ECOLOGICAL CORRIDORS AND SPECIES: LARGE CARNIVORES IN THE ALPINE REGION

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Committee for the Activities of the Council of Europe
in the Field of Biological and Landscape Diversity

Nature and environment, No. 127

ISBN 92-871-4989-6

French edition:
Corridors écologiques et espèces: grands carnivores dans la region alpine
ISBN 92-871-4988-7

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Foreword

This report is the result of the integration of environmental quality models developed by the Instituto di Ecologia Applicata (IEA) of Rome for the “Large Carnivore Conservation Areas in Europe” (LCCA) project funded by WWF International. The models were used, within the framework of the Large Carnivore Initiative for Europe (LCIE), to develop action plans for the three species analysed.

The integration of the results obtained from the LCCA project and the identification of a “summary” model of environmental quality for all the three species was possible thanks to the support of the Council of Europe, Directorate of Environment and Local Authorities.

A draft version of this report was circulated at the meeting of the Committee of Experts on the Pan-European Ecological Network which was held in Strasbourg from the 29th of September to the 1st of October 1999. The present version accounts for the comments of the participants to the meeting.

The authors would like to thank the Organisations that made this project possible and all the participants to the Committee of Experts on the PEEN for their helpful comments.

Introduction

The Council of Europe is promoting the development of Pan-European Ecological Network. In the context of this activity the present report addresses the problem of developing knowledge tools capable of driving the process for an informed management of the large carnivore populations.

This report is based on the results obtained from the "Large Carnivores Conservation Areas in Europe" (LCCA) project which was developed by the Istituto di Ecologia Applicata (IEA) of Rome on behalf of the Large Carnivore initiative for Europe and with funding provided by the WWF International.

The LCCA project aimed at developing environmental suitability models for the bear, the lynx and the wolf in the Alpine Range to identify sensitive areas (both in terms of areas particularly suitable for the survival of the species or those which represent broad unsuitable patches) and connecting corridors.

The Alpine Range was chosen as it represents a challenging area where none of the three species is currently present with a stable population, but at the same time is expected to represent an important conservation area once it is included in the range of the species. In the near future we will have a chance to measure the predictability of the models built for the LCCA as all the three species are currently enlarging their ranges towards the core of the Alpine Range (the bear from the east, the lynx from the west and the wolf from the south and possibly, from the east as well).

Simply said, the models where built maximising the available knowledge on the species. Known territories of the three species where used to derive their ecological requirements using the available environmental variables. Based on these characterisation of the ecological requirements, the entire study area was classified for ecological suitability according to a distance measure of the ecological characteristics of each portion of the study area from the ecological requirements of the species.

The results were produced in the form of maps depicting areas of increasing suitability. The first three classes used to produce the maps were considered to be respectively the core areas of the species distribution and its connecting matrix. The rest of the classes represent areas of decreasing quality reaching down to intensive agricultural sites and densely populated areas.

A summary of the final report produced for the LCCA project is included in appendix as integral part of the present report.

Although the LCCA project produced valuable information suitable for setting conservation priorities for each one of the three species analysed, the joint view of a synergetic conservation strategy addressing the three species (and potentially many other, being the bear, the lynx and the wolf three widely recognised umbrella species) as a whole was only marginally targeted and based essentially on a visual comparison of the three maps.

This report fills this gap in that it targets the development of a derived model which combines the other three and that can be used to address more synergetic conservation strategies.

Before going into the detail of the methodology used, it may be important to address a few words to the corridor concept and how it is used in this report. Although the ecological corridor concept is widely spread in conservation biology there are only vague definitions and, even worst, there is no accepted methodology to "design" corridors.

There are two main categories of ecological corridor design methods, and they derive from the convergence to the problem of nature conservation of two major branches of ecology:

landscape ecology on one side and animal and behavioural ecology on the other. Following the approach of the landscape ecologist, an ecological corridor is a portion of the landscape (generally elongated along one direction) with a certain level of pristine environments, and that connects wider patches of pristine environments. According to the animal and/or behavioural ecologist any portion of the landscape can act as a corridor for a given species as long as there is a level of environmental quality that allows individuals of the species to use it during dispersal.

There are advantages and drawbacks in both approaches. While the first enables an easier identification of landscape components (e.g. riparian vegetation) which can be classified as “corridors”, it is only loosely connected to real dispersal process of the species and leaves open to subjective judging the definition of "pristine environments". On the other hand the second approach is more “process oriented”, as it tries to account for species perception of the environment, but has the drawback of being more complicated on the side of corridor design, not being related to any specific landscape components and can only be applied on a species per species basis, given that each species has its own ecological requirements and a different perception of the environment.

