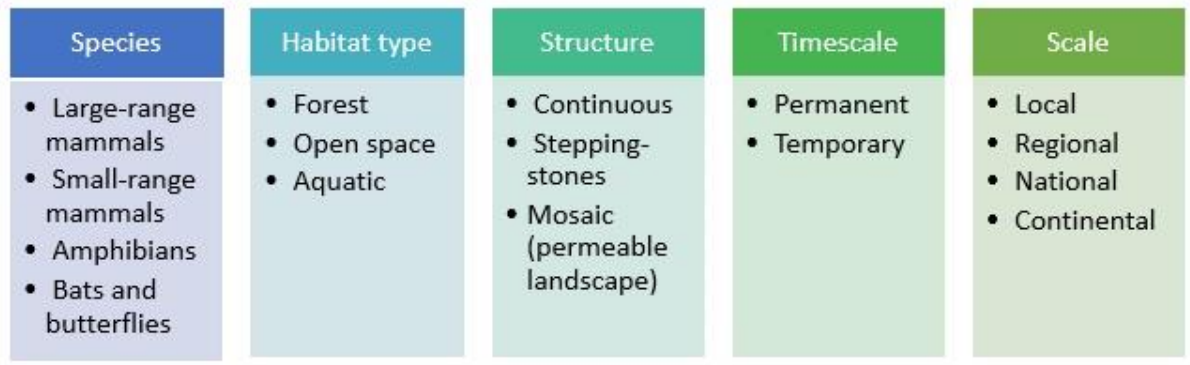


Figure 5 Corridor typology by various variables

2.2.5 Ecological networks

As discussed in the previous sections, scale is essential in thinking about corridors; a mere corridor for bears constitutes a habitat patch for many smaller organisms. As ecological corridors have come to mean individual structures, the notion of ecological networks (or *greenways*) has been carved to mean a system of corridors covering a whole region or even an entire continent. Ecological networks are usually composed of core habitats surrounded with buffer zones, restoration areas and corridor passages between them (Bouwma 2002) as illustrated in *Figure 4*. Most ecological networks are hierarchical and focus on certain species or habitats as well as adopting a certain scale (the area that the network is meant to cover). Areas for ecological networks are usually

selected based on occurrence of important/endangered/characteristic/endemic species or habitats or contribution to ecological coherence (Opstal 2000). There have been several attempts to design a measure of landscape fragmentation, which could inversely be used to indicate (lack of) connectivity. The best one to date calculates the probability that 2 randomly selected points located in a natural habitat are connected in such a way that an animal can move from point 1 to point 2 without having to cross a road/urban area etc. (EEA 2011b). However, as much as designing an ecological network poses a difficulty and comprises many subjective choices, so does measuring connectivity. Here too, one needs to select an appropriate scale, a species and decide whether to consider natural barriers such as rivers. This relates to frequent criticism that econets lack targets (Turnhout 2009) which will be discussed in more detail in the chapter on *Corridor criticism*.

The Natura 2000 Network

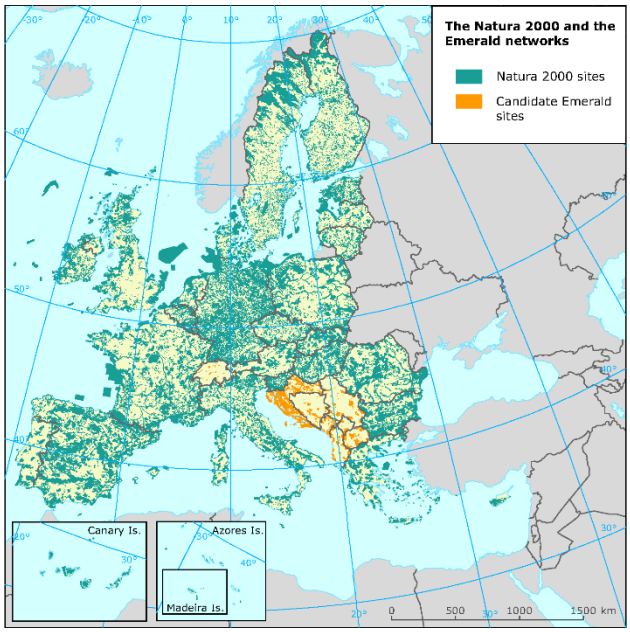


Figure 6 Natura 2000 Network (EEA 2011b)

The European Union adopted the Birds Directive (1979) and Habitats Directive (1992, known jointly as the Nature Directives) as a way to fulfil its obligation under the Bern Convention (1979) to create an Emerald Ecological Network on its territory. Thus, Natura 2000 sites (both Special Protection Areas for birds and Special Areas of Conservation) are the European Union's contribution to the Emerald Network which mandates the designation of Areas of Special Conservation Interest (ASCI).

The network presently covers 18% of the EU's territory. Although it is not a spatially continuous network as such, it aims to protect species important and threatened at the continental level, thus coordinating the nature conservation efforts of member countries. Natura 2000 sites are not strictly protected areas, however, certain regulations and limitations regarding environmentally harmful activities exist. Investments in SPAs and SACs undergo a compulsory environmental impact

assessment. Although projects detrimental to the natural environment should not be carried out, they may be granted permission in case of *overriding public interest* and in the *absence of alternative solutions* (Council Directive 92/43/EEC). In such cases ecological compensation and adequate enlargement of the affected Natura 2000 site in another place are mandatory.

While landscape representativeness was not one of the selection criteria for Natura 2000 sites, Gerlee (2010) argues that the Polish Natura 2000 network is also adequate for the preservation of landscape diversity. However, despite being a successful conservation tool and broadening the idea of protected areas to encompass sustainably managed zones, the network does not guarantee connectivity for large-ranging animals, at the regional, national and continental scales (Selva *et al.* 2011).

The Pan-European Ecological Network

The creation of a Pan-European Ecological Network was proposed by the Council of Europe as part of the Pan-European Biological and Landscape Diversity Strategy (endorsed by 54 European countries) to ensure the implementation of the Convention on Biological Diversity (1992) in Europe (Bouwma 2002). The network is composed of cores areas, buffer zones, corridors and nature development areas, which have the potential to become corridors or core areas in the future, e.g. sites in need of restoration (Opstal 2000). It should encompass all natural and near-natural areas, endemic European habitats and semi-natural habitats characteristic for Europe but globally endangered as well as all habitats of species endemic in Europe, habitats of characteristic European species that are globally endangered and all flagship species' habitats (Opstals 2000). Thus, PEEN's aims are to protect a range of Europe's ecosystems and species, ensure species' favourable conservation status (by preserving large

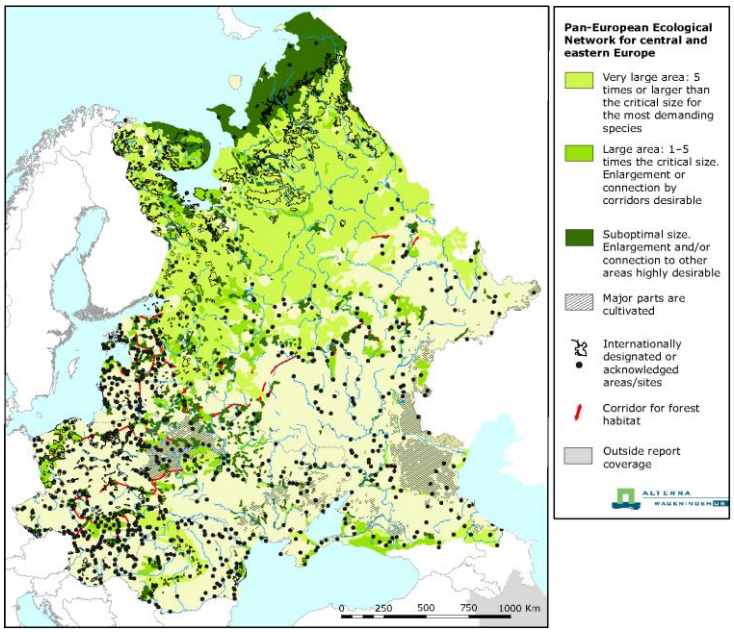


Figure 7 Pan-European Ecological network (ECNC)

habitat areas), protect wildlife's movement possibilities, restore degraded habitats and provide buffers from intensively used zones (Bouwna 2002). Mapping of the PEEN was divided into in three separate regions: central and eastern Europe, south-eastern Europe and western Europe, which were completed between 2002 and 2006 (Jongman *et al*. 2010). Numerous difficulties were encountered during the mapping activities, such as lacking or insufficient data and differing data formats (Jongman *et al.* 2010). PEEN attempts to connect conservation, planning and development policies across Europe using the EU Nature Directives and the Emerald Network as its tools. Its work is divided into three areas: implementation of existing instruments (Natura 2000 and Emerald Networks), development and implementation of national networks, and fostering transboundary cooperation. Accomplishments of PEEN's supervisory committee include developing methodologies, guidelines and targets, evaluating national networks, facilitating knowledge exchange and cooperation as well as awareness raising (Bouwma 2002). However, despite considerable international efforts, many national networks, including the Polish one, have still not been developed nor implemented.

Czech national network – the Territorial System of Ecological Stability

The first national ecological networks were created in Eastern Europe: Lithuania, Estonia and the then Czechoslovakia. They were strongly influenced by Rodoman's landscape polarization theory, to the extent that the Czechoslovak network was named the *Territorial System of Ecological Stability* (*Územní Systém Ekologické Stability* or ÚSES*)*.

The Czech Law on Nature and Landscape Protection (114/1992Sb) defines the role of the TSES as enhancing ecological stability through the protection and restoration of ecosystems and interaction elements. It should have a positive impact on surrounding less stable landscape, maintain a healthy gene pool and preserve and

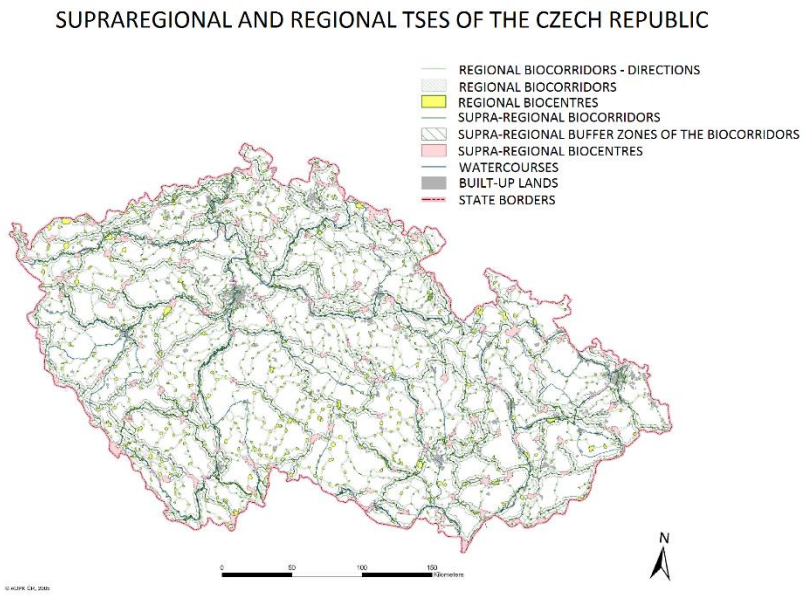


Figure 8 Czech territorial System of Ecological Stability (NLPA)

support species and ecosystem diversity (NLPA 2014). The Czech network is hierarchical and composed of *biocentres* (defined as a natural or semi-natural habitat whose state of health allows for its continued existence without human interference), *biocorridors* (an area of habitat insufficient for organisms to inhabit but which facilitates temporary migration of species between biocentres) and *interaction elements* (areas which connect biocentres with the surrounding unstable landscape). The latter include elements such as green urban spaces, parks, isolated nature reserves, hedgerows and tree clusters in fields which are important for small-range species with smaller spatial requirements. The network functions on three levels (corridors fall into one of the three categories): supra-regional (SR-ÚSES, habitats >1000ha, protects biodiversity at biome level, managed by the Ministry of Environment), regional (R-ÚSES, habitats >10/50ha, protects biodiversity at biochore level, managed by regional authorities and national parks)and local(L-ÚSES, habitats 5-10ha, protects biodiversity at the geo-biocenose level, managed by local municipalities) (NLPA 2014). TSES sites are governed by management plans which constitute the foundation for all land, forest and water management activities in the area and must be taken into account in spatial and other planning documents (Hlavac and Andel 2009).

Timeline

The following timeline summarizes the most important events in relation to ecological networks in Europe.

1965	Theory of Island Biogeography
	Metapopulation Theory
1970	Polarised Landscape Theory
1975	Bern Convention (Emerald Network)
	EU Birds Directive (SPAs)
1980	Lithuanian Nature Frame
	Estonian Network of Compensating Areas
1990	Czechoslovak Territorial System of Ecological Stability
	EU Habitats Directive (SACs and the Natura2000 Network)
1995	Econet Poland
	Pan-European Ecological Network endorsed
2005	Jędrzejewski *et al.*'s corridors
2010	EU Green Infrastructure Strategy

Figure 9 Ecological networks timeline

2.2.6 Corridor criticism

Although this thesis itself does not question the importance of corridors, it is valuable to bear in mind that much such criticism has been put forward.

Simberloff and Cox (1987) were the first scholars to draw attention to the negative consequences of ensuring connectivity such as the possibility of invasive species, diseases and fires spreading more quickly to other patches. Immigrating individuals can threaten local endemic species, cause a loss in local genetic distinctness (*homogenization*) or act as predators, competitors, parasites or pathogens to other species of higher conservation priority (Noss 1987). Thus, despite leading to a higher local diversity, increased immigration does not necessarily increase overall biodiversity. Additionally, there is the possibility that mating individuals from distant populations result in an outbreeding depression, where the resulting set of characteristics of an animal is disadvantageous to its survival (Templeton 1986). Simberloff and Cox (1987) claim that to some extent isolation is beneficial because it allows for differentiation between subpopulations and the development of locally specific adaptations. Secondly, as corridors have a large proportion of edge to habitat, edge effects render them unsuitable for species with narrow habitat requirements, such as strictly forest dwelling animals (Gustafsson and Hansson 1997). Some models (Soule and Gilpin 1991) have even suggested that an addition of low quality corridor habitat may cause individuals to emigrate from better patches and decrease the

overall population size. Despite some voices that poor quality thin corridors increase predation most scientists now agree that corridors can be both a safety hideout and a threat, depending on the species, the parameters of the corridor and the surrounding landscape matrix (Simberloff and Cox 1987). Yet another criticism put forward by Merriam and Saunders (1993) contests the idea of using an umbrella species which favours some habitats while overlooking others. Boitani *et al.* (2007) argue that ecological networks work solely for the few target species on species-dependent scales. Although networks at landscape scale have been proposed, no research has confirmed their uniform usefulness and efficiency (Harrison and Bruna 1999). Gustafsson and Hansson (1997) also stress that forested corridors are not stable ecosystems with natural disturbances such as wind or fire reducing corridor permeability. Fahrig (2003) argues that too often effects of habitat loss and habitat fragmentation are measured jointly. However, while the negative effects of habitat loss on biodiversity are well established, effects of mere fragmentation (separating habitats without a net loss of habitat size) can be both positive and negative and require considerable further research. A practical problem with the designation of migratory corridors is the difficulty of testing for success (Gustafsson and Hansson 1997). Only a limited number of migratory species have been sufficiently studied with regard to corridors; complete studies of *all* of the target species are practically impossible. Similarly, only few selected species have been studied enough to understand the principles behind correct corridor design (Lindenmayer and Nix 1993). Study design and implementation including marking and recapturing of animals or tracking seed dispersal are complex, difficult, lengthy and costly (Gustafsson and Hansson 1997). Thus, designation of corridors requires drawing analogies and guessing the various species' responses. The last major criticism put forward by Simberloff and Cox (1987) is the financial aspect – the worry that corridors, as an expensive conservation strategy, would compete for funding with protected areas.

