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PLANNING THE BROWN BEAR *URSUS ARCTOS* REINTRODUCTION IN THE ADAMELLO BRENTA NATURAL PARK. A TOOL TO ESTABLISH A METAPOPULATION IN THE CENTRAL-EASTERN ALPS

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ABSTRACT - In the 17th century, brown bears (*Ursus arctos*) were still abundant and widely distributed over the entire alpine area of northern Italy and even in large, dense forests of the prealps and the Po plain. The start of the decline coincided with increasing deforestation for farming at the end of the 18th century and, in the 19th century, increased access to previously remote wilderness areas of the prealpine and alpine mountains, where direct persecution by farmers and hunters caused the extinction of local bear populations. The last remnant population that occupied the Adamello-Brenta Alps was considered biologically extinct since 1989 (only three, non-reproducing bears). Here we present an analysis of the reintroduction process as the most suitable tool for brown bear recovery in the Italian Alps, taking into account both the benefits of reinstating a viable population and the risks that the coexistence between man and bear could cause. The reintroduction process is discussed aiming at an evaluation of its contribution to the global future efforts for brown bear conservation in the alpine region.

A GIS-based habitat suitability analysis was implemented to test for good-quality bear habitat in a vast mountainous area around the Adamello-Brenta Natural Park (6500 km^2), the release site of bears. The model was based on presence/absence data, gathered over the last 20 years, and habitat parameters in 25 ha cells in the core-area of the remnant bear population (645 km^2 study area). Other parameters of human disturbance and livestock densities, were considered at the scale of the municipality. Bears positively selected deciduous forest but seemed to avoid areas with intensive pasture activity, mainly of horses and sheep, despite the latter being a potential prey. Habitats containing large amounts of bare rock, farmland and urbanised areas were avoided. There were no significant differences between municipalities with and without bears in human population density and intensity of tourism. The

importance of a wide-scale and detailed analysis of human attitude towards the project and of education strategies to increase acceptance by local people are discussed.

Key words: *Ursus arctos*, reintroduction, metapopulation, Adamello-Brenta Natural Park, Italian Alps

RIASSUNTO – ***La reintroduzione dell'orso bruno (*Ursus arctos*) nel Parco Naturale Adamello Brenta: uno strumento per il ripristino di una metapopolazione nelle Alpi centro-orientali***. Nel XVII secolo gli orsi (*Ursus arctos*) erano ancora abbondanti ed ampiamente distribuiti in tutta l'area alpina dell'Italia settentrionale e nelle aree densamente forestate delle Prealpi e della Pianura Padana. Il declino delle popolazioni ebbe inizio a partire dal XVIII secolo con l'aumentare della deforestazione per ottenere maggiori aree coltivabili e, nel XIX secolo, si ebbero fenomeni di estinzione locale, causati principalmente da abbattimenti. La popolazione alpina residua, composta esclusivamente da 3 individui che non si riproducono dal 1989, occupa oggi l'area coincidente con il Parco Naturale Adamello-Brenta ed è da considersarsi biologicamente estinta.
Nel presente lavoro vengono analizzati rischi e benefici della reintroduzione, intesa come strumento ritenuto maggiormente idoneo per il recupero dell'orso bruno sulle Alpi italiane, con una valutazione più ampia sulla conservazione della specie estesa all'intero contesto della regione alpina. Le aree maggiormente adatte alla reintroduzione sono state identificate mediante un modello di valutazione della qualità dell'habitat basato su di un Sistema Informativo Territoriale. Il modello ha preso in considerazione tutte le segnalazioni di presenza dell'orso bruno relative agli ultimi 20 anni registrate nell'area del Parco Naturale Adamello-Brenta (6500 km^2), unitamente ad alcune variabili ambientali associate ad unità discrete di 25 ha ciascuna rilevate entro il territorio occupato dal nucleo residuo (645 km^2). Sono stati presi in considerazione anche alcuni fattori di disturbo antropico nonché la densità del bestiame, anche se ad una differente risoluzione spaziale, ovvero a livello di comune.
Il modello ha evidenziato un'influenza positiva delle foreste decidue sulla probabilità di presenza ed un effetto negativo per le aree sottoposte a pascolamento equino ed ovino, nonostante le greggi possano costituire potenziali prede. Un analogo effetto negativo è stato evidenziato per aree caratterizzate da presenza di roccia nuda, agroecosistemi ed aree urbane. Non sono state riscontrate influenze significative sulla probabilità di presenza dell'orso bruno a livello di comune per quanto concerne gli effetti della densità di popolazione umana e dell'intensità del flusso turistico.
Viene inoltre evidenziata l'importanza di un sondaggio dettagliato svolto su ampia scala per valutare l'atteggiamento delle comunità locali nei confronti del progetto di reintroduzione e sulle strategie di educazione ambientale adottate al fine di incrementare l'accettazione del progetto stesso da parte delle comunità locali.

Parole chiave: *Ursus arctos*, reintroduzione, metapopolazione, P. N. Adamello-Brenta, Alpi italiane.

INTRODUCTION

One of the major challenges of conservation biology is obtaining a broad consensus amongst local populations for the reintroduction, or even natural recolonisation, of large carnivores into areas of their historical range. The main problems with large carnivores, apart from their large area requirements, can be summarised as follows: (i) predation on wild prey populations causing conflict with hunters; (ii) damage to livestock, and, in the case of bears (*Ursus arctos*), beehives and some crops, causing conflict with farmers (Mysterud, 1980; Clevenger *et al*., 1994; Adamic, 1997; Koren and Adamic, 1997; Rauer and Gutleb, 1997, Quenette *et al*., 1997; Sørensen *et al*., 1999); and (iii) direct aggressive encounters with man (Herrero and Fleck, 1990; Kaczensky, 1996; Cicnjak and Ruff, 1990; Ciucci and Boitani, 2000), whereby the species is considered a direct personnel threat and a potential threat to tourism. Because of these problems, and previous negative experience with brown bear reintroductions and public attitude in other European countries (Rauer, 1997; Quenette, 2001), a large-scale public awareness campaign and polls targeted on various interest groups were considered a first step in a feasibility study for brown bear reintroduction in the eastern Italian Alps (Dupré *et al.*, 1998).

Reintroduction of brown bears has been a major topic in wildlife management and conservation of alpine landscapes and species in Italy for more than a decade, since it became obvious that the last population in the Italian Alps was declining rapidly and threatened with extinction (Lande, 1988; Mace and Lande, 1991; McLellan, 1994; Duprè *et al.*, 1998).

