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Research Article

Restoration of European beaver *Castor fiber* in Poland – a proper or wrong lesson of active protection for other European countries?

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Abstract

The natural increase in the European beaver population in Poland, noted after 1945, was unsatisfactory. In 1975, the population amounted to only 500 individuals and was not sufficient to guarantee the species' continued survival. Nearly the entire beaver population was confined to north-eastern Poland, and natural population dispersion was not observed. Beaver colonies were translocated to other Polish regions as part of the Program for the Active Conservation of the European Beaver in Poland, implemented in 1975, which saved the beaver population from complete extinction. Since the beginning of the 21st century, efforts have been made to manage the Polish beaver population by hunting without changing a protected species' status. The beaver population continues to increase uncontrollably, which results in costly conflicts as beaver activities infringe upon the intended use of the land by humans. The future status of the European beaver in Poland remains unclear.

Keywords: Poland, population increasing, reintroduction, species protection

Introduction

Deliberate reintroduction to specific regions or habitats, similarly to natural migration, contributes to restoring wild animal species populations. Species conservation and reintroduction lead to

increased biological diversity and genetic variability (IUCN/SSC, 2013). Numerous species reintroduction programs have been launched in Europe and on other continents (Holtmeier, 2015). The species that have been successfully reintroduced to the wild include the European bison (*Bison bonasus*) in the Białowieża National Park (Krasiński, 1978) and the Alpine ibex (*Capra ibex*) in several Alpine regions (Holtmeier, 1987). Efforts have also been made to restore the European beaver populations (*Castor fiber*) in many Central European countries (Żurowski & Kasperczyk, 1988; Halley et al., 2012).

Despite their high effectiveness, species reintroduction programs have also received considerable criticism, mainly on environmental, social, and economic grounds. Critics have argued that while the reintroduced species can form stable and sustainable populations, their former habitats often do not have sufficient carrying capacity to support them. It should be noted that the native habitats could have been considerably modified, mostly by human activity (Holtmeier, 1987, 2015).

The reintroduction of animal species and the resulting increase in their abundance can give rise to conflicts between a species' biotope requirements and the intended use of the land by humans for agriculture, forestry, and water management. For this reason, economic, social, and historical processes and the risk of human-wildlife conflict should be assessed before a given species are reintroduced into a given area.

This study aimed to analyze changes in the population size of the European beaver *Castor fiber* in Poland, with the main focus being the means and effectiveness of the active protection of the species in Poland. The effects of species reintroduction were evaluated because of the conflict between the environmental impacts of beaver activity and human management.

Material and methods

The study was based on quantitative and descriptive data found in the literature. A significant part of the source material concerning the development of the Polish beaver population comes from popular and scientific articles as well as local conferences and symposia because there were detailed numerical data on the abundance and development of regional beaver populations. Library databases and archives were used for data collection.

A lot of the information was previously published in national popular science magazines, which aimed at spreading the knowledge of the European beaver and its emergence in nature (for example, magazines: Lowiec Polski or Chrońmy Przyrodę Ojczystą described information about the biology of the species or how to recognize it in nature). For this reason, many of these are publications written in Polish. Thus, it is a comprehensive combination of data on the effects of reintroduction of this species.

The resulting findings are presented in some subchapters, which discuss changes in the conservation status and population of the European beaver throughout the protection system. The quantitative data relating to changes in the Polish population of the European beaver were obtained from Statistics Poland. Field data regarding the numbers of a given species in specific administrative areas are collected yearly by Regional Directorates for Environmental Protection and updated and published by Statistics Poland (Statistics Poland, 1981-2018).

Results

The passive protection system of European beaver in Poland

Immediately after World War II, beavers were regarded as a completely extinct species in Poland.

The Polish authorities turned for assistance to Soviet scientists and requested a certain number of beavers for reintroduction in exchange for other animal species. The first beavers arrived in Poland from Voronezh in 1948, and they were transported to specially prepared and fenced sites in the Oliwa Forest District in northern Poland. The second batch of beavers was resettled from the USSR to Osowiec in north-eastern Poland in 1949 (presently the Biebrza National Park). The animals could colonize numerous sites in that area of the country (Romashova, 2016).

