The experience in networks. Ecological spatial cohesion – basis for nature conservation

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Protected areas and biodiversity: a diverse picture

The distribution of protected areas over the European countries is far from regular (see Figure 1). Most protected areas in the central and western European countries are small, with a few larger ones. This picture is different for Spain, Norway and especially Russia, where the larger protected areas dominate, illustrating how difficult it is to develop general guidelines for ecological spatial cohesion. In this paper I will nevertheless develop lines of thought on such guidelines, from a scientific perspective. Experiences from several countries illustrate these principles.

The decline in biodiversity which – despite all efforts in nature conservation – is ever continuing, has its causes in decreasing sizes of natural areas, decreasing habitat quality, fragmentation by infrastructural and urban developments and decreasing land use variation due to land abandonment. The relationship between size of habitat patches and species richness has been shown already long ago, e.g. by Diamond (1984). Figure 2 shows that the chance of extinction of bird species is considerably larger in a small habitat patch than in a large habitat, and moreover shows that the rarer the species are the larger is the extinction rate.

Recent research confirms this evidence. Both for plant species and butterflies, species richness shows a clear relationship with the size of the habitat patches.

It is, however, hardly possible to increase the size of the protected areas because they generally have boundaries that are determined by naturally changing abiotic conditions of by conflicting land use categories. The solution for

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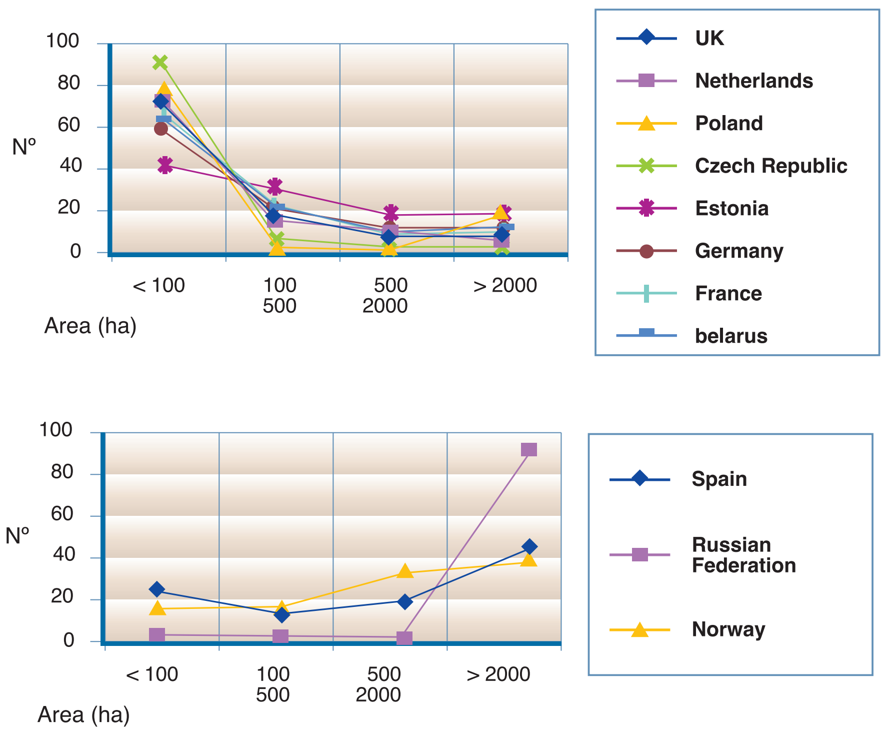

Figure 1. Frequency distribution of protected areas over different European countries (source: EEA / NATLAN, 2000)

this problem should be sought in a different strategy. The IUCN World Parks Congress in Durban in 2003 has characterised this strategy by its motto: *Benefits Beyond Boundaries*. This motto requests looking beyond the boundaries of protected areas, and this is exactly where a break in the trend of decreasing biodiversity could be found: enhancing ecological cohesion through designing networks of protected areas, connected through ecological corridors. Although this thought is not new and already implemented in several countries, the implications of this strategy are not always clear.