We use the term "reintroduction" to refer to the translocation of wild-caught animals into the historic range of an extinct species to re-establish wild populations. Reintroduction has proved to be a valuable tool for the recovery of large predator species that have become either globally or locally extinct in the wild (Phillips, 1995; Fritts *et al.*, 1997), but pose several biological, logistics, organisational and even legal problems that might jeopardise its success (e.g. Griffith *et al.*, 1989). This is even more so for large predators for two reasons: the traditional conflict between man and large predators, especially in areas with rural activity, and their habitat requirements. Bears can have very large home ranges (mean home range size for males and females respectively: Scandinavian population 5430 km^2 and 345 km^2, Croatian population 128 km^2 and 58 km^2, Trento relict population 100 km^2 and 300 km^2, Dupré *et al.*, 1998). Thus release areas for population re-establishment must be very large and corridors should exist between different blocks of suitable bear habitat to allow the formation of a metapopulation, as is the case for the South-East Balcan population (Mertzanis, 1999; Spassov and Spiridonov, 1999) (Tab. 1). Moreover, any predator reintroduction project must be met by a wide consensus of the local human population, particularly in those socio-economic environments where direct interaction, thus potential conflict, with the released animals can exist (Phillips, 1995; Woodroffe and Ginsberg, 1999). Taking into account the future expansion of the re-established population, also people inhabiting

Table 1 - Status (1997-98) of the 12 existing brown bear populations in Europe.

Population	Distribution (km^2)	Population size	Metapopulation structure*	Risk factors and Status	References
Russian	Russia, Finland, parts of Norway	37500	No	Not at risk.	Nyholm and Nyholm, 1999; Elgmork, 1994; Swenson *et al.*, 2000
Carpathian	Slovakia, Poland, Ukraine, Romania (38000)	8100	No	Not at risk.	Frackowiak *et al.*, 1999; Hell and Findo, 1999; Ionescu, 1997; Swenson *et al.*, 2000
Dinaric-Baltic	Eastern Alps in Austria and Italy, ex-Yugoslavia, Albania and northern mountains of Greece	2800	Yes, risks of isolation between sub-populations	Increase of Slovenian and Croathian subpopulations with colonization of Carinthia (Austria) and Friulian Alps (Italy).	Sorensen, 1990
Scandinavian	Sweden and Norway border	1000	No, four isolated populations	Increasing after bottleneck (130 ind.) in 1930.	Swenson *et al.*, 1995, 2000; Sorensen *et al.*, 1999
Mount Apuseni	Mountains of Bihor, Romania	600	Became isolated from Carpates population	At risk. Decreasing, poaching, habitat fragmentation.	Dupré *et al.*, 1998; Ionescu, 1997
South-east Balcan	Mountains of South-West Bulgaria (Rila, Pirin) and North-East Greece (Rodope)	520 (Greece 20)	Yes, three distinct sub-populations	At risk. Decreasing, poaching.	Dupré *et al.*, 1998; Mertzains, 1999; Spassov and Spiridonov, 1999
Central Bulgaria		200	Isolated population	Endangered. Decreasing, poaching, illegal persecution.	Spassov and Spiridonov, 1999

Table 1 - (continues)

Population	Distribution (km^2)	Population size	Metapopulation structure*	Risk factors and Status	References
Western Cantabric	Mountains of Western Cantabria (2600)	50-65	Isolated population	Critically endangered. Decreasing, increased rural activity and disturbance.	Cienfuegos and Quesada, 1997; Palomero *et al.*, 1993; Clevenger *et al.*, 1999
Eastern Cantabric	Mountains of Eastern Cantabria	20	Isolated population	Near extinction. Decreasing, illegal persecution.	Clevenger and Purroy, 1997; Clevenger *et al.*, 1999; Swenson *et al.*, 2000
Pyrenaic	Western Pyrenees (1115)	4/5 in the western part, 6 in Central Pirenes (last reproduction in 1995 and 1998)	No	Near extinction. Decreasing, illegal persecution by shepherds.	Quenette *et al.*, 1997, 2000
Abruzzese	Abruzzo National Park and surrounding Appennine mountains, Abruzzo, central Italy (4000)	40-80	No	Endangered. Subspecies *U. arctos marsicanus*. Stable over last century.	Fabbri *et al.*, 1983; Boscagli, 1987, 1991
Trentino	Brenta Dolomites (545 in 1995-97)	3 (see further)	No	Near extinction.	This study

*With metapopulation structure we refer to a set of sub-populations occurring in different blocks of suitable habitat that show regular dispersal between sub-populations.

areas with potentially suitable bear habitat around the release area must be included when an educational campaign of the public for the project is starting.

Recent plans for brown bear recovery in the Italian Alps were primarily based upon reintroduction, and reintroduction attempts were already carried out in the Austrian Alps, (Gerstl *et al.*, 1999), and in the Pyrenees (Camarra, 1997a; Quenette *et al.*, 1997). Based on these plans, we describe the historical changes in the range of the brown bear in the Italian Alps and the causes of its near extinction, and evaluate the extent to which reintroduction may contribute to the global future efforts for brown bear conservation in the alpine region. In particular we highlight the importance of a wide-scale and detailed analysis of human attitude towards the project and of education strategies to change this attitude where necessary. We underline the necessity of sufficient financial support for the logistic, scientific and socio-economic aspects of the project and the need for co-operation at various political levels to eliminate administrative and legal complications.

Within this context we present a GIS-based habitat suitability analysis for the release area, the Adamello-Brenta Natural Park (Trento province, North-Italy), and a wide mountainous area around the park.

METHODS

ANALYSIS OF THE PAST AND PRESENT BROWN BEAR DISTRIBUTION IN EUROPE

An analysis of the available literature on brown bear in Europe was carried out, in order to collect further information and to review the past distribution of brown bear throughout Europe (Sørensen, 1990; Servheen *et al.,* 1999). This allowed us to identify the existent European populations, and to clarify the potential relationships among them.

ANALYSIS OF THE PAST REINTRODUCTION IN EUROPE

The same approach was used in order to gather information about similar reintroduction experiences, focusing on papers and technical reports published in relation with Austrian and French reintroduction projects (Camarra, 1997a, b; Quenette *et al,.* 1997; Rauer and Guttleb, 1997; Erome and Michelot ,1990).

BROWN BEAR REINTRODUCTION IN THE ADAMELLO BRENTA NATURAL PARK

Although the Austrian and Slovenian populations have been expanding for more than a decade, no bears from Austria or the eastern Italian Alps immigrated into our study area. Therefore, in combination with continuous public education campaign in Austria and Italy, and fast and efficient damage refund, the formation of a new subpopulation using reintroduction was considered the only possible way to construct a MVP (Minimum Viable Population), at the metapopulation level, of brown bears in the Eastern Alps, which should help to connect the Austrian and Friulian-Slovenian populations.

