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Abstract: The number of brown bears (*Ursus arctos*) in the southeastern Italian Alps increased during the past decade due to the expansion of the Slovenian brown bear population, which is recolonizing the Julian and Carnic Alps. Overall, the habitat in these areas is still very good quality and suitable as permanent range for bears. However, the traffic system and human settlements form a massive artificial barrier and hinder recolonization of the Alps by brown bears. To quantify and categorize existing wildlife passages, we examined the freeway, main road and railway line for 76 km from Gemona to the Austrian border and recorded all walls higher than 3 m, fences along freeways, all measures against rockfalls and avalanches, cliffs with slopes  $>75^\circ$ , human settlements, and open landscapes  $>300$  m without any forest or scrub cover along the roads and railway line on a 1:5,000 map. We classified 21 corridors averaging 200 m (SE = 193 m) as high quality passages (total length = 4.2 km). Poor quality corridors, where bears are forced to cross roads or the railway line, and potential corridors had lengths of 9.2 and 14.6 km, respectively. We recommend that high priority be given to conserving and ameliorating the few existing corridors. The southeastern Alps act as a bottleneck between the Dinarids-Balkan and the Alps. The few remaining high quality wildlife corridors in this study area are a bottleneck within the bottleneck. The permeability of the southeastern Italian Alps is of crucial importance for the recolonization of the Alps by brown bears and other large mammals.

# IDENTIFYING PASSAGES IN THE SOUTHEASTERN ITALIAN ALPS FOR BROWN BEARS AND OTHER WILDLIFE

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**Abstract:** The number of brown bears (*Ursus arctos*) in the southeastern Italian Alps increased during the past decade due to the expansion of the Slovenian brown bear population, which is recolonizing the Julian and Carnic Alps. Overall, the habitat in these areas is still very good quality and suitable as permanent range for bears. However, the traffic system and human settlements form a massive artificial barrier and hinder recolonization of the Alps by brown bears. To quantify and categorize existing wildlife passages, we examined the freeway, main road and railway line for 76 km from Gemona to the Austrian border and recorded all walls higher than 3 m, fences along freeways, all measures against rockfalls and avalanches, cliffs with slopes  $>75^\circ$ , human settlements, and open landscapes  $>300$  m without any forest or scrub cover along the roads and railway line on a 1:5,000 map. We classified 21 corridors averaging 200 m (SE = 193 m) as high quality passages (total length = 4.2 km). Poor quality corridors, where bears are forced to cross roads or the railway line, and potential corridors had lengths of 9.2 and 14.6 km, respectively. We recommend that high priority be given to conserving and ameliorating the few existing corridors. The southeastern Alps act as a bottleneck between the Dinarids-Balkan and the Alps. The few remaining high quality wildlife corridors in this study area are a bottleneck within the bottleneck. The permeability of the southeastern Italian Alps is of crucial importance for the recolonization of the Alps by brown bears and other large mammals.

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**Key words:** Alps, barrier, brown bear, dispersal, expansion, Italy, *Ursus arctos*, wildlife passage

Brown bears disappeared from most of the Alps in the 19<sup>th</sup> and 20<sup>th</sup> centuries. One population, no longer viable, still survives in the Trentino. Individual bears always immigrated into the southeastern Alps from the adjacent Dinaric Mountains, where a healthy bear population survived (B. Gutleb, P. Molinari, M. Adamic, 1997, Did the brown bear ever disappear from the eastern Alps?). The southeastern Italian Alps are a key wildlife passage between the Balkans and the Alps for brown bears recolonizing the Alps (Schröder 1992, Molinari 1994, Perco 1994). The Tarvisiano in particular, with the lowest elevation passes, is a key crossing spot for animals that migrate or disperse long distances (Molinari 1998).

There are no natural biogeographical barriers between the Alps and the Balkans. Overall, the habitat in these areas is very good quality and suitable as permanent range for bears. During the past decade, the number of brown bears in the southeastern Italian Alps increased due to a reduction in hunting in Slovenia since the early 1990s (M. Adamic, University of Ljubljana, Ljubljana, Slovenia, personal communication, 1997). However, traffic and human settlements form a massive artificial barrier that hinders the recolonization of the Alps by brown bears. This reduces the number of bears that could migrate to the Alps to a few individuals that overcome this obstacle only by chance.

The purpose of this study was to evaluate currently existing wildlife passages with special reference to brown bears, to quantify and categorize the different passages and barriers, and to propose conservation measures.

## STUDY AREA

This study was conducted in the southeastern Italian

Alps in the main valley from Gemona to the Austrian border (Fig. 1.). The valley bottom is heavily developed and includes a freeway with 2 lanes in each direction, a main road with 1 lane in each direction, a railway line, and many human settlements.

