

Feasibility study for the translocation of European mink (*Mustela lutreola*) from the Danube Delta to the Southern Carpathians, Romania

A report to Fauna & Flora

Jenny MacPherson, Patrick Wright and Steve Carter May 2026

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Executive Summary

The European mink (*Mustela lutreola*) is among Europe's most threatened mammals, having experienced a steep decline in both numbers and range over the past century. Once widespread across Romania and much of Eastern and Central Europe, it now survives in only a few fragmented populations, with the Danube Delta holding Romania's last confirmed stronghold. This isolated population remains under conservation monitoring, but its singular existence leaves the species highly vulnerable to extinction from disease, environmental disasters, pollution, and climate change impacts.

A feasibility study, following IUCN translocation guidelines, assessed the potential for reintroducing European mink to historically occupied but now vacant habitats in Romania, particularly in the southern Carpathians. Establishing additional populations would reduce extinction risk, enhance ecological resilience, and help meet biodiversity goals under EU and national commitments. The southern Carpathians offer extensive suitable riparian habitat with intact river systems, abundant prey, and low human pressure, providing a buffer against risks to the Danube Delta. From a genetic standpoint, creating semi-independent populations could combat inbreeding, maintain diversity, and form a structured national metapopulation, bolstering both Romania's and Europe's long-term recovery strategy for the species. As European mink were not found in the study area, other Carpathian sites that are better linked to the Danube Delta and to a possible remnant population in the Ukrainian Carpathians may prove more suitable.

This feasibility study assessed habitat availability, connectivity, and potential threats for European mink reintroduction in Romania, focusing on the River Mureş watershed in the southern Carpathians, where a small remnant population may persist. Broad-scale mapping identified priority areas, particularly within Parcul Natural Defileul Mureşului Superior and between Joseni and Biseneu, with high-quality riparian habitat and good functional connectivity, though road mortality and habitat scarcity downstream could limit population expansion. The Danube Delta remains the species' last stronghold in Romania, though the precise conservation status of European mink in the Danube Delta is uncertain and may be lower than previously believed. The most recent population assessment conducted as part of this study indicated a likely population of between 400 and 500 individuals, though these estimates carry significant uncertainty due to low detection rates and varying survey effort over time. The population is thought to be relatively stable since 2000, but it is vulnerable to isolation, limited genetic diversity, and localised threats, making careful modelling and ground-truthing essential before the potential removal of any animals for translocation can be considered.

Population viability analyses appear to support a hybrid reintroduction strategy combining wild-caught individuals from the Danube Delta with captive-bred supplementation. Modelling suggests that removing 60 wild mink over three consecutive years would have minimal long-term impact on the source population, while supplementation with captive-bred animals could substantially increase the survival prospects of reintroduced populations. This approach balances genetic and ecological considerations with the need to minimise risk to the only remaining wild Romanian population, offering a cautious yet promising pathway toward restoring European mink in the Carpathians. However, these models should be viewed as an exploratory tool rather than a precise predictor, given the uncertainties in life history, survival rates, and baseline population size.

The reintroduction of European mink to western Romania presents a rare opportunity to restore a Critically Endangered carnivore of ecological and cultural importance. However, success will depend on integrating ecological planning with a deep understanding of the region's socioeconomic and cultural context. Rural livelihoods here are closely tied to natural resources, with agriculture, fisheries, and forestry all interacting with riparian habitats that mink depend upon. Potential conflicts may arise, particularly with fisheries and poultry owners, and the species is at risk of misidentification with the invasive American mink (*Neogale vison*), which is often associated with negative impacts on wildlife.

Pre-release work should assess awareness, attitudes, and knowledge gaps, using interviews, focus groups, and participatory mapping to inform engagement strategies.

Stakeholders include local communities, landowners, fishing groups, conservation bodies, and tourism operators. A preliminary social feasibility study has focused on identifying key stakeholders, gauging their knowledge of the species, their priorities and their support for a potential European mink reintroduction in future. Effective communication will be essential, particularly in clarifying the differences between European and American mink, promoting the former species' Critically Endangered status, and highlighting its role in healthy wetland ecosystems. By embedding socioeconomic and cultural considerations into all stages of planning and maintaining open, participatory dialogue, the legacy of this project can be to foster the trust, shared ownership, and mutual benefits needed to ensure the European mink's successful return to Romania's wetlands beyond the Danube Delta.

We identified the ecological, social, and political risks associated with translocating European mink from the Danube Delta to suitable river systems in the southern Carpathians, following IUCN Guidelines for Reintroductions and Other Conservation Translocations. Ecological risks include unsuitable or degraded habitat, competition from invasive American mink, high post-release mortality, disease transmission, low genetic diversity in the source population, and potential disruption of local ecosystems. Mitigation measures include detailed habitat assessments, American mink control, soft-release strategies, veterinary screening, genetic management, and long-term monitoring.

Social risks focus on potential human-wildlife conflict, public misinformation, and loss of trust if the project fails. These can be reduced through inclusive stakeholder engagement, clear communication distinguishing European from American mink, and proactive conflict mitigation. Political and regulatory risks, such as permitting delays, insufficient long-term commitment, and land-use conflicts, require early coordination with authorities, policy alignment, and secure multi-year funding. While these risks are significant, most are predictable and manageable. If addressed in planning and implementation, the ecological and conservation benefits of reintroduction are expected to outweigh the challenges.

Genetic research on the European mink shows strong population structuring into three main extant groups: Northeast (NE), Southeast (SE), and Western (WE) Europe, each genetically distinct but not deeply separated historically. The NE population holds the highest diversity, while the Danube Delta (SE) population exhibits moderate mitochondrial and nuclear genetic variation, with most haplotypes unique to the region. This population forms a distinct genetic cluster within Eastern Europe but shares recent evolutionary connections with NE populations, reflecting isolation caused by severe declines over the last two centuries. Although the Danube Delta stock has sufficient diversity to support translocation, its history of bottlenecks means removals must be carefully managed to avoid eroding resilience. Initial caution is advised in mixing SE and NE or captive-bred animals until risks of outbreeding depression are better understood.

While low genetic diversity raises long-term viability concerns, short-term survival is more dependent on environmental factors such as disease, habitat loss, and competition from invasive species. Over time, maintaining and enhancing genetic variation, particularly at disease-resistance genes, will be critical. This can be achieved through well-designed captive breeding, managed reintroductions, and habitat protection. For long-term recovery, coordinated management of all remaining populations as a single conservation unit, with measures to restore gene flow between isolated groups, is recommended to counteract inbreeding depression and preserve evolutionary potential.

1 Introduction



Background and Objectives

The European mink (*Mustela lutreola*) is one of Europe's most endangered mammal species, having undergone a dramatic decline in both population size and geographic range over the last century. Formerly widespread across Romania and much of Eastern and Central Europe, the species now persists only in a handful of fragmented wild populations. In Romania, the last confirmed stronghold of European mink is the Danube Delta, where a single, isolated population continues to survive in the extensive wetland. However, the persistence of a single wild population in one region presents a precarious situation for the long-term conservation of the species.

This feasibility study was carried out in accordance with IUCN Guidelines for Reintroductions and Other Conservation Translocations (IUCN, 2013) to evaluate the potential for translocating European mink from the Danube Delta or from a combination of Danube Delta and captive-bred animals to ecologically suitable, historically occupied river catchments in Romania, particularly in the southern Carpathians. The aim is to assess whether establishing one or more additional populations through carefully managed reintroduction would contribute meaningfully to the long-term recovery of the species.

There are compelling conservation reasons to consider such an initiative. First, creating additional populations would significantly reduce extinction risk by introducing demographic and geographic resilience. A single population is inherently vulnerable to stochastic threats, such as disease outbreaks, natural disasters, environmental pollution, and the unpredictable impacts of climate change. Second, expanding the species' distribution aligns with both national and international biodiversity commitments, including the EU Habitats Directive and the EU Biodiversity Strategy for 2030, which encourage restoration of species to suitable areas of their former range.

Moreover, Romania retains large tracts of ecologically suitable but currently unoccupied riparian habitat. These areas, particularly in the southern Carpathians, offer structurally intact river systems, adequate prey availability, and relatively low human pressure. They also present an opportunity to buffer the species against climatic or anthropogenic risks that may increasingly affect the lowland Danube region. Establishing new populations in such environments could also increase the species' ecological resilience and adaptive potential.

From a genetic perspective, expanding the number of semi-independent populations may help mitigate the risks within a single population of inbreeding and genetic erosion. Translocated populations could maintain or even enhance genetic diversity within a structured national metapopulation, especially if supported by long-term monitoring and targeted gene flow management. At the same time, this approach would reinforce Romania's role in the broader European recovery strategy for the species, which recognises the country's central importance to European mink conservation due to its remaining wild population and high habitat potential.

Finally, a reintroduction programme would provide a high-profile opportunity to engage stakeholders, promote biodiversity conservation, and strengthen national and local awareness of native species recovery. This study therefore investigates not only the ecological and logistical feasibility of such a translocation, but also the genetic, social, and institutional contexts necessary for its long-term success.

The translocation and reintroduction of European mink to suitable river systems in the southern Carpathians is strongly aligned with both national biodiversity objectives and broader European Union conservation policy frameworks. Establishing additional wild populations would support species recovery, habitat restoration, and the reversal of biodiversity loss, all of which are strategic conservation priorities at both the national and EU levels.

Romania's National Biodiversity Strategy and Action Plan (NBSAP) recognises the urgent need to conserve and restore populations of endangered native species, including through targeted reintroductions and habitat recovery. The European mink is classified as Critically Endangered in Romania and is considered a conservation priority. The Danube Delta population, while important, represents a single, isolated population with limited resilience and moderate genetic diversity. Translocating individuals to suitable catchments in the southern Carpathians would contribute to national objectives by re-establishing the species within its historical range, reducing extinction risk through the creation of additional viable populations and enhancing resilience through the occupation of diverse habitat types.

This approach is also consistent with the development of future national species action plans, which increasingly integrate ex-situ and in-situ conservation tools, including reintroductions supported by captive-bred or wild-sourced individuals.

At the European level, the translocation of European mink aligns with multiple key directives and strategies. The European mink is listed in Annex II and Annex IV of the EU Habitats Directive, requiring both the designation of Special Areas of Conservation (SACs) and the implementation of strict species protection measures. Article 22 of the directive specifically encourages the reintroduction of native species where it contributes to favourable conservation status. Reintroducing the species to suitable Carpathian River systems contributes directly to this objective and strengthens the Natura 2000 network in Romania. The EU Biodiversity Strategy for 2030, part of the European Green Deal, commits Member States to restore species and habitats protected under EU legislation and reintroduce native species where appropriate. The establishment of new European mink populations in Romania would contribute directly to these targets.

As one of the few countries still supporting a remnant wild population of European mink, Romania occupies a strategically important position in the pan-European conservation of the species. Translocations to additional sites would support the development of a genetically and demographically resilient metapopulation; reinforce coordinated regional conservation efforts, as recommended by IUCN and the European Mink EEP (European Endangered Species Programme) and increase the potential for future population exchange and genetic management across range states.

In summary, if feasible the reintroduction of European mink to the southern Carpathians would directly contribute to the fulfilment of national and EU biodiversity commitments by restoring a Critically Endangered species to its former range, enhancing population resilience, and improving the ecological condition of riparian ecosystems. The action is strongly justified not only on ecological and genetic grounds but also from a strategic policy perspective, and would position Romania as a leader in the recovery of Europe's most threatened carnivore (IUCN SSC Small Carnivore Specialist Group, n.d.).

2 European Mink



The Decline of European Mink

The European mink is a small riparian mustelid native to Europe. The species is classed as Critically Endangered by the IUCN, having catastrophically declined over the past century (Podra *et al.*, 2025) and it is now one of the most endangered mammals in Europe (Maran *et al.*, 2016). The species currently occupies only a fraction of its former range, consisting of a small number of isolated patches in northern Spain, Western France, Romania, Ukraine and Russia (Podra *et al.*, 2025). In addition, there are now small, reintroduced populations in Germany and Estonia (Maran *et al.*, 2017b). The European mink is a priority species in the IUCN Action Plan for Conservation of Mustelids and Viverrids (Schreiber, 1989) and is listed in Annex II and in Annex IV of the EU Habitats Directive, requiring Member States to establish a system for strict protection. European mink are also protected by law in all the countries of its range, although in Russia only the subspecies *M. lutreola turovi* is Red Listed (Maran *et al.*, 2016).

Historically, European mink were widespread throughout much of Europe, from Finland down to northern Spain. Now, however, small, remnant populations are only found in Spain, France, Romania, Ukraine, and Russia (Figure 1), but data from Russia are limited.



Figure 1 Most recent reported range of European mink. The presence of the European mink in Spain, France, Romania and Ukraine (shown in green) is known from field data and the information from Russia is based on questionnaires and anecdotal reports.

The IUCN Red List of Threatened Species. Version 2024-25. <https://www.iucnredlist.org>.
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The historical decline of the species has been studied both at a continental and local scale (Maran and Henttonen, 1995, Maran, 1994, Maran *et al.*, 1998b, Lodé *et al.*, 2001). The earliest reports of decline come from Germany where, according to historical records, the species was already extinct in a number of regions by the middle of the 19th century. During the same period, European mink disappeared from Switzerland and probably also from Austria. If there were remaining populations in southwestern France and eastern Spain at this time, they would have already become an isolated enclave in Western Europe by the beginning of the 20th century (Maran, 2003).

Between the 1930s and 1950s, the last remaining European mink disappeared from Poland, Hungary, Slovakia and the Czech Republic. In Finland, Estonia, Latvia and Lithuania, the species had declined into extinction by the end of the 20th century. Data for Ukraine, Moldova and Georgia are sparse. Apart from a small population in the Dniester Delta (Rozhenko, 2015; Pödra *et al.*, 2025), it was suggested that European mink went extinct in these countries during the 20th century. However, recent evidence suggests that a small population may survive in the Ukrainian Carpathians (https://mukachevo.net/news/u-karpatskomu-biosfernomu-zapovidnyku-pokazaly-ridkisnu-meshkanku-yevropeysku-norku-foto_6274827.html). By the late 1990s, the American mink had replaced the European mink across large areas of Russia, and now survives in only a few regions (Kiseleva, 2018, Maran *et al.*, 2016, Maran, 2007). However, the American mink is present in the whole remaining range of the species and Maran *et al.* (2016) suggested that this is likely to pose a serious threat to its persistence.

European mink in Romania

The European mink was once a common species in Romania, with historical reports of its occurrence in Burila Mare (Mehedinți county), Bucharest, Brăila, Malcoci (Tulcea county), Brașov, Berhomet-Bucovina, Sibiu and Biscaria (Hunedoara), as well as Covasna. As recently as 1997, Almășan *et al.* (1995, 1997) reported that European mink was still present in the Gurghiului Mountains, Târnava Mare and Mureș (Harghita County), Bistrița (Maramureș and Suceava County), Râul Mare (Retezat Mountains) and the Danube Delta, although there had been a drastic decline of the population in the Danube Delta. In 2001, individuals were reported from Lăpuș (Gurghiului Mountains), Azuga Valley (Prahova County) and Mădăraș (Harghita County) (see Alex *et al.*, 2013) and references therein). However, now the only remaining population known with any certainty occurs within the Danube Delta Biosphere Reserve (Maran *et al.*, 2016, Maran *et al.*, 2014).

Ecology and Behaviour

The European Mink is a small carnivore of the family Mustelidae. Adults in the wild rarely weigh more than a kilogram (Youngman, 1990) and are less than 50 cm long, with females being slightly smaller than males. It has a dense, short dark brown coat, once prized by the fur trade, and is distinguishable by a white patch on the upper and lower lips and chin. In contrast to the introduced American mink which only has a white patch on the lower lips and chin. Across most of its range, it occurs sympatrically with several other native mustelids: the European polecat (*Mustela putorius*), Eurasian otter (*Lutra lutra*), pine marten (*Martes martes*), stone marten (*Martes foina*), stoat (*Mustela erminea*), and weasel (*Mustela nivalis*), all of which, with the exception of stoats and weasels, are larger than the European mink.

The species has very specific habitat requirements: being semi-aquatic it is usually found in undisturbed freshwater wetland habitats, including lakes, marshes, wet meadows and slow moving, unpolluted rivers and streams (Lodé *et al.*, 2001, Zabala *et al.*, 2003, Macdonald and Sidorovich, 2001, Fournier *et al.*, 2007), where it occupies an intermediate niche between the otter and the polecat (Youngman, 1982), although having some overlap with both. In addition to freshwater, European mink need dense terrestrial vegetation close to the water's edge for shelter and protection from predators (Zabala *et al.*, 2003). Although road killed mink have been recorded more than 1km from the nearest river (Aihartza *et al.*, 1999), radio tracking studies show that they rarely move more than 100m from the water (Zuberogoitia and Zabala, 2003). They are solitary and territorial and, in common with many mustelids, male home ranges are larger than those of females and the territory of a male will usually overlap that of one or more females (Garin *et al.*, 2002b, Garin *et al.*, 2002a, Palazon and Ruiz-Ojmo, 1998, Fournier *et al.*, 2008, Palomares *et al.*, 2017). Reported home ranges vary according to habitat type and quality, and how they are calculated. In one study in Spain, European mink required between 15 and 75 ha (or 2.5 to 12.7 km²) of fluvial habitats to establish stable home ranges (Palomares *et al.*, 2017). Other reported home range sizes in Spain have been 11-17 km of

riverbank for males and 0.6km to 3.6km for females (Garin *et al.*, 2002a); and averages of 9.8km for males and 4.9km for females (Ceña *et al.*, 2003). In southwestern France, Fournier *et al.* (2008) found range sizes of 9km-16km for males and 2km-10km for females.

Activity patterns of European mink show that they are mainly nocturnal and crepuscular. They are opportunist, generalist predators, feeding mainly on amphibians, small mammals, fish, crustaceans (crayfish) and birds (Palazón *et al.*, 2004, Maran *et al.*, 1998a). European mink reach sexual maturity at around the age of ten months and a female will usually have only one litter per year of one to seven (mean 3.5) kits (Maran *et al.*, 1998b). The breeding season is from March to April and, following 40-43 days gestation with no delayed implantation, kits are born between late May and early June. Juveniles disperse at approximately 2.5 months (Peters *et al.*, 2009). The longest recorded lifespan of a European mink is seven years in captivity (Maran *et al.*, 1998b) but it is likely that life expectancy is considerably shorter in the wild. Predation by other carnivores is a common cause of mortality. Predators include red fox (*Vulpes Vulpes*), pine marten, lynx (*Lynx lynx*), and otter, as well as raptors, large owls and domestic dogs (Maran *et al.*, 2017b).

Threats

American Mink

It is impossible to attribute the local extinction of European mink to a single common cause across all regions. It appears that there have been a set of different factors contributing to the decline of this species. However, the three main factors thought to have been largely responsible are habitat loss/degradation, over-exploitation (hunting) and the effects of introduced American mink. Detailed analysis of the sequence of events across Europe suggests that the particular set of factors and their relative importance in the decline of this species has differed in each country and at different times (Maran and Henttonen, 1995, Maran *et al.*, 2016). In some parts of Europe, the decline and local extinction of European mink occurred before American mink were present, leading to the conclusion that the impact of American mink was not the initial cause of decline. The best available information suggests that these earlier extinctions were probably attributable to loss or degradation of habitat and, in some cases, also to over hunting (Maran, 2003).

Other factors that have been suggested include water pollution, disease transmission from domestic livestock, pets and American mink, declines in prey (ie, crayfish), competition and/or hybridisation with polecats and intraguild predation (Maran, 2007). However, it seems unlikely that any of these were the primary cause, although their impacts on already reduced populations could have been significant and exacerbated the decline.

