Networks for LIFE

Development of an ecological network for Persiceto (Emilia-Romagna, Italy)

S.A.M. van Rooij
T. van der Sluis
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 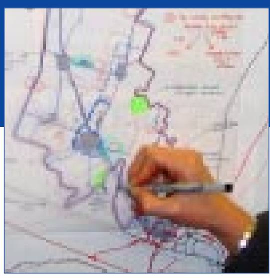 

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In assignment of Provincia di Modena & Provincia di Bologna

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ABSTRACT

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Three ecosystem types were selected, which cover most important natural habitat types in the study area: woodland, wetland, and grassland. To assess whether these ecosystem types might function for specific wildlife species, species were selected which can be considered representative for these ecosystems. For these species was assessed with the landscape-ecological model LARCH whether they can persist in the present network of habitat in the landscape. This is only partly the case: many species suffer from incomplete habitat networks.
For these ecosystems aims were defined. In a structured explorative way alternative options to improve the ecological network were assessed. Also expected developments or planned measures (opportunities) were included and expected developments in urbanisation and infrastructure development were taken into account. Based on that and the species requirements a proposal has been developed for an improved ecological network.
The proposed network is presented in a practical map, and the potential quality of the designed ecological network is assessed. The analysis shows in potential an improvement for all assessed ecosystems. Smaller organisms, both less mobile and mobile species, benefit from the proposed measures. It is therefore concluded that realisation of the proposed network will indeed improve conditions for biodiversity in the area of Persiceto.

Keywords: ecological network, metapopulation model, landscape ecology, LARCH, corridor, spatial planning

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Contents

Preface

The Provinces of Modena and Bologna have commissioned a study to analyse the ecological network for the area of Persiceto.
The set-up of the research follows the outline, as given in the project, which was discussed in September with members of the Steering Committee from the Provinces.

The Steering Committee consists of:

Giuseppe de Togni	(Provincia di Bologna)
Marta Guidi	(Provincia di Modena)
Roberto Ori	(Provincia di Modena)
Andrea Morisi	(Centro Agricoltura Ambiente S.r.l.)
Luigi Sala	(University of Modena and Reggio Emilia)

We would like to thank the Steering Committee, which has greatly helped to finish this study. Especially thanks to Giuseppe de Togni and Marta Guidi, for their enthusiastic cooperation and support. Luigi Sala and Andrea Moris added useful data on the ecology of species. Roberto Ori and others commented on the draft report and people from the Centro Agricoltura Ambiente hosted meetings in the area.
Furthermore, we wish to thank Alessandro Alessandrini and Patrizia Rossi who contributed to the meetings. Thanks also to our colleagues Jolanda Dirksen and Harold Kuipers, who worked on the map preparations, wrote scripts and did part of the LARCH modelling.

Summary

This report gives the result of a network design and an analysis of the ecological network for the area of Persiceto in Provincia di Modena and Provincia di Bologna. The ecological network should be optimal, considering local conditions, opportunities, and species requirements. The analysis is done to assess whether the designed ecological network will result in an improvement of the present situation.
The work builds further on a previous study done in assignment of Regione Emilia-Romagna (Van der Sluis *et al.* 2001a).

The landscape-ecological model LARCH was used to assess the present ecological network. LARCH provides information on habitat distribution in relation to wildlife populations, and sustainability of these populations.
Three ecosystem types were selected, which cover most important natural habitat types in the study area: woodland, wetland, and grassland. To assess whether these ecosystem types might function for specific wildlife species, species were selected which can be considered representative for these ecosystems (Table 1). For these species was assessed whether they can persist in the present network of habitat in the landscape. This is only partly the case: many species suffer from incomplete habitat networks.

For these ecosystems aims were defined, in discussion with the Steering Committee. In a structured explorative way alternative options to improve the ecological network were assessed. Also expected developments or planned measures (opportunities) were included and expected developments in urbanisation and infrastructure development were taken into account. Based on that and the species requirements a proposal has been developed for an improved ecological network.
For woodlands some core areas are proposed for the less mobile species. Herewith, and with the planning of stepping stones, the connectivity connectivity will improve for mobile species. For wetland clusters of microhabitats (ponds) are proposed for smaller immobile species, larger stepping stones or key areas are proposed for mobile species. Grasslands species are highly dependent on the quality of the grassland, so here measures should focus on management. In particular isolated areas should be connected to the extensive grasslands along rivers and dykes.

The proposed network is presented in a practical map, and the potential quality of the designed ecological network is assessed with the LARCH model.
The analysis of the proposed network shows in potential an improvement for all assessed ecosystems. Smaller organisms, both less mobile and mobile species, benefit from the proposed measures. It is therefore concluded that realisation of the proposed network will indeed improve conditions for biodiversity in the area of Persiceto.

1 Introduction

Biological diversity is highly dependent on the quality, quantity and spatial cohesion of natural areas. Fragmentation severely affects the abundance of species. 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. The 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. However, in first instance many small organisms will benefit from improvement of spatial cohesion and increasing natural habitat.

In this report we present the results of the spatial analysis.

This work in dis report builds forth on an ecological network analysis done for the Regional authority (Sluis et al. 2001a), but also other studies and local initiatives (Morisi 2000).

In the first chapter the study and area is introduced. Chapter 2 describes the method that has been applied, more specifically the model LARCH, and the network development process. The results of the analysis of the present situation in the study area are presented in Chapter 3.

In Chapter 4 the choices made for the scenario are presented, in chapter 5 the proposal is analysed on its effectiveness with the LARCH results, the evaluation of the developed ecological network. In chapter 6 finally the conclusions and recommendations are presented.

1.1 Study area

The study area is situated in the provinces of Bologna and Modena. The area encompasses the communities of Calderara di Reno, Sala Bolognese, San Giovanni in Persiceto, Sant Agata Bolognese, Crevalcore (all in the Province of Bologna) and Finale Emilia, Camposanto and San Felice sul Panaro (all in the Province of Modena). The total area measures some 52000 ha, the diameter is some 40 by 15 km.

Through the area run major rivers like the river Reno and Panaro. The hydrology is oriented south-north, from the Apennines to the Po river

Land use is agricultural, and in particular in Bologna province rather intensive, with much pressure from urban areas, industrial activities etc. Modena territory is at a larger distance from the Via Emilia, and therefore more rural with extensive agriculture.

Small natural areas are present, mainly small forests, wetlands, and some natural grassland along the river dykes (Morisi 2000).

2 Methods

2.1 Larch Model

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.
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, which is a crucial element of this project.
The input for the model is a land use map or vegetation map, here the land use maps provided by the Provinces of Bologna and Modena serves as input

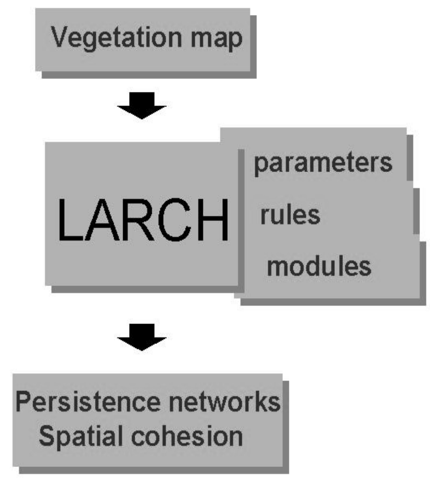

Figure 1: set-up of model LARCH

It should be kept in mind that the results from LARCH present the potential distribution of a species, i.e. disregarding the quality of an area.

LARCH is designed as an expert system, used for scenario analysis and policy evaluation. The model has been fully described elsewhere (Foppen *et al.* 1999c, Pouwels *et al.* 2002, Groot Bruinderink *et al.* 2003, Chardon *et al.* 2000, Van der Sluis & Chardon 2001, Verboom *et al.* 2001, Van der Sluis *et al.* 2001a, 2001b).

The principles of LARCH are simple: A species that is relevant for conservation, or an indicator species representing a guild of species is selected. The size of a natural area (habitat patch) determines the potential number of individuals of a specific species it can contain. The distance to neighbouring areas determines whether it belongs to a network for the species. The carrying capacity of the network determines whether it can contain a viable population. If that is the case, the network population is sustainable for the species.
LARCH requires input in the form of habitat data (e.g. a vegetation or land use map) and ecological parameters (e.g. home range, dispersal distance, and carrying capacity for all habitat types). LARCH parameters are based on literature and empirical studies. Simulations with the dynamic population model METAPHOR were carried out over the past twelve years to validate parameters and standards for the model (Foppen *et al.* 1999b, Verboom *et al.* 1993, 2001, Vos *et al.* 2001, 2002, and Opdam

2002). Actual species distribution or abundance data are not required since the assessment is based on the potential for an ecological network of a species.

Besides the surface area, also the connectivity or spatial cohesion is important (Verboom *et al.* 1993, Hanski & Gilpin 1997). The surface area determines the expected number of individuals in an area, while the connectivity primarily depends upon the carrying capacity of a patch and dispersal capacity of a species.
LARCH assesses the spatial cohesion of each habitat patch, using habitat features and dispersal characteristics (Vos *et al.* 2001, Groot Bruinderink *et al.* 2003, Sluis & Chardon 2001). The spatial cohesion provides insight into the degree that areas are connected and the potential of an area to function as a corridor for species.
In defining spatial cohesion roads are taken into account for some species.

Step by step is described how LARCH models the habitat, evaluates the network population the viability of the network population and spatial cohesion:

Habitat modelling
Based on the land use map (fig. 2a) is defined what relevant habitat is for the selected species. For each vegetation type is defined whether the habitat suitability is rated as optimal, sub-optimal or marginal. The carrying capacity for each habitat type is defined (fig. 2b), based on population densities which is derived from literature, and in some cases expert knowledge and the LARCH database information.
For each patch is defined, on the basis of the carrying capacity, suitability rating and the size of the area, what the number of individuals is that can be supported by the habitat patch.
Further criteria are possible, e.g. altitude. From literature is usually known what altitude range is acceptable for a species, and all habitat not within that range can be excluded in the analysis.

Defining local populations
Suitable patches that are located near to each other allow for movement of individuals on a daily basis, the so-called home-range. The home-range can be estimated from literature. The patches within the home range of a species form part of the local network or territory of the species. Such habitat patches are fused into a cluster and considered a local population (fig. 2c). In the event that species are vulnerable for barriers, roads or other features are taken into account. However, this requires more parameters for the model, e.g. traffic density of specific roads or railway lines, and sensitivity of the species for traffic, etceteras. Barriers, such as busy roads and channels with sheet-piled banks, may hinder the fusion of habitat sites into a local population, even though they are located within the network distance. This is particularly the case for less mobile species like small mammals, reptiles and amphibians. A total number of Reproductive units RU (Fahrig, 2001) is defined for the local population. Areas that are too small to support one Reproductive Unit are further disregarded in the analysis.

Determining reproductive units (territories/families) in an area and key populations

The areas that meet the threshold are habitat patches where, in potential, a population may be able to exist. However, one reproductive unit is not enough to maintain a viable population. A population is only large enough to cope with normal fluctuations in the population (see box 2) if the population is sufficiently large. This is called a 'minimal viable population' (MVP). In many fragmented landscapes, this is no longer a realistic option and we rather speak of key populations. The number of breeding pairs (RUs) for a key population should be large 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 individuals per year from other local populations in the same network (Verboom *et al.* 2001). If present, key populations can form the core of a network.

Determining the boundaries of the network

Sites located within dispersal distance of a species can be considered to belong to one network. A network is formed by local populations that are connected to each other, because the animals can go from one site to the other when searching for a new habitat site (dispersal). So in most cases, a set of local populations will form a population network, which may render it viable or sustainable (fig. 3D).
This is dependent on the total number of animals present, but also on the rate of fragmentation: is it a network population with a key-population, or does the network consist of only small local populations?
In delineating networks, also here effects of barriers (like roads) can be included. Also altitude can in some cases form a limitation for network formation.

Determining the viability of the network

In the final step the viability of the network is determined: for each population is indicated whether it is viable or not, and whether it meets the size requirements of a MVP or key population (fig. 3D). The criterion used is the chances of a (network) population still existing after 100 years are greater than 95% (Shaffer 1981, Verboom *et al.* 2001). Here it is assumed that the area does not undergo any changes, or only slight changes, during this period of time.
To define the viability of networks, either with or without key population, standards have been established in the form of the minimum required number RUs for a network. This information is derived from a standard for the minimum number of reproducing individuals required. The exact standard depends upon the species group and whether or not a key population exists within the network (Verboom *et al.* 2001). A Marsh heron in a network with at least a key population for example, requires a total of 60 reproducing females for a sustainable (meta-) population.

Besides the surface area, also the connectivity or spatial cohesion is important (Verboom *et al.* 1993, Hanski & Gilpin 1997). The surface area determines the expected number of individuals in an area, while the connectivity primarily depends upon the carrying capacity of a patch and dispersal capacity of a species. The dispersal distance of a Green lizard is much smaller than that of a large mammal, such as the Wolf. In effect, this dispersal distance defines whether habitat patches will form part of a network for a species. A Wolf has advantage of forest areas within a radius of 200 km, whereas an *Italian crested newt* has only advantage of habitat within a radius of 1000 m from breeding habitat. the total number of animals present, but also the rate of fragmentation: is it a

LARCH-SCAN (=Spatial Cohesion Analysis of Networks) assesses the spatial cohesion of each habitat patch, using habitat features and dispersal characteristics (Vos *et al.* 2001, Groot Bruinderink *et al.* 2003, Sluis & Chardon 2001). The dispersal range of a species in a landscape can be described by a function in which alpha is the key parameter (box 2), describing the distance over which potential source patches can still deliver immigrating individuals (Hanski & Gilpin 1997). The extent of potential habitat surrounding a cell that contributes to this measure of connectivity is determined for each grid cell. Here, the value of the potential habitat for a grid cell depends upon the carrying capacity (or the size) of the habitat. Because the method examines each individual grid cell, the degree of connection between habitats is considered in this measure as well as the surface areas of the habitats themselves. After all, a grid located in the middle of a very large habitat patch will have a high connectivity value. The spatial cohesion (fig. 3E) provides insight into the degree that areas are connected and the potential of an area to function as a corridor for species.
Also in defining spatial cohesion roads have been taken into account for some species.

