How to define European ecological networks

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Abstract

In this paper we discuss the steps to follow to develop an ecological network on a European scale. Crucial in a design of an ecological network is a proper problem definition, a choice of species aimed at and description of the type of ecosystem involved. Based on habitat distribution, population viability and species requirements, the functional parts of an ecological network are defined.

We present the ecological tool LARCH, which assesses species’ population structure and spatial cohesion of natural habitats, which form the basis of the design of an ecological network. The spatial cohesion is a relative measure that can visualise the weakest parts in the ecological network for a certain species.

Based on the existing network it is assessed if and where corridors are required. The resulting maps can form the basis for spatial planning and habitat protection plans. The two examples given for river networks can be applied for defining ecological networks at a larger, European scale. LARCH proves to be a powerful tool for quickly assessing habitat networks.

1 Introduction

Biological diversity is highly dependent on the quality, quantity and spatial cohesion of natural areas. Fragmentation severely affects the abundance of species with large habitat requirements. An answer to this problem is the development of an ecological network, linking nature reserves by means of corridors and small habitat patches. An ecological network is constituted of physically separated habitat patches, for a population of a particular species that exchanges individuals by dispersal. Development of ecological networks is part of European policy (Bern habitat directive, Natura 2000) and resulted in development of the Pan European Ecological Network PEEN. European ecological networks especially can be beneficial for large herbivores like red deer, or top predators like otter, bear, lynx and wolves.
This paper discusses the steps to follow to design an Ecological network on a European scale: at which species or communities do we aim, what should the network look like, and which approach to use? Next, the ecological model LARCH is briefly described, to assess the functional ecological network or compare alternative designs of ecological networks. Finally two examples are given of ecological network assessments on a transboundary, European scale.

2 Why ecological networks?

Landscape ecologists have made an important contribution to the concept of connectivity in ecology. Landscape connectivity is essential to support animal populations (Merriam [1]). Animal populations in small fragmented areas have a higher risk of extinction, due to stochastic processes and population dynamics. Small and isolated patches may remain unoccupied permanently or temporarily (Opdam [2]). Corridors facilitate recolonisation of those ‘vacant’ habitats, and will decrease the chance of extinction of a species from an area or region. Connecting corridors are crucial for small populations in a fragmented habitat, even if the corridors did not form part of the traditional habitat (Bleich et al. [3]). Corridors in a fragmented landscape are crucial for appropriate wildlife management (Schaefer & Brown [4]).

In this paper the term “corridor” is used in a broad sense: “a linkage between resource habitat of a species consisting of landscape structures that are different from the matrix, resulting in a favourable effect on the exchange of propagules of the species (individuals, seeds, genes)” (Foppen et al. [5]). The corridor strategy is fundamentally an attempt to maintain or restore natural landscape connectivity, not to build new connections between naturally isolated habitats. The ecological function of a corridor is highly dependent on the patches it is linked with: the smaller they are, the higher the ecological importance of the corridor (Forney & Gilpin [6]). Safeguarding of corridors for migration and dispersal between large reserves or ecological core areas, will effectively enlarge the habitat for many species and assure gene flow (Vos et al. [7]).

3 Design of European ecological networks

Crucial in a design of an ecological network for Europe is a proper problem definition and a choice of species aimed at or ecosystem type involved. Habitat configuration, population viability and species requirements determine whether and where corridors are required (Foppen et al. [5]).

The following steps are proposed in the design of an ecological network:

1 Problem definition
2 Selection of species or species group
3 Spatial analysis of current habitat
4 Analysis of functional ecological network
5 Consolidation or strengthening of ecological network
Step 1: Problem definition
A problem definition is crucial in the design of an ecological network. Some reasons for designing an ecological network are:

- fragmentation of natural areas, resulting in loss of biodiversity.
- Based on national and international policies measures are taken to consolidate natural habitats, to improve exchange of species/genes and facilitate recolonisation of empty habitat patches.
- protection status of certain threatened species
Threatened species, red list species etc. might require specific measurements, connection of reserves by corridors, to allow more natural processes and restocking of empty areas.
- spatial developments

In spatial planning projects (especially infrastructure developments) measures might be taken to decrease fragmentation of natural habitat. These measures can be formulated in Environmental Impact Assessments, especially when compensating and mitigating measures are considered in infrastructure development projects.