There is no doubt, however, that the American mink is now the main threat and is driving the decline of remaining European mink populations to extinction (Maran and Henttonen, 1995, Maran *et al.*, 1998b, Sidorovich *et al.*, 1999, Sidorovich, 2001). Although the American mink is very similar to the native European mink in both its ecology and appearance, it is larger and more aggressive than the European mink, which gives it an advantage in direct competition (Maran, 2007, Sidorovich *et al.*, 1999, Maran *et al.*, 1998b). It is also a supremely adaptable, generalist predator and this, combined with other traits, have enabled it to successfully spread widely beyond its native range and become an invasive species across two continents (MacDonald and Harrington, 2003).

In Romania, the dramatic decline in numbers and distribution of European mink over time was likely due to a number of anthropogenic causes. Among the most important were the loss, degradation and fragmentation of suitable habitat along with legal and illegal hunting for fur, which intensified in the 1990s, when the fur trade ceased to be state regulated (Turnock, 2007). Accidental mortality in traps or nets set to catch other species may also have had an impact, as well as water pollution, impacts of livestock grazing and feral dogs and cats. A significant reduction in numbers and genetic variability would have left small, remnant populations increasingly more vulnerable to the impact of stochastic demographic or environmental events which can accelerate the extinction process (Gilpin and Soulé, 1986). The historical impact of released or escaped American mink on European mink in Romania is unknown as data on the abundance and distribution here are limited. However, there is a long history of mink farming across all regions of the country, so it is likely that there have been many escapes.

The American mink is native to North America but, due to its dense, soft fur, it was introduced to countries from Europe to South America for fur farming in the early 20th century (Dunstone, 1993). As a result of deliberate releases or accidental escapes, feral American mink are now recognised as an invasive species in Iceland, Scandinavia, the former Soviet Union, Germany, France, Spain, Patagonia, Argentina and the UK (Gerell, 1967, Previtali *et al.*, 1998, Aliev and Sanderson, 1970, Birks, 1990, Cuthbert, 1973, Smal, 1988, Westman, 1968, Wildhagen, 1965). Wherever the American mink has been introduced, examples have been documented of their negative impacts on native species (Bjornsson and Hersteinsson, 1991; Nordstrom *et al.*, 2002; Kilpi, 1995; Craik, 1998; Craik, 2000; Rae, 1999; Sidorovich and MacDonald, 2001; Macdonald *et al.*, 2002).

The EU Invasive Alien Species (IAS) regulation provides for a set of measures to be taken across the EU in relation to invasive alien species included on the Union list. These are prevention of the intentional or unintentional introduction of IAS of Union concern into the EU; early detection and rapid eradication, as well as concerted management action to prevent them from spreading any further and to minimise the harm they cause. However, the IAS Regulation recognises that some species may provide economic benefits in certain Member States. In spite of the fact that the American mink significantly affects native mammals and birds, it is a hugely profitable species in some countries, (eg, Denmark, the world's largest producer of mink skins where, during a five-day fur auction at Kopenhagen Fur, skins worth more than €130 million can be sold <http://www.kopenhagenfur.com/auction/auctions>). As a result of this economic importance, the American mink has not been included on the Union list of IAS.

There is very little information available on American mink presence in Romania. There are two published records of American mink in the Danube Delta (Maran *et al.*, 2014) but there has been no national survey for the species. Many of the state-run fur farms that were established in Romania under the communist regime were shut down after 1990 (Turnock, 2007). Three fur farms were known from the Upper Mureş Valley but two were closed between the 1980s and 1990s, and the third ceased operating in 2013. There were 21 records of American mink caught in the wild from this area between 1986-2009. Those captured during the 1980s and early 1990s were probably escapees from farms. However, the more recent records from the vicinity of the closed-down farms as well as locations some distance away, suggested that some feral animals were living in the wild (Hegyeli and Kecskés, 2014).

A study in the Olt river basin collected data on American mink presence in the area between 2015 and 2017. In total, 13 records of American mink were collected within Braşov County in south-eastern Transylvania (Ionescu *et al.*, 2019). These were thought to have escaped from a large fur farm that opened in the area in 2014 with more than 40,000 American mink.

Ionescu *et al.* (2019) found that American Mink had spread in all directions from the fur farm where they originated, with some of the records being more than 8km-9km from the fur farm. They recommended that there should be a permanent monitoring scheme in the area.

Due to the lack of specific regulations on American mink farms in Romania, it is difficult to obtain official data on them. Historical, unofficial data that are available are presented in Table 1 (reproduced from Maran *et al.*, 2014).

Table 1 Known fur farms in the southern Carpathians

Farm	Owner	Location	Distance to rivers	Distance to potential E. mink habitat	Comments
Targu Mureş	Romsilva	Outskirts of Targu Mureş	c. 4.2km to Mureş river	c. 35km	c. 200 animals in 2012, closed in late 2013
Targoviste	Romsilva	Outskirts of Targoviste	c. 1km	?	Closed in 2011
Reghin	Romsilva	Solovastru	c.1km	c. 2km	Escapes in late 1980s, ADV virus recorded in 1981-1984, closed in 1991
Gilau	Romsilva	c. 0.5km	c. 0.5km	c. 0.5km	Many escapes in 1970s, AVD noted in late 1960s to mid 1970s. Changed to research station in 1978, closed in 1982 but stocks persisted until 1998 (?)
Sercaia	Private	Sercaia	c. 0.5km	c. 3km	Opened in 2014

In 2014, there were a reported 153 fur farms in Romania which produced 200,000 mink. This had increased significantly with the opening of a large new farm near Braşov (https://www.fureurope.eu/wp-content/uploads/2015/09/Fur_Europe_Annual_Report_September_2015_smallsize.pdf).

One of the reasons that American mink are a potential major threat in Romania was the lack of clear regulation on fur farms and biosecurity standards to prevent accidental releases (Ionescu *et al.*, 2018). However, in October 2024 the Romanian Parliament approved an amendment to prohibit breeding and farming of mink (and chinchillas) for fur. The new legislation mandates a complete ban on mink fur farming which will take effect on the 1st January 2027. As of 2022, only a dozen or so fur farms remained in operation (furfreealliance.com). Given the history of fur farms in nearly all regions of the country, it is likely that individuals or populations of American mink are present on many river catchments, particularly those with a colder climate such as the Carpathians (Hegyesi and Kecskés, 2014). As farms are forced to close, there is also an increased risk of remaining animals being released. Where mink farms are, or were present, but feral populations are not yet established in the wild, it is recommended that the main activities should be focused on early detection and early intervention by eradication. The best opportunity for control or reduction of the impacts of an invasive species such as American mink is during this early phase before it can achieve high densities or spread more widely (Wittenberg and Cock, 2001).

Native Predators and Competitors

Despite superficial similarities between them, the European mink and the American mink are not closely related. The European mink is much more genetically similar to the European polecat (Sato *et al.*, 2003), with which it can hybridise. Both hybridisation and genetic introgression occur at low levels (3% and 0.9% respectively) and the hybridisation is asymmetric, as only pure polecat males have been reported to mate with pure European mink females. Backcrossing and genetic introgression has been detected only from female first generation (F1) hybrids of European mink with Polecats (Ternovsky, 1977). Hybridisation and genetic introgression between the two species is uncommon (Lodé *et al.*, 2005, Cabria *et al.*, 2011) but may be an issue where numbers of European mink are low. In western France, mink and polecats only hybridised in areas where mink were scarce, supporting this hypothesis (Lodé *et al.*, 2005). When a species is rare, individuals may be unable to mate within their own species, increasing the likelihood of mating with individuals from closely related species. This underlines the need for sufficient numbers of European mink to be released in reintroductions to minimise this risk. There are no data suggesting aggressive encounters between polecats and European mink in the wild (Pödra *et al.*, 2013).

Eurasian otters are known to predate European mink (Grigor'ev and Egorov, 1969, Novikov, 1962), as are other members of the same carnivore guild. These include red fox, pine marten and stone marten (Sandor and Marinov, 2016, Marinov *et al.*, 2011). These are all species that have co-evolved together as part of the native fauna, nonetheless intra-guild predation by other predators has been suggested as a factor limiting population size in small mustelids (Latham, 1952, Powell, 1973). Certainly, where one species has already suffered significant declines as a result of habitat loss, fragmentation and other factors, even the lowest levels of predation may be significant. This is relevant for founder populations of European mink which will be vulnerable during the early stages of establishment and growth, and may be a particular risk for captive-bred individuals which have significantly higher mortality than wild-caught animals in a range of other carnivore species (Jule *et al.*, 2008). Therefore, it is important that mortality is closely monitored.

Roads, Traffic and Other Anthropogenic Threats

Wildlife mortality due to road traffic has increased over recent decades and is a major threat for many small to medium-sized carnivores across Europe (Van der Zee *et al.*, 1992, Philcox *et al.*, 1999, Jancke and Giere, 2011). In France and Spain, road traffic is now the main cause of human-induced mortality in European mink (Lodé *et al.*, 2001, Palazón *et al.*, 2012). The likelihood of mink being killed on the road is highest where there is a road intersecting a river within an animal's home range. Mink are then forced to cross the road while foraging or during dispersal. Several large transport infrastructure projects are under construction or being planned along the Carpathian Mountains, in particular the Lugoj-Deva Motorway and upgrading of the Curtici-Simeria railway sector (Moț *et al.*, 2019). However, there is a lot of experience already in Europe on how to minimise the negative environmental impacts of transport infrastructure and several initiatives, including green bridges and underpasses, which are being used to maintain connectivity for wildlife in the area and ensure that the transportation infrastructure is developed in a sustainable way (Moț *et al.*, 2019). In France, the Life Vison project focused largely on reducing direct mortality by adapting roads and bridges to make them permeable for the passage of semi-aquatic mammals, in particular European mink (<https://lifevison.fr/les-actions-du-life/securiser-lhabitat/>).

Other anthropogenic threats to European mink include accidental trapping and misidentification with similar species. Dark phenotypes of polecats and European mink can be difficult to distinguish (Lodé *et al.*, 2005), and while the European mink is strictly protected, the polecat is not. As a result, European mink may be killed either as bycatch in muskrat (*Ondatra zibethicus*) traps or when they enter fish traps. Fyke traps are thought to be a serious threat for mink and otters elsewhere in Romania (Marinov *et al.*, 2012). European mink are also vulnerable to secondary poisoning from anticoagulant rodenticides (Fournier-Chambrillon *et al.*, 2004) which are used in many countries to control coypu (*Myocastor coypus*), muskrat, brown rats (*Rattus norvegicus*), house mice (*Mus musculus*), and voles. Unfortunately, there is also evidence that illegal poaching of European mink still occurs where the species is present, albeit at very low levels (Marinov *et al.*, 2010). Both issues should be addressed with effective community engagement and public awareness raising campaigns.

Across Europe, there have been large-scale changes to the landscape and these changes, along with other anthropogenic activities, have had a substantial impact on numerous habitats and their species. The decline and localised extinction of European mink across the whole of its range cannot be attributed to a single universal cause, but analysis of the decline suggests that the main factors behind the extinctions have been loss and degradation of habitat, overly intensive hunting and, more recently, the impact of introduced American mink. Other contributing factors (eg, pollution, road kills and hybridisation with the Western polecat) are probably of minor significance. However, the causes of decline have varied between different localities and at different times. In addition to this, the time it takes for a threat or combination of threats, to lead to a noticeable decline or extinction can be highly variable, resulting in what is known as the extinction 'lag', meaning that, in some places, such as Finland (Maran and Henttonen, 1995), the historical decline of the species is very difficult to understand.

It seems that, in some regions, the impact of extensive habitat changes, trapping and other factors were so influential that the American mink had only a secondary role in the extinction process. However, there is agreement that currently the American mink, through various mechanisms, is the main threat to remaining European mink populations (Maran and Henttonen, 1995, Sidorovich, 1997, Maran *et al.*, 1998a, Sidorovich, 2001).



3 Review of Previous European Mink Reintroductions



Some of the earliest documented translocations of European mink took place in Russia. In central Russia, the effects of over-harvesting European mink for the fur trade in the early twentieth century were so catastrophic that a temporary moratorium on hunting the species was put in place in several regions. In the Yaroslav region, in central Russia, 130 European mink were translocated and released in an attempt at population reinforcement (Maran *et al.*, 2017b). However, not all of the causes of the original decline were addressed by the hunting ban alone. Extensive habitat modification (agriculture and forestry) continued and because European mink had become so scarce, more than 20,000 non-native American mink were also released into the wild to support the fur-trapping industry. These releases were intended to be outside of the range of European mink, but 4,000 of them were not. Escapes from fur farms also continued throughout the twentieth century, providing a continuous source of new immigrants, which quickly established and ousted any remaining European mink (Maran *et al.*, 2017b). Between 1981 and 1989, the species was introduced outside of its native range to the Russian Kuril Islands in the Pacific. This did not result in the establishment of a stable population (Maran *et al.*, 2016), although reports from camera trap data in 2016 suggest that, at that time, there was still European mink present on Kunashir, the southernmost island (Maran *et al.*, 2017a).

Translocations for the purpose of conservation are now common, but with an increasing body of associated research and appreciation of the risks (Fischer and Lindenmayer, 2000, Berger-Tal *et al.*, 2020, Griffith *et al.*, 1989, Ewen *et al.*, 2012). Any conservation translocation must be justified, with clear objectives, identification and assessment of risks, and with pre-defined, measurable criteria for success (Moehrenschrager, 2017, Schwartz and Martin, 2013). One of the primary considerations/tests should be that there is strong evidence that the threat(s) that caused any previous extinction have been correctly identified and removed or sufficiently reduced (IUCN, 1995, IUCN, 2013).

Due to its Critically Endangered status, there are now a number of both in situ and ex situ conservation programmes focused on reversing the decline of the European mink. Tallinn Zoological Gardens in Estonia started the first conservation breeding programme for the species in 1984 and has co-ordinated the European Endangered Species Programme (EEP) captive breeding programme for European mink since 1992 (Maran, 2003, Maran *et al.*, 2017b). The conservation goal of captive breeding programmes is to maintain the genetic diversity of the species in captivity and to provide individuals for reintroductions (Supple and Shapiro, 2018). The captive stock of European mink originates from 22 founders, mainly from Northeastern and central Russia. By 2023, the total European mink ex situ EEP population was 267 (Skorupski, 2020). This has provided animals for a number of conservation translocations and reintroductions to date (Maran *et al.*, 2017b). The role of captive breeding has been vital for the survival of European mink, however it is also critically important to conserve the genetic resources of the remaining wild populations in situ. European mink in captivity may be subject to reduced natural selection pressure and selective breeding may result in a genome wide loss of genetic variation (Becker *et al.*, 2009, Hughes, 1991).

Kunashir and Iturup Islands

European mink were introduced to two of the Kuril Islands, Kunashir and Iturup, in the early 1980s in attempts to conserve the species where American mink were absent. Between 1981 and September 1985, three batches of European mink totalling 127 animals (72 males and 55 females) from the captive breeding facility of the Biological Institute of the Siberian Branch of Russian Academy of Sciences were released across Kunashir Island. This was supplemented in October 1985 by a further seven wild caught animals from Russia. Camera trap photos and field signs (footprints) from surveys carried out in 2014-2021 confirmed that European mink were still present throughout the island in good numbers (Kisleyko *et al.*, 2022). American mink remain absent from the island although future incursion from the nearby island of Hokkaido is possible.

From 1986 to 1989, 254 European mink were introduced to Iturup, another of the Kuril Islands lying approximately 20km north of Kunashir. However, although sightings are occasionally reported on Iturup, there are no recent verified records of European mink or convincing evidence that a population persists (Kisleyko *et al.*, 2022).

Estonia

The European mink has been reintroduced to the Estonian island of Hiiumaa since 2000. The species was relatively widespread and abundant in Estonia until 1940, at around which time, American mink started to spread. By the late 1980s, when a survey of the two mink species was carried out (Maran, 2003), European mink were still extant only in the northern and eastern parts of the country, whereas in the south and west there had been a complete replacement by American mink. Since then, the non-native mink continued to spread, with the concurrent extinction of the native species and the last confirmed record of European mink in the wild was in 1996. A preliminary habitat assessment of Hiiumaa, Estonia's second largest island, suggested that the island was suitable and could support a viable population of European mink. Other advantages were that it was feasible to remove American mink from the island and the probability of re-invasion was low. The feral population of American mink originated from a mink farm which has since been closed. During five trapping sessions between 1998 and 2000, each lasting 2-5 weeks, a total of 53 American mink were removed from the island. Following a three-week snow-tracking survey in spring 2000, the island was declared free of mink (Macdonald, 2002). However, two additional individuals were subsequently captured after trapping efforts had ceased but before reintroductions began, underscoring the challenges of eradicating non-native species.

In 2000, two experimental releases of nine and eight European mink were carried out. All seventeen of the released animals were radio tracked. During the early stages of release, the survival rate was over 33% with predation being the main cause of mortality (Maran *et al.*, 2009). In 2001, a large-scale release began with another 41 mink, half of which were radio tracked (Maran *et al.*, 2009). In total, 597 individuals have been released over 17 years since 2000. In 2016, it was estimated that there were 65 European mink present on Hiiumaa Island, of which 75% were wild (Maran *et al.*, 2017b). The population has now spread beyond the release sites, is reproducing in the wild and occupies all the main waterways on the island. It is thought that it is established but may not yet be self-sustaining (Maran *et al.*, 2017b).

In common with other mammal reintroductions, achieving a viable population has proved to be a longer-term project than originally anticipated (Maran *et al.*, 2017). Releases ended in 2017, and subject to ongoing monitoring results, the reintroduction may go to a third phase to address gaps in the genetic diversity of the wild population by strategic releases from the captive population (Maran newsletter, 2018). There have been habitat improvements on Hiiumaa to benefit the European mink population, such as the (re)construction of ponds to boost amphibian numbers and increase prey availability for the mink (Remm, Lõhmus and Maran, 2014).

Preparatory work was carried out ahead of releases on Saaremaa Island and, in 2012-13, pilot releases of radio-tracked captive bred European mink were conducted. However, all died within a month of release ([https://circabc.europa.eu/sd/a/2253d3e8-b114-42b4-8d0b-1f33ee98f71e/EE%20-%20European%20Mink%20\(Mustela%20lutreola\)%20-%20Final.pdf](https://circabc.europa.eu/sd/a/2253d3e8-b114-42b4-8d0b-1f33ee98f71e/EE%20-%20European%20Mink%20(Mustela%20lutreola)%20-%20Final.pdf)). Nonetheless, much has been learned from these well monitored earlier releases, and techniques for breeding and releasing captive bred individuals have been improved. It was found that captive-bred mink were less able to handle live prey, so opportunities are now provided in captivity to help prepare mink for release (Macdonald, 2002). Local engagement and awareness raising activities ahead of each stage of the project have also been critical elements and a subsequent survey showed that 97% of respondents were aware of the project (Maran, 2004).

Germany

In Germany, a European mink reintroduction was carried out in Saarland, southwest Germany, in 2006. Prior to this, two experimental pilot studies had taken place in northwestern Germany in which animals were first acclimated to the release site in soft release pens which had been constructed on the banks of suitable streams (soft-release approach) and then released in sibling groups (Schropfer 2003 cited in Peters *et al.*, 2009). Subsequently, 48 animals were released over the course of two years into a nature reserve in Saarland as part of a larger programme of releases (75 founder animals within a three-year period; Peters *et al.*, 2009).

