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A future for European bison *Bison bonasus* in the Carpathian ecoregion?

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All European bison *Bison bonasus* saved from extinction about 80 years ago originated from just 12 founders. Now, the population totals about 3,000 very closely related individuals. Almost 40% live in small groups in captivity, and the rest live in a few, isolated, free-ranging and semi-free herds. Although some negative influences of inbreeding have been reported, further loss of genetic variability can be prevented by allowing exchange of genes among sufficiently large numbers of animals. The Carpathian Range, the largest and least altered mountain range in Central Europe, offers the best ecological conditions to establish a viable metapopulation of European bison. In this paper, we describe recent advances in reestablishing free-ranging bison in the Carpathians, the programme's benefits for the future of the species, and its implications for the restoration of a missing ecological role in the ecoregion.

Key words: European bison, inbred, introductions, metapopulation, restoration, viable population

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Restoration of European bison *Bison bonasus* was initiated in 1924, when the last 54 individuals were scattered in several breeding enclosures. Their pedigree records indicated that all of them likely had derived from just 12 individuals (Slatis 1961, Pucek 1991). Almost 1,200 individuals are now registered in zoos and breeding centres, mainly in Europe. Some 1,900 European bison live in the wild. About 65% of the free-ranging population belongs to the Lowland line derived from just seven (of the initial 12) founders

from the population of Białowieża Primeval Forest, Poland. The animals currently occur as herds scattered in forests of northeastern Poland, Lithuania, Byelorussia, northern Ukraine and the Cherga-Ural area of Russia. Other European bison belong to the mixed Lowland-Caucasian line (which among its ancestors includes one Caucasian bison that survived in a German zoo) and live mainly in Russia and in Poland-Ukraine along the northern macro-slope of the Carpathians (Pucek et al. 2002, Raczyński 2004). Several herds of both lines have health problems that could be linked to inbreeding (Kobryńczuk 1985, Olech 1987, Keller & Waller 2003).

Bison donations from Poland to various breeding centres (i.e. 400 animals over the last 50 years) have not maximised genetic variability (Olech 2002). Consequently, the mixing of both lines has diluted the genetic stock of the five initial ancestors from the Lowland-Caucasian line. Until the late 1990s, there were no transfers of animals from west to east. As a result, there are considerable differences in the genetic composition among the existing breeding groups (Belousova & Kudrjavtsev 1996, Olech 1999).

Virtually all bison bred in captivity have been registered since 1924 in the European Bison Pedigree Book. Nevertheless, only 400 European bison are included in the European Endangered Species Programme involving 62 zoos. In Poland, a similar programme exists for 160 animals of the Lowland line kept in 16 breeding centres (Olech 1997). Therefore, the level of genetic variability or founder representation in the mostly isolated breeding groups is still decreasing. It is necessary to extend the existing programmes to include the whole captive population and to design a plan for a routine exchange of animals to improve the genetic structure of the species.

European lowland forests are mostly monocultures managed to maximise the production of timber. Only a few sites are suitable habitat for free-ranging bison, and in most cases their areas are insufficient to support viable populations. An exception is the Białowieża Primeval Forest, which currently holds almost 600 European bison divided into two groups by a fenced border between Poland and Byelorussia. In the European part of Russia, the range of European bison is limited in the northeast by climate. Lowland populations, therefore, remain restricted mostly to small herds requiring constant monitoring and improvement of their gene pools through planned exchange of animals (Kozlo 2000).

The Carpathian Range, encompassing an area of almost 210,000 km^2 in six countries (Romania, Ukraine, Slovakia, Poland, Hungary and Czech Republic), remains relatively undeveloped and includes much highly productive, native, deciduous and mixed forest (Fig. 1). About 16% of the area of the Carpathians is protected as national, nature or landscape parks, most of which are relatively large, exclusive of

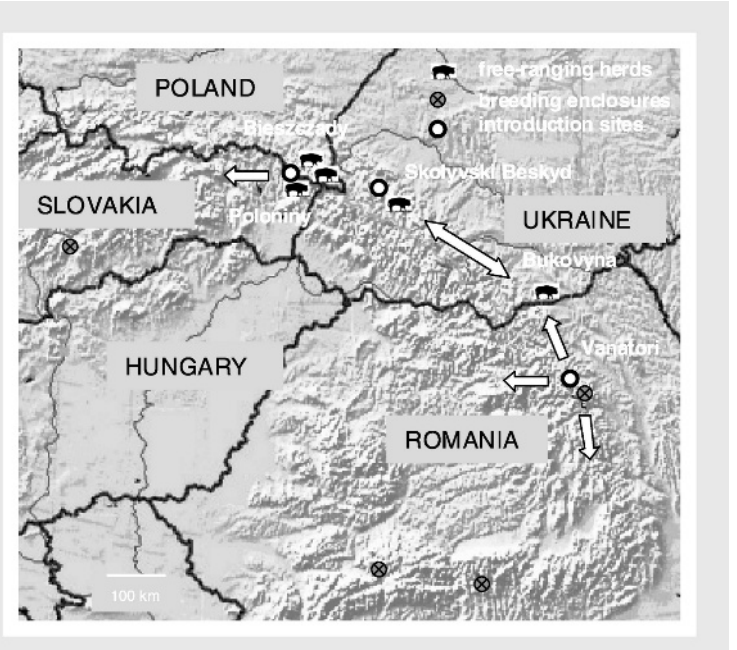

Figure 1. Distribution of free-ranging bison herds, breeding enclosures and planned introduction sites in the Carpathians. The white arrows indicate the potential for further dispersion.

Table 1. Founders' contribution (in %) in European bison; Polish and Ukrainian herds in the Carpathians compared with the captive world population.

