Ecological networks, a challenge for territorial planning—the case of Region Abruzzo, Italy

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Abstract

This paper presents the result of an analysis of the ecological network for Regione Abruzzo (central Italy). The aim of this analysis is (1) to identify the functional ecological network at present, and (2) to identify opportunities to optimise the ecological network. The landscape-ecological model LARCH was used to analyse habitat distribution in relation to wildlife populations, and sustainability of these populations. In addition, also the model METAPHOR was used, to assess viability of the population of Brown Bear (Ursus arctos) for Regione Abruzzo, and the movement model SmallSteps, to obtain an estimate of patch-based landscape connectivity for this species. For the LARCH analysis four ecosystem types were selected, which cover the most important natural habitat types in the study area: woodland, wetland, grassland, scrubland and steppe. To assess whether these ecosystem types might function for specific wildlife species, seven species were selected which can be considered representative for these ecosystems. For these species it was assessed whether the ecosystem still functions as an ecological network. As an example the results for one species, the hedgehog (Erinaceus europaeus), are presented.

It is shown that there is still ample habitat to support larger wildlife populations in this part of Italy. A preview is made of potential next steps. Similar projects, in preparation or done elsewhere in Italy (Regione Emilia-Romagna, Umbria, and Sicily), call now for the design of a comprehensive ecological network for the whole of Italy, with the Apennines as the backbone for this network. This network should be consolidated as soon as possible, with all required legal actions and protection. Finally what the next step should be for the development of an ecological network for all of Italy is explored.
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 (Van Opstal [1], Klijn et al. [2]).

Region Abruzzo is situated northeast of Rome, bordering the Adriatic Sea. Abruzzo is a region with large natural areas, mainly located in the highest part of the Apennine mountain range, with 5 large national parks, mountain areas and forests. These areas are of outstanding beauty, and in particular the wilderness aspect makes them of importance as refuge for e.g. large carnivores like the Brown bear, Wolf and Lynx, as well as for tourism and regional development.

This paper presents the results of an analysis of the ecological networks of Regione Abruzzo (Van der Sluis et al. [3]). Aim of the analysis is (1) to identify the functional ecological network at present and (2) to identify opportunities to optimise the ecological network. Several models are used for this analysis, the models LARCH, METAPHOR and SmallSteps.

2 Why ecological networks?

Landscape connectivity is essential to support animal populations (Merriam [4]). 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 [5]). 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. [6]). Corridors in a fragmented landscape are crucial for appropriate wildlife management (Schaefer & Brown [7]).

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. [8]). 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 [9]). Safeguarding of corridors for migration and dis-
persal between large reserves or ecological core areas will effectively enlarge the
habitat for many species and assure gene flow (Vos et al. [10]).

3 Ecological tools for habitat network assessment

To assess and evaluate the functioning of the ecological network the landscape
ecological model LARCH (Landscape ecological Analysis and Rules for the
Configuration of Habitat), developed at ALTERRA, was used. LARCH provides
information on the metapopulation structure and population viability in relation
to habitat distribution and carrying capacity. LARCH-SCAN assesses spatial
cohesion of potential habitat, and provides information on the best ecological
corridors in the landscape. The model LARCH is run with a land use map or
vegetation map as input.

LARCH is designed as an expert system, used for scenario analysis and
policy evaluation. The model has been fully described elsewhere (Groot Bru-
derink et al. [11], Van der Sluis & Chardon [12], Chardon et al. [13], Verboom
et al. [14, 15]). The principles of LARCH are simple: the size of a habitat patch
determines the potential number of individuals of a specific species it can con-
tain. 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 in potential sustainable for the species.
LARCH requires a vegetation map and ecological standards or rules (e.g. disper-
sal distance, population density etc.). As basis for this study the land use map for
the Regione Abruzzo has been used (Regione Abruzzo [16]). LARCH standards
are based on literature and empirical studies and simulations with the dynamic
population model METAPHOR, which were carried out over the past ten years
(Foppen et al. [17], Verboom et al. [14, 15, 18], Vos et al. [19]). Since the as-
essment is based on potentials for a habitat network of a species, actual species
distribution or abundance data are not required.

LARCH assesses the spatial cohesion of each habitat patch, using habitat
features and dispersal characteristics (Groot Bruinderink et al. [11], Van der
Sluis & Chardon [12]). Effects of barriers (like roads and urban areas) can be
included in visualising spatial cohesion of the landscape.