In Steinhuder Meer, Lower Saxony, a second reintroduction programme began in 2010 (Maran *et al.*, 2016). In 2015, a trail camera image of a female carrying a kit, provided the first evidence of European mink breeding in the wild there for 150 years. In 2018, 24 litters with a total of 45 kits were born in captivity in Germany. Of these, 19 (14 males and 5 females) were released as founders within the reintroduction project at the lake 'Steinhuder Meer'. The animals were released in September and October 2018, using the 'hard release' method. There is some indication that a small population is still present.

Spain

The first releases in Spain were into a wetland in the Basque Country in 2008. Trapping was carried out to suppress American mink, but their numbers quickly recovered and most of the 27 European mink that were released died within five months.

Between 2014 and 2019, a larger project was developed to contribute to the conservation of European mink in Spain. This project, co-funded by the European Commission under the LIFE+ programme, was carried out in the Basque Country, La Rioja, Aragon and the Valencian region. The overall purposes of the project were firstly to eradicate American mink within the range of European mink and in adjacent high-risk zones, and then to increase the viability of the wild population of European mink through releasing captive-born individuals from an existing breeding programme.

The project also aimed to create a new monitoring network to assess the conservation status of both species after the project. Between 2016 and 2019, 34 captive bred individuals were released. Of these, 26 were used to reinforce the population: 11 in the Cantabrian basins in Gipuzkoa in 2017, and 15 in the Ebro river basin in La Rioja and in Álava in 2018. Eight animals were also released in 2017 in Aragón, an area outside the current distribution of the European mink, in an attempt to increase its range, termed assisted colonisation. All of the released individuals were intensively monitored via radiotracking to evaluate their adaptation to the natural environment. During the first two weeks of the assisted colonisation, a high mortality rate was observed among the released individuals. However, this experience helped to improve release methods, and later results for population reinforcement were much better, with more than half of released animals surviving the first two months, the most critical for their adaptation to their natural habitat (<http://liflutreolaspain.com/>).

From 2018-2023, 89 captive-bred European mink were released and radio tracked for a period of two months following release (Gomez, 2024). At least 14 animals died during the period in which they were radio tracked. Predation and trauma from vehicle collisions were the most frequent causes of death (Aranda *et al.*, 2023).

Lessons Learned

American mink control is an essential part of any European mink reintroduction project. Increases in the size of the captive population at Tallinn Zoo have been achieved, as well as improvements in the facilities and more naturalistic enclosures. Pre-release enclosures and 'naturalistic enclosures' have been trialled at Tallinn Zoo in which pregnant females can raise kits to the natural dispersal age (2-3 months) for release into the wild. Supplementing and supporting released animals, for example by providing shelters, and appropriate 'training' of captive-bred mink prior to release to improve their survival skills has been shown to be effective. Complementing releases with practical measures such as habitat restoration for European mink can also boost the availability of prey.

Lessons have also been learned regarding which measures have not been successful. The release of pregnant females directly into the wild was not effective, as kits died. Also kits that had been hand-reared in captivity until the natural dispersal age were not suitable candidates for release, due to maladaptive behaviour. A major challenge for achieving a viable population is low mating success. In the Estonian project, only 11% of captive born males successfully bred during their lifetime. Analysis showed that lack of interest in the female or aggression towards her were the main behaviours likely to be causing this (Maran *et al.*, 2009, Kiik *et al.*, 2013).



4 Assessment of Potential Reintroduction Sites in the Southern Carpathians



Reintroduction biology is now a well-established field (Ewen *et al.*, 2012) and there have been a number of reviews published of reintroduction/translocation successes across different taxa (Griffiths and Pavajeau 2008; Germano and Bishop 2009; White Jr *et al.*, 2012). Several reviews of reintroductions and their outcomes have reported low rates of success (ie, Fischer and Lindenmayer (1996, 2000), with low habitat suitability and poor release site selection frequently cited as reasons for failure (Wolf *et al.*, 1996; Armstrong *et al.*, 2002; Cook, Morgan and Marshall 2010). Therefore, significant effort should go into evaluating potential release areas before considering going ahead with a reintroduction. Serious scientific uncertainty is inevitably an issue in reintroduction efforts because a species is being reintroduced into an area that it does not currently occupy. The more time that has elapsed between local extinction and a planned reintroduction, the greater the likelihood that the habitat will no longer be suitable. This means there is a need to evaluate habitat suitability regardless of historical occupancy. Sites should not be selected on the basis that a species used to be there or that the site looks right. Detailed knowledge of a species' ecology can provide information on the likely current suitability of a proposed release site, but modelling enables that knowledge to be put into a landscape context, projected into a range of current and future scenarios and compared against several objectively assessed alternative sites.

Indigenous populations of European mink once existed throughout much of Romania, but it cannot be assumed that current habitat conditions are still suitable. The IUCN Guidelines for Reintroductions and other Conservation Translocations clearly state that it is essential to 'evaluate the current suitability of habitat in any proposed destination area' during the biological feasibility study (Annex 5.3 - IUCN/SSC, 2013). In addition, a broader context of habitat available and the ability for species to move between these areas is essential to maintain resilient connected populations. Unlike structural connectivity, functional connectivity is species-specific and relates to the species' behaviour (Gustafson and Gardner 1996). Connectivity models aimed towards landscape connectivity for a single species are particularly useful for the study of vertebrates (Correa Ayram *et al.*, 2016; Wood *et al.*, 2022). They can also be useful to explore the connectivity in habitats that are particularly vulnerable to anthropic pressures, such as riparian habitat (Capon *et al.*, 2013).

The European mink relies heavily on riparian habitat. While the stronghold in Romania is in the Danube Delta, a small population may still be present in the southern Carpathians. The aim of this part of the feasibility study was to assess the habitat available for European mink and its levels of connectivity at a broad scale within Romania, the Carpathians and the study area of interest where a small population may still be present and where translocations could take place (shown in the maps in Figure 2). Then, to identify key areas which showed the most promise for the project team to ground truth in the field for the presence of the target species, American mink and other key species.

Geographical Scope of the Present Study

The River Mureş Watershed (Figure 2), overlapping with the Carpathian Mountains in central and western Romania, was the chosen area to assess the feasibility of European mink reintroductions and identify any potential threats that could hinder their successful establishment.

The Mureş River is the largest tributary of the Tisza in Romania, at 716km long. Its source is in the Hășmaș Mountains. In the upper reaches, in Harghita and Mureş counties, the Mureş River has the relatively narrow, sloping channel typical of a Carpathian mountain river. Downstream the river becomes increasingly wider, with many tributaries forming the Mureş basin of 27,830km².

In the lower reaches of the Mureş, the overall slope is low, the riverbed is highly meandered and there are many dead ends and wetland areas. The lowland section of the Mureş river is approximately 120km long, of which more than 80km comprise the Mureş Floodplain Natural Park, established in 2007. Along the main lowland stream is a system of connected canals, marshes and pools. This river stretch has different biotopes with very

characteristic and diverse fish fauna (Telcean and Cupşa, 2009). The largest urban settlements in proximity to the river in this area (Hunedoara and Arad counties) are Câmpia Turzii (26,000 inhabitants), Ocna Mureş (12,000), Aiud (22,000), Mediaş (over 55,000), Copşa Mică (over 5,300), Blaj (26,000), Tîrnăveni (22,000), Alba Iulia (over 103,000), Orăştie (21,000), Simeria (12,000) (Curtean-Bănăduc *et al.*, 2017). As a consequence of human activities, the river system habitats have become severely modified or degraded in some sectors, however the potential for their recovery is substantial (Curtean-Bănăduc *et al.*, 2007).

Within the Carpathians, the Mureş River supports a rich diversity of habitats, particularly riparian zones that are crucial for maintaining biodiversity and ecological connectivity. These areas form part of several Natura 2000 sites, such as ROSCI0368, ROSCI0019 and ROSCI0320, designated under the EU Habitats and Birds Directives. These sites protect key habitats and species of community interest. Protected species recorded along this stretch include European otter and European beaver (*Castor fiber*). This area is also one of the areas where European mink were last observed in Romania outside of the Danube Delta (Figure 2; Botnariuc and Tatole 2005) and close to some of the few American mink records in the country (Hegyeli and Kecskés, 2014).

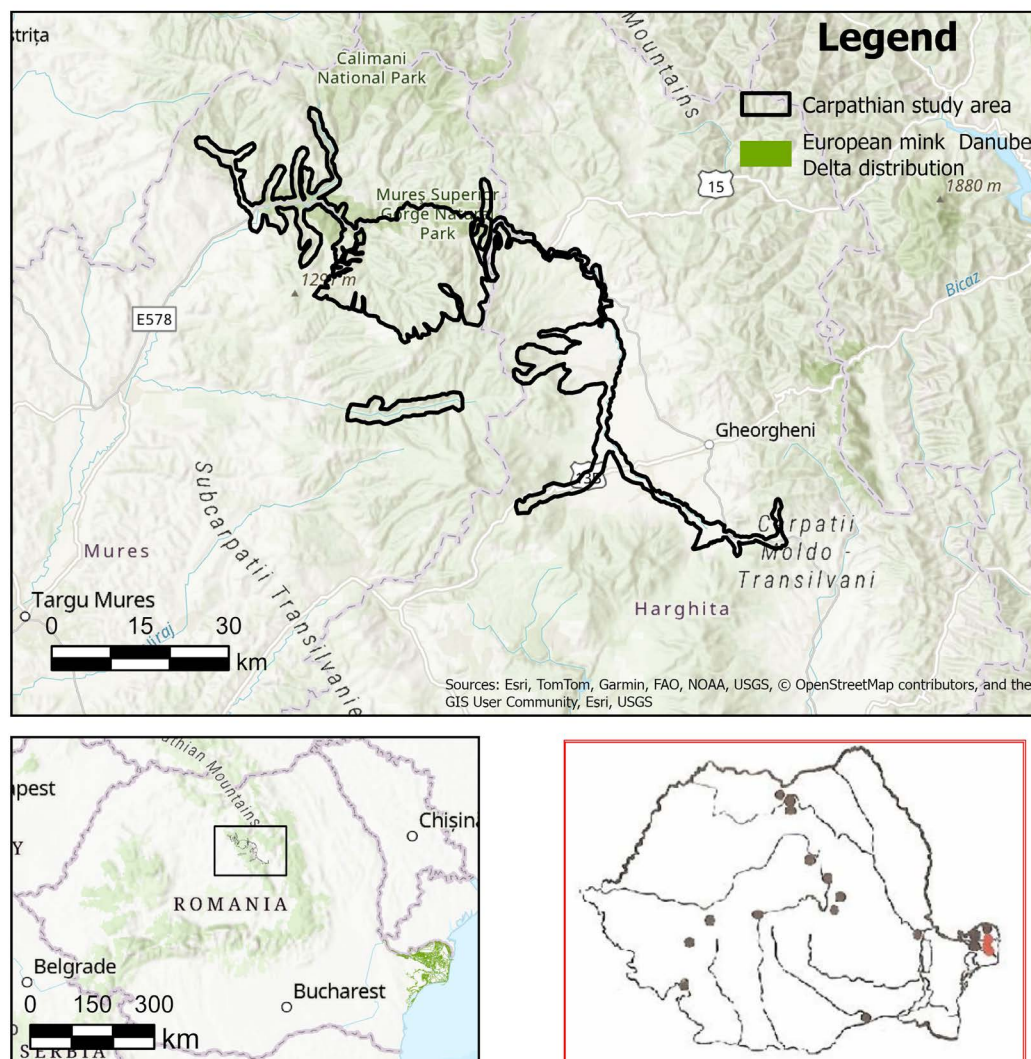


Figure 2 Showing the location of the area of interest in the Romanian Carpathians along with map from Botnariuc and Tatole 2005 representing historical and recent distribution of the European mink in Romania (red dots represent locations with confirmed presence, black dots represent locations where mink were previously present but populations have disappeared).

A reintroduction programme for European mink in the southern Carpathians would be successful if, in the short term, it resulted in a viable population in the release area(s); it would be successful in the long term if it resulted in population persistence, with the opportunity for connectivity with the extant population in the Danube Delta. This would establish an effective metapopulation, increasing the resilience of the Romanian population overall.

Methods and Results

Creation of a Resistance Surface

A significant amount of species data is typically needed to assess habitat suitability and landscape connectivity for wildlife. However, with a species like European mink, very little data are available and the data available could be somewhat biased, atypical and misleading. For example, most records for European mink are from the extensive wetlands of the Danube Delta – yet we know that the species does not rely only on wetlands. Therefore, we followed a similar approach to Leoncini *et al.* (2023) based on expert opinion for the creation of a resistance surface, which was also used as a substitute for habitat suitability in this study.

A resistance surface is a spatial layer whose values represent the ability of the study organism to move through each grid cell. High resistance values represent areas that are difficult for the species to move through. Therefore, when using these maps as a proxy for habitat quality, low values are more favourable for the species. The first step to construct a resistance surface involves the identification of variables relevant to the focal species. We selected the following eight environmental variables from seven different data sources expected to impact European mink movement and habitat preferences (Table 2 and Table 3). These variables are likely to impact the species in different ways as they could impact movement difficulty, increase mortality risk or behavioural avoidance.

Table 2 Source of environmental variables used for the creation of the resistance surface.

Variables	Source
Land cover	CORINE Land Cover, Copernicus Land Monitoring Service, European Environment Agency (EEA)
Distance from riparian habitat	Riparian Zones Land Cover, Copernicus Land Monitoring Service, European Environment Agency (EEA)
Watercourse density and Distance from watercourse	HydroSHED dataset, https://www.hydrosheds.org/products/gloric
Slope	European Digital Elevation Model, EU-DEM, version 1.1
Dams	Global Dam Watch dataset, GDW, http://globaldamwatch.org
Tree cover	Global Forest Watch (2023)
Roads	Global Roads Inventory Database, GRIP

The variables were rasterised to a 25m resolution initially and were aggregated to lower resolutions for further modelling in order to decrease computational effort. We used information from the literature and expert opinion to provide a resistance value ranging from 1 (minimum resistance) to 100 (total barrier) for each grid cell (Table 3).

Table 3 Resistance scores given to all features.

Variables	Source	Resistance
Land cover	Continuous urban fabric	100
	Discontinuous urban fabric and other urban features	70
	Green urban areas	40
	Arable land	50
	Permanent crops, pastures, heterogeneous agricultural areas (no agro-forestry)	30
	Forest, agro-forestry and shrub/herbaceous vegetation	10
	Beaches, dunes and sand plains	20
	Bare rock	60
	Sparsely vegetated areas open spaces	30
	Burnt areas	50
	Glaciers and perpetual snow	100
	Wetlands and waterbodies	1
Distance from riparian habitat	0-5	1
	5-100	5
	100-250	30
	250-500	50
	500-2500	90
	2500+	100
Watercourse density	0-0.28	100
	0.28-0.56	60
	0.56-0.84	30
	0.84-1.12	20
	1.12-1.42	10
Distance from watercourse	0-100	1
	100-250	20
	250-500	50
	500-1000	80
	1000+	100
Roads	Highways	100
	Primary and secondary roads	80
	Tertiary roads	60
	Local roads	40
Slope	< 45°	1
	≥ 45°	70
Dam	Absent	1
	Present	100
Tree cover	Present	10
	Absent	40

Finally, by applying a swing weights procedure (Malczewski, 2000), the variables were ranked according to their importance to the ecology of the species in descending order, with a starting score of 100. The weight of each variable was then obtained by dividing the ranking value itself by the sum of all ranking values, and these were used as a multiplier when combining the eight layers in the final resistance map (Table 4).

Table 4 Summary of weights obtained prior to combining all layers into a single resistance surface.

Variable	Priority value	Weight
Distance from riparian habitat	100	0.192
Distance from watercourse	90	0.173
Land cover	70	0.159
Dam	40	0.0769
Slope	40	0.0769
Roads	Forest, agro-forestry and shrub/ herbaceous vegetation	10
Tree cover	Beaches, dunes and sand plains	20
Watercourse density	Bare rock	60

The resistance surface illustrated in Figure 3 was first created nationally and identified good riparian habitat throughout the country, especially within the Danube Delta (Figure 3). Then a large surface area, which included the focal study area and parts of the southern Carpathians and Transylvania, was analysed to provide an overview of the riparian habitat around the area of interest. The outputs clearly showed that the focal study area is part of a large network of watercourses in the Carpathians with plenty of habitat within the Parcul Natural Defileul Mureşului Superior and the Parcul Naţional Călimani. Further down the Mureş, however, good habitat appears scarcer and tends to be found along the Mureş only (Figure 4).



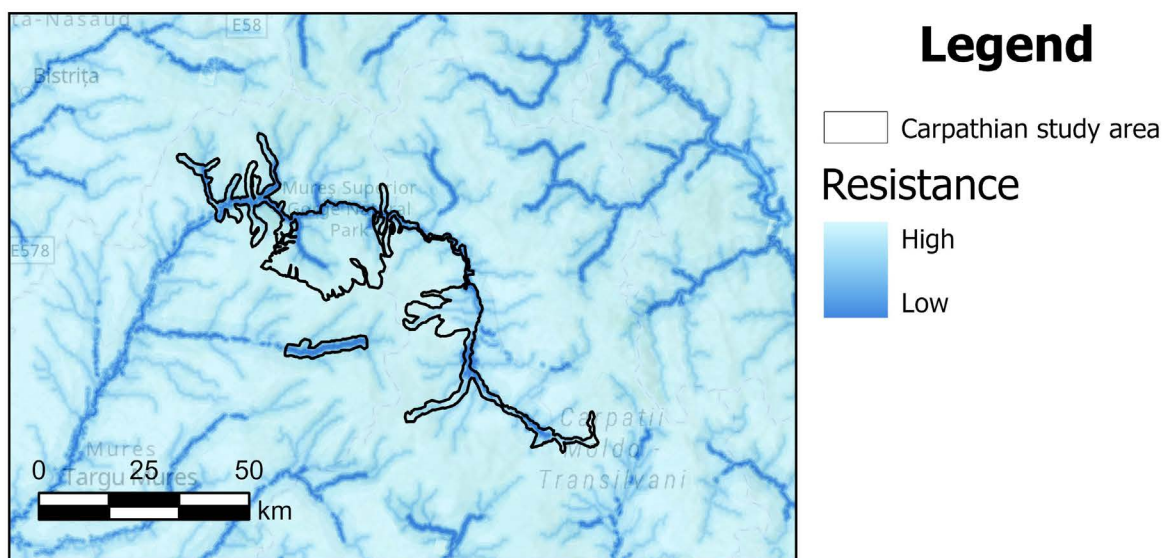
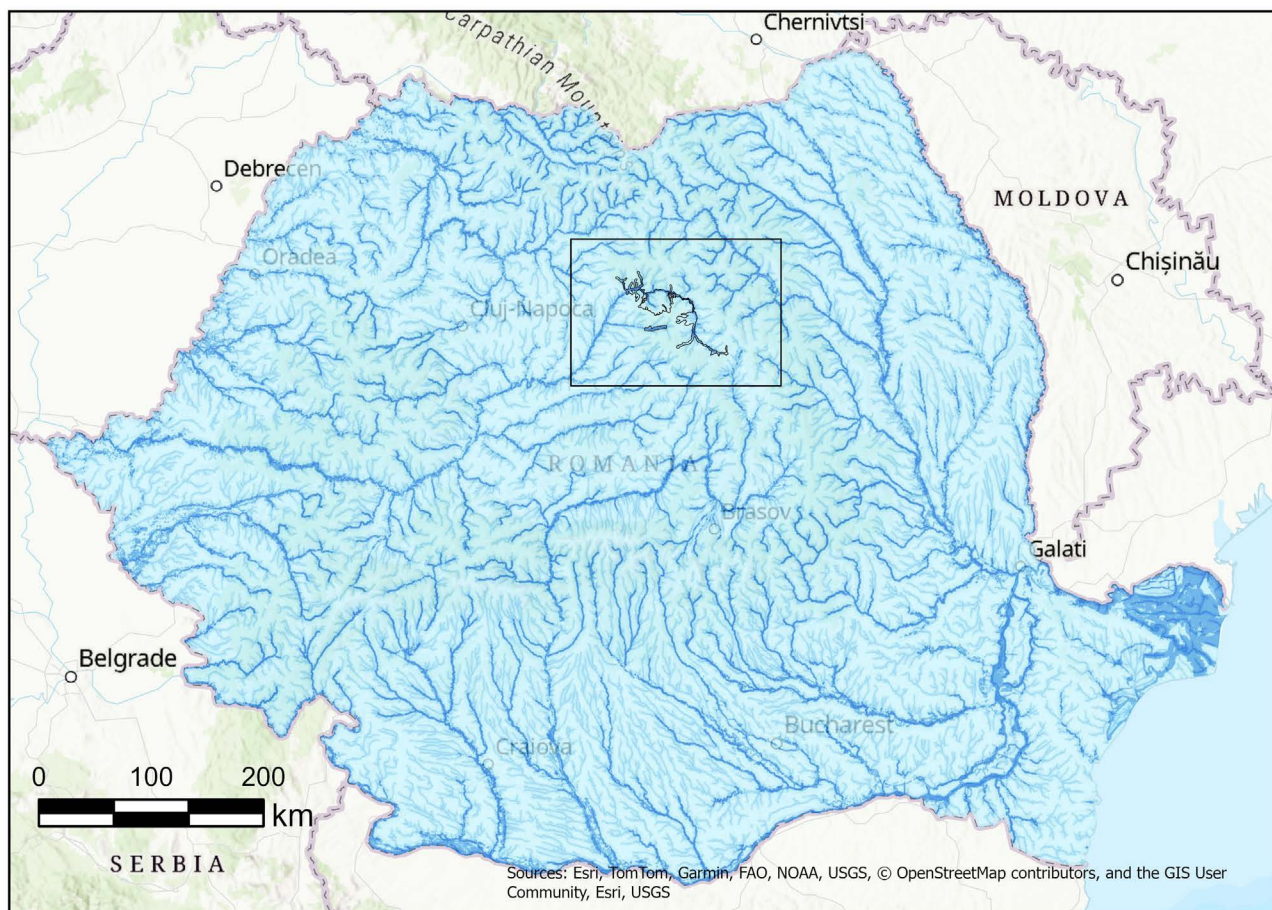


Figure 3 European mink resistance surface at a 25m resolution throughout Romania and highlighting the resistance surface within the area of interest in the southern Carpathians.

