Corridors for LIFE

Ecological Network Analysis Regione Emilia-Romagna - the plains of Provincia di Modena & Bologna

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ABSTRACT

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This report gives the result of an analysis of the ecological network, designed for the agricultural plains of Provincia di Modena and Provincia di Bologna. Three ecosystem types were selected: woodland, wetland, and grassland. Species were selected which can be considered representative for these ecosystems. The model LARCH was used to assess whether these ecosystems still function as an ecological network.
We found that the Region has a serious fragmentation problem. After implementation of the ecological network the situation would improve much. Larger areas for nature rehabilitation would further improve the functioning of the ecological network.

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

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Preface

Regione Emilia-Romagna has commissioned a study, to analyse the ecological network for the agricultural plains of Provincia di Modena and Provincia di Bologna. The set-up of the research follows the outline, as given in the project proposal and inception report, which was discussed with the Steering Committee from Emilia-Romagna.

The Steering Committee consists of:

Alessandro Alessandrini	(Regione Emilia-Romagna)
Willer Simonati	(Regione Emilia-Romagna)
Roberto Ori	(Provincia di Modena)
Giuseppe de Togni	(Provincia di Bologna)
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 Dott. Allessandro Alessandrini, who was helpful at many stages in the project, Giuseppe Togni, who contributed to the report as well and Luigi Sala and Andrea Moris who added useful data on the ecology of species, Marta Guidi, and Mauro Ferri for their comments on the draft report.
Furthermore, we wish to thank all other experts that contributed to the meetings and the field visit in the area.

Finally we wish to thank Roberto Rossi, Regione Toscana, for his contribution to the report, as well as the LIFE-Econet team UK (Ian Marshall and Gloria Pungetti).

Pict. 1: Old farmyard at San Giovanni in Persiceto. Such woodlots form important habitat in the study area

Pict. 2: Old rice fields, recently developed as wetland. Near Neville river, Bologna

Summary

Biological diversity is highly dependent on the quality, quantity and spatial cohesion of natural areas. Fragmentation of natural habitats severely affects the abundance of species. An answer to this problem is the development of ecological networks, linking nature reserves by means of corridors and small habitat patches.

Development of ecological networks is part of European policy (Bern Convention, Habitat Directive, Natura 2000) and resulted in the development of the Pan European Ecological Network PEEN.

This report gives the result of an analysis of the ecological network designed for the agricultural plains of Provincia di Modena and Provincia di Bologna. Aim of this analysis is (1) to identify the functional ecological network at present, and (2) to assess whether the designed ecological network will result in an improvement of the present situation, and (3) to identify opportunities to optimise the ecological network.

When natural habitat becomes fragmented as a result of landscape changes, small isolated patches often are too small to sustain viable populations. These small, local populations are always at risk to go extinct, due to local 'disasters', e.g. fire, pollution, or other catastrophes. Also, breeding results of populations of few individuals might fail. When these local populations are connected in an ecological network, the total area of habitat patches can offer possibilities for more persistent populations of species. A population is considered persistent if the chances of extinction are less than 5% in 100 years.

The landscape-ecological model LARCH was used to assess the ecological networks under the present situation and a development scenario. 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 2). For these species was assessed whether the ecosystem still functions as an ecological network. This is only partly the case: many species suffer from incomplete habitat networks.

Next, the functioning of the designed ecological network is assessed. The designed scenario is based on the ecological network as designed by the Provinces and developments that are expected or might be realised in due time. The scenario is drafted by ALTERRA, with feedback from the steering committee.
The backbone for this scenario forms the hydrographic system that forms the main corridors. In addition, east-west corridors were proposed as well.

In the scenario, areas are withdrawn from agriculture for nature rehabilitation, to increase the connectivity of the landscape. This results in an increase of habitat by 2917 ha, mainly based on floodplains which are converted into wetlands and woodland.

The scenario has a relatively large impact on the woodland ecosystems. Under the defined scenario total woodland habitat increases by 40% up to 8180 ha. In the new situation species dependent on woodland habitat are still limited due to lack of habitat.
As a result of the proposed scenario the fragmentation of woodland areas has decreased much, which is shown by the many areas linked to the network. However, there are still some areas isolated, allowing for local populations, esp. in Bologna Province.

For marshland the development scenario results in better spatial cohesion. Only few smaller areas do not form part of the ecological network. Large differences occur for the species analysed. For the *Italian crested newt* the number of local populations has decreased by 50% which merge into a more stable Minimum viable population. The population is persistent, both at present and after implementation of the development scenario.

For the *Bittern*, lack of extended marshland habitat is currently the main bottleneck.
Fragmentation is less of a problem for this species, owing to its large dispersal distance. In this scenario persistence improves much. Still the population is depending on immigration from other areas.
The results underpin that considerable efforts have to be made to improve substantially the situation for the *large marsh herons* in this area.

The *Stonechat* and *Yellow wagtail* differ in response to the new scenario. The *Stonechat* shows locally an improvement. Spatial cohesion has improved, as has the quantity of available habitat. Since sowed fields form part of the habitat, increase in habitat (just some 10%) and improved spatial cohesion still doesn't bring the species above the threshold level, for a minimum viable population.
The *Yellow wagtail* seemed already quite stable, and this does not change much with new developed habitat.

One of the main conclusions is that habitat requirements for most selected species are high. With realisation of the scenario, some species will still be under threat, despite the ambitious scenario.

This shows that the Region has a serious fragmentation problem. Obviously, the 5% of areas remaining with natural habitat (par. 3.1) is too little for many species at present, and efforts should be concentrated on increasing core areas for woodland and marshlands, and extensification of some meadows to create more natural grasslands. It is therefore recommended to implement the defined scenario to improve the situation for most species! The corridors should be realised as planned at present, whereby the dimensions should be considered to be the minimum of what is required. Priority should be given to the main corridors (north-south). The transversal (east-west) corridors are of lower importance but would definitely improve the cohesion of the network.

For some wetland species and woodland species, there is definitely a need for large core areas to be developed, to improve the situation. These areas should be located near other large areas. Corridors and some woodland areas should be strategically located between reserves in Bologna and Modena. New woodlands might be located near the woodlands already planted in Modena.

Marshlands would be required for persistent populations of large marsh herons, these should be located near the Po River or Campotto.

The (natural) grassland habitat as observed in the area is of high quality and very important for species dependent on field margins or roadside verges. In addition also sowed fields (grasslands) might be utilised, here not so much the quantity, but the quality seems a limitation. Management should be directed towards optimal conditions for the flora and insect fauna. This will benefit much of the bird populations studied in this analysis. One of the measures therefore might be improvement of extensive agricultural management. Also extensive grazing of wet open areas around marshlands could restore favourable conditions for species like the *Stonechat* and *Red-backed shrike.*

The study in Emilia-Romagna should be seen as a basis, an ‘exercise’ to assess the ecological network. It shows the possibilities for developments, it presents ideas and we think it forms a good basis for further development of the ecological network.
Furthermore, this research increases knowledge of Conservation Biology and land use planning, and might result in ideas for future developments.

The scenario which was drafted here is ambitious (almost 3000 ha set aside for nature rehabilitation), and at the same time it is still realistic, it can be realised by a committed government.

Pict. 3: Treefrog (Hyla italica, Raganella Italica)

Riassunto

La diversità biologica dipende fortemente dalla qualità, dalla quantità e dalla coesione delle aree naturali. La frammentazione degli habitat naturali influisce in modo severo sull'abbondanza delle specie. Una risposta a questo problema è la realizzazione di reti ecologiche, che colleghino le riserve naturali con corridoi e piccole "chiazze" (*patches*) di habitat.

La realizzazione di tali reti ecologiche fa parte della politica dell'Unione Europe (Convenzione di Berna, Direttiva Habitat, rete Natura 2000) che è culminata nella formazione della Rete Ecologica PanEuropea (*Pan European Ecological Network* PEEN).
In questa relazione sono riportati i risultati dell'analisi di un progetto di rete ecologica per le pianure agricole delle province di Modena e Bologna. Gli obiettivi dell'analisi sono: 1) individuare la rete ecologica funzionale attuale, 2) valutare se la rete ecologica progettata porterebbe a un miglioramento della situazione attuale e 3) individuare le possibilità di ottimizzazione della rete.

Con l'aumentare della frammentazione del paesaggio i cambiamenti che si verificano nel paesaggio fanno sì che le chiazze isolate spesso sono troppo piccole per sostenere popolazioni vitali. Queste piccole popolazioni locali sono sempre a rischio d'estinzione in seguito a 'disastri' locali, dovuti, ad esempio, al fuoco. all'inquinamento o ad altri motivi di disturbo. Inoltre una popolazione di pochi individui può non avere risultati positivi nella riproduzione. Quando queste piccole popolazioni sono messe in contatto tramite una rete ecologica, invece, la superficie complessiva delle chiazze di habitat può offrire le necessarie possibilità per popolazioni più "durevoli" (*persistent*) di specie (tavola 2). Una popolazione è considerata durevole se le possibilità di estinzione entro 100 anni sono inferiori al 5%.

Il modello matematico LARCH, che è un modello di analisi ecopaesistic (*landscape-ecological*, relativo alla "ecologia del paesaggio"), è stato impiegato per valutare la rete ecologica nelle condizioni attuali e in quelle previste nello scenario di sviluppo. Il modello LARCH fornisce informazioni sulla relazione tra distribuzione dell'habitat e popolazioni delle specie selvatiche e sulla sostenibilità di queste.

Sono stati scelti i tre tipi di ecosistema che coprono i più importanti tipi di habitat naturale nell'area di studio: le aree boscate, le aree umide e i pascoli. Al fine di valutare se questi tipi di ecosistema possono essere funzionali a determinate specie selvatiche, sono state considerate quelle ritenute rappresentative di tali ecosistemi. Per quest'ultime, quindi, è stato valutato se l'ecosistema svolgesse ancora un ruolo funzionale come rete ecologica. Quest'ultimo caso però si verifica solo in parte: le reti di habitat infatti risultano incomplete per molte specie.

Successivamente è stata valutata la funzionalità della rete ecologica progettata. Lo scenario definito si è basato sulla rete progettata dalle due Province e sugli sviluppi

prevedibili o che potrebbero verificarsi in un adeguato periodo di tempo. Lo scenario è stato delineato dall'istituto ALTERRA, sulla base delle indicazioni del comitato tecnico di coordinamento (*steering committee*). La struttura portante di questo scenario è rappresentato dalla rete idrografica, che costituisce i principali 'corridoi' (*corridors*). Oltre a questi sono stati proposti ulteriori corridoi trasversali, in direzione est-ovest. Allo scopo di aumentare la 'connettività' (*connectivity*) del paesaggio, lo scenario comprende anche il ritiro dalla produzione di superfici agricole per destinarle a interventi rinaturalizzazione (*nature rehabilitation*). Quest'operazione produce un aumento di habitat di 2.917 ettari (tavola 17), soprattutto derivante dalla trasformazione dei terreni alluvionali in aree umide e boschi.

Lo scenario determina un cambiamento piuttosto grande sugli ecosistemi forestali. Esso infatti prevede un aumento di habitat forestali del 40%, ottenendo una superficie complessiva di 8.180 ettari. Anche nella nuova situazione così definita, però, gli habitat forestali continuano ad essere insufficienti per le specie da essi dipendenti.

La frammentazione delle aree boscate diminuisce molto, come mostrano le molte aree connesse nella rete proposta. Continuano a rimanere, comunque, alcune aree isolate, che possono sostenere popolazioni locali, in particolare nella provincia di Bologna.

Per le aree umide lo scenario determina una migliore coesione spaziale. Solo poche aree minori, infati, rimangono isolate rispetto alla rete ecologica. Per le specie analizzate si determinano situazioni molto diverse. Per il Tritone crestato italiano (*Italian crested newt*) il numero di popolazioni locali si riduce della metà. La popolazione è durevole sia attualmente che nello scenario proposto.

Per il Tarabuso (*Bittern*) il problema principale attualmente è la mancanza di un habitat palustre sufficientemente eteso. La frammentazione rappresenta un problema minore, dato che il Tarabuso ha una grande ampiezza di 'dispersione' (*dispersal*). Nello scenario la durevolezza (*persistence*) aumenta molto. Nonostante ciò, la popolazione dipende dall'immigrazione da altre aree.

I risultati dell'ao studio mostrano che per migliorare la situazione per i grandi aironi di palude (Tarabuso, Egretta, Airone rosso, ecc.) in quest'area è necessario effettuare uno sforzo considerevole.

Le risposte al nuovo scenario da parte del Saltimpalo (*Stonechat*) e della Cutrettola (*Yellow watgail*) sono molto diverse. Il Saltimpalo mostra localmente un miglioramento. E' migliorata la coesione spaziale così come è aumentata la quantità di habitat disponibile, dato che l'habitat è in parte costituito da campi seminati. Nonostante l'aumento di habitat (del 10% circa) e la migliore coesione spaziale, la specie non supera il livello soglia per populazione durevole.

La Cutrettola appare già abbastanza stabile e non gode di grandi cambiamenti con il nuovo habitat previsto.

Una delle principali conclusioni dello studio è che per la maggior parte delle specie scelte la richiesta di habitat è grande. Con la realizzazione del nuovo scenario, nonostante le sue ambizioni, alcune specie resteranno sempre minacciate. Ciò dimostra che l'intera regione ha grossi problemi di frammentazione. E' evidente che il 5% di aree ancora con habitat naturali (paragrafo 3.1) è attualmente troppo poco per molte specie. E' necessario concentrare gli sforzi sull'aumento delle 'aree nucleo' (*core areas*) con aree boscate e aree umide e all'uso più estensivo di alcuni prati per creare nuovi pascoli naturali. Per migliorare la situazione della maggior parte delle specie, pertanto, si raccomanda di realizzare lo scenario definito. I corridoio devono essere realizzati così come previsto nel progetto. Deve essere data priorità ai corridoi principali (nord-sud). Quelli trasversali (est-ovest) sono meno importanti, anche se indubbiamente contribuiscono a migliorare la coesione della rete.

Per migliorare la situazione di alcune specie delle aree umide e delle aree boscate è senza dubbio necessario realizzare aree nucleo più grandi. Queste devono essere localizzate vicino ad altre grandi aree. I corridoi e alcune aree boscate devono essere localizzate strategicamente tra le riserve delle province di Bologna e Modena.

Per ottenere popolazioni più durevoli di grandi aironi delle paludi sono necessarie aree umide, che devono essere localizzate nei pressi del Fiume Po e di Campotto.

Gli habitat dei pascoli osservati nell'area sono di elevata qualità ed essi sono molto importanti per le specie dipendenti dai margini dei campi o dai bordi delle strade. In piu anche seminativi sono inclusi in questo tipo di habitat. Per questi, non è tanto la quantità, infatti, a rappresentare un problema, ma la loro qualità. La loro gestione deve essere indirizzata a migliorare al massimo le condizioni per la flora e per gli insetti. Ciò gioverà per molte delle popolazioni di uccelli studiate. Una delle misure da adottare potrebbe essere il miglioramento della gestione estensiva delle aree agricole. Anche il pascolamento estensivo delle aree aperte umide intorno alle zone palustri può ristabilire condizioni favorevoli per specie come il Saltinpalo e l'Averla piccola (*Red-backed shike*).

Questo studio effettuato in Emilia Romagna va visto come una base, una "esercitazione" per valutare la rete ecologica. Esso mostra le possibilità di sviluppo, formula idee e, crediamo, costituisce una buona base di partenza per un ulteriore sviluppo della rete ecologica.

Inoltre, questa ricerca costituisce un contributo alle conoscenze della biologia della conservazione e della pianificazione dell'uso del suolo e, in fine, può dischiudere idee per prossime possibilità di sviluppo.

Lo scenario che è stato delineato nello studio è ambiziooso (quasi 3.000 ettari ritirati dalla produzione a fini naturalistici) e, nello stesso tempo, esso è ancora realistico, potendo essere realizzato con il coinvolgimento partecipe dell'amministrazione.

Pict. 4: Old hedgerows, Northwestern part of Modena

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. 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, and recommendations based on these results.

Chapter 2 gives a short description of the area, as well as the research question and some more explanation on the problem of fragmentation.
Chapter 3 describes the method that has been applied, more specifically the model LARCH, and all choices that were made, especially regarding the selected species, in discussion with the Steering Committee.
In chapter 4 we discuss the input data, the land use map which is very important for the final results. The ecological network as it is planned by the Regione Emilia-Romagna, and based on that the scenario that has been developed is presented in chapter 5. The results are presented in chapter 6, this is followed by chapter 7 with discussion of the results, recommendations (chapter 8), conclusions (chapter 9), and recommendations for further research (chapter 10).

An explanation of terms frequently used in this report is found in paragraph 2.3.

Pict. 5: New planted woodrows and grass strips along dithches, near Riolo, Modena (control area 3)

2 Problem definition

2.1 Study area: Plains area Provincia di Bologna e Modena

The study area is the agricultural plains area of the provinces of Bologna and Modena, Regione Emilia-Romagna, northern Italy (fig. 1). The area analysed measures some 3880 km^2. Included in the analyses are some areas situated in Provincia di Ferrara: Cassa Campotto and Panfilia. On the south side the area is limited by the contour line of 110-m. ASL.

The Plains area is located at the foothills of the Apennines, in the South. The agricultural plains form an intensively used agricultural landscape with a high grade of urbanisation, especially around major towns like Bologna and Modena and the Via Emilia. Except for agricultural functions (including horticulture, orchards etceteras) also industry and other services are of importance for this flourishing region in Italy.
The intensive land use has resulted in a loss of biodiversity, and a decline in distribution of many organisms.

The provinces of Bologna and Modena in Regione Emilia-Romagna have developed a plan for an ecological network, meant to improve biodiversity in the region and increase the value and functionality of the landscape (Romano 1996, 2000). The network is currently worked out in more detail, and pilot projects to work out the concept for some areas have started.