What is an ecological network? A functional ecological network in my view is an arrangement of physically separated habitat patches for a population of a particular species, that exchanges individuals by dispersal. Taking this definition serious, the role of corridors is crucial. Let me focus on corridors for a moment. Several types and categories of corridors exist, all dependent of the species for

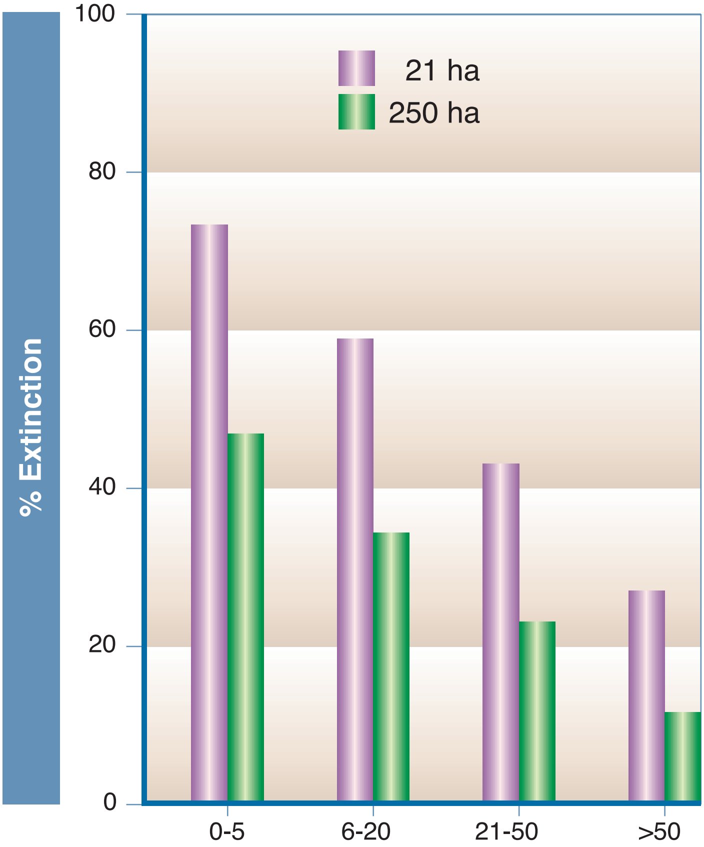

Figure 2. Extinction of bird species in two Brazilian jungle patches (source: Diamond, 1984)

which they are meant and on the scale relevant for these species. Figure 3 illustrates the different types of corridors. Many bird species e.g. will need a stepping stone corridor whereas many bat species prefer line corridors.

When developing design parameters for corridors, functional considerations are crucial. Conditions completely differ depending on the function the corridor should have for the species. So, badgers (*Meles meles)* require a landscape type corridor for commuting between sleeping and foraging habitat (Figure 4), brent geese (*Branta leucopsis*) require a corridor of stepping stones for staging during their migration between breeding and wintering habitats (Figure 5), and toads (*Bufo bufo*) use mainly line corridors when juvenile individuals spread to find their maturing habitats (Figure 6).