The models used for this report follow the second approach, using environmental suitability as the drawing tool for a connectivity network which takes its steps from areas of known presence and enables some inference on the possible expansion of the ranges of the three species. Furthermore the methodology described in the next paragraph is a proposal for an operational solution to the specificity of the species environmental quality models.

Methodology

Within the multidimensional space defined by the environmental suitability indexes of the three species analysed, each location of the study area can by plotted as a point. All the locations of the study area thus form a cloud of points within the same space. The cloud can be analysed to derive the most informative summary variable which, under specific circumstances, can be used to produce a map of joint ecological suitability of the species analysed. In the following paragraph the general steps to implement the models are described, while for further detail on the methodology used to derive the original suitability models for each one of the three species and the characteristics of the original environmental variables used for that analysis, the reader can refer to the full report of the project “Large Carnivore Conservation Areas” (IEA, 1998).

Building the synthetic model

The model has been implemented following three steps.

The original ecological suitability models were standardised subtracting the average value of the ecological suitability observed within the known territories of the species and dividing by its standard deviation. The resulting models had exactly the same characteristics of the original ones except for the fact that they averaged to zero (within the areas of the known territories) and that suitability was measured in terms of standard deviation from each one’s average.

This first step minimises the problem connected to the species-specific nature of the original models. According to Corsi *et al*. (1999) models based on the ecological distance from known species ecological preferences can only be interpreted as relative measures of suitability within each individual model; that is a value of 100 in one model does not compare to a value of 100 in another model. Standardisation based on the observed ecological distances within the known territories minimises this problem as it defines an equal unit of measure (standard deviations of observed ecological distances within the known territories) and an objective point of origin (the average of observed ecological distance within the known territories).

The three standardised models were used to perform a principal components analysis (PCA). PCA extracts summary variables which are linear combination of the original ones (in our case the environmental suitability indexes of the three species). Each summary variable is uncorrelated to the others and accounts for a percentage of the total variability of the original cloud. Summary variables which account for higher percentages of the original variability conserve most of the original information content of the cloud and thus can be interpreted instead of the original cloud.

Due to the very special nature of the model under development one of the constraints which need to be imposed to the summary variables is not only that it accounts most of the total variability of the original cloud, but also that it is homogeneously correlated to each one of the variables. Should the summary variable be directly correlated to two variables and inversely correlated to the other, its interpretation would have very scarce ecological meaning. Luckily our original environmental suitability models for the three species have broad areas of unsuitable conditions which tend to overlap and which drive the PCA process towards high degrees of homogenous correlation between the resulting variable and the three original ones.

Finally the summary variable has been partitioned to produce a map depicting joint environmental suitability for the three species. Like for the LCCA maps, also in this case it was chosen to produce the maps with a legend with seven classes. Nevertheless here the partitioning process was based on the comparison between the observed values of the joint suitability and the core areas of the species distributions derived from the original models. Thus the first class represent all values of suitability up to the average value observed in the areas highly suitable (first class of the original model) for all three species, the second extends up to the average plus one standard deviation. The third goes up to the average value observed within areas highly suitable only for two out of three species (the fourth being the same value plus one standard deviation) and the fifth is up to the average value observed within areas highly suitable for only one species (the sixth, again, being this last value plus one standard deviation). The seventh class accounts for the rest of the values obtained.

Although there may be some circularity in the process of deriving the classes of the legend it is extremely functional to the subsequent interpretation of the models as each class represents increasing opportunities of synergetic approaches towards the conservation of the three species.

To assess potential uses of the model it was overlaid with protected areas and areas of potential conflict between the three carnivores and human activities. The characterisation of these areas based on the result of the model can help to address management actions that can increase conservation potentials.

Results

The following have to be kept in mind in interpreting the model:

– Although the model can be very detailed, for the nature and the limitations on both the data sets and the type of analysis, interpretation should be limited to a regional scale and should concentrate on the general trends observed in the region.

– The last class of suitability (class 7) includes ecological distances of the original species models that are quite high (up to infinity). Thus other parameters must also be taken into account, especially when considering this class as a potential barrier. For instance, although both areas around large towns and areas around permanent icefields tend to pertain to this class, the ecological interpretation of the two barriers may be quite different. In fact, the disturbance caused by human activity should be regarded as dynamic and active, thus affecting the surroundings of the actual area humans occupy, while the disturbance produced by extreme ecological conditions is static and passive, limiting the negative influence on the areas it occupies. The maps distinguish major towns and areas above 2500 meters to help in the interpretation process.