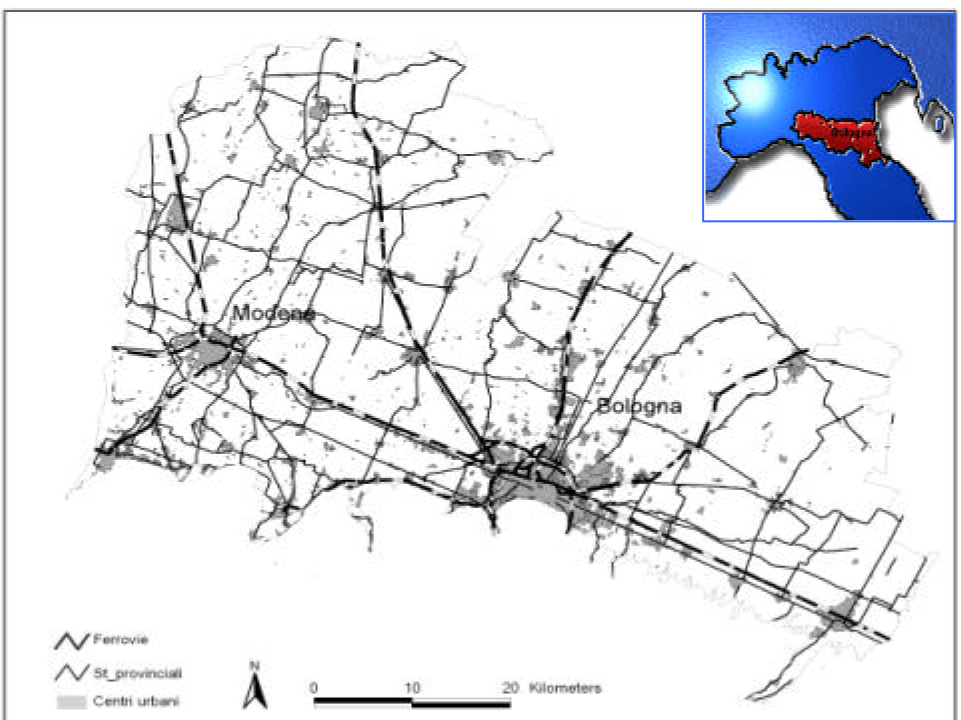

Fig 1. Location of the study area

2.2 Research question

Regione Emilia-Romagna has requested ALTERRA to analyse the proposed ecological network for the agricultural plains area of Provincia di Modena and Bologna. Aim of this study, as formulated by the Steering Group, is to identify

- what the functional ecological network at present is, and
- to assess if planned corridors and core areas will form a coherent network
- to identify which faunal species will benefit from this ecological network
- to assess if more corridors -other then currently planned- are required
- where new additional core areas are required.

2.3 Definitions of terms

carrying capacity: the maximum population of a species that a specific ecosystem can support indefinitely without deterioration of the character and quality of the resource, i.e., vegetation or soil
ecological network: network constituted of physically separated habitat patches, for a population of a particular species or a set of species with similar requirements, that exchanges individuals by dispersal.
habitat: an area which can support living organisms for at least part of its life cycle
habitat patch: spatially defined area of habitat for a species
key population: a relatively large, local population in a network, which is persistent under the condition of one immigrant per generation
key patch: a patch with a carrying capacity large enough to sustain a key population, and close enough to other patches to receive, on average, one immigrant per generation
local population: small population of at least one pair, in one habitat patch, or more habitat patches within the home range of a species. A local population on its own is not large enough to be sustainable
metapopulation: a set of local populations in an ecological network, connected by inter-patch dispersal.
minimum key population size: a population size with a probability of exactly 95% to survive 100 years under the assumption of one immigrant per generation
Minimum Viable Population (MVP): a population with a probability of exactly 95% to survive 100 years under the assumption of zero immigration
persistent or viable population: a population with a probability of at least 95% to survive 100 years.
spatial cohesion: a relative measure that can visualise the weakest parts in the ecological network for a certain species
viable population: see persistent population

3 Analysis Method

3.1 Background: metapopulation theory

To define the ecological network function an analysis method has been developed based on the theory on metapopulations and ecological networks (see box 1). The metapopulation theory states that in fragmented landscapes populations of animal species do not live in a continuous habitat but in a network of habitat patches, which are mutually connected by dispersal movements (Levins 1970, Andrén 1994, Hanski & Gilpin 1997). Whether an ecological network can sustain a persistent population or not, depends on:

- characteristics of a species: habitat preference, home range, dispersal capacity, the amount, shape and area of habitat patches in a landscape,
- connectivity of the landscape, which defines how easily species can move to other habitat patches (spatial configuration of habitat patches).

The network function of a scenario / landscape can be tested on the basis of a number of species, which can be related to an ecosystem type.

Box 1: Concept of metapopulations and ecological networks

When natural habitat becomes fragmented as a result of landscape changes, small isolated patches often are too small to sustain viable populations. These small, local populations are always at risk to go extinct, due to local 'disasters' or stochastic processes, e.g. fire, pollution, or results from a storm. Also occasionally breeding results might fail, which might be disastrous with small populations of few individuals. So the small populations regularly go extinct. When these local populations are connected in an ecological network, the total area of habitat patches can offer possibilities for persistent populations of species.

Large populations with a very low probability of extinction, the so-called "key populations", constitute the strong parts in a metapopulation occupying an ecological network (Verboom *et al.* 2001). From these "key patches" a net flow of individuals to other habitat patches in an ecological network takes place. In this way in-migration occurs from key patches to local populations that went extinct. If there are many patches this process can result in an increased overall sustainability. We consider this as a metapopulation (Levins 1970, Andrén 1994). A metapopulation is sustainable if the chance to go extinct is less than 5% in 100 years (Shaffer 1994, Verboom *et al.* 2001).
Standards used to decide whether a metapopulation is sustainable or not are specific for each species. Small, short living species (for example insects) are more vulnerable and require more individuals for a persistent population than larger, long living species (like the beaver). For less mobile species habitat patches should be situated closer together to form part of a coherent ecological network. On the other hand, the area demands of e.g. insects for habitat are smaller.

3.2 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.

Both LARCH and LARCH-SCAN are used: LARCH provides information on habitat distribution in relation to wildlife populations, and sustainability of these populations. LARCH-SCAN assesses spatial cohesion of potential habitat, and provides best information on the best ecological corridors in the landscape, which is a crucial element of this project.

LARCH is run for the present situation and the development scenario, for the selected species. The model LARCH is run with land use maps provided by the Provinces of Bologna and Modena as input.

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.

In the following paragraphs is explained in more detail the functioning of LARCH.

3.2.1 LARCH

LARCH is designed as an expert system, used for scenario analysis and policy evaluation. The model has been fully described elsewhere (Foppen *et al.* 1999, Groot Bruinderink *et al.* in press, Chardon *et al.* 2001, Sluis & Chardon 2001, Verboom *et al.* 2001) and only major steps briefly will be dealt with here.

The principles of LARCH are simple: the size of a natural area 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. The size 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 map) and ecological standards or rules (e.g. dispersal distance, population density etc.). LARCH standards are based on literature and empirical studies and simulations with a dynamic population model, which were carried out over the past ten years (Foppen *et al*. 1999, Verboom *et al.* 2001, 1993, Vos *et al.* 2001, in press). Actual species distribution or abundance data are not required since the assessment is based on potentials for an ecological network of a species.

Below is described, step by step, how LARCH defines the habitat map, the ecological network and the viability of the network population:

- *Fusion into clusters of habitat sites determining the local populations*

Based on the vegetation map or habitat map (fig. 2a) is defined what relevant habitat is for the considered species. Based on the area and density of species it is defined what the carrying capacity is for each area or 'patch' (fig 2b). Suitable ecotopes that are located near to each other allow for movement of individuals on a daily basis, the so-called home range. A threshold value is used for the home range of each species. Such habitat patches are fused into a cluster and considered a local population (fig. 2c).

- *Determining the number of reproductive units (territories/families) that may exist in an area and determining key populations*

The size of the area must meet at least a certain minimum in order to hold a territory or a breeding pair (or a 'reproductive unit') (Fahrig, 2001). Habitat patches that, even after fusion, are not large enough according to the species-specific standard are not further regarded as a suitable habitat patch.
The areas that meet the standard 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 1) 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 in terms of so-called key populations. These are populations of a certain size *within a network*, that are large enough to cope with the majority of normal fluctuations that a population is faced with.
The number of breeding pairs for a key population should be big enough to survive the majority of normal number fluctuations a population is faced with. The probability of extinction for a key population within a network is less than 5% in 100 years, assuming there is an immigration of 1 or more 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 that display a sufficient level of exchange with each other belong to the same network. In most cases, a set of local populations will form a population network, which may render it sustainable. Therefore, the distances between the habitat sites are calculated. Sites located within a certain distance can be considered to belong to one network. A network is a number of 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).
Barriers, such as busy roads and channels with sheet-piled banks, may hinder the fusion of habitat sites into a cluster, or they may mean that certain sites cannot be included in the network, even though they are located within the network distance. This is particularly the case for less mobile species, such as certain mammals and amphibians, but less important for birds.

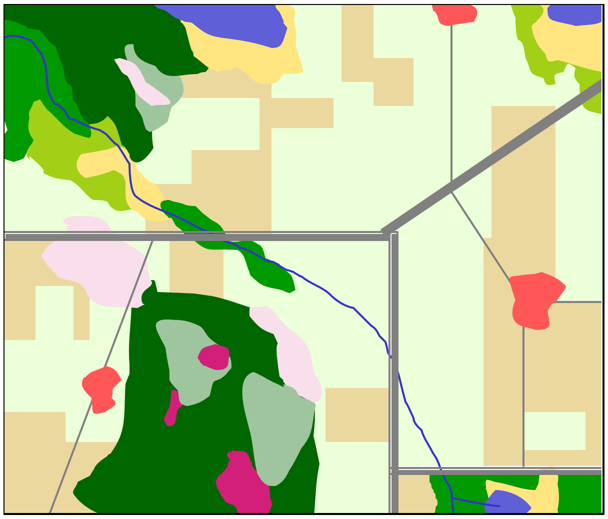

Fig. 2a: Input for LARCH is a vegetation or habitat map

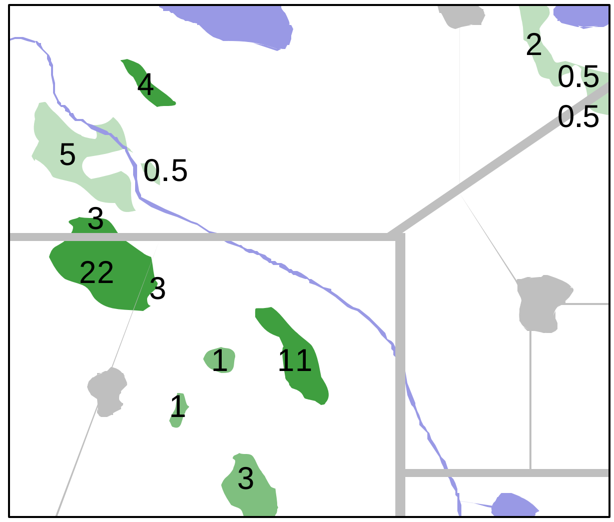

Fig. 2b: Assessment carrying capacity of suitable habitat

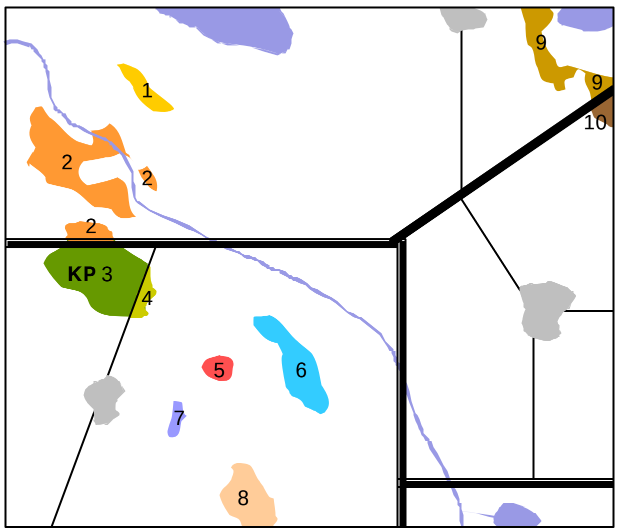

Fig. 2c: Identification of local populations and Keypatches (KP) based on carrying capacity

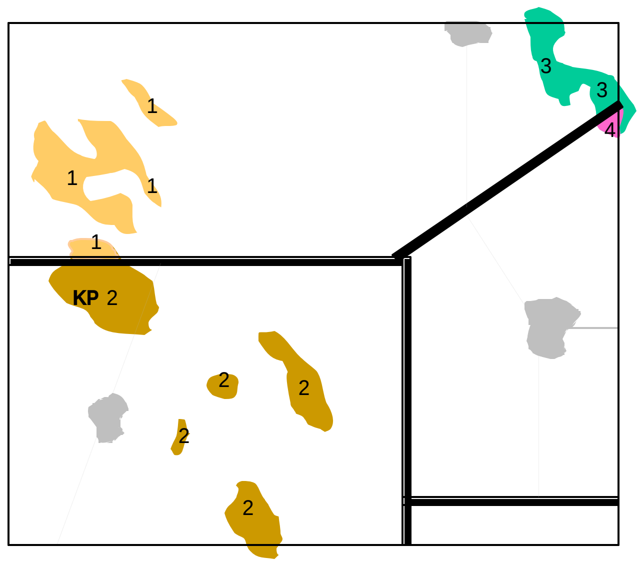

Fig. 2d: Identification of network populations

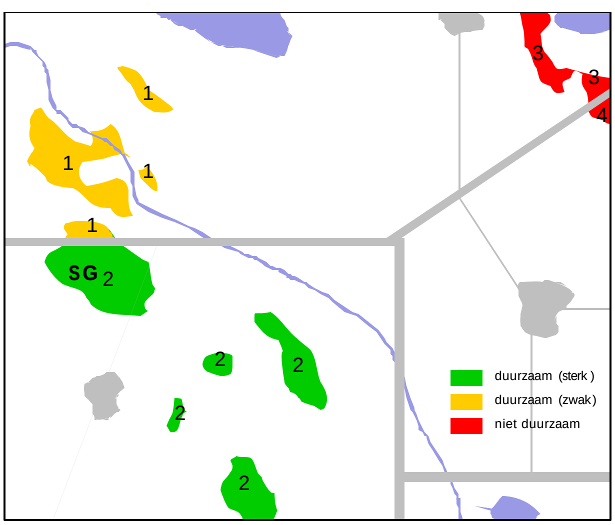

Fig. 2e: Viability assessment of network populations

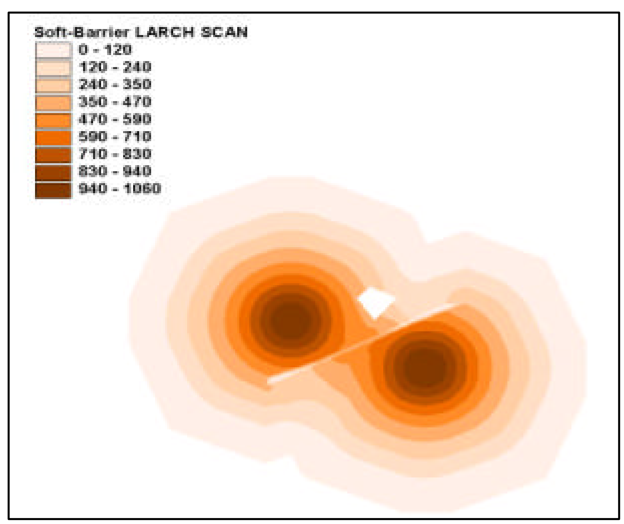

Fig. 2f: LARCH-SCAN analysis of spatial cohesion

Fig. 2: ***LARCH Network Assessment: fig. a to e indicate the steps taken in LARCH to come to a viabilty assessment on the basis of the habitat map, fig. f illustrates the spatial cohesion***

- *Determining the sustainability of the network*

In the final step the sustainability 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. 2e). In order to determine whether a certain landscape design causes problems for animal species, it is necessary to establish an assessment criterion. The criterion used is sustainability, i.e. the chances of a (network) population still existing after 100 years are greater than 95% (Shaffer 1981, Verboom *et al.* 1997, 2001). It is assumed that the area does not undergo any changes, or only slight changes, during this period of time. The lower the chances of survival, the more significant the problem, and the more reason to adjust the spatial planning so that the limit of 95% can (once again) be met. A network may or may not include key populations.
Concerning the sustainability of networks, either with or without key population, standards have been established in the form of the minimum required total surface area of all of the habitat sites within a network. This surface area 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.* 1997, 2001). A *Bittern* in a network with at least a key population for example, requires a total of 60 reproducing females for a sustainable (meta-) population.

3.2.2 LARCH-SCAN

Besides the surface area, also the connectivity or spatial cohesion is important (Verboom *et al.* 1991, Hanski 1994). The surface area determines the expected number of individuals in an area, while the connectivity primarily depends upon the dispersal capacity of a species. The dispersal distance of a Marsh grasshopper is much smaller than that of a large marshbird, such as the *Bittern*. In effect, this dispersal distance defines whether habitat patches will form part of a network for a species. A *Bittern* has advantage of marshland areas within a radius of 30-50 km, whereas an *Italian crested newt* has only advantage of habitat within a radius of 1000 m from breeding habitat.

LARCH-SCAN assesses the spatial cohesion of each habitat patch, using habitat features and dispersal characteristics (Foppen *et al.* 1999, Groot Bruinderink *et al.* in press, 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 1994). 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 image thus created, a 'spatial cohesion map' (fig. 2f), provides insight into the degree that areas are connected.
The analysis with LARCH forms the basis to determine whether available habitat is sufficient to maintain sustainable populations of a species. The spatial cohesion provides an idea of the potential of an area to function as a corridor for species. River regions in particular are extremely suitable for functioning as a corridor (Foppen *et al.* 1999, Sluis *et al.* 1999, 2001). This is obvious for aquatic organisms such as fish, but it is certainly important for birds and mammals as well.

In delineating habitat patches, effects of barriers (like roads) can be included. 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. Roads have not been taken into account here because most species chosen for this analysis are not very sensitive for barriers, and most data on traffic density is not available. However, the fragmentation effect of the motorway (autostrada) was included in the LARCH model.

Box 2: defining spatial cohesion in LARCH:
The probability that a dispersing individual will cover a certain distance d_{ij} is estimated as:

$$p(d_{ij}) = a \cdot e^{-a \cdot d_{ij}}$$

LARCH determines the connectivity SC_i of a habitat grid cell 'i' by weighting the carrying capacity of all grid cells within the potential dispersal distance:

$$SC_i = \sum RU_j \cdot e^{-a \cdot d_{ij}}$$

where:

SC_i	is a measure for connectivity of grid cell i
RU_j	is the maximum number of reproductive units RU in gridcell j (taking account of differences in carrying capacity between habitat types, and the effect of roads)
d_{ij}	is the distance between the contributing grid cell j and cell i, measured as the shortest distance between j and i, avoiding built-up areas.

3.3 Species selected for analysis

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 assess whether these ecosystem types might function as an ecological network, species were selected which can be considered representative for these ecosystems.

For each habitat type two species have been selected, i.e. in total six species. Six species are considered to give a representative result for the spatial cohesion of the ecological network.
To come to the selection of species, a stepwise approach was used.