2.2.7 Response to criticism

In response to the major criticism regarding whether or not corridors contributed to greater species mobility, several meta-data analyses have been conducted. Both Gilbert-Norton et al (2009) and Beier and Noss (1998) found that corridors do, in most cases, ease species dispersal. Having analysed multiple papers the meta-analyses were able to conclude what no single study was able to establish: that ecological

corridors did indeed increase permeability for a wide range of species in a variety of ecosystems. Notably, however, almost a quarter of studied species preferred to use the matrix outside of the corridor rather than the corridor itself. It was thus concluded that corridors are more useful for invertebrates, plants and non-avian vertebrates and less so for bird species. Regarding the connection of habitat fragmentation to biodiversity loss, a study by Collinge (1998) supports an interesting finding: corridors do reduce species loss in the face of fragmentation; however, only for medium-sized patches. It seems that they are not significant for large habitat patches and cannot help when the patches are so small that they cannot support the permanent population.

Arguing for ecological corridors, Beier and Noss (1998) pointed out that much of the debate has been exaggerated from questioning the weak scientific evidence of corridor usefulness to harmful questioning of the value of retaining or restoring connectivity. As Noss (1987) puts it “perhaps the best argument for corridors is that the original landscape was interconnected”. While isolated habitats have always existed, corridors are merely an attempt to restore some natural landscape connectivity and should therefore not be contested (Noss 1987).

2.2.8 Green infrastructure

Figure 10 Green bridge in Germany

As discussed above, a corridor for one species can be a boundary for another and so it is necessary to bear in mind the multiplicity of functions of landscape (Puth and Wilson 2001). It is now widespread to view landscape “as a matrix supporting the entire biotic community" (Simberloff *et al.* 1992). It is this multifunctionality that has led to the creation of a new broader concept of *green infrastructure*.

The European Commission (2013) defines green infrastructure as "a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings. More specifically green infrastructure, being a spatial structure providing benefits from nature to people, aims to enhance nature's ability to deliver multiple valuable ecosystem goods and services, such as clean air or water". The concept of green infrastructure addresses ecosystem connectivity at a multitude of scales, as it encompasses green urban spaces, green roofs, extensive agricultural fields, wildlife overpasses, forests and entire protected areas. GI's environmental purpose is combating habitat fragmentation, habitat loss and land use change to retain ecosystem connectivity in urban and rural areas, to enhance landscape's nature value and protect biodiversity (EEA 2011a). However, green infrastructure as proposed by the EU is also meant to enhance social and economic well-being, create jobs and sustainable economic growth by protecting ecosystem services and natural capital. Green infrastructure captures the socio-economic benefits of nature and ecosystem services such as mental and physical well-being and health, tourism and recreational use, water and air purification which are seldom mentioned when discussing ecological corridors (Noss 1987). Thus, retaining and restoring ecological connectivity is only one of the goals of deploying green infrastructure.

Figure 11 Green roof

2.3 Connectivity in Poland

The natural environment of central and eastern European countries, among them Poland, has for historical reasons remained relatively intact, when comparing it with other more developed parts of the continent. Areas such as the Carpathian Mountains, Masurian Lake District and the primeval forests in north-eastern Poland are still home to large mammals such as the grey wolf *Canis lupus*, brown bear *Ursus arctos*, Eurasian lynx *Lynx lynx*, European wisent *Bison bonasus* and European elk *Alces alces*.

As Eastern Europe is presently catching up with the level of development of its western neighbours, it is now the last moment to protect its remaining ecological connectivity (Keshkamat *et al.* 2009). Phenomena such as urban sprawl, development of linear infrastructure, land use change and construction, increasing tourist and recreational pressure as well as abandonment of High Nature Value farmland contribute to habitat fragmentation and pose a threat to wildlife mobility (Deodatus *et al.* 2013). Thus far, three major conceptions of ecological corridor networks have been proposed, two of which will be discussed in the following sections.

2.3.1 Econet

Devised in 1990s as part of the National Nature Plan project by IUCN Europe, Econet Poland was to be part of the European Ecological Network (Liro 1995). Composed of core areas, linear corridors and stepping stones (mainly bird sanctuaries) which together and cover 46% of Poland's territory, Econet is a hierarchical network of wide corridors that link habitat patches along the shortest path (Liro 1995; Liro 1998). The core areas were chosen based on landscape naturalness, diversity, representativeness, occurrence of rare species and sufficient size, while corridors were chosen to be composed of habitats similar to the patches they connected, represent diverse land use and use natural corridors such as river valleys (Liro 1995). The project proposed to divide the protection of connectivity into two stages: corridor designation and operationization by designing a policy and legal framework (Liro

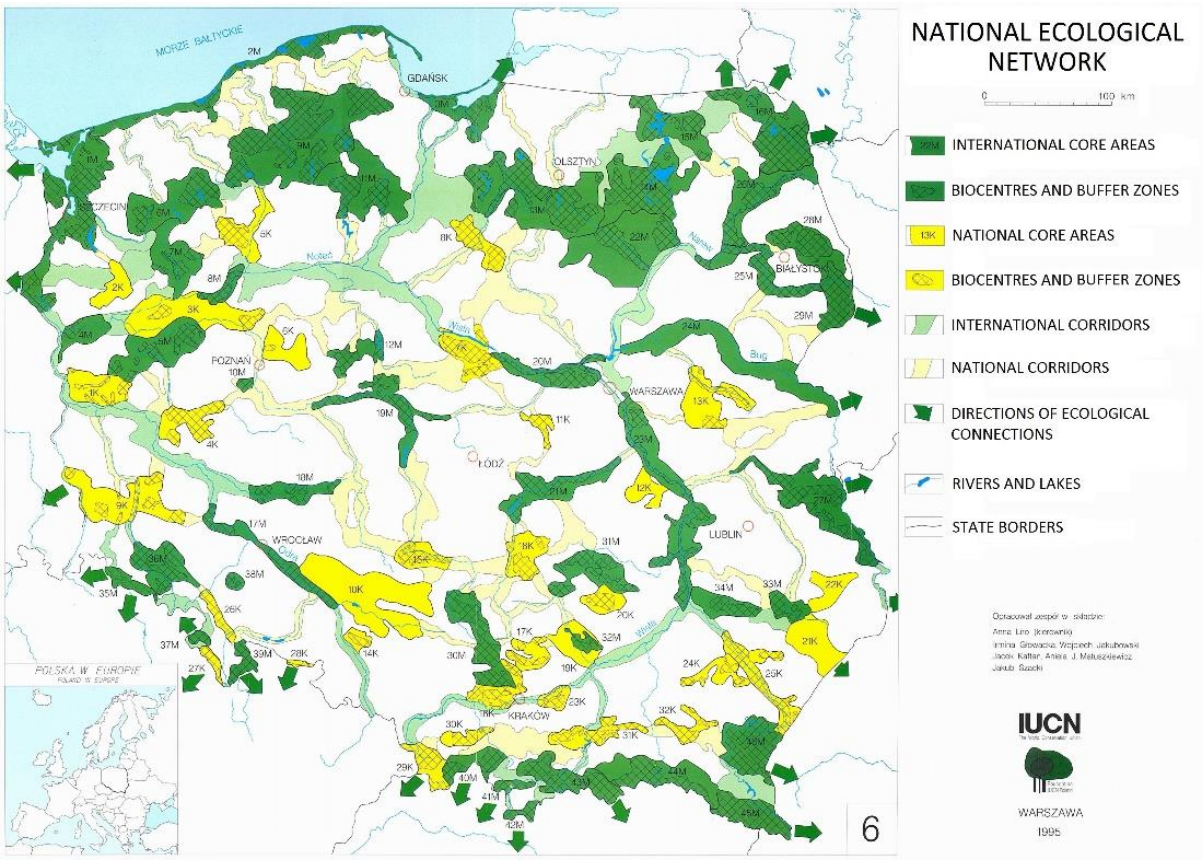


Figure 12 Econet

1995). Additionally, it suggested to enlarge existing protected areas and undertake large-scale ecological restoration work, which has not been carried out due to lack of agreement between different stakeholders. Neither has the necessary policy and legal framework been designed. Although criticized for lacking a strong scientific method, excessive breadth, insufficient consideration of threats to connectivity (Kistowski and Pchałek 2009) and being overly focused on river valleys and neglecting inland habitats (Gerlee 2010), the conception was incorporated into many county spatial plans and the “Poland 2000 Plus – Conception of Spatial Planning” (Liro 1998).

2.3.2 Jędrzejewski *et al.*'s (2005) corridors

In 2005 the Polish Ministry of Environment ordered a new conception of ecological corridors that would be based on the Natura 2000 sites (Jędrzejewski 2009). It was designed by prof. Jędrzejewski together with a group of scholars from two research institutions and an NGO centred around mammal research. The conception used national and landscape parks, Natura 2000 sites, reserves, protected landscape sites, forests, river valleys and other well-preserved natural habitats as core areas and connected them using spatial analysis with regard to naturalness, forestedness and percentage of built-up and agricultural area (Bernatek 2011). The network used the grey wolf *Canis lupus* as an indicator and umbrella species; it built upon its predecessor Econet and paid special attention cross-border connectivity (Bernatek 2011). As a result, more than half of the corridor area is forested, 42% comprises meadows, pastures and agricultural lands, 2.5% is covered by wetlands or water bodies and 0.5% by urbanised areas (Jędrzejewski 2009, *Figure 14*).

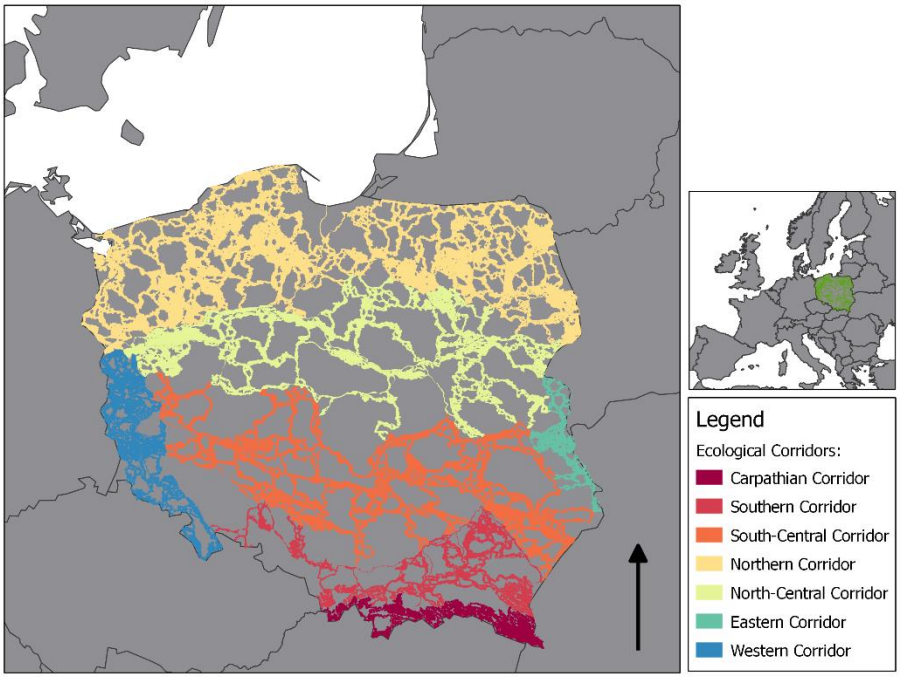


Figure 13 Jędrzejewski et al.'s corridor conception (2005)

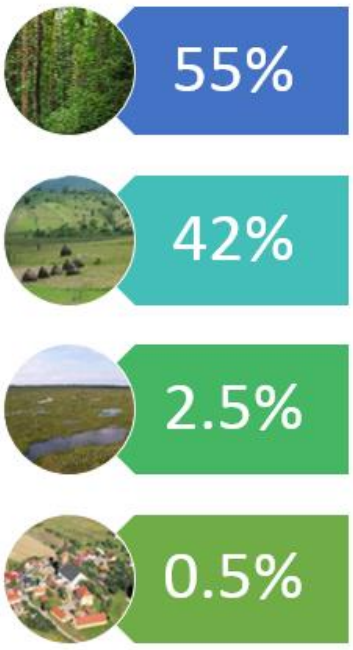


Figure 14 Landscape types as percentage of corridor surface

The network is hierarchical; it is comprised of seven international and numerous national corridors and was produced using the Least Cost Path GIS tool in order to connect suitable wolf habitats within Poland (Huck *et al.* 2010). Jędrzejewski *et al.*'s corridors were subsequently

criticized as focusing on forest species and thus not being suitable as an overarching conception of national connectivity. In response to this criticism, the network was expanded to include river valleys and other open-space corridors *(Figure 13).*

2.4 Implementation

2.4.1 Legal protection: international and European Union law

Numerous legally binding international conventions can be seen to contribute to the protection of ecological connectivity. The Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat orders signatories to designate protected wetland sites, while the Framework Convention on the Protection and Sustainable Development of the Carpathians mandates the designation of ecological corridors in the Carpathians (but does not afford them legal status or implementation, Pchałek *et al.* 2011). The Bonn Convention on the Conservation of Migratory Species of Wild Animals, the Rio Convention on Biological Diversity and the Bern Convention on the Conservation of European Wildlife and Natural Habitats provide general directions and are considered effective at facilitating conservation. Relevant for connectivity protection is the Florence Convention on European Landscape which, however, lacks implementation measures. Thus, when not transcribed into national law, as it is in Poland, it is essentially ineffective (Pchałek *et al.* 2011).

Within European Community law, the Council Directive 2009/147/EC on the conservation of wild birds and the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora are highly effective in designating and protecting Natura 2000 sites. However, as mentioned in the *Literature Review*, it does not set out to protect spatial connectivity. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy mandates retaining or restoring river connectivity thus directly addressing connectivity. While the Environmental Impact Assessment *Directive* (*85/337/EEC*) and the Strategic Environmental Assessment Directive *2001/42/EC* effectively regulate investment in natural areas, they do not specifically include ecological connectivity as a possible impact area (Pchałek *et al.* 2011).

2.4.2 Legal protection in Poland

Polish Nature Conservation Law (2004) defines ecological corridors as *"areas enabling the migration of animals, plants and fungi"*. Pchałek *et al.* (2011) believe such a definition to be too broad to match any existing scientific theory regarding the function of ecological corridors. Moreover, it does not encompass areas that due to anthropogenic pressure have lost their permeability and need to be restored to ensure healthy animal, plant and fungi populations. Aside from *areas of protected landscape*, one of whose functions is protecting ecological connectivity, Polish Nature Conservation Law (2004) does not devote a separate nature protection category to ecological corridors. Unfortunately, a*reas of protected landscape* do not adequately protect connectivity as they are created in close collaboration with local municipalities (who are usually against nature conservation) and lack legal and planning tools, management plans and protection from unsustainable investment (Pchałek *et al.* 2001). Protected area categories aside, corridor maintenance can be addressed by Natura 2000 management plans, however it is not mandatory. Although neither Econet nor Jędrzejewski *et al.*'s (2005) corridors were granted legal status, much of their area is protected through other nature protection categories (*Figure 15*). 60% of Jędrzejewski's corridor surface constitute existing nature protection categories (protected by the Nature Conservation Law (2006)) and 23% are sustainably managed forests (according to the Forest Law (1991)). 17% of corridor surface lack any kind of legal protection.