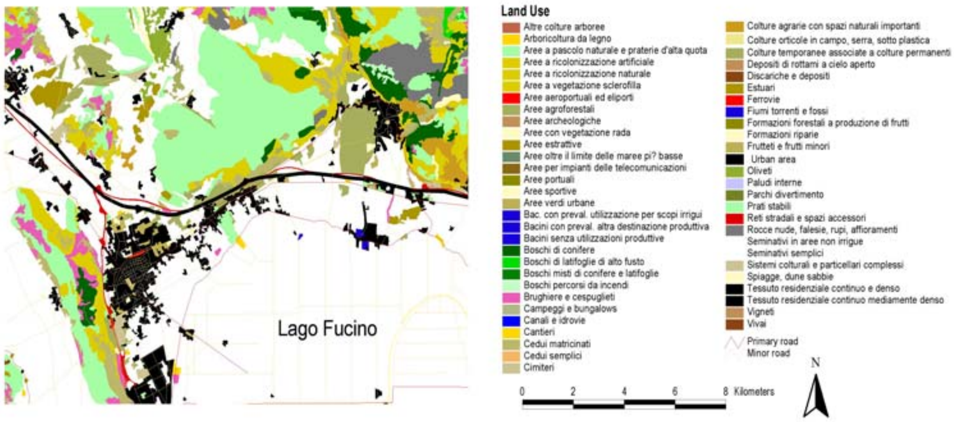

fig.2A: Input for LARCH is Land Use map from Abruzzo

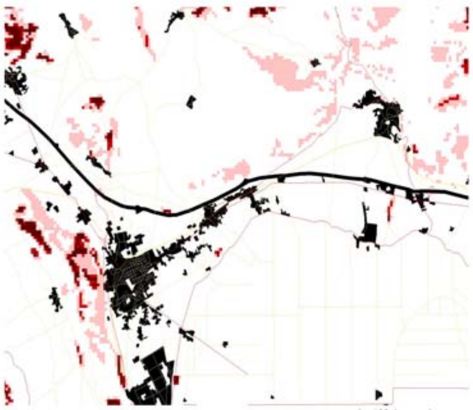

fig. 3B: Assessment carrying capacity

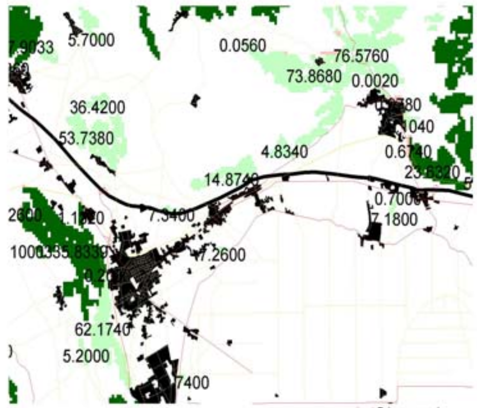

fig. 2C: Identification of local populations and key-patches

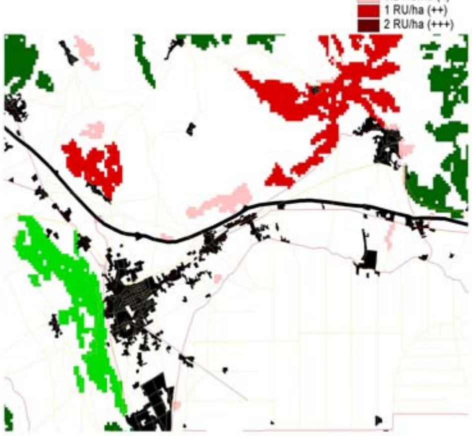

fig. 2D: Identification of network populations and sustaiability of

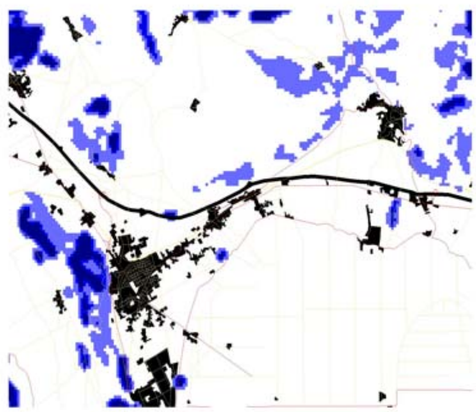

fig. 2E: LARCH-SCAN, analysis of spatial cohesion

Figure 2: LARCH analysis procedure; fig. 3a to3 e indicate the steps taken in LARCH to come to a viability assessment on the basis of the habitat map. Fig.3f. illustrates the spatial cohesion.. See text for further explanation of steps

2.2 Ecological profiles

Three ecosystem types were selected, which cover most important natural habitat types in the study area: woodland, wetland, and grassland. Each habitat type has its own spatial configuration. To optimise the spatial configuration of habitat (the ecological network), two species are selected which can be considered representative for these ecosystems, i.e. in total six species. These six species are leading in the optimisation of the ecological network.

The choice of species is based on the following characteristics

- The species is not too rare, not too common, and ecologically relevant
- The scale of the species (home-range) should be relevant for the scale of the area
- Preferably the species should have been analysed in the previous study for Emilia-Romagna
- if possible, analysed in other Life-Econet studies, for comparison reasons

In table 2 we see the pre-selection made in discussion with the Steering Group, and in particular Sala and Morisi, the biologists involved.
These six species are leading in the network design and will be analysed with LARCH.

Table 1 Selected species and ecosystems for Network development

Nome italiano	English name	Scientific name	Woodland	Grassland	Wetland, marshland	Shrubland, macchia
Licena delle paludi	Large copper	Lycaena dispar		X	X	
Ramarro occidentale	Green lizard	Lacerta bilineata		X		X
Tritone crestato meridionale	Italian crested newt	Triturus carnifex		X	X	
Averla piccola	Red-backed shrike	Lanius collurio	X	X		X
Saltimpalo	Stonechat	Saxicola torquata		X		X
Moscardino	Dormouse	Muscardinus avellanarius	X			

The selected species represent a range of dispersal capacities, from only few hundred meters for the **Green lizard** up to 10 kilometers for the **Red-backed shrike** or **Stonechat** (Table 2). The species also differ in sensitivity towards fragmentation. For each ecosystem one species sensitive to barriers was selected.

Table 2 Spatial characteristics of selected species – dispersal distance and area requirements

Network Distance Key Area	<1 km	1-3 km	3-7 km	7-15 km
0-0.1 km2				
0.1-1 km2	Green lizard Dormouse		Large copper	
1-5 km2				
5-10 km2		Italian crested newt		Red-backed shrike Stonechat
> 10 km2				

In the following paragraphs the species are briefly described and discussed per ecosystem type, regarding their characteristics relevant for this analysis. Per species is indicated what 'land use type' corresponds with the required habitat. These types are selected from the land use map.
The legend types of the detailed maps were therefore converted to the existing classification of the Land Use map.

2.2.1 Woodland

2.2.1.1 Red-backed shrike

The **Red-backed shrike** (*Lanius collurio*) breeds across most of Europe. It occupies a variety of half-open habitat, with shrubland, bushes for nesting and breeding. It requires a rich insect fauna to feed upon (Hagemeijer et al. 1997).
The densities may reach more than 5000 bp/50 km. squares in Northern Italy, due to fragmentation and edge effect the actual carrying might be much lower (European Bird Database EBD), no accurate data is available for the study area.

The species has shown a serious decline in most of Europe, being some 20% in the period from 1970-1990 (Hagemeijer et al. 1997). This might be related to bad summers, with its effect on insect populations, in conjunction with deterioration and destruction of prime farmland habitats (Hustings & Bekhuis 1993). The species was modelled in the previous study (Van der Sluis *et al.* 2001a).
The selected habitat of the **Red-backed shrike** consists of:

Table 3 Relevant habitat types in the land use map for Red-backed shrike

Habitat type	Description	Importance
shrubland	Zs	++
wet shrubland	Cl	+
Forest, linear elements, hedges	Bl	++

2.2.1.2 Dormouse

The **Dormouse** (*Muscardinus avellanarius*) is a little common ('poco numeroso') in Emilia-Romagna, and the species is protected under regional legislation and Bern Convention.
East of Finale Emilia is an old villa park where the species occurs. Since the Fat dormouse (*Glis glis* or Ghiro) is present in Argellato just outside the area, perhaps also the **Dormouse** is found there. In Bologna Province the **Dormouse** is found around the Bora visitor centre. In addition some forest along the river, e.g. along river Reno, are of importance.

The **Dormouse** occurs in diverse, species rich woodlands often associated with coppiced hazel understorey. Dormice have a preference for woodlands with an open canopy and a dense, varied shrub layer, sometimes also conifer forest (http://www.regione.emilia-romagna.it/parchi/fauna/moscard.htm). During the year different areas are utilised as different food sources become available, but all habitat should occur within approx. 1 ha. (Foppen & Nieuwenhuizen 1997, Foppen 1999a). The network distance might range from 250 to 1500 m, this is dependent on the landscape resistance and here it is likely to be less than 250 m.

The species is very vulnerable to fragmentation, all roads and railways are considered barriers, both at local and network level. According to some authors the species only moves through trees and shrubs
(http://www.wildlifetrust.org.uk/cheshire/dmbap.htm#**Dormouse**%20BAP%20Header). The species was modelled for Cheshire (Van der Sluis *et al.* 2003a).
The selected habitat of the **Dormouse** consists of:

Table 4 Relevant habitat types in the land use map for Dormouse

Habitat type	Description	Importance
broadleaved forest	B	++
coniferous forest	Ba	+
plantation	Br	+
chestnut	Cf	+++
parks	Lv	+
shrubbery	Zs	++
cultivated, special wood	Cp	+
forest, linear elements, hedges	Bl	++
old farm and villa parks ('Parco de villa')	new	+++

2.2.2 Wetland and marshland

2.2.2.1 Italian crested newt

The **Italian crested newt** (*Triturus carnifex*) occurs most in the Southern Alps and Italy (Nöllert & Nöllert 1992, Günther 1996). Its habitat has much similarity with the Great crested newt, *Triturus cristatus*, of which it sometimes is regarded as a sub-species as well (Bigazzi & Fellegara 1993).

The decline of the species is attributed to destruction of reproduction areas, intensive agriculture and urbanisation of rural areas. Also predation by fish is a detrimental factor (Caputo *et al.* 1993).

The population of the species might consist of fragmented local populations (Bigazzi & Fellegara 1993). It is mostly found in aquatic habitat (90% of the observations in this study were done in 'Umidi'), of which some 18% and 15% respectively is defined as 'lakes' and 'canals and streams' (Mazzotti *et al.* 1999). They occur in ponds, small lakes, sources, preferably with rich submerse aquatic vegetation. Its terrestrial habitat consists of meadows and forested areas, located near their reproduction areas (Giacoma 1988a, 1988b).

For Triturus cristatus maximum dispersal distances were measured up to 1490 m (van der Sluis *et al.* 1999). All roads are considered barriers at local population level, at network level only autostrada and major roads are considered absolute barriers. The species was modelled in the previous study (Van der Sluis *et al.* 2001a).

The selected habitat for the **Italian crested newt** consists of:

Table 5 Relevant habitat types in the land use map for Italian crested newt

Habitat type	Description	Importance
waterbody	L	++
wetland	Zp	++
watercourse	Al	+
wet forest	Bi	+
wet shrubland	Ci	+
forest, linear elements, hedges	Bl	+

2.2.2.2 Large copper

The **Large copper** (*Lycaena dispar*) is a small butterly. Several sub-species are known in Europe. The species occurs from Western Europe to Northern Italy into Asia minor. It is rare and rather vulnerable in most of its range (Bink 1992), in northwest Europe it is on the verge of extinction. In southern Europe the situation is better, here 2-3 generations can occur per year.
The decline of the species is attributed to land drainage, intensive agriculture and urbanisation of rural areas.

Large copper prefers a habitat characterised by marshlands, reedlands but also (grazed) rough meadows and mosaic park-like landscapes, provided that wet areas are present or marshlands adjacent to rivers and streams.
Host plants are Rumex species, preferred vegetation types are old reed lands, and Magnocaricion (tall sedges) vegetations.

The species is not very mobile (Bink 1992). The home-range of this species is estimated at 250 m. Network distance is estimated to be some 5000 m.

Only large, 4-lane+ roads are considered barriers at local population level and network level, so only the autostrada is considered an absolute barrier.
The selected habitat for the **Large copper** consists of:

Table 6: Relevant habitat types in the land use map for Large copper

Habitat type	Description	Importance
wetland	Zp	++
wet forest	Bi	+
wet shrubland	Ci	+
permanent grassland, wet grassland	Pp	++

2.2.3 Grassland

2.2.3.1 Stonechat

The **Stonechat** (*Saxicola torquata*) occurs in most of Central and South-eastern Europe (Hagemeijer et al. & 1997). Its habitat consists of extensively cultivated agricultural areas with varied grass cover, and especially the shrub-like habitats in between. Open macchia with esp. Cistus species is preferred. Grassland with tall herbs and shrubs forms it prime habitat. In prime areas in the Mediterranean it achieves breeding densities of 15-25 bp/10 ha. (Hagemeijer et al. 1997).

The total population of **Stonechat** in Italy is estimated at some 2,500,000 birds. There has been a marked decline due to agricultural intensification and a decline in cereals, which are being replaced by maize. The species was modelled in the previous study (Van der Sluis *et al.* 2001a). The selected habitat of the **Stonechat** consists of:

Table 7 Relevant habitat types in the land use map for Stonechat

Habitat type	Description	Importance
wet shrubland	Cl	+
shrubbery	Zs	+
permanent grassland	Pp	+
forest, linear elements, hedges	Bl	+

2.2.3.2 Green lizard

The **Green lizard**, (*Lacerta bilineata)* has only recently been identified as a distinct species from *Lacerta viridis*, through genetical research (Amann *et al.* 1997). The **Green lizard** is vulnerable in most of its habitat. The species has shown a decline as a result of habitat destruction. Also the weather conditions are of importance for this species (Gasc *et al.* 1997).