Criteria were used to come to a first selection of species. The selection criteria are:

- presence in the area and relevance of species
- mobility of the species, and dispersal range
- preferred habitat type
- frequency of species (not too rare, not too common)

Based on these criteria a pre-selection has been made of species that might be analysed (table 1). An additional criterium was used: availability of ecological information on habitat requirements, dispersal characteristics etcetera. Based on the pre-selection (table 1), and discussions and recommendations from the Steering Group, we arrive at a selection of species (table 2). The species are ordered according to their dispersal capacity and mobility and sensitivity for fragmentation (flying species or not).

This list includes the *European polecat* as well as the *Italian crested newt* (Triturus carnifex) which were not modelled in LARCH as yet, but have been modelled for this purpose.

In fact, the *European polecat* does not meet the requirements as formulated above, since it is rare, also in this area. The species was included in this assessment on request of the Provinces, to assess potential available habitat for this species. In addition, also a preference to have a mammal species included in the analysis.

The selected species represent a range of dispersal capacities, from only few hundred meters (*Italian crested newt*) up to 50 kilometers (*Bittern*). The species also differ in sensitivity towards fragmentation. Two species are sensitive to barriers, the *Italian crested newt* and *European polecat*, whereas other species, will not be affected much by fragmentation effects resulting from infrastructure (roads, railways).

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.

Table 1 Pre-selection of species, for analysis with LARCH (proposal prepared by L. Sala, for the Working Group meeting on 3rd of May 2001

Habitat type	Group	Species	Nome Italiano	Latin name
Woodlands	MAMMALS	Hazel dormouse	Moscardino	*Muscardinus avellanarius*
		Badger	Tasso	*Meles meles*
		Roedeer	Capriolo	*Capreolus capreolus*
		European polecat	Puzzola	*Putorius putorius*
	BIRDS	*Red-backed shrike*	Averla piccola	*Lanius collurio*
		Green woodpacker	Picchio verde	*Picus viridis*
		Nuthatch	Picchio muratore	*Sitta euroapea*
		Hoopoe	Upupa	*Upupa epops*
		Golden oriole	Rigogolo	*Oriolus oriolus*
		Turtle dove	Tortora	*Streptopelia turtur*
		Buzzard	Poiana	*Buteo buteo*
		Sparrowhawk	Sparviere	*Accipiter nisus*
	AMFIBIANS	Italian agile frog	Rana agile	*Rana dalmatina*
		Treefrog	Raganella italiana	*Hyla intermedia*
	INSECTS	Lesser purple emperor	Apatura	*Apatura ilia*
Wetlands / marshland	MAMMALS	Harvest mouse	Topolino risaie	*Micromys minutus*
		European water vole	Arvicola d'acqua	*Arvicola terrestris*
	BIRDS	*Bittern*	Tarabuso	*Botaurus stellaris*
		Little *Bittern*	Tarabusino	*Ixobrychus minutus*
		Purple heron	Airone rosso	*Ardea purpurea*
		Marsh harrier	Falco palude	*Circus aeruginosus*
		Great reed warbler	Cannareccione	*Acrocephalus arundinaceus*
		Sedge warbler	Forapaglie	*Acrocephalus schoenobaenus*
		Reed bunting	Migliarino di palude	*Emberiza schoeniclus*
	FISH	Pike	Luccio	*Esox lucius*
		Tench	Tinca	*Tinca tinca*
		Three-spined stickleback	Spinarello	*Gasterosteus aculeatus*
		Spined loach	Cobite	*Cobitis taenia*
	AMPHIBIANS	*Italian crested newt*	Tritone crestato italiano	*Triturus carnifex*
	REPTILES	European pond terrapin	Testuggine palustre	*Emys orbicularis*
	INSECTS	Scarlet darter	Libellula rossa	*Crocothemis erythraea*
		Banded demoiselle	Damigella	*Calopteryx splendens*
Grassland	BIRDS	Skylark	Allodola	*Alauda arvensis*
		Yellow wagtail	Cutrettola	*Motacilla flava*
		Stonechat	Saltimpalo	*Saxicola torquata*
		Corn bunting	Strillozzo	*Emberiza calandra*
		Fan-tailed warbler	Beccamoschino	*Cisticola juncidis*
		Quail	Quaglia	*Coturnix coturnix*
		Grey partridge	Starna	*Perdix perdix*
		Lapwing	Pavoncella	*Vanellus vanellus*
	REPTILES	Green lizard	Ramarro	*Lacerta viridis*
	INSECTS	Southern festoon	Polissena	Zerinthia polyxena
		Large copper	Licena delle paludi	*Lycaena dispar*
		Orange tip	Antocaris	*Anthocharis cardamines*

Table 2 Selected species for analysis with LARCH; shaded are species sensitive for barriers

Dispersal capacity Habitat type	Barrier sensitivity	small range (0-10 km)	large range (10-50 km)
Woodland	sensitive		Puzzola/ *European polecat*
	not sensitive	Averla piccola/*Red-backed shrike*	*(alternative Tortora/Turtle dove)*
Wetlands/ marshland	sensitive	Tritone crestato italiano/ *Italian crested newt*	
	not sensitive	(*alternative Damigella/ Banded demoiselle)*	Tarrabuso/*Bittern*
Grassland	sensitive		
	not sensitive	Saltimpalo/*Stonechat*	Cutrettola/*Yellow wagtail* *(alternative quaglia/Quail)*

3.3.1 Woodlands

3.3.1.1 Red-backed shrike (Averla piccola)

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 & Blair 1997, pp 660).
The densities may reach more than 5000 bp/50 km. squares in Northern Italy, with an estimated number of 30000 breeding pairs for Lombardia (European Bird Database EBD).

The species has shown a serious decline in most of Europe, being some 20% in the period from 1970-1990 (Hagemeijer & Blair 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 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	+

3.3.1.2 Turtle dove (Tortora)

The *Turtle dove* (*Streptopelia turtur*) occurs in most of Europe, except for the northern countries. The *Turtle dove* inhabits areas of fragmented woodlands and shrubs (hedges, woodland fringes, orchards, wooded marshland, shrubby wasteland and macchia). It feeds on grains and seeds from agricultural land (Hagemeijer & Blair 1997).

The species has shown a serious decline in Northern Europe. In Southern Europe the population is considered stable (Hagemeijer & Blair 1997), but in Italy the species declines (Morisi, pers. comm.). The estimated population size is appr. 80,000. Causes

of decline are habitat destruction (esp. of hedges, which provide nesting), use of herbicides, and hunting pressure. However, land use changes as well as land degradation and droughts in the Sahelian wintering areas play a role too.
The selected habitat of the *Turtle dove* consists of:

Table 4 Relevant habitat types in the land use map for Turtle dove

Habitat type	Description	Importance
wetland	Zp	+
broad-leaved forest	Bl	++
wet forest	Bi	++
parks and playgrounds	Lv	+

3.3.1.3 European polecat (puzzola)

The *European polecat* (*Putorius putorius*) occurs all over Europe, including most of northern and central Italy (Mitchel Jones *et al.* 1999). It is a secretive animal, not really rare, but not much observed. Field data and scientific research on the *European polecat* is quite scarce, as are data on movements and home ranges.

The species frequents especially edge habitats: shores from rivers and lakes, dry ditches, hedges, forest and field edges (Broekhuizen *et al.* 1992). The species is quite versatile in its habitat choice (Weber 1987). No data is available yet on presence in the Regione Emilia-Romagna.

G. Muskens and S. Broekhuizen (ALTERRA) provided the ecological data for modelling. They base the habitat requirements (table 5) on expert judgement and several years of data collection on radio-collared specimens of the *European polecat* in the Netherlands, as well as a publication on the ecology of the *European polecat*, based on extensive fieldwork in Switzerland (Weber 1987).
The selected habitat of the *European polecat* consists of:

Table 5 Relevant habitat types in the land use map for European polecat

Habitat type	Description	Importance
water course	Al	++
water body	L	++
wetland (esp. edges)	Zp	++
broad-leaved & conifer forest	B	++
wet forest	Bi	+
forest plantation	Br	++
wet shrubbery	Ci	+
shrubbery	Zs	++
cultivated, orchard	Ct	+
cultivated, vineyard	Cv	+
cultivated, mixed orchard / vineyard	C	+
cultivated, specialized wood cultivation	Cp	+
urban parks, playground	Lv	+
meadow, wet meadow	Pp	+
railway and roads (verges)	Zf	+

3.3.2 Wetlands and marshland ecosystems

3.3.2.1 Italian crested newt (Tritone crestato italiano)

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 population of the species might consist of fragmented local populations (Bigazzi & Fellegara 1993). For Triturus cristatus maximum dispersal distances were measured up to 1490 m (Sluis *et al.* 1996).

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).

It is most found in aquatic habitat (Umidi, 90%), 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 a rich submerse aquatic vegetation (pict. 2 and 7). Its terrestrial habitat consists of meadows and forested areas, located near their reproduction areas (Giacoma 1988a, 1988b).

Some 7% of the observations occur in anthropogenic habitats, such as gardens, parks etcetera (Mazzotti *et al.* 1999), which is also known habitat for Triturus cristatus (Sluis *et al.* 1999).
The selected habitat for the *Italian crested newt* consists of:

Table 6 Relevant habitat types in the land use map for Italian crested newt

Habitat type	Description	Importance
waterbody	L	++
wetland	Zp	++
watercourse	Al	+
wet forest	Bl	+
wet shrubland	Cl	+

3.3.2.2 Bittern (tarabuso)

The *Bittern* breeds in most of Europe. It has a patchy distribution, with a preference for densely vegetated lowland marshes and dense reed areas (canneto). The bird is secretive and shy (Balletto 1998), which makes it difficult to have good species accounts (Hagemeijer & Blair 1997, pp 40).

The species occurs in wetlands, lakes, shores of lakes, large streams and retention basins. Required is the presence of a floating vegetation Brichetti 1992, Boano 1997). In all of Italy there are some 40-50 breeding pairs (Batten *et al.* 1990, Brichetti 1992). Due to drainage of wetlands and marshes the species has shown a serious decline in

Western Europe of appr. 50% (Hagemeijer & Blair 1997). Also in Emilia-Romagna the species is considered very vulnerable. The *Bittern* has shown a decline here of 20-49%, due to a change in reedlands area as a result of agriculture, different management, fires etc, and a change in the hydrological system. Water pollution causes less visibility of preys as well. The species is included in the red-list of Emilia (Gustin *et al.* 2001). In Piemonte and Tuscany, a slight increase occurs (Brichetti 1992).

In all of the Regione the population consists of some 10-20 birds, spread over the Province of Bologna, Modena, Ferrara and Ravenna.
The selected habitat of the *Bittern* consists of:

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

Habitat type	Description	Importance
waterbody	L	+
wetland	Zp	++
wet forest	Bl	+
wet shrubland	Cl	+

3.3.2.3 Banded demoiselle (damigella)

The *Banded demoiselle* (*Calopteryx splendens*) is locally common in suitable habitats. The flight period is May to August. The *Banded demoiselle* is found on rivers, streams and drains of moderate to slow-flow with beds of silt and marginal vegetation.
Its favoured habitat is unimproved rivers, particularly when meandering through meadowland.

This explains why the species is relatvely rare, since man has modified many river habitats.

Table 8 Relevant habitat types in the land use map for Banded demoiselle

Habitat type	Description	Importance
watercourse	Al	++
waterbody	L	++
wetland	Zp	+

3.3.3 Grassland ecosystems

3.3.3.1 Stonechat (Saltimpalo)

The *Stonechat* (*Saxicola torquata*) occurs in most of Central and South-eastern Europe (Hagemeijer & Blair 1997, pp. 528). 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 & Blair 1997).

The total population of *Stonechat* in Italy is estimated at some 2,500,000 birds. There has been a marked decline of the *Stonechat*, due to agricultural intensification and a decline in cereals, which are being replaced by maize.
The selected habitat of the *Stonechat* consists of:

Table 9 Relevant habitat types in the land use map for Stonechat

Habitat type	Description	Importance
wet shrubland	Cl	+
shrubbery	Zs	+
permanent grassland	Pp	+

3.3.3.2 Yellow wagtail (Cutrettola)

The *Yellow wagtail* (*Motacilla flava*) has a wide distribution over Europe (Hagemeijer & Blair 1997, pp 494) and prefers grasslands, especially wet grasslands. In general there has been a decline in numbers, which is probably a result of changing agricultural management practices and drainage of grasslands. In Italy the population consists of some 20.000-40.000 pairs (Brichetti & Meschini 1993).

Over the past years the species has showed an increase in arable fields. (In some parts of the Netherlands the species 95% of the *Yellow wagtail* bred on arable land, with densities locally as high as 12-36 breeding pairs/km^2!).

We assume that only part of the land is suitable, because it is less intensively used.
The selected habitat of the *Yellow wagtail* consists of:

Table 10 Relevant habitat types in the land use map for Yellow wagtail

Habitat type	Description	Importance
grassland	Pc	+
permanent meadow, wet meadow	Pp	++
sowed field	S	+

Pict. 6: Grapes, growing along trees

4 Basemaps

4.1 Land use map Bologna & Modena

The basis for the analysis with LARCH forms a habitat map or vegetation map (fig. 3). A land use map can be used, as long as the land use type can be linked to required habitat of a species.

An updated land use map has been provided by the Provinces (uso_p15,). The contents of the maps were briefly checked during a three-day field visit in Italy (par. 3.2).

The habitat types relevant for the analysis can be described as: ‘wetlands and streams’, ‘agricultural areas’ (meadow, orchards, sowed fields), and ‘woodland’ (forest, hedgerows, woodrows, and farmyards).

The land use map includes several relevant land use types (table 11):

Table 11 Land Use Types most used for habitat classification

Code	*Descrizione uso del suolo*	*Land use*
Al	Corsi d'acqua	Water course
L	Corpi d'acqua (laghi, bacini)	Waterbody (lakes, rivers)
Zp	Zone umide	Wetland zone
B	Formazioni boschive a prevalenza di latifoglie	Broadleaved forest
Bi	Boschi di tipo igrofilo	Wet forest
Br	Rimboschimenti recenti	Forest plantation
Ci	Cespuglieti igrofili con prevalenza di salici	Wet shrubbery, mainly willow
Iv	Zone verdi urbane e impianti sportivi	Urban parks, playground
Zs	Cespuglieti, arbusteti	Shrubbery
Pp	Prati stabili, prati umidi, prati con cespugli	Meadow, wet meadow, meadow with shrubs
C	Colture specializzate miste (frutteti e vigneti)	specialized cultures (orchards and vineyards
S	Seminativi	Sowed field

In table 12 the distribution and quantity of land use types occurring is presented. It is clear that the area is intensively used, with cultivated areas (mainly sowed fields, cultivated area) amounting up to 87%. Urban or similar habitats form some 8%, and natural habitats relevant for this analysis account only for some 5% of the total area (appr. 3% wetland and 2% woodland).

In the north-eastern corner in Ferrara province are important marshland areas (Campotto-Valle Santa) which are included in the analysis. Not taking such areas into account would underestimate the biodiversity and the potential networks in the region. Therefore this area will be accounted for in LARCH as well.
This area is labelled as wetland (Zp), with wet forest (Bi) around it, the area measures some 1900 ha.

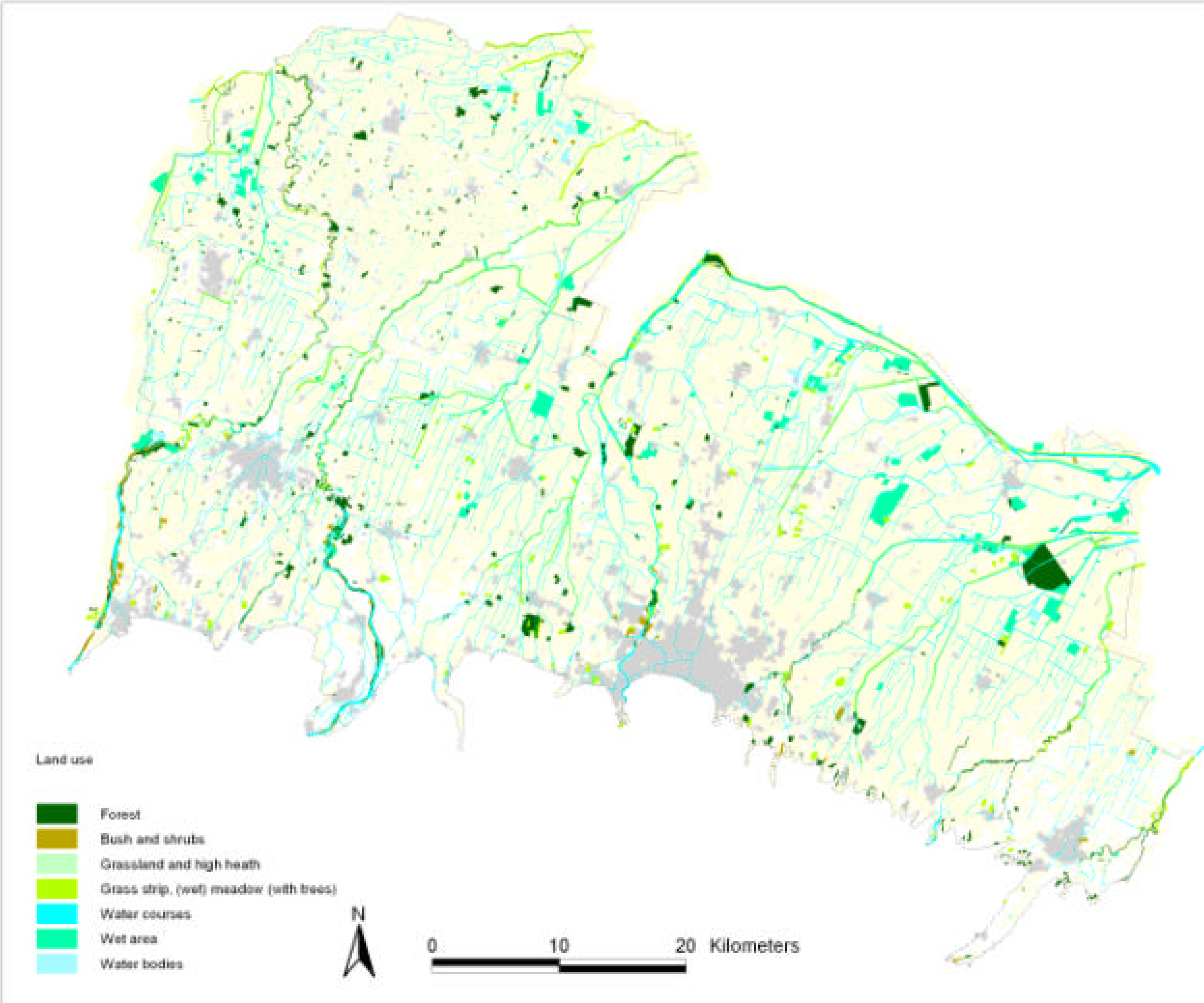

Fig. 3 Natural habitats in Bologna and Modena Provinces (based on Land Use map)

4.2 Field check on data

The quality of the analysis results is especially determined by the quality of the base maps and the parameters used for LARCH. It is important to know for the assessment of the ecological network whether e.g. all woodland patches have been mapped or not. To be able to assess the reliability of results, a check on the accuracy of the map was done.