– For many countries, the data obtained for the efficacy of protected areas suffers from major shortcomings and this calls for some caution in reading the results.
– All variables which influence the species' distribution but cannot easily be included in a spatial analysis, such as historical constraints or the species' behavioural patterns, are assumed to be represented by the Extent of Occurrence (EO). In this methodology, mapped results should be read as expected environmental suitability within the EO and potential environmental suitability outside the EO.

Due to the process used and to the nature of the data involved (see methodology, discussion on correlation between original variables and summary variable) the PCA gave highly significant results. The first principal component (PCA1) accounts for over 74% of the total variance and is directly correlated to all the three suitability indexes of the three species. Furthermore it is highly correlated to all three of them; respectively 0.91 for the bear, 0.83 for the lynx and 0.85 for the wolf.

To allow a better interpretation of the results described in the following paragraphs, Table 1 shows the percentage of each one of the countries included in the study area.

Table 1 Percentage of each country included in the study area

Country	%
Austria	74
France	13
Germany	6
Italy	32
Switzerland	100

Transferring the results of PCA onto a map (Figure 1) shows essentially the same overall structure already observed in the individual suitability models (refer to: “Large Carnivore Conservation Areas” - IEA, 1998). A narrow strip of suitable environments connecting the Alps to the Appennines towards south and a widening of the suitable areas on the Alpine Range moving eastwards along with a general increase of suitability. Areas suitable for all three species (first two classes) account for just below 7.5% (just over 22 000 km^2) of the entire study area, while considering suitability for at least one species brings the percentage slightly above 60% (about 183 000 km^2).

Broad areas of general concern can be identified north of Genoa, in the corridor connecting the Appennines to the Alps; in the western Alps, along the border between Italy and France and Italy and Switzerland, where the presence of high peeks increases the fragmentation of the entire area; in the Swiss Mittelland which separates the Jura Range from the rest of the Alps; and finally in the Adige Valley which wedges deep inside the suitable areas of the eastern Alps.

Interesting are the areas of high suitability for all three species in the western part of the Alpine Range. Although most of the areas are not occupied by any of the species, most of them are well within the reach of at least the lynx and the wolf and some are already included into protected areas (e.g. the National Park of Vercors and the PAs of the Haut-Giura and of la Chartreuse on the French side of the Alps). Similarly the patchy structure of areas of the first two classes included in wider areas pertaining to the other four suitable classes seem quite promising for the future expansion of the species range in the central and eastern portion of the study area.

For the analysis of the overlay between the model and the other GIS layers available it has been decided to produce tables with joint figures for the classes 1-2, 3-4 and 5-6. Although the original six classes are very functional to increase the readability of the maps they would decrease it in the tables. Please keep in mind, when looking at the tables, that the threshold for the even classes (2, 4, and 6) is equal to that of the odd classes (1, 3, and 5) plus one standard deviation. Combining the two classes accounts for slightly more than 68% of the total variability of the measure of joint suitability within optimal areas for 3, 2 and 1 species respectively.

Table 2 Surface and percentages of the different classes of joint suitability within the known Extent of Occurrence (EO) of the three species

		1-2	3-4	5-6	7	Total
Bear	km^2	1 697	2 959	879	26	5 561
	%	30.52	53.21	15.80	0.46	
Lynx	km^2	4 566	8 133	13 295	3 726	29 720
	%	15.36	27.37	44.73	12.54	
Wolf	km^2	177	1 045	2 607	157	3 987
	%	4.45	26.21	65.39	3.95	

The detail analysis of the overlay between the known extent of occurrence (EO) of the three species and the joint suitability model (Table 2) shows that the present range of the species is distributed mostly within suitable areas (classes 1 to 6).

Only the lynx shows a higher percentage of EO (12.54%) which falls within the unsuitable class, this probably reflects a yet unstable situation which could be due to the reintroduced origin of the populations from which the ecological characterisation was derived. As a general comment, the higher percentages of bear’s EO within the first two classes account for its higher selectivity; considering the way the classes where defined, the species that has the more strict ecological requirements drives the process defining the principal constraints of the joint suitability index. As a matter of fact, the wolf being the most opportunistic of the three species, shows a higher range of adaptation with higher percentages in the classes 5 and 6.

Table 3 Overlay with available protected areas (PAs) in the study area. Figures show a) proportion of total PAs surface within each suitability class and b) proportion of each suitability class within PAs.