The presence of more than 50 beavers was also confirmed in the valley of the Pasłęka River in northern Poland. Their origin was unclear because a certain number of North American beavers (*Castor canadensis*) had escaped from a local breeding farm to the Pasłęka River in 1926 (Dehnel, 1948). Additionally, in 1961 two European beavers from the nature reserve in the Oliwa Forest District (described above) were also released into a refuge on the Pasłęka River. The fate of the local subpopulation during that period remains unknown, as North American beavers did not have an endangered species' status and could be freely hunted (it is not possible to distinguish American and European beavers from a distance) (Panfil, 1971, 1973). However, a genetic study conducted in the second half of the 20th century by Sysa and Żurowski (1980) revealed that the area was inhabited only by European beavers.

A detailed survey conducted in 1950-53 revealed a beaver pair near the Czarna Hańcza River. These animals migrated from the USSR, and local poachers hunted most of them. Despite the above, the inflow of new animals contributed to a steady rise in the beaver population. All of the described localities were situated in north-eastern Poland too (Żurowski, 1979).

In 1955, the Russian authorities reintroduced 40 beavers to the catchment area of the Pregolya River and 30 animals to a site on the Sheshupa River. In 1958, beavers were identified in habitats in the Białowieża National Park. According to estimates, more than 30 European beavers had colonized Polish territory by 1958 (Żurowski, 1973). Beavers continued to migrate to north-eastern Poland from foreign lands throughout the 1960s (Goździewski, 2010).

The first signs of beaver activity in the southern part of the Land of Great Masurian Lakes were noted in 1968. Beavers migrated from this site in large numbers, and by the 1980s, their localities were found in an area of around 60 km^2. The above processes gave rise to another beaver site in northern Poland, large and relatively densely populated. Three other regions in north-eastern Poland were also naturally colonized by beavers (Pucek, 1972; Żurowski & Kasperczyk, 1988).

The natural increase in the size of the European beaver population in Poland led to the steady growth of beaver colonies. Despite the above, the observed increase was slow and unsatisfactory, and in 1975, the beaver population amounted to only 500 individuals and was not sufficient to guarantee the propagation of the species. However, the small population size was not the only problem. Nearly all individuals colonized only one region in north-eastern Poland, and long-distance migration was not observed.

Active Beaver Protection Program

The restoration of a strong European beaver population was the primary goal of Polish biologists in the second half of the 20th century. Passive species conservation measures initiated before 1970 had not been successful, and the "Program for the Active Conservation of the European Beaver in Poland" was implemented in 1975 (Żurowski, 1978, 1979; Kasperczyk, 1990). The program covered Poland's entire territory and was carried out in collaboration with scientists from the Polish Academy of Sciences and the Polish Hunting Association. The program had the following main

objectives:

- to adequately protect the existing beaver habitats,
- to reintroduce beavers to natural habitats by artificial means,
- to actively manage beaver localities with the aim of ensuring that beavers have ample access to foraging grounds and water,
- to control the beaver population in refuges and minimize uncontrolled migration,
- to introduce farmed beavers that had interacted with humans from an early age to sites that were particularly exposed to human presence, such as tourist trails.

Live trapping and translocation were the essential management methods during the active conservation program. The vast majority of beaver localities were situated in north-eastern Poland, and the existing drainage divides made natural migration to other Polish regions difficult or even impossible. On the other hand, a large and dense beaver population in a single region enabled the translocation of 30 to 50 animals each year.

The long-term reintroduction of the European beaver to the catchment areas of the two largest Polish rivers, the Vistula and the Oder, supported the establishment of several dozen beaver micro populations across Poland. New beaver localities populated by animals from new colonies continued to be discovered after 1979, which indicates that the Program for the Active Conservation of the European Beaver in Poland was a success (Graczyk, 1978, 1979; Żurowski, & Kasperczyk, 1988; Twardowski & Kasperczyk, 1992; Piotrkowski, et al., 1995; Pawłowska-Indyk & Indyk, 1996; Dzięciołowski & Goździewski,1998, 2000).

A survey conducted in 1977 revealed that the beaver population had exceeded 1000 animals in more than 250 sites (Żurowski, 1979, 1992). Live-trapping and translocation effectively contributed to the observed increase in the beaver population. According to Żurowski (1992), by 1987, Poland's European beaver population was estimated at 3000 animals (Fig. 1), of which 60% continued to colonize habitats in the north-eastern parts of the country.

In October 1999, 51 beavers were captured over around 14 days in one area in north-eastern Poland (Misiukiewicz, 1999). The animals were relocated to montane regions in southern Poland due to the shortage of free sites for reintroduction in other parts of the country. These were probably the last hunting and relocation operations in Poland as part of the active protection program. Further operations, few and small in scale conducted in subsequent years, were only aimed at preventing damages caused by the animals.