For this check on the map, 4 sample areas were chosen at random, in areas with more natural habitat present (sample area 1 and 3) and in areas mainly consisting of agricultural lands (sample area 2 and 4). Sample areas are located in both Provinces (fig. 4):
San Giovanni in Persiceto - north (Bologna)
San Giovanni in Persiceto - south (Bologna)
Riolo (Modena)
Castelfranco Emilia (Modena)

Table 12 Total land cover and contents land use map

Code	Land use	No. polygons	Max area (ha)	Average area (ha)	Sum (ha)	% area
Al	Water course	31	3699	211	6769	1.7
L	Waterbody (lakes, rivers)	437	65	3.9	1673	0.4
Zp	Wetland zone	259	389	16.5	4264	1.1
B	Broad-leaved forest	681	65	3.2	2176	0.6
Bi	Wet forest	142	26	1.9	272	0.1
Br	Forest plantation	188	530	13.8	2601	0.7
Ci	Wet shrubbery, mainly willow	46	11	1.5	68	0.0
Zs	Shrubbery	140	45	6.0	854	0.2
Iv	Urban parks, playground	707	88	6.0	4256	1.1
Pp	Meadow or grassland	320	207	7.5	2390	0.6
S	Sowed field	1644	11885	146	239544	61.7
Cp	Cultivated, specialized wood cultivation	358	73	5.8	2068	0.5
Ct	Cultivated, orchard	338	653	23.0	7794	2.0
Cv	Cultivated, Vineyard	94	57	7.5	712	0.2
Ze	Heterogeneous agricultural area	33	115	16.4	541	0.1
C	Cultivated, mixed Orchard/vine	2239	1626	15.0	33565	8.6
O	Vegetable plots, plastic tunnels	79	38	6.8	535	0.1
R	Rice field	11	112	29.0	319	0.1
Za	Airport	8	199	30.3	243	0.1
Zf	Railway and roads	84	116	10.6	893	0.2
I	Urban zone	924	1247	18.2	16872	4.3
Zi	Industrial area	817	371	13.6	11099	2.9
Zc	Quarry, scrap yard	113	61	10.1	1144	0.3
Zr	Rocks	1	0	0.1	0	0.0
Zm	Not interpreted	20	42	9.4	188	0.0
	SUM	**9716**			**388039**	**100%**

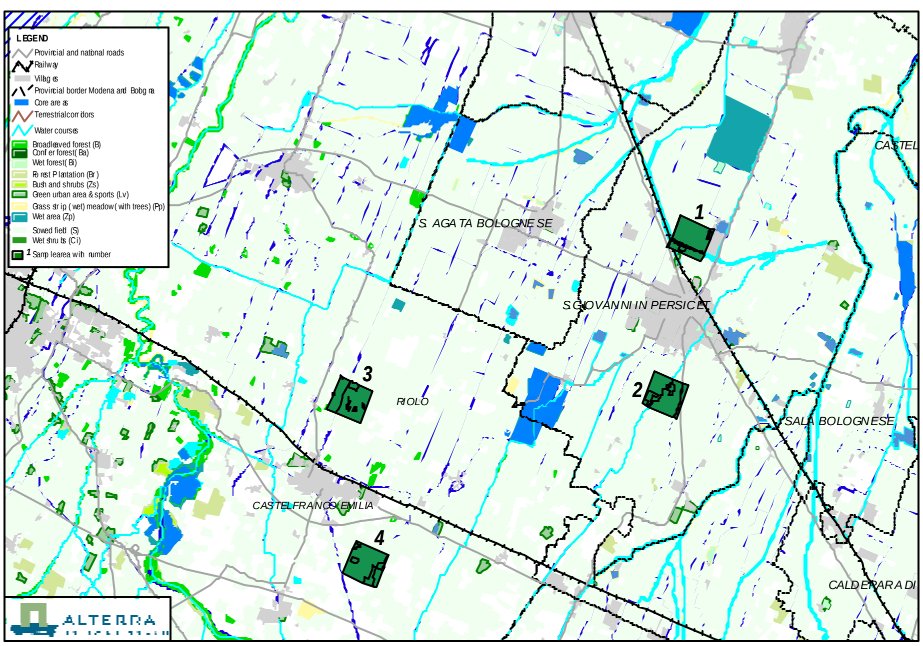

Fig 4 Location of the sample areas

The squares sampled are 1 by 1 km, i.e. 100 hectares each. For each square in the field, a general sketch map was made of land use in that square. A percentual sum of land use types, as well as the length of natural features (woodrows, hedges and ditches) was estimated.

In Arc-View was determined what the contents are of those control squares on the land use map. This information is confronted with the actual land use data as observed in the field.

The following tables (table 3-6) shows the difference in mapped habitat and observed habitat in the field.
Differences in cultivation pattern are of little interest for this study, therefore only the important differences occurring in natural habitats are described here.

The first sampled area (table 13) shows that results of mapping are quite accurate. Despite differences in detail visible on the sketch map prepared in the field, total areas do not differ much. It is mainly a difference in grasslands mapped as Sowed field, which results in a difference of 7 ha. or 7%.
Furthermore, there are some 2.5 km. ditches as well as a (fish?) pond that are not mapped, which seem to be in potential suitable for a species like the *Italian crested newt*.

Along the railway line a strip with wooded vegetation and herbs (4 m. wide) is not mapped. Also this will function as corridor for some species.

Table 13 Mapped versus observed land use; San Giovanni in Persiceto - north (Bologna)

Sample Area 1 Land Use	Map content (ha)	Observed (ha)
Broad-leaved forest	3.05	2
Cultivated area, orchard / grapes	1.89	-
Meadow, wet meadow	2.31	10
Sowed field	89.52	80
Industrial area	1.93	-
Wet zone	1.32	0.25
Built-up area	-	0.25
Water course	2434	-
Woodrow, hedge	-	-
Shallow ditch	-	-

The second area (table 14) shows a similar pattern; sowed fields forms almost 90% of land use, whereas in reality agriculture is more diverse, with orchards, horticulture and meadows.
For linear elements we see that some hedges were missed out. However, more watercourses were mapped in this case[1]. A fishpond is lacking in the map.

1 Some observations were done in the ditch by netting; this, however, yielded mainly some aquatic fauna and fish (Libellulae larvae, Dytiscus spec., Guppy (introduced, Gambusiaholbrooki), tubifex and *Acilius sulcatus*. These species indicate a partly disturbed situation, with water low in oxygen. No Triturus species were recorded.

In the field a hare (*Lepus europaeus*) was observed, and along the ditch Broad-bodied chaser (*Libellula depressa).*

Table 14 Mapped versus observed land use; San Giovanni in Persiceto - south (Bologna)

Sample Area 2 Land Use	Map content (ha)	Observed (ha)
Broad-leaved forest	1.72	0.25
Cultivated area, orchard/grapes	10.51	20
Meadow, wet meadow	-	20
Sowed field	87.80	40
Horticulture	-	20
Industrial area	-	-
Wet zone	-	0.25
Built-up area	-	-
Water course	2355 m	1000 m
Woodrow, hedge	-	1000 m
Shallow ditch	-	-

At Riolo (table 15) differences occur specifically in mapped sowed fields (too high) which are in fact partly meadows and horticultural areas. An electrical transformation station is present as well (industrial or built-up area?), which is not mapped. In fact, the area is vegetated with grasses and rough growth, and will form valuable habitat.

Hedges and shallow ditches were planted fairly recently, for that reason these might not have been included in the map (pict. 5). These hedges, and a pond with small woodland patches might form good examples for creating corridors!
The quality of the ditches is rather poor.

Table 15 Mapped versus observed land use; Riolo (Modena)

Sample Area 3 Land Use	Map content (ha)	Observed (ha)
Broad-leaved forest	3.00	5
Cultivated area, orchard/grapes	5.25	10
Meadow, wet meadow	-	16
Sowed field	91.03	55
Horticulture	-	10
Industrial area	-	3
Wet zone	-	1
Built-up area	-	-
Water course	2060 m	1000 m
Woodrow, hedge	-	1500 m
Shallow ditch		5000 m

The last sampled area show quite accurate mapping result (table 16). Also here some areas mapped as sowed field are in use as horticultural area or vineyards. Otherwise it corresponds well.

The woodrows were not mapped, and are to some extent of importance.

Table 16 Mapped versus observed land use; Castelfranco Emilia (Modena)

Sample Area 4 Land Use	Map content (ha)	Observed (ha)
Broad-leaved forest	-	3
Cultivated area, orchard/grapes	13.14	30
Meadow, wet meadow	-	-
Sowed field	86.17	60
Horticulture	-	10
Industrial area	-	-
Wet zone	-	-
Built-up area	-	-
Water course	1984 m	1000 m
Woodrow, hedge	-	1000 m

It is obvious that this visual assessment is just a rough indication of actual land use. The error in this assessment might be some 10-20% (estimated). However, the results give an indication of the coverage of the land use map. No check was done afterwards to see whether changes in land use, or whether errors in the control samples cause large differences.

In conclusion we see that the mapping is very reasonable. The area of sowed fields in general is too high due to horticultural areas, vineyards and meadows partly included in this unit.
Especially the meadows lacking might have effects on analysis results.

Linear features are not mapped, in most cases, except for grass strips, e.g. along dykes. Woodrows, hedges, ditches and so on are not included in the map. This gives an underestimate of the real situation in the field, for potential biodiversity and habitat present and for dispersal of migrating species.

The results in the more natural areas (sample area 1 and 3), i.e. the more complex land use patterns, give less satisfying results than the areas which are mainly in agricultural use (area 2 and 4).

5 Regional developments

5.1 Introduction

In this chapter the provincial plans for the ecological network are presented (par. 4.2, prepared by Arch. G. de Togni). ALTERRA designed a network, based on actual plans and some assumptions for requirements of species.
This designed network is further referred to as the 'development scenario'.

5.2 Planned ecological network

The provinces prepared a report on the design of the ecological network. Based on these features the design of the ecological network is drafted (fig. 5).
Two general choices were made for this design:
1. completing (quantitatively) and improving (qualitatively) the existing network along the direction North-South;
2. completing (quantitatively) the existing network in the East-West direction;

In both cases, corridors follow existing rivers, canals, wetlands, hedges etc. The elements of the ecological network have been classified as follows:

Core areas:
- *nodo complesso* (*complex core area*, "multifunctional, in ecological sense"): geographical area in which it is possible to find some core areas and corridors. Also areas for other uses or purposes, not immediately related to a natural rule (e.g. cultivated fields), are included within a complex core area;
- *nodo semplice* (*uncomplex core area*, "monofunctional"): elements basically isolated in respect of other similar elements;
- *nodo non funzionale* (*unfunctional core area*): too small element to be significant at a provincial level;
- *area di incremento dei nodi* (*core areas increase zone*): zones of both Provinces in which it is necessary to increase the number of core areas.

Corridors:
- *collegamenti* esistenti (*existing good quality corridors*): corridors related to existing rivers and canals, functioning like corridors already;
- *corridoi terrestri* (*terrestrial corridors*): existing corridors, consisting of edges of significant size;
- *direzione di collegamento* (*indicative "corridors"*): these just indicate directions of connection; it is still unknown what they are made of (wet or terrestrial corridors, a mix of them, stepping stones…), but they have been considered important to realise the Provincial ecological network (to "close" the meshes, or improve the spatial cohesion).

Criteria used to map core areas and corridors have been:

- core areas: area dimensions, proximity or distance between them, presence of corridors between them;
- corridors: linear elements, continuity or proximity to other or similar elements, to be situated between two core areas.

Besides, for all elements it has been checked what possible limiting factors are, based on the surroundings (e.g. towns and urban areas, productive areas, highways).

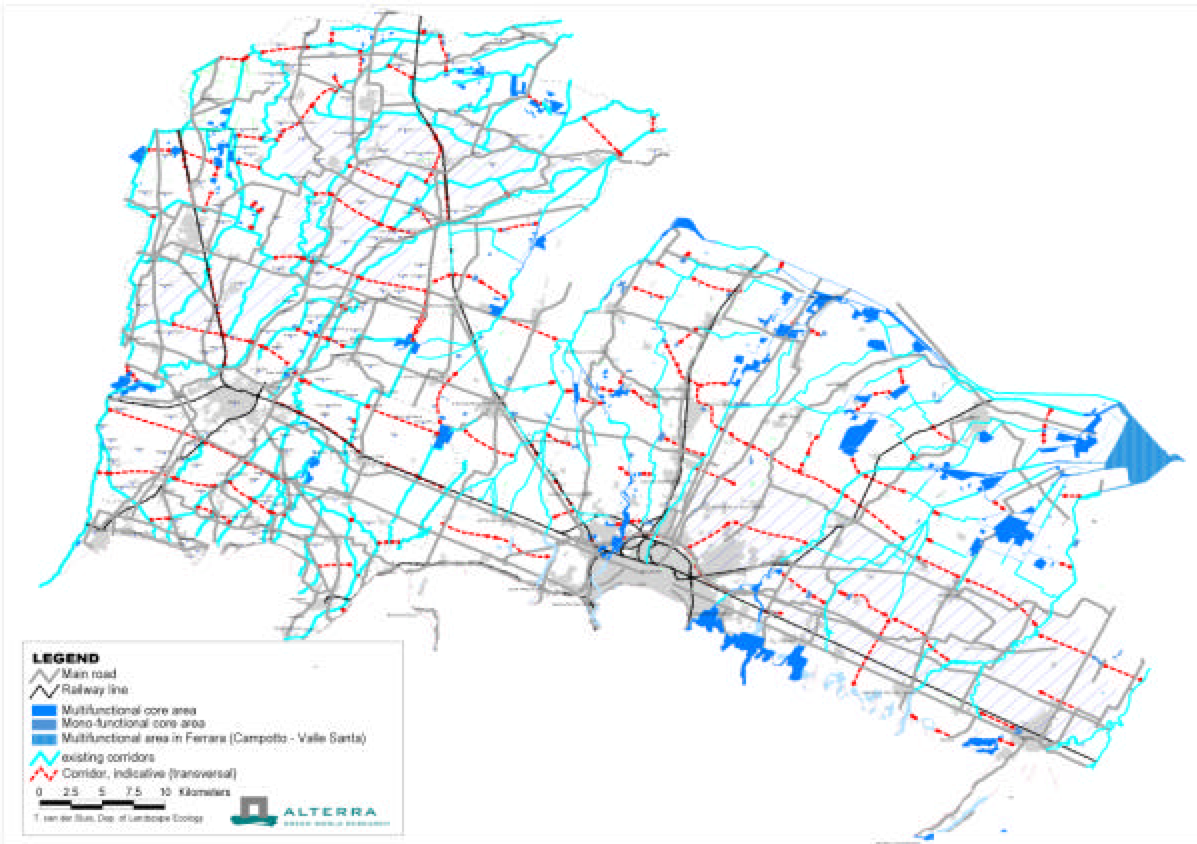

Fig. 5 Proposed ecological network

5.3 Scenario development

5.3.1 Introduction

The development scenario is based on the ecological network as planned by the Provinces and developments that are expected or might be realised in due time. The scenario is drafted by ALTERRA, with guidance of the steering committee.

The instructions from the Steering Committee with regard to the scenario development are as follows:

- ALTERRA will prepare a proposal for corridors, which have dimensions appropriate to allow for migration of species
- The areas within the embankments of the river might (partly) be zoned for nature rehabilitation; some areas have been indicated as planned water retention basin
- red lines on the map are indicative for the corridors; it is up to ALTERRA to propose how these corridors are designed and included in the scenario
- The scenario will be sent beforehand to the Regione, for their approval and comments

The water drainage system forms the backbone for this scenario i.e. approximately north south oriented lines formed by the rivers. This in fact gives the landscape its current appearance, it is the 'carrier' of the landscape (Pedroli 1999, 2000) and defines the presence of human habitation, but also nature present. Therefore rivers form a good basis for network design (Sluis *et al.* 1999, 2001).

We propose to include in the scenario additional areas to be withdrawn from agriculture for nature rehabilitation, to increase the connectivity of the landscape. During the field visit some of those areas that are considered for other developments (possible nature restoration or nature rehabilitation) were discussed.

5.3.2 Strategy scenario design

The scenario design is based on:

- planned ecological corridors
- nature rehabilitation areas

It is proposed that the ecological corridors follow the existing landscape pattern. This means that landscape elements present are strengthened, and landscape elements might be developed in line with existing structures, to improve the network and spatial cohesion.

North-south corridors that follow the drainage pattern, existing rivers and watercourses are clearly visible in the landscape (fig. 5). The woodrows and hedges (pict. 4) lining them accentuate existing landscape elements.

The transversal lines exist partly, as small drainage waters or ditches. They are currently not so clearly visible. We suggest here to improve or -partly- develop these corridors with more open vegetation, with rough growth, shrubs, etc. that might be developed along these lines. These might especially guide smaller species, often vulnerable for fragmentation (insects, amphibians, and mammals).

5.3.3 Design corridors

The main existing corridors are formed by the watercourses, rivers and streams, and should be strengthened. Ideally the corridor is formed by the river and is lined with woodrows, upgoing trees up to 10-15 m. high and some 6-m. wide, with undergrowth/shrubs on one side (fig. 6a, Cobelli *et al.* 2000). This 6-m. which forms the basis for this desingned scenario should be considered the absolute minimum required!

Within the river embankment areas woodrows can be located along the water. Where this is not possible, due to other forms of land use, the width of the floodplain or management requirements from the Water Boards, these woodrows should be realised outside the embankment areas.

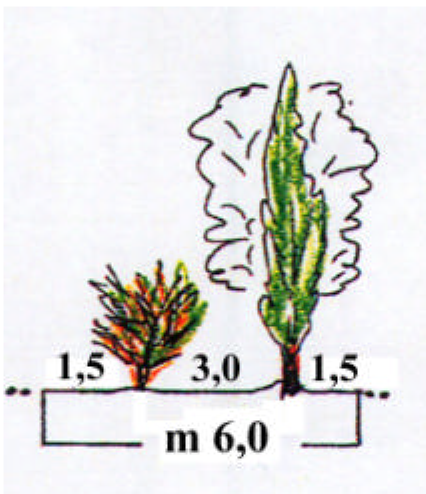

Fig 6: Figure 6a shows proposed woodrows, as used for the scenario design.