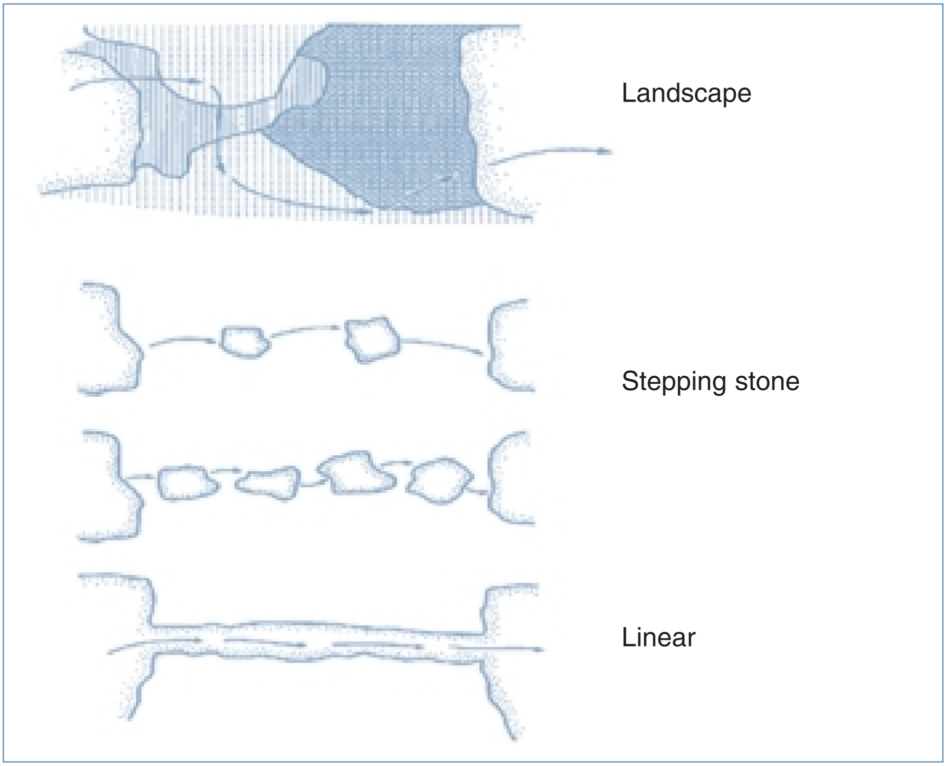

Figure 3. Types of corridors.

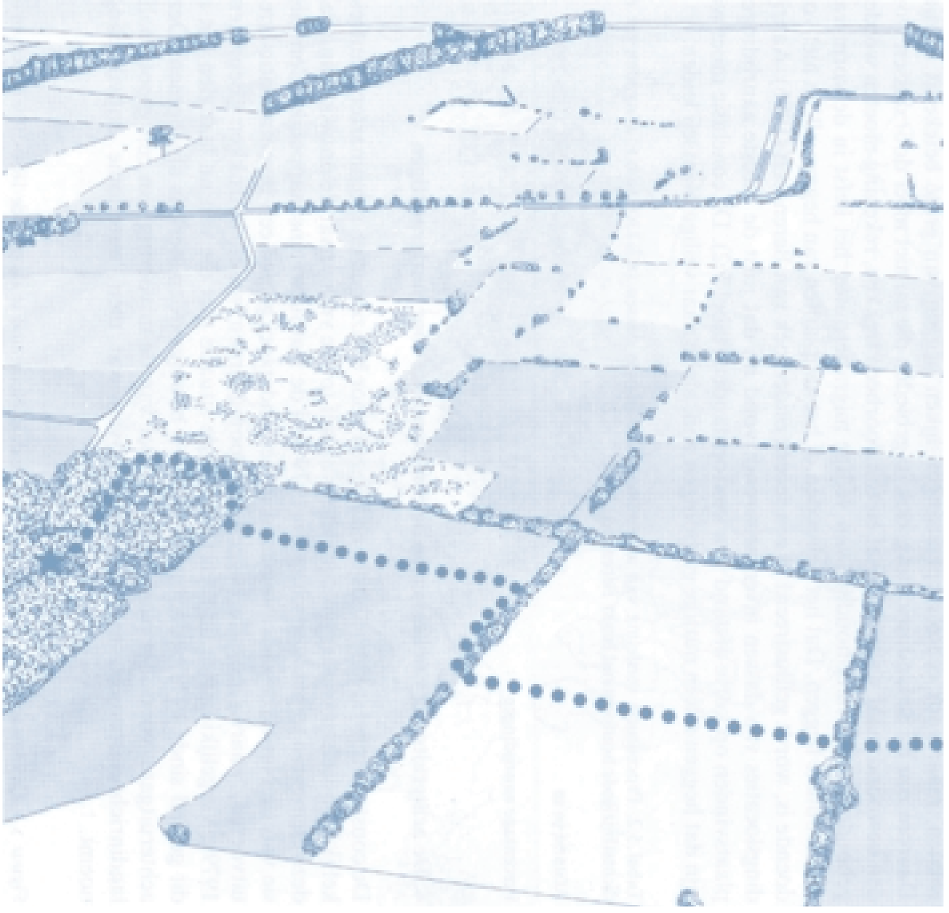

Figure 4. Commuting corridor: Badgers *(Meles meles)* preferably use linear elements like hedgerows for their daily movements through semi-natural landscapes (source: Broekhuizen and Vink, 1985).

Figure 5. Migration corridor: Brent Goose *(Branta leucopsis)* migration and stopover pathway (source: Ebbinge, 2000).