The Program for the Active Protection of the European Beaver in Poland, which lasted for 25 years (1975-2000), successfully prevented the extinction of beavers and contributed to the translocation of their colonies to new regions in the country. At the time of its implementation, the program was a massive undertaking on a European scale. Through hunting, population management was one of the options considered during the program, but such measures were never undertaken.

Beaver as a problematic protected species in the 21st century

The Polish beaver population had expanded considerably by the 1990s, and beavers were no longer regarded as an endangered species at the beginning of the 21st century. According to various estimates, Poland's beaver population had reached 15,000 to 20,000 by 2000 (Statistics Poland, 1981-2018). The exact size of the beaver population could not be determined because beaver sites are difficult to survey due to the unique character of their habitats and the animals' behavior (Janiszewski & Hanzal, 2015). Comprehensive surveys of European beaver sites deploying similar and comparable research methods have never been carried out in Poland until the 21st century.

Accurate estimates of the beaver population were also challenging to perform because at least 60% of beavers continued to occupy their native habitats in north-eastern Poland. A total of 1369 beaver colonies inhabited by around 5000 individuals were inventoried in 1998. The average population density was determined at 14.8 colonies/100 km², ranging from 10 to more than 40 colonies/100 km² in north-eastern Poland. By 2007, the above region's average population density reached 16.9 colonies/100 km², and the minimum population density was determined at ten colonies/100 km² (Goździewski, 2008).

After the year 2000, the Polish population of this protected species became increasingly challenging to determine. The number of reports on beaver-inflicted damages on private farms also increased substantially (Janiszewski & Hermanowska, 2019). Beaver population statistics were published each year by Statistics Poland, but presented data were mere estimates.

The data presented in figure 1 indicate that the European beaver population increased 80-fold between 1980 and 2017 (38 years) in Poland. These data constitute the official estimates of Statistics Poland, but the beaver population's real size remains mostly unknown. However, the presented statistics shed some light on the population trends and beavers' status in Poland.

Beaver shooting permission has been issued in Poland since the beginning of the 21st century, even though beavers have been given protected status. According to table 1, the number of issued licenses and beaver harvesting quotas continued to increase in subsequent years. The beaver harvesting quota was expanded 5-fold in just nine years (2009-2017). Nevertheless, Poland's beaver population continued to increase uncontrollably, and it grew from over 64,000 to over 124,000 animals in the examined period (Fig. 1).

In Poland and most European countries, beavers' status as a protected species is regulated by two legal acts. The first is the Bern Convention on the Conservation of European Natural and Wildlife Habitats (Journal of Laws 1996, No. 58, item 263), where beavers are listed in Annex III on protected fauna species. According to Article 7 of the Bern Convention, each Contracting Party is obliged to take the appropriate and necessary legal and administrative measures to protect the wild fauna species listed in Appendix III to keep those populations out of danger. The second legal act is Council Directive 92/43/EEC of 21 May 1992 on conserving natural habitats and wild flora and fauna (Habitats Directive). The European beaver is listed in Annex II on the animal and plant species of Community interest whose conservation requires particular protection areas. The European beaver is also specified in Annex IV as an animal species of Community interest in need of strict protection. However, the Polish beaver population is not included in Annex IV, but is instead listed in Annex V on animal and plant species of Community interest whose taking in the wild and exploitation may be subject to management measures.

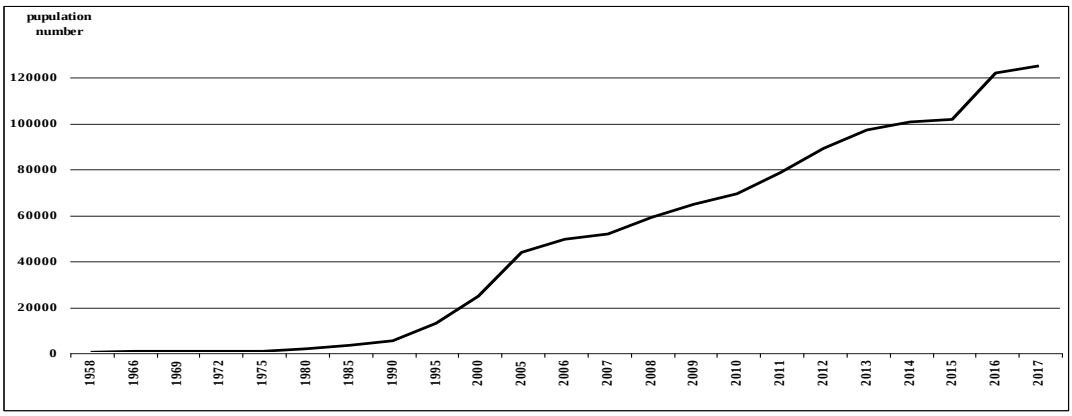

Figure 1. Changes in the European beaver population numbers in Poland between 1958-2017