The surrounding habitat was characterized by a remarkable variety of forests. Pure and mixed stands of fir (*Picea abies*), spruce (*Abies alba*), beech (*Fagus sylvatica*), pine (*Pinus sylvestris*, *Pinus nigra*), and larch (*Larix decidua*) represented the main species, which cover more than 60% of the mountain ranges. Deciduous forests with alder (*Alnus* spp.) and willow (*Salix* spp.) become more frequent southward until they become dominant. Roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), chamois (*Rupicapra rupicapra*), and wild boar (*Sus scrofa*) are common. Large carnivores are represented by lynx (*Lynx lynx*) and a small brown bear population estimated at 5-10 individuals in the border region of Italy, Slovenia, and Austria (P. Molinari unpublished data).

## METHODS

The study area was divided into 3 parts of approximately the same lengths: Val Canale, Canal del Ferro, and Moggio to Gemona (Fig. 1). The area south of Gemona is agricultural land unsuitable for bear migration. We followed 76 km of freeway and 84 km of main road (SS 13 Pontebbana, 72 km; SS Carnica, 12 km) on foot or by car, averaging 7 km/day. For long stretches, the railway line ran parallel to the main road; therefore, only 25 km of the railway line had to be analyzed separately. Along this traffic system (freeway, main road, and railway line), we recorded on a 1:5,000 map ( $\pm 10$  m) all natural and artificial barriers that could prevent bears from crossing the valley bottom from

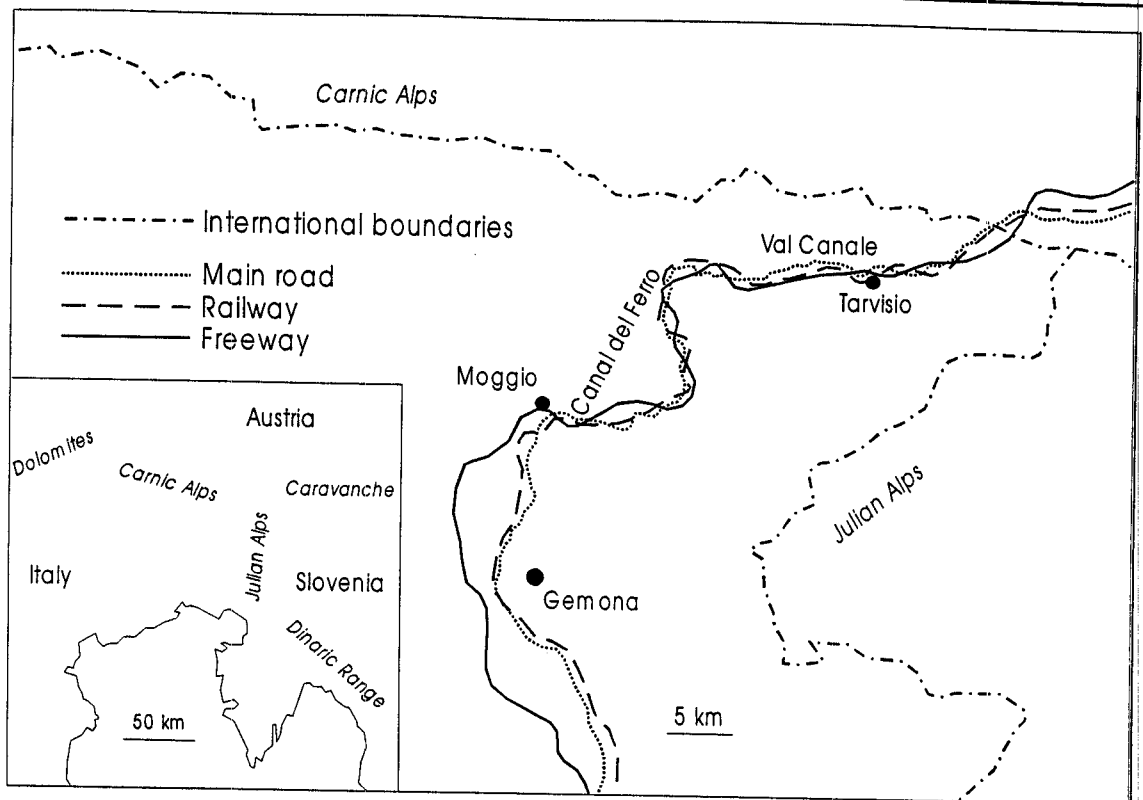


Fig. 1. Location of the study area and the traffic system in the southeastern Italian Alps.

east to west. All walls  $\geq 3$  m high, fences along freeways, all measures against rockfalls and avalanches, steep cliffs ( $>75^\circ$ ), human settlements, and open landscapes  $>300$  m from forest or scrub cover were considered barriers.