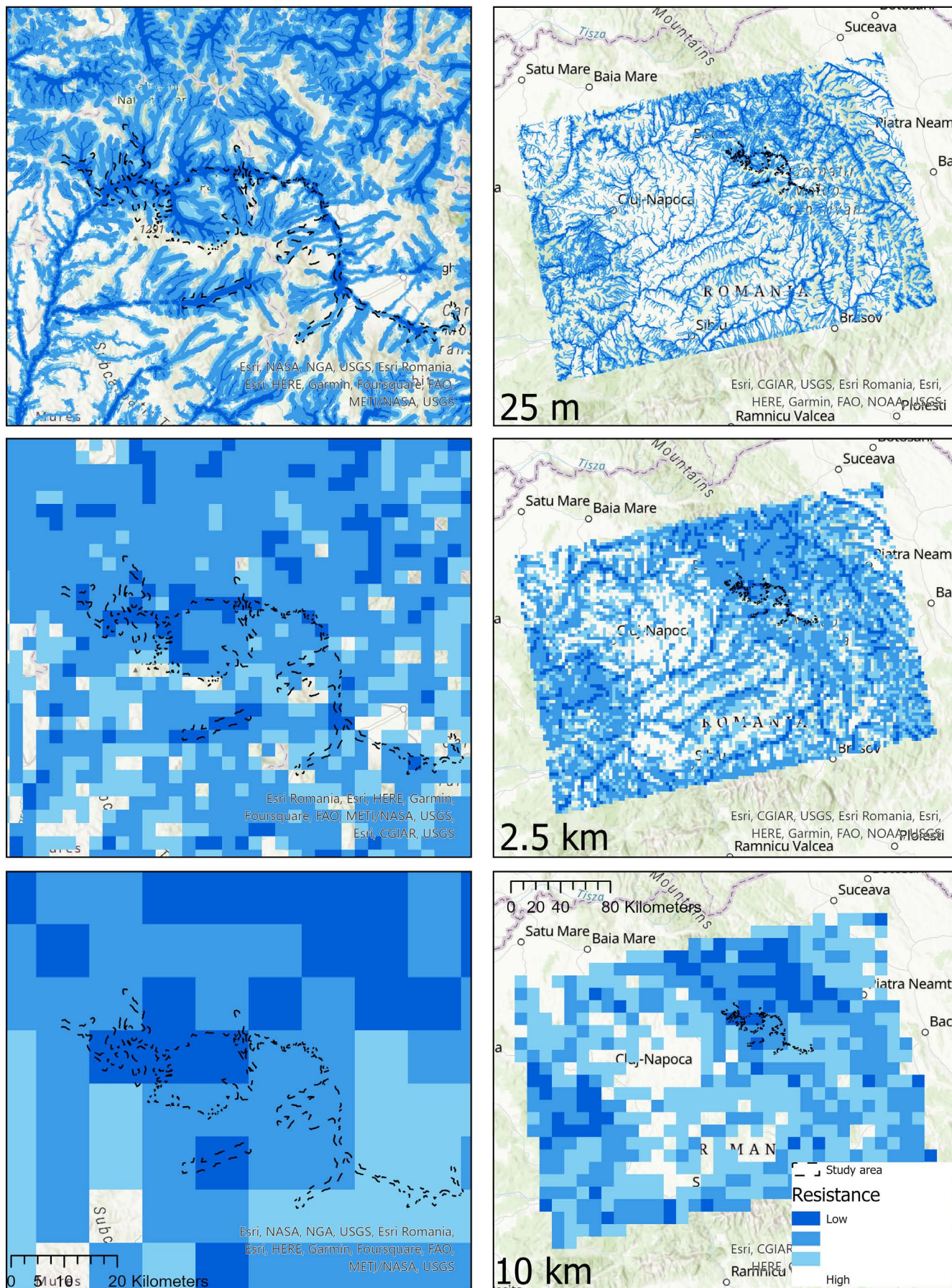


Figure 4 European mink resistance surface at 25m, 2.5km and 10km resolutions in the focal study area and along the Mureș catchment.

We also created a map to optimise surveying effort undertaken by the Romanian Wilderness Society (RWS) by multiplying the habitat score (ie, inverted resistance surface – see graphab section) with the total length of water courses for each 10km grid cell. Therefore, grids with the highest scores correspond to areas with the most water courses and the most favourable habitat (Figure 5). The priority areas for surveying in dark blue/purple grids were identified within the Parcul Natural Defileul Mureşului Superior and further east, between Joseni and Biseneu.

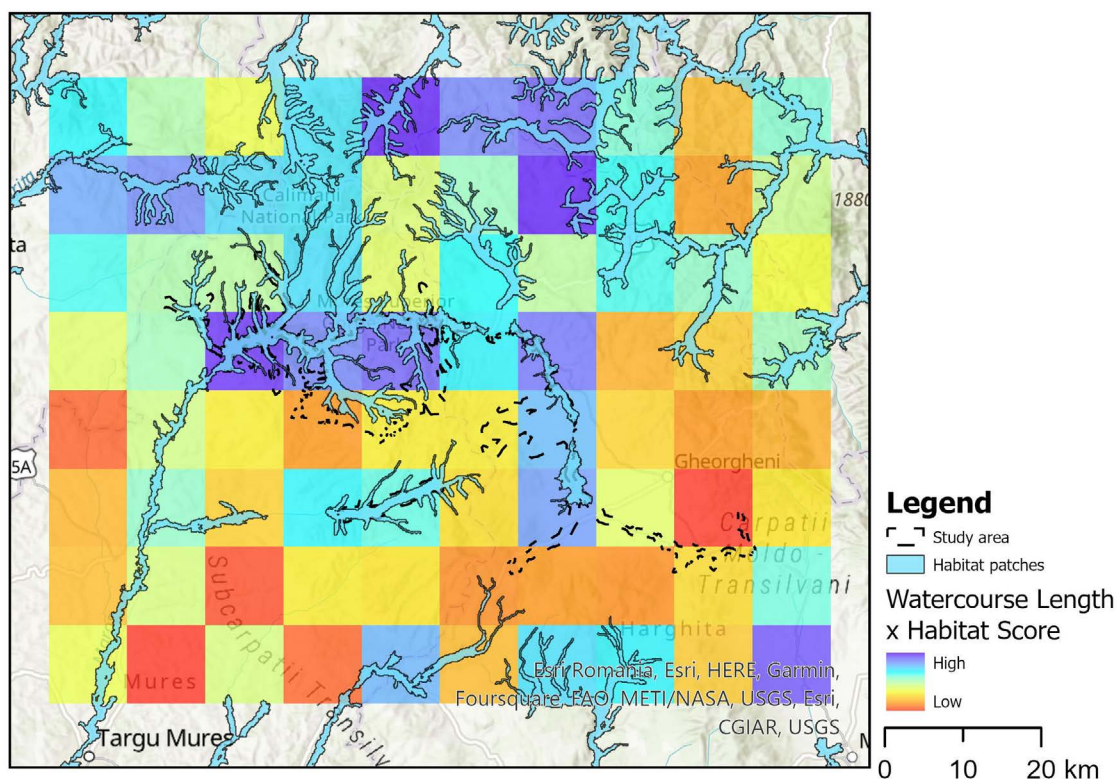


Figure 5 Map representing the priority 10km x 10km grids based on the habitat and watercourse length of each grid along with habitat patches identified in graphab (See Figure 4).

Graphab

We used the software graphab (Foltête *et al.*, 2021) which is dedicated to the modelling of landscape networks to quantify habitat connectivity. For this, the resistance layer was converted to a habitat layer by inverting values. A habitat patch was determined as being an area of at least 100ha with all pixels scoring at least two thirds of the highest habitat value. In this case, these values range from 51 to 76. The resistance layer was also used to identify least-cost paths between patches; and the corridor function determined the number of pathways connecting each habitat patch whilst using a maximum dispersal value equivalent to the cost of a 100km dispersal, which has already been observed with European mink.

Figure 6 confirms the large network of connected riparian habitats within the Carpathians and particularly within the focal study area where a single habitat patch was identified along most of the Mureş River. However, the tributaries south of Reghin were very rarely identified as habitat patches, which raises the question of whether there is sufficient habitat for a thriving population to expand from potential release sites within the Carpathians.

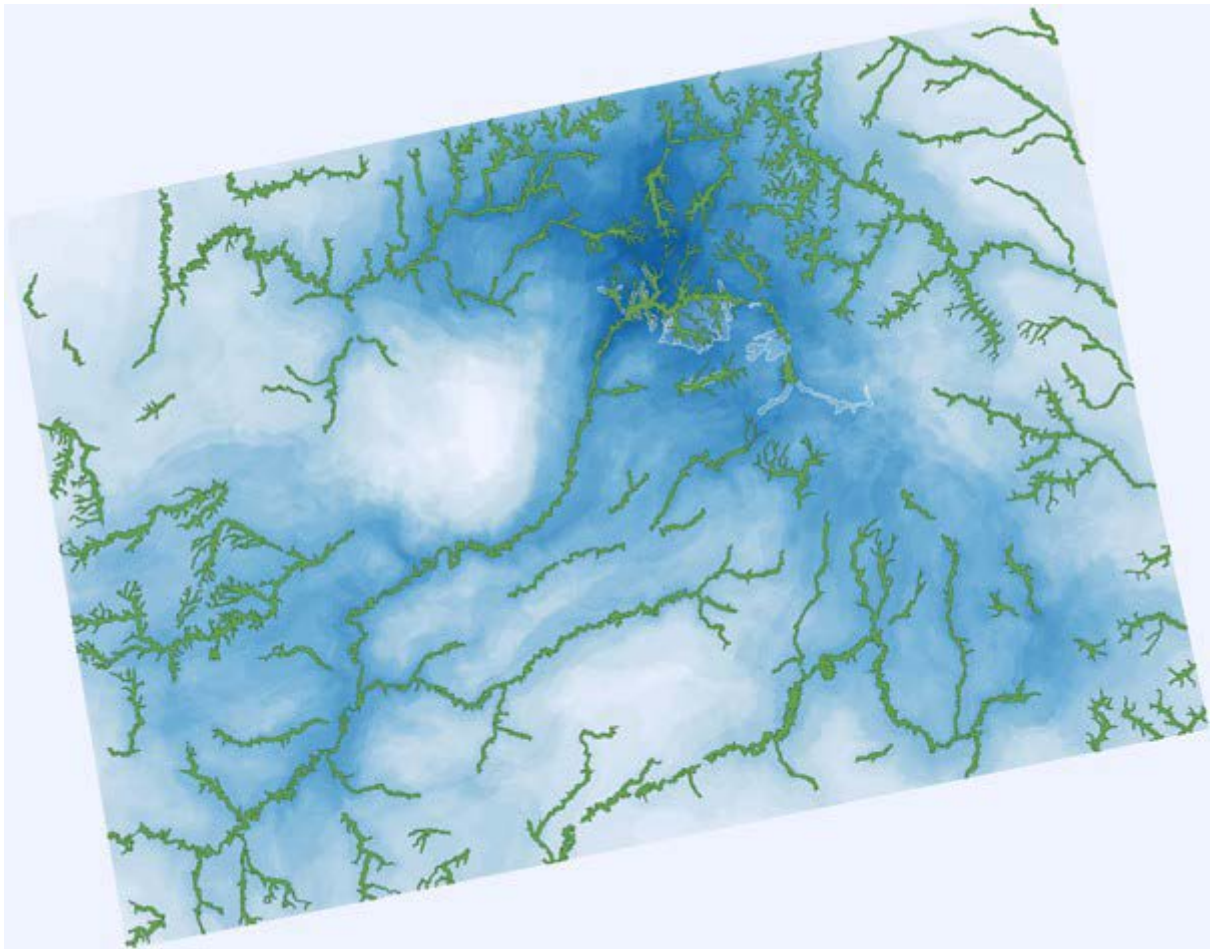


Figure 6 Habitat patches (green) and number of corridors identified for the species (dark blue is representative of a large number of corridors).

Circuitscape Modelling

We used Circuitscape v4.0.5 (McRae and Nünberger 2006), a software linking circuit and random walk theories, to visualise the amount of connectivity and identify barriers and pinch points in the landscape. As opposed to least-cost-path analysis, Circuitscape investigates all possible pathways connecting points (or habitat patches) through the landscape based on a resistance surface and provides a current map identifying areas of high connectivity in the landscape. In our case, we need to have an overall idea of connectivity as we are not interested in connecting specific points in the landscape yet. Therefore, a total of 30 points/nodes were randomly selected within a 50-75km buffer outside the study area to avoid any bias created by the nodes when they are located within the study area. The models were run at a 100m resolution to reduce computation time.

The Circuitscape output in Figure 7 highlights the importance of the Mureş river in maintaining connectivity while the tributaries appear less important. This is to be expected as Circuitscape works similarly to river networks as the current somewhat accumulates from the tributaries down to the Mureş. Rivers are typically narrow, and therefore pinch points are not easily identified. However, barriers along the Mureş river can be detected. For example, a lack of connectivity can be identified along Gheorgheni, Toplita and Hodac. These can be a result of less riparian habitat combined with the presence of roads, urban areas, and other less favourable features.

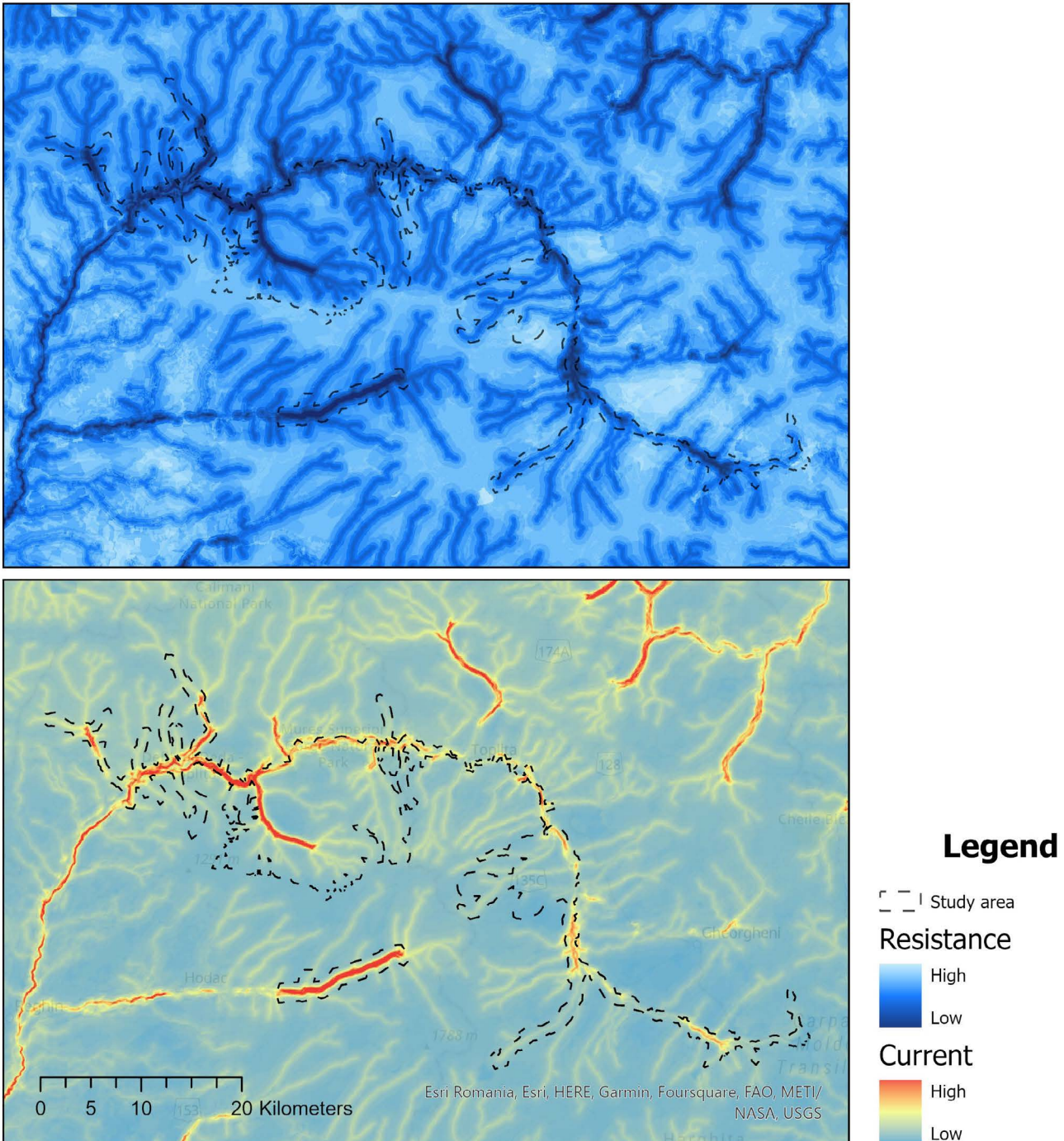


Figure 7 Resistance surface and Circuitscape output illustrating the current/probability of movement of European mink.