Table 1. Number of beaver hunting licenses (number of issued licenses/animals) (Statistics of Poland, 1981-2018)

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Number of issued permissions	63	124	86	129	166	269	407	304	235
Beaver harvesting quota [animals]	1076	1874	1656	2293	3516	4470	8887	5785	5313

Discussion

In the past, the European beaver *Castor fiber* was a widespread species on the European continent, and changes in its population proceeded at a similar rate in most countries. Nolet and Rosell (1998) give a detailed historical account of the European beaver's extinction and reintroduction. According to these authors, excessive hunting reduced the beaver population to 1200 animals in eight relict populations in Europe and Asia at the beginning of the 20th century, including Poland. After hunting, restrictions had been put in place, and beaver reintroduction programs had been implemented in 15 countries. The beaver population was restored to the original size and reached around 3 million individuals towards the end of the 20th century. The Voronezh National Park, where approximately 3000 beavers were trapped until 1977 and relocated to 52 regions of the former USSR and Poland, Germany, and other European countries, played a significant role in the translocation of beavers (Romashova, 2016). However, new beaver populations established due to reintroduction programs often consist of a mixture of geographical forms (Mai et al., 2018). Therefore, the preservation of the original, unmixed populations of the European beaver should be the top priority of contemporary conservation programs.

In many cases, reintroduction programs were preceded by theoretical analyses of their benefits and possible risks. Potential reintroduction sites were surveyed, social consultations were held, and promotional campaigns were organized. New beaver colonies were closely monitored after translocation. The Voronezh Nature Reserve, USSR initiated a pioneering relocation program already in the 1920s (Romashova, 2016). The majority of planned reintroduction schemes were carried out in the second half of the 20th century and at the beginning of the 21st century, including in Austria (Sieber, 1999), Holland (Dijkstra, 1999), England (Gaywood et al., 2008, Gurnell et al.,

2008), Wales (Anthwal et al., 2005) and Scotland (Gaywood, 2018).

In Wales, the European beaver's reintroduction was preceded by extensive field investigations (Anthwal et al., 2005). These appraisals revealed that the reintroduction of beavers would be ecologically feasible in six river systems in Wales. In most of these areas, beavers and other wild animals are treated mainly as an element of a managed ecosystem (Halley & Rosell, 2002, 2003), rather than as an individual element that is managed in isolation. The authors thus concluded that the reintroduction of beavers to Wales should be viewed in these terms. In human-dominated landscapes, the human factor plays a crucial role in the success of reintroduction programs involving beavers and other mammalian species. The biology of reintroduced beavers has been extensively researched, and the course of population development can be predicted with a certain degree of confidence. However, the anthropogenic (social) aspects of reintroduction require the most care and deliberation (Gaywood et al., 2008).

Similarly to Wales, a simulation analysis was carried out to predict the consequences of reintroducing European beavers to Norfolk, England (South et al., 2001). An existing spatial population model, developed and implemented to assess European beavers' reintroduction to Scotland, was applied for that purpose. Habitats suitable for beavers were analyzed with the use of a land cover map (classified satellite imagery developed by the Institute of Terrestrial Ecology). The analysis revealed that Norfolk could support 18 to 40 beaver colonies. Beavers were likely to expand after reintroduction and spread to new areas when high and medium parameter values were input into the model. Low parameter values increased the risk that beaver populations would decline after reintroduction become extinct or would not colonize new areas (South et al., 2001). The cited study was a preliminary analysis of the likely result of beaver reintroduction to Norfolk. The authors concluded that the modeled predictions should be verified by evaluating the availability of potential habitats in the field (South et al., 2001).

In November 2016, the Scottish government announced that it would allow two "trial" programs aiming to reintroduce the Eurasian beaver to Scotland. The species would be allowed to expand naturally, and it would receive legal protection (Gaywood, 2018). The program was a historic event as the first formally approved reintroduction program of a mammalian species in the United Kingdom. The European beaver's reintroduction to Scotland had been preceded by intense studies and public debates in the previous 21 years. The feasibility of beaver reintroduction was assessed during extensive multidisciplinary and interdisciplinary research. This was one of the most detailed evaluations to have been carried out for any species introduction scheme. Considerable emphasis was placed on social consultations, and more than 2500 publications relating to beavers and their environmental impact were analyzed to assess the benefits and threats associated with beaver reintroduction (Gaywood, 2018).