STUDY AREA

The study area (Fig. 1), comprising 5 provinces and 255 townships, extended over 6500 km^2, with 3000 km^2 covered by forests. Elevation ranged from 65 m a.s.l. at the southern border around Lake Garda, to

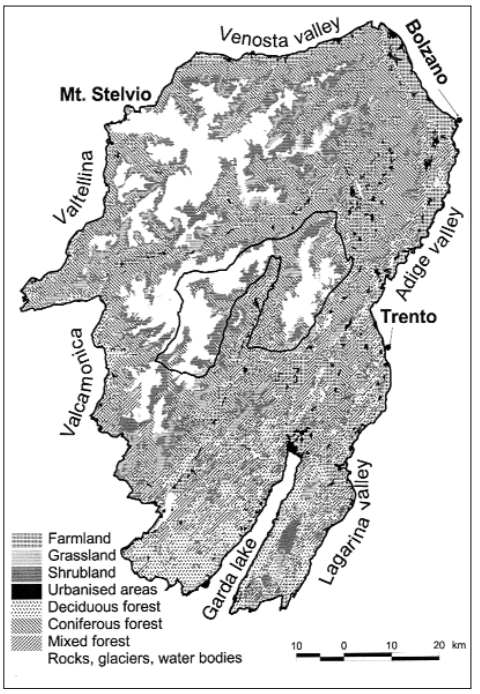

Figure 1 - Study area and distribution of habitat types. Outline at center: Parco Naturale Adamello-Brenta area.

3905 m a.s.l. of Mount Ortles. About 4000 km^2 are comprised between 500 and 2000 m a.s.l., the elevation range preferred by bears in South Europe (Dupré *et al*., 1998), covering submontane, montane and subalpine vegetation belts. Most of the area (80%) consists of mountain ridges, with slope between 10° and 60° (average 25°), and less than 8% of the area is flat (slope < 5%).

CHOICE OF THE SOURCE POPULATION

As a first factor determining the choice of source population we relied on the results of a genetical analysis carried out by the National Wildlife Institute (Randi *et al.,* 1994), in order to identify among western European bear populations the most genetically similar to the former Adamello-Brenta population. Other criteria, derived from French and Austrian experiences, also took into account the evaluation of a possible population depletion effect on the source population, according to the Action Plan for the Conservation in Europe of the Brown Bear (Swenson *et al.,* 2000).

HABITAT SUITABILITY ANALYSIS AND MINIMUM VIABLE POPULATION

CORINE Land Cover level III (Commission of the European Communities, 1993) vegetation types were used to describe habitat structure (Fig. 1). Distribution and density of beehives and livestock (sheep, goats, cows and horses) were available at the level of the communal territory, while distribution and densities of wild ungulates (roe deer, red deer, chamois), considered as an index of carrion available to bears, were based on counts carried out in different types of game management units (national or regional parks, provinces, game reserves, game management areas). Further data were collected on forest felling and management. These data were used to estimate potential food resources available for bears, as well as for identifying potential risk-sites for conflict with humans (shepherds, bee-keepers, foresters). Anthropic pressure was described using the following variables: roads, forest roads (dirt roads), number (and density) of inhabitants, number (and density) of overnight stays by tourists, number of hotels and number of beds. To have more precise information on the areas most intensively used by mountain tourists, we gathered extra information on the location of alpine huts, the number of beds they had available, number of overnight stays and the number of meals served, and the preferred hiking trails. Data on the number (density) of hunters, major hunting practise, and game bags were recorded for each hunting district, to evaluate the potential disturbance created by hunting and the risks of direct bear-hunter encounters and of poaching. Potential risks of conflict with

farmers was evaluated using data on the number of farms, number of farmers and other personnel, area cultivated with vineyards, orchards, or berries, number of livestock (sheep, goat, cows, horses) and number of bee-keepers and beehives.

Overall, road density in the study area was 1.1 km/km^2, a high value when compared with other bear habitats in Europe (Kasworm and Manley, 1990; Ciucci and Boitani, 1997; Huber *et al.,* 1998). Density of the local human population (52.1 inhabitants/km^2) was comparable with Austrian areas re-occupied by bears (Carinthia: 43.5, Lower Austria: 73.0, Higher Austria: 44.0, Saltzburg region: 63.7, Stiria: 42.2, Tirol 23.9, Knauer in Duprè *et al*, 1998.), but the intensity of tourism, which has been shown to be potentially a limiting factor for bear presence (Swenson *et al.,* 1995; Rauer and Gutleb, 1997; Ciucci and Boitani, 2000) was very high.

In order to have a conservative model, we decided to proceed in the following way:

(1) Defining a restricted study area where the last bears were known to be present on which to construct the habitat suitability model: a heterogeneous landscape of 645 km^2 in the Brenta Dolomites, containing most of the habitat types available in the whole study area and delimited by large roads in the main surrounding valleys.

2) Construction of a grid system to discretise habitat variables at a spatial scale level appliable to the ecology of brown bear. In order to obtain a fine-grained

Table 2 - Mean values (± SD) of the 18 habitat variables used in the grid-cell based logistic regression model to predict the probability of bear presence, and significance of the differences between occupied and unoccupied cells (Mann-Whitney U-test).

Habitat variables	**Bear presence**	**Bear absence**	**P**
Farmland (%)	4 ± 12	17 ± 30	<0.001
Grassland, alpine meadows (%)	8 ± 19	9 ± 24	0.85
Shrubland (%)	8 ± 20	5 ± 14	0.31
Urbanised areas (%)	0 ± 0	3 ± 12	<0.001
Deciduous forest (%)	21 ± 33	2 ± 12	<0.001
Coniferous forest (%)	36 ± 40	32 ± 39	0.18
Mixed forest (%)	19 ± 33	14 ± 27	0.37
Rocks (%)	4 ± 15	18 ± 34	0.001
Mean elevation (m a.s.l.)	1316 ± 424	1393 ± 620	0.43
Elevation range (m)	291 ± 114	295 ± 150	0.97
Road density (m/25 ha)	38 ± 160	174 ± 339	<0.001
Forestry tracks (m/25 ha)	236 ± 399	246 ± 409	0.87
% area with slope < 30°	61 ± 28	60 ± 32	0.94
% area with 30°< slope <45°	32 ± 23	29 ± 24	0.32
% area with 46°< slope <60°	6 ± 9	9 ± 13	0.37
% area with slope > 60°	1 ± 3	2 ± 4	0.10
Roads (m) within 100 ha	242 ± 539	550 ± 975	0.011
Roads (m) within 225 ha	379 ± 825	1176 ± 1755	0.001

enough spatial detail, we choose a 25 ha cell size (2581 cells), and set up a GIS data base describing 18 habitat variables (Tab. 2), retained important based on the ecology of brown bears in mountainous landscapes, and for which data were available over the entire 6500 km² of the whole study area.

