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# Brown bear reintroduction in the Southern Alps: To what extent are expectations being met?

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ABSTRACT

Large carnivores, such as brown bears (*Ursus arctos*), are flagship species for the conservation of biodiversity and their reintroduction represents a strong challenge. However, the results of reintroductions have only recently been documented in the literature. Given the global decline of large carnivores, documenting the results of such attempts is crucial for future conservation management. Here we examined the reintroduction of brown bears into the Italian Alps. The majority of bears released (10 individuals) adapted well to the release area and this resulted in the increase of the brown bear population. At the end of 2012, the area with a stable presence of females was around 1250 km$^2$ (minimum density = 3 bear/100 km$^2$). Between 2002 and 2012, 34 reproductive events occurred and a total of 74 cubs were born, thus reaching a minimum population size of 47 individuals. No less than 21 young males dispersed into adjacent Italian regions or into other countries, such as Switzerland, Austria, and Germany. However, despite a high mortality rate and at least two cases of illegal killing reported in the last 2 years (2013 and 2014), a remarkable population growth rate (current level of 15.6%) has been observed.

The damages correlated with bear population size ($F = 17.922$, $p < 0.01$) were primarily inflicted on beehives (39%) and livestock (26%), with an economic relevance of € 41,374 per year for compensation and € 23,527 per year for prevention. The only case of injury to humans ever since the beginning of the project was recorded in 2014, when a female defending her two cubs inflicted minor physical injuries to a man. And yet, public opinion changed radically, from a widespread acceptance of bears at the beginning of the project to an opposition to their presence, the increase of their population, and the new translocations aiming at replacing problem bears that had previously been removed. According to the present trend, the population may reach a range of 60–94 individuals in 2017. Therefore, a proper management of problem bears should be considered a key factor for the restoration and improvement of the social acceptance of this species.



## Introduction

Relocating animals within their former range has become a commonly used and potentially powerful tool for the conservation of biodiversity (Breitenmoser et al. 2001; Griffith et al. 1989; Hayward et al. 2007; Hinton et al. 2013; Kleiman 1989; Ripple & Beschta 2012; Stanley Price 1991; Wolf et al. 1996). In this context, large carnivores, such as brown bears (*Ursus arctos*), are especially demanding species, as their reintroduction can cause a wide array of potential problems related to their biology, but also to their impact on human activities and the ensuing public opinion (e.g., Bjerke & Kaltenborn 1999; Kellert et al. 1996).

Despite these potential threats, reintroductions are often carried out in an ad hoc fashion and not carefully monitored. As a consequence, the success rate of animal reintroductions is quite low (Griffith et al. 1989; Wolf et al. 1996) and their results are often poorly documented (Breitenmoser et al. 2001; Fischer & Lindenmayer 2000). In general, the success rate of the reintroductions of carnivores is considered to be lower than that of herbivores (see Griffith et al. 1989 for a review, and the following references for more recent examples: Apollonio et al. 2014; Krasinska & Krasinski

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2007; Komers et al. 1999; Matson et al. 2004; Tosi et al. 2009; Wronski 2010). However, despite possessing most of the morphological traits of carnivores, brown bears were observed to evolve with a generalist omnivore strategy in several different ecosystems and their diet was found to comprise primarily plant matter (Ciucci et al. 2014; Robbins et al. 2004; Sacco & Van Valkenburgh 2004). Historically widespread throughout its circumpolar range, the brown bear became locally extinct across large parts of North America and Europe in the 19th and 20th centuries. The main causes of such local extinctions were overhunting, habitat fragmentation, habitat loss (UNEP 2001; Uotila et al. 2002; Waller & Servheen 2005), and even state-sponsored extermination campaigns (Clark et al. 2002; Elgmork 1988, 1996; Swenson et al. 1994, 1998a; Zedrosser et al. 1998). Moreover, during the 20th century, the development of roads, settlements, mineral exploration sites, and the intensified forestry resulted in a dramatic reduction in wilderness areas, with a subsequent loss of undisturbed habitats for bears and the increase in conflicts with humans (Gibeau et al. 2002; Kaczensky et al. 2003; Nielsen et al. 2004a, 2004b).

Thanks to a change in conservation-oriented management which was introduced in the late 20th century, many bear populations are now increasing again on both continents. At present, reintroductions are being carried out across most of their former ranges, but with highly variable success rates (Clark et al. 2002; Servheen 1998; Swenson et al. 1998b; Zedrosser et al. 2001), so that the species occurs only in a small part of its historical range. Despite the seemingly higher level of suitability of North America, bears seem to respond faster to conservation measures in Europe (Zedrosser et al. 2011), where rural depopulation and the decrease in sheep pastoralism are playing a relevant role (e.g., in Majella National Park, Italian Apennine brown bear population – van Gils et al. 2012, 2014).

Currently, then, 10 brown bear populations occur throughout Europe and 4 of them count less than 150 individuals (Linnell et al. 2008). Among these, the small Alpine population is the result of a reintroduction project in the Central Italian Alps.

The main issues of brown bear reintroduction projects and, more in general, of brown bear presence, are: (i) large area requirements (Mustoni et al. 2003; Swenson et al. 2000); (ii) predation on wild ungulates, causing conflict with hunters (Skogen 2003); (iii) damage to livestock, beehives and crops, causing conflict with farmers (Adamic 1997; Kaczensky et al. 2002; Koren & Adamic 1997; Krystufek & Griffiths 2003; Quenette et al. 1997; Rauer & Gutleb 1997; Sørensen et al. 2000); (iv) direct aggressive encounters with humans (Cicnjak & Ruff 1990; Herrero & Fleck 1990; Kaczensky 1996), which pose a direct threat to people and a potential threat to tourism; and (v) emotional impact on the resident human populations, possibly resulting in a poor public acceptance (Clark et al. 2002; IUCN/WWF 2009; Kruckenhauser et al. 2009; Quenette et al. 2001; Rauer 1997; Rigg & Adamec 2007; Swenson et al. 2000). Two former reintroduction attempts in Poland and Austria failed for the same reasons listed above (see Buchalczyk 1980 for the Polish project and Kaczensky et al. 2013 for the Austrian project). The most recent attempt was performed in the Pyrenees Mountains but, despite the consistent translocation (8 bears), the native population became extinct in 2010. In 2013, the population counted 22 bears, all of Slovenian origin, continuously threatened by illegal killings, car accidents, and hunting accidents (Kaczensky et al. 2013).

In Italy, the reintroduction of brown bears has been a major topic in wildlife management and conservation of alpine biodiversity for more than a decade, i.e., ever since it became obvious that the last population in the Italian Alps was rapidly declining and was threatened with extinction (Dupré et al. 2000; Lande 1988; Mace & Lande 1991; McLellan 1994).