All barriers were ranked according to the likelihood that a bear would cross them: (1) walls higher than 3 m, measures against rockfalls and avalanches, and steep cliffs were considered true barriers, (2) fences along freeways, human settlements, and open landscapes were considered potential barriers. Often barriers coincided; for instance a bear might cross the main road but find a barrier at the railway line. Sites absent of true barriers were defined as corridors. Corridors were ranked of high or poor quality or as potential corridors: a corridor was designated high quality if bears could cross the valley without crossing any traffic line (e.g. through tunnels or viaducts), and poor quality if no barrier was reported on any of the traffic lines, but bears ran the risk of getting hit by a car or train. An area was designated a potential corridor if a potential barrier (fences, human settlements, open landscapes) was reported on one or several traffic lines.

Special interest was given to the corridors used by red deer. They move great distances daily and seasonally and recolonized the Alps in the 1950s from the east as bears are doing today. Red deer occur in high numbers and their movements are well known.

## RESULTS

Twenty-eight km (37%) of the traffic system remained along the valley bottom we studied as corridors for brown bears; 4.2 km were high quality corridors, and another 9.2 km were ranked as poor quality corridors (Table 1). On 14.6 km, a potential barrier existed on one or several traffic lines. The length of the high quality corridors ranged from 10 m in the Val Canale, a tunnel built especially as a wildlife passage, to a 550 m long viaduct over a natural riverbed in the stretch from Moggio to Gemona. In the Val Canale, we identified 11 high quality corridors with a mean length of 206 m (SE = 200 m). In the Canal del Ferro and from Moggio to Gemona, we identified only 6 and 4 high quality corridors with mean lengths of 192 m (SE = 184 m) and 193 m (SE = 239 m), respectively.

The length of the poor quality corridors ranged from 20 to 900 m. Poor quality corridors were most frequent in the Val Canale ( $\bar{x} = 341$  m; SE = 269 m;  $n = 14$ ). In the Canal del Ferro and from Moggio to Gemona we found 14 and 6 poor quality corridors with mean lengths of 238 m (SE = 205 m) and 178 m (SE = 193 m), respectively.

Considering only passages where bears encountered no barrier (high and poor quality), the 76-km freeway with passages along 33 km was more permeable for bears than the 72-km main road with passages along 14 km. The most important barriers were (1) human settlements, be-

**Table 1. Length of corridors in the 3 parts of the study area in the southeastern Alps of Italy in 1997. See text for definitions of corridors.**

Area	Total length (km)	High quality km (%)	Poor quality km (%)	Potential km (%)	Total km (%)
Val Canale	29	2.27 (7.8)	4.78 (16.5)	9.40 (32.4)	16.45 (56.7)
Canal del Ferro	23	1.15 (5.0)	3.33 (14.5)	2.55 (11.1)	7.03 (30.6)
Moggio-Gemona	24	0.77 (3.2)	1.07 (4.5)	2.60 (10.8)	4.44 (18.5)
Total	76	4.19 (5.5)	9.18 (12.1)	14.55 (19.1)	27.90 (36.7)

cause they stretch over long distances, and (2) walls higher than 3 m, and (3) measures against rockfall and avalanches, because they were impermeable. Natural barriers consisting of steep cliffs were especially common in the Canal del Ferro.

As confirmed by snowtracking and direct observations, red deer frequently used all corridors of high quality to cross the valley. However, where they had to cross a traffic line (poor quality corridor), they ran a high risk of being hit by a car or train, as demonstrated by the average of 49 red deer traffic mortalities/year for the last 10 years. Red deer use of the potential corridors has never been reported.

## DISCUSSION

The return of the brown bear to the Alps depends on its acceptance by people, favorable habitat, and especially on corridors through which to immigrate. There are, however, 3 obstacles for bears that hinder their return to the Alps: the Osimo freeway from Trieste to Ljubljana, the traffic system analyzed in this study, and the Brenner freeway from Verona to Innsbruck. Brown bears are thought to be common northwest of the Osimo freeway (Adamic 1994). Few bears are known to have reached and tried to cross the traffic system in our study area; however, no bear has yet reached the Brenner freeway. Therefore, for the colonization of the Alps, the traffic system we analyzed, where 37% (28 km) remained available as corridors, is of great importance. However, this 37% has to be interpreted cautiously: it consists of 3 different types of corridors. The high quality corridors are only 4.2 km long (5.5%). Poor quality corridors, where bears are forced to cross roads or the railway line, and potential corridors have a length of 9.2 and 14.6 km, respectively. The significance of potential corridors is difficult to evaluate. Bears might be able to pull down or climb a fence, but they may prefer to turn back or to search for alternatives. There are only 3 anecdotal observations of brown bears trying to cross the valley: twice brown bear tracks turned back when they arrived at one of the tunnels of 10 m width designed especially as wildlife passages, and once a bear tried to cross the main road close to a tunnel, but was killed by a car. The behavior of bears varies individually, depending

on their experiences. Some individuals have been known to climb high fences or walls frequently to cross a freeway and do not avoid human settlements, whereas others systematically avoid these areas (P. Kaczensky, Munich Wildlife Society, Munich, Germany, personal communication, 1997).