Conservation area type	IUCN category	Protecting Law	Percentage of corridor area	Total without overlap
Areas of protected landscape	varies	Nature Conservation Law (2006)	35%	60%
Landscape parks	V		21%	
National parks	II		4%	
Nature reserves	I		1%	
Natura 2000 sites	varies	EU Nature Directives	36%	

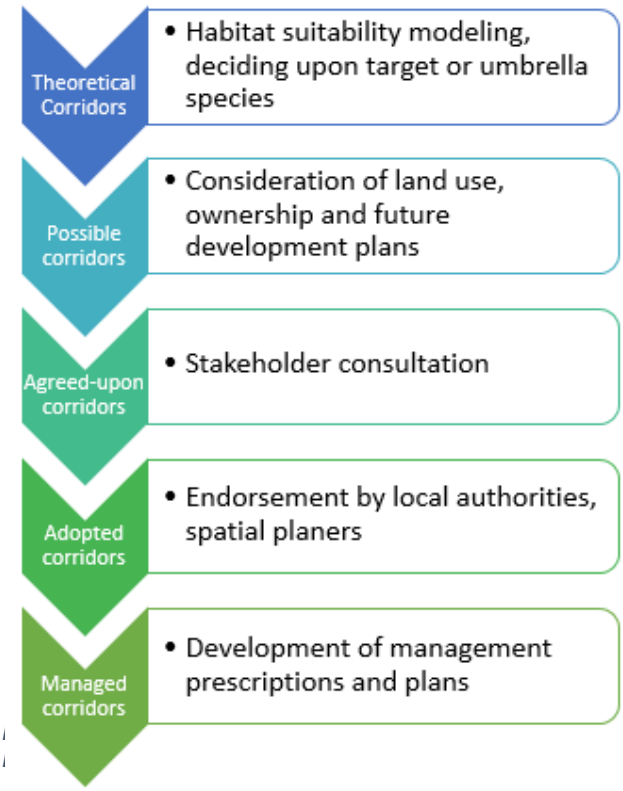
Forest (excluding any of the above)	-	Forest Law (1991)	23%	23%
			Total	83%

Figure 15 Nature protection within corridors

Overall, Pchałek *et al.* (2011) believe the regulations regarding ecological corridors in the Polish law to be scattered, incomplete and not fully coherent.

2.4.3 Implementation

Figure 16 illustrates the necessary steps to corridor protection. It is evident that Poland has only carried out the initial step – mapping theoretical or "raw" corridors (Deodatus *et al.* 2013). The following steps, such as consideration of land ownership, use, consulting stakeholders, local authorities and developing management plans have not yet been attempted. Much work thus remains to be done, as recognition, acceptance and respect by stakeholders such as local authorities, administration and planners is crucial to creating a well-functioning corridor network (Mackey and Watson 2010). Inclusion into law, spatial planning and development of policy objectives are necessary for successful implementation of corridors (Deodatus *et al.* 2013). Successful corridors must be both "natural, socio-economic and legal entities" (Deodatus *et al.* 2013:705) and while modern GIS tools have simplified corridor designation, the reality of multi-stakeholder land management makes corridor implementation extremely complicated.



The Dutch policy experience

While discussing corridor implementation, it is interesting to look at the reasons behind the downfall of the Dutch ecological corridor policy. Turnhout (2009) argues that using the simple and captivating idea of animal mobility, the Dutch National Ecological Network (NEN) was launched primarily to improve the stagnant and negative

image of the nature conservation authorities and constituted an ambitious and fresh PR move more than a rational well-planned policy (Turnhout 2009). Large financial support for corridors was planned which resulted in the regional governments being too keen and planning too many corridors for what the government could afford to compensate for. Moreover, not enough cooperation took place between scientists and policy makers during the development phase and once the policy was launched, no criticism was accepted as it would undermine the basis of the policy. This was a major mistake, as in policy making adaptive management is crucial to creating functioning locally tailored policies (Windt and Swart 2008). Turnhout (2009) argues that the idea of ecological corridors is oversimplified, or, as Windt and Swart (2008) put it, it is vague, flexible and almost metaphorical. While this may mean that initially it is easy to get various stakeholders on board, disagreements at later stages render its implementation nearly impossible. A good policy, they argue, must relate to societal values and practices rather than merely reflecting the latest stage of scientific discovery.

3. Methodology

3.1 Philosophy

The assumptions behind a research approach reveal much about the researcher's philosophical position, whether it is positivistic, subjectivist or an intermediate stance between the two (Evely *et al.* 2008). While a positivist understands the world to be an objective and measurable reality, independent from the observer, a subjectivist believes the world to be inherently subjective and held inside of the observer's mind. As this mental image is as close as we can ever get to experiencing the world, instead of searching for external truth, research should focus on how individuals experience and interpret reality. Thus, studies following the positivistic approach attempt to quantify and measure the world, while subjectivist research tries to understand the meaning behind qualitative data. Understanding one's philosophical stance is crucial, as it has implications for the kind of research approach one should take, the appropriate methods and study design. As the author of present thesis places herself in an intermediate position between subjectivism and positivism, this study follows a mixed methods approach containing both elements of qualitative and quantitative research, where the former prevail.

3.2 Data collection process

Firstly a literature review of scholarly papers was conducted in order to gain an understanding of ecological corridors and the science and policy issues behind them. Additionally, a review of reports, project documentation and other non-academic documents prepared by both governmental and non-governmental institutions was carried out in order to complete the picture of ecological connectivity in Poland. Following the literature review, original research included a document review and in-depth qualitative interviews.

Firstly, a document review was conducted looking at the following policy documents: The 2030 Conception of Spatial Planning for Poland, The Environmental Impact Assessment of the National Road Construction Program 2011-2015 and 40 thus far completed Natura 2000 management plans. The aim of the document review was to understand how ecological connectivity was being incorporated into planning documents.

Secondly, 20 interviews were carried out in Warsaw and over the telephone between 5th and 23rdMay 2014. The interviews were conducted in Polish and lasted between 10 minutes and 1 hour, the average length being 25 minutes. Research participants were selected based on the literature review, as well as using the snowball sampling strategy, where previous participants suggest concurrent interviewees (Coyne 1997). The interviews were problem-oriented and semi-structured, allowing for the interviewees to place the emphasis on issues they considered most important while at the same time ensuring comparability across interviews by following an outline of basic questions (*Figure 17*). Most of the interviews were participant-led and open-ended, as the main purpose of the study was not to extract answers to a predefined set of questions but rather learn about the issue as the participants viewed it. It was anticipated that the literature review would not have provided a complete picture of corridor implementation challenges and thus the interviews were an important tool in learning about what other problems exist. The researcher was interested in hearing interviewees' personal opinions, examples and stories rather than the official stances of the organizations they represented which the participants would have more likely reiterated had they been asked narrow questions (Seidman 1998).

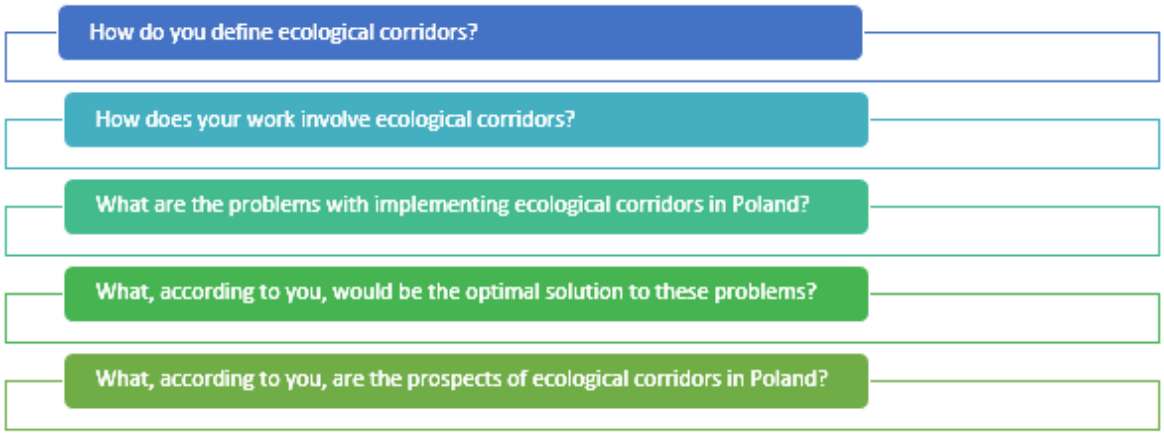


Figure 17 Sample interview questions

3.3 Ethical considerations

As part of the research involved human beings, special attention was paid to ensuring that the interviewees were treated ethically in terms of participant consent and anonymity. All interviewees consented to expressing their opinion for the purpose of this research; they were in charge of how long the interview lasted and were free to not disclose any information they considered confidential. Participants were provided

with brief information regarding the study (prior to the study via email) and encouraged to ask questions should they have any. Interviewees were guaranteed anonymity in order not to create pressure or exacerbate any potential conflicts. Prior to analysis all data (including names and organizations) was anonymized leaving only the sector tag in order to conduct the analysis. It is for the purpose of ensuring anonymity that this thesis does not make public the list of institutions approached for interviews.

3.4 Difficulties

Difficulties arising from the research design involved the inability to locate and contact all stakeholders, due to time constraints as well as unavailability of some stakeholder groups compared to others, which resulted in the small number of NGO employees interviewed.

3.5 Participant typology

Participants in the study were categorized according to the sector (central and regional government, local government, NGO, scientific institution) and branch (spatial planning, environmental protection, road authorities). The combination of sector and branch resulted in six tags assigned to interviewees: road authorities, environmental NGO, local authorities, environmental scientist, spatial planning authorities and environmental protection authorities. *Figure 18* presents the simplified participant typology including the label and number of research participants interviewed (full typology can be viewed in in the appendices).

Figure 18 Participant typology

3.6 Research analysis

Qualitative interview data was translated into English and analysed using thematic content analysis, which involved coding and labeling interview data in order to identify common themes across interviews (Strauss and Corbin 1998). Following the *oscillation* process, codes were extracted both from interview data and literature (Stoll-Kleemann 2001). Emergent themes were then compared across participant labels in a cross-tabulation process to search for patterns, commonalities, and differences. Interview results were organized by themes relating to designation and implementation challenges and presented in the *Results* section. Document review of the 2030 Spatial Planning Conception for Poland and the EIA of the National Road Construction Program 2011-2015 was conducted by verifying how the concepts relating to ecological connectivity were included in the text and how this influenced the level of protection that they received. Forty Natura 2000 management plans were screened for mention of ecological corridors and assigned scores based on how much space was devoted to discussing issues relating to ecological connectivity. Results were presented in a numerical manner, focusing on cross-tabulation between level of corridor inclusion and location and habitat type.

Throughout this thesis the terms *ecological corridors* and *ecological network* are used interchangeably as in the Polish language the plural form of *corridors* (*korytarze*) is often used to denominate a network *of corridors*.

3.7 Reliability of the findings

As the research was restricted due to finite time and financial resources it is possible that some important stakeholders were inaccessible at the time or simply overlooked. Despite efforts to obtain comparable numbers of participants in each category, the research would have benefitted from interviewing more stakeholders in the *scientific institution* and *NGO* sectors. Although telephone interviews were considered successful, the research might have been more complete had all interviews been conducted in person. However, this was impossible due to the multiplicity of locations (counties) contacted and the difficulty in contacting interviewees at a convenient time.

4. Results

4.1 Document Review

In the following section an examination will be carried out of how and to what extent ecological corridors are present in key planning documents in Poland: the Environmental Impact Assessment of the National Road Construction Program 2011-2015, the 2030 Conception of Spatial Planning for Poland and the to-date completed Natura 2000 Management Plans.

4.1.1 Environmental Impact Assessment of the National Road Construction Program 2011-2015

Within the Environmental Impact Assessment of the National Road Construction Program 2011-2015 ecological corridors are mentioned in five chapters, two of which will be discussed here: baseline scenario (Chapter 7: *"Present state of the environment and potential changes in case the program is not carried out"*) and environmental impacts (Chapter 10: *"Environmental impact assessment of the program"*). While the report acknowledges the importance of ecological connectivity (especially river valley corridors, the Natura 2000 Network and the main North-South and East-West corridors) and the necessity to mitigate any impacts from road construction, it also emphasizes the difficulties arising from lack of an official corridor network conception (especially bird corridors *(Figure 19)*), insufficient monitoring, inaccessible data, lacking knowledge and technology to deal with connectivity.

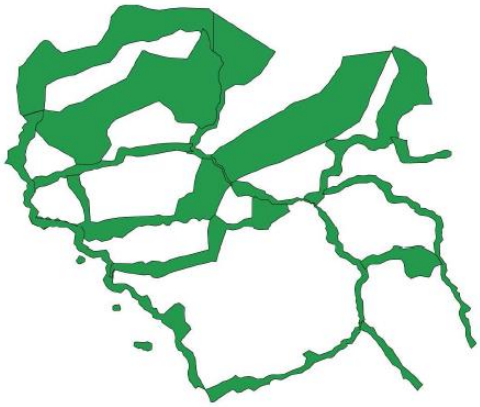


Figure 19 Bird concentration areas and bird corridors – makeshift map

The report states that the new road infrastructure will ease the environmental pressure from the existing road network. Not only is the construction of new roads expected to reduce the traffic on the old roads, but the new network has been designed to have fewer collisions with bird corridors and protected areas. Thus, the authors portray the road construction program as potentially environmentally beneficial.

The report lists the following negative effects of road construction: İsolation of habitats and populations, reduced migration (for food, shelter or mating), colonisation and gene flow, lower genetic variability and finally the disappearance of local populations and

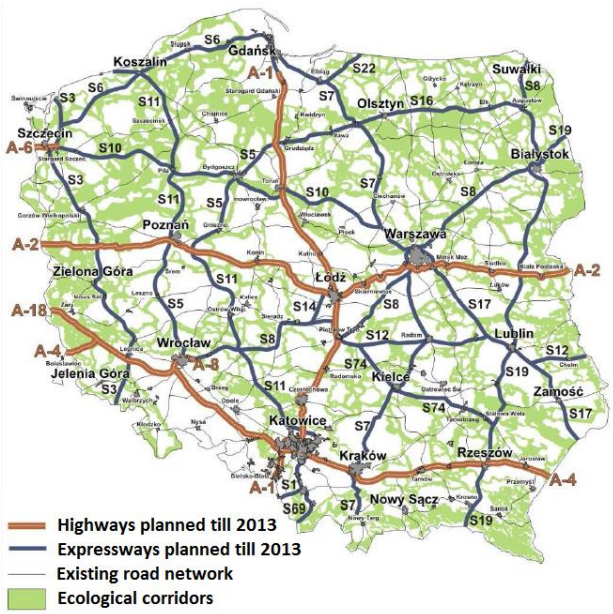


Figure 20 Collisions between planned roads and ecological corridors

lower local biodiversity. The document identifies the two underlying causes of these phenomena to be the physical barrier that a road (and the fences and ditches around it) constitutes and the psychophysical (behavioral) barrier resulting from noise, light and chemical pollution. Both hydrological and terrestrial corridors can be affected in case of badly designed culverts and embankments, collisions with bridges and vehicles, drained and discontinuous habitat resulting in impact on fish, amphibians, birds, bats, semi-aquatic and terrestrial mammals.

Having examined the map of existing and planned highways and expressways together with Jędrzejewski *et al.*'s corridors *(Figure 20)*, the report presents a map of collisions between the two *(Figure 21)*. The EIA concludes that most of the planned construction does collide with ecological corridors of national or transnational importance. All problematic sections face the problem of cumulative impact as the corridors that they affect are already fragmented by existing roads. The report concludes that without mitigation measures (designed for individual investments) the negative effects of road construction on habitat fragmentation and the associated animal species would be very significant. However, linear infrastructure collides with migratory corridors by definition and thus rejection of an investment should not be based on collisions but on the lack of possibility to implement adequate mitigation measures. In addition to discussing

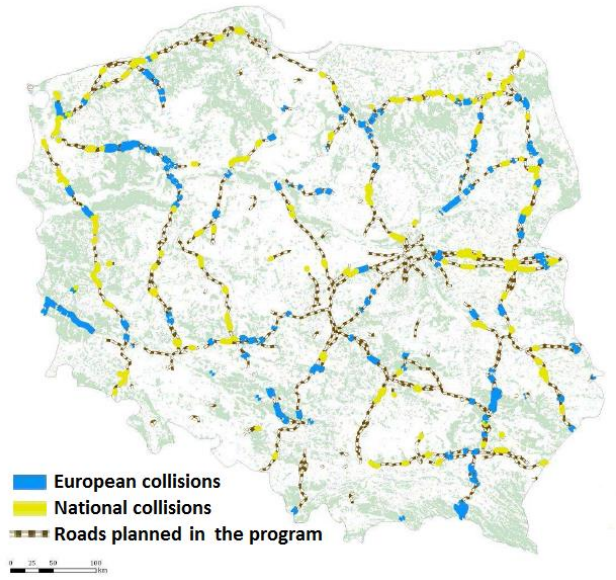


Figure 21 Collisions of the planned road network with ecological corridors

impacts on movement possibilities of specific taxonomic groups and collisions with rivers, the report also analyses the collisions between the planned roads and the existing nature protection areas, such as national and landscape parks and Natura 2000 sites. Thus it addresses impacts on connectivity as many of the protected areas constitute core areas of the proposed ecological network.