Until the 17th century, brown bears were still abundant and widely distributed over the entire Southern Alps and even in the large, dense forests of the Pre-Alps and the Po plain. The start of the decline coincided with an increase in deforestation for agricultural and livestock activities at the end of the 18th century. During the 19th century, then, the increasing access to previously remote wilderness mountainous areas, and the direct persecution by farmers and hunters caused the extinction of local bear populations in the Western Italian Alps. Subsequently, between the first half of the 19th century and the 1930s, brown bears became extinct also in most areas of the Central and Eastern Italian Alps, with few individuals persisting only in the eastern range of the Brenta Mountains (Castelli 1935; Daldoss 1976; Dupré et al. 2000; Mustoni et al. 2003; Oriani 1991).

Economic and emotional factors have accounted for the direct persecution and the quasi-extermination of the species ever since the second half of the 18th century in Trentino (Dupré et al. 2000). In an effort to reinstate and preserve its presence, the Adamello Brenta Nature Park (Southern Alps, Italy) promoted a project of reintroduction supported by the European Union through LIFE Nature funding (*Life Ursus*) in cooperation with the Province of Trento and the Italian Wildlife Institute. The project aimed at restoring a minimum vital population (40–60 individuals) in the Southern Alps in the mid-long term. To the purpose, 10 bears (7 females and 3 males) were translocated from Slovenia, where the population is genetically similar to that of Trentino (Randi et al. 1994; see also Mustoni et al. 2003; Preatoni et al. 2005), into the area where bear presence was still documented.

In order to envisage future scenarios for the Italian Alpine bear population and to gain new insights in preparation for further reintroduction efforts, we analysed the outcomes of the reintroduction project in Trentino, focusing on (i) the study area/used space in relation to the population growth and structure, and (ii) the human–bear conflict, i.e., economic damages and social acceptance.

## Methods

### *Study area*

The reintroduction area covers the Adamello Brenta Nature Park (620.51 km$^2$; Province of Trento, Central Alps, Northern Italy, lat. 46°10′ N, long. 10°45′ E) and the surrounding mountainous area (Tot. 6500 km$^2$, Fig. 1). The Adamello Brenta Nature Park was established in 1988 in order to protect the Alpine and pre-Alpine ecosystems, as well as to promote scientific research and a sustainable use of natural resources (Trento Province Law n. 18/1988). On the whole, the reintroduction area includes five provinces and 255 settlements, with 3000 km$^2$ covered by forests (21.38% broad-leaved forest, 53.55% coniferous forest, 24.68% mixed forest). The most representative coniferous species are European spruce (*Picea abies*), European silver fir (*Abies alba*), and European larch (*Larix decidua*), while beech (*Fagus sylvatica*), downy oak (*Quercus pubescens*), manna ash (*Fraxinus ornus*), and hop hornbeam (*Ostria carpinifolia*) are the most widespread broad-leaved species.

Elevations range from 65 m above sea level (a.s.l.) at the southern border around Lake Garda, to 3905 m a.s.l. of Mount Ortles. Most of the area (80%) consists of mountain slopes and ridges (slope steepness between 10° and 60°, average 25°), while less than 8% of it is flat (slope < 5°). The urban area covers 1.7% of the study area, with about 374,000 inhabitants (average density = 58 inhabitants/km$^2$; Dupré et al. 2000) and a road density of 1.1 km/km$^2$ (Mustoni et al. 2003). Tourist traffic (both summer and winter tourism, the latter being largely based on skiing) was evaluated for the reintroduction project in 2400 overnights/km$^2$; livestock farming is heterogeneously distributed over the area, with an average density of 9 cattle/km$^2$, 1.4 sheep/km$^2$, 0.7 goats/km$^2$, and 0.2 equine/km$^2$ (Dupré et al. 2000). Beehives have a wide and rather homogeneous

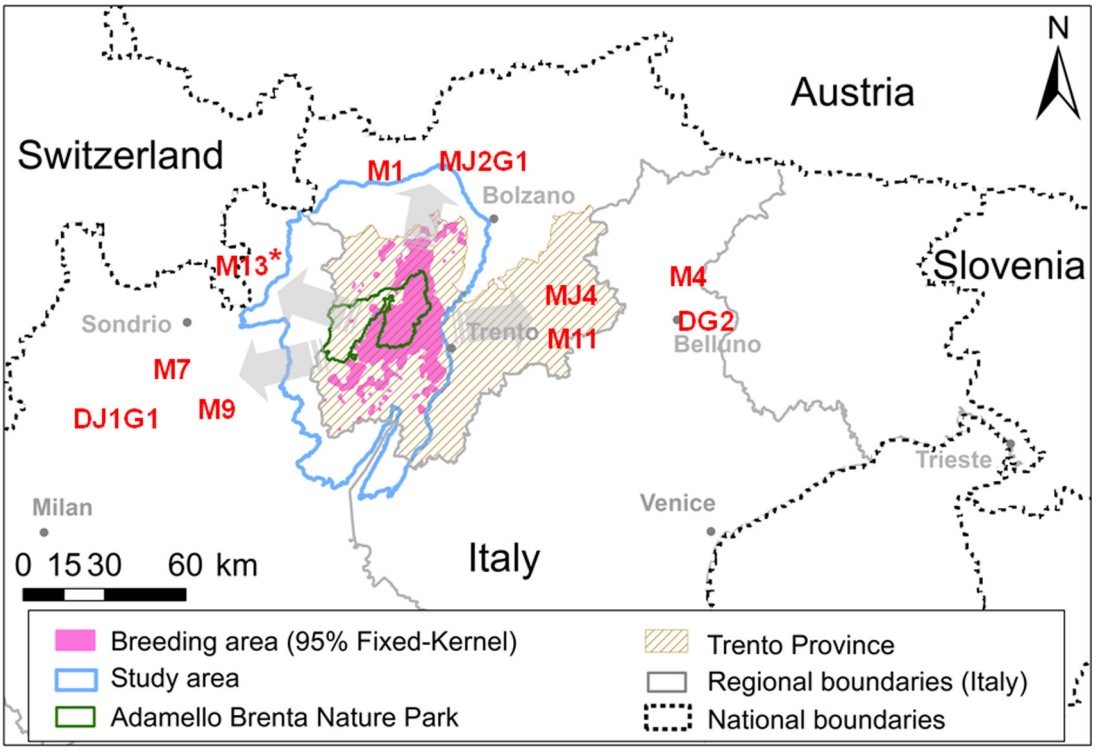


**Fig. 1.** Map of the study area. Breeding area (i.e., the area consistently occupied by females; 1246.41 km$^2$ by means of 95% kernel density estimation) and displacement direction of the 10 (at present 9) young males (grey arrows, ID names) present at the end of 2012 and monitored (i.e., genetically determined) for the brown bear population in the Southern Alps (Italy) are shown. *M13 was killed on 19th February 2013 in Val Poschiavo (CH) by gamekeepers in the Grigioni Canton, thus it is not counted in the latest update of the population size.

distribution. The agricultural area is constituted by 69.01% of cultivated lands and 30.99% of orchards and covers 14.1% of the study area, while 4.9% of the inhabitants work in the agricultural sector (Dupré et al. 2000).