Swinnen et al. (2017) relied on a species distribution model (SDM) to identify potential beaver habitats in Flanders, Belgium, based on 1792 data from 71 territories. Their study revealed that sufficient habitats were available to support beaver populations, even in landscapes highly dominated by humans. The authors emphasized the importance of the distance between beaver habitats and water, willow stands, aquatic vegetation, and poplar trees as essential ecosystem components. Their research revealed considerable expansion potential of beavers 12 years after the reintroduction. The study results can be used as a tool to evaluate possible risks associated with the return of beavers to urbanized landscapes (Swinnen et al., 2017). Similar simulation research works were conducted to identify the potential distribution of Eurasian beaver reintroduced to Serbia and

Bosnia and Herzegovina in 2004-2006 (Smeraldo et al., 2017). Simulations of beaver spreading can be recommended not only before the reintroduction but also on new subpopulations created due to natural animal migration, for example, in Italy (Pontarini et al., 2018) plan for means and methods of protecting the species.

The rate of natural dispersion has to be taken into account when planning beaver reintroduction. This issue was addressed by the observations conducted in Karelia (Danilov et al., 2011). The annual dispersal range along rivers and water bodies was determined at 6-8 km and around 5.5 km in a straight line. Beaver colonies tended to remain longer in areas with abundant food supply. The dispersal range in these locations was smaller at 4 km per year, along with watercourses and around 2 km in a straight line (Danilov et al., 2011).

As follows from the above, many countries conducted simulations regarding the future long term effects of reintroducing the European beaver species before deciding to do so. Described simulations aimed at directly or indirectly investigating the characteristics of the local habitats, the rate of growth of species numbers, as well as the risks that followed.

Also, in many countries, social consultations were conducted to investigate the public opinion on the matter of introducing the beaver species into a given area. It is worth noting that such simulations were not performed in Poland before realizing the European beaver's active protection.

Kassal (2016) examined the development and dispersal of the European beaver population reintroduced to the Irtysh River's middle reaches. Five stages in the local population's development were identified: adaptation, recovery, stabilization, depression, and expansion. Each stage proceeded at a different statistical rate. The beaver range was not completely restored in the analyzed area (Middle Irtysh) because commercial hunting had decreased the local population by 4% and narrowed down beavers' territorial reach. As a result, the beaver population's quantitative and spatial development in the Middle Irtysh zone was delayed by approximately 25 years (Kassal, 2016).

This type of data can help plan population development in countries where beaver reintroduction is still performed and when planning methods of managing developing populations with an inevitable reduction in species numbers. There are no further reintroductions planned in Poland. Still, it is noteworthy that the provisions of the 1975 "Program for the Active Conservation of the European Beaver in Poland" contained straightforward suggestions and recommendations to control the population numbers to avoid uncontrolled migration of the animals. However, such measures were never undertaken over the period when the program was in place, which is until the year 2000. The currently allowed reduction of the beaver population using firearms is marginal, with the population numbers still growing despite a yearly increasing quota of beaver numbers to be reduced.

According to Sieber (1999), beaver reintroduction programs substantially contributed to the expansion of beaver populations in Austria's 1990s. Beavers caused considerable damage to private property, which swayed public attitude towards beaver reintroduction from enthusiasm to a more practical approach. The social and economic consequences of the rapid growth of Austria's beaver population revealed numerous problems and risks, which prompted the establishment of sensitive areas where beavers should be strictly controlled and territories where beavers would be tolerated. The future implications of beaver management through hunting were also analyzed (Sieber, 1999).

A similar situation occurred in Poland, where the initial societal enthusiasm regarding saving an endangered species and increasing numbers of emerging beaver preservation societies for 20 years turned into pointing out the problems connected with the phenomenon. The problems mainly concerned flooding of agricultural and forestry areas as a result of building dams or cutting down

trees by the beavers. The situation was further worsened because there were no damages estimation procedures in place and no damages paid out to those affected by beaver activity.

The sensitive area concept proposed in Austria was implemented in the Czech Republic (Vorel et al., 2016). Three zones (A, B, and C) were created to support beaver colonies' rational management. These zones differed in the extent to which beaver colonization was allowed and the methods of resolving human-wildlife conflicts.