4.1.2 The 2030 Conception of Spatial Planning for Poland

Regarding ecological connectivity, two parts of the 2030 Spatial Planning Conception for Poland are of relevance: the *2030 Vision of Spatial Planning* and *Aim 4: Shaping spatial structures that support a high quality natural environment and landscape*.

The 2030 Vision of Spatial Planning

In 2030 the Natura 2000 Network encompasses more than 20% of Poland's territory, including many river valleys. Together with nationally protected areas and ecological corridors it constitutes a coherent nature and landscape protection system both in terrestrial and marine environments. By taking into account the different components of the environment, spatial planning reduces habitat isolation and supports ecosystem stability in order to preserve unique Polish biodiversity. Mechanisms for controlling economic development in naturally valuable areas, originally devised for the purpose of managing the Natura 2000 Network, limit the possibilities for environmentally damaging investment such as large-scale afforestation or farming intensification while supporting sustainable land management. Developing ecological corridors and raising forestedness above 30% of the country's area have contributed to a healthy balance between developed and natural areas. Migration to sparsely populated areas is encouraged and reclamation of marginal land is preferred to taking up of natural land. Protected areas are incorporated into spatial plans, which reduces the loss of natural biologically active land to urbanization. Small-scale farming and diversification of functions of rural areas are applied in areas experiencing population growth. The functioning model of socio-economic development supports the restitution of traditional agrarian landscapes, preservation of river valleys and deployment of wetlands as a measure for flood control. The environmental as well as socio-economic interconnections are mutually consistent and are taken into account when planning transportation and communication infrastructure. Ecological compensation is one of the ways of solving environmental conflict as well as enhancing Poland's ecological potential. A strong, coherent and hierarchical ecological network has been created,

protecting ecological corridors as well as core zones as part of the continental ecological network. Aquatic and air corridors for birds, bats and aquatic species are designated separately. Core areas of the ecological network – biocentres – are areas of particular ecological value – national parks, parts of landscape parks, large Natura 2000 sites, forest complexes, transboundary protected areas and geoparks. Relatively small expansion of the Natura 2000 Network can be explained by the compensation procedures for the necessary sustainable socio-economic development. Three new national parks have been created, and a few existing parks have been enlarged. The network of landscape parks has also been developed to ensure the cohesion of the ecological system. Buffer zones of lower protection status surround all biocentres.

Aim 4: To shape spatial structures that support a high quality natural environment and landscape.

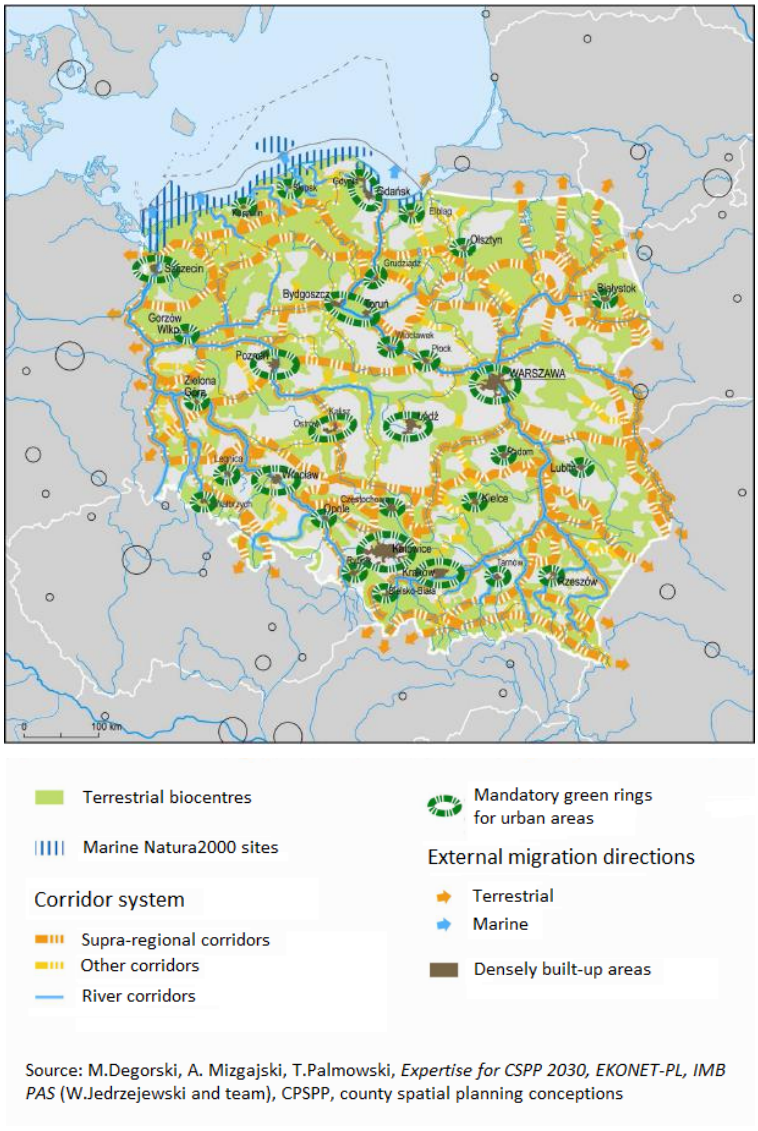


Figure 22 Main elements of the 2030 ecological network

The authors of the document believe that low importance assigned to spatial planning, lack of hierarchy in planning, missing protected area management plans and low priority attached to Studies of Determinants and Directions in Spatial Planning (which constitute bases for local plans) have led to excessive exploitation of the natural environment and destructive landscape use, which constitute a barrier to socio-economic development. Ecological cohesion has recently been lowered due to urban sprawl, changes in the functions of rural areas, development of transportation and communal infrastructure,

agricultural intensification, reduction of urban green areas, construction in river valleys and wetlands and damming of rivers. Other factors contributing to low ecological integrity include uneven forestedness and forest fragmentation. The document notices that Poland has two weakly coordinated and very different in terms of criteria systems of protected areas – Natura 2000 and the nationally designated protected areas. Green spaces in cities, despite their crucial role in maintaining urban biodiversity, air and climate, are not included in either of the systems. Ecological corridors are very weakly defined in the law and better legal tools are needed in order to ensure the correct designation and protection of ecological corridors. However, legal protection is often not enough and negative social attitude towards conservation and related restrictions needs to change in order to grant full protection to Poland's nature. In addition to law, policy documents must also focus more on counteracting fragmentation, ensuring ecological connectivity and migration possibilities for protected species.

In order to achieve a coherent system of protected areas and ecological corridors, the authors outline the need to designate a legally protected network of ecological corridors as well as map out the Pan-European Ecological Network (PEEN). Ecological corridors should encompass areas outside of the Natura 2000 Network and the nationally designated protected areas, as an important asset for ecological compensation in case of necessary investment in Natura 2000 areas. Following the inclusion of ecological corridors into county spatial plans, they should be fluently transcribed, at an adequate scale, into local spatial plans, including the integration of urban green spaces in urban spatial plans. Ecological connectivity should further be protected and restituted through afforestation and monitoring and standardization of wildlife overpass construction. 'Spatial order' should be improved as a means to ensuring condensed construction and reducing pressure on natural areas.

4.1.3 Natura 2000 management plans

Between 2009 and 2015, 406 management plans for Polish Natura 2000 sites are to be completed. Ecological connectivity issues are not a mandatory component of the plans, however, many plans do mention or even discuss ecological corridors. Present section presents the results of the analysis of the 40 to date completed management plans.

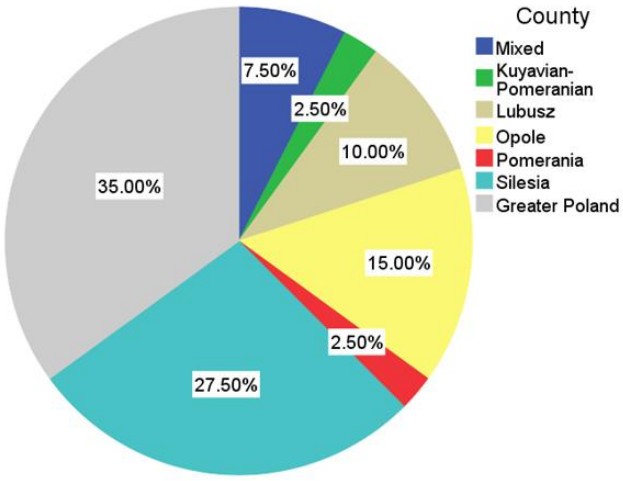


Figure 23 Completed management plans by county

Two thirds of the to-date covered sites are located in just two counties: Silesia and Greater Poland, while several are located in Opole and Lubusz counties. Out of 16 counties, only 7 have completed at least one plan thus far. Regarding prevailing habitat types, 22.5% of the plans were drafted for forest habitats, 20% for lakes, 15% for mixed habitats, another 15% for buildings or caves, 12.5% for river valleys, 7% for fens, 5% for wetlands and 2.5% for grasslands.

Methodology

In order to assess how well plans addressed connectivity issues, they were awarded points, one each for including: a list of corridors in reach of the site, a specification of corridor target taxonomic group, corridor habitat types, connectivity-wise important areas, transnational corridors, local threats to connectivity, suggested management measures and citation of corridor conception source. Thus, a ranking emerged and the scores were assigned the following labels: 0 – no mention, 1 – very little mention, 2 – little mention, 3 – some mention, 4 – considerable mention, 5 – much mention, 6 – very much mention, 7 – exceptional mention (relative to one another).

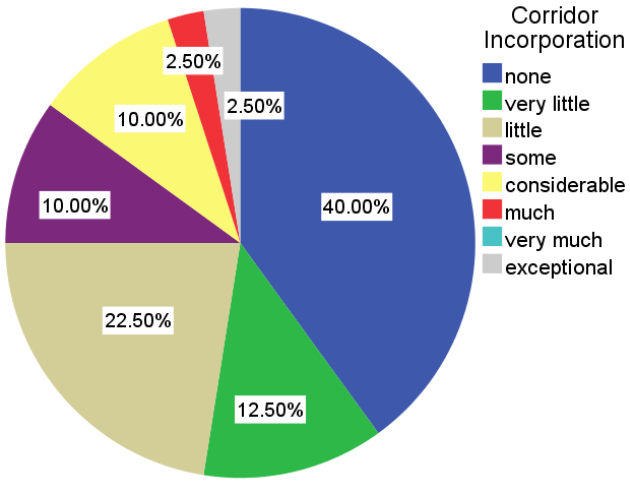


Figure 24 Completed plans by degree of corridor incorporation

Results

The mean level of corridor incorporation was calculated to equal 1.57 (Std. Deviation = 1.723). Thus, the overall standard of corridor incorporation is quite low: between *no mention* and *very little* mention of ecological connectivity in the plans. 40% of plans did not mention connectivity at all, a further 35% mentioned corridors *little* or *very little*.

10% devoted *some*, and a further 10% *considerable* space to connectivity issues.

The research then attempted to determine whether the quality of connectivity incorporation was different across counties and habitats. Are some counties better at safeguarding their ecological connectivity? Are corridors more likely to be taken into account for certain types of habitats, e.g. forests?

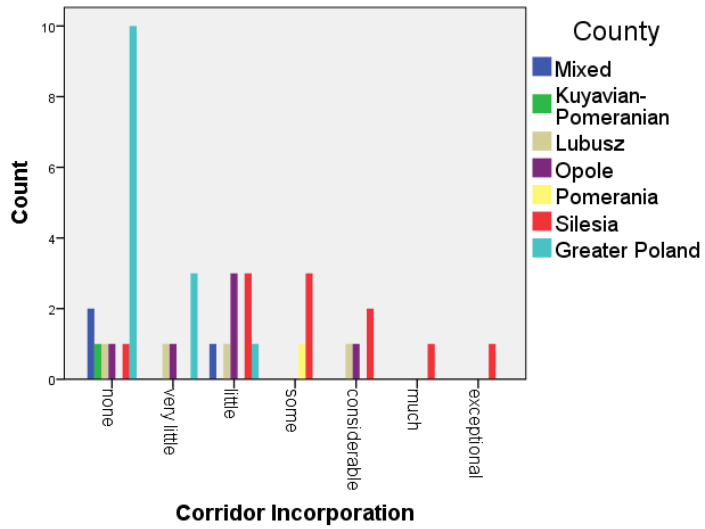


Figure 25 County plans by corridor incorporation

The mean level of corridor inclusion was 3.18 for Silesia, 3.00 for Pomerania, 1.83 for Opole County, 1.75 for Lubusz, 0.67 for mixed sites, 0.36 for Greater Poland and 0 for Kuyavian-Pomeranian County. *Figure 25* shows the cross-tabulation between the level of corridor incorporation and the county the site is located in. For habitat type, the mean levels of corridor inclusion were found to be: 3.00 for forests, 2.5 for wetlands, 1.5 for mixed sites, 1.4 for river valleys, 1.33 for buildings and caves, 1 for grasslands, 0.75 for lakes and 0 for fens. *Figure 26* portrays the cross-tabulation between level of connectivity incorporation and the prevailing habitat in the site.

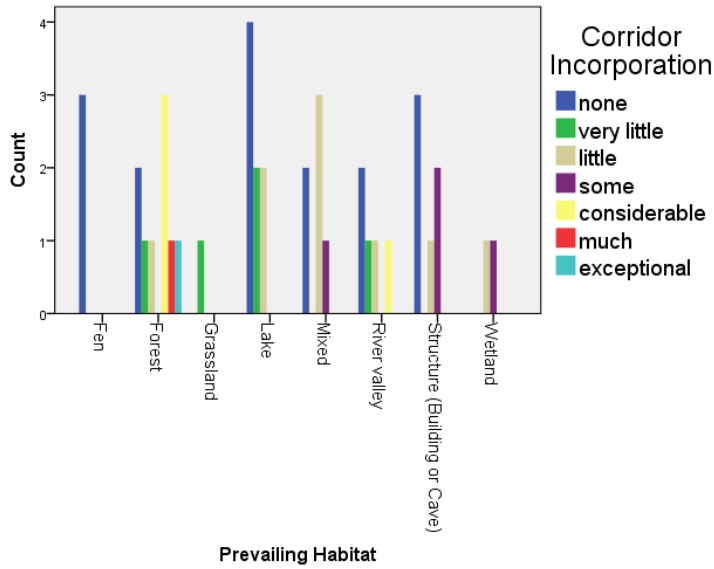


Figure 26 Corridor incorporation by habitat type

Thus, the best cases of corridor inclusion in Natura 2000 management plans were found in Silesia and Pomerania counties and for sites where the prevailing habitat type was forest and wetland which are stereotypically viewed as priority corridor habitats.

4.2 Interviews

From interview data, the following problems regarding ecological corridors appear:

4.2.1 Designation problems

Lack of coherent conception

Most interview participants stressed that Poland lacks a good conception of ecological corridors. While there have been a few attempts to draw an ecological corridor network, none of them has been officially endorsed by the Ministry of Environment and The Ministry of Infrastructure. The 1995 Econet conception is thought by many to have lacked a strong scientific basis, while Jędrzejewski *et al.*'s (2005) corridors are criticized for being designed mostly for large mammals, despite the fact that they were later supplemented with river valleys. Some interviewees stressed the importance to design a network that would encompass all groups of animals, including birds, amphibians, reptiles, semi-aquatic mammals, fish and aquatic and terrestrial plants.