(3) Determining presence/absence of bears in each grid-cell. A cell was marked as positive taking into account both direct and indirect point presence data (sightings, tracks and other indirect records) collected over the last 20 years: 209 grid-cells were positive for bear presence, 106 of these with more than one record. These cells were considered a suitable sample of bear habitat and defined as "bear presence" cells. After eliminating all 25-ha grid-cells that had >90% rock cover (bare mountain tops never used by bears and therefore excluded from the analysis), we randomly extracted a sample of 117 (5%) "empty" grid-cells from the 2372 grid-cells where no bear signs occurred, hereinafter defining them as "bear absence" cells.

(4) Some 223 grid-cells (9% of restricted study area) were then used to compare mean values of all 18 variables between "bear presence" and "bear absence" cells (Mann-Whitney U-test; Tukey, 1977; Tab. 2). A stepwise forward logistic regression model (Hosmer and Lemeshow, 1992) was calculated to obtain a model of the probability of bear presence.

(5) Parameters linked to "human disturbance" and presence/abundance of livestock (Tab. 3) were only available at the township level (N = 255 municipalities). Using the Mann-Whitney U-test we compared these parameters between townships with (N = 59) and without (N = 196) bear records.

(6) In a final step, the selected logistic model was applied to the whole study area (25980 grid-cells of 25 ha) to estimate the probability of presence of brown bears in each grid-cell and produce a Habitat Suitability Model (HSM).

ANALYSIS OF THE RISKS FOR REINTRODUCTION

A poll was carried out by telephonic interview on a random sample of 1512 subjects (0.5% of local population), classified into one of four sub-areas (Lombardy, containing Sondrio and Brescia provinces, Alto

Table 3 - Mean (± SD) of the variables related to human disturbance and/or farming activity in the municipalities where bears occurred in 1977-1996 compared to those of municipalities without bears (Mann-Whitney U-test).

Variables	**Bear presence (N = 59)**	**Bear absence (N = 196)**	**P**
Human population (inh./km²)	1307 ± 1649	1891 ± 3780	0.34
Tourist presence (n)	112808 ± 239140	73658 ± 150910	0.45
Bovines (n/ km²)	247 ± 323	305 ± 465	0.87
Horses (n/ km²)	4.4 ± 9.1	9.1 ± 15.0	0.024
Sheep (n/ km²)	10.7 ± 31.7	53.5 ± 156.1	0.001
Goats (n/ km²)	16.3 ± 31.9	22.5 ± 60.8	0.32

Adige, with quite intensive sheep farming, northern Trentino, including the Adamello-Brenta Park, and southern Trentino and Verona province).

The principal aims of the enquiry were to evaluate: (i) general knowledge on bear status and ecology; (ii) attitude towards bears; (iii) degree of fear for direct attacks; (iv) attitude towards a possible reintroduction; (v) perception of potential negative effects on human activity (e.g. agriculture and tourism); (vi) awareness of compensation schemes in case of damage caused by bears; (vii) expectation of poaching events and evaulation of people's attitude towards illegal killing; (viii) "economic value" appreciation of each single bear present in the area; (ix) potential strategies aimed to reduce negative attitude towards bear reintroduction. These data (23 specific questions) have been analysed in detail according to sex, age, work situation, level of instruction, geographic sub-area, degree of basic knowledge about bears and degree of acceptance of bear presence (Dupré *et al.*, 1998).

RESULTS

PAST AND PRESENT BROWN BEAR DISTRIBUTION IN EUROPE

Originally, the brown bear, a holarctic species, occurred over most of Europe, with exception of the main islands (Iceland, Ireland, Corsica and Sardinia). It went progressively extinct over most of its European range, because of large-scale habitat destruction (deforestation and continuous increase of farmland) accompanied by a fast-growing human population, fragmentation of remaining natural habitats (mountain forests) and their increased accessibility and active legal as well as illegal persecution by man (Dupré *et al.*, 1998). At present, the total number of brown bears in Europe is estimated at about 50000, of which 37000 animals ranging over a wide area in Russia, the Baltic states and Finland (Servheen, 1990; Nyholm and Nyholm, 1999; Sørensen *et al.*, 1999; Linnel *et al.*, 2002; Swenson *et al.*, 2000). Another large population (8100 bears) occurs in the Carpathian mountains in Slovakia, Poland, Ukraine and Romania (38500 km^2), where about 7700 animals occupy all suitable habitats with an average density of 1.5-2 bears/100 km^2, and a peak density in high-quality habitats of 5-8 bears/100 km^2 (Slobodyan, 1993; Ionescu, 1997) (Tab. 1). Of the other ten populations known, four can be considered at low risk and six as endangered or critically endangered (Tab. 1). At present, only six of the populations with more than 500 individuals can be considered viable in the long term, while the others are relict populations occurring in mountainous regions of southern Europe (Tab. 1).

PAST AND PRESENT BROWN BEAR DISTRIBUTION IN ITALIAN ALPS

In the 17th century, brown bears were still abundant and widely distributed over the entire alpine area of northern Italy and even in large, dense forests of the prealps and the Po plain. The start of the decline coincided with an increase of deforestation for farming at the end of the 18th century. In the 19th century, increased access to previously remote wilderness areas of the prealpine and alpine mountains, and direct persecution by farmers and hunters caused the extinction of local bear populations,