The Green lizard (*Lacerta viridis*) occupies well vegetated habitats, especially where there is some dense cover adjacent to open areas for basking in the sun. The species seems to be diffuse; it only occurs in cut grassland (sfalciati), along dykes and in roadside vergets. Not much in other habitats, like hedgerows Often edges of forests are used, as well as meadows and floodplains (http://www.regione.emilia-romagna.it/parchi/fauna/retanfi.htm). **Green lizards** often use woodpiles, dead branches and similar structures, or stone walls and rocks for basking in the sun (Cabela *et al.* 2001)

Limited information is available on both dispersal distance and vulnerability for barriers. Assumptions were made on the basis of available literature: the home range for **Green lizard** may be up to 100 m, network distance up to 200 m. for Italian conditions. Only the autostrada and major roads are considered absolute barriers. Probably dykes do not form barriers, since roads go over the river and wildlife passes are therefore present underneath. The species was also modelled in the Abruzzo study (Van der Sluis *et al.* 2003b). The selected habitat of the **Green lizard** consists of (table 8):

Table 8 Relevant habitat types in the land use map for Green lizard

Habitat type	Description	Importance
Permanent Grassland & shrubs	Pp	++
Forest, linear elements, hedges	Bl	++

2.3 Base Maps

The maps used in the analysis are the Provincial Land Use maps and more detailed inventories of natural areas. The latter is based on inventories done by Centro Agricoltura Ambiente for the provinces, and contains detailed information on small landscape elements, i.e. ponds, hedgerows, piantate, and even single trees.

The model LARCH was run with the land use map of the two provinces. The more detailed maps were pasted in the provincial maps, so that the area could be analysed in detail, taking into account the natural areas surrounding it.

Opportunities and constraints for the development of sound ecological networks in the study area were mapped. Constraints are e.g. planned urban developments and infrastructure. These should be taken into account to develop a future ecological network. Opportunity areas are areas were nature development or restoration can be realised relatively easily, as a result of other spatial developments, initiatives etc.
The information on opportunities and constraint in the study area was gathered at a workshop with the steering committee. As a preparation on the workshop the committee was asked to gather information on future developments. This resulted in a map on the opportunities (Figure 3), and a map on the constraints for the development of ecological networks (Figure 4).

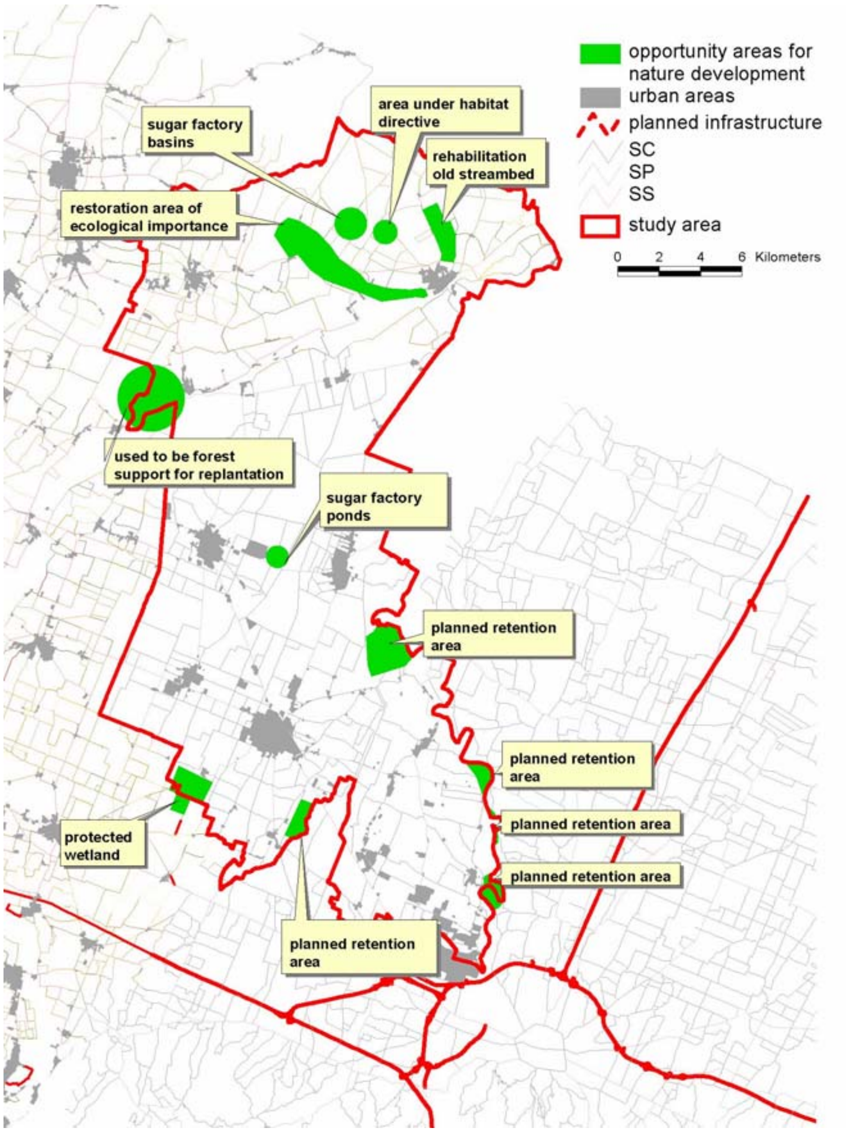

Figure 3 Opportunities for nature development

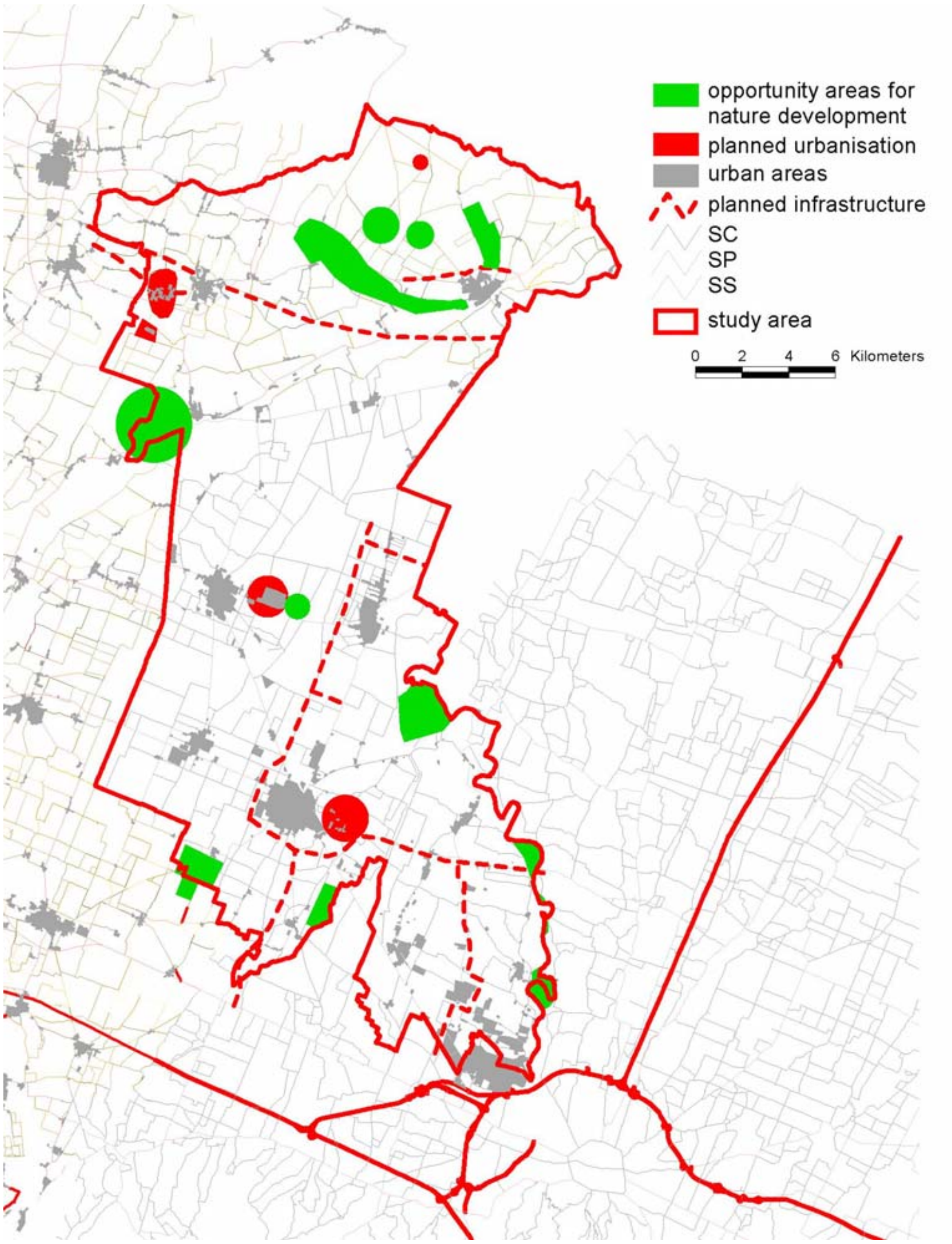

Figure 4 Constraints for nature development

2.4 Network design

For the design of an integrated ecological network for Perciseto, the following steps were taken:

a. A map of the study area was drawn on which the **first ranked spatial options** for all barrier-sensitive and barrier-insensitive ecoprofiles for each of the three ecosystems were indicated.
b. The map was combined with the map of the future developments (Figure 4). Assessed was, whether **planned infrastructure** decreases the ecological benefits of a "first choice" option for a barrier-sensitive ecoprofile. If this was the case, this option was substituted by the second ranked spatial option.
c. Then it was assessed whether future **industrial development** or **urbanisation** will interfere with the ecological benefits of the mapped options. If that was the case this option was replaced by the spatial option next in rank.
d. Next, the map with the remaining spatial options was combined with the **opportunities** map for nature development (Figure 3). Assessed was if these opportunity areas for nature development could be integrated into the ecological design, by comparing the specific locations and potencial for nature development with lower ranked spatial options for any of the ecosystems. If these coincided the lower ranked option to the map were added, because of the high feasibility.
e. Finally, the resulting ecological design was **checked and refined** for each of the ecoprofiles and ecosystems.

At each stage, all options are explored in a systematic way (Figure 5). The resulting options are ranked, according to local potential and ecological benefits (Van Rooij et al. 2003). The design is translated in a 'map' and description of measures.

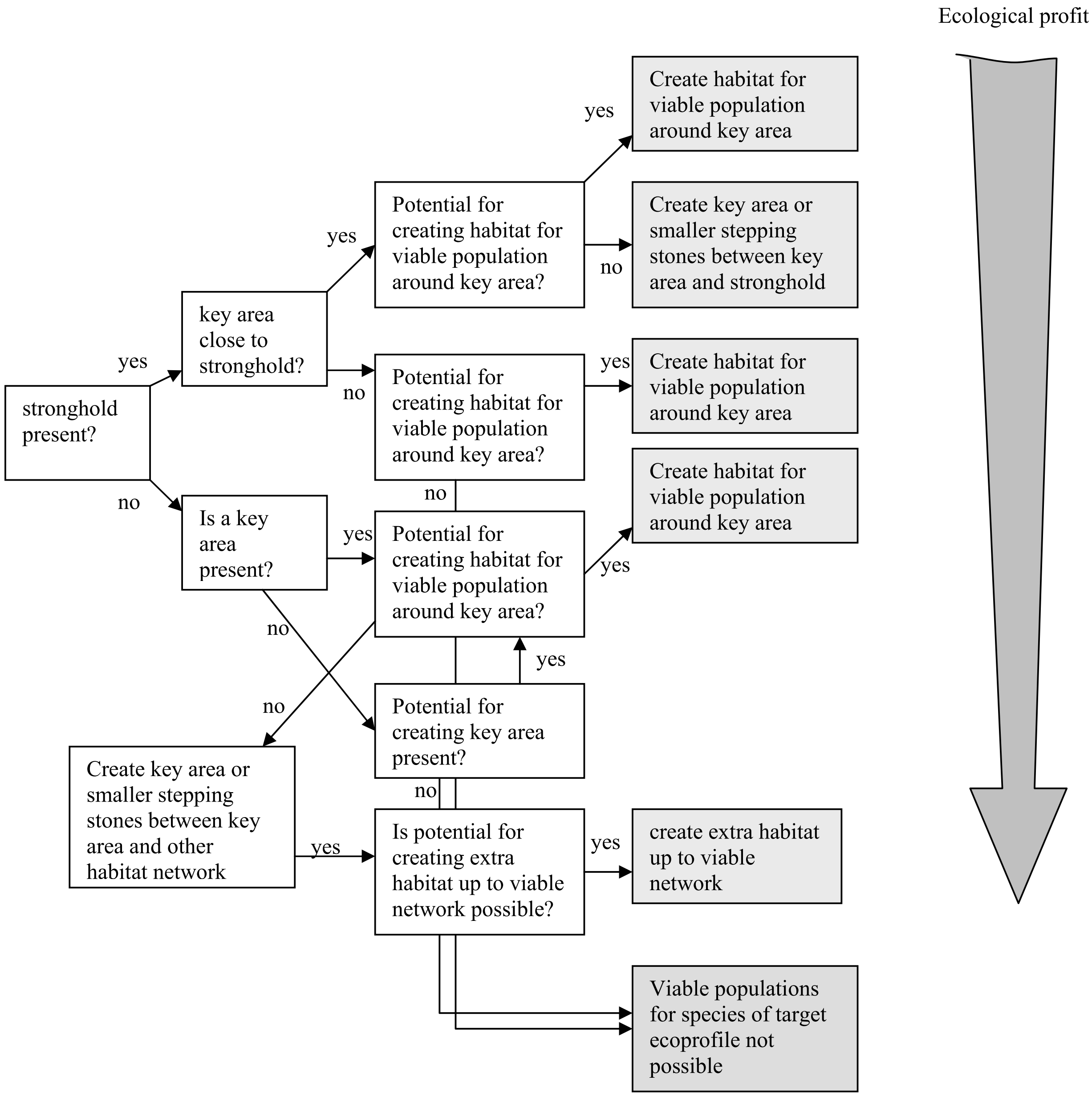

Figure 5 Decision tree for prioritising spatial options (Van Rooij et al. 2003)

3 Analysis ecological network

3.1 Woodland

The woodland in the Plains area of Emilia-Romagna is formed by small woodlots or landscape elements like hedges (siepe) or other woody vegetation. Some more extended 'true' forest areas were recently planted. Most valuable woodlands might be the farmyards, which can be very old at times.
The selected species for woodland ecosystems (Table 2: **Red-backed shrike** and **Dormouse**) are both versatile species, using a wide range of habitats which can expand in areas with little woodland.