For each problem the same steps might be followed, only in the final network design stages the procedure might differ.

Step 2: Species or ecosystem selection
An ecological network should be geared towards an ecosystem (forest, marshland, moors) or species. A strategic choice of target species benefits many more species than a sole species in the network design. There are focal species that have broad-scale ecosystem level effects (Simberloff [8], Dale et al. [9]): turnstone species (top predators, like wolf, bear, otter) ecological engineers (beaver, red deer) and umbrella species (red deer). Umbrella species either have large habitat requirements or use multiple habitats and thus overlap habitat of many other species (an example is worked out by Groot Bruinderink [10]).

Step 3: Spatial analysis of habitat
The area or ecosystem is assessed on presence of habitat for the selected target species. Based on the quality and quantity of habitat it is defined what potential populations are, and if these populations can be considered viable (Shaffer [11]).

Step 4: Analysis of the functionality of the ecological network
The important nature reserves (based on the function for the metapopulation) and migration corridors are defined. This assessment can be based on species requirements and a landscape assessment. The areas are selected that form the backbone of an ecological network.

Step 5: Consolidation or strengthening of the ecological network
Habitats are defined which are crucial within the larger network, requiring zoning and protection, to consolidate the network. Parts of the habitat network might be isolated and have no function in the metapopulation structure at present. By strategic development of corridors the spatial cohesion of the network can be strengthened. In some cases land is zoned and transformed for specific wildlife migration (e.g. providing shelter by planting a semi-natural vegetation), to strengthen the ecological network. The functionality of the planned ecological network is assessed.
4 LARCH, ecological tool for habitat network assessment

The landscape-ecological model LARCH (Landscape ecological Analysis and Rules for the Configuration of Habitat), developed at Alterra, is a tool to visualise the viability of metapopulations in a fragmented environment and to assess spatial cohesion of potential habitat. LARCH is designed as an expert system, used for scenario analysis and policy evaluation. The model has been fully described elsewhere (Foppen et al. [12], Groot Bruinderink et al. [13, 10], Chardon et al. [14], Verboom et al. [15, 16]) and only major steps briefly will be dealt with here.

The principles of LARCH are simple: the size of a habitat patch determines the potential number of individuals of a specific species it can contain. The distance to neighbouring patches determines whether it belongs to a network. The size of the network determines whether it can contain a viable population. If so, the habitat network is sustainable for the species.

LARCH requires a vegetation map and ecological standards or rules (e.g. dispersal distance, population density etc.). LARCH standards are based on literature and empirical studies and simulations with a dynamic population model, which were carried out over the past ten years (Foppen et al. [12, 17], Verboom et al. [15, 16, 18], Vos et al. [19]). Since the assessment is based on potentials for a habitat network of a species, actual species distribution or abundance data are not required.

The size of a (potential) key population is based on the number of reproductive units (RU’s), which should be big enough to survive the majority of normal number fluctuations a population is faced with. The probability of extinction for a key population within a network is less than 5% in 100 years, assuming there is an immigration of 1 or more RU’s (or individuals) per year from other local populations in the same network (Shaffer [11]). If present, key populations form the core of a network.

The vegetation map has thus been converted into a RU map, then into a habitat network map, showing the spatial configuration of habitat, an ecological network of potential MVMP’s and ‘smaller’ populations.

LARCH assesses the spatial cohesion of each habitat patch, using habitat features and dispersal characteristics (Opdam et al. [20]). The dispersal range of a species in a landscape can be described by a function in which alpha is the key parameter (Box 1), describing the distance over which potential source patches can still deliver immigrating individuals (Hanski [21]). In delineating habitat patches, effects of barriers (like roads) can be included. If urban areas are present, the connectivity is calculated by going around the build-up areas. In this final step, the population viability map is converted into a map visualising spatial cohesion of the landscape.

5 Examples of ecological networks on a European scale

Two examples are worked out for a design of a cross-border ecological network. Important ecological networks on a European scale are the (transboundary)
rivers. Rivers form in principle ribbons of a linked mosaic landscape with forests, marshland, brushwood and floodplain channels, which not only connect areas within the river zone to each other, but also the areas located along the floodplains.