		1-2	3-4	5-6	7	Total
a	km2	3 553	6 684	7 795	5 400	23 431
	%	15.16	28.52	33.27	23.05	
b	km2	22 102	62 937	98 121	113 931	
	%	16.07	10.62	7.94	4.74	

Unfortunately the overlay of protected areas with the model suffers form the very low quality of the PAs data set (Figure 2), and thus Table 3 is only given here as a general indication of the efficacy of protected areas. The rather homogeneous distribution of the percentages of total PAs surface within the various classes of the model evidences the many different scopes that drive the process of setting up a protected area. Many protected areas are devoted to the conservation of natural heritage and cultural sites thus limiting theirefficacy for the protection of wildlife. Nevertheless when we analyse the proportion of each class that is included within the protected areas we see that a rather high percentage (16%) of the first two classes fall within PAs.

Table 4 Percentage of protection granted by each country to the different classes of joint suitability

	1-2	3-4	5-6	7
Austria	7.63	10.70	9.82	1.52
France	41.93	23.89	44.04	31.17
Germany	0.22	4.98	7.80	1.51
Italy	49.56	58.42	37.94	65.76
Switzerland	0.65	2.02	0.39	0.03
TOTAL	100.00	100.00	100.00	100.00

If we look at the detail of the contribution of each country to the overall protection of the suitable areas (Table 4) the bias in the PAs data sets becomes quite evident. The data set can be considered almost complete for Italy, and this country accounts for highest percentage for all the classes but one (5-6). While for Germany and for Switzerland the data set contains very limited information (only one protected area in Switzerland). Interesting is the situation in France, where although the data set is far from complete, PAs seems to be very well located with respect to the results of the model.

Table 5 Percentages a) of each country pertaining to each joint suitability class and b) of each joint suitability class within each country

		1-2		3-4		5-6		7		
			B		**b**		**b**		**b**	
Austria			49.40		32.88		19.88		10.02	
	a	17.46		33.09		31.19		18.26		100.00
France			20.51		19.71		30.02		22.95	
	a	6.25		17.10		40.61		36.04		100.00
Germany			0.10		2.35		11.75		9.00	
	a	0.10		6.34		49.50		44.06		100.00
Italy			25.64		28.14		23.60		44.65	
	a	5.82		18.18		23.77		52.23		100.00
Switzerland			4.35		16.92		14.75		13.37	
	a	2.33		25.77		35.03		36.87		100.00
			100.00		100.00		100.00		100.00	

Further comparison can be made between the proportion of each joint suitability class within each one of the countries and the percentage of overall availability of each class which is included in each country (Table 5). Austria shows the highest percentage of its territory which is classified by the model in class 1-2 (almost 17.5%) and contributes to the overall extension of this class by almost 50%. Similarly this country contributes the highest percentage of land (about 33%). Considering that almost 75% (Table 1) of the country is included in the analysis, the importance of Austria for the conservation of the large carnivores populations is quite high.

An intermediate situation is shown for France and Italy which give similar contribution to the overall extent of classes 1-2 and 3-4 (around 6% and around 17.5%, respectively). The two countries diverge in the extent (and percentage contribution) of the last two classes; Italy's figure is highly influenced by the inclusion in the study area of most of the Pianura Padana (Table 6) which increases the overall contribution of the country to class 7 (almost

45% of the total) and gives to the country the highest percentage of unsuitable land (well over 50%).

Switzerland, whose territory is totally included in the study area, show a rather low overall suitability. This situation is probably linked to the low rating of the entire Mittlelland (Table 5) and the very low percentage of areas of class 1-2 (only 2% of the entire country).

According to the model, the situation of Germany is even worse. Nevertheless only 6% of the country is included in the analysis and its territory is located at the northern limit of the Alps, at the periphery of the Range.

Table 6 Extent of areas of potential conflict with human activities and percentage of total extent within each joint suitability class

		1-2	3-4	5-6	7	Total
France	km^2	721	2 587	7 368	5 122	15 798
	%	4.56	16.37	46.64	32.42	
Italy	km^2	223	455	1 244	1 339	3 260
	%	6.84	13.95	38.15	41.06	

Areas of potential conflict between carnivores presence and human activities (Table 6) were defined as the areas where the livestock densities (sheep and goats) is higher than the average national density. Table 6 shows the result of the overlay of these areas with the model. This analysis was limited only to France and Italy as these two countries were the only ones for which livestock data were available. It is important to notice that the total areas of potential conflict in the two countries varies considerably; while in France it represents 22% of the total surface of the country included in the study area, in Italy it is only 3% of the total. In Italy sheep-rearing is mostly concentrated in the central and southern parts of the country, areas which are not included in the study area. In the study area the problem does not seem to be particularly important, given that more than 40% of the areas of potential conflict fall within the less suitable class.