> *"There is no complex, all-encompassing analysis of connectivity in Poland" (interviewee 1, environmental protection authorities).*
>
> *"What are the problems with implementing a conception of ecological corridors? Mostly, there isn't such a conception" (interviewee 15, spatial planning authorities).*
>
> *"On the national level the issue of corridors has only recently been taken up, it's still in its crawling baby phase" (interviewee 6, spatial planning authorities).*

Poland was supposed to designate and protect ecological corridors as part of the Pan-European Ecological Network until 2008 but has not fulfilled its obligations. While until recently a valid argument for not having done so was the active process of Natura 2000 site designation, it has now been complete for a few years and thus there is no

reason to wait any longer with designating corridors. The Natura 2000 Network only partly protects connectivity as well as obliging Member States to safeguard its *'integrity',* which could be understood as protecting ecological connectivity. Resulting from the confusion regarding ecological corridors, some counties use the Econet conception, some base their work on Jędrzejewski *et al.*'s (2005) corridors for large terrestrial mammals and some prepare their own conceptions and maps. However, as one participant pointed out, it is often difficult and sometimes impossible to get hold of the necessary data.

> *"We are looking for bird corridors to add them but they are nowhere to be found, there are little bits here and there. Corridors for plants do not exist at all; they should at least have been drawn at the national scale" (interviewee 15, spatial planning authorities).*

Many participants stressed the need to employ sound scientific methods while designating ecological corridors. While many people can draw a network of corridors by merely looking at the map of land use, we need species and population monitoring, research and strong arguments.

> *"Everything has to be justified, supported with real life scientific arguments and strong evidence" (interviewee 1, environmental protection authorities).*

Expert knowledge and the consensus among scientists, forestry practitioners, game managers etc. is needed to designate operationisable migratory corridors. However, many interviewees reported that such a consensus among the various stakeholders and even experts was difficult to achieve. As one participant explains,

> *"There are guidelines regarding how to correctly select places for wildlife crossings, but there is not enough site-specific knowledge. There are disagreements between NGOs and hunting committees, someone believes the crossing should be here, someone else thinks it should be located in another place" (interviewee 3, road authorities).*

Divergent requirements of different species

Study participants agreed that various species, animal groups and plants have various habitat preferences and often divergent needs. Corridors designed for wolves will not be suitable for fish (which need aquatic corridors), butterflies and bats (which need open areas and find forested areas a barrier to migration) or birds (which prefer

stepping stones). On the other hand, many participants mention that wolves are widely considered as an umbrella species which does ensure connectivity for most terrestrial forest organisms. While large forest mammal corridors are the only ones to have been dealt with at the national scale, interviewee 6 (spatial planning authorities) emphasized the need to designate other corridors such as xerothermic grassland corridors for open-space species. As species vary in their migratory ranges (in addition to having various habitat requirements) interviewee 7 (environmental scientist) proposed that mammal corridors be dealt with on the national scale and other corridors for animal groups that are less mobile, such as amphibians or small mammals be taken into account in county corridor schemes. To take into account needs of all groups of animals would not only be extremely difficult but physically impossible.

> *"We need to decide which species we are aiming for, one cannot please them all" (interviewee 7, environmental scientist).*

Another question is that of which corridors need to be connected with which ones. As one interviewee points out,

> *"It is impossible to connect corridors for wolves with corridors for birds, for they have different requirements. To a bird a wind farm is a barrier but to a wolf it is not" (interviewee 7, environmental scientist).*
>
> *"Often by saying that we need to protect ecological connectivity we mean something abstract. For which areas should be connected with which ones, for example there is no need to connect valley corridors with xerothermic grassland corridors" (interviewee 6, spatial planning authorities).*

The complexity arising from the different habitat preferences of mammals, birds, butterflies or fish was considered by many interviewees as rendering the design of such complex all-encompassing corridors either straightforwardly impossible or practically impossible as they would take up too much land away from the society.

Scale

Many participants talked about the issue of scale and how planning and implementing takes place at completely different scales which disconnects the two processes. As one interviewee puts is,

"Corridors function fine on maps with a large scale, the level of detail is small there. The corridors are designated but at this large a scale they are of little use to municipalities" (interviewee 3, road authorities).

"We draw corridors in a large scale, for example on a map of Poland that fits onto an A4 sheet of paper, but we have to implement them in a scale 1:1" (interviewee 10, environmental NGO).

While various national conceptions have been proposed, they are all characterized by a high level of generalization and uncertainty.

"In order to implement, the general corridors must be scaled down to concrete areas. (…) We generally base local corridors more on our imagination and guesses than the scientific certainty that a corridor for such and such a species runs in this and that place" (interviewee 10, environmental NGO).

Dynamic environment

Many interviewees emphasized that animals change the ways they use the land, which further complicates the issue of corridor designation. At the very local level animal paths tend to change seasonally and annually, but this flexibility is difficult to account for in spatial and corridor planning.

"If you have to use dynamic populations to designate corridors the whole thing falls apart (…). Corridors as a fixed structure don't work" (interviewee 12, environmental authorities).

Thus, a few of the interviewees proposed that corridors should not be designated where animals are present but rather where it is convenient for humans that animals should be present.

"It would be best if corridors were designated in places used by animals. But they have to be part of spatial planning. (…) Designating corridors based on actual land use by animals doesn't work. We reserve some areas for animal migration, a corridor is a future movement possibility; it is unimportant whether animals walk that way now or not. (…) Corridors should not be drawn where animals are, it is humans who determine the areas for other organisms to live now; we have to make them walk where we want them to" (interviewee 12, environmental authorities).

4.2.2 Implementation problems

Contrary to the belief that corridor designation poses serious difficulties, some interviewees expressed the belief that precise designation was of minimal importance as compared to lack of sufficient implementation of any proposed conception thus far. One study participant expressed the view that

> *"We already know everything and now it is time to do something with this knowledge. (…) I am not interested in new conceptions, I'm interested in their implementation, ideas for making them work, steps taken to consult them with the many stakeholders. Without this they are all useless. Every now and then there is some new work, new method, so what? So animals travel along such and such a path, but this is insignificant. What is significant is to what extent we have an idea to implement corridors in practice, we have to narrow it down to a scale at which we can tackle at least the priority areas. It is a humongous step from designation to implementation. (…) Rather than trying to figure out which conception is the best we should start mitigating the barrier effects in priority places" (interviewee 10, environmental NGO).*

Another research participant shares this view:

> *"The scientific knowledge is there, it has been verified on many occasions. (…) Corridors as construed spatially are not a problem, we have their coordinates; the problem is finding an instrument for implementation. The key to success it to be able to realize one's ideas" (interviewee 5, spatial planning authorities).*

Weak spatial planning

As environmental protection is an inherently spatial discipline, it heavily relies on spatial planning. As one interviewee phrased it, "everything in nature conservation boils down to spatial planning" (interviewee 11, spatial planning authorities). In the European Union spatial planning lies completely within the competencies of Member States. While the EU has binding laws which enter into the sphere of planning, such as the Birds and Habitats Directives, Member States govern their spatial planning independently of the EU. Most interviewees regarded the Polish system of spatial planning as lacking coherence, weak and not functioning well, many referred to it as *"Poland's greatest bane"*. Due to its many administrative levels, concepts such as

ecological connectivity can easily get lost on the way from national to the local level. At the national level, Poland has completed the 2030 Conception of Spatial Planning which places considerable focus on retaining ecological connectivity in the country. At the regional level, most counties have a conception of ecological corridors with the necessary maps inscribed in the county spatial plan. However, there is no tool which ensures that county corridors are entered into local spatial plans which, unlike county spatial plans, constitute local law. As one interviewee describes the situation:

> *"Local municipalities have too much independence, every mayor manages their land as they wish. Until we have regulations that ensure the transcription of corridors from county to local spatial plans the situation will remain unresolved" (interviewee 5, spatial planning authorities).*

While spatial planning is currently an accredited profession, it is set to be deregulated, which, in the opinion of some interviewees, will further worsen the quality of local plans. Additionally, as local planning is currently not mandatory, most municipalities prefer to not draft local spatial plans but issue construction permits which go around formal requirements that plans need to fulfill. Many interviewees saw the planning situation as messy and believed that greater employment of spatial plans would create more order. As one study participant explains this situation:

> *"The mayor prefers not to have a plan, he can just order it for some part of the municipality… A plan makes the terms for investment more rigid. And if a friend of his wants to build a house it easier to make any decision he/she wants" (interviewee 1, environmental authorities).*

In addition to municipalities not making enough spatial plans, there is no effective way to ensure that ecological corridors are present in the plans. While there is an obligation to enter natural areas into the municipal spatial plan, there is no control over how it is done. Thus, as one interviewee portrays it,

> *"Connectivity can be there in the form of one tiny bit of a corridor and we [the county planning authorities] cannot say a thing" (interviewee 6, spatial planning authorities).*

Although municipalities are obliged to consult their plans with the Regional Directorate for Environmental Protection, the latter's opinion is not binding.

"There is a discord between nature protection efforts and spatial planning" (interviewee 1, environmental authorities).

Another interviewee highlights another problem:

"Municipalities and investors are cunning, they make spatial plans for parts of the land at a time so that we do not notice the cumulative effect. Bit by bit and then the neighbouring municipality presents their plans" (interviewee 11, environmental authorities).

This poses a serious problem as Polish villages tend to be overly dispersed. Faced with the fact that mayors are unlikely to order spatial plans which would go against the interests of their local electorate, some research participants voiced an opinion that an external impartial agency should draft spatial plans for all municipalities. As one interviewee explains,

"Every mayor orders a plan that will suit local investors because otherwise he will not be reelected" (interviewee 11, spatial planning authorities).

However, to local municipalities environmental protection and creation of ecological corridors means the exclusion of a portion of their land from profitable economic activity and does not contribute to the local people's economic wellbeing. Rather than building hotels or supermarkets which create jobs, green areas are not thought to contribute much to local prosperity. As one interviewee puts is:

"There are too many corridors, they comprise too large an area. The planners are fine with it but the road authorities and the local municipalities do not like it and there is a conflict. Natura 2000 and national parks protect well preserved areas but corridors enter into areas that are intensively used. (…) Some municipalities lie entirely in a corridor (…). People are afraid of restrictions. What if they agree to a corridor and then one day it becomes a legally binding nature protection category? They don't want to tie their own hands" (interviewee 7, environmental scientist).

However, while the fear of economic stagnation can be understood, another interviewee draws attention to its scale:

"There was a report which calculated that local authorities in Poland protect area for investment that would suffice for 290 million people!

[Poland has under 39 million inhabitants.] This shows our way of thinking" (interviewee 10, environmental NGO).

"In village X in the mountains the locals are planning to increase the built up area twofold! The issue of corridors is urgent because in 10 to 15 years there will be nothing to work with" (interviewee 11, environmental authorities).

While local municipalities are generally thought to not care about conservation and sabotage efforts to safeguard connectivity, poor understanding of ecological connectivity is also to blame.

"In our county there were mistakes, corridors were drawn as lines, so some municipalities understood this literally. A municipality does not understand that the line is merely an indication of the direction of migration. That they must identify the corridor based on the line and draw it on the map as an area, not a line" (interviewee 6, spatial planning authorities).

Many research participants mentioned the fact that corridors rely completely on continuity, a corridor broken in one place is no longer functional and permeable as a whole. Thus arises the question of coordination, the need to work effectively across municipalities, counties, regions; the need for collaboration among various levels of governance and all of the different stakeholders.

"Every pencil line used to draw a corridor on the map has a thickness and an area that it covers, this land belongs to someone. Someone owns and manages it, it may be state owned but more often it belongs to a private person. (…) Different pieces of the land are governed by different institutions and somebody else decides what will be their use" (interviewee 10, environmental NGO).

Most interviewees agreed that roads, however dangerous to ecological connectivity, pose a smaller threat to wildlife than urban sprawl, as there are tools dedicated to mitigating the fragmenting effect of roads and highways, such as wildlife bridges, ecoducts or culverts. Despite that, a prominent problem highlighted especially by road authorities' representatives is the lack of coordination between the construction of wildlife overpasses and the surrounding land use. Many interviewees recalled cases where costly green bridges were built to be soon rendered non-functional because the

municipality gave permission for a housing estate or a supermarket to be built nearby. Such lack of coordination is often followed by a discussion regarding whose fault it is that the migratory corridor is broken, was the wildlife overpass badly designed or was it the municipality that did not respect the road authorities' work.

> *"We spent millions of zloty on a wildlife bridge which is not functional. (…) We cannot do anything about this, we must build overpasses but we cannot ensure that no land use change occurs around them. We give the coordinates of the overpasses to the Regional Directorate for Environmental Protection as they are the body that issues opinions on local spatial plans. But that opinion is not binding and the municipalities often do as they wish" (interviewee 3, road authorities).*

Another road authorities' representative elaborates:

> *"We organize consultations regarding the localization of wildlife crossings but municipalities don't usually attend. I'm not even sure if they would agree to have green bridges, maybe they would ask us to place them on the worst available land so that they can keep the good land available for future investments. Everyone protects their own interest. (…) Near city X there is an industrial park planned right next to green bridges and animals will no longer be able to use them. But the mayor doesn't care as he wants development for his municipality. When the bridges are non-functional, will this be our fault?" (interviewee 4, road authorities).*

While local municipalities are accused of non-cooperation, they too find the environmental authorities uncompromising and uncooperative. Oftentimes, corridors are designated *"from behind a desk",* and while they consider animal migratory patterns, they do not match actual human land use. When interviewed, local authorities' representatives usually emphasize lack of consultation of corridors drawn around national and landscape parks with the local people and the inadequacies resulting from not knowing the local surroundings well enough. As one research participant describes it,

> *"Parts of the corridors were designated from behind a desk. They were drawn in places where it is not possible to have a migratory corridor, for example in village X where there is a crossroads, a railroad, a river,*

a wall and an altitude difference. You do not need to have a university diploma to know that animals cannot migrate that way" (interviewee 17, local authorities).

"These places are unsuitable for ecological corridors, unless maybe for birds" (interviewee 18, local authorities).

"They drew ecological corridors slightly wrong. I think they didn't take into account all the elements, all the existing buildings, maybe they had old maps" (interviewee 19, local authorities).

Thus, lack of coordination and cooperation between the local and regional authorities poses a serious obstacle to implementation.

Finally, many interviewees expressed the concern that the central government is aware of the problems in spatial planning but is reluctant to enact any changes that would upset local municipalities.

"There is political will and stubbornness to avoid spatial planning at the local level, the mayors can make any decision they wish, they can take bribes" (interviewee 1, environmental authorities).

"The government's strategy is that spatial plans should not be required at the local level… This is unofficial, planners tell us this, but nobody will say it out loud. There is no political will to enforce spatial planning in order to not restrict investment tendencies" (interviewee 10, environmental NGO).

Lacking legal protection

Faced with a weak system of spatial planning in Poland, many regional actors share the view that *"spatial planning is a good tool but it will never replace legal nature protection" (interviewee 6, spatial planning authorities)* and corridors should be a category of nature protection inscribed in the Polish Nature Protection Law alongside the other nature protection categories such as national parks, nature reserves, landscape parks, areas of protected landscape, Natura 2000 sites etc. At present there is no nature protection category dedicated solely to ecological corridors; only *areas of protected landscape* have as one of their functions safeguarding ecological connectivity. Most interviewees referred to the lack of inscription of corridors in the law as a *'problem'*, and a *'mistake'*. Experts across the environmental, spatial planning and road authorities, NGOs and scientists express the need for *"legal instruments"*.