Road Density and Crossings

Roads can have a serious detrimental impact on the overall functional connectivity of the landscape for European mink and affect the viability of populations through direct collisions. Although crucial for the feasibility of reintroducing the species to the region, identifying road crossings over rivers is rarely possible due to the lack of precision of most datasets. We decided to identify all these crossing points manually by following the river Mureş and its tributaries within the extended study area. Figure 8A highlights the density of sites where roads intersect watercourses. The area around Hodac appears to have the highest density of road crossings and also seems to coincide with a barrier in the Circuitscape output (Figure 7 and Figure 8). While the Mureş does not suffer from as many road crossings throughout the extended study area, the highway runs mostly parallel to the river and is rarely further than 1,000m away from it (Figure 8B). This is an additional threat to bear in mind.

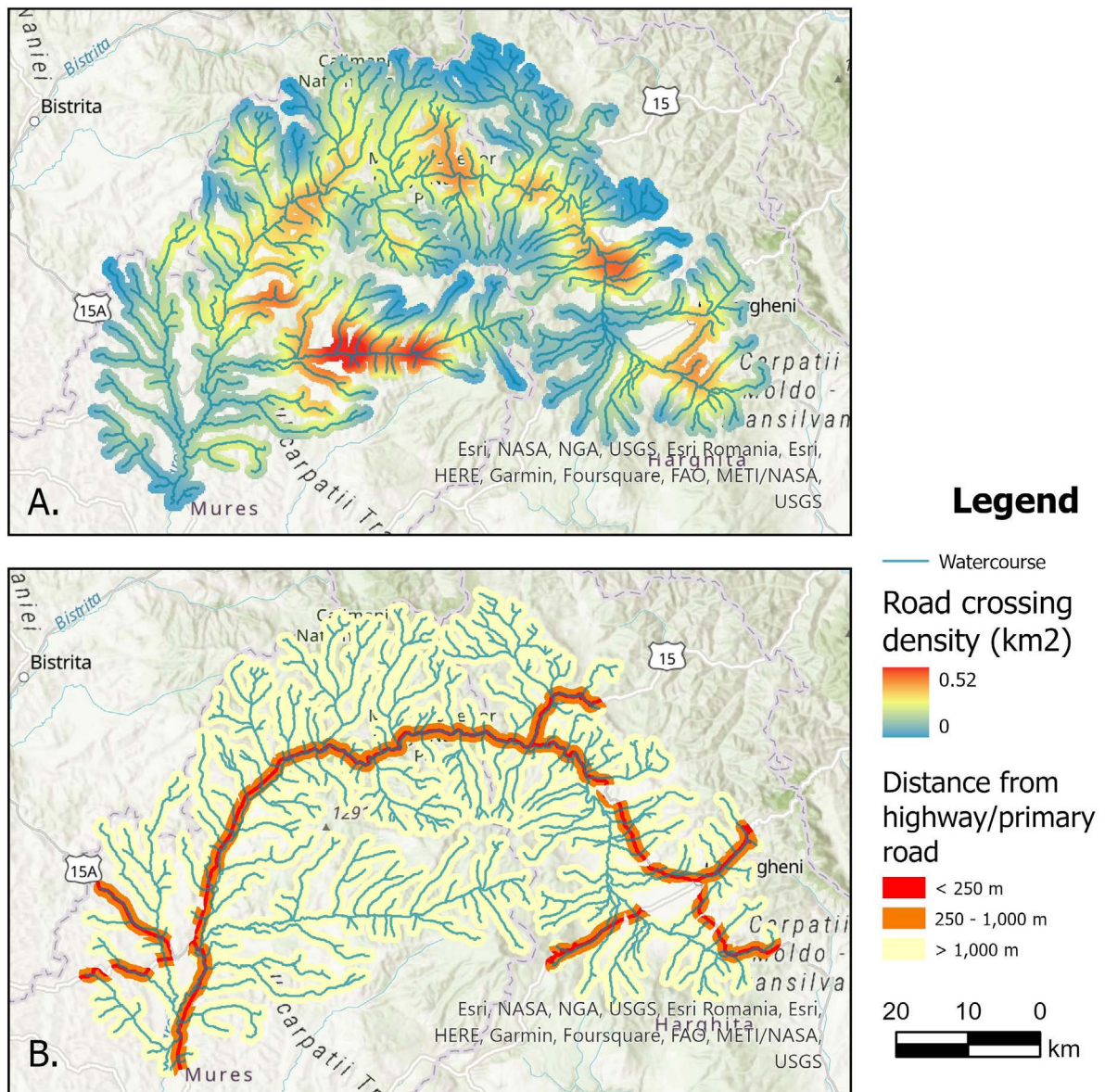


Figure 8 Kernel density of road crossing points (A) and distance of watercourses from a highway or primary road (B).

The results from this piece of work show that there is ample riparian habitat with good functional connectivity for European mink. However, there may be concerns around the potential threat of roads that could pose a serious threat to the viability of small, reintroduced populations. Additionally, habitat further down the Mureş river appears scarcer and could hinder the expansion of the population.

The river catchment that we are primarily focused on (visible in Figure 4) comprises approximately 1,841km of watercourses and the Carpathian study area includes 414km of watercourses. The landscape models performed here allowed us to identify 177km of priority habitat to investigate in the field. Results of field surveys are detailed separately in the RWS reporting.

Field work performed by RWS confirmed the value of ground truthing as i) GIS data and analyses do not include the full range of diversity of habitats available for the species (eg, wetlands, mountainous rivers) and ii) the datasets used lack precision and are not always up to date (as an example, a recent dam construction identified in the field but not shown in the dataset could be a significant barrier to mink movement and dispersal).

5 Assessment of the Danube Delta as a Potential Source Population(s) for Conservation Translocations of European Mink



It is generally recommended that, where sufficient stock is available, wild caught animals are used for reintroductions, particularly with carnivores. Wild caught animals generally show higher survival and better adaptation to new environments than captive bred animals (Jule *et al.*, 2008).

Founder animals should show characteristics based on genetic provenance, morphology, physiology and behaviour that are appropriate in comparison with remaining wild populations. It is likely that the remnant population of European mink in the Danube Delta is genetically representative of the formerly widespread Romanian population. Therefore, we carried out population estimates and population viability analyses to assess its potential as a donor population for 'harvesting' and translocations to suitable reintroduction sites in the southern Carpathians.

Population Size Estimates of European Mink in the Danube Delta

Methods and Results

Integrated Species Distribution Model

In 2024, Twinning *et al.* published an integrated model that combines presence-only data from various sources with detection/non-detection data from structured surveys to estimate distribution and expected abundance of three elusive mammals in New York State (USA). Although this model benefited from a large dataset (>100,000 sampling days; >3,800 sampling sites; ~1,500 independent detections) collected systematically over the span of nine years, we decided to test this technique on the Danube Delta European mink population as it can make use of both presence-only and presence-absence data.

Data Preparation

All European mink records and live trapping data were provided by the Danube Delta National Institute for Research and Development. As observed in Table 5 and Figure 9, live trapping and opportunistic observations of the species have been relatively sporadic over the years due to limited means to survey the area on a regular basis. Ideally, we would have incorporated the original dataset. However, the presence of numerous years lacking records was likely to result in models not converging. Therefore, to implement a simple model, we first grouped years into four categories (every five years) and then two categories (records before and after 2013). Trapping and observation data for 2024 and 2025, during the lifespan of the current project, were subsequently provided and have therefore been added to Table 5, and the original analyses on data provided at the start of the current project ie, years 2003-2023, were repeated with the additional data for the Bayesian statistical analysis (see p37).

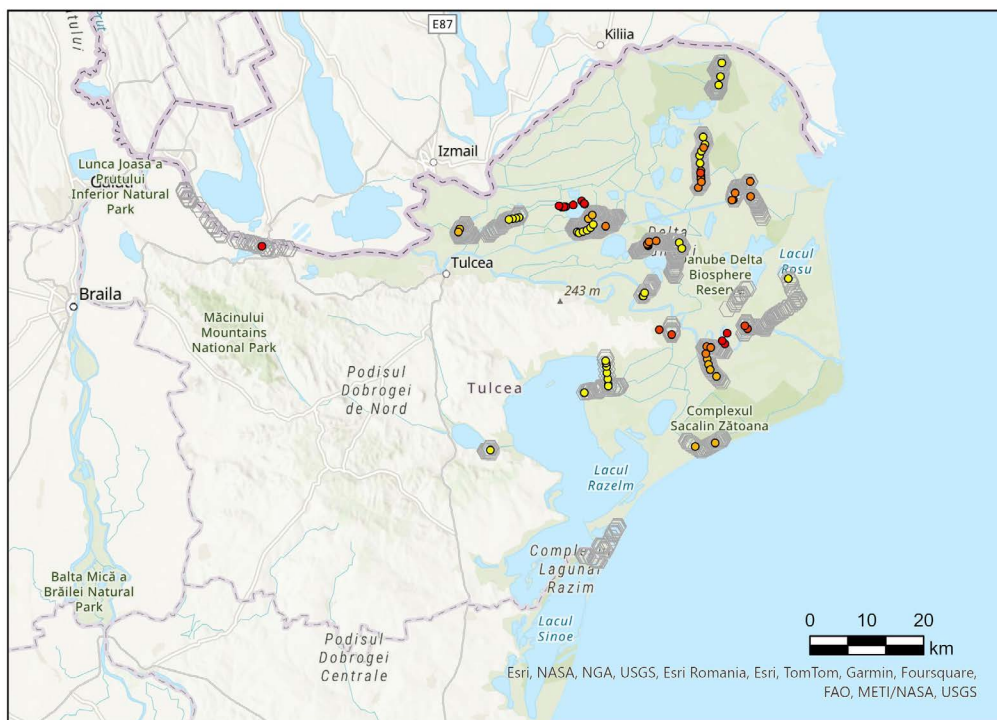


Table 5 Summary of European mink observations and captures in the Danube Delta since 2003

Year	Captures	Observations
2003	28	0
2004	7	0
2005	0	0
2006	2	0
2007	6	0
2008	2	0
2009	0	14
2010	27	28
2011	4	0
2012	6	0
2013	0	1
2014	4	19
2015	0	0
2016	0	69
2017	0	55
2018	0	59
2019	0	34
2020	0	66
2021	9	18
2022	5	7
2023	8	0
2024	2	5
2025	2	5

To prepare the trapping data, for simplicity, we assumed three trap checks were performed over three days for all traps (although this was not always the case). For traps where a European mink was caught, we determined the capture date based on the start date of the trapping transect. For example, if a trapping transect started on 15/02/2014 and a mink was caught on 16/02/2014, the trapping history of this site would be 0,1,0.

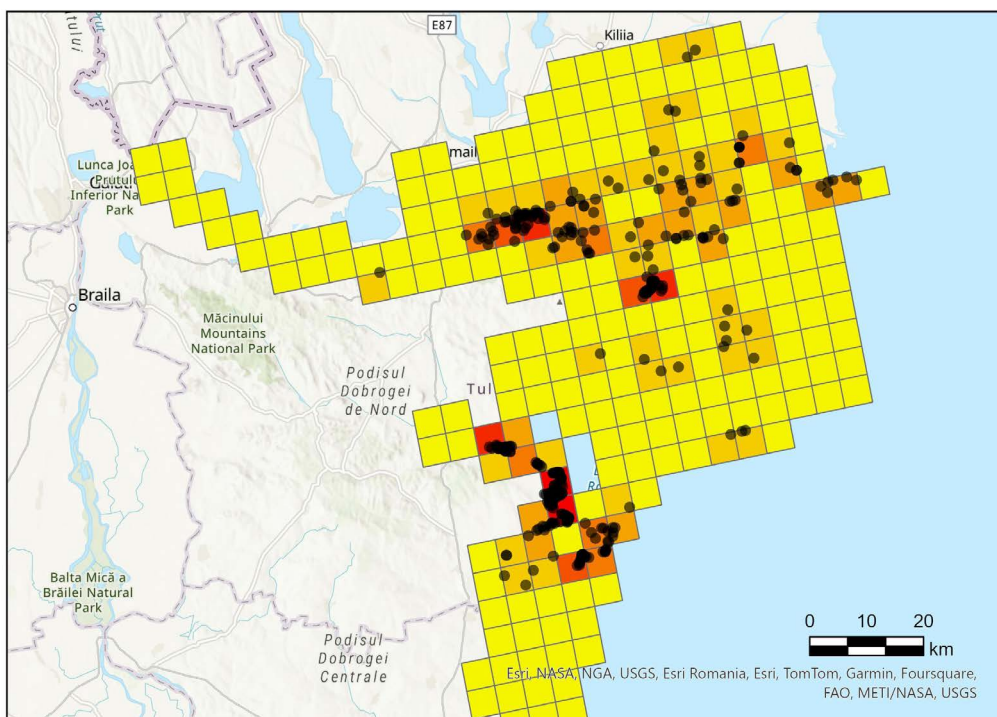
The landscape was divided into $i=250$, 5 km² pixels (Figure 10). To explain spatial variance in expected abundance in each 5 km² grid, we used the mean resistance score in each pixel from the habitat map we created during the habitat assessment described in section 4.



Legend

Capture	● 2008-2011
Year	● 2011-2014
	● 2014-2023
	○ No capture
	● 2003-2004
	● 2004-2008

Figure 9 Summary of European mink trapping effort in the Danube Delta from 2003 to 2023.



Legend

● Observations	3 - 5
Observations per 5 x 5 km grid	6 - 8
0	9 - 16
1 - 2	17 - 24
	25 - 55

Figure 10 Summary of European mink observations in the Danube Delta from 2003 to 2023.

Model Preparation

Detailed information on the model can be found in Twining *et al.* (2024). However, to summarise, this is an integrated species distribution model that combines presence-only data with detection/non-detection data from structured surveys to estimate the distribution and expected abundance of European mink.

The spatial point density of all bird and mammal records available from 2003 to present day were extracted from GBIF to inform the thinning process and account for unknown spatial sampling in the presence-only data. Using this approach, we examined the habitat association and provide spatially explicit estimates in expected abundance across the entirety of the Danube Delta.

We conducted our modelling in C++ via the nimble package version 0.13.1 (de Valpine *et al.*, 2022) in R. We used three chains in parallel with 30,000 iterations and a thinning rate of 3. We removed a burn-in of 5,000 from the thinned chains yielding 5,000 posterior samples per chain. Models were considered to have converged only if visual inspections of chains displayed good mixing for all parameters and the upper credible intervals for parameter-specific values were <1.10 (Gelman *et al.*, 2013). We used posterior predictive checks to ensure acceptable model fit (Gelman *et al.*, 1996). We provided evidence of a statistically important effect by calculating 95% credible intervals for each parameter and determining whether they overlapped 0.

The final dataset used 3,519 trapping days at 1,173 sites and 328 independent observations. The model resulted in good mixing with acceptable R-hat values and effective sample sizes (<1.1).

The results from the models would suggest that occupancy and abundance of European mink in the Danube Delta is highest where the habitat is thought to be less suitable for the species (Figure 11). However, these areas are also where no trapping has taken place and with few or no presence-only records over the past twenty years. We found these results unlikely and therefore decided to try a different technique.

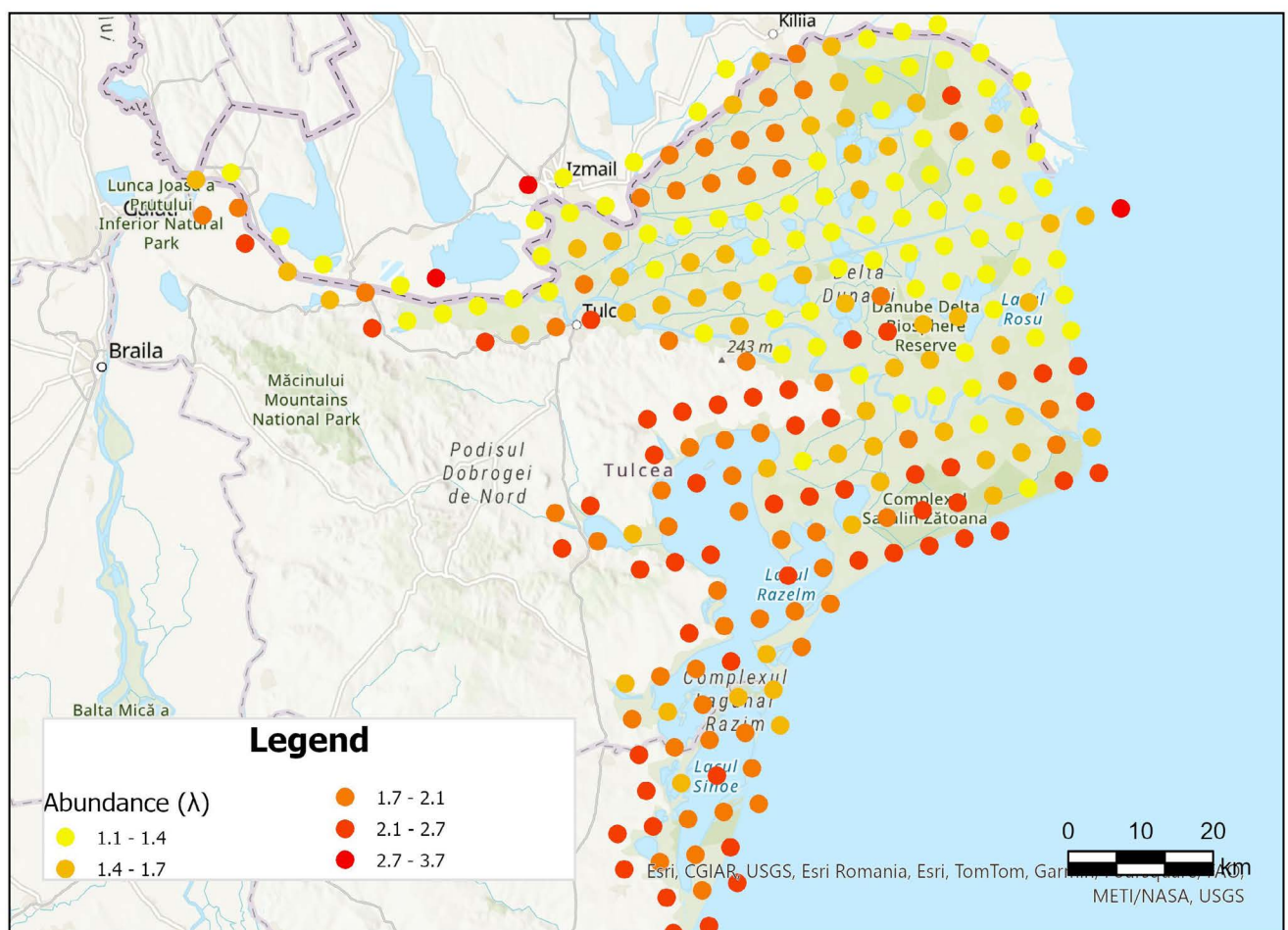


Figure 11 Spatially explicit predictions showing mean expected abundance (λ) of European mink.

Unmarked Bayesian Models

Since the integrated population models provided unreliable results, we decided to simplify the dataset and combine it into a single-season model where we would not use ad hoc observations and assume all captures were made during the same season. This violates certain assumptions as these models assume that the population is closed (ie, no colonisation or local extinctions possible). It is thought that the local population has remained relatively stable and there is only a single known incidence of a mink being caught twice in different traps, therefore we judged that the estimates would, despite these limitations, be a fair approximation of the current population size.