Two other models, METAPHOR and SmallSteps, examine in more detail
respectively metapopulation viability and landscape connectivity. Their applica-
tion is relative time-consuming and therefore limited to a single species, the
Brown bear. SmallSteps, a movement model, provides an estimate of the connect-
ivity of habitat patches (the probability of reaching another habitat patch when
dispersing from the natal patch), taking into account the properties (resistance) of
the landscape in-between (landscape matrix). Calculated connectivity is used in
METAPHOR, a population dynamic simulation model, to estimate metapopula-
tion viability. Both models require identification of habitat patches, the starting
and endpoints for dispersal movements, as the spatial units where local popula-
tions reproduce. LARCH can be used to produce such a classification of habitat;
here a species-specific habitat suitability model was used (Posillico [20]).
4 Ecological network analysis Regione Abruzzo

Four ecosystem types were selected, which cover most important natural habitat types in the study area: woodland, grassland and steppe, wetland, and scrubland. Priority ecosystems, and very particular for Abruzzo, are the forests, and the Alpine meadows, grasslands and steppe of the higher Apennines. In addition, also the aquatic ecosystem is very important since most species are to some extent dependent on water, and species tend to migrate along water courses.

Seven species were selected as indicators to be able to assess in more detail the functioning of ecosystems and ecological networks (table 1). These species differ not only in habitat requirements, but also in dispersal range and area requirements.

Table 1: Species selection and ecosystems; o and x indicate respectively minor and major importance of this ecosystem for the species.

<table>
<thead>
<tr>
<th>English name</th>
<th>Scientific name</th>
<th>Forest (Alpine)</th>
<th>Grassland</th>
<th>Wetland</th>
<th>Scrubland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common toad</td>
<td>Bufo bufo</td>
<td>o</td>
<td>x</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>Hedgehog</td>
<td>Erinaceus europaeus</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Green lizard</td>
<td>Lacerta bilineata</td>
<td></td>
<td>x</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>Wolf</td>
<td>Lupus canis</td>
<td></td>
<td>x</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>Italian crested newt</td>
<td>Triturus carnifex</td>
<td></td>
<td>o</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Chiffchaff</td>
<td>Phylloscopus collybita</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stonechat</td>
<td>Saxicola torquata</td>
<td></td>
<td>o</td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

An example for the model input, as well as for the underlying data for modelling, is given for the hedgehog (*Erinaceus europaeus*). The Hedgehog is a fairly common and widespread species that occupies many different habitats, including antropogenous habitats. The hedgehog prefers in particular open and cultural landscapes such as meadows, parkland, fields, gardens and areas near human settlement.

Traffic mortality in hedgehog can be high, due to the high density of hedgehogs in semi-urban areas. In the Netherlands traffic mortality is estimated 6.1-9.0 % (Huijser et al. [21]). However, hedgehogs were frequently observed crossing busy secondary roads. Roads are therefore not absolute population boundaries, some exchange is always likely to occur.

The hedgehog may migrate distances of up to 5 km. Primary roads and highway are considered barriers at local population level and network level. The hedgehog occurs in the Apennines up to 2000 m altitude (Biondi & Tete [22]). The home-range is 2 km, network distance 5 km and the optimal density (carrying capacity) might be some 15 pairs/100 ha (Huijser et al. [21]).
Figure 1: Result of LARCH modelling for the Hedgehog *Erinaceus europaeus* in Region Abruzzo (Van der Sluis *et al.*[3]). Dark grey colours indicates the potential for a Minimal Viable Population, whereas the pale grey colours indicate small fragmented populations, not viable on its own.

**5 Results**

Abruzzo has a lot of natural areas, amounting to almost 50% of forests, scrubland and natural (partly alpine) grasslands. Cultivated areas (mainly sowed fields) form only some 46%, part of which is extensively used, or tree plantations orchards or olive yards. Urban or similar habitats form some 4% of the total area. Limited are aquatic habitats, waters and lakes.

The specific analysis for the Hedgehog shows that the population is fragmented, due to the area requirements for viable populations (fig. 1). However, the species still might occur in most of the area, forming MVPs in the higher parts of Abruzzo, and key populations or small populations in the coastal plain, and intensively cultivated agricultural areas. In the higher part the populations are highly sustainable, in the more fragmented areas still sustainable or nearly sustainable (Van der Sluis *et al.* [3]).
The hedgehog is considered a representative species for open grassland ecosystems, be it that it is very much a mosaic species, requiring forest areas too. For all ecosystems a number of species is evaluated in a similar way as the hedgehog. Most ecosystems seem in potential large enough to sustain potential wildlife populations in Regione Abruzzo. In the coastal plain and intensively farmed areas, e.g. the main valleys and Lago Fucino, some species populations are small and fragmented. Species affected by fragmentation are Wolf, Hedgehog, Green lizard, Stonechat and Italian crested newt.

Observing network viability it is obvious that all species are viable on its own, except for the Wolf. The Wolf is dependent on neighbouring regions in Italy. For hedgehog some local networks are presently not sustainable due to fragmentation, but overall even for this species the network is sustainable.