Origin of animals	Sum of founder contribution for seven founders common for both lines	Founder contribution of five founders occurring only in the Lowland-Caucasian line				
		Founder #				
		100	35	46	95	96
Carpathian herds						
Poland (Bieszczady)	89.3	3.2	0.9	0	2.2	4.4
Ukraine (Bukovyna)	88.8	2.8	0	0	2.8	5.6
Captive animals						
Mean	78.3	7.1	3.2	1.3	3.8	6.4
1st quartile	60.6	4.0	0.8	0	3.0	5.7
Median	77.8	6.1	2.6	0.6	3.8	6.6
3rd quartile	94.8	9.2	4.7	1.8	4.6	7.7

commercial activities suitable as refuges for wildlife. Additionally, since 2004, a network of Natura 2000 sites is being introduced into Poland and Slovakia, mostly overlapping with already existing parks. But according to a European Union Habitat Directive it emphasises the protection of ranges of priority species like the European bison. The Carpathian fauna comprises a complete set of large predators: brown bear *Ursus arctos*, wolf *Canis lupus* and lynx *Lynx lynx*. However, it lost its wild, large grazers (aurochs *Bos primigenius*, bison and wild horses *Equus caballus*) some 200-400 years ago. Restoration of this ecological niche, apart from bringing back a keystone species to the ecosystem, would increase biodiversity in the region and facilitate ecologically sound management of the forest habitats (Vera 2000, Webster et al. 2001).

Programme concept

European bison were reintroduced to the Carpathians in the 1960s and 1970s at two sites in Poland and three in Ukraine. The 300 free-ranging bison in the Carpathians are still increasing in numbers, as the habitat is very suitable for this large herbivore. Unfortunately, however, the herds are located far from each other, and there is no planned effort to exchange individuals. Therefore, the effective numbers of even the largest Carpathian herds are too small to assure their long-term genetic and demographic stability (Perzanowski & Kozak 1999).

The primary objective of the current restoration programme for European bison in the Carpathians is to increase their effective population size, thereby assuring their long-term population viability. The success of this programme depends on the proper design of future refuges and an increase in genetic variation within the population (Pucek et al. 2004).

The current programme is based on two large herds of bison: the western (around the International Biosphere Reserve composed of three national parks: Polish 'Bieszczady', Slovak 'Poloniny' and Ukrainian 'Uzhansky') and the eastern (the 'Zubrovica' Reserve in Ukrainian Bukovyna region). There are about 200 animals in the western herd and about 100 in the eastern herd, and the seven founders common to both lines provided almost 90% of the combined gene pool (Table 1; Olech 1999, Perzanowski & Paszkiewicz 2000, Olech & Perzanowski 2002). Major effort, therefore, is directed at increasing the genetic variation of these herds by including animals with genes from the five founder represented only in the Lowland-Caucasian line. The work was initiated in 2002 by releasing into Bieszczady, Poland, four young European bison from Scandinavian breeding centres, and in August 2005, two young bison from Prague Zoo were brought there. Another free-ranging herd, to supplement the neighboring Bieszczady herd, was established in December 2004, in the Slovak 'Poloniny' National Park with five animals from Dutch, Italian and Swiss breeding centres. The herd in Ukrainian Bukovyna will have its counterpart at Vanatori Neamt Nature Park in Romania, whereto the first four animals arrived from Swiss zoos in May 2005. The minimum target for these herds is an effective population size of 100 individuals each. Assuming the present sex structure (1 male:1.2 female) and proportion of young and non-breeding animals (about 30%) remain stable, this equates an increase in population size by 3.5-3.9 times (i.e. at least 800 bison in the two Carpathian herds). The sources of animals for reintroduction are captive breeding centres. The cur-

rent genetic structure of these animals is much less skewed than in the Carpathian herds, and the contribution of the five founders for the Lowland-Caucasian line (Numbers 100, 35, 46, 95 and 96) is on average twice as great (see Table 1).

Additional protected areas, in which bison foraging is not regarded negatively, are needed for the planned growth of the herds. Such areas are more readily available for the western herd, i.e. the International Biosphere Reserve contains more than 200,000 ha, than for the eastern herd. The eastern, Ukrainian-Romanian herd requires migration corridors connecting the two subpopulations on either side of the border. A pilot study conducted since 2002 in the Bieszczady Mountains of Poland examines habitat preferences, seasonal patterns of home range and permeability of natural and man-made barriers. Preparations for a Romanian network of Natura 2000 sites, connected with the inclusion of Romania in the European Union in 2007, should facilitate this objective (Perzanowski & Deju 2005).

Natural exchange of animals is expected only to occur within the two major herds. Additional reintroductions are, however, planned within the Ukrainian Carpathians (e.g. Skolyvsky Beskyd), which could speed up the linkage of western and eastern herds. The intended result is a metapopulation able to disperse along the Carpathian chain (see Fig. 1; Hedrick & Gilpin 1997). That would double the effective size of the total population and help maximise its dispersion, thus minimising the risks of overgrazing and epidemic disease. One predicted ecosystem effect of the significant, wild populations of this large grazer is a change from widespread, closed canopy forests to a more patchy and diverse landscape (Vera 2000).

Conclusions

The approach outlined here for the restoration of the highly threatened species provides a unique opportunity to reestablish a truly self-sustaining, wild population of European bison in the centre of the European continent. Additionally, by focusing the efforts in major protected areas, it should be possible to incorporate the programme of bison recovery into more general plans for nature conservation at an ecoregional scale, with European bison being a major umbrella species. Restoration of a viable metapopulation of this species would be a first step in restoring an ecological niche that has been missing from the Carpathians for at least 200 years; i.e. that of wild, large grazers. In the future, European bison could become an 'ecological tool' contributing to the maintenance of a highly diverse habitat.

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