We used a Bayesian statistical analysis approach to estimate the detection and occupation probabilities of European mink for each method. We estimated the probability of detecting European mink when present throughout the study area using the R (v. 4.3.2; R Core Team 2023) package *ubms* (Kellner *et al.*, 2021) and STAN software (Carpenter *et al.*, 2017) implemented in R Studio (v. 2023.12.1.402; Posit Team 2024) with 4,000 iterations, 4 chains and the default burn-in setting of half the number of iterations. Then, we ran a N-mixture abundance (Royle *et al.*, 2004) model using the same parameters using the habitat as a covariate. Both models were run against a habitat/resistance covariate, initially calculated at a 25m resolution, which was averaged to a 5km resolution.

To estimate the population in the Danube Delta from the N-mixture abundance model, we tried three different data filtering methods. First, we ran abundance predictions in the cells which had a probability of occupancy superior to 0.6. Then, we used a minimum occupancy threshold, which estimates the abundance of each cell which has occupancy probability superior to the lowest occupancy where the species has been detected. Finally, we also estimated abundance in the cells within 5km of any European mink observation (captures and observations).

Following the 2024 and 2025 surveys along the Prut River, these analyses were repeated with the addition of these results. The models included in addition an extra covariate, 'river' (Danube Delta or Prut River), as we were expecting some differences between both after no captures along the Prut River.

Danube Delta

The overall probability of occupancy of European mink derived from live trapping data was 0.77, with a Bayesian Credibility Interval ranging from 0.45 to 0.99. Occupancy of the species was highest in areas with low habitat resistance scores (ie, good habitat) and decreased in high resistance habitat although wide credibility intervals are observed throughout all habitats (Figure 12A).

The overall probability of detection of European mink with live trapping was 0.04, with a Bayesian Credibility Interval ranging from 0.03 to 0.06; and the species was less likely detected in areas of low resistance than in areas of high resistance (Figure 12B). Despite credibility intervals ranging from 1 to 20, higher abundance of European mink was predicted in areas of low resistance (~5) and this reduced in areas of high resistance (~2).

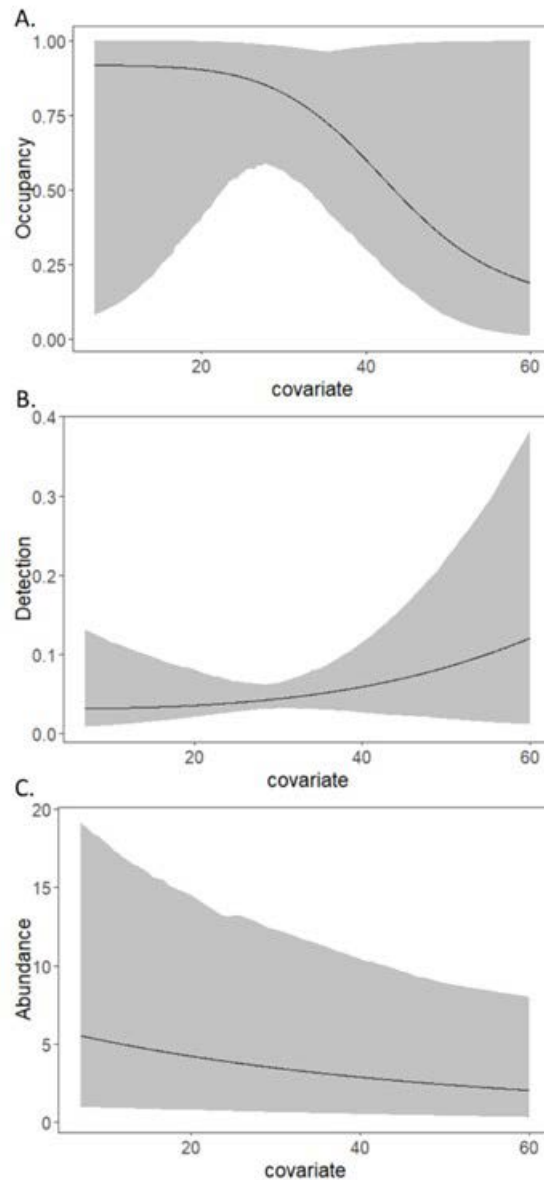


Figure 12 Probability of occupancy (A), detection (B) and abundance estimates (C) against the habitat resistance covariate (low values = good habitat).

The occupancy of European mink was predicted as high throughout the Danube Delta (Figure 13), but abundance estimates were restricted to a limited number of grid cells and mostly produced estimates below 500 individuals but with large uncertainty intervals (Table 6). The minimum occupancy threshold was low (0.22) and, consequently, estimates were calculated over a larger area than the other estimates and is probably less representative of the actual population size. Therefore, using this approach, the most representative population estimate, whilst bearing in mind the uncertainties, is estimated to be closer to 400-500 individuals (Table 6).

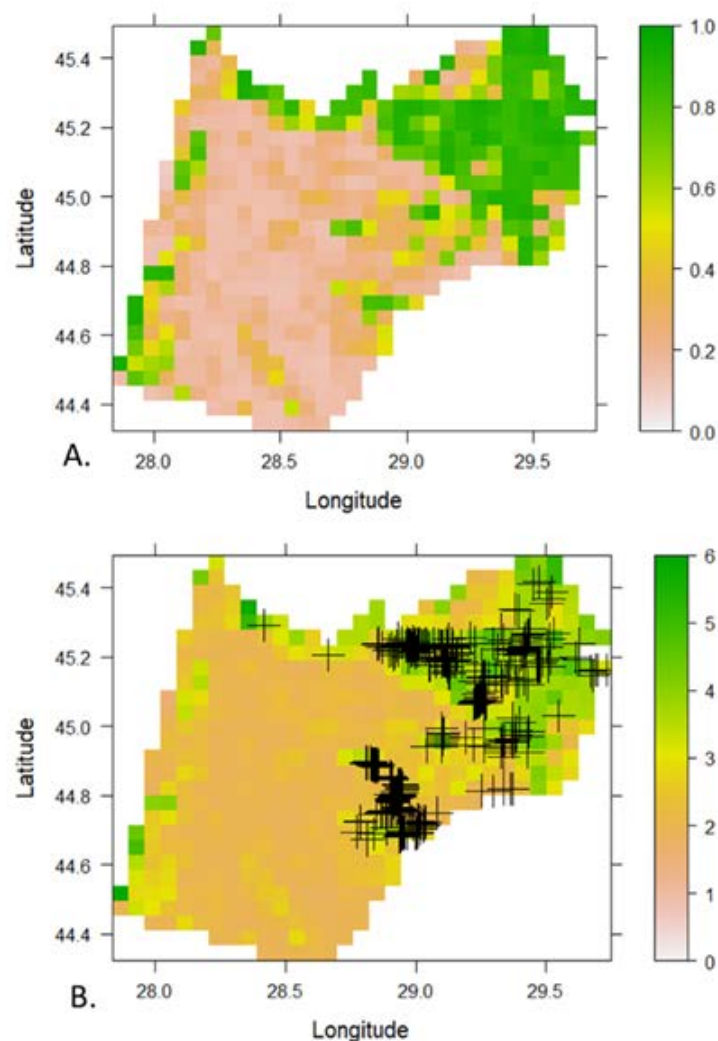


Figure 13 Predicted occupancy of European mink against the habitat covariate (A) and predicted abundance estimate with all the presence data of the species (B) which were used to determine threshold estimates.

Table 6 European mink population size estimates in the Danube Delta employing a Bayesian statistical analysis on 22 years of trapping data.

Estimate threshold	Abundance estimate (UI)
0.6 Occupancy threshold	436 (84-1,495)
Minimum Occupancy threshold	738 (137-2,552)
Presence threshold	413 (78-1,426)

Incorporating the Prut River

The overall probability of occupancy of European mink derived from live trapping data was 0.73, with a Bayesian Credibility Interval ranging from 0.37 to 0.99. The probability of detection of European mink by live trapping was 0.04, with a Bayesian Credibility Interval ranging from 0.02 to 0.07. Although trends were not as evident, we identified similar patterns for the probability of detection and occupancy of European mink. However, as expected, these estimates were lower along the Prut River (Figure 14). The population size estimate using the 0.6 occupancy threshold provided an estimate of 717 (C.I. 127-2,393). This is larger than the initial estimate that did not include the Prut River, but the uncertainty intervals are also larger.

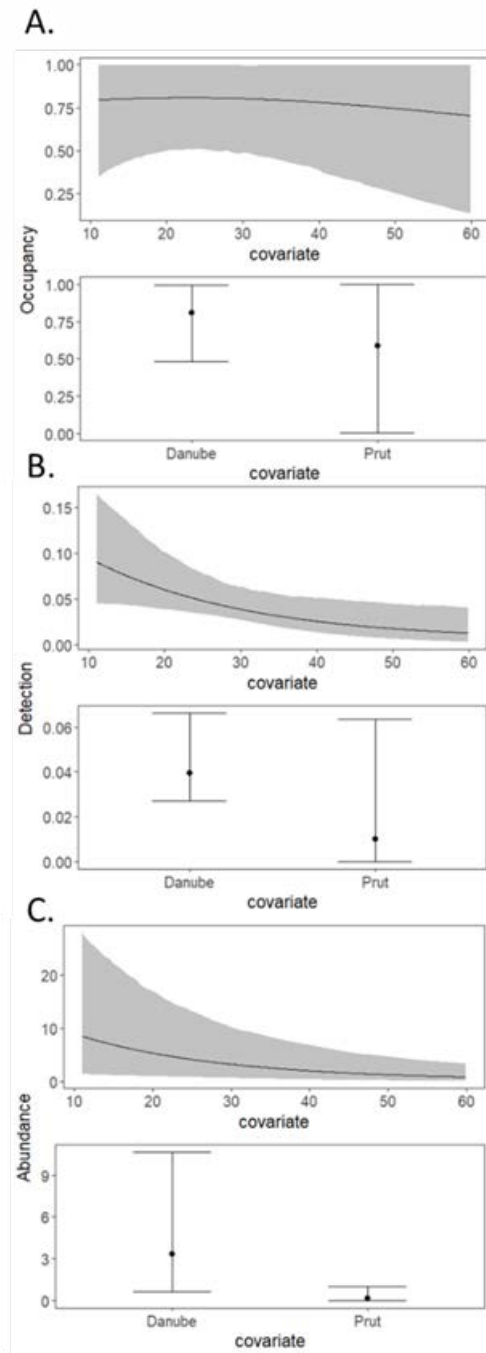


Figure 14 Probability of occupancy (A), detection (B) and abundance estimates (C) against the habitat resistance (low values = good habitat) and river covariates.

Discussion

Significant efforts have been put in place to detect European mink in the Danube Delta since 2003. However, these data were not sufficient for deriving precise population size estimates. Long periods of time with no trapping (up to six years) and the inability to survey large areas over a single season are the main limiting factors. In addition, European mink have proven to be difficult to capture as more than 3,000 trapping days have resulted in only 105 captures with almost no known recaptures. Consequently, by grouping all trapping effort into a single-season model, the estimates provided have large caveats. The best way to improve the population size estimate would most likely be to survey more regularly throughout the Danube Delta, mark animals so that recaptures can be recorded, and survey/trap in all types of habitats, and not just the most favourable habitat.

The probability of detection over three trapping days is particularly low (~ 0.05). In Spain, Croose *et al.* (2023) found that European mink first detection occurred on average on day five, but this resulted in a probability of detection of 0.85 over 10 nights. Therefore, increasing the number of trapping days would likely provide more records. Whilst such efforts can be particularly challenging to meet over large areas and difficult terrain, it could be particularly useful for detecting mink in areas where the species' presence is still uncertain. Live trapping could potentially be combined with other methods such as the use of environmental DNA (eDNA) sampling, which by itself only provides presence/absence data, but is highly sensitive at detecting species at low density.

For population size estimates, the identification/marketing of individuals must be prioritised where possible (Gilbert *et al.*, 2021). However, where this is not possible, non-invasive techniques can be used to estimate abundance and density which do not require the capture and identification of individuals may be considered, although these must be approached with some caution (Gilbert *et al.*, 2021). Non-invasive techniques such as camera trapping and hair tubes, could be used as the detection of European mink using these methods in another setting has been shown to be equally effective as live trapping (Croose *et al.*, 2023). This may allow the surveying of a much larger area and provide estimates that would be less likely to violate the model assumptions from the estimates we have provided in this study. Camera trapping does come at a significant cost due to the cost of purchasing numerous camera traps and the extensive time required to review and classify the camera trap images (Croose *et al.*, 2023). However, these costs can be reduced by (re)using cameras over multiple years and the time required to classify camera trap images can be optimised using existing Citizen Science platforms and/or emerging AI technology. The use of polecams, a tube-based camera-trapping system, may be particularly useful as it has the potential for individual recognition (Hofmeester *et al.*, 2024), although this has not yet been tested on European mink.

Effective population size estimates must also be considered as these provide a method that can inform the genetic health of the Danube Delta population, the size of the breeding population and potentially detect the scale of ancestral bottlenecks. These techniques, require the collection of DNA samples through trapping or hair tubes, but these can be accumulated over multiple years (the equivalent of a generation length) for a reliable effective population size estimate.

The analysis of trapping data from the past 22 years suggest the population of European mink in the Danube Delta may be lower than current estimates suggest. The most representative models suggested there may only be between 400 and 500 individuals in the Danube Delta, however there are large uncertainty intervals associated with these estimates, so the actual population may be considerably higher, or even lower. Given the level of uncertainty and that the population estimates provided here are lower than previous estimates based on expert opinion using known numbers of animals trapped and assessments of habitat availability (Pödra *et al.*, 2025) a robust estimation of the current population size and conservation status of European mink in the Danube Delta is required before this population can be considered as a source population for any future translocation plans.

The trapping of European mink in the Danube Delta is particularly challenging and the probability of detecting the species over the conventional three-day trapping period appears to be particularly low. If resources permitted, we would recommend that live trapping be extended at least to five or six days and captured animals given a permanent mark, such as using pit (passive integrated transponder) tagging (Gibbons and Andrews 2004). Alternatively, hair tubes and associated genetics analysis to estimate effective population size may be considered. Camera trapping, potentially combined with eDNA sampling, could provide a good option for

estimating abundance using an appropriate method such as occupancy modelling (MacKenzie *et al.*, 2006) as there may be potential to increase sampling effort with records of the species occurring over a longer period, although these techniques all have limitations and may be best considered as complimentary to live trapping.

Population Viability Analyses

To inform the feasibility and sustainability of translocating European mink from the Danube Delta to new sites in the southern Carpathians, it is essential to understand the demographic resilience of the source population. A robust estimate of the current population size in the Danube Delta is required before serious consideration can be given to the removal of animals from the Danube Delta. In the meantime, this section presents a population viability analysis (PVA) and simple harvesting models to evaluate the likely outcomes of removing individuals from the extant wild population, using population estimates provided in Section 5.

Our estimates suggest that the Danube Delta may support a stable European mink population with an estimated population size between 400 and 500 individuals. While this population is of critical conservation value, it remains vulnerable due to its isolation, limited genetic diversity (Cabria *et al.*, 2015; Skorupski *et al.*, 2024) and exposure to localised threats. Any removal of individuals for the purposes of translocation must therefore be carefully modelled to avoid undermining the viability of the source population.

The use of PVA allows for simulation of population dynamics under different removal scenarios, incorporating parameters such as survival rates, reproductive output, environmental stochasticity and demographic structure. Harvesting models are applied to explore thresholds for sustainable ‘harvesting’ (in this case removal of individuals for translocation). This provides information on the number, age class and frequency of individuals that could be translocated without causing long-term population decline. This analysis provides an evidence base for determining whether the Danube Delta population can support removals, how many individuals can safely be removed for translocation and whether supplementation from captive populations may be necessary.

Methods

We developed models with VORTEX (Lacy, 1993), a software tool designed to simulate the impact of deterministic factors, as well as demographic and environmental stochastic events, on small populations. It models population size over time by incorporating random variables and distributions specified by the user. The program is particularly suited for assessing the viability of small populations of long-lived, diploid, sexually reproducing species with relatively low reproductive rates, such as most mammals, birds, and reptiles. Key variables in the simulation include reproduction, mortality, carrying capacity (K), and migration (Lacy, 1993). VORTEX has been widely used to assess and guide management strategies for various species.

Very limited data exist on the life history traits of the European mink. Consequently, we based our demographic input parameters on those used in previous population viability analyses (PVA) of the American mink by Pertoldi *et al.* (2013). We initially ran a PVA for the Danube Delta population using the parameters presented in Table 7, with a starting population size of 488, one of the most plausible estimates derived during the feasibility study prior to receiving trapping results from 2024 and 2025. However, this simulation resulted in immediate extinction, driven by adult and juvenile mortality rates that were likely too high. The Danube Delta European mink population is, despite large declines during the 20th century, currently considered relatively stable. Whilst bearing in mind this assumption, we conducted a sensitivity analysis to explore a range of mortality values. From this, we selected combinations of adult and juvenile mortality rates that would support a relatively stable population from which individuals will be harvested in further models (Table 7).

Table 7 Input parameters used for the PVA* Values used during the sensitivity test.

Variable	Value
No. of years	100
No. of iterations	100
Extinction definitions	Only 1 sex remains
Lethal equivalents	3.14
% due to recessive lethal alleles	100
Reproductive system	Polygynous
Age of first offspring	1
Maximum breeding age	5
Maximum brood size	4
Sex ratio	50:50
% adult females breeding 100%	100
Mortality rates 0 to 1 yr*	58,60, [...],78
Mortality rates after 1 yr*	30,40,50
Initial populations size*	488 (95,200,300[...],3000)
% males in breeding pool	33.3%
Density dependent reproduction	No
Specified age distribution	No

Using these adjusted mortality values, we then performed a second sensitivity analysis in which the initial population size was varied across the full range of available estimates. This allowed us to assess the immediate risk of extinction while accounting for the wide confidence intervals associated with current population size estimates. We tested the impact of harvesting individuals from the Danube Delta population and the viability of the new population. First, we translocated 20 individuals (50:50 sex ratio) for three years (Scenario A; Table 8). Then, we tested the impact of the supplementation of captive bred individuals to the newly established population by supplementing 4 (B), 8 (C), 12 (D) and 16 (E) individuals (50:50 sex ratio) for five consecutive years after the translocations were completed. We set the percent survival of translocation at 68% based on recent monitoring of reintroduced European mink in Spain (Gomez, 2024). See settings in Table 9.

Table 8 Input parameters used for the translocation and supplementation of individuals to a new population. *50:50 sex ratios.

Variable	Danube Delta	Carpathians
Initial population size	488	0
Carrying capacity	2500	1000
Individuals harvested per year*	20	NA
Harvest years	5,6,7	NA
Individuals supplemented per year*	4,8,12,16	NA
Supplement years	NA	8,9,10,11,12
Survival of translocated individuals	NA	68%

Table 9 Summary of reintroduction strategies.

	Harvest	Supplementation
Scenario A	20 x 3 = 60 individuals	None
Scenario B	20 x 3 = 60 individuals	4 individuals for 5 years – 20 individuals
Scenario C	20 x 3 = 60 individuals	8 individuals for 5 years – 40 individuals
Scenario D	20 x 3 = 60 individuals	12 individuals for 5 years – 60 individuals
Scenario E	20 x 3 = 60 individuals	16 individuals for 5 years – 80 individuals

Results

Sensitivity Analyses

Figure 15 highlights the impact of different mortality rates on population size. The sensitivity test suggested that a juvenile mortality rate of 64% along with an adult mortality rate of 40% would result in a relatively stable European mink population when using an initial population size of 488.