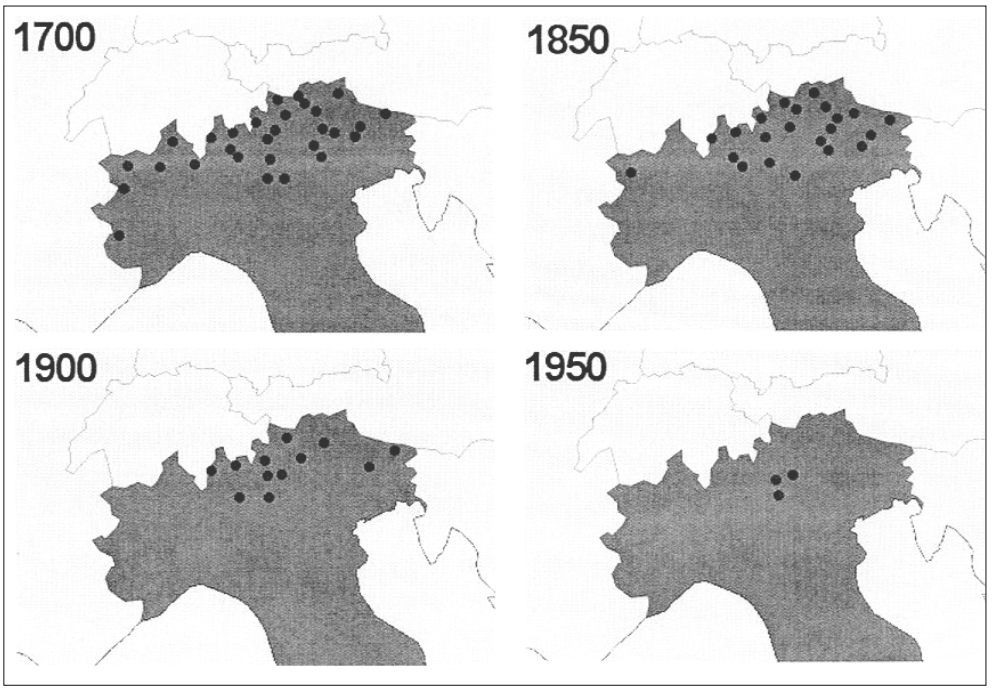

Figure 2 - Historical distribution of brown bear (*Ursus arctos*) in the Italian Alps.

first in the western Alps (Fig. 2). Brown bears went extinct in most areas of the Central and Eastern Italian Alps between the first half of the 19th century and 1910-1930, with low numbers persisting in the upper valleys surrounding the Adamello-Brenta and the Monte Cadria-Altissimo mountains (Fig. 2) (Castelli, 1935; Pedrotti, 1972; Daldoss, 1976; Oriani, 1991).

THE ADAMELLO-BRENTA POPULATION

The recent history, from the last decade of the 19th century until 1997, was reconstructed using various sources of bear killings and observations (Dupré *et al.*, 1998). At the end of the 19th century, bears were still common in most of the 6500 km^2 of the study area (Fig. 2), and a minimum convex polygon using 95% of all sightings (95% MCP) over the period 1850-1899 (N = 186) covered an area of 6922 km^2. Based on bear killings, densities of 1.5-3 bears/100 km^2 have been estimated (Dupré *et al.*, 1998). In the next 50 years, intensive persecution caused a drastic reduction of the population range, and no more bears were seen in the province of Verona (Monte Baldo, Alto Garda and Valle Sabbia, Fig. 2). Between 1950-80, bears went extinct in Lombardy (Valtellina, Sondrio province, and Valcamonica, Brescia province), and Alto Adige (Bolzano province), and a single relict population, of about 12 animals (Osti, 1979), remained in a 2330 km^2 area of the Adamello-Brenta and Monte Cadria-Altissimo mountains

and in a part of Val di Sole (Fig. 2). Part of this decline might be attributed to fragmentation of suitable habitat caused by the construction of roads and structures for tourism in particular in upper alpine valleys. However, some evidences suggest that direct persecution (19-32 kills per decade between 1860-1920, 10-12 between 1920-1960), by farmers to protect livestock or beehives, and by hunters for sport or for money (bounties were paid in most provinces over several decades), was the main factor responsible of the dramatic population contraption. Only in 1939 bears became legally protected, but poaching continued (about one bear per year from 1940 to 1970 in the study area), further reducing bear numbers well below the 50-90 individuals treshold that is considered to constitute the minimum viable population size for brown bear in the Eastern Alps (Schröder, 1992).

During the last two decades, bear sightings became increasingly rare and the area occupied decreased further to only 1280 km^2 between 1990-94 and only 545 km^2 between 1994-97 (Dupré *et al.*, 1998). Overall, the brown bear range decreased on average by 10% every decade between 1850 and 1995. Starting from 1980 the number of bears belonging to the relict population seemed to level at about 14-16 animals, with an average birth rate between 1.2 and 1.4 cubs per year (Duprè *et al.*, 1998). However, from 1990 onwards, despite intensive monitoring of the entire area occupied by bears (N = 331 sightings, tracks and other bear signs in 1990-94, Parco Adamello-Brenta unpublished data) there has been no more evidence of reproduction, and a lack of sightings and tracks of immature animals in the early 1990 suggests that juvenile mortality was high. Demographic stochasticity, genetic drift and high levels of inbreeding (Lande, 1988), probably contributed to the local extinction, and in 1997 only three animals were estimated to be still alive on the Brenta massif. The presence of only three bears in 1996-97 was ascertained using fixed cameras near feeding sites baited with carcasses and DNA-analyses of hair and bear faeces using microsatellite markers (Genovesi *et al.*, 2000).

Recent observations using cameras, sightings and tracks, suggest that in 2000-2001 only one animal, an old (> 18 years) and partly blind male, was still alive. Thus, it was concluded that by the end of the 20th century, Adamello-Brenta population could be considered extinct (Genovesi *et al.,* 2000).

LESSONS FROM PAST BROWN BEAR REINTRODUCTION IN EUROPE

In Austria, the last brown bears were shot in 1885 (Carinthia) and 1913 (East-Tirol) (Gutleb, 1994). From 1950 onwards, sightings of dispersing bears from the increasing Slovenian population became progressively more frequent in Carinthia and later in Stiria. Between 1989 and 1993 three brown bears caught in the wild in Croatia (one female) and Slovenia (two males) were released in a mountainous area of Stiria to restock the existing population. After a period of exploration, the animals settled in and near the release area, with

350-550 km^2 home ranges (Rauer and Gutleb, 1997). Between 1993-1995 the project went through a critical period because of insufficient publicity on the media and lack of local people involvement. As a result, hostility towards bears by hunters, farmers and shepherds increased, eventually coming to the killing of two bears (Gutleb, 1998; Gerstl, 1999). As a consequence, in the second phase of the project (1995-97) it was decided not to release any more bears, to intensify the effort towards a large-scale information campaign of the Austrian public, in particular in the areas interested by bear presence, and to develop an efficient, fast system of damage prevention, control and compensation. In addition, an emergency team was constituted, in order to immediately act in case of bear damage reports, and to intervene when "problem-bears" needed to be "re-educated" to avoid them returning to previously damaged or potential conflict sites (Rauer and Gutleb, 1997).

Despite these difficulties, the Austrian population now counts about 20-25 bears, with a male-biased sex-ratio, distributed over a wide area ranging from Carinthia, the Stirian-Low Austria borders and the Saltzburger Alps (Rauer and Gutleb, 1997; Gerstl *et al.*, 1999).