Alpine chamois (*Rupicapra rupicapra*), roe deer (*Capreolus capreolus*), and red deer (*Cervus elaphus*) are abundant throughout the study area, although with different local densities. Despite different game management units (national and regional parks, provinces, game reserves, game management areas), within the whole study area hunting is controlled through licenses issued by local wildlife boards.

The brown bear was added to the list of protected species in Italy in 1939 (National Law 1016/1939).

In order to guarantee people's safety and to prevent strong damages to economic activities, the prohibition of killing bears may be derogated only when the lack of alternative solutions and the persistence of the bear population in a favourable conservation status are ascertained (Presidential Decree 357/1997). In this context, The Action Plan for the Interregional Conservation of Brown Bear in the Central Eastern Alps – PACOBACE (AA.VV. 2007) is the reference document for management and conservation of the species in the Italian Alps. In particular, it reports the monitoring protocols and the criteria and procedures for prevention and compensation of damages, for intervention in critical situations and emergencies, as well as for the training of operators and communication activities.

### *Distribution and dynamics of the brown bear population*

#### *Telemetry data*

These data refer to 2 monitoring phases: (1) from 1999 to 2003, consisting of 6390 radio-tracking locations (VHS radio-collar Model 505, and 2 ear-tag tracking device Model 5902, Advanced Telemetry System – Telonics Inc.) of 10 bears (7 females and 3 males) which were released during the *Life Ursus Project*; and (2) from 2004 to 2012, consisting of 8512 radio-tracking locations (GPS-VHF radio-collar Vectronic Aerospace) of 6 bears which were captured and collared for management purposes. We selected only highly accurate telemetry data. For VHF radio-collars we estimated bear locations by the intersection of three compass bearings (triangulation), taken from three different stations within 30 min. All bearings were plotted on a detailed map of the study area (1:10,000 and Digital Elevation Model with 10 m pixel resolution) and those bearings that apparently bounced off mountains, or were otherwise inaccurate (bearings not converging), were deleted. For GPS-VHF radio-collars we considered only data validated with a dilution of precision $\leq$7.

#### *Direct and indirect point of presence data*

These data consist of sightings, tracks, faeces and other indirect records collected from 2002 to 2012 (see Groff et al. 2013). All the data were provided by UTM WGS84 *x*–*y* coordinates placed by professionals (zoologists and forest rangers) and based on either GPS readings or topographic maps (1:10,000).

#### *Distribution and habitat use*

We calculated annual home ranges by means of the fixed kernel density estimator (least square cross validation; 100 m raster cell size, in accordance with the level of accuracy and precision of positions) using point of presence data. Thus, we correlated the annual home range size (95, 90, 75, 70, 50 percent isopleths) to the population size (i.e., number of bears in the Province of Trento) by means of the Spearman correlation coefficient.

We compared the locations obtained during the 2 monitoring phases (1st phase: 1999–2003 – telemetry dataset; 2nd phase: 2004–2012 – telemetry dataset and direct/indirect presence signs) with the habitat suitability model (HSM; 73.75% of suitable and

**Table 1**
Number and percentage of brown bear locations in suitable, moderately suitable and unsuitable areas of the habitat suitability model (HSM; Dupré et al. 2000) in the 6495.81 km$^2$ study area for the 2 monitoring phases. Difference in use versus availability of model categories was detected by means of $\chi^2$ (2 degree of freedom). Bonferroni confidence intervals (BCI) are also reported.

| HSM | 1st phase – Life Ursus data | | | 2nd phase – ordinary monitoring | | |
|---|---|---|---|---|---|---|
| | *N* | % | BCI | *N* | % | BCI |
| Suitable area (1704.96 km$^2$; 34.55%) | 3694 | 57.81 | $0.29 \leq 0.58 \leq 0.40$ | 6309 | 53.13 | $0.31 \leq 0.53 \leq 0.39$ |
| Moderately suitable area (2244.53 km$^2$; 39.20%) | 1948 | 11.71 | $0.34 \leq 0.12 \leq 0.45$ | 3710 | 31.24 | $0.35 \leq 0.31 \leq 0.43$ |
| Unsuitable area (2546.42 km$^2$; 26.25%) | 748 | 30.48 | $0.21 \leq 0.30 \leq 0.31$ | 1855 | 15.62 | $0.23 \leq 0.16 \leq 0.30$ |
| | | $\chi^2 = 1639.3$<br>2 dof; $p < 0.01$ | | | $\chi^2 = 1889.4$<br>2 dof; $p < 0.01$ | |

moderately suitable habitat in 6495.81 km$^2$ study area; Table 1) of the reintroduction project (Dupré et al. 2000). The model was based on presence/absence data in the core area of the remnant bear population (645 km$^2$) gathered over the 20 years prior to the reintroduction. Habitat suitability analysis was carried out on 26 variables describing environmental characteristics (land cover classes, elevation, slope, aspect, distribution and densities of roe deer, red deer, and Alpine chamois) and human disturbance (distribution and density of beehives and livestock, sky-areas, road and forest road density, inhabitants, hunters, major hunting practices, game bags, number of farms, and tourism traffic) (see Dupré et al. 2000; Mustoni et al. 2003 for major details about HSM). We grouped the locations into suitable, moderately suitable, and unsuitable areas and we calculated the percentage for each group. Difference in use versus availability of model categories was detected by means of $\chi^2$ (2 degree of freedom) (Neu et al. 1974). Whenever a significant difference was detected, a Bonferroni *Z*-statistic (Beyers & Steinhorst 1984) was applied to construct Bonferroni confidence intervals.

*Size, density, structure and dynamics of brown bear population*

We compared the size, structure, density, and dynamics of the studied brown bear population with the predictions of the feasibility study of the reintroduction project (Dupré et al. 2000). The number of bears, their reproductive success and the parental relationships were obtained through non-invasive genetic analyses performed on biological samples (done by the ISPRA lab; see De Barba et al. 2010), direct sightings, and the use of camera traps (Groff et al. 2013).

Densities were calculated in relation to the areas identified by 95% kernel area occupied by the locations of the bears from 2002 to 2012.

According to the average annual population increase calculated from 1999 to 2012, we identified a possible scenario of demographic development of the population, including the minimum viable population (MVP) and a theoretical carrying capacity for the study area (Fig. 2).