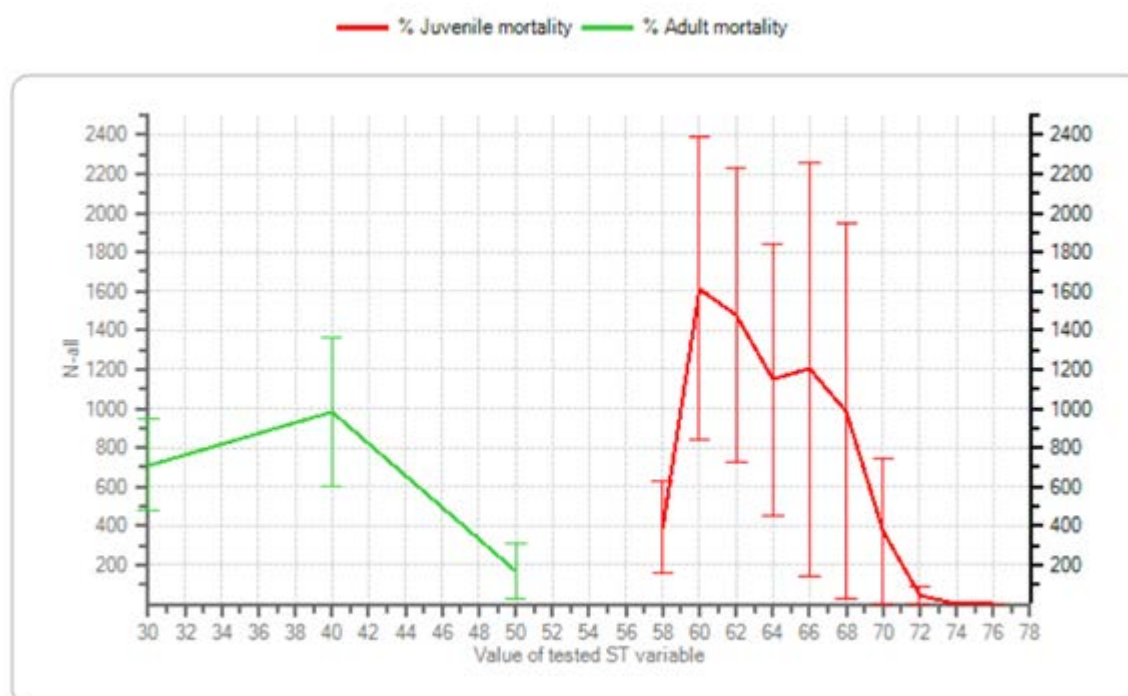


Figure 15 Sensitivity test highlighting the impact of different levels of juvenile and adult mortality rate on population size.

The mortality rates mentioned were used against multiple initial population sizes. The probability of survival after 100 years is above 0.8 with a population close to 400 individuals and above 0.95 with a population of 1,000 individuals. Population size remained stable over time with different initial population sizes except for the highest initial values which stabilised below 2,000 individuals at the end of the simulations (Figure 16).

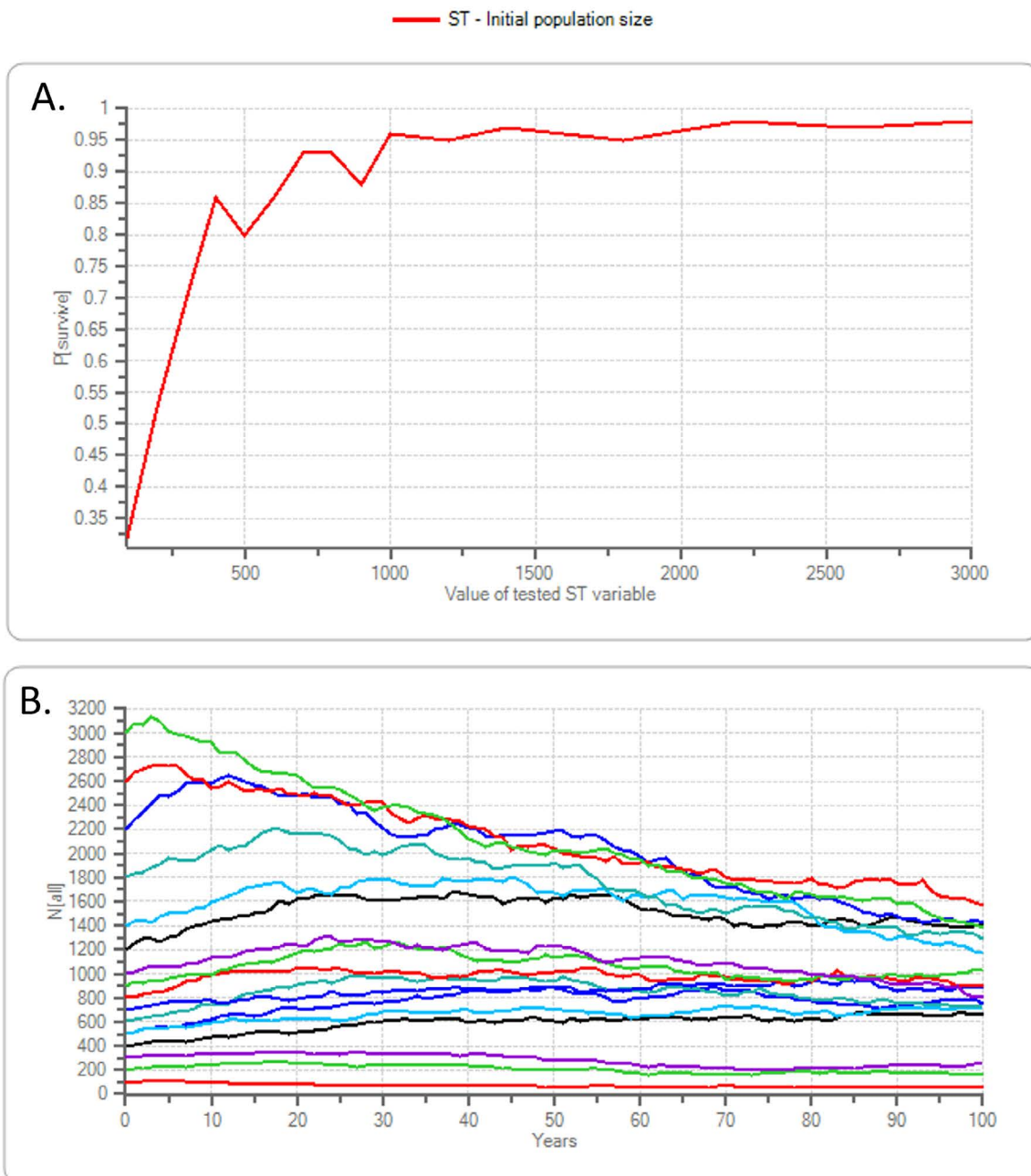


Figure 16 **A** Sensitivity test results highlighting the probability of survival against different initial population sizes and **B** Examples of population trends from the sensitivity test using different initial population sizes (Y axis).

Harvesting and Translocations

The impact of harvesting on the Danube Delta population was relatively low. A small decline in the population was observed, but the probability of survival remained close to 0.95 after 50 years with and without harvesting individuals (Figure 17).

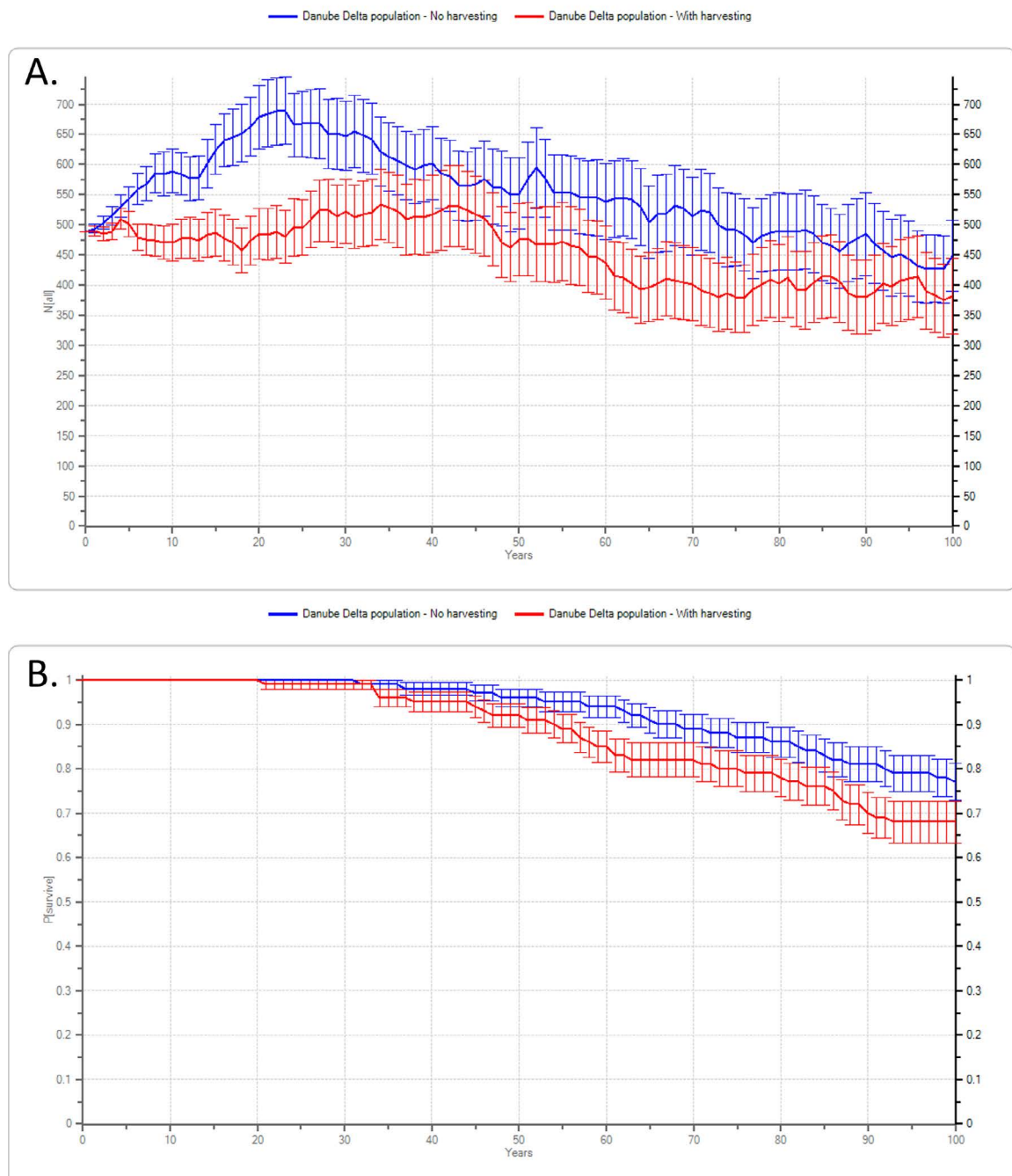


Figure 17 **A** Population trend **B** The probability of survival of the Danube Delta population with and without individuals harvested.

Under each reintroduction scenario, the newly established populations would decline and stabilise approximately 20 years after the translocations. The population stabilised around 100 individuals in scenario E, 60 in scenario D and below 50 for other scenarios (Figure 18A; Table 10). The probability of survival of the new translocated population with no supplementation and with four individuals added each year was below 0.5 after 50 years. This would increase to 0.61 in scenario C and 0.74 with 12 individuals supplemented (scenario D) and 0.75 in scenario E (Figure 18B; Table 10). However, the probability of survival for each scenario is below 0.5 over a 100-year period.

— Carpati population - Harvest only
 — Carpati population - Supplementation of 4 individuals per year
 — Carpati population - Supplementation of 8 individuals per year
— Carpati population - Supplementation of 12 individuals per year
 — Carpati population - Supplementation of 16 individuals per year

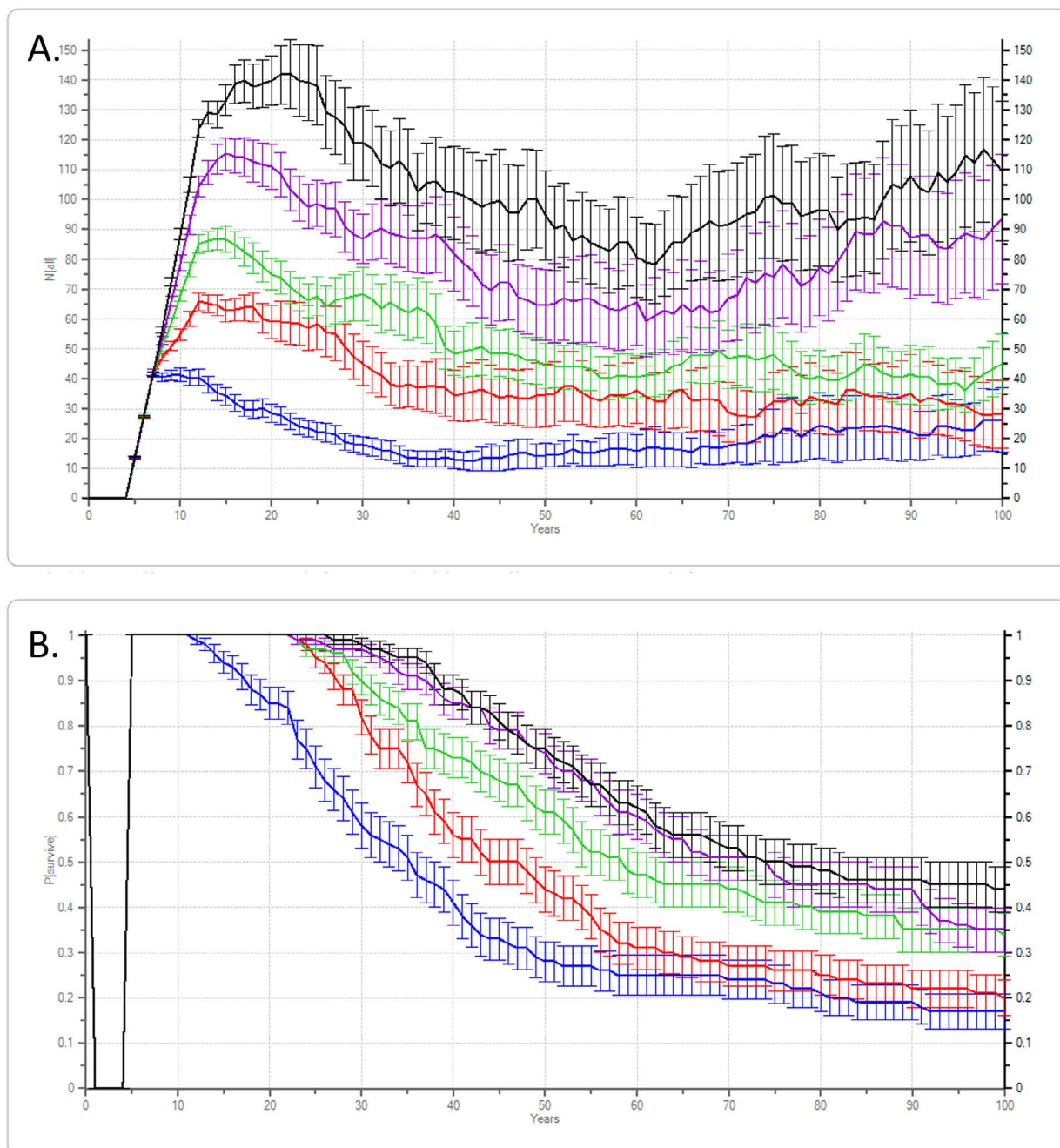


Figure 18 **A** Population trends **B** The probability of survival of the newly reintroduced population under different reintroduction scenarios.

Table 10 Mean population size and probability of survival of the reintroduced population after 50 years under different scenarios.

	Harvest only (A)	Harvest+ 20 individuals supplemented (B)	Harvest+ 40 individuals supplemented (C)	Harvest+ 60 individuals supplemented (D)	Harvest+ 80 individuals supplemented (E)
N	14.55	34.58	44.39	64.63	94.64
p	0.28	0.44	0.61	0.74	0.75

Discussion

The restoration of European mink populations presents multiple challenges. Identifying suitable source populations is one of the key limitations when considering reintroductions, translocations or population reinforcements. Today, wild populations are so small and isolated that translocations are rarely considered. Captive populations are very small and concerns over outbreeding reduces the availability of individuals for Romania to the Central/Eastern European haplotypes only. Today, most efforts tend to be focused on the reinforcement of wild populations at risk (eg, France and Spain) as opposed to reintroductions to their former range.

Little is known about the success of the few reintroductions of European mink. The two cases in Hiiumaa (Estonia) and Germany do not provide clear information on the feasibility of reintroducing the species. Indeed, the first releases of European mink on the island sanctuary of Hiiumaa (Estonia) took place in 2000. Up to 60 individuals have been supplemented most years from 2000 to 2015 (Maran *et al.*, 2017b). Initial releases resulted in very rapid and high mortality rates. On the other hand, still very little is known about the success of the reintroductions in Germany. Of the 48 individuals released in Saarland over the first two years of the programme (75 releases in three years), 29% of individuals died after 12 months (Maran *et al.*, 2016). The scale, extent and context of these releases do not provide sufficient evidence on the efficacy of reintroductions based solely on captive breeding.

Here, we propose a hybrid approach for the reintroduction of European mink in the Romanian Carpathians in the hope that a balance can be found between the risks of both captive breeding and the translocation of wild European mink. However, these models should be viewed as an exploratory tool rather than a precise predictor, given the large uncertainties in life history, survival rates, and baseline population size.

Firstly, our results suggest that the Danube Delta population would not be impacted severely by the removal of a relatively small number of individuals for translocations. Our models suggest the removal of 60 individuals over three consecutive years would only slightly affect the population and the probability of survival was similar with and without any harvesting and remained higher than 90% after 50 years.

The ‘harvest only’ approach, however, does not offer an effective approach as, in our simulations, a translocated population of 60 founders had a low probability of survival (0.28). However, increasing the number of individuals harvested from the Danube Delta would then impact the viability of the harvested population. Supplementing the founder population with captive-bred individuals following translocations had a beneficial impact on the population size and survival of the reintroduced population. A minimum of 60 individuals would need to be released to increase the probability of survival to 0.74 and increasing the number of releases would have a beneficial impact on the average population size. A higher probability of survival would be preferable using this approach; however, this could be due to imprecision in life history traits and can be improved by increasing the number of captive-bred releases.

The proposed hybrid approach has multiple advantages. A high number of individuals can be released rapidly before having captive-breeding facilities in place and translocated wild caught individuals will probably have a higher survival rate than captive-bred animals. A hybrid approach would place less pressure on the small captive population but there would be the possibility to continue the release of individuals after reaching initial targets if captive breeding is successful.

The captive breeding of European mink is particularly costly, time-consuming and complex, but multiple programmes have successfully been set up. However, this is the first time that wild to wild translocations have been suggested for the species. The impact that harvesting will have on the Danube Delta population is considered to be the main risk of this approach as a decline in numbers or genetic diversity of this population could be catastrophic for the species. Therefore, it is essential to ensure that the population size is sufficiently large to sustain the harvests. Monitoring of the population before and after each harvest year will be critical to ensure the population can sustain additional harvests. The strategy may also have to be adapted by capturing individuals every other year if monitoring suggests that the population is more impacted than predicted.