Beavers received the highest degree of legal protection in zone A. This zone was characterized by a large area, supportive hydrological structure, abundant food supply, and potential migration routes. The zone was created to ensure the stable and long-term development of the beaver population. Zone B is a transitional zone open to permanent beaver colonization (breeding and migration), but preventive measures can be applied to minimize conflict and damage. This zone was not established to preserve a stable beaver population directly but to create supportive conditions for beavers' survival without generating considerable adverse consequences for human activities. Zone B was also created to facilitate excess beavers' migration from zone A (Vorel et al., 2016). Zone C is characterized by a high density of fish ponds and other water bodies and a supportive biotope with ample food resources. Such territories are readily colonized by beavers, which increases the risk of damage to aquafarming infrastructure and poses a direct threat for humans. Zone C combines several critical parameters, including a high density of aquatic habitats (ponds and aquafarming systems), the availability of foraging grounds, and the presence of barriers with historical value. Human intervention should be limited to individual animals migrating from the neighboring territories (Bavaria, Upper, and Lower Austria). The elimination of permanent beaver colonies in zone C requires extensive collaboration between various services (nature conservation services, hunting ground users, landowners) (Vorel et al., 2016).

After reintroduction, the expansion of the existing and potential beaver populations can have serious financial consequences if beaver colonies are not effectively managed. The relevant risks can be minimized through monitoring, which is not easily accomplished concerning beavers. Campbell-Palmer et al. (2015) estimated the costs associated with the payment of compensation for beaver-inflicted damage. In Denmark, where the first beaver reintroduction scheme was introduced only in 1999, equipment costs range from EUR 1000 to 3000 per year, the cost of field staff dealing with beaver conflicts was estimated at EUR 50,000 per year. In contrast, EUR 40,000 is additionally spent on monitoring. In the Czech Republic, which has a stable beaver population, more than EUR 2.8 million has been paid in state compensation for damages to crops and forestry in the last 15 years (average of EUR 187,000 per year). In Bavaria, voluntary state compensation for beaver damage is estimated at EUR 450,000 per year, and around 1000 beavers are now culled annually. However, while the costs associated with the mitigation of human-beaver conflicts and the payment of compensations can be estimated, the potential benefits of beavers are much more challenging to determine.

In 2017 a total of 6772 damages caused by animals protected by law were reported, for which financial recompense was paid out by the government (Domańska, 2018). Beavers caused a majority of those - 5735 cases, amounting to 85% of all the reported cases. As a result of those, an amount of 24,8 million PLN (over 5 million EUR) was paid out in damages, out of which 90% was paid out in damages due to beaver activity. An average of 3900 PLN (ca 900-1000 EUR) was paid out for a single beaver related damage claim.

In many countries, beaver populations are controlled through hunting as part of carefully planned

management schemes (Nolet & Rosell, 1998). In Belarus, Estonia, Finland, Latvia, Lithuania, Norway, Russia, Sweden, and the Ukraine, beaver populations recovered so well that hunting was once again allowed, but only in fall, winter, and spring (Nolet & Rosell, 1998). These measures are initiated mainly to control beaver damages. Due to the absence of natural predators in most European and Asian countries, beaver populations continue to increase until food supplies are depleted. Beaver populations should be controlled through hunting to maintain densities that support steady growth. Population censuses and harvest schemes should accompany such measures.
There is no general social acceptance for changing the European beaver's status from protected to hunting game animal (to be subject of game management) in Poland. The species is somewhat of a peculiar symbol of animal protection.

Conclusion

The Program for the Active Conservation of the European Beaver in Poland, during which beavers were captured and relocated to new habitats over 25 years, was undoubtedly successful in preventing the complete extinction of the species. However, based on 50 years of experience, the current status of the European beaver in Poland, as well as similar conservation schemes in other countries, it appears that the program should have included several essential goals such as:

- simulation of the biological and social consequences of the program evaluated at each beaver site in the long-term (10, 20, and more years after beaver reintroduction),
- promotional and educational campaigns aimed at disseminating knowledge about the ecological significance of beavers, prevention of conflicts and reducing the risk of beaver damages,
- regular monitoring (at several-year intervals) of the development of beaver subpopulations, and consistent and reliable surveys of active family units,
- implementation of effective hunting and harvesting schemes in areas that were most susceptible to human-beaver conflict.

The above goals, as well as the experiences relating to beaver trapping and translocation during the Polish program, should be taken into account in the process of planning beaver and other wildlife reintroduction schemes. One should also know the answer to the question: when does the strict protection of a mammal species finish and the rational management begin?

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