Considering only suitable and moderately suitable areas located by the feasibility study (see Table 1 for more details), we calculated the potential bear density (from a minimum of 2 bears/100 km$^2$ to a maximum of 4 bears/100 km$^2$). Moreover, we calculated the percentage of area occupied by bears which was identified by the preliminary suitability study and the proportion of suitable and moderately suitable area not yet occupied. The area occupied was calculated from all available locations (i.e., telemetry and direct/indirect points) with the kernel method to 90% and 95%. According to the proportion of occupied/not occupied suitable areas, we deduced a range that bears could potentially occupy within the study area. We also calculated a short-term development trend of brown bear population size based on 2002–2012 annual recruitment, mortality rate, and increasing local density.

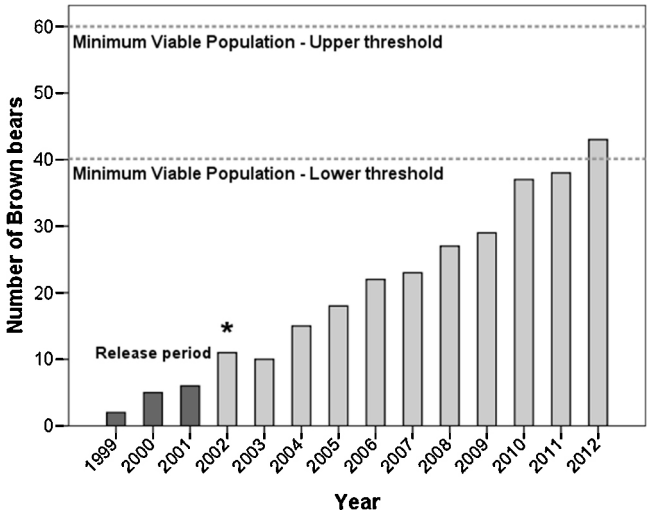


**Fig. 2.** Annual population trend of brown bear in the Central Italian Alps during and after the release period (dark grey bars; 1999–2001: tot = 10 bears). The dotted lines represent the minimum viable population (MVP, lower and upper threshold). The asterisk marks the year (2002) of the first reproduction: 2 cubs.

*Human–bear conflict*

*Damages (prevention and compensation)*

Since 1976, the regulation of the Province of Trento has allowed 100% reimbursement of the material value of assets damaged by bears. It has also promoted the prevention of damages to beekeeping and livestock by funding (up to 90% of the cost) interest-free loans for preventive equipment (Groff et al. 2013).

On such basis, the Province of Trento can provide a complete database of the damages refunded (number of events per year, kind of damages, and amount of reimbursement) and the prevention activities financed (e.g., number and type of prevention equipment and economic value of the contribution). The 2 levels of damages (high level: 26,500 € of damages/bear/year; low level: 500 €/bear/year) hypothesised in the feasibility study of the reintroduction project (Agriconsulting S.p.A. 1997) were compared to these data.

*Danger for humans (attacks and car collisions)*

A special unit of the Autonomous Province of Trento is in charge of the management of emergencies caused by bears, and keeps track of each issue in a weekly report. Such reports provided data about bear interactions with humans and collisions between cars and bears. Furthermore, a questionnaire on bear reactions during random encounters was submitted to 157 people that experienced such event at least once. Between 2007 and 2009, a total of 355 questionnaires were filled in (GRICO 2013).

**Table 2**
Report of the most significant events during the years 2013 and 2014.

| Data | Events |
|---|---|
| 19th February 2013 | M13, a 3 y.o. male bear, was shot down by the Swiss authorities (Canton Grigioni – Switzerland) because his over-confident behaviour was considered dangerous |
| Spring 2013 | Two reproductive events (making a total of 3 cubs)<br>Sudden disappearance of the bear M11 from Monte Baldo (Province of Trento) probably linked to an illegal killing |
| 28th September 2013 | M2, a 5 y.o. male, was found dead (illegal killing) in Rabbi Valley (Province of Trento) |
| October 2013 | An adult male was shot in Rendena Valley (Province of Trento) |
| Spring 2014 | Four reproductive events (for a total of 7–9 cubs) |
| 25th May 2014 | Bluff charge in Sole Valley (Province of Trento) by a female with a cub |
| 15th August 2014 | Daniza, a 19 y.o. female, attacked a mushroom collector that met her and her cubs in the woods near Pinzolo (Trento Province). Due to the attack, the man suffered minor injuries |
| 11th September 2014 | During an attempt to capture Daniza (a 19 y.o. female) and to transfer her into a fenced area, the bear did not recover from the sedation. |

*Bear removal*

The interregional management protocol agreed between the Province of Trento and the Ministry of the Environment (AA.VV. 2007) considered the removal of problem bears in case of threat to human security (i.e., tendency to get close to human settlements, to break into human buildings, and to follow and/or attack humans).

*Human attitude*

Within the study area of the reintroduction project, the attitude of the resident population has been surveyed 3 times. In the preliminary phase of the reintroduction project (1997), the survey involved only the residents of the study area of the project (DOXA 1997 in Dupré et al. 2000). The subsequent interviews, conducted in 2003 and 2011 (Doxa-PAT 2003; OGP Research-PAT 2011), involved the whole Province of Trento.

*2013–2014 data*

Data from 2013–2014 were not fully considered in the analyses, as they were not completely summarised by the Forest and Wildlife Service of the Province of Trento. Nevertheless, we decided to include some very recent facts which are thought to be relevant to the understanding of the development of human–bear conflicts in the area (Table 2).

## Results

*Distribution and dynamics of the brown bear population*

We observed a correlation between annual home range sizes (95%, 90%, 75%, 70%, and 50% isopleths, $n = 11$, 2002–2012) and population size ($\rho_{95\%} = 0.945$, $p < 0.001$; $\rho_{90\%} = 0.945$, $p < 0.001$; $\rho_{75\%} = 0.836$, $p = 0.001$; $\rho_{70\%} = 0.836$, $p = 0.001$; $\rho_{50\%} = 0.755$, $p < 0.007$).

We documented the number and percentage of locations that fell into each class of the HSM of the reintroduction project (Dupré et al. 2000; Table 1). We found significant differences between use versus availability of model categories in both monitoring phases (Table 1).

After the release period (1999–2001, 10 bears translocated), the average annual growth rate of the brown bear population was 20% (2002–2006), but then gradually settled down to the current level of 15.6%.

After the release period, litters were ascertained in the last 11 years (32 reproductive events genetically documented and 2 repeatedly observed in 2011), and at least 74 cubs were born (37 males, 28 females and 9 of unknown gender; cubs sex ratio = 1:0.76 ($n_{2002–2012} = 65$). Fourteen females and 5 males therefore reproduced in the period 2002–2012. The average age of *primiparous* females was 3.67 y. ($n_{2006–2012} = 9$) and the average interval between consecutive litters for the same female ($n_{2002–2012} = 18$ intervals of 9 females) was 2.11 y. The average number of cubs per litter was 2.06 ($n_{2002–2012} = 34$), with an average age of mothers of 7.2 y.