The **Red-backed shrike** forms small local population of (in potential) at most some twenty pairs. The species forms small local populations at present, which form together a metapopulation (i.e. one network).
Overall, the network is very viable, which is due to the presence of the Apennines which forms a major core area, or a source area, and the Plains can be considered a 'sink'.

The **Dormouse** shows in potential a large number of small local populations, however, none is viable on its own, due to the fragmented situation, the presence of a large number of roads, and the low carrying capacity. The network is nearly sustainable, since large key areas or MVPs are lacking.
The largest patches might be sufficient for some tens of pairs (maximum 80) of the **Dormouse**, most are located in Modena province and along the river Reno and Panaro.

3.2 Wetland and Marshland

For marshland ecosystems the **Large copper** and the **Italian crested newt** are selected which are really dependent on wetlands. They can be considered representative for this ecosystem type. They display different characteristics in regard of dispersal ranges. The **Large copper** has a dispersal distance of approximately 5 km. whereas the **Italian crested newt** has a dispersal distance of only some 1000 m.
The analysis done for the **Italian crested newt** differs from the approach in the first study, since more detailed maps were available with all small ponds included. The assessment is done on the basis of the number of natural areas, within range of each other, i.e. which consist here of ponds, sugar factory basins, flaxum processing ponds, fish ponds and (sometimes abandoned) rice fields. The size of the wetland is a factor that is also taken into account, but not of major importance, since amphibians mainly use the edge habitat, i.e. vegetated parts of the ponds.

The network of the **Italian crested newt** consists of several minimal viable population and a number of key patches and small local populations.

In Modena an MVP and key patches are found in the north of Finale Emilia. In Bologna territory key patches are present in Crevalcore, MVPs are present around Tivoli (San Giovanni) and Certosa (Sala Bolognese).
However, it should be noted though that this is based on the ponds and basins present. Not all of these might be suitable, since some of the ponds used for fish farming are useless for amphibian species. No field data is present to confirm the quality of the present ponds.
In some cases the effect of the main road, running north-west to south-east, is clearly visible as a barrier which hinders migration and which is fragmenting populations in this area.

The metapopulation of the **Large copper** currently consists of a number of MVPs, key and local populations (figure 8). All areas of sufficient size together form one network. The network is sustainable.
The connectivity of the northern part (Modena) with the southern part (Bologna) is poor. Some important core areas are situated just north of the study area, near the Po river.

3.3 Grassland

The two species analysed for grassland ecosystems are **Stonechat** and **Green lizard**. Both have very different characteristics, the dispersal range for the **Green lizard** is much smaller than for the **Stonechat**, resp. 200 meter and 10 km.

The **Stonechat** forms, with more than 100 pairs an MVP. In additon a larger number of local populations is present. These together form a viable population. Only the herb-rich lands with a rich insect fauna are suitable.
The species might have a wider presence in bologna province, which was confirmed by local biologists.
The spatial cohesion is poor for the **Stonechat**.

The **Green lizard** utilises grasslands along the rivers and dykes, and can form here extensive populations which are in potential large enough for an MVP. Other (natural) grasslands might sometimes be large enough for key populations, but most are too small to form a functional part of the ecological network. The population is very viable along the rivers Panaro, Reno, Collettore delle acque alte and the grasslands located west of San Felice sul Panaro. However, the quality of the grasslands and dykes can not be assessed, so in reality the situation may differ….
The dykes form in fact the network for this species, these are best connected. The population is however fragmented as a result of the large number of roads. Limited information is available on both dispersal distance and vulnerability for barriers.

4 Design proposal for an ecological network

4.1 Mapping opportunities and constraints

In the joint workshop of the authors of this report and the steering committee, the opportunities and constraints for the development of a future ecological network were discussed and mapped. This resulted in a map for opportunities (Figure 3.) and a map with the constraints (Figure 4).

4.2 Ecosystems approach

4.2.1 Woodland

Choice and characteristics target ecoprofiles

The ecoprofiles used in the LARCH-analyses are used as target ecoprofiles for the design of an ecological network. Habitat requirements for these ecoprofiles are presented in table 9.

Table 9 Ecological spatial characteristics of species of the used target ecoprofiles for woodland: "Dormouse" and "Redbacked shrike"

Characteristics \ ecoprofile	Dormouse	Redbacked shrike
Sensitive to barriers	yes	No
Dispersal distance	1.5 km	10 km
Home range	100 m	500 m
Key area	20 ha	40 ha
Area sustainable network (including key area)	30 ha	120 ha
Area sustainable network (without key area)	40 ha	200 ha

Spatial options "Dormouse"

- Present situation

At present, the habitat network of a species like the **Dormouse** is very fragmented. In the study area many small local populations can occur. The amount and coherence of habitat is insufficient to sustain a persistent population. Few local population can be found in this area, only at two sites the **Dormouse** is observed: Near La Bora and near Argelato (Morisi, Sala, pers. comm.). The **Dormouse** was never inventoried in the study area and observations mentioned are anecdotical.

- Spatial options

Vulnerable species like the **Dormouse** are only present at a limited number of habitat patches. We assume that these patches are of better quality, which contain relict populations of species of old forests.
The area where the **Dormouse** has been observed are considered to be of a good quality and might hold relict species as well. Therefore these areas should be starting points for building a habitat network for woodland species.

Two other areas are likely to host populations of **Dormouse**, but no knowledge is available on their actual presence. An inventory of the study area of **Dormouse** could reveal other woodlands that house relict populations of species, very sensitive for fragmentation. These patches also would be suitable as a starting point for a sustainable habitat network.

- Priorisation of options

At this moment only two sites are known where **Dormouse** is actually observed (area 1 and 2; Figure 6). The highest priority of investing in a ecological network of woodland would be in area 1; this area is situated in the heart of the study area. Area 2 is just outside the study area, and therefore this area is out of the scope of the study. Also, no large amounts of forests in the study area adjoin area 2.

When observations confirm the presence of **Dormouse** in area 3 and 4, the priority range will be to extend the habitat network starting from:

- Area 3: along the river, the habitat is unfragmented by roads.
- Area 1: Barriers are present
- Area 2: Barriers are present, area is adjoining the study area.
- Area 4: Barriers are present, population is remote.

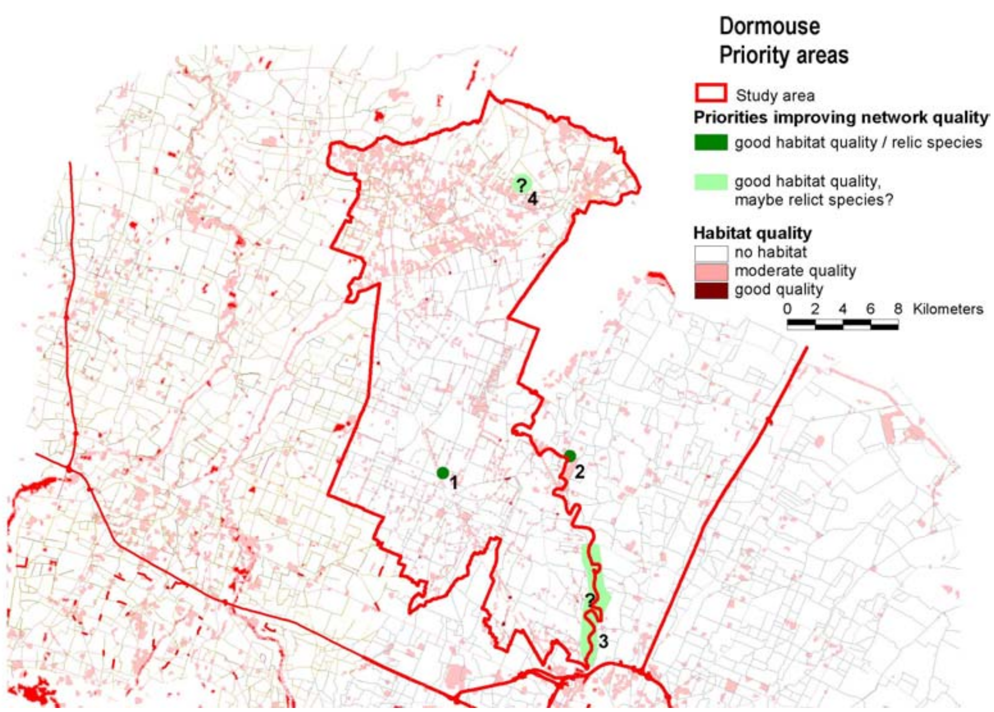

Figure 6 Priorities in improving habitat network for species as Dormouse

- *Guidelines for development*
Extend or connect old woodland patches to unfragmented woodland larger than 30 ha (sustainable habitat network for a species like the **Dormouse**).
If that is not possible, extend or connect old woodland patches to unfragmented woodland larger than 20 ha (key area for species like the **Dormouse**; note that this is not sufficient for a minimal viable population).

Spatial options "Redbacked shrike"

- *Present situation*
In the study area, small populations of a species like the Redbacked shrike can occur. As a result of their large dispersal distance the habitat network is part of a very large sustainable network, of which a stronghold is situated in the Apennines. The Redbacked shrike however only occurs sparsely in the study ares.

- *Spatial options*
Creation of stepping stones in between the Apennines and the north of the study area will facilitate a larger dispersal flow from the Apennines towards the north of the study area. Herewith the occupation rate of habitat patches will increase. Also the creation/enlargement of a key area of woodland will have a positive effect on the presence of the species in the study area.

- *Priorisation of options*
1. Key area in area 1
2. Stepping stones in area 1
3. Key area in area 2
4. Stepping stones in area 2
5. Key area in area 3
6. Stepping stones in area 3

- *Guidelines for development*

Key area:	at least 40 ha of suitable habitat, more or less adjoining.
Stepping stone:	at least 4 ha of suitable habitat.

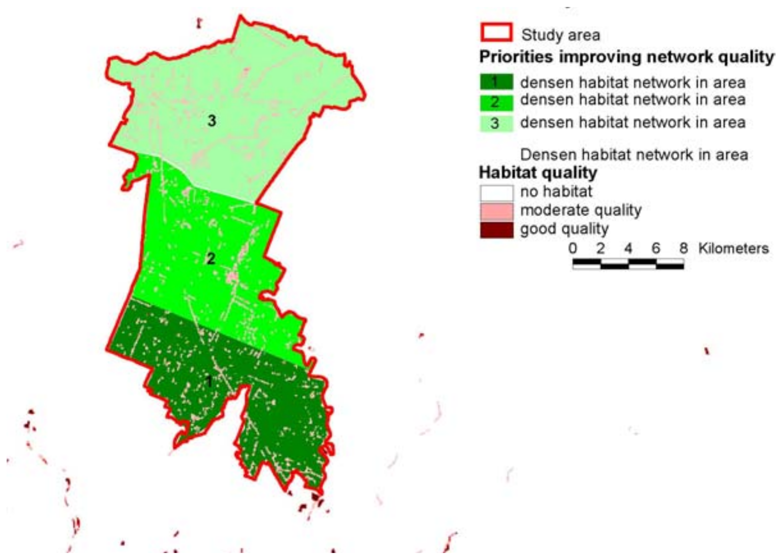

Figure 7 Priorities in improving habitat network for species as Redbacked shrike

4.2.2 Wetland and Marshland

Choice and characteristics target ecoprofiles:
The ecoprofiles used in the LARCH-analyses are used as target ecoprofiles for the design of an ecological network. Habitat requirements for these ecoprofiles are presented in table 10.

Table 10 Ecological spatial characteristics of species of the used target ecoprofiles for marshland: "Italian crested newt" and "Large copper"

Characteristics \ ecoprofile	Italian crested newt	Large copper
Sensitive to barriers	yes	No
Dispersal distance	1 km	5 km
Home range	250 m	250 m
Key area	5 patches	65 ha
Area sustainable network (including key area)	15 patches	95 ha
Area sustainable network (without key area)	20 patches	155 ha

Spatial options "Italian crested newt"

- Present situation
The analysis of the present situation of the habitat of species as the **Italian crested newt** is very complicated. Data of e.g. small canals and ditches that are suitable as habitat for these species or an inventory of the presence of this species in the study area are lacking. Therefore it was not possible to make a realistic habitat map of the present situation.

- Spatial options

The available information on the present habitat in the study area is too limited to be able to differentiate between high and low potential areas for a sound ecological network for species as the **Italian crested newt**. Therefore it is not possible to present realistic detailed spatial options for a sustainable network.

- Guidelines for development

In general, the following guideline can be given for sustainable populations for species as the **Italian crested newt**:

- Try to realise / protect clusters of at least 20 suitable water bodies (e.g. ponds) that are situated no more than 1 km from eachother (sustainable network), not divided by busy roads.
- Try to realise / protect the presence of 5 good quality ponds that are situated no more than 250 m from eachother, not separated by busy roads (key area). If a key area is present in a habitat network, less ponds are required for the same sustainability level (15 ponds).