On the other hand, in France the Provence area up to the Rhone-Alps has very high densities of sheep and goats. According to the model only 4.5% of the total potential conflict area falls within the most suitable classes, nevertheless this accounts for almost 16% of the total availability of class 1-2 in France. Moreover considering all suitable classes the total percentage of areas with both high densities of livestock and potential presence of large carnivores rises to just below 68%. Considering that the entire area is well within the reach of both individuals of wolf and lynx dispersing from their present range, the chances of conflicts are very high.

Discussion

Models are simplified and partial picture of reality. They are meant to provide interpretation keys that can help in the process of understanding natural phenomena.

To this extent the model developed for this report is meant to provide the “big” picture of potential distribution of three species of large carnivores in the Alpine Range. The “big” picture means that this model can be used to highlight regions which will need further investigation to assess their correct placing within the context of species conservation.

There is a broad literature on the different aspects that influence models reliability and use. This range from generic issues on assumptions and validation which influence any type of model to more specific issues concerning scale, portability and species-specificity that concern more directly the model presented here. For a more accurate discussion on these issues we refer the reader to one of the many papers available on the topic (e.g. Corsi *et al.* in press).

Here we would like to discuss one specific aspect: is it worth it? The answer can be found in the many different issues that are targeted by these kind of models. And obviously these same issues can help in defining the limits and the range of applicability of these models!

First of all it is generally accepted that the knowledge accumulated in many years of practice is synthesised by the specialist which defines the action plan for the species. Similarly when there comes the need to integrate the management of a number of different species, the problem is targeted finding the best compromise between the arguments of the different specialists which tend to defend "their" species.

Far from being the final response to the problem, models can bring some objectivity into the discussion. What are the synergies between the different species? Can we find a "statistical" (objective?) weight for each species when combining them? Can we have a "number" which identifies the overall performance of a given place for the conservation of a certain number of species? Probably the answer is that we still need more research (which is certainly true) because we don't even know why a given species is in a certain place and not in others. We cannot predict that we will find an individual of a given species in a certain place and to the best of our knowledge, in some cases, we can state that we will not find a given species "outside" its known geographical range.

On the other hand there is a problem of being active before it is too late. If we could stop the succession of natural events up to the point when we will understand the underlying processes, then we could safely wait until the moment in which we will be able to master the entire biosphere. Unfortunately we need to cope with constantly changing situations which can rapidly drive to obsolescence even the most proven knowledge. Models can help extract the most of the information available at any given point of our current knowledge. There is much more behind the fact that an individual of a species has been studied and followed in a territory. For instance the ecological characteristics of that territory can be compared with the ecological characteristics of the areas surrounding the territory. Using statistical techniques it is possible to identify areas that are "similar" to the one that has been studied. The result is that, if every individual of that same species acts in the same way as the one that has been followed (the model's simplification!), we are describing other potential territories locations. What we achieve is not reality but a simplification that can draw our attention towards specific sites, thus helping us in the process of defining priority sites for further investigations.

Finally, going back to the "big" picture, species management (especially when dealing with big carnivores, such as the ones targeted by this report) cannot be only a local matter. And this is especially true in a fragmented and crowded environment such as the European continent. The population dynamics of carnivores in Europe (western Europe) is essentially that of a meta-population. If there is no way of linking the population patches into a functional network which guarantees the necessary exchange of individuals among different populations, then our goal of conserving the species is lost. Again, the "big" picture helps in addressing those areas that are most critical, either because they can act as source areas or because they can be an obstacle to free ranging individuals, for the species.

Furthermore we must not forget that within heavily populated areas such as Europe, the need to accommodate different needs of different actors in the management of the resources (among which we must enumerate also wildlife) is extremely important. Thus the need to identify potential priority areas which need total protection and secondary areas were, due to conflicting activities and interests, the species needs to be removed is very important. This can only by achieved through a regional analysis that can give the necessary overview to the problem.
We hope that this is enough to set the scope and the limits of the present report. The areas highlighted in the results paragraph are the result of the extrapolation of our current

knowledge to the entire study area. Different levels of knowledge on the different species influence their individual models. We are quite confident that the wolf model is providing a fair picture of the environmental suitability for the species. Evidences of wolf range expansion are in total accordance with the results of our model.