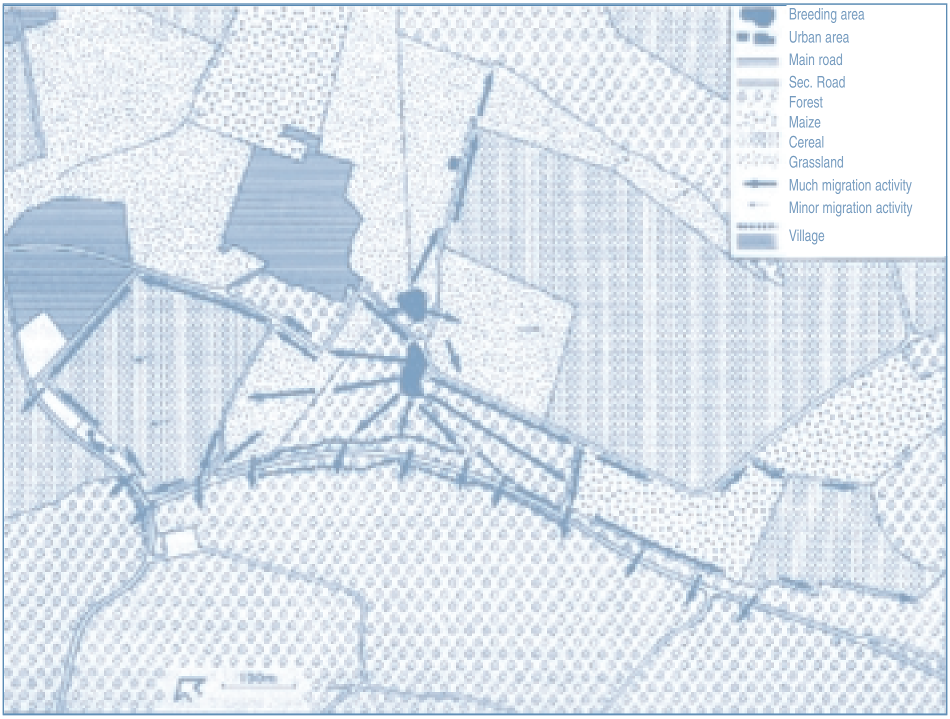

Figure 6. Dispersal corridor: Movement routes of juvenile Toads *(Bufo bufo)* during their dispersal phase in an agricultural landscape in the Siebengebirge in Germany. The toads prefer ditches and hedgerows and avoid grassland and arable fields (source: Müller and Steinwarz 1987).

From a selection of corridor-dependent species out of the lists of European priority species (Foppen *et al.*, 2000), it appears that particularly in the Mediterranean region many species occur that require corridors, 50% of the species occur in this biogeographical region (Table 1).

Table 1. Distribution (%) of selected* corridor-dependent species over biogeographical zones. (*dispersal ranges of more than 10 km; minimum area requirements for reproduction less than 10 ha) (source: Foppen *et al.*, 2000).

BIOGEOGRAPHICAL ZONES												
Especies	*sea*	*arctic*	*mediterranean*	*macronesian*	*alpine*	*atlantic*	*continental*	*boreal*	*pontic*	*anatolic*	*pannonic*	*steppic*
Mammals (25)	8	24	36	0	28	16	28	32	12	16	8	8
Birds (69)	9	16	51	7	28	29	41	35	20	7	32	36
Fish (12)	50	17	42	17	17	50	58	42	17	8	42	33
TOTAL (106)	***13***	***18***	***46***	***7***	***26***	***28***	***40***	***35***	***18***	***9***	***27***	***29***

All this information makes clear that apart from the conservation of the current values in protected areas and outside, a functional analysis is needed of the relationships that exist between the habitats. Therefore, the following steps should be taken:

- Define ecosystems of importance,
- Identify core areas and important local populations of selected species,
- Restore networks where necessary:
    - Identify (degraded) areas that can be restored,
    - Replace areas that were lost, stimulate restoration,
    - Improve the connectivity of the landscape.

To be able to assess these functional relationships, especially regarding the dispersal possibilities for key species, the modelling tool LARCH was developed (Chardon *et al.,* 2000; Van der Sluis and Chardon, 2001). LARCH assesses the persistence of populations of selected animal species on the basis of GIS information on the habitat pattern on the one hand and habitat requirements, dispersal rates and population dynamics of the species on the other hand. The model is based on metapopulation theory, where a metapopulation is a population of a species consisting of several sub-populations connected only through dispersal movements (Hanski and Gilpin, 1997; Verboom *et al.*, 1993, 2001; Vos *et al.*, 2001, 2002).

Figure 7 indicates that the total size of habitat required depends on the strategy chosen for the ecological cohesion between the habitats: the more scattered the habitat patches, the larger should be the total surface needed.