Zooming in on Brown bear population viability, results indicate that the current Abruzzo population may be viable or not, depending on demographic
rates, the amount of environmental stochasticity affecting these rates, and the estimated carrying capacity of the area. In any case, an increase in the size of the network due to re-colonization of habitat within the historical range, will benefit the population. Movement simulations however indicate that habitat patches for the bear are currently not well-connected (fig. 2, table 2), even for an optimistic estimate of an individual’s inclination to venture out into low quality or hostile habitat. Corridors may thus improve connectivity a lot, but (according to scenario studies) only when these corridor zones are connected to relatively high quality habitat. Further investigations are required to evaluate the planned corridors on this aspect.

6 Discussion

The study shows that the Region has no serious fragmentation problem at the moment, considering the viability of the networks, obviously the 50% of natural habitat is sufficient for most species. However, corridors are essential to maintain the high quality of nature as we find it in Abruzzo. This is in particular shown with the SmallSteps and Metaphor analysis, which shows that in the present landscape dispersing chances are low for such a species as the Brown bear. With all habitat present still, it means that with little investments a well functioning sustainable ecological network can be realised, so now it is the time to propose an optimised ecological network. Through the development and consolidation of an optimised ecological network good opportunities are created for the long-term future development.

Table 2: The connectivity matrix for the Brown bear in the Abruzzo part of the Apennine mountains region. Patch numbers: 11 - Gran Sasso-Monte della laga, 17 - Sirente-Velino, 20 - Parco Nazionale D’Abruzzo & Majella. The arrival probabilities larger than 0.05 (rounded) are highlighted, as well as the patches with an low total connectivity.

<table>
<thead>
<tr>
<th>from</th>
<th>to</th>
<th>11</th>
<th>17</th>
<th>19</th>
<th>20</th>
<th>22</th>
<th>28</th>
<th>sum</th>
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<tr>
<td>11</td>
<td>0.0000</td>
<td>0.1899</td>
<td>0.0026</td>
<td>0.0011</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.2855</td>
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<tr>
<td>17</td>
<td>0.4041</td>
<td>0.0000</td>
<td>0.4143</td>
<td>0.0537</td>
<td>0.0428</td>
<td>0.0000</td>
<td>0.9149</td>
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<tr>
<td>19</td>
<td>0.0324</td>
<td>0.6378</td>
<td>0.0000</td>
<td>0.0006</td>
<td>0.2666</td>
<td>0.0000</td>
<td>0.9374</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0.0118</td>
<td>0.0455</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.1595</td>
<td>0.0276</td>
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<tr>
<td>22</td>
<td>0.0016</td>
<td>0.0478</td>
<td>0.3661</td>
<td>0.3319</td>
<td>0.0000</td>
<td>0.0002</td>
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<tr>
<td>28</td>
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<td>0.0000</td>
<td>0.0000</td>
<td>0.1509</td>
<td>0.0006</td>
<td>0.0000</td>
<td>0.1515</td>
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</tr>
<tr>
<td>AREA</td>
<td>3433</td>
<td>778</td>
<td>184</td>
<td>1603</td>
<td>642</td>
<td>219</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the results for the spatial cohesion, a layout for a possible ecological network has been prepared (fig. 3). This is a layout for terrestrial corridors, i.e. for the forest, scrubland and grassland ecosystems. The indicative ecological network is based on areas with the best potential for realising corridors (based on existing habitat), with the national parks as the ‘core-areas’ for the ecological network. If this network is designed for smaller
ground-dwelling species like reptiles, amphibians and small mammals, attention should be paid to development of natural vegetation in the corridor areas, providing protective cover.

Particular points along the Autostrada (highway) and railway line in potential conflict with the proposed ecological network. Here measures should be considered to decrease the negative impact of infrastructure.

Figure 3: Tentative design of an ecological network for Region Abruzzo. Core areas form the large national and regional parks, the lines indicate possible locations for terrestrial corridors, based on the analysis of spatial cohesion for different species (Van der Sluis et al. [3]).

7 Conclusions

A detailed design can be prepared for corridors in Abruzzo, as was done in Cheshire (Van Rooij et al. [23]) and a study currently underway for Emilia-Romagna. A detailed design should indicate where corridors should be devel-
oped, as well as dimensions based on the specific requirements of species (AL-TERRA [24]). This would detail more precisely the optimal solutions for the planning context of Abruzzo.

The challenge is to extend the ecological network nationwide. Turnstone species like top-predators might be a good choice for design of an ecological network (Simberlof [25], Van der Sluis & Chardon [12]), in particular in the case of Abruzzo. Similar projects done elsewhere, like Regione Emilia-Romagna (Van der Sluis et al. [26]), Sicily (Van der Sluis & Pedrol [27]) and Umbria, call now for an analysis and design of an ecological network for all of Italy. The Apennines should form the backbone for this network, as is also shown by this study and in the APE project. This network should be consolidated as soon as possible, with all required legal actions and protection.

A network for large carnivores requires intensive co-operation across regional boundaries. Abruzzo can be one of the leading regions in Italy for development of such a national ecological network, targeting at e.g. Lynx, Wolf, and Brown bear as indicator species for sustainable ecological development.

References