The reintroduction of three bears from Slovenia in the Central Pyrenees in 1996-97 (two females and one male) had as major objectives: (i) to evaluate the reaction of the local public on such a delicate operation; and (ii) to study the bear's ranging behaviour and their adaptation to the new habitat. The public relation campaign aimed to create among people a high degree of acceptance for the reintroduction project, and in particular to provide correct information about bear movements and eventual bear damage towards the social categories most closely involved: hunters, shepherds, tourists and hotel managers. During the first six months after release, the two female bears preyed heavily upon livestock (about 20000 unprotected sheep were present in the 1200 km^2 range used by the bears): in 19 registered attacks, 41 sheep and one horse were killed, with an average attack rate of one every 7.5 days (Quenette *et al.*, 1997; Camarra, 1999; Quenette, 2001). All damages were immediately compensated for, and shepherds were contacted and informed when a radio-tracked bear was within the area used by their herds, and even helped by a team of experts to move their herds to safer areas, while hunters were informed about bear presence in areas where they hunted wild boar (*Sus scrofa*). Nevertheless, there was growing criticism and an increasingly hostile attitude of the local public towards the bears, and one female that had given birth to three cubs the previous winter was shot (Quenette *et al.*, 1997; Quenette, 2001).

This study underlines that a continuous and correct information campaign is essential when reintroduction of large carnivores is planned, but still might have some shortcomings. Therefore, we decided to explicitly include in the brown bear reintroduction project in the Adamello-Brenta Park, the possibility to remove any "problem-bear", whenever intensive monitoring by radio-tracking would reveal repeated cases of conflict with human activities.

In general, the Austrian and Spanish experience highlighted two major objectives to include in a reintroduction feasibility study: (i) assessment of the economic and cultural sustainability of conflicts that may arise between bears and human activity; and (ii) identification of the main factors that could negatively affect the establishment of a population in the release area (Genovesi *et al.,* 2000).

SUITABILITY OF THE SOURCE POPULATION

Although the translocation of bears from the Slovenian population can cause little risk of introducing infectuous diseases into Trento province, many precautions have been taken in collaboration with the Italian Health Ministry, whose authorisation is needed for importing bears.

Although during the past twenty years rabies occurred in the founder population, there were no rabies cases during the last six months before bear catching, whereas Italy is considered rabies free at least since 1998 (Müller *et al.*, 2000). Although there have been cases of bears being positive for *Arbovirus* in the founder population, the risk of virus transmission through bear translocation was very low, considering the low virulence of *Arbovirus*. Moreover, captured bears had been treated with an acaricide to prevent risks of diffusion of *Arbovirus* through infected ticks. Finally, all wild boar tested in Trento province were negative for pseudo-rabies, the only lethal disease that could potentially hit brown bear in the release area (Genovesi *et al.*, 2000).

The Slovenian sub-population is part of the large Dinaric-Baltic metapopulation (2500 bears), and is harvested for hunting, with about 40 bears shot each year until 1999, and a hunting plan of 104 bears in 2002. Therefore, the removal of 2 to 3 animals per year, for a total of 10 bears, presumably will not have any demographic consequences on the source population (Krze, 1994). Finally, screening of mitochondrial DNA sequences has demonstrated that bears from Trento and Croatia share the same genotype (Randi *et al*., 1994). In fact, the former Brenta population was the residual of a continuous population ranging from the Alps to the Balcans (Genovesi *et al*., 2000). Hence it is assured that the reintroduced bears come from a population identical to the extinct one.

HABITAT SUITABILITY AND MINIMUM VIABLE POPULATION

Five variables entered the logistic regression model (Tab. 4), which correctly reclassified 84% of the cases: the percentage of deciduous forest cover and the percentage of mixed forest positively affected the probability of bear presence (partial effects: $\chi^2 = 14.1$; df = 1; $p < 0.001$ and $\chi^2 = 5.02$; df = 1; $p = 0.024$ respectively), whereas the percentage of rock cover, road length within a 225 ha window, and elevation range negatively affected bear presence (partial effects, all df = 1: $\chi^2 = 7.16$; $p = 0.007$; $\chi^2 = 10.8$; $p = 0.001$ and $\chi^2 = 5.40$; $p = 0.019$ respectively). Based on partial effect and total chi-square ratio, the model explained 28% of the total deviance, which suggested the influen-

Table 4 - Coefficients (B) and standard errors (SE) of the grid-cell based logistic regression model to predict the probability of bear presence.

Variable	B	SE
Percentage of deciduous forest cover	0.05	0.01
Road length over 225 ha window	-0.001	0.0009
Percentage of rock cover	-0.021	0.008
Elevation	-0.003	0.001
Percentage of mixed forest cover	0.013	0.006
Constant	1.1	0.5

ce of other factors not considered in the model (i.e. variables linked to human disturbance).

The logistic model was then applied to the entire study area, classifying the 25980 cells by probability of bear presence. Since the classified cells probability density function was quite skewed towards low probability values (average p = 4.3%, S.D .= 7.6%, maximum p = 65.3%), output has been classified defining as "suitable bear habitat" all the cells having a probability value greater than the average plus one standard deviation (Slocum, 1999). According to this classification, almost 90% of the study area has been classified as unsuitable (23251 cells out of 25980, Fig. 3). HSM results pointed out the south-eastern part of the study area as the most suitable for bears.

"Bear presence" grid cells were characterised by a lower percentage of bare rock, farmland and urbanised areas if compared with values for the unoccupied ("bear absence") cells. Moreover, unoccupied cells showed a higher road density, both at a small (25-ha grid cell window) and at a larger scale (100 and 225 ha windows). Cell occupancy did not seem to be affected by the presence of forest tracks (Tab. 2). A significant difference in occupied vs. unoccupied cells was found taking into account deciduous forest cover: in fact average total forest cover was 76% in grid cells used by bears against only 48% in cells with no bear presence records (Tab. 2).

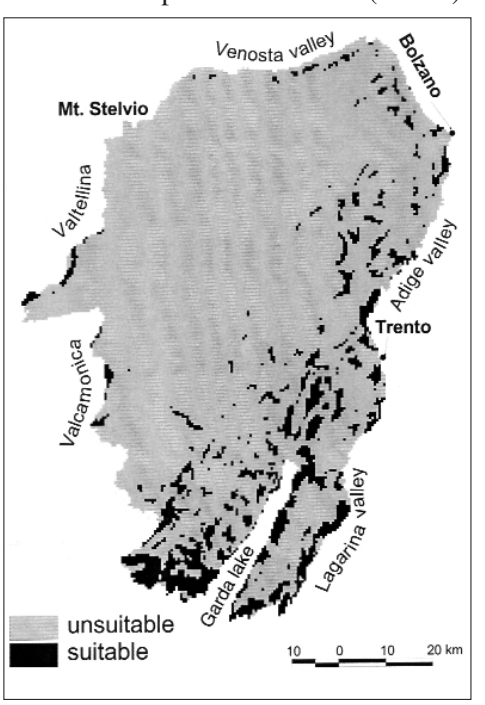

Figure 3 - Habitat suitability map showing suitable (black) and unsuitable (gray) areas, as predicted by a probability of presence model based on a logistic regression.