For the design of sound ecological networks therefore, based on functional relationships for specified species, the following guidelines apply:

1. Identify *indicator species* (or define species groups) that differ in habitat requirements and for which enough information about current distribution and population dynamics is available.

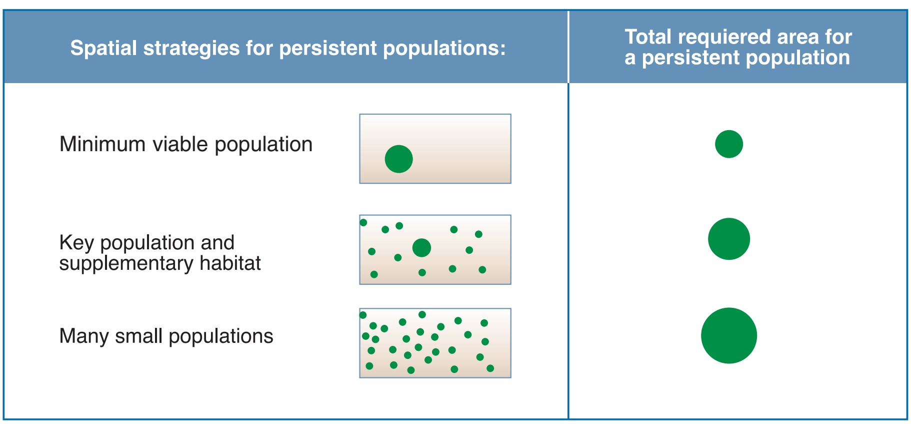

Figure 7. Different strategies enhancing persistence of species populations.

2. Look for / plan *key areas* of suitable habitat (differentiated in feeding, breeding and commuting habitats if necessary) for the selected species groups.
3. Look for / plan *supplementary habitat* for persistent populations (within dispersal range on regional and on national level).

These steps should be taken in good co-ordination between the researcher and the stakeholders, to guarantee that the analysis give clues to the further development of the ecological network under consideration.

For the selected species the following information is required

- Carrying capacity of habitats for species (groups), as derived from:
  - Distribution data of species,
  - Literature and expert judgement.
- Criteria for persistence of populations (size of key populations, amount of required supplementary habitat), as derived from:
  - Population dynamic models and expert judgement.

Such information should well be checked with local ecologists, and may differ for the same species in different environments (Verboom *et al.*, 2001).

Three examples illustrate the use of such assessments. In all cases it is important to note that the analysis serves explicit aims, as defined by the competent authorities.

Example 1. Development of an ecological network for Red deer in Northwestern Europe

Aim was to develop a network of core forest ecosystems for Northwest Europe (Groot Bruinderik *et al.*, i.p.). As the umbrella species was chosen red deer (*Cervus elaphus*). Input for this analysis was the CORINE Landcover data (250 x 250 m^2), and barriers based on Digital Chart of the World. The result is a map showing core areas and most important corridors for the red deer (Figure 8). Especially in the Netherlands the network is insufficient to sustain large populations of Red deer, but it is also clear that with small expansions of the network especially outside the traditional nature reserved this situation might improve considerably.

Example 2. Development of an ecological network of peat areas in the Moscow region

Aim in this case was to design a network strategy based on restoration possibilities for bird and butterfly species. Also here the instrument used was LARCH. The result is a map showing the potential increase of persistent populations of the various selected species when more habitats outside the existing nature reserves of peat areas are made suitable for them.

Example 3. Improvement of the spatial cohesion in the ecological network of Emilia Romagna, Italy

The Region Emilia-Romagna and the Provinces of Bologna and Modena have taken the initiative to assess the ecological networks of their agricultural plains, within the framework of the Life-ECOnet project (see the contribution of Pungetti, this volumen). The LARCH model was used as a tool to evaluate the ecological network and the spatial cohesion of the landscape in a GIS environment on the basis of a vegetation or land use map. On the one hand, this region is fast-developing, characterised by intensive agriculture and small industries. On the other hand, there is a very old farming tradition which evolved since the Roman period. Over the past century natural habitats vanished and became increasingly fragmented. The rivers, which run north from the Apennines to the Po river, form the backbone of the ecological network. In the Provinces of Bologna and Modena, a first design of the ecological network was already attempted before the Life-ECOnet project started. In the planned network, corridors were envisaged which connect the mentioned main rivers (Simonati and Alessandrini, 2000).