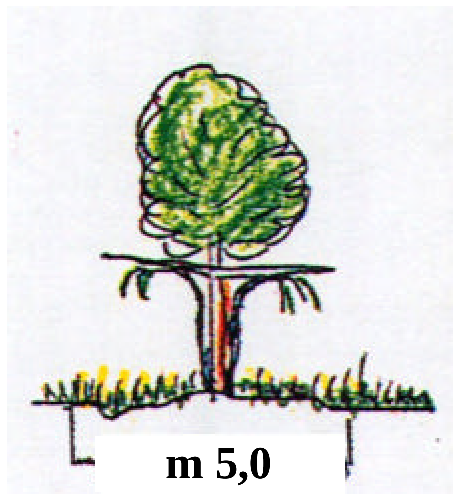

Fig. 6b Shows a design for 'cultural' corridor, with Acer supporting grapes (Cobelli et al. 2000)

In addition to those planned corridors we suggest that also more cultural elements might be brought in, parallel to these watercourses on the higher ground in between the rivers. This might be an extensive form of farming, e.g. Acer rows with grapes growing along it (pict. 6, fig. 6b, Cobelli *et al.* 2000). In addition, a humid drainage course or shallow ditch might be developed, which might serve for water retention during the season (fig. 7a and 7b, Cobelli *et al.* 2000). The width might be some 5 meters wide.

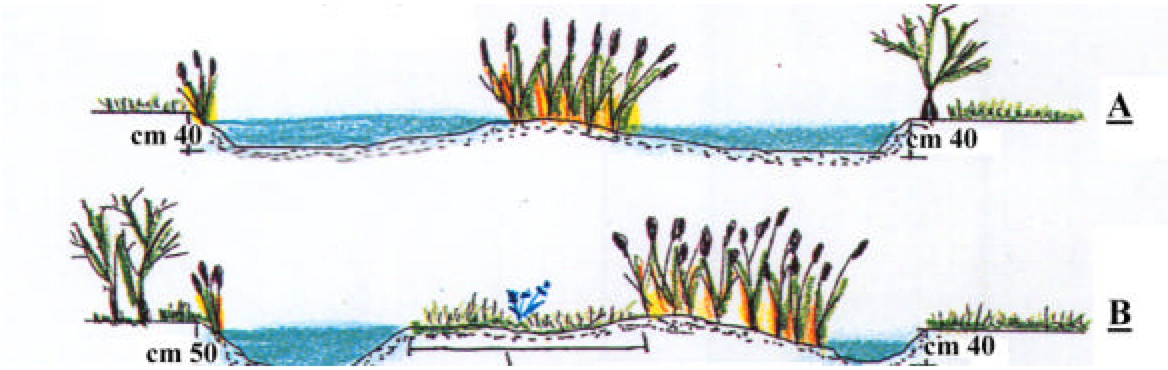

Fig 7a., 7b: Humid drainage course for transversal corridors (Cobelli et al. 2000)

The transversal corridors might be a strip of 10 meters wide, consisting of shrubs and grassland (macchia radura, fig. 8a and 8b, Cobelli *et al.* 2000).

The vegetation should for all corridors consist of natural vegetation, indigenous species, preferably developed by spontaneous germination and settlement.

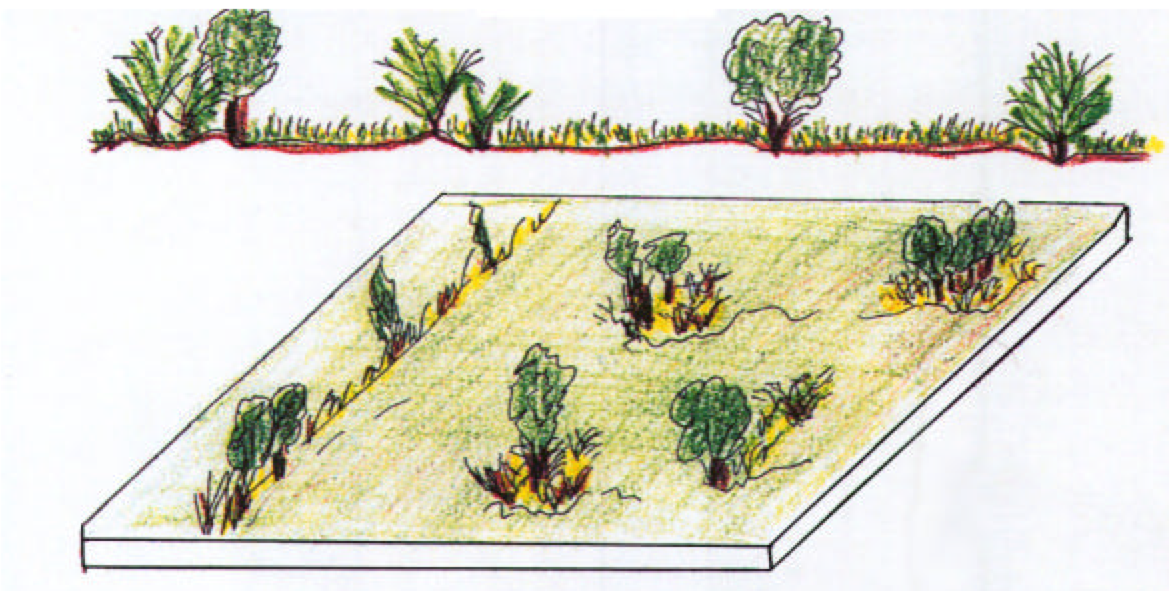

Fig 8 Macchia radura, open vegetation for transversal corridors (Cobelli et al. 2000)

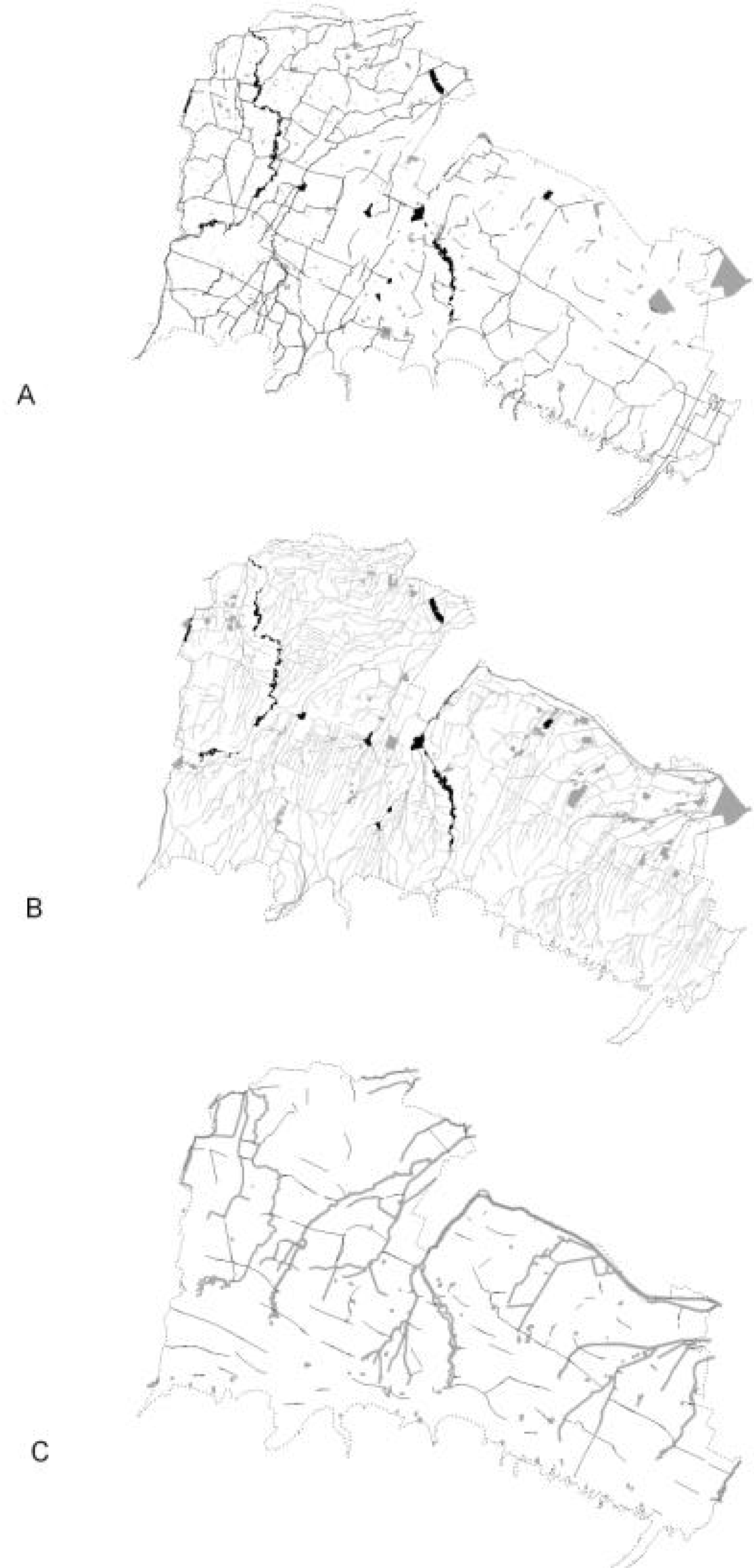

Fig. 9a, 9b and 9c Existing habitat and new habitat for woodlands (9a), wetlands (9b) and grasslands (9c)

5.3.4 Nature rehabilitation areas

Some large nature rehabilitation areas are included in the scenario. Areas within the embankments of the river might partly be zoned for nature rehabilitation. At present there are plans to develop along the river water retention basins, and some nature restoration areas. Additional areas were mapped to realise a substantial increase in natural habitat. In total 1881 ha. of additional natural areas are included. For this analysis it is assumed that part of these areas is developed and managed as wetland (50%), and part of the area is wet forest (25%) or broadleaved forest (25%).

Also outside the embankments of the river there are some nature restoration areas. We assume that 25% of these areas are developed as wetlands and 75% will be broad-leaved forest.

This means actually an increase of the total area of woodland of almost 60%, wetlands by some 12%, and more than a doubling of wet forest and wet shrubs area. The nature rehabilitation areas are visible in fig. 9.

5.3.5 Practical design scenario

For nature rehabilitation areas we selected those parts of the floodplains, which are currently labelled as sowed fields. In addition some other areas were selected, which seemed strategic for the network design, to link some larger areas.

The corridors as well as the nature rehabilitation areas were transformed to gridmaps, for each land use type (see appendix 3). The carrying capacity for each species in these land use types is dependent on the proposed development of those corridors and areas. The present situation as well as the resulting network for each ecosystem type is presented in fig. 9.

The defined scenario results in a change of habitat by 2917 ha. (table 17), mainly based on floodplains which have agriculture land use changed into wetlands. The total cover of the land use types after implementing the new scenario is presented in table 18.

Table 17 New realised habitat under development scenario

Type	Total Area (ha)	(current) main land use	(current) other land use	Development: new vegetation type
East-west corridors	385.3	80% S	9% C	50% Pp, 50% Ci
North-south corridors	650.8	84% Ai	7% S	50% Ci, 50% B
Floodplains	1029.9	100% S	-	50% Zp, 25% Bi, 25% B
Other nature rehabilitation	851.6	89% S	6% C	75% B, 25% Bi

Table 18 Total land cover and contents land use map after implementation of scenario

Code	Land_use	Present situation		New situation		
		Sum (ha)	**% area**	**Nature rehabilitation**	**Corri-dors**	**Sum (ha)**
Al	Water course	6769	1.7			6769
L	Waterbody (lakes, rivers)	1673	0.4			1673
Zp	Wetland zone	4264	1.1	515		4779
B	Broad-leaved forest	2176	0.6	896	325	3397
Bi	Wet forest	272	0.1	470		742
Br	Forest plantation	2601	0.7			2601
Ci	Wet shrubbery, mainly willow	68	0.0		518	586
Zs	Shrubbery	854	0.2			854
Iv	Urban parks, playground	4256	1.1			4256
Pp	Meadow or grassland	2390	0.6		193	2583
S	Sowed field	239544	61.7			236627
Cp	Cultivated, specialized wood cultivation	2068	0.5			2068
Ct	Cultivated, orchard	7794	2.0			7794
Cv	Cultivated, Vineyard	712	0.2			712
Ze	Heterogeneous agricultural area	541	0.1			541
C	Cultivated, mixed Orchard/vine	33565	8.6			33565
O	Vegetable plots, plastic tunnels	535	0.1			535
R	Rice field	319	0.1			319
Za	Airport	243	0.1			243
Zf	Railway and roads	893	0.2			893
I	Urban zone	16872	4.3			16872
Zi	Industrial area	11099	2.9			11099
Zc	Quarry, scrap yard	1144	0.3			1144
Zr	Rocks	0	0.0			0
Zm	Not interpreted	188	0.0			188
	SUM	**388.039**	**100%**	**1881**	**1036**	**388.039**

5.3.6 Maintenance corridors

Nature rehabilitation areas and north-south corridors do not need any form of management; at most fencing in some cases where wildlife conflicts (e.g. hares, roedeer) can be expected, although this should be avoided if possible.
Natural development should be promoted if possible, and little human interference, as far as possible.

The east-west corridors, open shrubland vegetation, do require some maintenance, otherwise the open character will soon be lost, as a result of vegetation succession. Maintenance might be similar to the grassland maintenance along the dykes or embankments of the rivers: mowing, once a year, or grazing with sheep.

6 Results spatial analysis

6.1 Introduction

In this chapter general results are presented for the spatial analysis with LARCH.
Two points should be kept in mind, when interpreting these results: first of all, LARCH assesses the potential situation, i.e. the situation in which habitat is considered optimal. An area assessed as suitable might not always correspond with the actual presence of species in that area. In reality, the situation might be much more complex as ever can be predicted with models.

Second, to be able to give useful advice on the quality of the proposed network, we look at more species at a time, and try to extract a 'general' result for the modelled species for this specific ecosystem. The species are therefore to be seen as 'indicative' for a number of species, a species group with similar characteristics. This result is of much more importance than the result for one sole species.
The figures with results are included at the end of chapter 5.

6.2 Changes in wildlife populations

6.2.1 Woodland ecosystems

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 woodland areas might be the farmyards (pict. 1), which can be very old at times.

The selected species for woodland ecosystems (table 2: *European polecat* and *Red-backed shrike*) are both versatile species, using a wide range of habitats which can expand in areas with little woodland. For that reason also the *Turtle dove* was analysed, as a more 'true' woodland species.

The *Red-backed shrike* forms a small population of (in potential) at most a hundred birds (fig. 10). The LARCH-Scan results and habitat maps show that most important functional habitats are in the Southwest of the area, upstream along the river Secchia and other rivers. The species is not viable, it forms a small population at present. Several minor habitat patches of shrubs in the interior of the Provinces do not form part of the network, either because they are too small, or too isolated from other parts of the network.
Under the development scenario we see that many of the smaller patches are linked in the network. In addition, along rivers habitat has increased, owing to wet shrubs. These shrubs along the north-south corridors form the backbone of the network for the shrike. The habitat forms a key-patch. So the network can still not be considered viable, despite the improvements.

The *Turtle dove* shows a typical metapopulation structure: some well connected, areas are present, mainly in the western part in Provincia di Modena along the rivers Fiume Panaro and Secchia (fig. 11). These parts of the network form viable metapopulations (MVPs). Also Cassa de Campotto forms a MVP. Besides these, there are several 'key-patches', e.g. Valle Benni, north of Mezzolara and lower stretches of the mentioned rivers. Furthermore there are many local populations, which form a substantial part of a network.
The development scenario results in a consolidation of fragmented areas, habitat along rivers is linked to the network. Along the river Reno we also see an important increase of aerial extent of the MVP, extending into the heart of the Plains area. This is due to the floodplain transition through nature rehabilitation.
The potential increase in population size amounts up to some 25%. The number of local populations has decreased by some 30%, which form now part of a larger population network. In other words, the spatial cohesion has improved greatly, since local populations are now linked to- or form part of- a Minimum viable population.
The LARCH-Scan image for the *Turtle dove* shows a pattern of two areas, in the west and east of the study area, which are at present not well connected. The development scenario shows an improvement (fig. 11) due to the development around the river Reno.

The *European polecat* at present forms a key-population (fig. 12). Without immigration from outside it is not viable because habitat (or the number of local populations) is limited. Under the development scenario the population just meets its area requirements for a Minimum Viable Population (MVP) and can be considered viable. Small core areas are situated just north of Modena, with dispersed woodland patches, and north of Imola. It is likely that the Polecat will utilise the Apennines as corridor. The species has a high dispersal range, and uses a wide range of habitat types, also in the Plains area. Therefore the bottleneck for this species is not so much connectivity, but more the quantity of habitat.
Within the network there is a local population, which is not linked to the key area. In the North of Provincia di Bologna are still some areas that do not form part of the network, with too low a carrying capacity for a local population.

6.2.2 Marshland ecosystems

For marshland ecosystems the *Bittern* 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 *Bittern* has a dispersal distance of approximately 30 up to 50 km., whereas the *Italian crested newt* has a dispersal distance of only some 1000 m.
For analysis of a large *marsh heron* like the *Bittern* some areas in the neighbouring region are included in this analysis: Campotto, Panfilia and the Po river. This is justified because of the relative importance of those areas as a source for dispersing birds, as well as the large home range of this species.

There are reasons to assume that the *Italian crested newt* does not favour rivers and watercourses with running water. On the basis of the land use map a selection was done of relevant habitat. Rivers wider then 8 meters were excluded for the newt.

The network of the *Italian crested newt* consists of a large minimal viable population and a number of small local populations. The effect of the Autostrada, running east-west, is clearly visible as a barrier which hinders migration and which is fragmenting populations in this area (fig. 13).
As a result of the development scenario the habitat of the *Italian crested newt* is linked up, so that almost all potential habitat is included in the network. Only in Bologna there are few areas isolated yet. The network consists initially of 10 populations, the development scenario results in a linking of populations and a fusion into 5 populations. In both cases viability increases much as well.
LARCH-SCAN shows that only few areas consist of substantial habitat, where in potential higher densities of newts might be expected: in the north, near the Po River, but also Cassa Gazza.

The metapopulation of the *Bittern* currently consists of a number of local populations (fig. 14). Habitat is presently not sufficient to maintain a viable population on its own, the population can only exist by the virtue of marshland present in the North.
The situation improves considerable under the development scenario. The habitat links up local populations to a key-area, due to watercourses with reedlands adjoining these potential corridors. The population persistence improves much, but it is still not viable and the population is depending on immigration from other areas.

For the *Banded demoiselle* the spatial cohesion improves, especially wetlands situated in the northern part of Province of Modena are better embedded in the network of the region (fig. 15). This species population is already persistent, due to its large home ranges.