Spatial options "Large copper"

- Present situation

All habitat is part of one large, sustainable habitat network. Habitat along the river is well connected and can house viable populations of species such as the **Large copper**. Further away from the rivers, local populations can occur. However, the species is not as abundant in habitat patches as the potential of the habitat network allows.

- Spatial options

To improve the probability of occurance of individuals of species as the **Large copper**, three sectors (all part of the same network) can be selected for improvement (Figure 8).

Sector 1 includes the area north of the study area, where important habitat is situated. In this area in potential very stable populations of **Large copper** are found. This area could therefore well function as a source area for species like the **Large copper**. Creating more habitats in area 1 has therefore the highest preference from an ecological point of view.

Also near sector 2b, large patches of good quality seem to exist, just outside the study area (Argelato). However, due to a.o. a very different soil type, the occuring species of butterflies and other insects are different from the habitat types in the study area (written comment A. Morisi). This area therefore is not included in area 2b.

Improving the habitat network along the rivers in sector 2a and 2b can result in more abundance of species as the **Large copper**. In these sectors already relatively large areas of moderate/good habitat are present. Improving the quality of habitat and/or creating compact (key) patches of suitable habitat will result in a more stable population in these sectors.

- Priorisation of options

1. If improvement of connectivity with stepping stones between habitat in the study area and strong parts of the habitat network North of the study area is possible (area 1): Improve habitat quality and/or creating more suitable wetland habitat.
2. Realise compact key areas with good quality habitat in area 2a and/or 2b, sufficient for large, stable populations of species like **Large copper**, and that can serve as a source area for the adjoining habitat patches.

- Guidelines for development

- Improvement of connectivity: realise stepping stones (6-7 ha of good quality habitat; see annex 3) in a connection zone between existing habitat patches and strong area.
- Key area: realise high quality habitat of at least 65 ha, preferably well connected with other habitat patches in the sector.

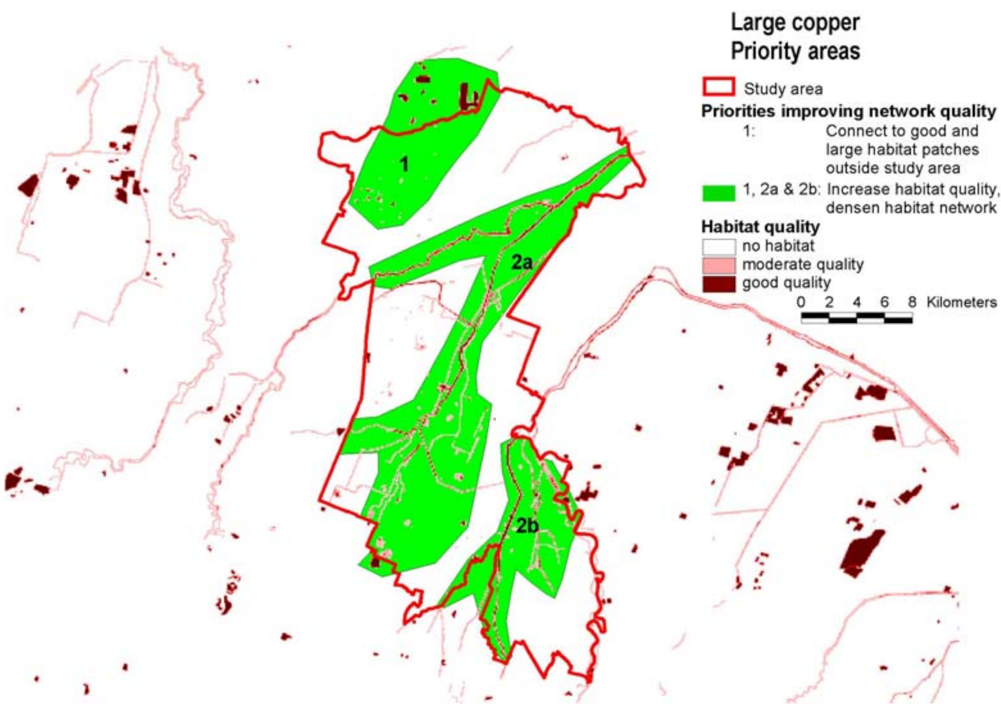

Figure 8 Priorities in improving habitat network for species as Large copper

4.2.3 Grassland

Choice and characteristics target ecoprofiles

The ecoprofiles used in the LARCH-analyses are used as target ecoprofiles for the design of an ecological network. Habitat requirements for these ecoprofiles are presented in table 11.

Table 11 Ecological spatial characteristics of species of the used target ecoprofiles for grassland: "Green lizard" and "Stonechat"

Characteristics \ ecoprofile	"Green lizard"	"Stonechat"
Sensitive to barriers	yes	No
Dispersal distance	200 m	10 km
Home range	100 m	200 m
Key area	10 ha	40 ha
Area sustainable network (including key area)	25 ha	60 ha
Area sustainable network (without key area)	40 ha	80 ha

Spatial options "Green lizard"

- Present situation

Along most rivers in the study area sufficient habitat for very sustainable populations of species as the green lizard is present at the moment. As most riverbanks are not fragmented by infrastructure, habitat along the rivers is well connected. The riverbanks can be seen as a strong key area in the study area. In potential the habitat configuration is good enough to sustain viable populations of species as the Green lizard in the study area. This applies in particular to the province of Bologna; in Modena the situation is less favourable.

- Spatial options

The most efficient way to safeguard or even improve the present habitat network in the study area is to maintain or improve the habitat quality of the present habitat patches. Herewith the present potential for viable populations of species as the Green lizard along the rivers and adjoing areas is saveguarded.

In the north of the study area, along the river Panaro only little habitat or habitat of poor quality is present. Some important habitat is present, even large enough to sustain viable populations. This habitat however is isolated. It also appeared that the Green lizard is not very abundant in these areas. This could be the result of the isolation of these habitat patches.

The ecological network in this area can be improved by connecting the present habitat patches to the (viable) network along the river Panaro (Figure 5) so that the habitat patches will become part of a very sustainable habitat network. This is a good starting point for the recolonisation of these habitat patches.

- Priorisation of options

1. Safeguard the quality and area of the present habitat patches, particularly in the areas sufficient for minimum viable populations (areas numbered 1 in Figure 9).

2. Connect habitat in area 2 (Figure 9) via the riverbanks of the canale Diversivo Burana with the sustainable habitat network along the river Panaro.
3. Connect habitat in area 3 to the riverbanks of the canale Diversivo Burana River and to habitat in area 2 (this is only effective if all habitat in area 2 is well-connected to the habitat network of the Panaro river).
4. Connect habitat in area 4 to habitat in area 3 (this is only effective if all habitat in this area too is well-connected to area 2).

- Guidelines for development

The corridor to connect the present habitat patches to the river Panaro should be about 25 m and at least 15 m wide, consisting of suitable habitat (see annex 3).

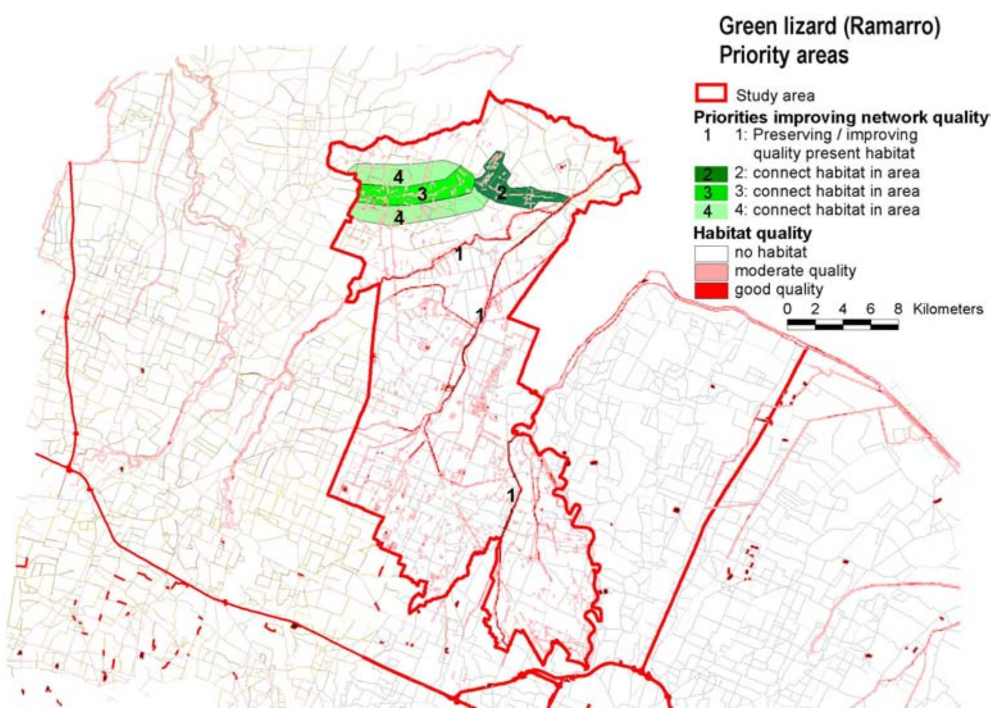

Figure 9 Priorities in improving habitat network for species as Green lizard

Spatial options "Stonechat"

- Present situation

The network for species represented by the ecoprofile "**Stonechat**" is very sustainable. The habitat along the rivers can at least hold a minimum viable population of these species. Further away from the rivers, some small populations can occur. All patches where local populations can occur are part of one and the same habitat network.

The Apennines is a stronghold for the **Stonechat** and resembling species.

- Spatial options

The LARCH results show that in potential a very sustainable network population is possible. However, at the moment the presence of species is limited. Improving the connectivity with the stronghold in the Apennines will increase the colonisation of uninhabited habitat patches in the study area. This is ecologically the most beneficial option to improve the quality of the habitat network (Figure 5).

- Priorisation of options

1. Safeguard the quality and total area of habitat present (a.o. areas 1 in Figure 10).
2. Improve the quality of habitat patches and increase the density of the habitat network with stepping stones in area 2 (Figure 10) to improve colonisation from the Apennines.
3. Improve the quality of habitat patches and increase the density of the habitat network with stepping stones in area 3 to improve dispersal to the nort of the study area.
4. Improve the quality of habitat patches and increase the density of the habitat network with stepping stones in area 4 to increase dispersal to the nort of the study area.

- Guidelines for development

Area 2: Optimise habitat quality.
Create/expand habitat patches that can function as stepping stones (at least 4 ha of good quality habitat; see annex 3). These stepping stones should be situated in the axis from south to north.

Area 3: Optimise habitat quality.
Create/expand a number of habitat patches that can function as stepping stones (at least 4 ha of good quality habitat). These stepping stones should be situated in the axis from southh to north.

Area 4: Optimise habitat quality.
Create/expand a number of habitat patches that can function as stepping stones (at least 4 ha of good quality habitat; see annex 3).

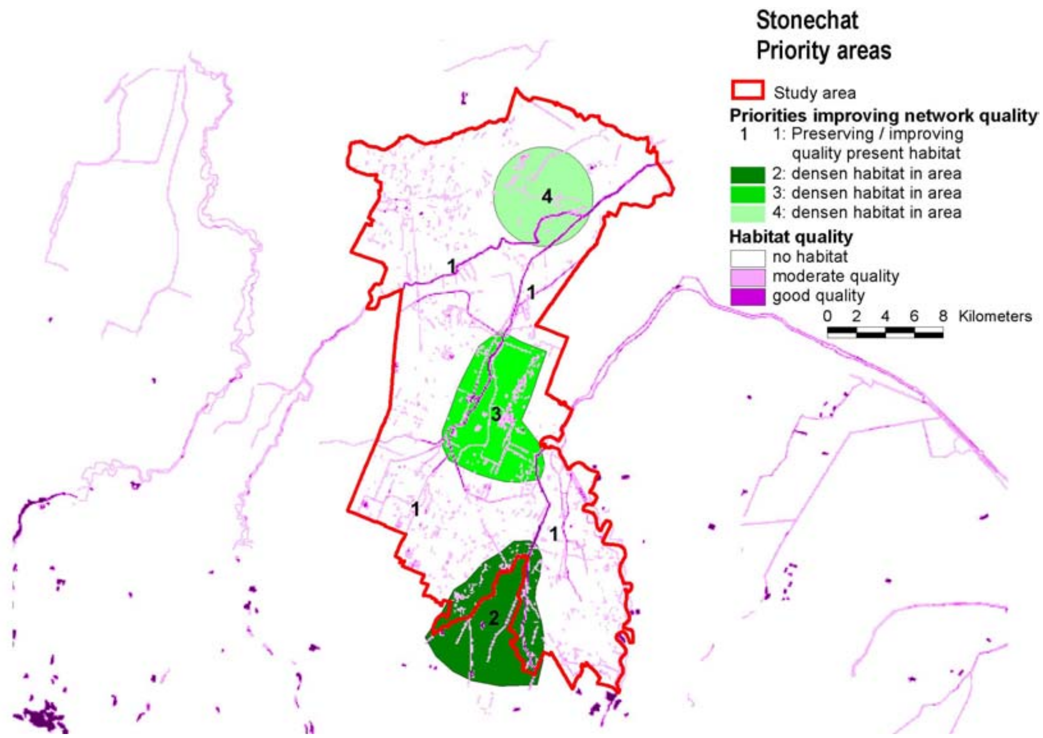

Figure 10 Priorities in improving habitat network for species as Stonechat

4.3 Vision for an ecological network

A. Mapping the first ranked spatial options

The first ranked spatial options for the ecoprofiles of grassland ("Green lizard" and "**Stonechat**"), wetland ("**Large copper**") and of forest ("**Dormouse**" and "Red backed shrike") were put on a map of the study area.