The number of cubs per litter increased with the age of the mother ($n_{2002–2012} = 31$), with $1.65 \pm 0.13$ cubs for females aged 3–7 and $2.75 \pm 0.13$ for females aged 8 or over (ANOVA: $F_{2,32} = 30.94$, $p < 0.01$).

In 2012 the population structure was composed of 17 cubs (5 female, 7 males, and 5 undetermined), 14 young bears (males between the age of 1 and 5 y. and females between the age of 1 and 3 y.; 3 females and 11 males), and 16 adults (males over the age of 5 y. and females over the age of 3 y.; 11 females and 5 males). At the end of 2012 the sex ratio M–F was 1:0.83 ($n_{2012} = 42$).

The minimum density value in Western Trentino was around 3 bears/100 km$^2$ (data referred to 34 bears considered permanent residents in 2012 and 95% kernel surface of all locations in the same year). The density rose to about 4 bears/100 km$^2$ with 90% kernel surface.

We documented the dispersion of 21 young males outside Western Trentino from 2005 to 2012 (Fig. 1). Four died (2 shot in Germany and Switzerland, 2 killed in car accidents in the Province of Bolzano), 1 disappeared in 2005 in the area between Engadine (Switzerland) and Bolzano, 2 immigrated into the Dinaric-Balkan population. Six of the remaining bears came back to the Province of Trento and 8 are still outside the Province. No dispersion of females born in Trentino was detected. The breeding area (i.e., the area consistently occupied by females) covered a surface of 1250 km$^2$ (95% kernel density estimation). The feasibility study reported a suitable area of 3949 km$^2$, with further 6495 km$^2$ of moderately suitable habitat. Taking into account that more than 70% of the locations were included in suitable and moderately suitable classes of the model (see Table 1 for more details), a theoretical carrying capacity of 104–156 bears was expected for the study area, with a density ranging between 2 and 3 bears/100 km$^2$.

From another perspective, since the percentage of available suitable and moderately suitable land occupied by bears varied from 17 to 22%, in relation to the different computational approaches (i.e., (i) 656.08 km$^2$, 16.61%; (ii) 882.78 km$^2$, 22.35%), and the number of bears permanently settled in the area was 34 in 2012, the number of bears could theoretically range from 152 to 205.

Finally, on the basis of the number of animals detected in 2012 (47 bears in the Central Italian Alps) and the increase in the average annual growth rate (15%), we identified three different development scenarios over five years (see Table 3). According to the values obtained, the population may reach a range of 60–94 individuals in 2017.

*Human–bear conflict*

*Damages (prevention and compensation)*

We observed the following pattern of damages caused by brown bear in the Province of Trento: (1) the number of damage events in

**Table 3**
Three different development scenarios for the brown bear *status* in the Italian Alps over five years (2013–2017). The previsions are based on the number of animals detected in 2012 (47 bears in the Italian Alps) and 3 different values of average annual growth rate (15%, 10%, 5%).

| Year | Average annual growth rate | | |
|---|---|---|---|
| | 15% | 10% | 5% |
| 2013 | 54 | 52 | 49 |
| 2014 | 62 | 57 | 51 |
| 2015 | 71 | 63 | 54 |
| 2016 | 82 | 69 | 57 |
| 2017 | 94 | 76 | 60 |

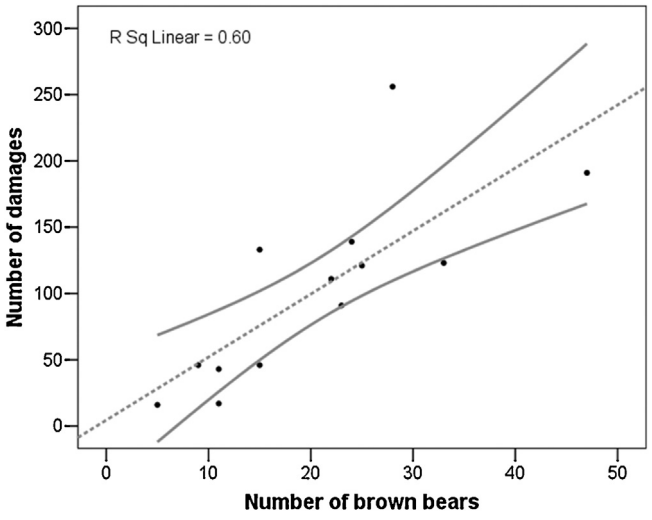


**Fig. 3.** Linear regression between the number of damages recorded in Trentino in the period 2000–2012 and bear consistency in the same area ($F = 17.922$ $p < 0.01$). (*Data from 2005; Jurka, a particularly damaging bear, was present. **Data from 2010; particularly damaging bears were present and young bears dispersed in areas with poor prevention structures.)

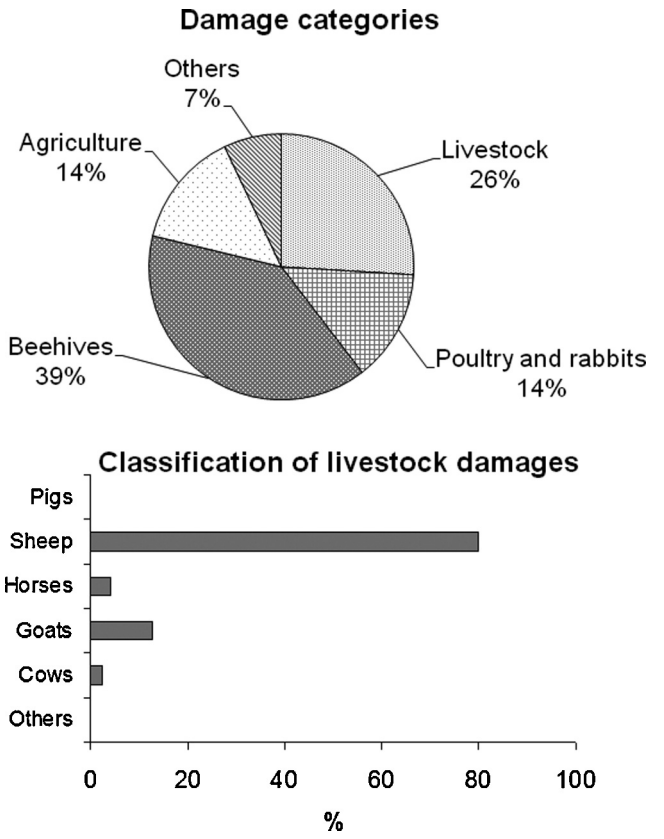


**Fig. 4.** Pie chart showing the overall number of damage events (upper panel) grouped according to the category of damage for the period 2000–2012 in the Province of Trento. Livestock is further distinguished into 6 groups in the second diagram (bottom panel).