At the township scale, bears seemed to be absent from areas with intensive grazing activity, mainly by horses and sheep, despite the latter being a potential prey (Tab. 3). There were no significant differences in human population density and intensity of tourism, measured as the number of overnight stays in hotels, guesthouses and mountain huts, between municipalities with and without bear observations during the last two decades. Thus, bear presence occurred in undisturbed forested areas, dominated by deciduous trees, and absence depended on human disturbance.

POPULATION VIABILITY ESTIMATE

We used estimates from Schröder (1992) and considered a MVP of 50-90 brown bears as a threshold for a successful reintroduction of bears in the area historically occupied by the extinct Trento subpopulation. However, dispersal of bears between Austrian, Slovenian-Friulian and Trento subpopulations will be essential for maintaining a metapopulation dynamics of bears in the eastern Alps. The carrying capacity for brown bear in the Trento area, based on density estimates from other South-European populations and historical data, was estimated being 2-3 bears per 100 km^2 of suitable habitat. Hence, the release site must contain at least 3000 km^2 of good bear habitat, that is relatively dense forests containing areas with rich shrub layer. A GIS-based map of the area was used to define the borders of the study area using the following criteria: (1) large enough to ensure the highest probability of containing a MVP; (2) centered in the Adamello-Brenta Natural Park, where the last non reproducting bears survived; (3) low degree of fragmentation of natural habitats, forests, alpine shrub, alpine meadows, and high degree of suitable habitat types; and (4) borders at least 50 km from potential release site (Valle di Tovel), allowing larger than expected dispersal movements of released bears (Genovesi *et al.*, 2000).

RISK FOR REINTRODUCTION

To evaluate the potential conflict factors with the human population in and near the study area, we analysed the socio-economic situation in the area.
Some 7574 km^2 of the study area cover the land of 226 municipalities in 5 provinces, with 365397 inhabitants (48.2 km^{-2}), and can be divided in three distinct subareas with different socio-economic development classes: the main valleys, lower mountains (submontane and montane areas) and higher mountains (subalpine and alpine areas). In the valleys there is a strong tendency to modern, large-scale agriculture with permanent crops, growing industrial activity near large towns and a positive demographic trend. In the lower mountains (500 – 1000 m a.s.l.) small-scale farming, combining livestock (mainly dairy cattle) and crops, is the main activity, with a rather high density of small rural communities. In the higher mountains, traditional farming with small herds of cattle or sheep and goats is still common, although continuously decreasing, and the demographic trend is negative, especially with young people migrating towards the large towns.

Hence, many areas used for farming in the 1940-60 are now abandoned. In contrast, tourism has strongly evolved and some rural centres have grown considerably, especially in areas where both summer and winter (skiing) tourism takes place. Overall, in the areas that are potential bear habitat (lower and higher mountains), agriculture, particularly livestock farming is a major human activity as revealed by land-use data: of the 6496 km^2, 21.5% (1400 km^2) is covered by pastures and natural grassland, against only 9.8% (637 km^2) of cultivated land, and 4.4% (288 km^2) of orchards. A further 1.7% (109 km^2) is urbanised areas, 0.6% (37 km^2) water (lakes, rivers, small streams), 16.2% (1055 km^2) rocks and glaciers (no vegetation), and 45.7% (2970 km^2) are woodlands and forests. Thus, the rural activity is concentrated on livestock with a trend towards less but larger and more specialised farms and growing number of dairy cattle, especially in the submontane and montane regions. The distribution of the major rural activities throughout the study area is heterogeneous and concentrated in the provinces of Trento and Bolzano.

AGRICULTURE CROP DAMAGE

In the Adamello-Brenta area, the lower hills contain apple orchards and vineyards. Bears rarely enter these plantations, feeding mainly on fallen fruits. Hence damage is extremely limited (2.5% of total damage compensation in the last 20 years). Fast compensation of damage is considered a sufficient measure to avoid conflict with bears.

LIVESTOCK DAMAGE

In the past bears attacked cattle and sheep (699 cases recorded between 1956 and 1977), but this kind of damage became progressively less important with the bear population decrease (9 cases from 1978 to 1989).

HUNTING

South-European bear populations have generally little impact on natural ungulate or other wildlife populations. In the study area, chamois (*Rupicapra rupicapra*) is relatively abundant in four provinces (1995 population size estimates: Bolzano 16300, 4.3 km^{-2}, Trento 18500, 4.8 km^{-2}, Sondrio 4900, 2.1 km^{-2}, Verona 100, 3.9 km^{-2}, Stelvio National Park 3550, 8.4 km^{-2}) but very rare in Brescia with a stock of only 400 animals (0.3 km^{-2}). In Verona province drive-hunts using dogs not only causes over-harvesting of most game populations, but could produce serious disturbance to bears, also adding the risk of dogs attacking bears. In the other provinces, where selective culling of ungulates is practised, it seems there exist little risk of conflicts between bears and hunters, and thus a low risk of bear poaching.

CURRENT PUBLIC OPINION

Overall, attitude towards the brown bear was positive and bear reintroduction for conservation purposes was readily accepted by more than two thirds of interviewed people. This positive opinion, raised from 73% to 80% of the interviewed sample, when the esta-

blishment of an emergency team was assured. People were more suspicious or uncertain about reintroducing bears in the Lombardy provinces (Brescia, Sondrio), where they were also more concerned about potential damage and where hunting methods (drives using dogs) have a higher risk of illegal killings. The degree of acceptance of bear conservation and recovery tended to increase with the increasing level of general knowledge about bear behaviour and potential problems the animals might cause. Two main decisions were drawn from the poll results: (i) to start a large-scale public information campaign, producing concise information leaflets, small books and holding public lectures in strategically chosen places throughout the region interested by the project; and (ii) to conduct continuous monitoring of the public opinion, in particular of "risk" groups (hunters, farmers, bee-keepers), while the project proceeded, in relation to how bears will behave, and the level of bear-man conflict that will occur.

DISCUSSION

HABITAT SUITABILITY AND MINIMUM VIABLE POPULATION

According to conservation biology concepts, the brown bear can be considered a flagship species (Soulé, 1987). The conservation/management of wide areas necessary to host populations of a widely ranging animal will have positive effects on the conservation of various types of semi-natural and natural habitats, and thus favour the conservation of a large number of species in the montane, subalpine and alpine vegetation zones. Hence, a carefully designed management plan for the reconstruction and conservation of a brown bear metapopulation in the Eastern Alps will result in the long-term conservation and sustainable use of renewable resources for the entire alpine ecosystem in the area involved. Moreover, one of the major objectives of the "Action Plan for the European Brown bears" is to safeguard the persistency of small and isolated populations, by increasing their population size and their distribution (Swenson *et al.*, 2000).