"The problem is the lack of employment of legal solutions, everyone emphasizes that" (interviewee 14, spatial planning authorities).

"Until ecological corridors are made a legal nature protection category it will not be fine. (…) Ecological corridors should be a category of nature protection such as Natura 2000 where there aren't huge restrictions, but potentially environmentally detrimental investments have to undergo environmental impact assessments" (interviewee 15, spatial planning authorities).

Most study participants expressed the belief that corridors are already protected to some extent by the requirement to carry out environmental impact assessments for large investments and for all Natura 2000 sites. Most interviewees stated that EIAs are currently the best tool to safeguard ecological connectivity. While corridors can also be protected through the process of spatial planning, legal protection can be seen to have more strength.

"Legal protection differs from protection through spatial planning in that the moment the law would be passed corridors would be protected instantaneously" (interviewee 6, spatial planning authorities).

However, most experts admit that a separate corridor category is not likely to be added into the Nature Protection Law in the near future. This is attributed to *"unfavourable political conditions"*. As one research participant explains the situation:

"I don't know if this will happen, it depends on the current political situation. If the political forces decide that this is politically worth it for them to change the law they can do it, if the current government gets reelected then there will be a chance" (interviewee 1, environmental authorities).

"We are in a complete political impasse, without the possibility to implement ecological corridors, a rightful idea (interviewee 12, environmental authorities).

It seems that the stronger the presence of right-wing parties in the government, the smaller the chance to pass a law contrary to the interests of local municipalities. As one interviewee reflects on their efforts to propose a new nature protection category,

"A high rank governmental official told us that there are no favourable political conditions to start a discussion regarding changing the law. If

we cannot even start a discussion, then I wonder, is this the right way? Corridors take up a very large portion of the country; there is this approach in conservation that it is better to ask for more in order to get less. But I'm thinking that maybe as a result of this we will get nothing" (interviewee 10, environmental NGO).

Cost

Many study participants mentioned the costliness of ecological corridors. However, only some acknowledged that this cost is somewhat hidden. The designation of corridors is a one off event and as such does not constitute a major expense, unless the cost of forest corridor restitution is considered. However, it is the hidden cost to municipalities, the cost of not being able to develop on certain lands and forgoing certain potential profits that matters. Thus, a few of the interviewees expressed the belief that the government should compensate local municipalities and private land owners for not being able to develop on their land or buy out that land.

"Personally I believe that there should be a fund for land buy-outs, for land which would be excluded from economic activity in order to create corridors, you have to compensate for that" (interviewee 11, environmental authorities).

When talking about roads and issues pertaining to wildlife crossings the question of cost is more straightforward. Wildlife bridges are expensive structures and despite the fact that EU funds devoted to mitigating connectivity loss can minimize the need for investors to pay from their pocket, they create some debate. One interviewee mentioned the issue of cost versus gain, or how much we are willing to pay for safeguarding connectivity.

"They [environmental NGOs] want numerous culverts for amphibians, but the cost will not be adequate to the gain" (interviewee 3, road authorities).

Offsetting the fragmentation effects of new roads is obligatory since Poland's entry into the European Union. However, one interviewee emphasizes the dangerousness of the existing road network to animals.

"The old roads are not fenced and they result in animal mortality that is four times higher than on the new roads. The level of traffic on them creates a large barrier to wildlife migration, but to try to fence all of them

and build wildlife crossings is unimaginable, no institution could financially handle this problem" (interviewee 4, road authorities).

5. Discussion

5.1 Concept

Having experienced much criticism, the concept of ecological corridors has undergone much evolution. The connectivity discussion among ecologists (including the Polish new legal definition proposed by Pchałek *et al.* (2011)) is increasingly shifting towards the broad concept of *green infrastructure.* The idea of using all space available to wildlife such as city parks and human structures is slowly beginning to be applied to traditional ecological corridors. Green infrastructure aims to improve overall ecosystem services and preserve and create as much naturally productive habitat as possible with green roofs, permeable pavements, urban gardens etc. The 2030 Spatial Planning Conception for Poland mentions the need to designate ecological corridors in cities and Walasz (2009) stresses the need to incorporate green city areas into local spatial plans. This has already been done in other ecological networks, such as the TSES which explicitly includes an urban green infrastructure category. While GI in cities might not be suitable as a corridor for wolves (although is increasingly frequently used by moose and wild boars), it provides important ecosystem services such as climate regulation and provision of recreational grounds (Szulczewska and Kaliszuk 2005). Interestingly, although corridors were originally conceptualized as a tool for connecting habitats, in heavily disturbed systems and anthropogenically modified landscape they increasingly constitute a valuable habitat in themselves (Gustafsson and Hansson 1997), which is recognised by the concept of green infrastructure. However, GI has its drawbacks. In addition to safeguarding ecological connectivity, green infrastructure also aims to satisfy socio-economic needs. It emphasises ecosystem services, natural capital, socio-economic wellbeing and sustainable growth and stresses that natural

The word *corridor* can be used to mean both a **physical** and a **legal** entity. Specifying the exact meaning is especially important when talking about the (lack of) need to create a corridor, for this may mean either ecosystem restoration activities or granting a piece of corridor land protected status be it through law or spatial planning tools.

Figure 27 Moose with calf in Warsaw Allotment Gardens

solutions and protected areas create jobs and contribute to local development. However, this seems somewhat simplistic and ideal. Although a paradigm shift in the way we think about nature and divide the natural and the man-made is welcome and can contribute to greater environmental responsibility and an improvement in the quality of our environment, it seems that it is nevertheless useful to keep ecological connectivity as a separate concept and goal in itself. As seen above, the concept of an ecological corridor network is complex enough in itself and combining it with other objectives such as socio-economic growth could render it unoperationisable. However, the concept of green infrastructure can be seen as useful for promoting multifunctionality of green spaces, recognising ecosystem services that are essential to our society and the socio-economic benefits that humans reap from natural spaces.

5.2 Designation problems

5.2.1 Divergent habitat requirements

Many sources and stakeholders express doubts regarding the correctness of using the umbrella species concept for designating corridors. It seems that using umbrella species in order to obtain habitat and scale parameters is a necessary simplification when designating and managing corridors. Although categorisation of corridors based on taxonomic groups has been done (e.g. in Silesia county), it does require more work than creating corridors for "*umbrella habitats*": forest, open-space and aquatic. However, it is physically impossible to maintain linear structures of forests, grasslands and rivers as well as man-made infrastructure without intersections. Jędrzejewski (2009) believes that forest corridors should be given priority due to the fact that forest dwelling species are less likely to cross unforested land than open-space species are

Figure 27 Socio-ecological hierarchy of corridors.

to cross a forest. Largest-ranging animals in Poland such as the grey wolf, the lynx

and the brown bear are forest species and they are also higher on the conservation agenda than other mixed habitat species. *Figure 27* illustrates our current corridor hierarchy. Highest are river corridors, for they are non-moveable and force road developers to build bridges over them. Second on the hierarchy are human needs – roads – for it should be safe to say that nobody, not even conservationists, dispute the necessity to have continuous quality roads in the country. Third, and first among arguably moveable natural corridors come forests with green bridges over roads and fourth and last come open-space grassland corridors. While bar length represents uninterrupted corridor length (without bridges), it also signifies the scale at which the corridor must be considered (with bridges).

However, it is important to note that not all habitat types need to be connected. Thus, building an ecological network based on the Natura 2000 sites may be an inherently flawed concept as the SPAs and SACs can be designated for completely different habitats and species that may not use the same ecological niches.

5.2.2 Scale

Various life forms have home ranges of various sizes, ranging from spending one's entire life in one location to migrating thousands of kilometres. Even organisms immobile as an individual (e.g. plants, lichens or fungi) spread as a species in time. Differentiating between large and small-ranging mammals for corridor designation can be practical, however, it must be noted that scale is merely a lens, a choice of close-up that one uses to look at an issue or object. Despite making the object appear different, the chosen frame does not change its substance or properties. Author of present thesis disagrees with scholars who, like Solon (2009) believe that local (inter-landscape) and (inter) regional corridors have different properties. To give the example of barriers, it is not that regional corridors have barriers while local corridors do not. In order to constitute a corridor, a regional corridor has to be permeable as a whole, even if some of its *"branches"* are not. On the other hand, when looked at in a close-up, a local corridor contains gaps between trees or streams which can constitute an impervious barrier to some species, as discussed in the *Literature Review*. However, creating a scale-based corridor hierarchy, such as the one used in TSES can be helpful for managing purposes, even if the hierarchy does not accurately reflect natural patterns.

A separate scale-related issue mentioned by many stakeholders relates to the divergent scales used when mapping corridors (e.g. national or regional) and implementing (all corridors must be implemented locally) which often creates problems at the implementation stage.

5.2.3 Dynamic data

Many interviewees mentioned the problem of *dynamic data* – the fact that drawing corridors for mobile wildlife whose preferences change as well as the constantly changing landscape is difficult if not impossible. However, while the first example of moving animals might pose some problems, the second one of unpredictable land-use seems to be begging the question. Potential change such as the disappearance of a forest is precisely something against which ecological corridors should be protected. Thus, it is possible to designate corridors correctly according to the current land-use and protect them from detrimental change.

As mentioned in the previous sections, it seems that the many designation issues stem from the fact that corridors are a very intuitive and simplified idea (Dawson 1994). While they are useful in human transformed environments in which we need to recreate wildlife habitats, we should bear in mind that due to the oversimplifications we are bound to run into numerous conceptual and practical obstacles described in the following chapter.

5.3 Implementation problems

5.3.1 Legal protection

Definition

Prior to discussion of suitable protection tools, the legal definition of corridors must be adequately adjusted. Pchałek *et al.* (2011) believe that ecological corridors should be defined both functionally and structurally**,** as a route that enables the migration and dispersion of animals, plants, fungi, protists and diaspores. Thus, a corridor can be both linear and non-linear, continuous and discontinuous, natural, semi-natural or anthropogenic, including biotic and abiotic elements and airspace (Pchałek *et al.* 2011).

Financial Compensation and Cost

The Dutch experience shows how devoting significant funding to the creation of an ecological network resulted in the regional authorities being more eager to create corridors than the central government could afford (Windt and Swart 2008). Many

research participants shared this view, that financial compensation for inability to invest on one's land and income forgone would solve the problem of local opposition. However, it seems that the central government is not presently willing to spend financial resources on a compensation or land buy-out scheme. Nevertheless, many environmentalists do believe that such a scheme in necessary. Pchałek et al. (2011) suggest that a new Agency for the Preservation of Biodiversity should be set up to land buy-outs and conservation management contracts on private lands.

An interesting related question appears regarding the cost-efficiency of corridor protection. While initial effort and expenditure, e.g. on wildlife over and underpasses creates much net gain (by saving many animals), cost-efficiency goes down as we build more passes. Thus we must answer ourselves the question of how much a species or an individual of that species is worth to us.

5.3.2 Spatial planning system

The spatial planning system in Poland has been constantly reformed since 1990s with several proposed amendments of the law on spatial planning currently in circulation. Environmental regulations as well as the institutions and authorities responsible for them have recently undergone much modification, partly due to Poland's joining the EU (Kołpiński 2009). Following the annulment of old spatial plans (further discussed in the *Local Spatial Plans* section), revoking of protection of urban agricultural lands and exclusion of infrastructural investments from spatial planning constraints altogether (Kołpiński 2009) the Polish planning system is now thought to be very weak. Spatial planning in Poland occurs on the following levels:

Figure 28 Local Planning Documents

1. The Conception of Spatial Planning for Poland (ordered by the minister responsible for regional development) – outlines the aims and directions of sustainable development and environmental protection.
2. County Spatial Plans (ordered by regional authorities) – include strategies for county development, nature protection, achieving 'spatial order', rational use of nature and its resources and shaping of the natural environment.

3. Local Spatial Plans based on Studies of Determinants and Directions in Spatial Planning (ordered by municipal authorities) – constitute local law and determine physical land use.

Successful implementation of connectivity protection must thus be synchronised and take place at all levels of planning.

2030 Spatial Planning Conception for Poland

The 2030 Conception of Spatial Planning for Poland devotes much space to discussion of environmental protection, ecological connectivity and expresses the belief that corridors should be protected similarly to the Natura 2000 Network. The document lists three main terrestrial corridors: *Baltic-lakeland*, *upland* and *montane*. Although this seems to be a mere indication of location/terrain, it is not consistent with either Econet or Jędrzejewski *et al.*'s (2005) corridors. This might be explained by the fact that the General Directorate for Environmental Protection is planning to order a new corridor network conception, a fact confirmed by many research participants. The Conception also proposes the creation of a network of landscape parks. In the absence of any unanimously acknowledged and functional corridor network conception, this idea to focus a separate network on just one nature protection category seems somewhat unnecessary to the author of present thesis.

The Conception views excessive use of the environment as a barrier to development, an opinion not shared by the spatial plans of many counties, which often declare environmental protection as a barrier to socio-economic development.

County spatial plans

It is the task of regional authorities to draft a county spatial plan as well as providing opinions on local spatial plans drafted by local authorities. However, such opinions are not binding with the exception of legally designated protected areas (Blicharska *et al.* 2011). Bernatek (2011) conducted a study which analysed inclusion of connectivity into the spatial plans of all 16 Polish counties. Although by the time of writing this thesis 5 out of the 16 plans should have been replaced by new ones, *Figure 29,* which is a graphic presentation of qualitative data obtained from the report, should nevertheless provide an indication of connectivity incorporation in county spatial plans. As of 2011, 13 out of 16 counties were basing their corridor conception on Econet, one county used both Econet and Jędrzejewski *et al.*'s (2005) corridors, one declared that the Natura 2000 Network was enough to protect connectivity, and one county did

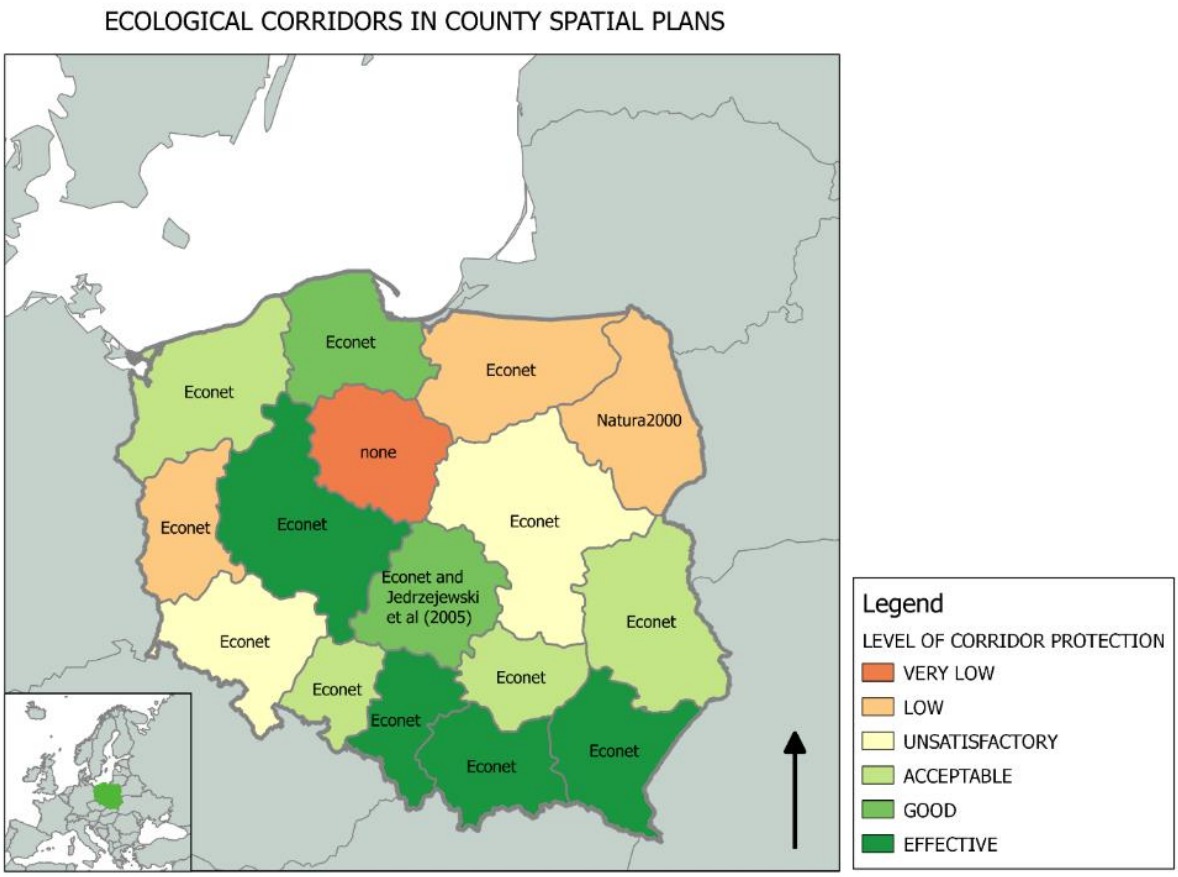


Figure 29 Inclusion of ecological corridors into county spatial plans

not indicate any conception of ecological connectivity in its plan. While most counties use Econet, Kistowski (2009) emphasizes that the conception was designed at the national scale (1:500 000) which in not appropriate for county maps (1: 100 000-1: 200 000). As discernible from Bernatek's (2011) study and mentioned by Miłosz-Cielma *et al.* (2009), who conducted similar research in 2008, the use of various conceptions across counties and varying degrees of importance assigned to connectivity render the national ecological network incoherent and its protection uneven. Miłosz-Cielma *et al.* (2009) emphasize the need to apply consistent methodology across all counties, define concepts and terms identically, develop GIS data and tools to the same extent and make the same institutions responsible for corridor designation and implementation in order to achieve coherent protection. Kistowski (2009) emphasizes that both the Conception of Spatial Planning for Poland and County Spatial Plans should undergo strategic environmental assessment to evaluate their environmental performance, corridor and proposed solutions for resolving environment versus development conflicts.