B. Comparison of first ranked spatial options of barrier-sensitive ecoprofiles with planned infrastructure (Figure 4)

Grassland:

> For the barrier-sensitive ecoprofile "Green Lizard", no advantage is expected of the first ranked spatial option as a result of planned infrastructure. Because the priority area is located along the river and river banks, roads probably do not fragment the habitat since often grassland continues underneath the bridges.

Wetland:

> For the barrier-sensitive ecoprofile "**Italian crested newt**", not enough data are present to be able to prioritise areas for these kind of species. Therefore this ecoprofile was not taken into account in the design of the ecological network.

Woodland:

The construction of the road around the town of San Giovanni, will negatively affect first ranked option for the barrier-sensitive ecoprofile "**Dormouse**" around La Bora,. Therefore, the second ranked option (Argelato) is included in the measures.

C. Comparing all ranked spatial options with industrial development and urbanisation areas (Figure 4)

Grassland:

No impact of urban areas and industrial development on the ecological benefits of the options is expected.

Wetland:

Only in the North near the village of Medolla, the ecological improvement will be less than might be expected as a result of the planned urbanisation and industrial area. Therefore this option was dropped.

Woodland:

For non-flying forest species the planned industrial area near San Giovanni poses a problem. The second ranked spatial options for this ecoprofile were already proposed in step b, to mitigate the effects of infrastructure. These measures can also mitigate the effects of future urbanisation.

D & E Ecological opportunities

- The development of natural grassland and the development of forest along a river can increase its ecological potential. A varied landscape can be developed, suitable for a range of species that make use of these ecosystems. Patches of forest along the river can be used as stepping-stones by flying species, this will improve dispersal from the Apennines to the study area. Also the planned retention area along the Torrente Samoggia offers opportunities for simultaneous development of wetland, grassland and forest in its vicinity (Figure 4).
- The proposed natural grasslands along the rivers can enhance the dispersal of flying (grassland) species and have a positive effect on their presence in grassland habitat.
- New patches of forests in the south of the study area and the stepping stones along the rivers can enhance the dispersal of flying (woodland) species from the Apennines to the north of the study area. This will have a positive effect on their presence in the study area. Also the existing patches of old woodland around old villas can function as stepping stones, and are part of the ecological network for woodland species.
- Along the river Reno several opportunities are foreseen for nature development (Figure 3 and Figure 4). Large areas along this river will be converted into retention areas. These retention areas have a large potential for the development of wetlands of high ecological quality.
- Another opportunity is the wetland south of Sant Agata Bolognese. The development of adjoining forest and natural grassland will enhance the ecological value of the area.

- With an ecological development of the ponds of the sugar factory near Crevalcore, important wetlands can be realised. These ponds are situated close to the Collettore delle Acque Alte. A link between the river habitat and these ponds will strengthen the ecological network for wetland species along the river.
- The planned retention area south of Torrente Samoggia has a good potential for a valuable wetland area. Combined with some forest development and natural grassland in its vicinity the ecological value of the area will increase even more.
- Between San Felice sul Panaro and Finale Emilia, the opportunities for nature development can be seized by development of wetlands linked with the wetlands North of the study area. The spatial option 1 in Figure 8 is adjusted according to the opportunities in this area. The shape of the potential suitable area is changed and shifted in easterly direction. The combination of wetland development in combination with the development of natural grassland and woodland will further enhance the ecological value of this area.
- Near Camposanto it is proposed to plant new forest. In the long term this forest can have a stabilising effect on the populations of forest species in this area.

The result from the process described above is a proposal for an ecological network in the study area (Figure 11). This ecological network should be considered as a firm backbone of an ecological network that can house viable populations of species that now are endangered or little abundant in the study area. Natural areas that are present or realised outside the ecological network will also profit from this ecological network; an increase in occupation rate of habitat patches and thus a raise in biodiversity can be expected.
Indicated in Figure 12 are areas that are required for a sustainable ecological network. Realising more hectares of nature is preferred: this will result in a more stable wildlife population in the area.

Woodland
For old woodland species like the **Dormouse** it is important to extend old patches of woodland to create larger habitat networks in the long run. Therefore it is beneficial to expand the present woodland around La Bora (as much as possible) and especially near Argellato.
In the scenario an expansion up to 40 ha is proposed. This forest will on the long term be large enough for a key area of species as the Redbacked shrike and will offer ample habitat for a viable population of species as the **Dormouse**.
Furthermore, an increase in woodland area, beginning in the south of the study area, can increase the dispersal flow of flying species from the stronghold in the Apennines to the north of the study area. It is profitable to create ribbons of stepping stones of woodlands to the north. The rivers flowing north are excellent natural ribbons along which these stepping-stones can be realised. The combination of natural grassland, river habitat and woodland offers habitat for many more species that depend on the combination of and transition between different ecosystems. Examples are fish eating birds, birds that nest in trees and forage in grasslands, or specific butterflies.
Stepping stones for flying species like the Redbacked shrike should consist of woodland of at least 4 ha. If more stepping stones are present along the rivers, there

will be more dispersal from the Apennines to the north and abundance of species like the Redbacked shrike will increase.
Besides large woodlands near La Bora and Argellato, two other large woodland area of 40 ha are proposed in the south and middle of the study area, to improve the dispersal and to stabilise the populations of species such as the Redbacked shrike in the study area. One of them is planned near Camposanto, where the people have a positive attitude towards the development of woodland. In this area used to be a large forest in the past.

Grassland
More extensive grassland management in the floodplains, on dykes and adjoining areas (preferably not divided by a large road) appear to be the most effective way to improve the coherence and area of habitat for grassland species such as the **Green lizard** and the **Stonechat**. These riverine grasslands form long well connected ribbons of grassland through the whole study area. Roads that cross these rivers do not fragment the habitat of grassland patches, because the grasslands continue under the bridges. These grasslands can also connect populations within the study area with populations along the river outside the study area. Herewith, the ecological benefits will be even higher. Furthermore, these south-north oriented ribbons of natural grassland can improve the dispersal from the Apennines to the north of the study area. Herewith, an increase in biodiversity can be expected in the whole study area.
In the scenario development of some 40 ha of natural grassland is proposed along the Panaro river, the Colletorre delle acque Alte and along the Reno river (Figure 12). This natural grassland is sufficient for key populations of species as the **Stonechat** and for viable populations of species such as the Green lizard. These (key) areas can stabilise the population in the study area and increase its presence.
Also, the area north of San Felice sul Panaro and Finale Emilia offers good potential for the creation of a viable habitat network of natural grassland for species as the Green lizard. Moreover, the local government supports the development of natural areas (Figure 3). The new grasslands should be more or less adjoining with a total area of at least 40 ha. Aconnection with the grasslands along the Panaro River will connect populations and improve their viability.

Wetland and marshland
For wetlands species like the **Large copper**, the most effective way to upgrade their habitat and network is to improve the quality of the present habitat along the rivers. This by securing good water quality in the rivers and by restoring natural, preferably not too steep graded banks and accompanying vegetation as much as possible (see e.g. Morisi 2001). This can be realised by a more extensive management of the riverbanks and by restoring a more natural shape of the riverbed. Also, wetlands in or adjoining to the riverbed can be part of the network of wetlands. As for grassland species, also for river- and water related species the rivers offer well-connected habitat. Besides that, rivers can link habitat in the study area with habitat along the river outside the study area.
Further, wetlands next to the river are part of the proposed wetland network: present wetlands south of San Agata Bolognese, but also planned retention areas along the Reno river, the Torrente Samoggia and the ponds of the sugar factory along the

Collettore delle Acque Alte. Populations of many species in these wetlands will be connected with the populations in the floodplains and the viability of the populations will increase much.
The development of some 65 ha of natural wetland area is proposed along the Panaro River, the Colletorre delle Acque Alte and along the Reno River In the scenario (Figure 12).

No proposal has been made for an ecological network for wetland species like the **Italian crested newt**. However, the potential for the restoration of natural grassland north of San Felice sul Panaro and Finale Emilia can well be combined with the development of a viable network of wetlands. This can be realised by securing and creating wetland habitat patches, such as ponds and natural management ditches. North of the study area a network of wetlands is present. A link between this stronghold and the area North of San Felice sul Panaro and Finale Emilia can improve the sustainability of populations in this "wetland" area.
In the scenario wetland patches of at least 65 ha are proposed in this area are proposed. This is sufficient for key populations of species as the **Large copper**. If the number of wetland patches exceeds the number of 15 (within a distance of a kilometre), this is also sufficient for viable populations of species like the **Italian crested newt**.