Habitat suitability models (HSM) have been applied to brown bear habitat in Gorski Kotar, Croatia (Kusak and Huber, 1999), the Cantabric mountains in Spain (Clevenger *et al.*, 1992), and in Austria (Kusak and Huber, 1999). All models agree in using parameters that indicate habitat quality in terms of food availability and vegetation cover, elevation, degree of access to remote areas and human disturbance (e.g. distance to nearest village).

We must stress that the HSM here presented was developed using only bear presence data from the last 20 years, when bear numbers were already critically low and the remaining population probably used only part of the suitable habitats available in the study area. Thus our model has to be held as conservative, probably underestimating the suitable bear habitat availability. Therefore, continuous monitoring of the bear population after release, using radio-tracking and other methods, will be necessary to: (i) validate the habitat suitability model, and (ii) assess population dynamics and in particular rate of

increase. Comparing these data with the original model parameters will allow to develop a more reliable model needed for continuous reassessment and for future planning.

SOCIO-ECONOMIC ASPECTS OF BEAR REINTRODUCTION

Bears can enter in direct conflict with human activities because of predation on livestock or beehives, and by direct aggressive interaction with men, causing injuries or even deaths. In Slovenia, the area from where founders were taken, as well as in the recently recolonised areas of Austria, some "nuisance bears" occur: animals that forage near villages or farms, attack beehives or cattle inside the stables, or even attack man (Adamic, 1997; Rauer and Gutleb, 1997; Koren and Adamic, 1997; Gerstl *et al.,* 1999). These problems can be reduced when a task-force immediately acts to remove such bears. Hence, this potential problem is another reason to continuosly monitor released animals by radio-tracking.

Intense tourism, especially during the summer months, can cause disturbance to bears and increases the risks of encounters between bears and men (Mc Cullogh, 1982; Mattson *et al*., 1996). The study area is characterised by intense summer tourism, mainly in the high mountain areas where a well developed road network and large numbers of hiking trails allow tourists to reach many and quite remote areas. Tourism impact in the area is quite high, since local population density (48 inhabitants km^{-2}) has a 50-fold increase in peak season (2446 tourists km^{-2} over a whole year). However, the majority of tourists remain on a few traditional trails. Tourism is most developed in Trento and Bolzano, where next to the larger hotels there exists a dense network of "bed and breakfast" at private houses and a widely-distributed system of alpine huts in the high-mountain areas, intensively used in summer.

LIVESTOCK DAMAGE

In countries were bear populations are increasing, also damage to livestock increased, resulting in increased risk of bear poaching by farmers (Swenson *et al.*, 1995 and 2000; Adamic, 1997; Koren and Adamic, 1997; Rauer and Gutleb, 1997; Gerstl *et al.,* 1999). Since Slovenian bears from the source population are known to attack livestock, one can predict an increase of damage by bears released into the study area, with sheep being most at risk. Hence, a fast and financially adequate compensation scheme must be rigorously applied in order to avoid creating a hostile attitude by farmers, which constitute the most important target group for a public-education campaign and a considerable proportion of the local population (David *et al.*, 1997).

DAMAGE TO BEEHIVES

This is, numerically and economically, the most important type of damage caused by bears. In the study area beehives have a wide and rather homogeneous distribution in the submontane and montane vegetation belts, habitats highly preferred by bears (52% of all damage reported over last 30 years in

Trentino, Duprè *et al.*, 1998; 47% in Austria, Gerstl *et al.,* 1999). Nevertheless, beehives can be efficiently protected by supporting bee-keepers in constructing bear-proof electric fences around the hives. This management option will have to be applied for beehives in "high-risk" zones (suitable bear habitat), while for those in other parts of the study area, information to bee-keepers and constant monitoring of bear movements should allow to adopt fence construction only when considered necessary to avoid attacks.

TOURISM

The presence of bears, can have positive effects on local tourism. Correct information about the existing, but very limited risks of bears attacking man, and public-relation campaigns to all levels of the population are necessary to create a positive attitude towards bears within the study area, but also at a much wider (regional, alpine, national) scale.

AGGRESSION TO MAN

All possible measures must be taken to avoid bears adapting themselves to human presence and start selecting foraging sites near human settlements. Therefore, care must be taken not to leave food remains near picnic or camping sites, not to have open garbage dumps near villages and not to create artificial feeding sites for bears, except those rigorously controlled for scientific research and monitoring purposes. People must be made aware, through a correct information campaign, that bear attacks can never be completely excluded, but that the risk can be extremely reduced when some basic guidelines are followed. Also, people should be informed how to behave, and what certainly not to do, in case of close encounter with a bear.

All of these problems are often caused by one or very few bears within the population (Gerstl, 1999). Therefore, direct action again these "nuisance bears" will have to be planned and implemented in two phases: (i) to deter nuisance bears by frightening them and chasing them away from risk sites; and (ii) removal of nuisance bears for which dissuasion was not successful.

A general framework for damage prediction is presented in Genovesi *et al.* (2000).

CONCLUSIONS

The feasibility study for reintroducing brown bears in the Trento area of the Italian Alps has revealed that: (i) there was no possibility for the natural reconstruction of a viable population if no action had been undertaken; (ii) the factors that caused the extinction no longer persisted; (iii) a sufficient amount of suitable habitat for a viable bear population, with a MVP of at least 50 animals, is available; (iv) habitat structure and the increase of bear numbers in Austria and Slovenia-Croatia are likely to result in the formation of a metapopulation of bears in the Eastern Alps; (v) public opinion is quite positive towards a reintroduction project; (vi) the necessary legal-financial framework exists. Furthermore, the various political administrations involved in the project have constructed a "bear wor-

king group" that will deal with all the practical problems that might arise during the capture, transport and release of the animals and has the legal power to make immediate decisions about how to handle "nuisance bears". The possibility that one or a few animals will cause conflict with human activities, and therefore will negatively affect public opinion, is considered the key factor that might jeopardise the success of the entire project. Therefore, constant information of the public and in particular of the "risk-target" groups (hunters, farmers, bee-keepers, and to a lesser extent tourists) is essential. Finally, farmers and bee-keepers (in high-risk areas) will be directly contacted and given financial help to build electric fences to prevent bears attacking livestock or beehives. Continuous monitoring of released bears using radio-tracking will also help to prevent damage, since each animal movements can be followed and farmers can be alerted when bears are in the vicinity. A "bear emergency team", composed by a biologist that coordinates the monitoring program, a veterinarian, a park ranger and a ranger of the interested province, will be created and trained to intervene immediately on "nuisance bears" (Genovesi *et al*., 2000). In case damage does occur, a special insurance will allow for complete and fast damage compensation.

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