With the spatial model LARCH, the present situation has been compared with a design of the network based on these local ideas, and the network quality and spatial cohesion of the landscape have been evaluated. Using the LARCH model for Emilia-Romagna, three priority ecosystem types were selected, for which eight indicator species were assessed (Table 2). The species have different characteristics with regard to habitat requirement, spatial scale, and sensitivity to barriers (Van der Sluis *et al.,* 2001).

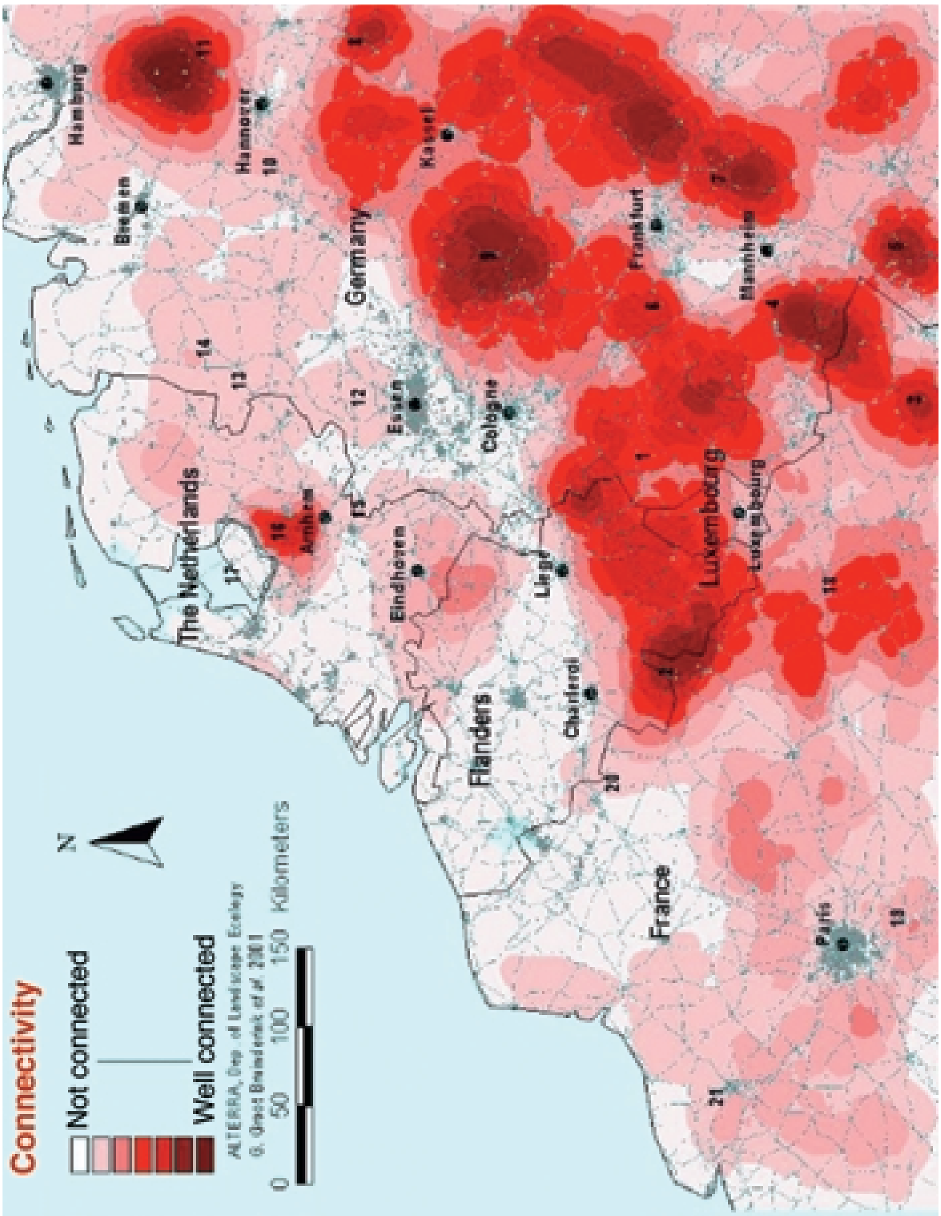

Figure 8. Connectivity for Red deer in Northwestern Europe based on network analysis (source: Groot Bruinderink *et al.*, i.p.)