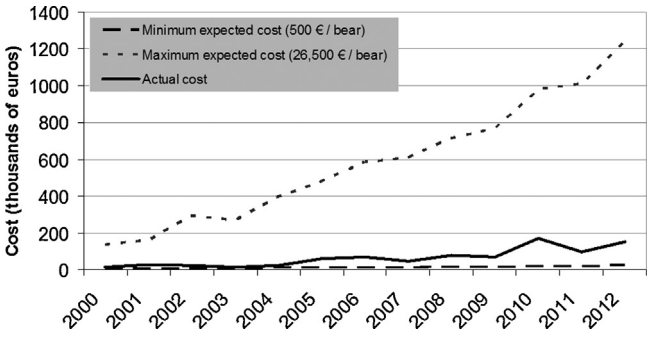


**Fig. 5.** Observed amount of reimbursement and prevention measures paid by the Province of Trento for the period 2000–2012, compared to "low level" (500 €/bear) and "high level" (26,500 €/bear) scenarios cited in the feasibility study of the reintroduction project (Dupré et al. 2000). Expected costs include both damage reimbursement and compensation for preventive measures.

2000–2012 was directly correlated with the number of bears (Fig. 3, linear regression: $F = 17.922$, $p < 0.01$). Among all the damage events recorded in the period 2000–2012 ($n = 1333$), 17% were attributed to individuals recognised by DNA analyses and caused by 29% of the bears present ($n = 82$) in the same period in the Province of Trento; (2) Bear damages were primarily inflicted on beehives (39%, Fig. 4 – upper panel) and livestock (26%, Fig. 4 – upper panel), especially sheep and goats (80% and 13%, respectively, Fig. 4 – bottom panel); (3) taking into account only the damages caused by bears in the HSM area of the reintroduction project (Dupré et al. 2000) in the period 2002–2012, more than 80% of the damages fell into either unsuitable (436 damages above 942; 46% of occurrences) or moderately suitable habitat (332 damages; 35% of occurrences); (4) concerning the economic relevance of the damages caused by bears, the overall expense for the whole period 2000–2012 was € 537,865 for damage compensation and € 305,859 for prevention measures. Therefore, the average expense amounted to € 41.374/per year for compensation and 23,527 for prevention, with a huge variation from one year to another (damage compensation: minimum € 8655 in 2000; maximum 122,564 in 2010. Damage prevention: minimum € 3060 in 2003; maximum € 55,500 in 2011). These data did not exceed the interval defined by the 2 expected scenarios presented in the socio-economic study developed prior to the reintroduction (Agriconsulting S.p.A. 1997) (Fig. 5). Considerable damages were produced by few individuals. In particular, in 2010 (the year with the highest number of damage events), 10% of the bears caused individually more than 10% of the damages recorded, and 3% of the bears (i.e., 1 bear) caused individually more than 20% of all the damages recorded.

*Danger for humans (attacks and car collisions)*

Only one case of attack with contact was reported in 15 years. Namely, in 2014, a 19 y.o. female attacked a mushroom collector that met the bear and her two cubs in the woods near Pinzolo (Province of Trento). The man suffered minor injuries. Among the 355 encounters collected by PNAB before 2014 (GRICO 2013), bear reactions varied between flight (60%), distant observation (36%), and approaching (4%); only in one case there was a reaction (a bluff charge). According to all the available data for the whole Province, 8 bluff charges have been recorded so far (usually a female in defense

**Table 4**
Resident population (% of interviewed persons) attitude towards bear presence within the reintroduction project area and the whole Province of Trento (data in brackets). Data from 1997 refer to the project area only (DOXA, 1997 in Dupré et al. 2000), while data from 2003 and 2011 refer to the whole Province of Trento (Doxa-PAT 2003; OGP Research-PAT 2011).

| Question | 1997 | 2003 | 2011 |
|---|---|---|---|
| Awareness of bear presence in Trentino | 77.6 | 97.4 (80.3) | 98.2 (97.7) |
| Perception of bears as abundant in Trentino | 2.0 | 33.3 | No data |
| Perception of bears as a rarity in Trentino | 69.0 | 32.0 | No data |
| People in favour of increasing the current densities | 68.0 | No data | 8.0 (2.0) |
| People in favour of maintaining the current densities | 23.0 | No data | 62.0 (66.0) |
| People in favour of decreasing the current densities | 4.0 | No data | 28.0 (32.0) |
| Liking the presence of bears | 70.0 | 70.0 (76.8) | 30.0 (30.4) |
| Bears liable for damages to agriculture | 29.0 | 65.0 | (63.0) |
| Bears liable for damages to animal husbandry | 23.0 | 59.0 | (63.0) |
| Bears liable for damages to beehives | 69.0 | 81.0 | (79.0) |
| Bears liable for damages to wildlife | 23.0 | No data | 30.0 (30.0) |
| People who remember a bear attack to humans | 2.8 | 10.6 (9.6) | 11.7 (10.1) |
| People decreasingly going into the woods with bear presence | 31.0 | No data | 53.0 (60) |
| People increasingly going into the woods with bear presence | 15.9 | No data | 2.3 |

of her cubs, the most recent one is reported in Table 2). Moreover, bears were repeatedly reported near anthropogenic food sources and in residential areas. Some events also involved bears trying to break into man-made structures (e.g., inhabited houses, shelters for shepherds). In particular, 14% of the bears accounted for more than 70% of the dangerous situations but were not listed among the more damaging individuals.

Since 1999, 22 car accidents involving bears have been recorded in the Region of Trentino Alto Adige; in these events humans were never injured, while 3 bears were killed.

*Bears removal*

Three bears have been removed from the Province of Trento since 1999. An adult female translocated from Slovenia in 2000 was removed in 2007 (Jurka, 10 y.o.), while another female was removed in 2011 (DJ3, 7 y.o.) (see Groff et al. 2008, 2012 for major details). In both cases, bears made intense use of urbanised areas and broke into rural buildings. They were live-trapped and retained in captivity. In September 2014 the 19 y.o. female responsible of the only attack to humans ever recorded in the study period died during a capture attempt (see Table 2).

*Human attitude*

Public opinion on the presence of brown bears appears to have substantially changed over time (Table 4). While the awareness of their presence increased, in fact, the species has been progressively perceived as more and more widespread and numerous and its social acceptance has strongly decreased. The latter tendency was expressed either as a growing will to stop the expansion of the bear population and even to see its reduction, or, more simply, as a general disagreement about the presence of bears on the whole. The bear is perceived, to different extents, as a damaging and dangerous species. Interestingly, although only a limited number of people considered it as truly dangerous for humans, more than 11% of the people interviewed in Adamello-Brenta Nature Park stated that bears had attacked humans after the reintroduction, which was not true at that time. On the other hand, the opinion of 42% of those who happened to come in close contact with a bear changed, with 62% of these expressing a more favourable opinion of this species after the encounter (Table 4).