6.2.3 Grassland ecosystems

The two species analysed for grassland ecosystems are *Stonechat* and *Yellow wagtail* (alternative species: *Quail*). Both have quite similar characteristics, be it that the dispersal range for the *Yellow wagtail* is higher then for the *Stonechat*, resp. 15 and 10 km. The *Stonechat* has a preference for areas with rough growth and shrubs, whereas the *Yellow wagtail* prefers more the grasslands and fields.

The *Stonechat* forms, with some tens of birds, a local population, no MVP is present and the population therefore is not persistent (fig. 16). Besides, many areas are rather small for this species, the species requires larger areas and occurs only in low densities.
The development scenario results in a marked increase in population size and population persistence. This results in a local population almost twice as large, with only few smaller local populations remaining. The species benefits from smaller patches of grasslands and wet shrubland, which are linked in a network. The increase in habitat and the improved spatial cohesion still doesn't bring the species above the threshold level: the relative increase in grassland habitat is limited, just some 10%.

However, this does not take into account large areas of pastures, which are mapped as sowed field, so total available grassland habitat is much more. Only the herb-rich lands with a rich insect fauna are indeed suitable.
The spatial cohesion is poor for the *Stonechat*.

The *Yellow wagtail* forms one metapopulation, and is viable. Most local populations merge in one MVP, and locally there are some small populations in areas fragmented by the autostrada (fig. 17). Here the negative impact from the Autostrada is clear. The development scenario does not result in much change for the *Yellow wagtail*, since the species utilises a wide range of habitat types, including sowed fields, which is widely available.

The *Quail* forms a MVP, be it that numbers are not large in the area. This species uses agricultural lands too, and is therefore not giving significant (new) information. The development scenario gives hardly an improvement of the situation.

6.2.4 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 19).

Table 19 Summary of the results for the spatial analysis 0 = no change; 0+ = slight improvemen; + = some improvement; ++ = improvement; +++ strong increase

Change occuring under scenario Species	Change LARCH population assessment	Change LARCH-SCAN – Spatial cohesion
Woodlands:		
Red-backed shrike	+++	0
Turtle dove	+++	++
Polecat	++	+
Wetlands:		
Italian crested newt	+++	0
Bittern	++	+
Banded demoiselle	0+	0+
Grasslands:		
Stonechat	++	+
Yellow wagtail	0+	0
Quail	0	0