Table 2. Selected species for LARCH analysis in Emilia Romagna. Bold indicates species sensitive to barriers (source: Van der Sluis *et al.*, 2001)

Habitat	Dispersal capacity	
	Small (0–10 km)	Large (10–50 km)
Woodland	Red-backed Shrike (*Lanius collurio*)	**European Polecat (*Putorius putorius*)** Turtle Dove (*Streptopelia turtur*)
Wetland	**Italian Crested Newt (*Triturus italicus*)** Banded Demoiselle (*Agrion splendens*)	Bittern (*Botaurus stellaris*)
Grassland	Stonechat (*Saxicola rubetra*)	Yellow Wagtail (*Motacilla flava*)

Results

The proposed ecological network will substantially improve the environmental continuity of the study area. This is based on the viability of wildlife populations and on the assessment of the spatial cohesion of networks.

The analysis has pinpointed the locations where additional rehabilitation measures might be considered (Figure 10). However, despite this rehabilitation, the available habitat will still be limiting for species like the Bittern. Such results present essential information about the potential for the realisation and maintenance of cohesive ecological networks.

Conclusion: ecological networks to be designed on sound basis!

- Population viability models like LARCH quickly provide insight into the potentials and bottlenecks for dispersal of animals and restoring habitats and linkages between protected areas. Barriers like roads and railways can be taken into account as well, which is especially important for ground-dwelling species.
- Such models are explicitly also suited for comparison of development scenarios and are a useful tool in ecological land use planning and management (Pedroli *et al.*, 2002).