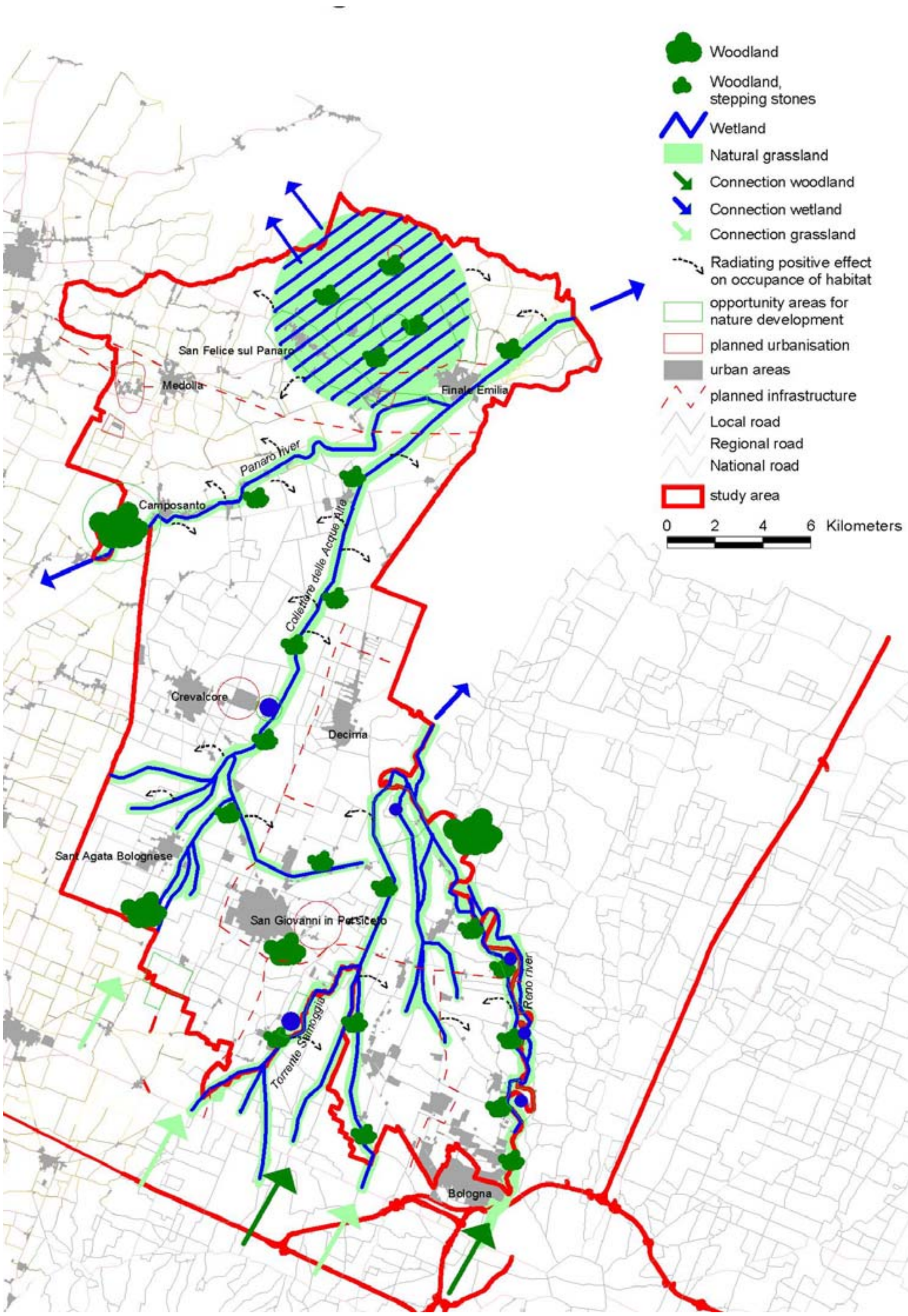

Figure 11 Vision on an ecological network in Persiceto

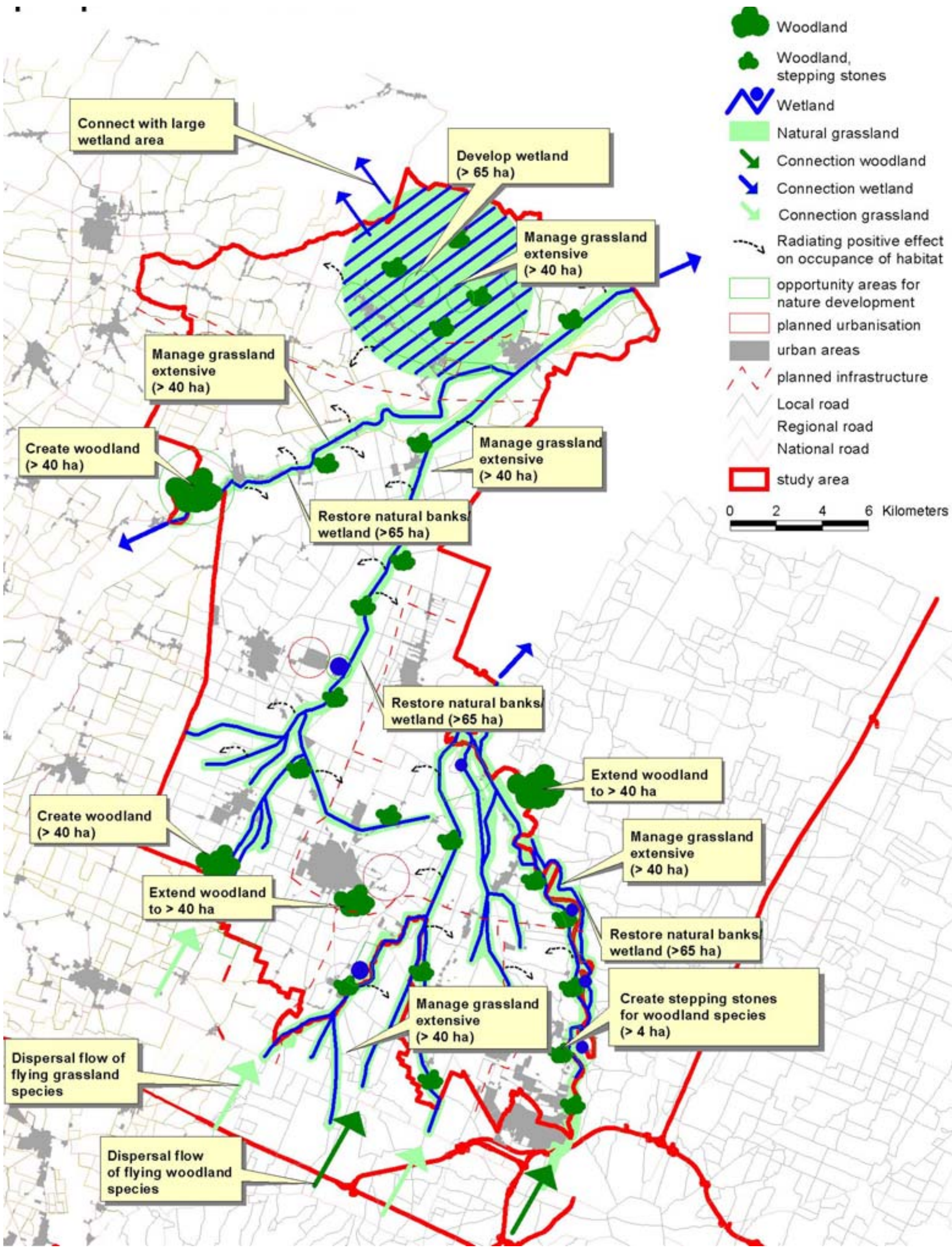

Figure 12 Proposed measures in the vision on an ecological network for Persiceano and bassa modenese. Numbers of hectares that are indicated in the figure are the minimum required for viable populations or key populations (see text). Developing more area will strengthen the ecological network

5 LARCH analysis of the new situation

5.1.1 Woodland

The scenario results in an increase in number of local populations, in particular in the southern part of Persiceto area where some three larger natural areas are proposed.
In the Province of Modena some areas are extended as well, which results in an enlargement of populations.
The small local populations form a metapopulation for the Red-backed shrike. Some two new populations are created, and the habitat increase results in an increase in population size by 60 pairs.
In both situations the population is very viable, which is largely a result of the presence of the Apennines. The measures result in an improved spatial cohesion, in particular an improved connection with the core area of the Apennines.

For the **Dormouse** the increase occurs in particular on the River Panaro (near Camposanto), the Bora and Argellato. Here the habitat is extended to the level of MVP, it becomes a viable population in the four areas where a forest extension has been proposed.

5.1.2 Wetland and Marshland

Since there is not sufficient information available on the quality and quantity of ponds, it is not possible to develop a scenario for the **Italian crested newt**. The general guidelines, to increase the number of wetlands upto a certain number, applies for those areas where the best opportunities arise.

The **Large copper** shows an improvement in the central part of the area. The two different networks (north and south) become connected through new created habitat. A larger MVP is the result, which forms one network that extends far into Modena territory. The viability of the population increases.

5.1.3 Grassland

The development scenario results for the **Stonechat** in a marked increase in population size and population persistence. The species benefits from an increase in habitat quality and to some extent an increase in area, which increases the population size by some 30%. In the area of Finale Emilia this results in a new MVP. The overall viability improves. Still a considerable number of areas is too small for a pair of **Stonechats**.

The spatial cohesion improves for the **Stonechat**, in particular in the central part of Bologna cohesion improves, which strengthens the link with the Apennines.

The **Green lizard** increases in Modena territory (the area of Finale Emilia) as a result of the habitat increase (habitat of good quality). This results in an MVP. It should be kept in mind though that the quality of the grassland will define whether this will actually be realised. There is an overall increase in sustainability in the Modena territory and around Crevalcore, where areas formerly too small become now part of a larger network and increase in viability.
The connectivity increases much in the Modena area.

5.1.4 Summary LARCH-analysis

In general, wetlands and woodlands show a marked increase in population viability and size, and some increase in spatial cohesion. Grassland only shows a limited increase in population viability of the selected species (Table 12).

Table 12: Summary of the results for the spatial analysis
0 = no change; + = some improvement; ++ = improvement; +++ strong increase; n.a. = not applicable

Change occuring under scenario Species	LARCH population assessment	LARCH population viability	LARCH-SCAN Spatial cohesion
Woodlands:			
Red-backed shrike	+	0	++
Dormouse	+++	+++	0
Wetlands:			
Italian crested newt	n.a.	n.a.	n.a.
Large copper	+	++	+++
Grasslands:			
Stonechat	++	+	+++
Green lizard	++	++	++

6 Conclusions and recommendations

The proposed ecological network results for **woodland ecosystems** in the creation of valuable core areas. These are of particular importance for the less mobile species (small and medium-sized mammals, invertebrates, reptiles). The connectivity is improved as well, in particular the connections with the Apennines, which is an important source area for forest species. This benefits in particular the mobile species (birds, some flying insects like butterflies, dragonflies, Coleoptera, medium sized mammals like carnivores)

For **wetland and marshland ecosystems** development and improvement of microhabitats is proposed, which benefits smaller, less-mobile organisms (amphibians, fish species, insects, small birds, plant species).
For larger organisms steppings stones and key areas might be most beneficial, in particular for mobile species (insects like butterflies, dragonflies, small birds, marshland birds, amphibian species)

Grassland ecosystems are very much dependant on the quality, in particular in an intensively used and urbanised area as we find in Persiceto. Measures should therefore focus on quality improvement of habitat, in particular hay-cutting (sfalci) and extensive management resulting in a structured vegetation which will benefit the development of an insect-rich fauna, and attract many other species.
Mobile species will benefit most (invertebrates, reptiles, small mammals, small and medium sized birds, birds of prey). In addition the connection of isolated areas with the extensive grasslands along the dykes and rivers might be restored, which will benefit less mobile species (invertebrates, reptiles, small and medium sized mammals, insects).

Table 13: Summary of the results ecosystems
0 = no change; + = some improvement; ++ = improvement; +++ strong increase; n.a. = not applicable

Ecosystems	Improvement ecological network
Woodland ecosystems:	++
Wetland and marshland Ecosystems:	++
Grassland ecosystems:	++

Based on this analysis it can be concluded that the measures as defined in this study result in a positive change of the evaluated ecosystems (table 13). It is therefore recommended to implement the proposed measures, whereby it should be kept in mind that the measures proposed here are to be considered as the minimum required (there is no real maximum). If these areas are developed, the aims are met: the proposed measures will result in an increase in biodiversity.

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Annex 1 Checklist for stakeholders opinions

Goal:

1. Gain insight in the interests of the stakeholder in the study area in Bologna/Modena.
2. To know the opinion of the stakeholder on ecological restoration of specific areas that can be part of an ecological network.

As described in the proposal, we require your input on these questions: you should inform us about interest (in specific areas) from stakeholders. **This is crucial information!**
This information can be obtained by visiting key stakeholders, as they do now in Cheshire, in preparation for their workshop in January.

Questions

What are the key stakeholders in the study area?
Which parties have interests in the area and the developments, and which of these stakeholders are most important for decision making?
(Important is that we do not consider individuals, but representatives for them. Not the farmer, but think of farmers unions, Ente di bonifica etc.)

What are spatial developments for stakeholders in the field of his interest:

- Are *decisions* made that will have an effect on the land use in the municipalities? What will be the effect on the land use?
- Are there any *intentions* or *tendencies* in the field of their interest that will have effect on the land use in the municipalities?

If so:

- What do these decisions/intentions/tendencies exactly comprehend?
- In which *specific* area(s) can these decisions/intentions/tendencies be expected (indicate on map!)?
- Are the mentioned intentions or tendencies *necessary* for the interest of the stakeholder (or of the people he represents), or are they *desirable*?

Output per stakeholder:

⇒ **Overview of future developments** in land use in the municipalities and the natural quality (what kind of developments) and status (already decided or not, if not: necessary or desirable).

⇒ **Map** of the municipalities, **on which the areas are indicated** where future developments will have effect on the land use.

- <u>*Assess what possibilities for the development of ecosystems in specific areas are of interest for stakeholders*</u>

In the development of spatial options, a number of areas are selected that offer potential for a sound ecological network. These areas are prioritised. We will provide you with some maps coming weeks.

What is the view of the stakeholder on the ecosystem development on the selected sites: is the suggested development of the ecosystem within the point of view of the stakeholder:

A	positive: serves also his interest	(+ / +)
B	no problem, doesn't effect his interest	(+ / 0)
C	can effect his interest, but solution can be found	(+ / ±)
D	effects his interests seriously: development is impossible	(+ / -)

Important is to get to know and to put down the argumentation of their choice!

Output per stakeholder:
- ⇒ Overview of opinion on the restoration of suggested areas in an ecological network.
- ⇒ Argumentation of the opinion of stakeholders (per area; EXAMPLE: see table below).

EXAMPLE:
Stakeholder: (e.g. chairman agricultural union)

	view of stakeholders Areas of interest	A: positive	B: no problem	C: solvable	D: impossible
Declining ecological profit	Area network a (e.g. near Campoto)	(e.g. unprofitable land)			
	Area network b (e.g. fiume Reno)			(e.g.recreation has to be regulated, costs have to be compensated)	
	Area network c		arguments		
	Area network d				
	Area network e				arguments
	Area network f			arguments	
	Area network g	arguments			
	Area network h		arguments		
	Area network I	arguments			

Forest development:
In area 10 and 11 we foresee habitat improvements for **Dormouse**, with adding habitat and connecting natural forest areas present here.
The other areas serve as stepping stones, where areas are developed upto 80 ha. (dependant on what is present here).

Wetland development
We foresee here development of small wetlands, in some cases ponds, in some cases small marshland areas or wet meadows. Ponds stocked with fish or intensively used are not suitable. Marshland areas could be along rivers, in some cases just outside the floodplain area.

Grassland development
Grassland development would require high quality grasslands with interesting grassland vegetation along it. We think of patches of some 80 ha. in total, in particular along river which can be used as stepping stone for wildlife, e.g. **Stonechat.**

FOREST/ WETLAND/GRASSLAND Development area
Stakeholder:

	view of stakeholders Areas of interest	A: positive	B: no problem	C: solvable	D: impossible
(not prioritised yet!)	Area network 1				
	Area network 2				
	Area network 3				
	Area network 4				
	Area network 5				
	Area network 6				
	Area network 7				
	Area network 8				
	Area network 9				
	Area network 10				

Annex 2 Workshop report on network design

Introduction

On the 30th of January 2003, a workshop was held at Bologna Provincial offices.
Present were: Giuseppe de Togni, Alessandro Alessandrini, Patrizia Rossi, Marta Guidi, Sabine van Rooij, Eveliene Steingröver, Theo van der Sluis

Eveliene gives a presentation of the necessity of ecological networks, and the approach that can be used in design in ecological networks (Appendix 1).
The principle is explained of the thresholds in habitat quantity and quality; the principles of MVPs versus fragmented populations; for fragmented situations basically more natural area is required. The meeting has been prepared by ALTERRA, with an exploration of all options, based on the analysis (diagnosis) with LARCH of the present situation. The Provinces prepared from their side what stakeholder opinions might be. Furthermore Giuseppe and Marta checked the previous evening with Luigi and Andrea the fauna distribution data, in relation to LARCH results. Today we will start with prioritisation of measures.

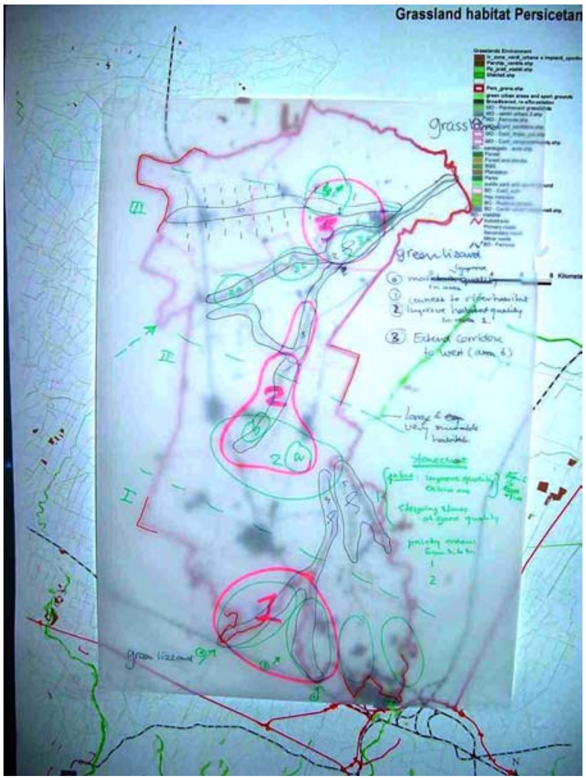
Grassland habitat

Results LARCH Green lizard (Ramarro): the results are quite OK. In Modena the species seems to be more diffuse in reality; not much in other habitats, like hedgerows, but cut grasslands, and roadside verges. In Bologna, the populations might be slightly better, like a key population, with a higher density. Probably roads do not form barriers of floodplain habitat, since roads go over the river and wildlife passes are therefore present underneath.
The **Stonechat** (Saltimpalo) uses larger areas, perhaps home-range is larger, but there are only very few territories in Modena – so presence of this species is more diffuse than in LARCH-results. They also use small road edges. In Bologna , the LARCH-resultsseem realistic.
Based on comments, and additional information from Luigi and Andrea, the LARCH modelling will be improved where necessary.