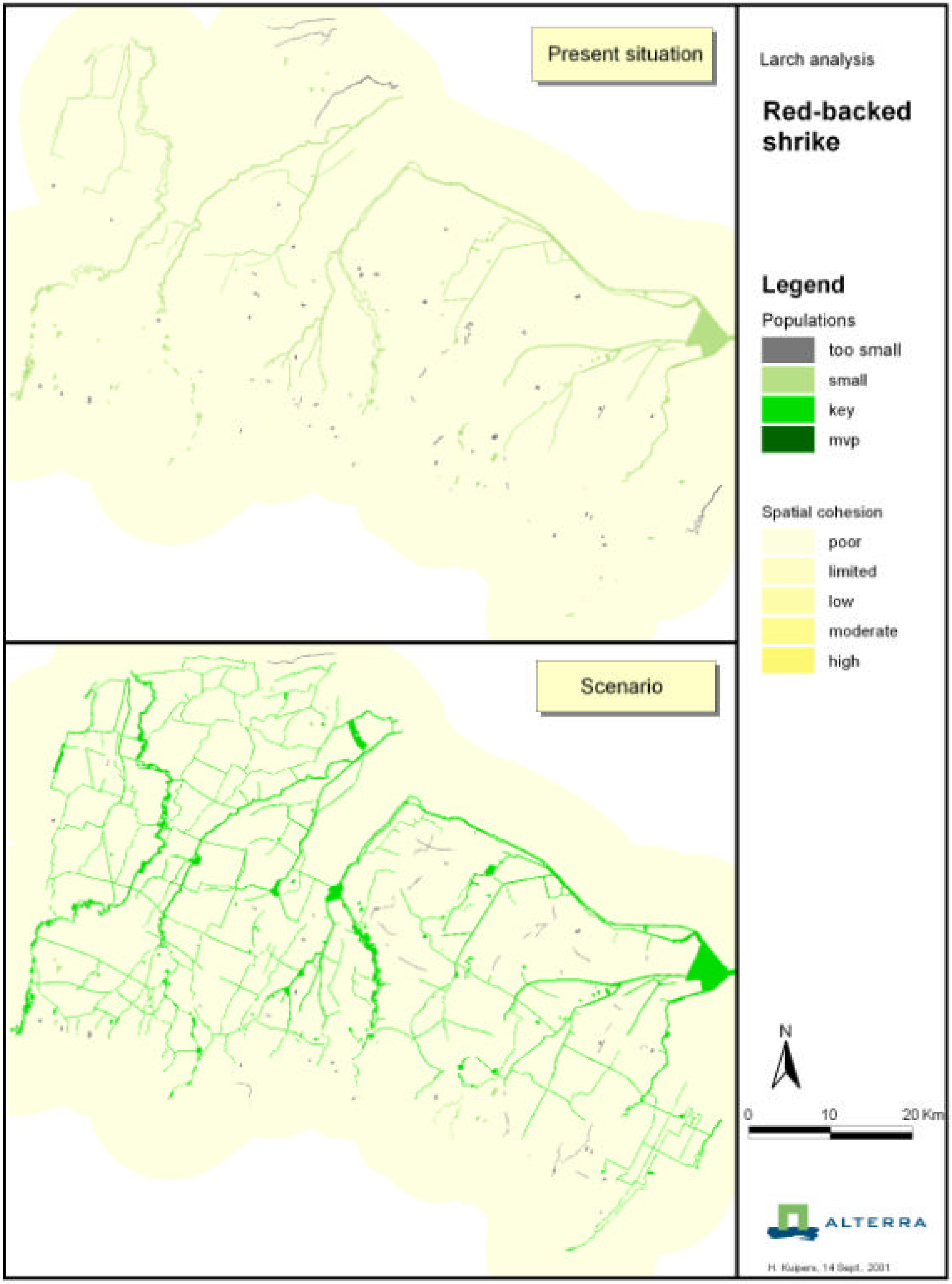

Fig. 10 Results LARCH analysis: Red-backed shrike

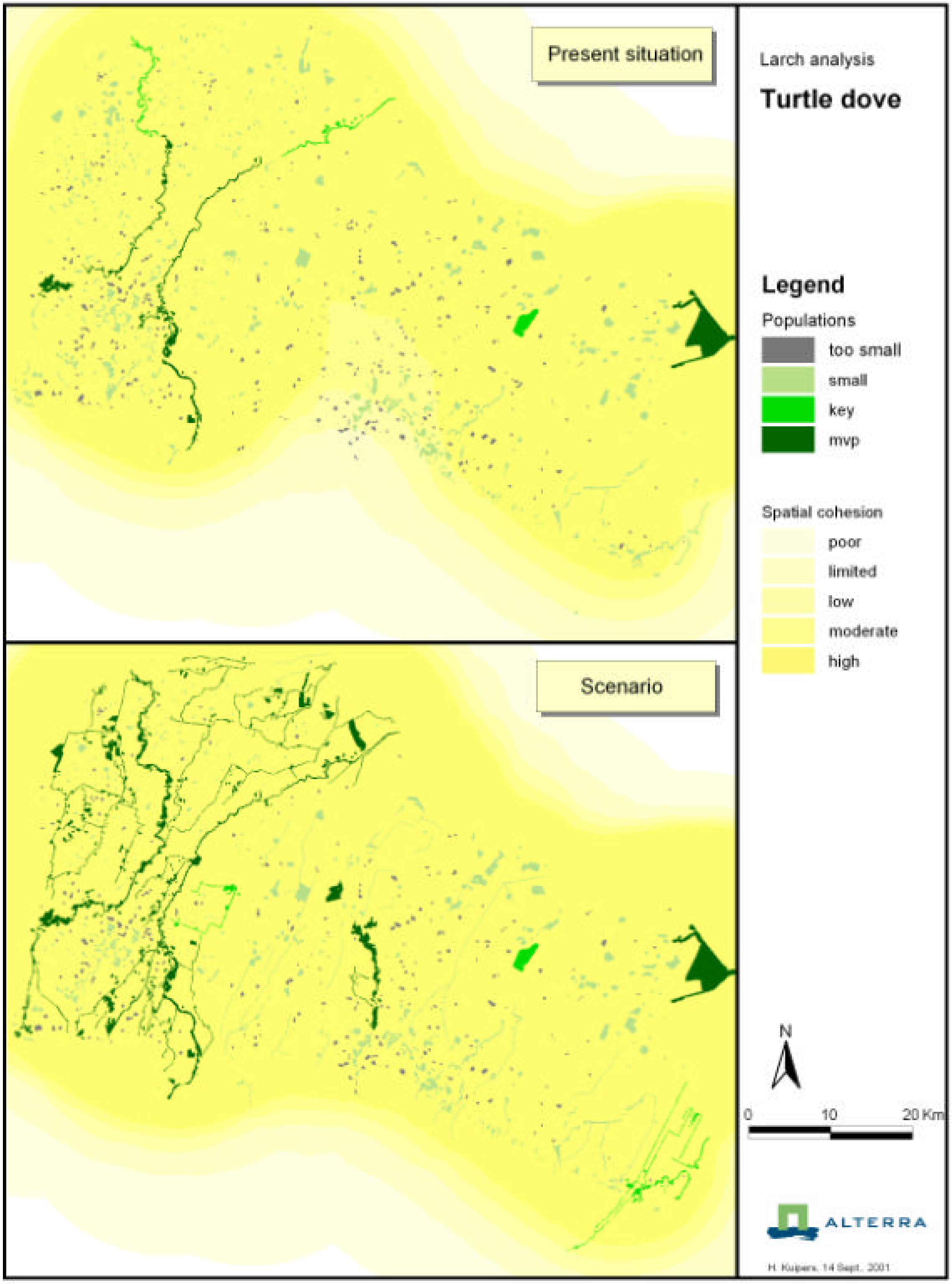

Fig. 11 Results LARCH analysis: Turtledove

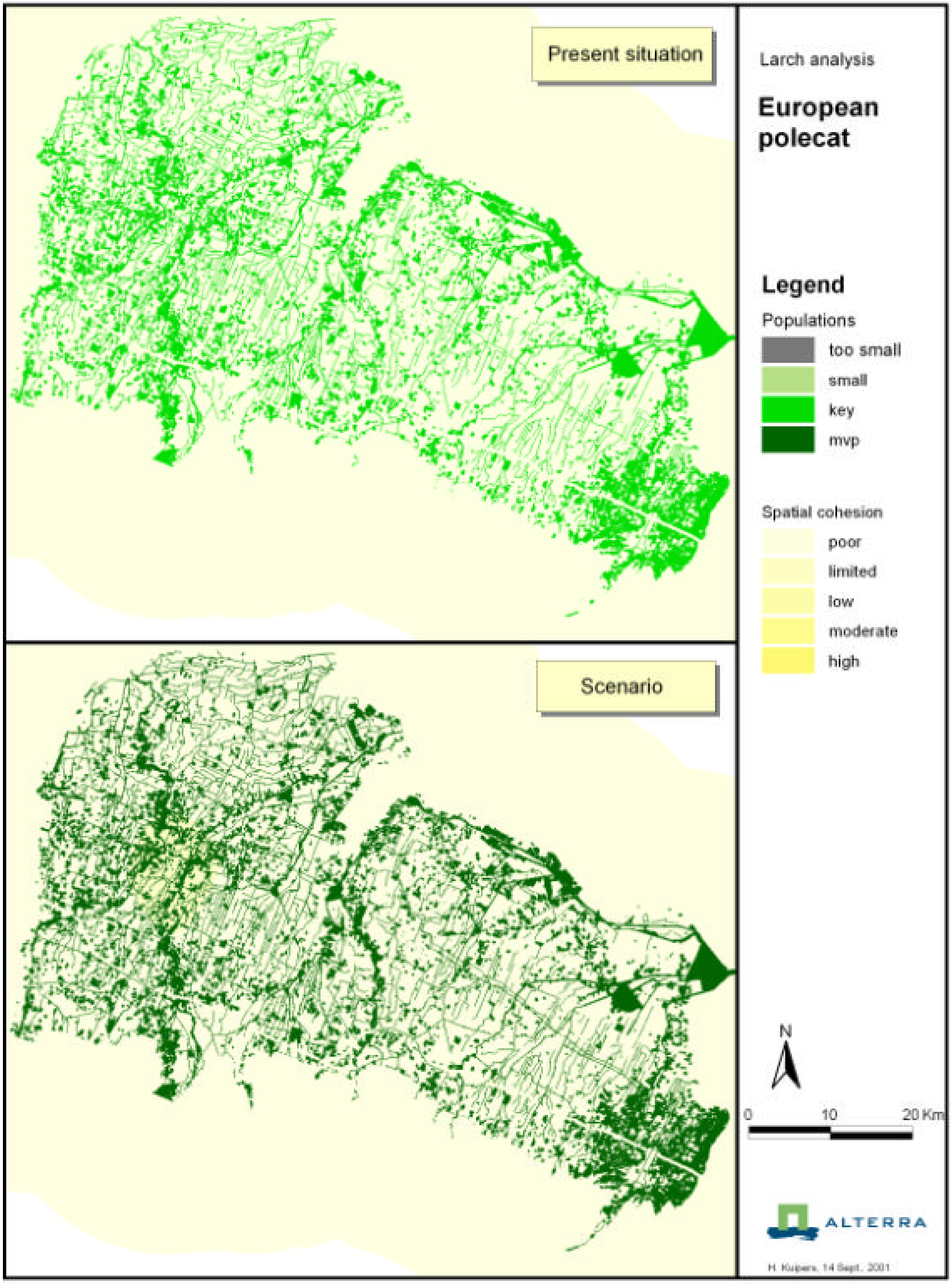

Fig. 12 Results LARCH analysis: European polecat

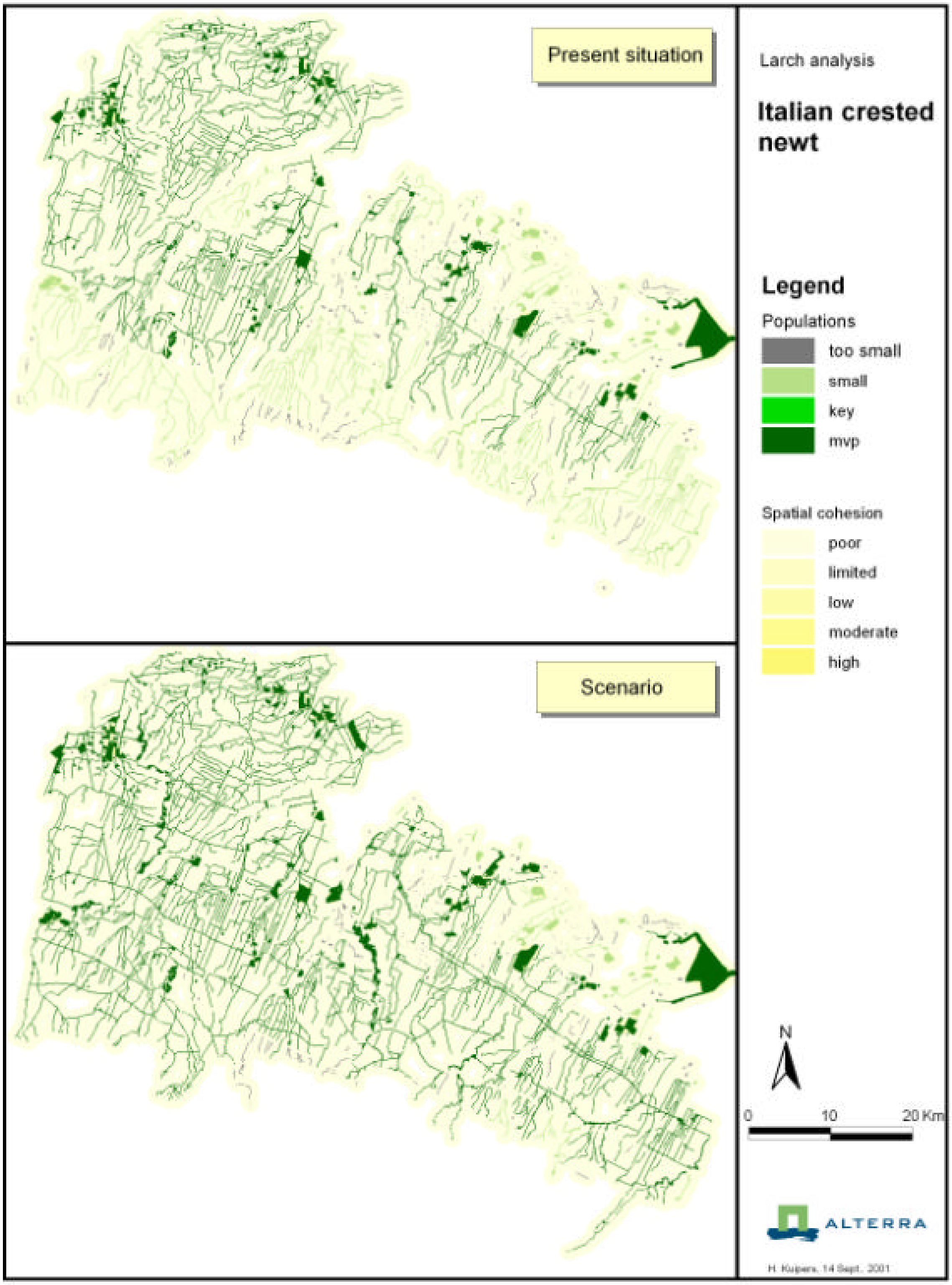

Fig. 13 Results LARCH analysis: Italian crested newt

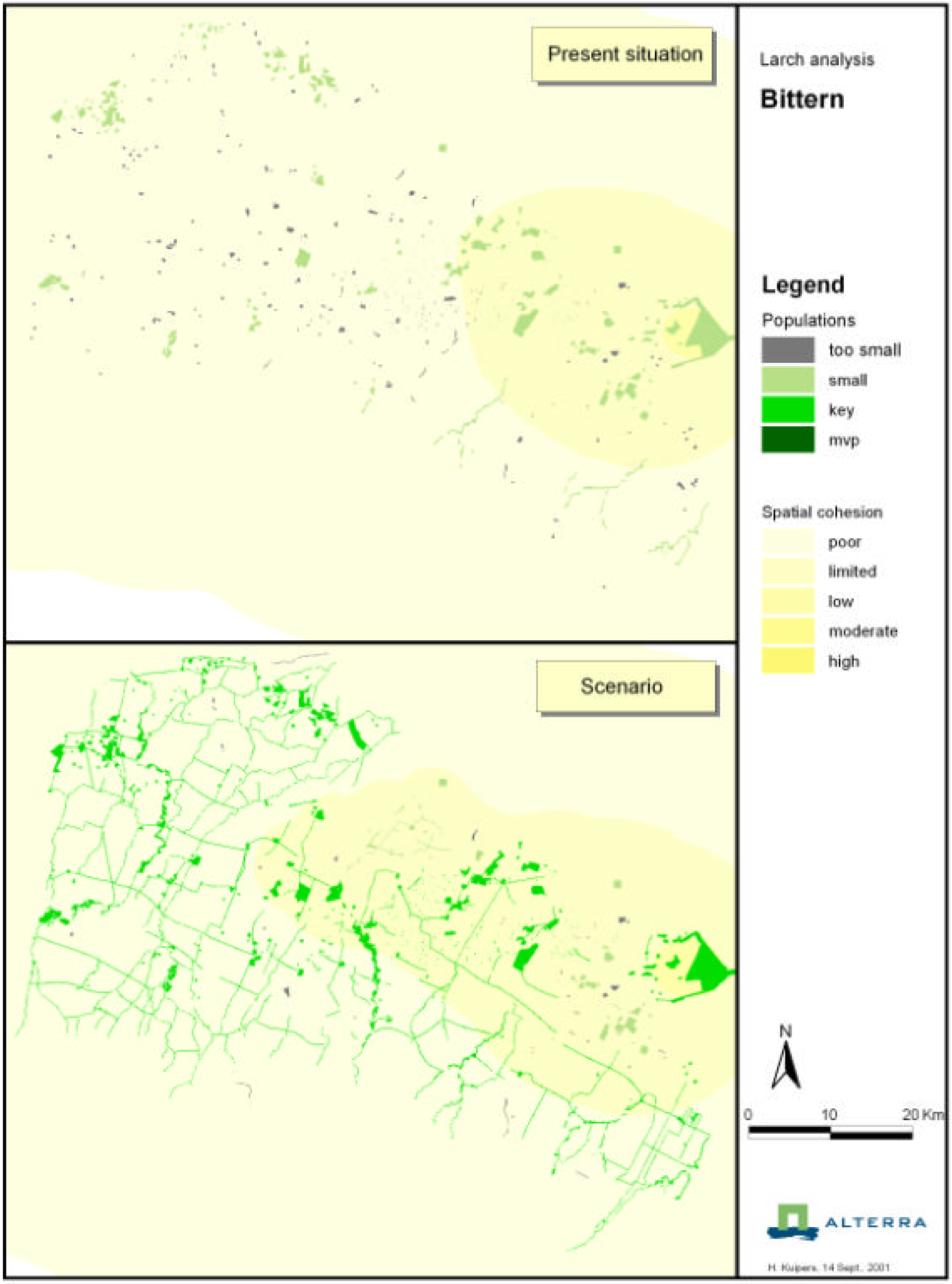

Fig. 14 Results LARCH analysis: Bittern

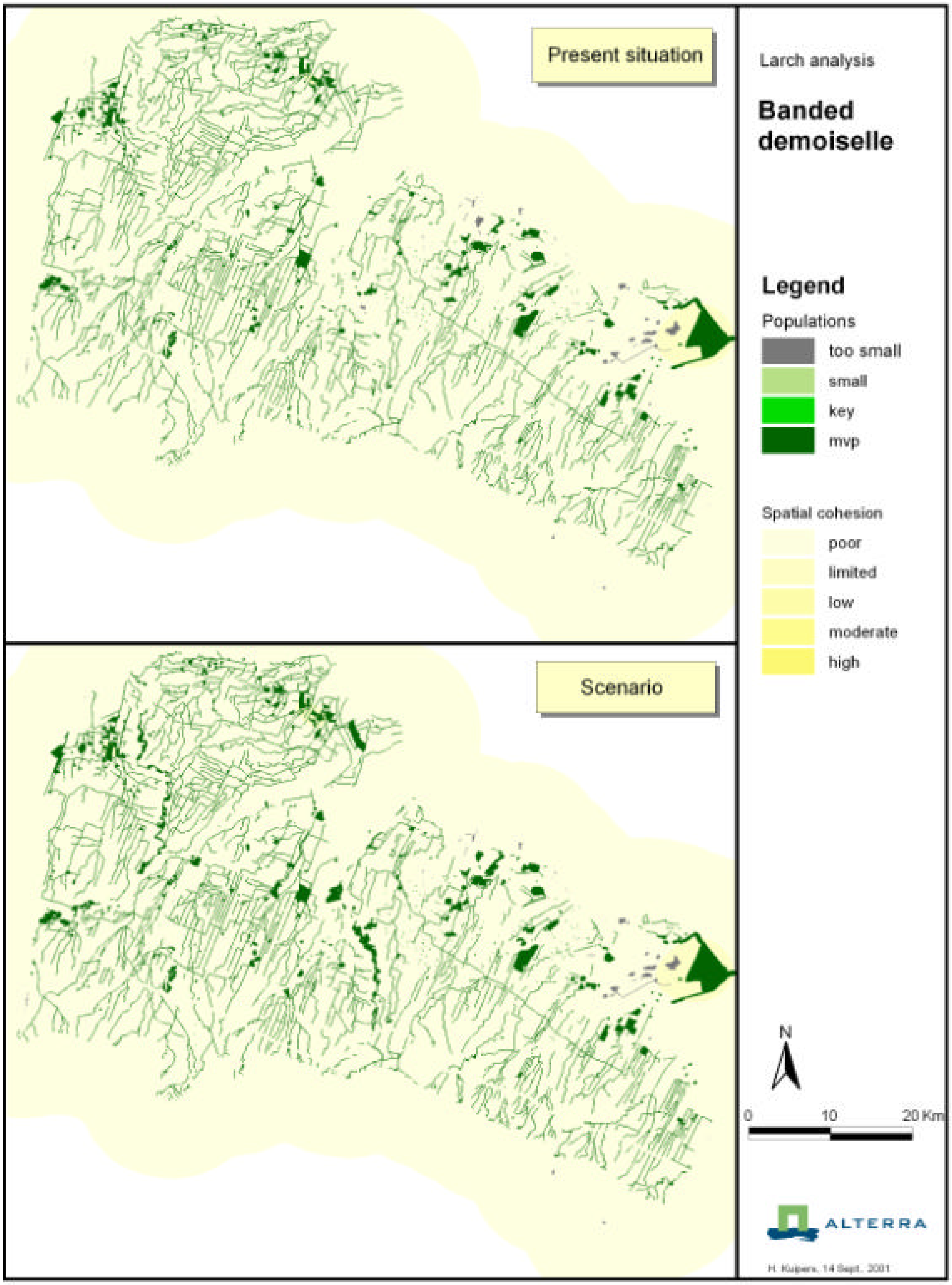

Fig. 15 Results LARCH analysis: Banded demoiselle

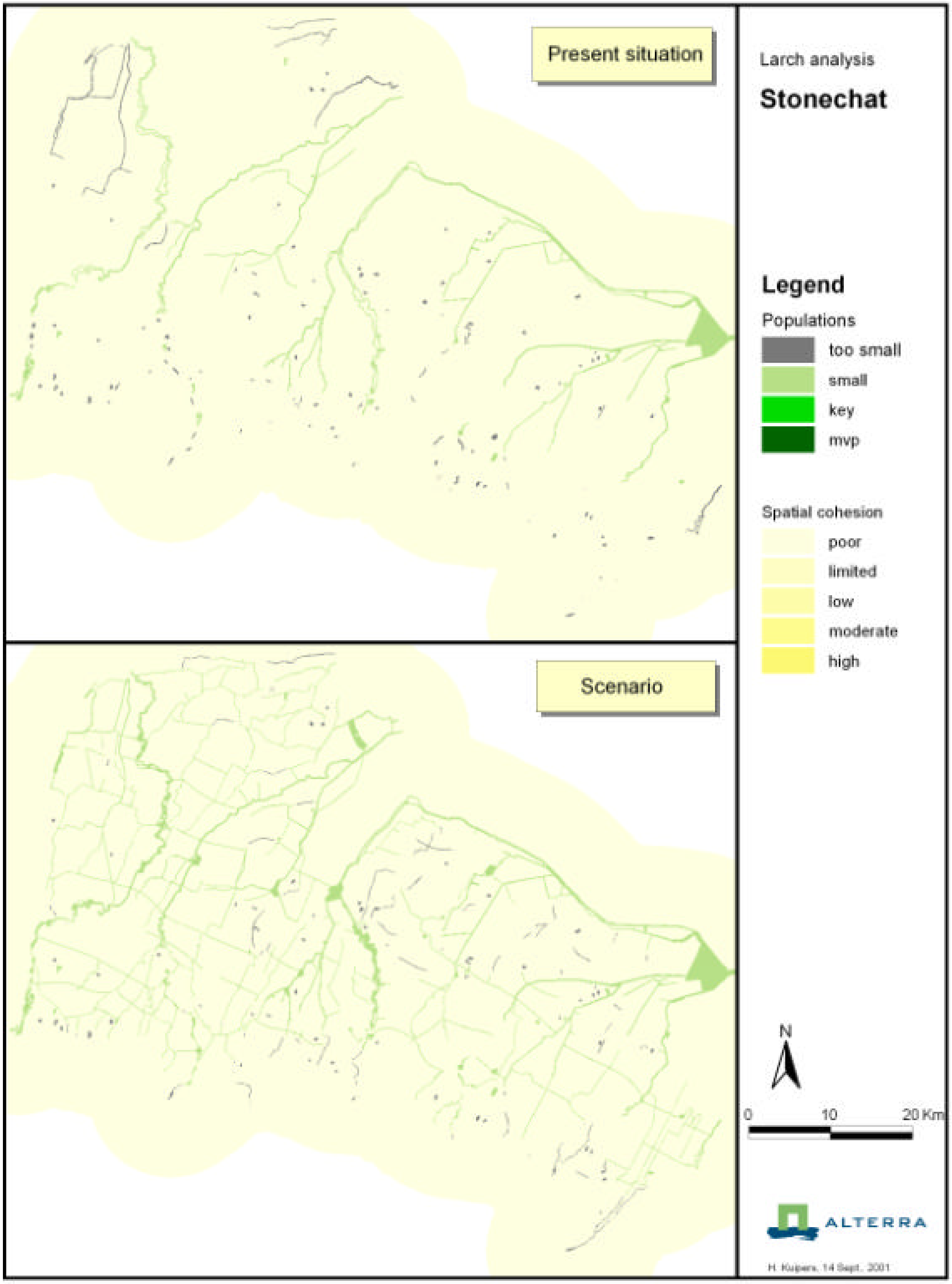

Fig. 16 Results LARCH analysis: Stonechat

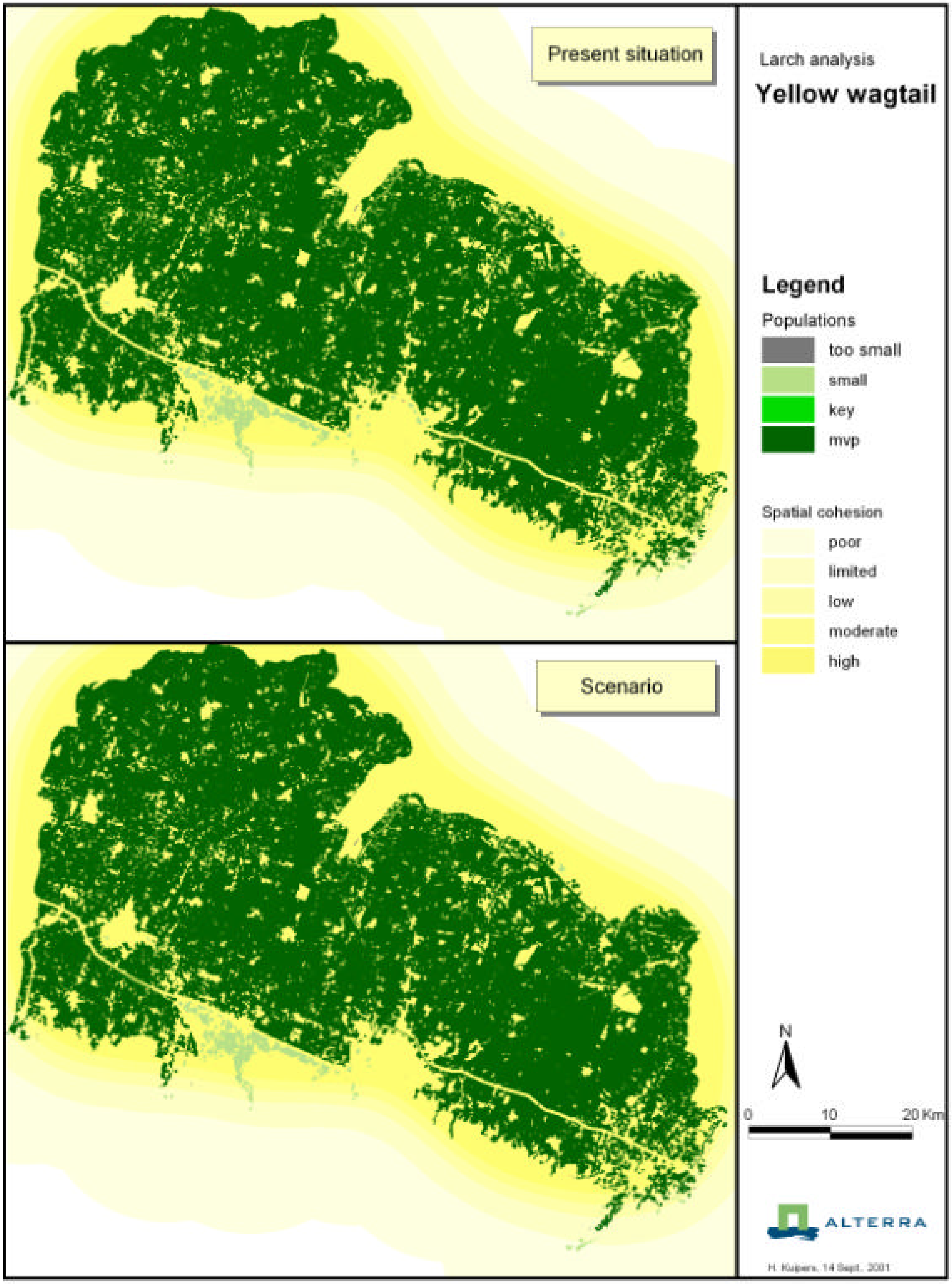

Fig. 17 Results LARCH analysis: Yellow wagtail

7 Discussion

7.1 General discussion method

For this analysis maps for the two provinces of Bologna and Modena are used. No data on habitat just outside these provinces is available. This might result in some underestimation since also in adjoining provinces nature reserves will contribute to the local networks of Bologna and Modena Provinces. Since this concerns especially the *Bittern*, the species with the largest dispersal distance, two important marshland areas in Ferrara are included in the analysis to compensate for this underestimation of wetland habitat, wet forest and shrubland. For other species this is not considered to be a serious problem.

The habitat maps in general seem to be sufficient for this analysis. In some aspects we noted some problems or inconsistencies though. Meadow or grassland (Pp) forms only 0.6% of total land cover (table 12) What is mapped as grassland (Pp) are mainly grass strips along the river embankments, which were especially mapped for this analysis. In fact these grassland habitats are roadside verges, embankments along the river etceteras. Some are quite rough, with some shrubs, tall herbs, and extensively managed, in that respect they form valuable habitat for wildlife.

In the field check on the maps (par. 3.2) we noted a proportion of land use to be grassland, which were mapped however as Sowed field. Probably this is not permanent grassland, in that sense it is correctly mapped as sowed field. However, the species selected will use some of these grasslands as well. Further differentiation in sowed fields would improve analysis results for species of grassland habitat.

7.2 Woodland ecosystems

The scenario has a relative large impact on the woodland ecosystems. The total area of broad-leaved forest is at present app. 2176 ha (0.6%), in total there is 5791 ha. (1.5%) of woodland in the Plains area. These woodland areas consist of many tiny woods and farmyards. As a result, much of it is edge-habitat, i.e. for true woodland species this might be insufficient. In addition, the quality of woodland areas might be low, since there is a lot of urban or human pressure, especially along the rivers. Finally, some new-planted woodlands are still too young to be functional under present conditions.

Woodland habitat is therefore a bottleneck for formation of viable populations of woodland species. Under the future scenario there is an increase of total woodland habitat by 40% up to 8180 ha. (2.1%).

The *Turtle dove* and *Red-backed shrike* are mainly dependent on woodlands. In addition they suffer both from lack of habitat and fragmentation. The *Polecat* also utilises cultivated areas, and has especially a bottleneck in total available habitat, less in fragmentation, although it's home range isn't large (2 km).

Under the development scenario the situation of all species improves. The *European polecat* in potential will form a MVP and will be viable.

The spatial cohesion for *Turtle dove* and *Red-backed shrike* improves as well, since local populations (which are not considered sustainable in the long run) are integrated in a larger Minimum viable population. In other words, the fragmentation decreases, but the *Red-backed shrike* is still not viable though.

At local scale, small farm woodlands might be sufficient for smaller organisms, which were however not assessed in this analysis.

Very little is known about occurrence of the *Polecat*, its habitat requirement and dispersal ranges. On the knowledge we have now we conclude that most of the area might be potentially suitable habitat and the corridors will further improve the situation.

All in all we might conclude that in the new situation species dependent on woodland habitat are still limited due to lack of habitat. No real core areas for woodlands are present. Especially in the Bologna plains more core areas are required, to improve this situation available habitat should be further increased.
The fragmentation has decreased much. However, there are still some areas isolated, which form local populations, esp. in Bologna Province. Situating corridors and some woodland areas strategically between reserves in Bologna and Modena can further improve the situation (fig. 18).