Not quite the same for the lynx and for the bear. Both models are based on very limited data sets and for the lynx they are only based on reintroduced individuals. This limits our ability to get hold of the complete spectrum of ecological variability that suites the species; which can eventually be transmitted to the result of the models through an underestimate of the environmental quality for the species.

We do not want to hide that critiques were risen following the presentation of the results of these last two models. Areas that appeared underestimated from the model were criticised by the species experts arguing that many of them will certainly host the species in the near future. This is part of the scope of the models themselves. Highlighting inconsistencies drives the process a step backwards allowing to identify the lack of information currently available for the species. At the same time, models such as the ones used for this report, can be constantly enhanced integrating in the process new information that becomes available.

Obviously there is a need to assess how this two models influence the overall reliability of the synthetic model implemented for this report. The highest correlation observed between PCA1 and the bear suitability index would suggest the this species is influencing the overall model the most. Thus considering absolute values obtained by the model, there might be an underestimate of quality. Nevertheless the process used to partition the classes to draw the map ensures that, at least for the last two classes (5 and 6), the actual representation should reflect the real situation (the wolf accounts for most of the areas where suitability is high for only one of the species, and the wolf is probably the most opportunistic species of the three).On the other hand there may be some chances of underestimating the real extent of higher classes (e.g. 1 and 2).

Recommendation

The result of our work must be a stimulus to undertake more detailed studies in the areas evidenced by the analysis to be of particular interest. Just to summarise the results by country we can outline to following points that emerge from the model:

- Most of Austria has been rated among the suitable classes by the model. The entire area could become an important source for viable populations of large carnivores in the region. For this country, however, the model is based on some data set of lesser quality (e.g. population data were only available at the NUT 3 level, whereas the other countries had data up to the NUT 4 level). It would be safe to conduct a more detailed analysis of the ecological conditions within the country to increase the reliability of the model.
- Although France is not as outstanding as Austria, it represents the core of the present expansion of the ranges of wolf and possibly of the lynx. The large patches of very suitable areas, particularly those included within protected areas, appear to guarantee the survival of healthy populations in the area. Nevertheless the risk of rising conflicts with human activity calls for adequate management of the species. Further analyses should address in more detail the extent of the potential conflict.
- The limited extent to which Germany is included in the study does not allow any specific recommendation, apart from the general ones valid for all countries. Nevertheless its location at the margin of the suitable areas calls for adequate co-ordination with neighbouring countries (e.g. Switzerland and Austria) to maximise the efficacy of conservation actions.
- Italy has been up to recent years the source of an expanding wolf population. Most of its problems and issues related to large carnivores conservation are located in the central

and southern portion of the country. As for the area included in the study, there are some evidences of an expansion of the range of the wolf from France into northern Piemonte and in Valle d'Aosta, a similar, more detailed study as been conducted by IEA in Valle d'Aosta to assess local ecological conditions for the bear, the lynx and the wolf. Of great concern appears to be the situation of the relict population of bear in the Adamello-Brenta.

– The situation in Switzerland appears to be less favourable than in the other countries (except for Germany) and this calls for more accurate studies within the country to assess its cause. Among the causes there may be some inconsistency between the data sets used available for the analysis for Switzerland and those used for the other countries (Switzerland does not have a standard Corine land cover data set), but there may be also other important causes more connected to the land use pattern of the country. Due to the high expectation and the related issues connected to the expansion of the lynx, it is advisable to conduct a more accurate analysis at the local level to clarify the causes of the poor rating of the present model.

To conclude, this is only one of the possible ways of targeting the problem of identifying ecological corridors and hence of defining ecological networks. Other methods use a deductive approach based on experts knowledge of ecological requirements needed to set up a corridor for wildlife. The model presented in this report is based on the assumption that corridors are species-specific and that what may be a corridor for a species can be a barrier for another one. Following this belief we recommend that the implementation of an ecological network should be preceded by accurate modelling of the environmental suitability based on the available information for as many species as possible. Such models will be the answers to the original question of allocating land to the network, but will be the starting blocks to discuss the implementation of a functional network which will address the needs of as many species as possible.

Developing models at the national level, and possibly at a trans-national level, can help to define conservation strategies which minimise the negative interactions with human activities and maximises the chances of survival for the species.