However, rivers also formed a nucleus for human settlement and human activity. This caused a proliferation of infrastructure and building activities in river valleys, and, consequently, fragmentation of natural habitat. A solution for this problem is the development of river restoration plans, which are being developed for ecological restoration of floodplains and creation of water retention areas. However, where should those areas be planned, and what is needed for different species?

One example presented here concerns the spatial cohesion of forests along the River Rhine. With LARCH the spatial cohesion of the Rhine landscape has been assessed. A second example deals with the comparison of the ecological networks of the River Meuse, for river development scenarios.

5.1 Spatial cohesion of marshland along the River Rhine

The study for this specific example was performed for the Ministry of Transport, Public Works and Water Management in the Netherlands (Foppen et al. [12]). We assessed with LARCH the spatial cohesion of forest and marshland ecosystems with CORINE land cover data (European Commission [22]). There are two areas with strong spatial cohesion for larger marshland species, e.g. the Bittern (Fig. 1). The region in between shows very low cohesion, due to the fact that a limited area is suitable and large enough for marshland birds.
Fig. 1: Spatial cohesion of marshland areas assessed with LARCH. The West of the Netherlands and South of Germany form the core wetland areas. Nature reserves in the Rhine valley seem of less importance for the ecological network of marshland species (Foppen et al.[12]).

5.2 Ecological network of the River Meuse

The River Meuse, with a length of approx. 890 km, has its origin in Northern France and flows via Belgium and a large part of the Netherlands to the North Sea. There are governmental plans to change the management of the Meuse in the nearby future. The objectives are to improve the transport capacity for ships and to create better flood protection for the inhabitants of the region. Apart from these main objectives there is also room for improvement of the ecological functions. LARCH was used for an Environmental Impact Assessment for the Sand Meuse, to assess the effects of alternative scenarios for 15 different wildlife species (Chardon et al.[14], Rooij et al. [23]).

Figure 2 and Table 1 show the results for the Bluethroat (*Luscinia svecica* L.), a typical bird of marshes along rivers and in peat areas. The Sand Meuse forms a potential corridor for the populations in the south-eastern part of the Netherlands.
and the western river area. The habitat area for the Bluethroat increases considerably from the present situation to the target scenario. The present situation shows six potential networks in the study area, however, for those populations to be sustainable habitat is limiting.

The intermediate scenario has much more proposed habitat along the river, but patches are not large enough for a key population (Table 1). Habitat is sufficient for a potential sustainable network in the northern half of the study area. The target scenario offers the best potentials for the Bluethroat: two sustainable networks (including key populations) almost covering the whole stretch. In this scenario the habitat area has increased and also the spatial configuration of the patches has improved.

Table 1. LARCH-RIVER output of the present situation and two scenarios for the Bluethroat (viability score: - = not viable, +/- = possible viable, + = viable; key population score: - = absent, + = present).

<table>
<thead>
<tr>
<th>BLUETHROAT</th>
<th>Viability</th>
<th>Key population(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present situation</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Intermediate scenario</td>
<td>+</td>
<td>-</td>
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<tr>
<td>Target scenario</td>
<td>+</td>
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Lack of habitat in the middle course results in a gap in the network. Restoring natural areas and thus creating new habitat at this point would connect the two networks and therefore increase the sustainability of the network for the Bluethroat.

Only the Bluethroat has been presented here, however, further measurements should be decided upon based on all analysis results of 15 species.

6 Conclusions

The approach presented in this paper seems useful to tackle the problem of fragmentation of natural areas on a European scale. Step by step the goals are defined, populations and habitats are labelled, and important corridors are identified. The ecological tool LARCH quickly provides insight in potentials and bottlenecks for dispersal of animals and restoring habitats and linkages between sites. The required input is limited, and therefore there are no vast costs involved. Barriers like roads, railways and so on can be taken into account as well, which is especially important for ground-dwelling species.

The approach presented here can be used at different scales, from local to regional and international scale, from floodplain to watershed management, as is shown by these examples. Existing land cover data from CORINE can be used for large-scale assessments. Results like these produce essential information about potential valuable areas for cohesive habitat networks. Examples are given of ecological networks for relevant species at European: red deer, lynx, or marshland birds like the bittern. The realisation and safeguarding of these networks, finally, should be realised in spatial planning procedures.
Fig. 2: Viability analysis of Bluethroat with LARCH, for three river development scenarios (Chardon et al.[14].)
References