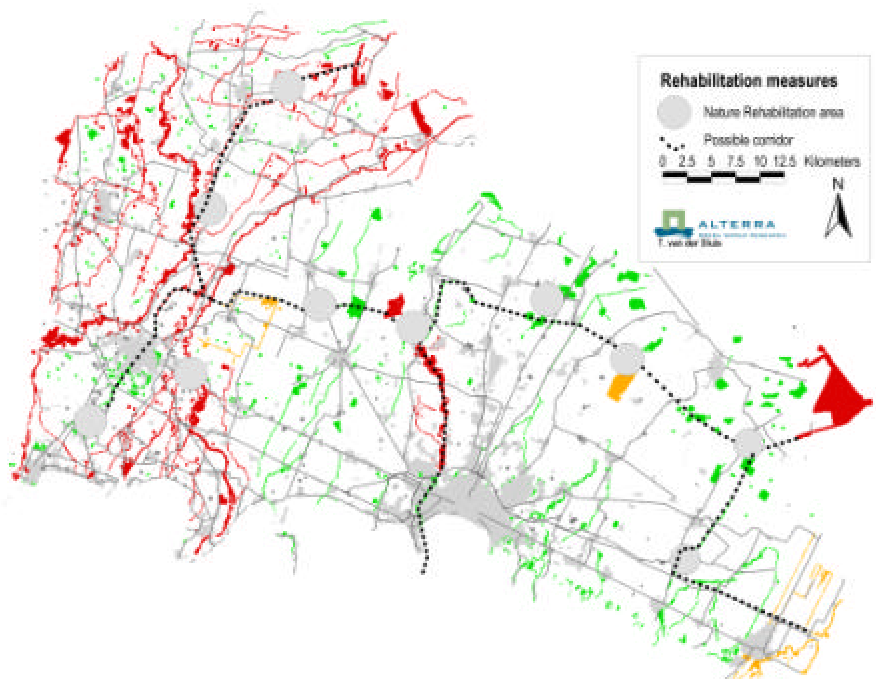

Fig. 18 Possible interventions to improve further the ecological network

7.3 Marshland ecosystems

The areas available seem already quite substantial, spatial cohesion is in general good, measurements considered could be creation or enlargement of some core areas.

The *Bittern* and the *Italian crested newt* both benefit from the increase of wetlands. Especially for the *Bittern* the increase is considerable since it brings the population from few birds near the level of a local population. In conjunction with surrounding provinces the new wetlands and Campotto can function well as a core area.

The *Italian crested newt* is viable at present. The species benefits from the development scenario, many local populations merge into a large MVP. Only few smaller areas do not form part of the ecological network, this number has decreased though by 50%. After implementation of the scenario the situation is of course still very viable.
One should keep in mind though that the potential situation is better then the actual situation. Local 'disasters', like a drying up of a watercourse, or local intensive use of pesticides or herbicides might eliminate a local population, which on its turn might fragment the population that forms a MVP. But even the smaller MVPs are likely to persist in the long run.

For the *Italian crested newt* water quality is very important. E.g. intensive-farming practices can be very detrimental. This might effectively reduce available habitat, or worse, split populations into smaller populations, which can not be considered viable anymore.

The habitat for the *Bittern* is difficult to assess. The species requires wetlands with reedlands (Canneto) or dense vegetation with Magnocaricion, Typha and sedges. The land use map however gives no information on these different types of vegetation within 'wetland'. Therefore it is only a rough assumption that reedlands form some 10% of the wetlands. As a result, the carrying capacity is low; the population assessment reflects indeed quite well the actual situation.

The population of *marsh herons* currently exists of a few local populations, and does therefore not suffice for a MVP. The population can only exist by the virtue of the reserves and marshland in the adjoining provinces. Therefore, lack of extended marshland habitat is currently the main bottleneck. The situation improves considerable under the development scenario. The habitat links up local populations to a key-area, due to potential corridors, watercourses with adjoining reedlands. The population persistence improves much, but it is still not viable and the population is depending on immigration from other areas. Fragmentation is for this species less of a problem, since the *Bittern* has a large dispersal distance. However, the species requires large areas of at least appr. 100 ha.
The results also underpin that to improve substantially the situation for the *Bittern* in this area, considerable efforts have to be made.
Additional habitat would be required for a MVP. Best would be large extended reedland and Magnocaricion vegetation types, located near the Campotto and the Po river. An area of approximately 2000 ha. of optimal reedland probably would result

in a MVP. However, a more in-depth study would be required at metapopulation level (see e.g. Chardon, 2001). He found under optimal conditions in Belgium that an area of 174 ha. reedland could sustain 6 breeding pairs, and simulated viability of the population under different area sizes.
In addition to increasing total habitat, specific management aiming at restoring this habitat type is very important.

Both species operate on a scale that makes it difficult to assess the ecological network: either the network is too fragmented (newt) or much connected, but with a low carrying capacity (*Bittern*). The alternative species, *Banded demoiselle*, gives additional information. For this species we see that spatial cohesion improves, especially wetlands situated in the northern part of Province of Modena are better embedded in the network of the region. Also this species population is persistent, due to its large home range.

It should be considered that we discuss few species here. For a range of species like great reed warbler, fan-tailed reed warbler or reed bunting the increase in habitat might mean an important improvement in population viability. Focussing on a species like the *Bittern* means aiming at targets that are ambitious, but at the same time many other species benefit.

7.4 Grassland ecosystems

The area of meadows is underestimated, as meadows in the land use map are partly mapped as ‘Sowed fields’ (par. 3.2). Most grassland mapped form effectively ‘edge habitats’. Those grassland strips observed seem to be of high quality for several species, e.g. butterflies, specific bird species etc.

The *Stonechat* and *Yellow wagtail* differ in response on the new scenario. The *Stonechat* shows locally an improvement, up to the level of a key population. The increase in habitat and the improved spatial cohesion still doesn’t bring the selected species above the threshold level: the relative increase in grassland habitat is limited, just some 10%.

Under current conditions and the development scenario the spatial cohesion of grasslands is poor for the *Stonechat*.

The *Yellow wagtail* seemed already quite stable, due to abundance of habitat, and this does not change much with newly developed habitat. The MVP is already persistent, and hardly changes because sowed fields form part of the habitat.

Management of land and intensity of land use is critical for the *Stonechat*. Management of productive land could be adapted, with measures beneficial for those species e.g. set aside policies, land-stewardship payments for abandoning fertiliser and pesticide use. This would effectively increase available habitat, and improve the quality of the ‘Sowed fields’.
Also increasing the width of corridors –especially transversal corridors with macchia type vegetation- might prove to be beneficial for these species.

8 Recommendations

General recommendations:

- The habitat requirements for most selected species are high. With realisation of the scenario, some species will still be under threat, despite the ambitious scenario. This shows that the Region has a serious fragmentation problem. Obviously, the 5% of areas remaining with natural habitat (par. 3.1) is too little for many species at present, and efforts should be concentrated on increasing core areas for woodland and marshlands, and extensification of some meadows to create more natural grasslands.
- It is recommended to implement the defined scenario to improve the situation for most species
- It is recommended to implement the corridors as planned at present. Priority should be given to the main corridors (north-south). The transversal corridors are of lower importance but would definitely improve the cohesion of the network.
- If it is not possible to realise a corridor as proposed here (par. 4.2.3) it is recommended to make instead stepping stones. For amphibian species (which is most limited in dispersal possibilities) it would be advisable to create ponds at distances of (at most!) 300 m. apart (pict. 3). The ponds should be surrounded by terrestrial habitat as well (e.g. shrubs and rough growth), also to prevent pollution of the water by spray of chemicals.

Recommendations regarding wetlands:

- If large herons (like the *Bittern*) are the target for conservation policy, large areas are required, preferably extended areas with older reed and other helophyte vegetation, like Carex and Magnocaricion. For the *Bittern* an area should be at least 50 ha. in size. For a MVP app. 2000 ha is required, which would best be located in a large core area near Campotto.
- Smaller marshland bird species with less habitat requirements do benefit already from the designed scenario. For some critical species like the fan-tailed reed warbler or the great reed warbler, the quality of reedland is also of importance, and larger, old reedland areas are required. At present much wetlands have only to a limited extent reedland, and management should be aimed at increasing reedland and improving the quality of the vegetation.
- Connectivity of wetland habitat for amphibians and *Banded demoiselle* seems to be sufficient after realisation of the scenario: not many local populations are isolated and not included in a larger population network.
- Farming intensity can affect habitat and water quality, which is not assessed in this analysis. Larger marshland areas are less affected by intensive farming, and ensure healthy core areas for sensitive populations. The existing areas in the north of the provinces might form such key-patches. Preferably, those areas should not be stocked with fish, in favour of amphibian species, or smaller ponds should be included which fall dry during the course of the season, so that fish will disappear each year.

Recommendations regarding woodland habitat:

- Woodland areas are limited in this area. Only species with limited habitat requirements will thrive under present conditions, that is, in the case that they are not sensitive for barriers or if they have a medium or large dispersal range (like the *Turtle dove*). Species that are sensitive suffer in this area from severe fragmentation.

- Strict woodland species with larger habitat requirements might not reach minimum habitat standards, and will not form MVPs. For these species larger forest areas are required still. These areas should be linked to the larger forests, e.g. those planted in the north of Modena Province.
- Due to the limited availability of woodland habitat, optimal protection is required of the remaining area of woodlands
- Woodland species that utilise a large variety of habitats, or the 'fringe' species that use the edges, might meet their requirements, and have less of a fragmentation problem. For those species the forested corridors are important

Recommendations regarding grassland habitat:

- The grassland habitat as observed in the area is of high quality and very important for species dependent on field margins or road side verges
- In a follow up of this analysis, specific species should be selected to assess better these margins
- Management should be directed towards optimal conditions for the flora and insect fauna. This will benefit much of the bird populations studied in this analysis. One of the measures, in addition to constructing new corridors, might be improvement of extensive agricultural management.
- Extensive grazing of wet open areas around marshlands could restore favourable conditions for species like the *Stonechat*, as well as *Red-backed shrike* and preserve grassland habitat

More specific recommendations regarding corridors:

- Specific corridors required for woodland, grassland and wetlands networks seem to overlap quite well; this would justify development of multiple use corridors (i.e. of combined habitat types).
- The Autostrada still forms a barrier for a number of species. Especially for barrier-sensitive species like the *Italian crested newt* and *Polecat*, as might be expected. It is recommended to increase corridors across the Autostrada East of Bologna, since very few corridors are present or planned here.
- The river Reno runs corridor through the town of Bologna. At present it does not function as a corridor, so that riverine habitats are not linked with the Apennines. This river should be opened and improved, to improve the functioning of a corridor. Preferably it should be linked with urban green areas. The same counts for the Secchia river, running through Modena. Despite that the rivers go through densely populated areas, examples elsewhere show that even in the limited area available improvements can be made, in the form of e.g. vegetated areas or reeds along the rivers.
- In areas with little connectivity and larger agricultural plains, it should be considered to develop 'cultural' corridors to increase natural habitats (fig. 5b)

Regarding a follow-up of this analysis of ecological networks for some smaller parts of the two provinces, the reader is referred to Chapter 9.

9 Conclusions

The study in Emilia-Romagna should be seen as a basis, a first 'exercise' to assess the ecological network. It shows the margins for developments, it presents ideas and might form a good basis for further development of the ecological network.
The scenario drafted here is quite ambitious in its aims (almost 3000 ha set-aside for nature), and at the same time it is still realistic, it can be realised with dedicated government.

Furthermore, this research increases knowledge of Conservation Biology and land use planning, and might open ideas for future developments.

Specific conclusions:

- The spatial analysis with LARCH has yielded useful results. For quantification and calibration of the results, the scenario should still be tested better though.
- Through the development scenario very good opportunities are created, especially for long-range species. After improvement of corridors also the situation for species with a short home-range conditions might improve
- Efforts for implementation should be geared towards creation of larger woodlands and wetland areas. Opportunities to rehabilitate natural areas in the floodplain (as suggested in the development scenario) should be used!
- In prioritising in corridors to be developed or improved, the lateral (river) corridors should get priority, above the transversal corridors. See Chapter 7 for more details on specific corridors
- East of Bologna the Autostrada forms especially a barrier for sensitive species

Specific conclusions for the different ecosystems:

- Wetlands gives a good improvement, due to increase habitat
- Grasslands: the *Stonechat* is a suitable species for this analysis; there is an improvement of grassland under scenario, but limited
- Natural grassland areas might be increased around wetlands;
- A more specific map with grassland is required, (at least two classes: natural/productive grassland)
- Woodland: population size as well as spatial cohesion increases. This although no real core areas present. Especially in the Bologna plains more core areas are required.

Pict. 7: Old sugar factory ponds - Vasca ex zuccherificio

10 Further research

It is recommended to collect data on distribution of target species and to monitor population and distribution trends, to be able to adjust regional environmental policies and launch further conservation plans.

Landscape ecological data is required for assessing more accurately landscape ecological relationships. This data includes dispersal ranges, home ranges, and specific information on habitat and habitat use by species. Further research undertaken in this field by e.g. universities should be stimulated.

Further study is required on the *Polecat*. The species occurs in the area, but it is rarely sighted, and very little is known about its ecology. Further research might shed light on further protection requirements for this species.

Better vegetation maps would be beneficial for regional planning purposes, as well as for spatial analysis as carried out in this study. It is therefore recommended to prepare a map based on aerial photographs or other Remote Sensing images.

On the basis of these results we conclude that the LARCH model is suitable for application at this scale, in this region. It is advised to continue with a detailed study for the community areas. A more detailed study would allow the study of species that operate on a smaller scale, butterflies, small mammals, amphibian species, as well as birds with a smaller range. The more detailed habitat mapping would allow a better assessment then the current study.
Furthermore, zooming in on a smaller area will allow making a more realistic development scenario, preferably in co-operation with the residents.
With use of the present results a design could be prepared for corridors, detailing specific site locations where corridors should be developed, as well as some corridor designs based on the specific requirements of species.

Pict. 8: Field visit Steering Committee

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Appendices

Appendix 1 Protected, rare and endangered species

VERTEBRATI RARI E/O MINACCIATI NELL'AREA DI STUDIO
DEL PROGETTO ECONET EMILIA-ROMAGNA (a cura di L. Sala, Università di Modena e Reggio Emilia)
NB: escluse le specie della fauna "originaria" oggi dubbie (es. *Rana latastei*) o estinte da più o meno lungo tempo (es. Lontra *Lutra lutra*)

Pesci	*Cheppia (*Alosa fallax*)*
	*Triotto (*Rutilus erythrophthamus)
	*Lasca (*Chondrostoma genei*)*
	Tinca (Tinca tinca)
	*Cobite (*Cobitis taenia*)*
	*Luccio (*Esox lucius*)*
	Spinarello (*Gasterosteus aculeatus*)
	Ghiozzo padano (*Padogobius martensii*)
	Panzarolo (*Knipowitschia punctatissima*)
Anfibi	Tritone crestato italiano (*Triturus carnifex*)
	Tritone punteggiato (*Triturus vulgaris*)
	Raganella italica (*Hyla italica*)
	Rana agile (*Rana dalmatina*)
	Rospo comune (*Bufo bufo*)
Rettili	Testuggine palustre (*Emys orbicularis*)
	Lucertola campestre (*Podarcis sicula*)
	Ramarro (*Lacerta viridis*)
	Orbettino (*Anguis fragilis*)
	Colubro liscio (*Coronella austriaca*)
	Colubro di Esculapio (*Elaphe longissima*)
Mammiferi	
	Toporagno d'acqua (*Neomys fodiens-N. anomalus*)
	Topolino risaie (*Micromys minutus*)
	Arvicola d'acqua (*Arvicola terrestris*)
	Moscardino (*Muscardinus avellanarius*)
	Ghiro (*Glis glis*)
	Scoiattolo (*Sciurus vulgaris*)
	Puzzola (*Putorius putorius*)
	Faina (*Martes foina*)
	Tasso (*Meles meles*)
	Capriolo (*Capreolus capreolus*)
Uccelli	(selezione dalla comunità dei nidificanti)
	Svasso maggiore (*Podiceps cristatus*)
	Tarabuso (*Botaurus stellaris*)
	Tarabusino (*Ixobrychus minutus*)
	Airone rosso (*Ardea purpurea*)
	Airone bianco (*Egretta alba*)
	Garzetta (*Egretta garzetta*)
	Sgarza ciuffetto (*Ardeola ralloides*)
	Airone guardabuoi (*Bubulcus ibis*)
	Nitticora (*Nycticorax nycticorax*)
	Marzaiola (*Anas querquedula*)

Alzavola (*Anas crecca*)
Poiana (*Buteo buteo*)
Albanella minore (*Circus pygargus*)
Falco palude (*Circus aeruginosus*)
Sparviere (*Accipiter nisus*)
Lodolaio (*Falco subbuteo*)
Falco cuculo (*Falco vespertinus*)
Quaglia (*Coturnix coturnix*)
Starna (*Perdix perdix*)
Voltolino (*Porzana porzana*)
Schiribilla (*Porzana parva*)
Porciglione (*Rallus aquaticus*)
Corriere piccolo (*Charadrius dubius*)
Piro piro piccolo (*Actitis hypoleucos*)
Fraticello (*Sterna albifrons*)
Sterna comune (*Sterna hirundo*)
Mignattino piombato (*Chlidonias hybridus*)
Gabbiano comune (*Larus ridibundus*)
Tortora (*Streptopelia turtur*)
Succiacapre (*Caprimulgus europaeus*)
Assiolo (*Otus scops*)
Martin pescatore (*Alcedo atthis*)
Upupa (*Upupa epops*)
Gruccione (*Merops apiaster*)
Picchio verde (*Picus viridis*)
Calandrella (*Calandrella brachydactyla*)
Topino (*Riparia riparia*)
Beccamoschino (*Cisticola juncidis*)
Forapaglie (*Acrocephalus schoenobaenus*)
Canapino (*Hippolais polyglotta*)
Bigia padovana (*Sylvia nisoria*)
Sterpazzola (*Sylvia communis*)
Salciaiola (*Locustella luscinioides*)
Pigliamosche (*Muscicapa striata*)
Basettino (*Panurus biarmicus*)
Codibugnolo (*Aegithalos caudatus*)
Picchio muratore (*Sitta europaea*)
Pendolino (*Remiz pendulinus*)
Rigogolo (*Oriolus oriolus*)
Averla piccola (*Lanius collurio*)
Strillozzo (*Miliaria calandra*)
Migliarino di palude (*Emberiza schoeniclus*)

Appendix 2 Map transformations for LARCH

The habitat module of LARCH requires grid maps of ASCII format. A resolution was chosen of 100 meter. Per land use type an ASCII map a cell-value was assigned for the area of the respective land use type

The vector map ‘Land use” was transformed to a 10 meter grid, the cell values refer to the land use type. The Land use grid was aggregated per land use type to a 100-m grid. The cell values of these grids reflect the area of the land use type within the cell, and are based on the number of 10-m grid cells of land use within the 100-m. grid cell.

The scenario maps were in a similar way transformed to an input grid for LARCH. Because the scenario ASCII grids were added to the set of ASCII grids of the present situation, the scenario area is larger then it in reality is. However, since main land use is currently ‘Sowed field’, (table 12), which forms only for few species very marginal habitat, the effects on the overall results will be very limited, if noticeable.

The scenario results for corridors is based on maps provided by the Provinces. The east-west corridors are based on the maps ‘Dircol.shp’ and ‘Direz.shp’. Some adjustments were made, where required, so those corridors would link with natural areas present. The corridor lines were buffered with 5 meters, resulting in 10-meter wide corridors.

For north-south corridors the maps ‘corridoi.shp and ‘coles.shp’ were used. Corridors of 6 meters wide were made.