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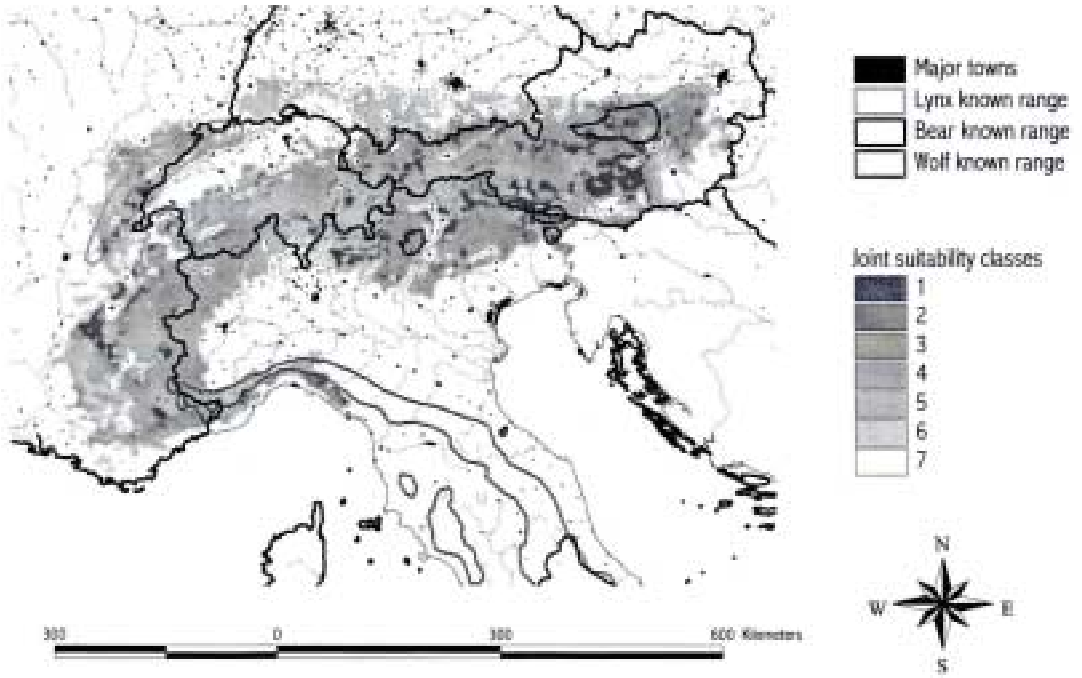

Figure 1 Map showing the result of the principal component analysis and the study area (areas outside the study area are masked in white)

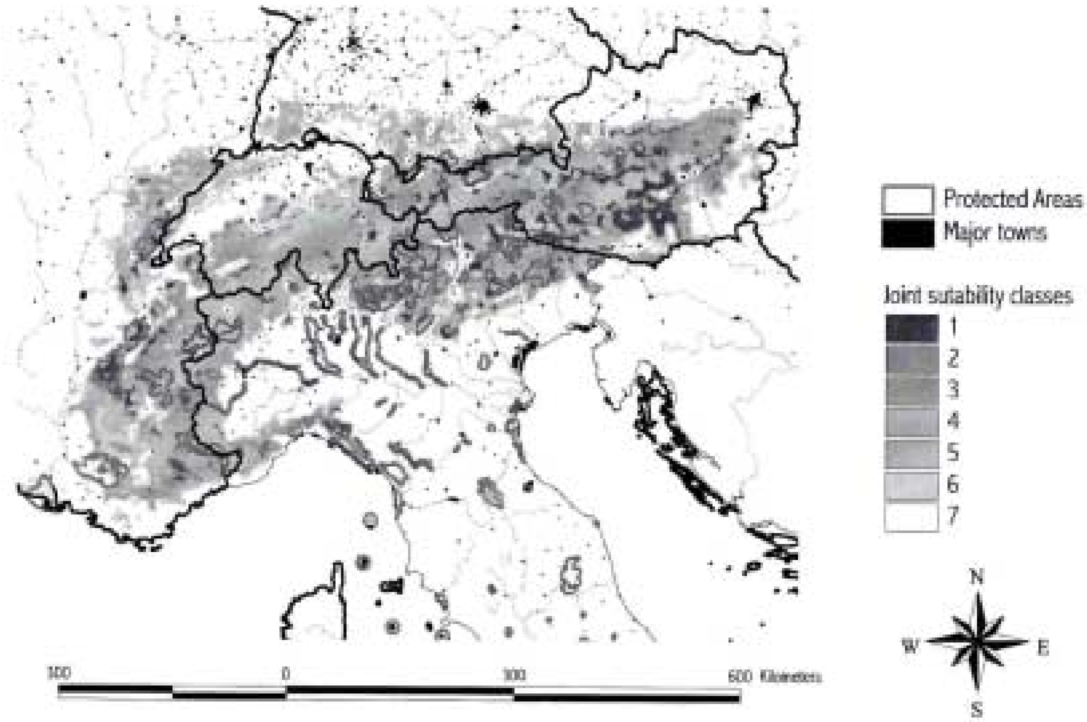

Figure 2 Overlay of protected areas data set on the joint ecological suitability model