The Val Canale, where 80% of the red deer that cross the traffic system traverse, could become as important a migration route for large carnivores as for red deer. It is also in this part of the study area where the highest number of corridors occur: 11 (52%) high quality corridors and 14 (41%) poor quality corridors. The high quality corridors are frequently used by red deer. The high number of red deer hit by cars and trains shows the importance, but also the danger, of the poor quality corridors.

## MANAGEMENT IMPLICATIONS

There is a high risk that the corridors still existing will be destroyed, especially in the Val Canale, because these valley bottoms are potential construction sites. Natural riverbeds crossing the traffic lines were used by red deer, wild boar, and probably brown bears. Efforts should therefore be made to protect these riverbeds. High priority should be given to the conservation and amelioration of the few existing corridors of high quality. A mean of 49 red deer and 28 roe deer were killed annually during the last decade when they crossed the valley using poor quality corridors. This shows the urgent need to provide some kind of crossing aid. However, the 10-m wide by 20–30 m long tunnels built for wildlife are hardly ever used. Furthermore, measures against avalanches and rockfalls could easily be ameliorated so that wildlife may overcome this barrier.

The southeastern Alps act as a bottleneck between the Dinarids-Balkan and the Alps. The 5.5% of the valley bottom described by us as high quality wildlife corridors is a bottleneck within the bottleneck. The number and length of corridors necessary for bears to colonize a new area is unknown. Future efforts should therefore aim at gaining more data on migration dynamics of bears. Of crucial importance for the recolonization of the Alps by brown bears and other large mammals is the permeability of the southeastern Italian Alps.

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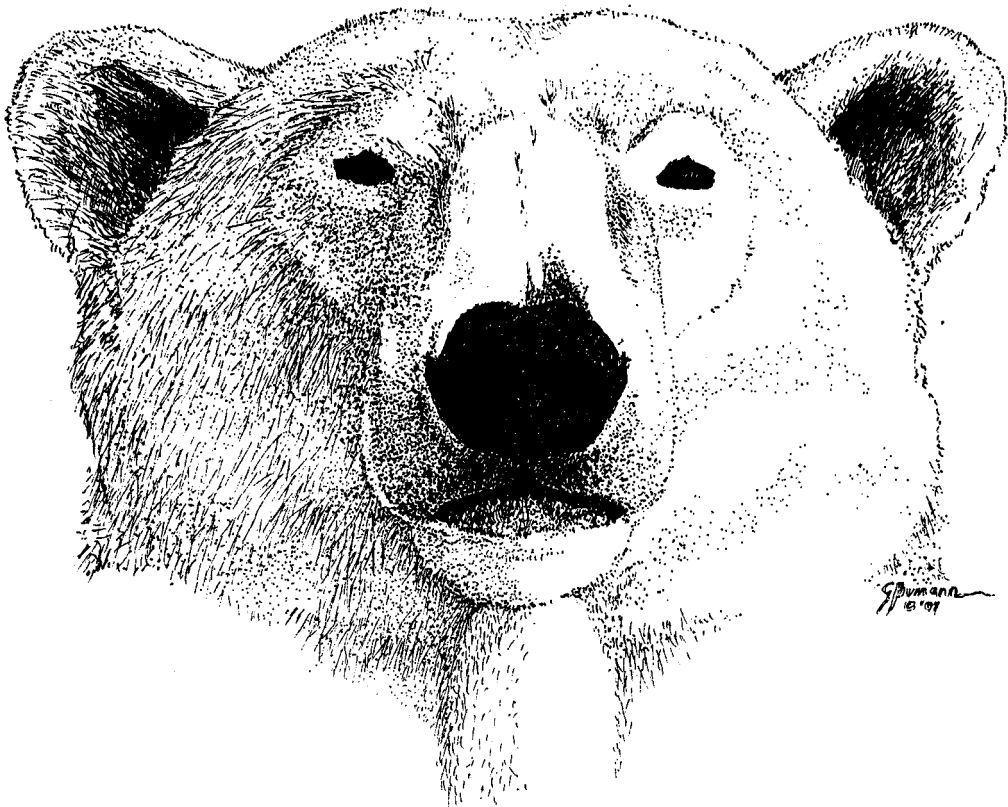
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