Unfortunately, despite improving inclusion of corridors into county spatial plans, county plans are not binding for local plans and county corridor conceptions are usually not transposed into local spatial plans.

Local spatial plans

In addition to local plans being independent of county plans, local plans are seldom devised at all. Following a much contested reform in 1995, preparing new local plans is not mandatory while the plans created prior to 1995 were annulled. As municipalities do not get additional funding for spatial planning, 75% of the Polish territory has no spatial plans (Selva *et al.* 2011). Thus, majority of construction and investment do not follow any spatial planning conception and decisions regarding permits are undertaken in a non-standard procedure without public participation (Kołpiński 2009). Yet, as emphasized by Blicharska *et al*. (2011) in order to successfully protect a species, we must protect a functioning network of its habitats as well as relevant ecological processes (Noss 1990) which may not be entirely known and understood. Thus, it is crucial for spatial planning to be practiced for all land rather than being limited to protected areas (Blicharska *et al.* 2011).

In a situation where there is no continuity between the spatial planning levels and higher order plans do not determine the contents of lower order plans, the resulting connectivity protection is very weak (Kołpiński 2009). Many planners believe that delineation of ecological corridors within Studies of Determinants and Directions in Spatial Planning and urban Spatial Plans should be mandatory. Regulations regarding land use, corridor protection and restoration solutions should be a mandatory component of all planning documents, from the national down to the local level. The example of the Netherlands has been used to illustrate a system where local spatial plans are drawn by an external agency thus reducing the threat of favouring developers' interests and bribery and ensuring national planning cohesion. The TSES also provides an interesting solution, where only the lowest hierarchy corridors are managed by local municipalities. Thus, if local nature protection efforts are insufficient, two higher levels of corridor hold the network together. However, despite major flaws in the Polish planning system, corridor protection is beginning to be strongly present in higher level plans thus allowing one to hope that connectivity ideas will in time trickle down the hierarchy.

5.3.3 Forestry planning

Separate from administrative spatial planning, forestry planning is carried out by the State Forests enterprise. It takes place at the local level of forest districts but should comply with larger scale annual management plans. Although regional authorities can provide comments on the content of the plans, they are unable to exert any direct pressure on the State Forests institution. Despite frequent concerns over the State Forests' excessive focus on invasive forest management, lack of appreciation of oldgrowth forests and the biodiversity reliant on them, Polish forests are protected against clear-cutting and unsustainable management by the Forest Law (1991). Nevertheless, it could be interesting to study the permeability for migratory species of managed and unmanaged forests. As forest corridors are considered by many to be a priority, several corridor afforestation programmes have been carried out (Błaszczyk 2009). Pchałek *et al.* (2011) believe that forests constituting migratory corridors should be included under the *protected managed forests* category as well as no hunting being permitted within them in order to align connectivity protection efforts across sectors.

5.3.4 Protected area management planning

Deodatus *et al.* (2013) as well as many other scholars believe that management plans are a necessary protection tool for corridors. While such a step could only follow legal designation of corridors, inclusion of connectivity protection can presently be traced in existing Natura 2000 management plans.

As mentioned in the *Results* section, the amount of space devoted to connectivity in the management plans for Natura 2000 sites is low. Many plans do not mention corridors at all and only one in ten describes ecological corridors to a considerable extent. However, it is considerable only as compared to the other plans, thus the overall level of connectivity inclusion in Natura 2000 management planning being poor. Corridors were more likely to be considered for forest and wetland habitats which is consistent with greater overall priority assigned to forest corridors. As in case of county spatial plans, some counties were found to be better than others at addressing connectivity issues. As inclusion of corridor management measures is optional (Pchałek *et al.* 2011), only one out of the forty analysed plans proposed such management measures for corridors outside of the Natura 2000 site. In general the plans appear to be focused on inventorying rather than proposing management measures and conservation targets.

Many environmentalists believe that ecological connectivity protection measures should be a mandatory component of Natura 2000 and other protected areas' management plans and both conservation and forest management plans should be binding for spatial planning on all levels.

5.3.5 Environmental impact assessments

EIAs are a preventive method to ensure compatibility of development with national as well as EU environmental regulations. Through engaging with the public they are meant to create greater objectivity and transparency in decision making, lead to a higher awareness of the environmental consequences of investments and finally lead to the adoption of the least environmentally harmful option (WWF 2006). EIAs are regulated by the EIA and SEA Directives of the EU which have been transposed and adopted nationally.

EIAs in Poland

Appropriately conducted EIAs were indicated by many research participants to be one of the best tools for protecting landscape connectivity in Poland. However, as portrayed in a report by WWF Poland and the Institute for Environmental Economics (2006), the quality of Polish environmental impact assessments remains unsatisfactory. All too often EIAs do not consider alternatives or seek the least environmentally harmful option but rather present the results so as to suit the investor (WWF 2006). Ignoring adverse effects or belittling their significance, mitigation or compensatory measures which remain a mere declaration and lack of consideration for the public opinion are frequent shortcomings of Polish EIAs. Using the example of Via Baltica, Keshkamat *et al.* (2009) argue that alternative locations and solutions are not insufficiently explored, especially so in the Polish road construction sector. As development which is not suspected to have a negative environmental effect does not require an EIA, the cumulative effects of many construction projects are overlooked (Selva *et al.* 2011). Thus, although the European EIA regulations have been correctly transcribed into the Polish law, their practice remains flawed. Quality of analyses, qualifications of their authors as well as the knowledge and qualifications of decision-makers who interpret the EIAs and make decisions based on them often remains unsatisfactory. However, when conducted correctly, EIAs do prevent unsustainable development and facilitate the selection of the least environmentally harmful option (Wodzyński 2009). Proponents of granting corridors protection similar to that of Natura

2000 sites believe that in designated corridors investments that by themselves or in combination with other investments may negatively impact an ecological corridor should be permitted only once lack of impact has been confirmed through an EIA. Similarly, article 6 of the Habitats Directive regarding *absence of alternative solution* and *overriding public interest* should apply in relevant cases while guaranteeing compensatory connectivity measures.

EIA of the National Road Construction Program 2011-2015

Although not representative of inclusion of connectivity issues in EIAs, the Environmental Impact Assessment of the National Road Construction Program 2011-2015 gives an indication of the state of corridor recognition in high level EIAs. From its analysis several interesting issues emerge. Firstly, the report claims that as a result of new road construction the environmental pressure resulting from traffic on existing roads will decrease. Although potentially true, better roads will likely encourage Poles to buy more cars thus increasing overall traffic. Additionally, as the new roads are often fenced, they constitute an impervious boundary to most creature for most of their length. The document emphasizes that the environmental impact of existing roads will decrease after the completion of the new road network. The underlying assumption is that from the environmental impact of planned investments one can subtract the decrease in environmental impact of existing ones. Even if that were considered justified, the report misleadingly portrays the new roads as decreasing the overall environmental impact, which is very clearly not so. The report further underlines that the number of collisions of the new transportation network with bird corridors is less than that of the old network. This might at first appear as net gain; however, it merely has the potential to slightly decrease the overall number of physical collisions with birds under the assumption that twice more roads would mean twice less traffic. The aforementioned issue of scale came up in the *Report* as well. The document rules out any considerable impact on small-range species at the regional and national scales. However, it seems that multiple impacts at the local scale would cumulatively result in increased amphibian mortality at the national scale. Interestingly, the *Report* attempted to divide the impact on species and on corridors. This seems to the author of present thesis difficult, if not illogical, for the function of corridors is securing the possibility of movement and not merely long-distance migration. Thus, any animal

death on the road can be understood as death while using a movement corridor which renders the impact roads have on species and on corridors indistinguishable.

5.3.6 Public participation

Figure 30 Hierarchy of public participation (Countryside Council for Wales 2007)

The principle behind public participation is recognising the value of local contextual knowledge (EC 2000). As the process of planning should be transparent and accountable, informing, teaching, consulting and asking for the opinion of the local public is necessary to achieve a functioning and respected decision-making system and a deliberative democracy, where decisions are not only majority-rule based but are also discussed and deliberated (Dryzek 2000). A good public participation process should be open to everyone and reciprocal, i.e. involve dialogue – both speaking and listening – as well as learning (Hajer and Versteeg 2005). *Figure 30* illustrates the hierarchy of stakeholder consultation as mapped by the Countryside Council for Wales (2007).

Deodatus *et al.* (2013) argue that creation of ecological corridors is a good opportunity for involving the public and gaining more acceptance of biodiversity conservation efforts. However, given widespread lack of understanding of and support for environmental protection among the rural population in Poland, at present corridor designation seems to constitute more of a challenge than an opportunity. Kluvankova-Oravska *et al.* (2009) believe the Natura 2000 Network which constitutes a large part of the ecological corridors, was designated without engaging the public and with excessive reliance on scientific criteria in central and eastern Europe. The process was a top-down initiative; local populations were not prepared for it, educated about it or provided with incentives to comply with and contribute to this largest to-date nature conservation scheme. Difficulties relating to economic activity and perceived limitations have led to widespread negative attitude towards the network, a phenomenon which bodes badly for any efforts to introduce an even larger-scale

network of ecological corridors. Lack of importance assigned to the participatory approach and cross-sectorial cooperation in planning, which constitutes legacy of the previous undemocratic system, pose a major obstacle to gaining public support for nature conservation (Kluvankova-Oravska *et al.* 2009; Blicharska *et al.* 2011). While the advantages of wildlife corridor comanagement often remain undervalued (Brown and Harris 2004), development of corridors without public participation and focusing solely on biodiversity protection may reinforce uneven levels of development across landscapes (Finley-Brook 2007). While certain public participation tools for regional and local plans as well as environmental impact assessments do exist in Poland, local inhabitants are often unaware of this possibility, as reported by research participants.

5.3.7 Landscape as a socio-ecological system

Following the importance of public participation in determining local land use, it is vital to understand and treat landscape as a socio-ecological structure and take into account landscape's contribution to local culture and social identity (European Landscape Convention 2000). Jongman (2002) believes that next to fragmentation, landscape homogenisation resulting from globalisation, agricultural intensification and abandonment of traditional agricultural practices is the most serious threat. Thus, biological and cultural diversity loss and the disappearance of regional differences are inextricable linked. Importantly, planners in holistic socio-ecological planning should act as negotiators rather than landscape designers (Jongman 2002). The shape of the surrounding environment should thus be the result of a shared vision between environmental

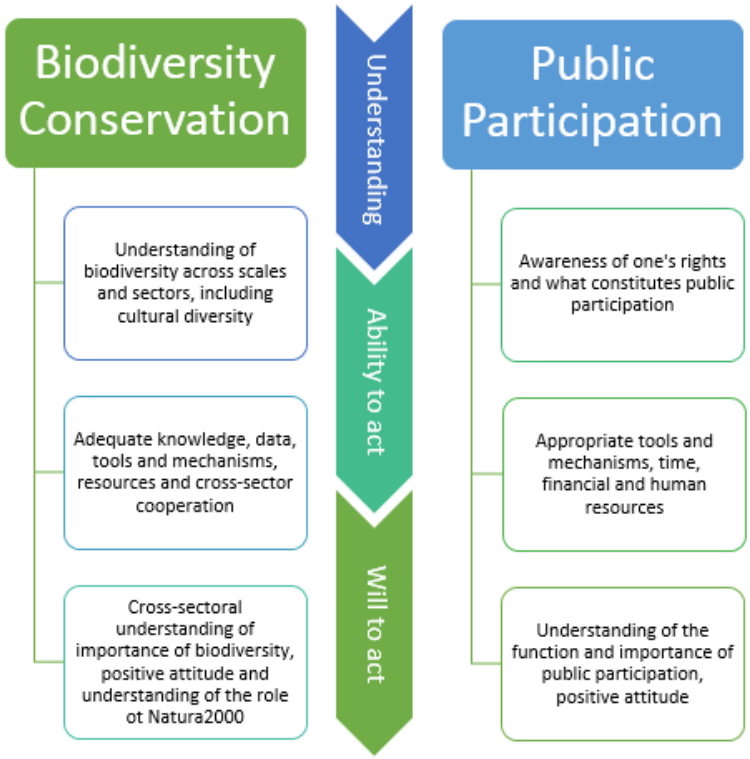


Figure 31 Landscape as a socio-ecological system: parallels between biodiversity conservation and public participation (modified from Blicharska et al. 2011).

managers and the local people who live and work within that environment (Saunders 2007). Effective comanagement seems especially important in case of Jędrzejewski *et al.*'s (2005) corridors, as 42% of their surface is constituted by farmland. *Figure 31* portrays the parallels between effective biodiversity conservation and public participation, where both can be seen to require understanding, ability to act and finally the will to act.

6. Policy Recommendations

Based on interview results, general research findings and the review of literature the following recommendations for central and regional authorities can be made for advancing the issue of implementing ecological connectivity protection in Poland:

Recommendation 1: Order an all-encompassing coherent and sufficient by itself conception of an ecological corridor network and adopt it nationally.

Rationale: Lack of coherent and undisputed corridor network conception that covers all species and habitats.

Recommendation 2: Enforce the new conception and make it the standard conception mandatory to take into account in planning documents to ensure coherence of the ecological network across counties.

Rationale: Currently different counties employ different conceptions or devise their own which does not ensure coherence on the national level.

Recommendation 3: Enforce the transposition of county corridors into local spatial plans.

Rationale: Local spatial plans are currently independent of county plans which undermines the point of delineating corridors in county spatial plans.

Recommendation 4: Strengthen the system of spatial planning and enforce drafting of local spatial plans for all territories.

Rationale: Drafting local spatial plans is not obligatory in Poland resulting in chaotic development that does not follow a spatial pattern. Additionally, numerous exceptions from spatial planning regulations for infrastructural investments are in place.

Recommendation 5: Create a new nature protection category – *the ecological corridor* – and give it protection status similar to that of Natura 2000 sites.

Rationale: At present *areas of protected landscape* are the only category meant to protect ecological connectivity and the protection they grant is very weak.