At least two cases of illegal killing were reported and one was suspected in 2013. Before this date, some suspicions regarding the destiny of the first reintroduced bear were raised.

## Discussion

The reintroduction project in the Central Italian Alps was successful, since the majority of the bears released adapted to the new area, the number of bears increased to 47, and a total of 74 cubs were born. In 2012 the area with a stable presence of females was estimated to cover around 1250 $km^2$, to be fully included in the Province of Trento (minimum bear density of 3 bear/100 $km^2$) and to contain the sites where bears were first released. This newly established population, is comparable in size to the isolated population of brown bears in the Central Italian Apennines, with 35–67 bears in the core National Park of Abruzzo, Lazio and Molise, where most of the Apennine brown bears still survive (520 $km^2$; Ciucci & Boitani 2008; Gervasi et al. 2008).

The average annual growth rate has been very high up to now (20% just after the release, 15.6% at present). Analysing the expansion of brown bears after the Austrian reintroduction project, Wiegand et al. (2004) estimated a growth rate of the population in Austria and in the adjacent parts of Italy of ca. 14% during 1996–2000; a high proportion of this growth was due to immigration from Slovenia. Consequently, the growth rate of the subpopulation in central Austria, which probably was functionally isolated (i.e., no exchange of females) from the nuclei along the Austrian–Slovenian border, yielded some 7%. Kindberg et al. (2011) estimated that the Swedish brown bear population was composed by 3298 (2968–3667) individuals in 2008, thus reporting a yearly increase of 4.5% on the national level and from 0 to 10.2% on the county level for the period 1998–2007. This rate is comparable to that of other expanding populations in Europe (Rigg & Adamec 2007). Thus, the population growth rate in our case study can be considered similar to the growth rate of the expanding Scandinavian brown bear population (Sæther et al. 1998) and higher than the North American one (Garshelis et al. 2005; Pease & Mattson 1999; Wakkinen & Kasworm 2004). As evicted by means of data collected from 42 radio-tagged bears during four bear research projects in the Eastern Alps and the Dinaric Mountains, Güthlin et al. (2011) interpreted this growth in the light of the favourable habitat which the species can find in the Eastern Alps. Within a 5200 $km^2$ bear core area, Slovenia houses a bear population of 400–500 individuals, which corresponds to a density of roughly 9 bears/100 $km^2$ (Skrbinšek et al. 2008). This is also the source for the reintroduction project in Trentino. However, the low number of confirmed reproductive events and the smaller litter sizes in 2013 and 2014 suggest a possible decrease in its annual growth rate.

As expected, the annual home rage size of the population in Trentino was correlated to the population size. Habitat use data suggested a good correspondence between the HSM (Dupré et al.

2000) and land use by reintroduced bears, even though a high percentage of moderately suitable area was used by bears, thus suggesting an underestimation of the overall suitability of the reintroduction area. Habitat selection by brown bears has been intensely studied. In Europe, brown bears live in rather densely settled multi-use landscapes and therefore they seem to look primarily for cover, avoiding human infrastructure. For example, Clevenger et al. (1992) reported that, in Cantabrian Mountains (Spain), bears prefer beech- and oak-dominated forests and avoid roads and villages. In the case of Slovenia, due to its natural process of forestation, the area which represents a favourable habitat for bears is increasing rapidly (Jerina et al. 2003). In accordance with these findings, this reintroduced population appears to select deciduous forests and avoid areas with anthropogenic disturbance (Preatoni et al. 2005). Moreover, on a broad scale, Güthlin et al. (2011) showed that successful bear recovery in the Eastern Alps is unlikely to be inhibited by a lack of biophysical habitat. If bear conservation is stagnating or failing (e.g., the Austrian project), the reasons likely have to do with human-related factors (e.g., fear, damage compensation and prevention) and hunting issues (Kaczensky et al. 2002; Krystufek & Griffiths 2003). Swenson et al. (2000) reported that population density varies in relation to food availability, rate of harvest by humans, and stage of population expansion/retreat. The highest densities (10–20 bears/100 km$^2$) are found in Romania and in the Dinaric countries (e.g., Rozylowicz et al. (2011) referred to optimal brown bear habitat in Carpathian Mountains with a density of 25 bears/100 km$^2$), whereas extremely low densities (0.05–0.1 bears/100 km$^2$) are found in some areas of Fennoscandia. In general, the average density of the European populations is around 3 bears/100 km$^2$ (Swenson et al. 2000), and this value complies with the minimum density value recorded in Western Trentino in 2012. A recent estimate of the Apennine brown bear population size counted about 43 individuals in 1462 km$^2$ in the National Park of Abruzzo, Lazio and Molise and the buffer zone (i.e., 2.9 bears/100 km$^2$, Gervasi et al. 2008 – data refer to 2004), and a density of 3.2 bears/100 km$^2$ was reported by Gervasi et al. (2012 – data refer to 2008). Thus, at this fine scale, population estimates of this area are commensurate to those of the Adamello Brenta Nature Park, although population demographics are in contrast (see Ciucci & Boitani 2008; Gervasi et al. 2012 for an historical estimate of population size up to the present time). Considering the positive trend in the Central Alps, dispersal of young males is fully consistent with the available European data. We recorded the dispersal of 21 young males from 2005 to 2012, while females born in Trentino have never been found outside their natal area. Even in the Slovenian brown bear population the extreme population densities were most likely tempered by the dispersion of young bears from the female-reproductive areas with a high population density into external areas with a lower population density (Jerina & Adamič 2002; Jerina et al. 2003). This attitude complies with those reported in several other studies (e.g., Kojola et al. 2003; Swenson et al. 1998a; Zedrosser et al. 2007).

Despite the disappearance of a high number of young males (a phenomenon also linked to their strong tendency to disperse), the sex ratio and age class distribution in this rapidly increasing population was biased towards males and young individuals. As for the source population of Slovenia, brown bear females give birth to their first litters at the age of 4–5 years (Jerina et al. 2003). However, the early age (3 years) of female sexual maturity and the inter-birth interval of 2 years have been reported in other European populations (Dahle & Swenson 2003; Schwartz et al. 2003a; Zedrosser et al. 2004). This potential of growth is reflected in a mean litter size that was comparable to that of other brown bear populations (Frkovic et al. 2001; Swenson et al. 2001; Schwartz et al. 2003b). The brown bear litter size can range from one to four cubs, but in the source population of Slovenia the average litter size ranged between two and three cubs and the number of cubs per litter was related to the age of the mother, with *primiparous* females having significantly smaller litters of cubs than *multiparous* females (Jerina et al. 2003). As Zedrosser et al. (2006, 2009) reported in the case of the brown bear population of Sweden, *primiparous* females were significantly younger in the South than those in the North. Moreover, 4 y.o. females in the North were slightly smaller than those in the South, perhaps due to less favourable climatic conditions, which may prevent them from reproducing. Our data suggest that our study population is close to the source one in terms of reproductive potential, and, as expected, that these areas have more favourable climatic conditions than Northern Sweden.