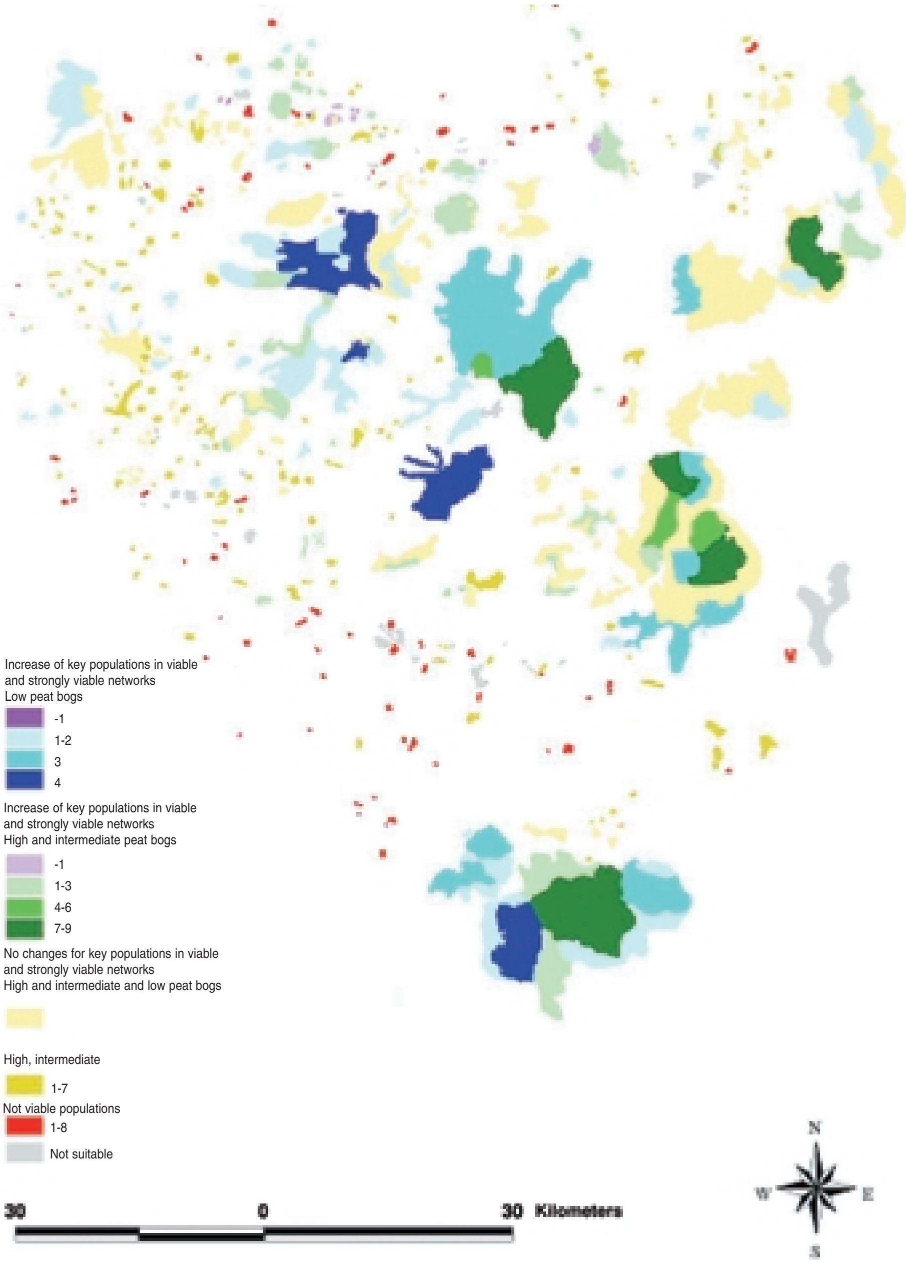

Figure 9. Increased potential for persistent populations of selected bird and butterfly species in peat marshes east of Moscow.

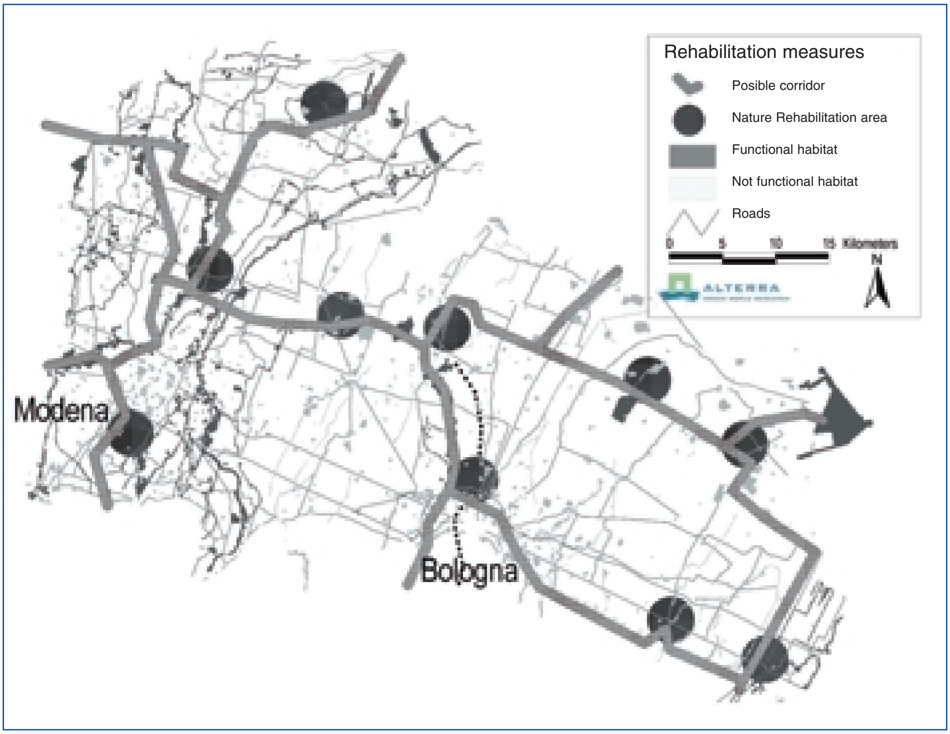

Figure 10. Additional rehabilitation measures for the studied ecological network in the plains of the Bologna and Modena Provinces (Italy) (source: Van der Sluis *et al.*, 2001)

- There are no limitations on species groups, as long as ecological information regarding habitat requirements and dispersal capacity is available. The scale of implementation ranges from provincial to international.
- Ecological networks are crucial to maintain biodiversity in protected areas, especially in fragmented landscapes like the Mediterranean ones (cf. Romano, 1996, 2000; Pungetti and Van der Sluis, 2002).
- Measures are thus required to restore ecological networks.
- Design parameters for the networks should be derived from requirements of selected key species, scale dependent; the selection of key species and design parameters is a political choice, to be based however on scientific information.

- Scientifically sound methods are available to assess connectivity in the landscape, also under scenario conditions, thus allowing for participatory planning.
- Integrated land use planning should balance the needs of land users and the requirements of ecological networks.

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