Recommendation 6: Render protected areas management plans binding for local spatial plans.

Rationale: Currently, protected areas management plans cannot put forward any binding requirements towards their surrounding lands.

Recommendation 7: Set up a fund to finance land-buy-outs and conservation management activities on private corridor land.

Rationale: Local populations cannot be expected to support and respect ecological corridors unless they are compensated for the income forgone. Moreover, municipalities located fully in corridor areas can be significantly economically disadvantaged by corridor designation.

Recommendation 8: Conduct widespread educational, information and awareness raising campaigns among the rural population.

Rationale: Currently the level of understanding of the purpose behind nature conservation is poorly understood. Bad image of the Natura 2000 network contributes to the lack of support for new protected areas.

Recommendation 9: Improve the level of public participation in environmental decision making, develop new participatory approaches and tools.

Rationale: Present level of public participation in management planning, environmental impact assessments and spatial plans is very low. Often local inhabitants are not aware of the possibility to impact decisions.

Recommendation 10: Promote alternative sources of income (e.g. eco-tourism) in corridor areas, support sustainable and smart growth through informational campaigns and financial support.

Rationale: Nature conservation is widely perceived as an obstacle to socio-economic growth. The advantages and income generating potential of protected and natural areas is undervalued.

Recommendation 11: Devise a set of high nature value farmland practices and promote them in corridor areas.

Rationale: Much of the corridor surface in constituted by agricultural lands occupied by small family farms. Such areas have high biodiversity potential and should be preserved together with their biodiversity-friendly agricultural management practices.

7. Conclusions

Landscape connectivity is species and scale specific, where for different species the same landscape can be permeable or impervious. Natural connectivity levels for habitats are hard to determine as they depend on past land use, local ecosystem dynamics and the exact habitat type. Lack of sufficient habitat connectivity has been shown to have negative consequences for many species, especially those with large home ranges and thus establishing ecological corridors and networks has been proposed to remedy landscape fragmentation and has been proved beneficial in case of certain species and habitats. However, as a context specific structure corridors cannot follow any generalization or be employed as an overarching conservation strategy applicable to all landscapes and species (Schmiegelow 2007). Many arguments against treating ecological corridors as a conservation priority have been made including claims of corridors being an oversimplified, unoperationisable and cost-inefficient strategy. Proponents of ecological networks counterargued that "the original landscape was interconnected" (Noss 1987) and that "fragmentation-sensitive focal species identified at multiple spatial scales and representing a variety of habitat types may capture the movement needs of many other species" (Noss 2007). Most scholars agree that landscape is more than a mere sum of its components (Cale 2007) and thus a network of core and buffer zones linked by corridors presents a higher value to wildlife than sum of its parts (Noss 2007). In response to criticism the concept of ecological corridors has shifted towards green infrastructure and improving the general quality of our landscape matrix. Landscape heterogeneity can be seen to be advantageous to the concept of corridors as it addresses connectivity at various spatial and temporal scales (Schmiegelow 2007).

While tracing the evolution of the concept of ecological corridors, it becomes apparent that they are neither a protected area nor a human use zone, but constitute something in between. Thus, the break the polarized divide between *the natural* and *the man-made* environment and remake it into a spectrum. The concept of green infrastructure explicitly acknowledges the natural value of some man-made structures and encourages *multifunctionality* in the former place of *divide*. The debate around ecological connectivity is going towards a new and holistic approach to planning, where the needs of nature and humans are awarded equal priority and the divide between *humans* and *nature*, *the protected* and *the used* is disappearing.

A clear disconnect exists between corridor science, policy and practice, where the level of science already allows us to designate corridors, some policies are beginning to take connectivity account but practice lags behind. Advanced GIS mapping, modelling and general designation tools separated from successful implementation the implementation gap caused by the complicated reality of land management, ownership rights, multiple stakeholders and the conservation versus development discourse. Successful corridors are not merely ecological but "natural, socio-economic and legal entities" (Deodatus *et al.* 2013:705). Thus, ensuring that environmental research feeds into policy making and local governance is essential for sustainable landscape and land use planning (Evans 2006).

Ecological connectivity has been an important point on the environmental policy agenda in Poland since 1990s. Although no single conception of an ecological network has been officially endorsed, ecological connectivity is strongly present in several high level policy documents. Unfortunately, the focus devoted to connectivity by higher level institutions does not ensure their implementation at the local level. Numerous obstacles to effective corridor management include designation issues such as divergent habitat requirements of different species and problems relating to scale and deficient data and implementation issues such as the weak and uncoordinated system of spatial planning in Poland, lack of legal and other protection tools assigned to corridors, the potential high cost of a financial compensation scheme, low public participation and support for conservation and the unwillingness of the central government to start a discussion on connectivity protection. The vision of environmental protection described in the 2030 Spatial Planning Conception for Poland is very ambitious yet it seems disconnected from the Polish reality and makes one wonder whether its realisation is even remotely possible. While the Conception clearly states that unsustainable use of the environment poses a barrier to economic development, the majority of regional and local decision makers believe the opposite. As a country whose nature is relatively well-preserved compared to Western Europe and who is trying to catch up with its Western neighbours' level of development, Poland faces an exam in the understanding and implementation of the principles of sustainable development (Pasek 2009). The existing debate on protecting ecological connectivity and improving the spatial planning system and spatial order let one hope that the result of the exam will be positive.

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Picture References:

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9. Appendices

9.1 Interview participant typology

Branch	Sector	Number interviewed	label
Environmental protection	Central and regional government	4	Environmental protection authorities
Spatial planning	Central and regional government	4	Spatial planning authorities
Environmental protection	NGO	3	Environmental NGO
Local authorities	Local government	4	Local government
Environmental protection	Scientific Institution	2	Environmental scientist
Road infrastructure	Central and regional governmental	3	Road infrastructure authorities
In total		20	

9.2 Natura 2000 management plans analysis data

Site code	Site name	County	Dominant habitat type*	Site size (ha)	Corridors addressed	Corridor inclusion
PLH300016	Bagno Chlebowo	WP	Fen	465.31	No mention	none
PLB240002	Beskid Żywiecki	SL	For	34988.9	Local corridors and core areas indicated based on the county environmental authorities' conception (**Parusel *et al.* 2007**) and the county spatial plan, mention of type of species particular corridors are for, and list of places crucial for permeability, connections between sites and other core areas listed, transnational corridor listed,	much
PLH240006	Beskid Żywiecki	SL	For	35276.06	Local corridors and core areas indicated based on the county environmental authorities' conception (**Parusel *et al.* 2007**) and the county spatial plan, mention of type of species particular corridors are for, and list of places crucial for permeability, connections between sites and other core areas listed, transnational corridor listed, + Use of **Jędrzejewski *et al.*'s (2005)**corridor conception, mention of threat (construction, building up of the area, transportation infrastructure)	exceptional
PLH300001	Biedrusko	WP	Wet	9938.1	Mention of a major corridor (North-Central Corridor according to **Jędrzejewski et al. (2005)**) of which the site is part, brief description of that corridor (mostly location, mention of general importance, also transnational)	little
PLH220005	Bytowskie Jeziora Lobeliowe 2	PM	Mix	2490.32	Mention of localization within **Jędrzejewski et al.'s (2005)** corridors, stated that the site is mostly located outside any corridor, mention of distance to other Natura 2000 sites, description of connectivity with surrounding areas with	some

					identification of the type of forest, mention of lack of hydrological connections	
PLH240001	Cieszyńskie Źródła Tufowe	SL	For	266.9	Use of county corridor conception (**Parusel *et al.* 2007**), list of corridors (according to above conception) with species specification that the site lies in reach of, list of protected area integrity network corridors, mention of local construction restriction measures, greenery protection requirements,	considerable
PLH300038	Dolina Cybiny	WP	Riv	2424.72	Statement that linear shape (river valley) renders the site an ecological corridor	very little
PLB240001	Dolina Górnej Wisły	SL	Mix	24740.2	List of corridors within the site (with mention of taxonomical user group),	little
PLH080009	Dolina Ilanki	LB	Riv	2232.83	Mention that the plan can regulate activities inside as well as outside the site, e.g. to maintain ecological connectivity, mention that the site lies almost completely within an ecological corridor (according to **Econet**)	little
PLB300006	Dolina Małej Wełny	WP	Riv	1252.3	No mention	none
PLH160008	Dolina Małej Panwi	OP	Riv	1106.3	Mention of the site constituting a local ecological corridor and proximity to a national core area (according to **Econet**), description of the corridor's localization and mention of most transformed and non-functional areas. Mention of the county spatial plan and the Program of Environmental Protection for Opolskie County 2012-2015 as potential sources of corridor management meausres	considerable
PLH160001	Forty Nyskie	OP	Str	55.43	No mention	none
PLH300048	Glinianki w Lenartowicach	WP	Lak	7.4	No mention	none
PLH300018	Jezioro Brenno	WP	Lak	79.5	No mention	none

PLH080053	Jezioro Janiszowice	LB	Lak	206.1	Mention that according to **Jędrzejewski *et al.*'s (2005)** conception site is located within a corridor	very little
PLH300006	Jezioro Kubek	WP	Mix	1048.78	No mention (despite mention that grey wolf inhabits surrounding forests)	none
PLH160003	Kamień Śląski	OP	Gra	832.4	Statement that the site is located outside ecological corridors according to **Badora and Rosik-Dulewska (2010)** (county conception)	very little
PLH080037	Lasy Dobrosułowskie	LB	For	11192.9	Mention of use of **Jędrzejewski *et al.*'s (2005)**publications regarding corridors, mention of localization of site within the Western corridor **(Jędrzejewski)** and statement of its importance in connecting wolf populations in north-western and north-eastern Poland, mention of insufficient habitat connectivity as a threat to wolf populations, mention of retaining ecological connectivity as a protection measure for wolves, mention of the necessity to implement a national system of ecological corridors and incorporate it into spatial planning on all levels, statement that any changes to local spatial plans should be preceded by assessment regarding their effect on connectivity	considerable
PLH240013	Meander Odry	SL	Wet	156.6	Mention of ecological corridors in reach of the site according to county corridor network conception (**Parusel *et al.* 2007**) and county spatial plan and mention of importance of rivers as ecological corridors	some
PLH300030	Ostoja koło Promna	WP	For	1399.01	Single mention of importance of canals as corridors,	very little
PLH300009	Ostoja Nadwarciańska	WP	Riv	26653.1	No mention	none
PLH160004	Ostoja Sławniowicko-Burgrabicka	OP	Str	771.6	Mention that the site lies outside of the Opole County ecological corridor network **(Badora and**	little

					Rosik-Dulewska 2010) and near to a core area of national importance according to **Econet**	
PLH240022	Pierściec	SL	Str	1702.1	List of corridors (with taxonomical specifications) that run through the site according to **Parusel *et al.* (2007)**	some
PLH240003	Podziemia Tarnogórsko-Bytomskie	SL	Str	3490.8	List of corridors (with types) in reach of the site according to the county conception **(Parusel *et al.*2007)**	some
PLH300026	Pojezierze Gnieźnieńskie	VA	Lak	15922.1	No mention	none
PLB300011	Pojezierze Sławskie	VA	Lak	39144.8	No mention	none
PLB080001	Puszcza Barlinecka	VA	For	26505.63	List of corridors within reach with their function (simple)	little
PLH300011	Puszcza Bieniszewska	WP	For	954	No mention	none
PLH300012	Rogalińska Dolina Warty	WP	Mix	14753.6	No mention of corridors in the text) despite mentioning **Jędrzejewski**'s publication in *literature*)	none
PLH080041	Skwierzyna	LB	Str	0.3	No mention	none
PLB240003	Stawy Wielikąt i Las Tworkowski	SL	Mix	914.5	Mention of site as important for Odra river ecological corridor, mention of corridors in reach according to county conception **(Parusel *et al.* 2007)**	little
PLH240016	Suchy Młyn	SL	Mix	518.1	Mention of the national importance of the site as a river valley corridor, mention of corridors within reach of the site according to **Przemyski *et al.* (2010).**	little
PLH240004	Szachownica	SL	Str	13.1	No mention	none
PLH300019	Torfowisko Rzecinskie	WP	Fen	236.36	No mention	none
PLH040020	Torfowisko Linie	KP	Fen	5.3	No mention	none
PLH240040	Las kolo Tworkowa	SL	For	115.1	Mention of the location of the site in an important river valley corridor (according to **Parusel *et al.***	considerable

					2007), list of corridors within reach (types of species, mention of transnational corridor)	
PLH300002	Uroczyska PłytyKrotoszyńskiej	WP	For	34225.2	No mention	none
PLH300014	Zachodnie Pojezierze Krzywińskie	WP	Lak	5494.83	Mention of lack of local connectivity between lakes (for the pond turtle),	very little
PLB160002	Zbiornik Nyski	OP	Lak	2127.9	Mention of the site being part of a national ecological corridor (according to county conception by **Badora and Rosik-Dulewska (2010)** and an important bird migratory corridor, mention of distance to nearest surrounding Natura 2000 sites	little
PLB160003	Zbiornik Otmuchowski	OP	Lak	2027.01	Mention of the site being part of an ecological corridor according to the county conception by (**Badora and Rosik-Dulewska 2010)**, description of which sites said corridor connects	little

* For (forest), Wet (wetland), Gra (grassland), Str (structure), Lak (lake), Riv (river) Fen (fen), Mix (mixed).

9.3 Incorporation of ecological corridors into county spatial plans

(based on qualitative data from Bernatek (2011)

County	Conception of ecological corridors used	Level of protection of corridors*	Details
Greater Poland	Econet	Effective (5)	Mention of corridors on all stages of spatial planning, recommendations for protection in local plans, proposed protection measures, recommendations for future corridor designation and legal protection, environmental protection seen as an opportunity
Kuyavian -Pomeranian	None	Very low (0)	Little mention of corridors, protected areas seen as a barrier to development
Lesser Poland	Econet	Effective (5)	Mention of corridors on all stages of spatial planning, emphasis on importance of corridor protection for the preservation of biodiversity, proposed measures for safeguarding connectivity, proposed new protected areas, quality of the natural environment among the four strategic goals
Lodz Voivodship	Econet Jędrzejewski *et al.* (2005)	Good (4)	Mention of corridors on all stages of spatial planning, integrity of protected areas seen as an opportunity
Lower Silesia	Econet	Unsatisfactory (2)	Some mention of corridors
Lublin Voivodshiop	Econet	Acceptable (3)	Mention of corridors, description of planning protection tools
Lubusz Voivodship	Econet	Low (1)	Little mention of corridors
Masovia	Econet	Unsatisfactory (2)	Mention of corridors and connectivity issues, strategic goals development-oriented, environmental protection further down on the list
Opole Voivodsip	Econet	Acceptable (3)	Mention of corridors in many parts of the document, suggestions of protection measures (excluding transportation)
Podlaskie Voivodship	Natura 2000	Low (1)	Some mention of corridors, some proposed protection measures
Pomerania	Econet	Good (4)	Mention of corridors on all stages of spatial planning, acknowledged importance of spatial integrity, suggestions of protection measures, environmental protection and development of equal priority
Silesia	Econet	Effective (5)	Mention of corridors on all stages of spatial planning, proposed protection measures (but not enough for transportation)

Subcarpathia	Econet	Effective (5)	Mention of corridors in many parts of the document, separate sub-chapter devoted to connectivity, proposed protection measures
Swietokrzyskie Voivodship	Econet	Acceptable (3)	Some mention of corridors, not enough protection measures (only fragmentation adequately addressed), environmental protection 'should' be equal priority as socio-economic development
Warmian-Masurian Voivodship	Econet	Low (1)	Little mention of corridors, few proposed protection measures
West Pomerania	Econet	Acceptable (3)	Some mention of corridors, some protection measures

* Based on strength of inclusion into the county spatial plan and number of measures proposed to address connectivity the level of protection was categorised into the following categories: effective, good, acceptable, unsatisfactory, low and very low.