Solutions/measures:
Sabine shows the priority areas for Green lizard: area 1, 2 and 3.
(Marta) Area 1 in Modena, along the river, might be OK. The area might be widened to the North, in Modena. Also quality of habitat might be improved. Both areas inside and outside river dykes might be suitable. (Giuseppe) Along Canale collettore acquealte are good possibilities, good natural banks, rather wide.
The network is connected to Modena Province along the rivers. Along the river Reno is good grassland, also Samoggia is good. (Marta) an area in the north along the river (Reno?) is an area which can be flooded. Here it is not allowed to build houses etc. It is possible to contact farmers to have better grassland developed. (Theo: This could be integrated in a scheme to stimulate e.g. botanical grassland management).
Required habitat of good quality would be 50 ha (50% cc) upto 250 ha (10% cc). It might be that this quantity of habitat is available, so than no additional measures are required. (Marta) In Modena measures are required. It might be considered OK already, but better will be to have additional aims, e.g. to have fragmented populations up north improved and linked up along Canaletto Diversivo.

For the **Stonechat** (Saltimpalo): stronghold in the Apennines, important source area. The whole area forms one network, and perhaps one network with the Apennines. The population for the study area alone is not viable.
Three areas have been selected as priority area: near/west of Bologna, Middle of the area (near Piantate) and confluence of rivers in Modena.
An MVP might not be feasible, but a key-population perhaps is.

(Giuseppe): Bologna is difficult due to urban pressure. Samoggia, Lavigno, Gironda rivers are all possible. All are more or less equal. (Marta): measures for Modena: not per se through Bologna corridors, other rivers in Modena might be suitable source areas.
Also stepping stones, patches with grassland and shrubs, could be a possibility: they should be of moderate quality, higher than present habitat (cc 50 %), like botanical reserves.
Integration: Three areas are crucial: south, middle, north, in this priority.



The administrative boundary (Bologna/Modena) is a slight problem.

General recommendation: further research is required, on how **Stonechat**s do use isolated trees for corridors.

Final conclusions:
Green lizard
Maintain or improve habitat quality
Connect to river habitat
Improve habitat quality in area 1
Extend corridor to west (area 6)

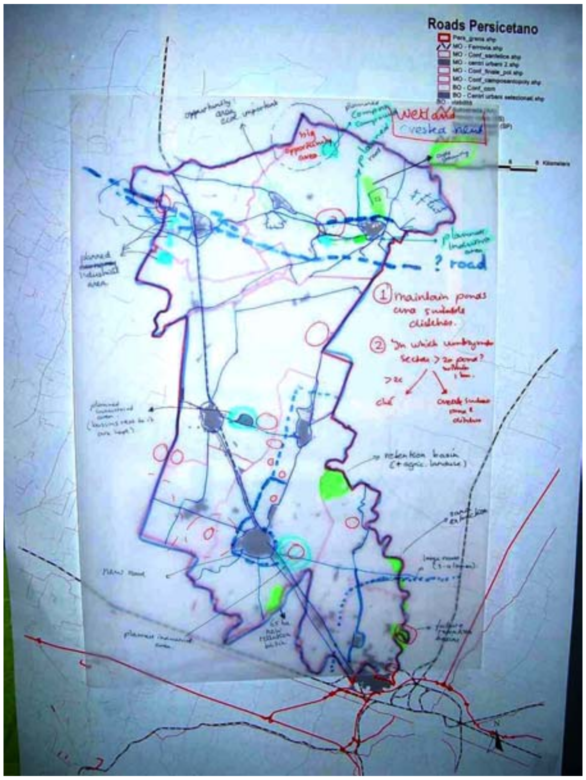
Stonechat
Area A, b, c, or d:
Improve habitat quality
Extend area
first priority
Stepping stones of good quality

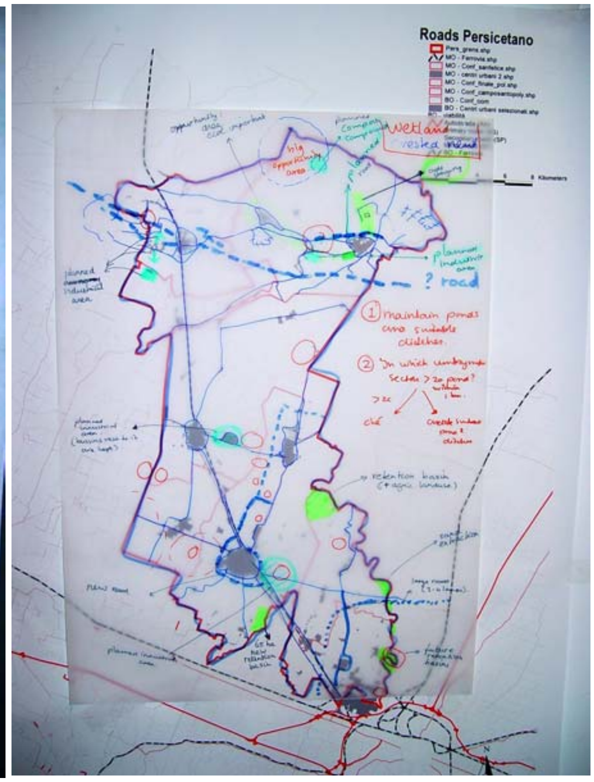
Priority order: from south to north

Wetlands

LARCH analysis: (Luigi) **Italian crested newt** are in two areas in Modena known for sure, but he never did a specific survey to assess situation. Luigi knows two areas for sure, he will check for other sites. For Bologna is indicated on the LARCH map where they are (handdrawn). Here the species in more places present. They also occur in small ponds with fish (but not fishponds).
Luigi: stay in water with stable water level, and smaller waters (ditches). *ALTERRA will do a new analysis based on the number of patches*, which is a different approach, better suited to these maps than the modelling the previous year.
(Andrea): **Large copper** is quite OK for Bologna. Also small ditches are used (Rumex). Even in intensive agricultural areas. Luigi has no data for this species, only vertebrates. Argellato is just outside the area, *check with Andrea if that is perhaps a source area*.
Do the Rumex grow all along the river? Check, also with Alessandro.
Based on comments, and additional information from Luigi and Andrea, the LARCH modelling will be improved where necessary.
For crested newt: check number of ponds within 1 km range of places that they are seen

For **Italian crested newt** (Tritone crestato) measures are confined to those areas where there are ponds/ditches, since the species is not mobile. Where populations are present, we suppose there are viable populations. Here populations might be extended, with more ponds. Species can disperse from here further into other areas with potential. Aim is to increase number of ponds up to 20, per sector (area). The barriers are often no real barrier, because the newts can cross the river. Recommendation: Eutrophic water is not good, mesothrophic might be OK. (Presence of Lemna minor is often the difference). Presence of aquatic vegetation is essential for crested newt. Prioritisation will be done later based on additional modelling result; map will be send still.





Final conclusions **Italian crested newt**:
Maintain ponds and suitable ditches
Find out in which unfragmented sectors more than 20 ponds/ditches are present, on less than 1 km distance from another
Find out in which unfragmented sectors potential is for more than 20 ponds/ditches are, on less than 1 km distance from another
(NB: on this map, also future opportunities for wetland developments are indicated)

For **Large copper** (Licena): try to improve three areas, by increasing habitat. Area 1 seems to be slightly better than 2. In particular if Argillato is included. Also 2 might be promising
Some areas seem to be missing in habitat modelling in Modena; this will be checked still. Adding some large patches might improve the population. Connect also to core areas just north of the study area. We can not further integrate the results for the two species at this moment.

General recommendation: a survey is required to confirm presence of Tritone crest.
Based on comments, and additional information from Luigi and Andrea, the LARCH modelling will be improved where necessary.

Final conclusions **Large copper**:
Area 1 Increase habitat quality + patch densening, connect with strong patches outside study area.

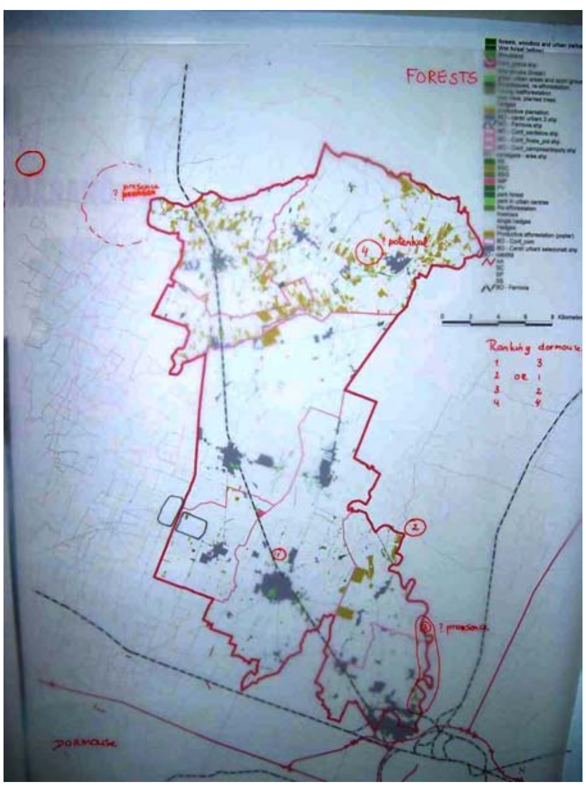
Area 2 Increase quality and add patches with high quality
Area 3 Check if animals are present. Increase quality and dense towards strong area outside study area

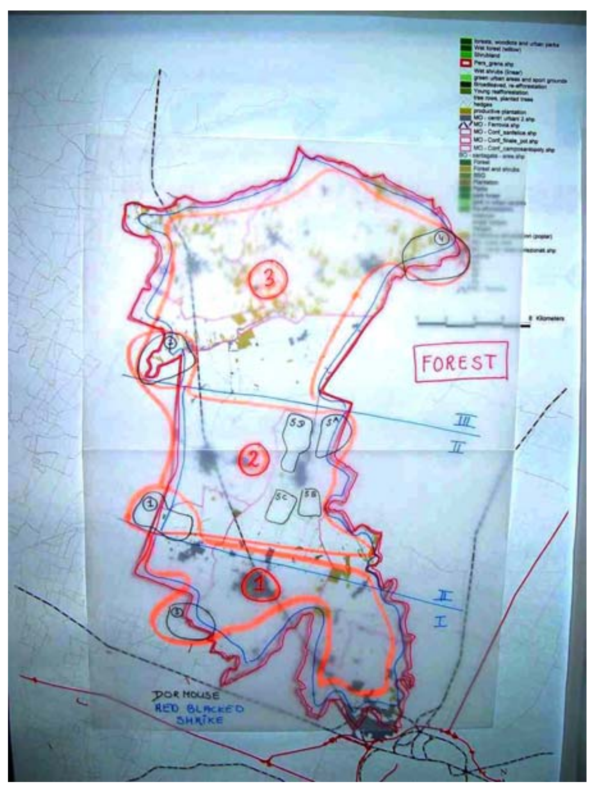
Forest

LARCH Results: No areas are large enough for **Dormouse** (Moscardino), based on LARCH analysis. Luigi confirms the habitat requirements for Moscardino in Modena: old forest, with a well developed understorey, or more recently planted forest with old nuclei. East of Finale Emilia is an old villa park where the species occurs. The Ghiro is also present in Argellato just outside the area, perhaps also the **Dormouse** is found there. In Bologna the **Dormouse** is found around the Bora visitor centre. In addition some forest along the river, e.g. along river Reno, are of importance.
The map 'Parco de villa' is important for old forest areas: Bologna\Boschi_parcivl.shp, this is only old forest.

Results for **Red-backed shrike**: low carrying capacity, but still some MVPs and key populations. The density in Bologna is lower than suggested in the results. This can be due to the use of parameters of the analysis in 2001, based on different maps. The LARCH-results of Modena seem ok. The species uses also orchards, organically cultivated, or grasslands with some shrubs. Results look reliable, but densities should be lowered in Bologna. Core area is found in the Apennines. Based on this additional information, the LARCH modelling will be improved.

Strategy for **Dormouse**: use existing populations, and expand from there with optimal forest. So small, local measures and habitat expansion. Corridors are for this species of little use, probably, since the species is very vulnerable for fragmentation and also the habitat quality is crucial.





Ranking areas for "**Dormouse**": 1, 2, 3, 4 or: 3, 1, 2, 4

Strategy for red-backed shrike: three zones can be identified, perpendicular to the Apennines; here we might densify the habitat, to a level of key population.

It is decided now that at this stage we can not integrate results and opportunities.

For some species habitat improvement is the most important strategy.

Annex 3 Minimum requirements fauna corridors

Source: Broekmeyer & Steingröver, 2001. Figures were developed for the Dutch situation.

Ecoprofile	Width dispersal corridor	Minimum width corridor	Explanation
Amphibians			
All ecoprofiles	25 m	15 m	- Wet corridors: width equals width of watercourse, including banks and minimal 5 m wide dry strips on both sides - Dry corridors: minimal width 15 m
Reptiles			
Adder Smooth snake Slow worm Common lizard	25 m	15 m	
Grass snake	25 m	15 m	- Wet corridors: width equals width of watercourse, including banks and minimal 5 m wide dry strips on both sides - Dry corridors: minimal width 15 m
Mammals			
European harvest mouse	25 m		
Tundra vole European water shrew	25 m		-width of a combined wet-dry corridor equals width of watercourse, including banks and minimal 5 m wide dry strips on both sides
Beaver Otter	50 m	Watercourse + 5 m on both sides	-width of a combined wet-dry corridor equals width of watercourse, including banks and minimal 5 m wide dry strips on both sides
Squirrel	25 m	15 m	
Pine marten Badger Red deer	 100 m 1000 m	 50 m 200 m	
Butterflies			
All ecoprofiles that are sensitive for barriers	25 m	15 m	

Stepping stones
First you have to wonder if the species you are aiming at use stepping stones? Most flying species (e.g. butterflies and birds) or species with a large dispersal capacity (e.g. pine marten, roe deer) do.

Guideline area stepping stones: 10% of key area (and not less then 1 ha).