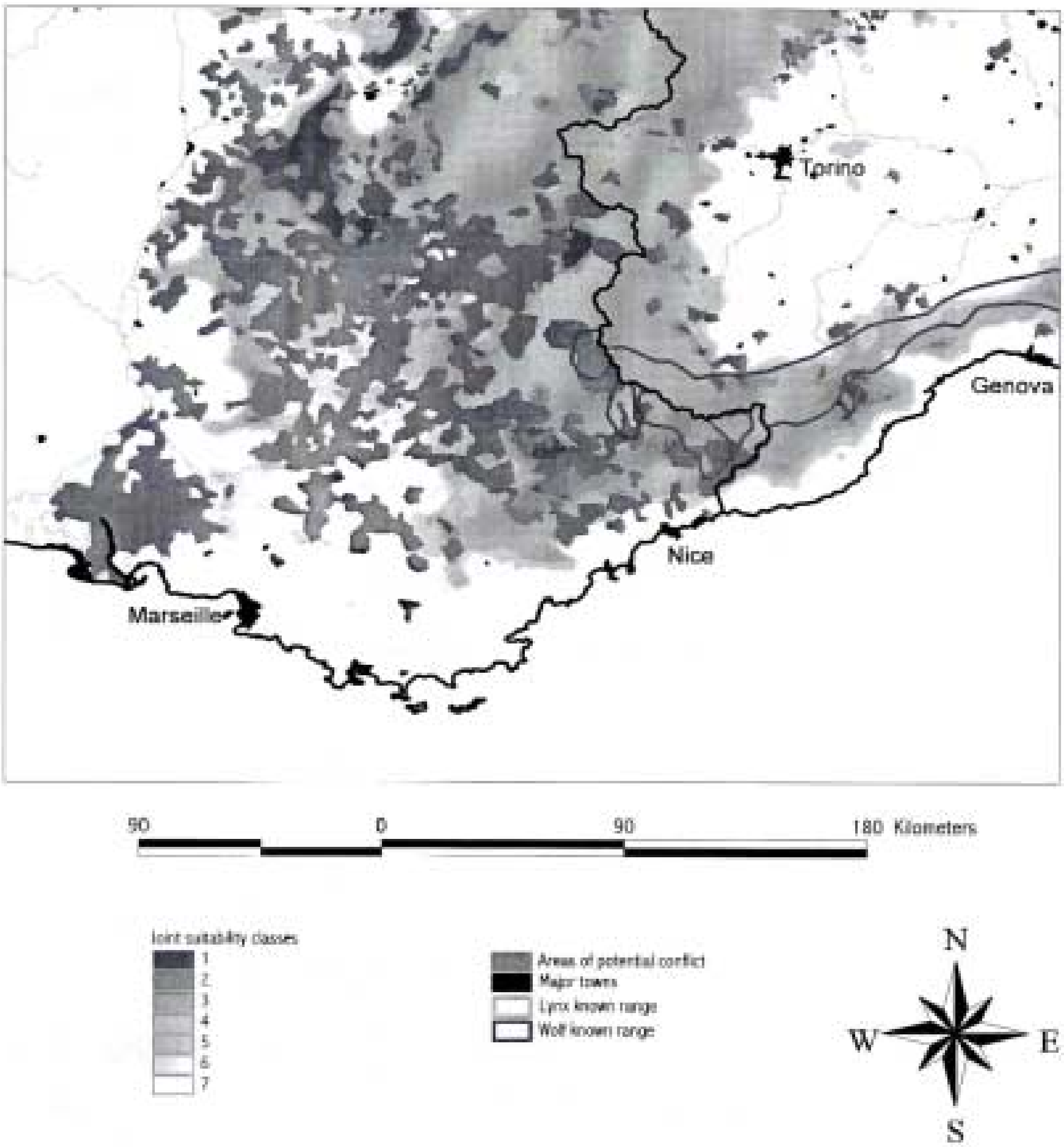

Figure 3 Map of potential conflicts between large carnivores presence and human activities

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