As reported by Linnell et al. (2008), the increase in population size was combined with an increase in the number of conflicts, which included mainly predation on livestock, destruction of beehives, damage to crops and fruit trees, and, in exceptional cases, the risk of injury to humans. Although there may be a range of non-material social conflicts, damage is mainly economic and usually occurs disproportionally to the rural communities within the bear's range.

In Trentino, the yearly entity of damages is probably related to the availability of natural food items in the environment, but it is reasonable to argue that any future increase in the number of bears will correspond to an increase in the number of damage events. Moreover, since many suitable areas are not permanently occupied, an increase in the number of damage events is to be expected along with the future colonisation of such areas. In this framework, particularly damaging individuals can negatively influence the overall trend of damage: in fact, outliers in Fig. 3, concerning years with a number of damage events higher than the confidence interval, derive from their presence (Koren & Adamic 1997; Rauer & Gutleb 1997).

As regarding the categories of damage, beehives are the most frequently damaged items (e.g., Mertzanis et al. 2011), although relatively easy to protect from incursions. Bears can damage a wide variety of anthropogenic food sources, including a broad range of livestock. Among them, sheep are the easiest and most accessible prey (Zimmermann et al. 2003). Likewise, Kavčič et al. (2013) reported that sheep represented 97% of all predation events by brown bears in Slovenia. Notably, in the Apennine area occupied by bears residual sheep pastoralism currently persists in the montane belt at approximately a tenth of its historic level (Bemigisha 2008), and sheep–bear conflicts appear to be effectively prevented through corrals for sheep and shepherd dogs during the night (van Gils et al. 2014). Although the damage caused by bears was of little economic importance, and pastoralism is nowadays less relevant than previously, these situations might have modified the generally positive attitude of local people towards bears (e.g., Ciucci & Boitani 2008; Ciucci et al. 2014; van Gils et al. 2014): indeed, apart from the economical values, such damage had strong consequences in terms of emotive impact (see below). According to damage/compensation statistics, even in the Central Apennines bear livestock depredations were deemed to have low productive and economic importance to local communities (Latini et al. 2005). However, the incursions in some small villages by a few food-conditioned bears preying upon some poultry and domestic rabbits became socially upsetting episodes (Latini et al. 2005). From an economic point of view, including both reimbursement and prevention works financed, bears in the Central Italian Alps appear to have a lower impact than expected in the feasibility study, that is comparatively lower than that of bears in the Austrian Alps and the Pyrenees (data cited in Dupré et al. 2000).

In areas where large carnivores are increasing and expanding, people often become more afraid of potential encounters with them and their level of tolerance decreases. Concerning the danger for humans, available data confirm that the brown bear represents a

limited threat for their safety, in particular in the case of direct encounters (Ordiz et al. 2013; Revenko 1994; Swenson et al. 1999; Zavatskii 1987). Bears of Trentino usually avoid direct contacts with humans and their activities, and are prone to flee in case of sudden encounters (e.g., Moen et al. 2012; Mustoni 2004; Swenson et al. 1999). Some individuals were liable to cause potentially harmful situations. However, these individuals were limited in number and their identity did not coincide with the bears responsible of the damage events, thus posing the question of the management of different kinds of problem bears. Car collisions can be another dangerous occurrence for both bears and humans (e.g., Huber et al. 2008): in this regard, 2012 represented the worst year ($n = 6$ collisions), thus suggesting that the growth of the bear population in Trentino may actually account for an increase in car crashes.

Since the beginning of the reintroduction project, then, the public opinion has progressively become more aware of and hostile towards bears. The change is evidently related to the bears' increase, which seem to have generated a feeling of insecurity (cf., Clevenger et al. 1994; Mysterud 1980; Sørensen et al. 1999). In this sense, a major role is played by the few bold individuals responsible for the majority of damage events or potentially critical encounters. The public opinion is highly influenced by the presence of such problem bears which ultimately contribute to a biased representation of the entire population: their management thus appears as a key factor for the social acceptance of the species in the Province of Trento. The two cases of illegal killing in 2013 are possible outcomes of this no longer friendly attitude and may be meant to reduce the damage caused by bears and/or to mark the opposition to their presence. However, this value is lower if compared to the Apennine population. Indeed, in 1991 the Apennine National Park of Abruzzo, Lazio and Molise averaged 2.5 bears killed/year, with half of these being females (L. Gentile, National Park of Abruzzo, Lazio and Molise Veterinary Service, quoted in Lorenzini et al. 2004). The removal of problem bears can cause substantial debate but it is necessary to reduce conflicts with local people and to avoid further episodes of illegal killing. For instance, the recent incident of a man attacked by a female in defense of her two cubs led to a strong conflict as to its removal between local people and provincial Government on the one hand, and animal rights movements on the other.

In general, wildlife can pose serious problems when its activities intersect with those of humans. In this regard, the socio-political setting is as influential as the biophysical one for the effective management of human–wildlife interactions (e.g., Hill 2004; Treves & Karanth 2003). As Treves et al. (2006) reported from experiences in Bolivia, Uganda, and Wisconsin, the capacity to effectively manage wildlife-related threats to human safety and property – without compromising wildlife population viability or human life and livelihoods – should combine co-managers' technical expertise with local knowledge and embrace transparent and democratic processes of participatory planning. In this sense, useful examples, although in different socio-economical settings, come from Southern Africa, where the 'benefits equal conservation' idea suggests the importance of direct benefits in shaping support for and commitment to conservation (e.g., Scalton & Kull 2009).

## Conclusion

Brown bear reintroduction in the Central Italian Alps can be considered successful since the *Life Ursus* project fulfilled the expected goals (e.g., released bears adapted well, the population growth rate is high, economic relevance of damage complies with expectations). However, public opinion shifted from a major acceptance of the bear population at the beginning of the project, to an opposition to their presence, to their increase, and to new translocations aiming at replacing problem bears previously removed. In this context, the lack of a rational approach able to focus on the conservation of the bear population rather than on single individuals can be very detrimental. A more rational management of problem bears is strongly needed in order to restore the social acceptance of this species. Moreover, the instrumental use of bears that mass media and politicians made in the last few years has probably played a key role, by over-exposing brown bear and hyper-awakening public opinion. Accordingly, a second critical aspect that needs to be considered for brown bear conservation in Trentino is the necessity to implement a better media management of bears on a local scale, by to applying new strategies of communication about the species.

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