There is a risk that uncertainty regarding the biological data used in the PVAs could result in misleading conclusions, as there is very little information on the life history traits of the species. The sensitivity test showed that small differences in adult and juvenile survival rates can have a severe impact on the survival of populations. In addition, the survival of released individuals has varied a lot since first releases approximately 25 years ago, but we used latest survival estimates which were relatively high as these were thought to be due to improvements in release strategies. Finally, and crucially, there are large uncertainties around the current Danube Delta population size. We strongly suggest that translocations should not be advised if a more robust estimate suggests the population is any lower than the estimate of 488 used in this study.

To summarise, the PVAs presented here, despite their limitations, provide evidence that a hybrid approach combining the translocation of 60 individuals from the Danube Delta and the release of at least 60 captive-bred individuals should result in a viable population. While this method has multiple advantages, it is critical to ensure that it would not impact the survival of the Danube Delta population. It is also reliant on being able to trap many more animals per year than are routinely trapped in years when trapping has been conducted, so would require considerable more effort and resources than has been available for the surveillance trapping conducted to date.

The disadvantages of a hybrid approach are that it is complex, as it would need to focus both on trapping and translocating wild individuals alongside developing a captive breeding programme in Romania. The costs of this in infrastructure and staff would be substantial. Nonetheless the advantages would be that a higher number of individuals could be released relatively quickly, therefore increasing the likelihood of population establishment at the reintroduction sites. The use of a combination of wild caught animals and captive bred means that there is less pressure on either source (wild or captive) and the potential for captive bred animals to integrate with and learn from the wild caught population. This may improve survival rates.



6 Genetic Considerations



Research on the genetic diversity of European mink across its remaining wild populations show strong population structuring, consistently identifying three primary extant populations. Northeastern Europe (NE), Southeastern Europe (SE) and Western Europe (WE). These form genetically distinct, but not deeply phylogeographically separated clusters (Table 11).

Table 11 Summary from published literature of key genetic parameters for European mink populations.

Region/ Population Group	Sample Size (mtDNA sequences)	Nucleotide Diversity (π)	Haplotype Diversity (h)	Number of Haplotypes	Reference
Northeastern Europe (Russia, Belarus, Estonia)	ca. 89–176	$\pi \approx 0.012\text{--}0.0134$	$h \approx 0.939\text{--}0.98$	8–13 (multiple private)	Michaux <i>et al.</i> , 2005; Cabria <i>et al.</i> , 2015; Korablev <i>et al.</i> , 2003 (Korablev <i>et al.</i>)
Southeastern Europe (Romania, Danube Delta)	ca. 54	$\pi \approx 0.0012\text{--}0.0019$	$h \approx 0.352\text{--}0.469$	4	Cabria <i>et al.</i> , 2015; Michaux <i>et al.</i> , 2005
Western Europe (France (Aquitaine), Spain (Navarre))	ca. 170 total (76+94 etc.)	$\pi \approx 0$ (single haplotype)/as low as ~ 0.00024	$h \approx 0$ (or up to 0.981 in mitogenome study)	1 (traditional mtDNA); ~ 5 in mitogenome study	Michaux <i>et al.</i> , 2005; Skorupski <i>et al.</i> , 2024

The Northeast population (NE) shows the highest diversity among the three. Studies by Michaux *et al.* (2005) and Cabria *et al.* (2015) analysed the mitochondrial DNA (mtDNA) control region (~ 614 bp), finding high nucleotide diversity ($\pi \approx 0.012$) and haplotype diversity ($h \approx 0.94$), with 8–13 haplotypes, many of them private to NE populations. The same studies found lower diversity in Romania ($\pi \approx 0.0012\text{--}0.0019$, $h \approx 0.35\text{--}0.47$) and around four haplotypes in total. Michaux *et al.* (2005) reported only a single haplotype in all sampled western animals ($\pi \approx 0$; $h \approx 0$). However, more recent full mitogenome sequencing revealed slightly higher haplotype diversity in Western (French-Spanish) individuals ($\pi \approx 0.00024$; $h \approx 0.9810$) across ~ 5 mitogenomic haplotypes, suggesting previously undetected diversity within that region (Skorupski *et al.* 2024). This highlights that genetic diversity estimates are sensitive to sample size, suggesting that broader sampling is likely to uncover additional haplotypes and alleles.

Bayesian clustering analysis groups extant European mink populations into two main genetic units or haplogroups. One unit consists of the Russian, Romanian and German (conservation breeding stock) animals while the other contains the French and Spanish populations (Skorupski *et al.* 2024; Cabria *et al.* 2015). However, results suggest that separation of the two is relatively recent and that they were historically connected throughout most of their evolutionary history. The same microsatellite alleles are found within all groups and their current isolation is likely a result of the drastic population decline that occurred during the previous two centuries (Cabria *et al.* 2015).

Genetic Status of the Danube Delta European Mink Population

The Danube Delta (SE) population exhibits moderate Mitochondrial DNA (mtDNA) diversity, with nucleotide diversity (π) around 0.0019 ± 0.0015 and haplotype diversity (h) approximately 0.35 ± 0.01 , based on a 614 bp fragment from the *cytb* and control regions. Around 75% of haplotypes in this group are unique to the region. Analysis of 11 polymorphic loci reveals heterozygosity levels (H_e) of approximately 0.47-0.48, and allelic richness intermediate between NE and W populations.

Clustering methods support the Danube Delta population as a distinct genetic cluster within Eastern Europe, albeit without deep phylogeographical separation from NE populations (Skorupski *et al.*, 2024).

Key Implications are that the Danube Delta population possesses sufficient genetic variation to support potential translocation initiatives, if carefully monitored and managed. However, its moderate diversity and signs of recent bottlenecks mean that removal of individuals for reintroduction must be carefully monitored to avoid eroding genetic resilience. Limiting interpopulation translocation (ie, between the NE and SE or captive populations) may be preferable in the first instance to prevent potential outbreeding depression and erosion of local adaptations (Skorupski *et al.*, 2024). Certainly, the potential risk of outbreeding depression needs to be further investigated and assessed (Skorupski 2020).

However, a key conservation concern is whether European mink populations with relatively limited genetic diversity can persist over the long term. Research on other wildlife shows that both conservation initiatives and species survival can succeed even when founder populations have low genetic variation. In the short term, survival is likely to be influenced more by environmental pressures such as disease and habitat loss, but in the long term, genetic diversity, particularly at disease resistance genes, becomes more critical. Species with reduced genetic variation face higher extinction risks than those with greater variability. Given that the European mink is already under intense environmental pressure from habitat degradation, pollution, and the introduction of Aleutian disease, its best prospects for long-term survival lie in maximising genetic diversity, especially through captive breeding and reintroduction programmes, alongside continued efforts to protect and restore habitats.

It has been suggested that to return to the historical optimum of the species, European mink populations should be managed as a single management unit, with steps taken to promote gene flow among the fragmented existing populations. This will counteract inbreeding depression and preserve evolutionary potential. Therefore, enhancing genetic connectivity, either through managed gene flow with NE populations or via integration with captive breeding programmes, may be advisable for long-term viability.

7 Socioeconomic and Cultural Factors



The European mink is one of the most endangered carnivores in Europe, now surviving only in fragmented populations. Its reintroduction to suitable areas of western Romania offers a unique opportunity to restore a species of both ecological and cultural significance. However, the long-term success of such a programme depends not only on ecological feasibility, but also on careful assessment of the socioeconomic and cultural landscape into which the species will be reintroduced. This section outlines the key human dimensions that must be understood and integrated into project planning.

Human Communities and Land Use Patterns

Western Romania is a region where rural livelihoods remain closely tied to natural resources. Key land use activities include the following.

- **Agriculture** Mixed crop-livestock farming, with riparian zones often used for grazing or hay production
- **Fisheries** Both commercial and subsistence fishing in rivers, lakes, and floodplain wetlands
- **Forestry** Management of riparian woodlands for timber, fuelwood, and non-timber forest products

Understanding the spatial overlap between mink habitat and areas of human economic activity is essential. Reintroductions must consider potential competition with, or perceived impacts on, these livelihoods, particularly in relation to fisheries.

Perceptions, Attitudes and Awareness

Public knowledge of the European mink is likely to be extremely low, with the species often confused with the non-native American mink, which is present in parts of Romania and associated with predation on waterbirds and fish. Misidentification could lead to unintended persecution of reintroduced animals.

Pre-release work should therefore assess local awareness of the European mink's conservation status and the degree of recognition of its differences from American mink as well as increasing knowledge and awareness and promoting positive cultural attitudes towards small carnivores and predators more generally.

This could be achieved through structured interviews, focus groups, and participatory mapping workshops.

Potential Sources of Conflict

Even though the European mink's diet is broad, its predation on fish and aquatic birds may be perceived negatively by commercial, recreational and subsistence fishers, poultry keepers and hunters. Key potential conflicts include the following.

- **Fisheries impacts:** Concerns about loss of stocked fish or reduced catches
- **Poultry predation:** Fear of mink attacking domestic fowl kept near water bodies
- **Perceived competition:** Concerns from trappers or hunters over impacts on fur-bearing or game species

Conflict risk mapping, overlaying mink habitat models with resource-use maps, can help prioritise areas for proactive engagement and mitigation measures.

Stakeholder Identification and Engagement

Stakeholders in western Romania are diverse and include:

- Local communities and landowners
- Fishing cooperatives and angler associations
- Conservation NGOs and academic institutions
- Water and land management authorities
- Regional tourism operators

Early engagement has focused on discussions with some of these groups and should continue to build trust, clarifying future project aims, and explore co-benefits.

Economic Opportunities and Incentives

Well-managed reintroductions can bring socio-economic benefits, which should be explored and communicated. These may include:

- **Ecotourism:** Wildlife tourism focused on riverine and wetland biodiversity can provide income streams for local businesses
- **Branding and local products:** Associating local produce or experiences with the ‘return’ of a lost species can enhance regional identity
- **Conservation employment:** Field monitoring, habitat management, and eco-guiding can create jobs for local residents

The potential for such benefits will depend on accessibility, infrastructure, and tourism demand in the target area.

Cultural Heritage and Identity

Although the European mink may not have as prominent a cultural profile as larger carnivores, small mustelids have featured in local folklore and oral traditions. Research into historical place names, proverbs, and stories may uncover cultural connections that can be used in outreach. Aligning the recovery of the species with regional pride in natural heritage can strengthen public support.

Education and Outreach Strategies

Effective communication is critical for building acceptance. Priority actions include developing clear, accessible materials explaining the difference between European and American mink; highlighting the species’ endangered status and its role in healthy wetland ecosystems and working with schools, local media and community events to normalise the species’ presence before reintroductions take place.

Conclusion

A European mink reintroduction will succeed only if ecological planning is matched by a thorough understanding of local livelihoods, values, and governance. By integrating socioeconomic and cultural assessments from the earliest stages and maintaining open, participatory engagement throughout, the project can build the trust, ownership, and shared benefits needed for the species to thrive once again in Romania’s wetlands.

Details of the preliminary social feasibility study undertaken by RWS during the period of this study are provided in a separate report by RWS: Sociological Analysis on the Presence/Absence of the European Mink (Mustela lutreola) in the Middle-Lower Prut River Area and the Upper Mureş River Basin.

8 Risk Assessment



This chapter outlines the key risks associated with a proposed translocation of European mink from the Danube Delta to suitable river systems in the southern Carpathians. The assessment draws on established conservation translocation frameworks, including the IUCN Guidelines for Reintroductions and Other Conservation Translocations (2013), and considers ecological, social, and political dimensions.

While translocations present significant opportunities for species recovery, careful planning is required to identify and manage risks that may compromise conservation outcomes.

Ecological Risks

The success of any reintroduction effort depends heavily on ecological conditions at both donor and recipient sites. A number of ecological risks may influence the viability of a newly established population. These are shown in Table 12.

Table 12 Ecological risks of European mink reintroduction.

Risk	Description	Potential Consequences
Habitat unsuitability or degradation	Target river systems may lack essential features such as secure denning sites, abundant prey, or suitable riparian vegetation. Environmental degradation from forestry, agriculture, or infrastructure development may further reduce habitat quality.	Low survival and reproduction; failure to establish a self-sustaining population.
Presence of American mink	The invasive American mink is a known ecological competitor. Its presence in or near release sites could threaten the success of reintroduced European mink through competition, territorial exclusion or aggression.	Reduced survival and dispersal; risk of displacement or population suppression.
High post-release mortality	Translocated individuals may be subject to predation, disorientation, starvation, or human-induced threats in the unfamiliar release environment.	High mortality in early stages; low population growth.
Disease transmission	Movement of animals between geographic regions carries the risk of introducing or spreading pathogens among donor, recipient or surrounding wildlife populations.	Morbidity or mortality in released mink or other species; reputational risk to the project.
Insufficient genetic diversity	The Danube Delta population may contain limited genetic variation. A small founder population may not carry sufficient genetic diversity to support long-term adaptation.	Inbreeding depression, reduced reproductive fitness, lower resilience to environmental changes.
Disruption of local ecosystems	Although European mink are native, their reintroduction may alter ecological balances, particularly if prey species are already under pressure or if habitat restoration has not been fully completed.	Potential negative ecological impacts; concern from local conservation stakeholders.

Mitigation measures for ecological risks should include thorough, on the ground, habitat suitability assessments, pre-release and ongoing American mink surveillance and control, soft-release strategies, veterinary screening and long-term post-release monitoring.

Social and Community Risks

Human attitudes and land-use practices strongly influence the outcomes of species reintroductions. Several social risks should be considered, as described in Table 13.

Table 13 Social and community risks of European mink reintroductions.

Risk	Description	Potential Consequences
Human-wildlife conflict	Local landowners, game managers or fishers may express concern that European mink could prey on poultry, gamebirds, or fish. Such perceptions may be based on experience with the more aggressive American mink.	Opposition to the project; potential for illegal persecution or sabotage.
Negative public perception or misinformation	Mistrust of conservation authorities, lack of awareness or confusion between native and invasive mink species could hinder local support.	Public resistance, negative media coverage, reputational risk.
Loss of trust if the project fails	If the reintroduction fails or is perceived to have caused unintended consequences, this may erode trust in future conservation efforts.	Long-term damage to institutional credibility and public willingness to support biodiversity projects.

These risks highlight the need for an inclusive and proactive stakeholder engagement strategy, including clear communication, community involvement and education on the ecological role and conservation status of European mink.

Political and Regulatory Risks

Conservation translocations require coordination with governmental agencies, adherence to regulatory frameworks, and stable institutional support. Key political and regulatory risks are shown in Table 14.

Table 14 Political and regulatory risks of European mink reintroductions.

Risk	Description	Potential Consequences
Regulatory or legal delays	Permits are required for trapping, transporting, releasing and monitoring protected species. Delays may occur due to complex legal processes or inter-agency coordination issues.	Postponement or cancellation of translocation activities.
Lack of long-term institutional commitment	Successful reintroduction projects require multi-year funding and sustained coordination. Limited institutional support beyond initial funding phases can jeopardise success.	Insufficient capacity for follow-up monitoring and adaptive management.
Conflicts with land-use policies	Forestry operations, infrastructure development or hydropower interests may overlap with proposed release areas.	Habitat degradation or fragmentation, reduced habitat suitability over time.

To manage these risks, early and continuous dialogue with authorities and land-use stakeholders is essential, along with securing clear policy alignment and multi-year financial commitments.

Summary and Recommendations for Mitigation

While there are multiple ecological, social, and political risks associated with the translocation of European mink, many of these are predictable and manageable (detailed in Table15). Provided that these risk factors are addressed during planning and implementation, the potential benefits of reintroduction are likely to outweigh the associated risks.

Table 15 Risk Assessment Matrix: European mink translocation.

Risk	Description	Likelihood	Impact	Risk rating	Mitigation measures
Competition with American mink	If present, American mink may outcompete European mink and undermine establishment.	Medium	High	High	Conduct full American mink surveys; implement local control/eradication before release. Ongoing post-release monitoring.
Low genetic diversity in source population	Limited gene pool in Danube Delta could reduce fitness of founding population.	High	Medium	High	Genetic screening prior to selection; consider supplementing with captive-bred individuals.
Disease transmission	Risk of pathogens being spread between donor and recipient sites or to released individuals.	Low	High	Medium	Implement veterinary screening, quarantine, and post-release health checks.
Inadequate habitat quality	Degraded or fragmented riparian zones may not support viable mink territories.	Medium	High	High	Use habitat suitability modelling; conduct restoration in advance where needed. Avoid sites with high anthropogenic disturbance.
Conflict with local stakeholders	Fishers, landowners, or tourism operators may oppose the project.	Medium	Medium	Medium	Early and ongoing stakeholder engagement, including local education and compensation schemes if necessary.
Regulatory or legal barriers	Delays or complications in obtaining permits for capture, translocation, or release.	Low	Medium	Low	Early liaison with authorities and legal experts; align with national and EU conservation goals.
High post-release mortality	Genetic screening prior to selection; consider supplementing with captive-bred individuals.	Medium	High	High	Soft-release strategies (eg, pre-release acclimatisation); close post-release monitoring and adaptive management.
Public backlash or misinformation	Negative media or local opinion could damage project credibility	Low	Medium	Low	Transparent communication plan with media engagement, community workshops, and clear messaging.
Climate-related vulnerability	Long-term viability of river systems could be affected by climate change (eg, drought).	Medium	Medium	Medium	Prioritise climate-resilient river catchments; include climate change in long-term habitat assessments.

Risk Rating Key

Likelihood Low / Medium / High

Impact Low / Medium / High

Risk Rating Based on combination of Likelihood × Impact

Table 16 shows progress so far against some of these mitigation measures

Table 16 Progress so far against mitigation measures for risks identified.

Mitigation measure	Completed	In progress	To be commenced
Detailed pre-release ecological and habitat assessments in the field	✓		
Invasive species monitoring and control (especially American mink)		✓	
Veterinary health protocols and quarantine			✓
Community engagement and public education		✓	
Transparent communication and cross-sector collaboration		✓	
Long-term monitoring and adaptive management			✓



9 Legal and Institutional Framework



EU Legislation Relevant to European Mink Reintroduction

Habitats Directive (Council Directive 92/43/EEC)

On Annex II & IV, European mink is listed as a priority species, meaning Member States must ensure its strict protection and designate Special Areas of Conservation (SACs). Article 12 prohibits killing, disturbance, capture, or destruction of habitats for Annex IV species. Therefore, any translocation or reintroduction must be justified and will require derogation. However, Article 16 provides for derogations (exceptions) under strict conditions, including for reasons of public interest or species conservation.

EU Biodiversity Strategy 2030

This supports species recovery and includes funding mechanisms for species restoration, such as the EU LIFE Programme and Nature Restoration Law (pending final approval). The Strategy promotes reintroductions as a tool to reverse biodiversity loss under targets for species recovery.

Regulation (EU) 1143/2014 on Invasive Alien Species

This is relevant because of interactions with American mink which threatens European mink and therefore requires management of an invasive alien species before and throughout any reintroductions.

Relevant Romanian National Legislation

Emergency Government Ordinance (OUG) No. 57/2007

This is the main biodiversity law in Romania which transposes the EU Habitats Directive into national law. It specifies European mink as a strictly protected species, requiring permits for any handling, movement, or release.

Law No. 49/2011 (Approval of OUG 57/2007)

This legislation strengthens enforcement and clarifies protected species management. It establishes the need for environmental impact assessment (EIA) for reintroductions in protected areas.

Ministerial Orders (eg, Order No. 410/2008)

These set rules on species translocations and reintroductions. They require a scientific justification, risk assessment, genetic assessment, and feasibility study. Permits must be issued before any introduction or movement.

Animal Welfare Legislation

Law No. 205/2004 on Animal Protection

Ensures humane treatment during transport, handling, and release of captive animals.

10 Conclusion



The European mink is among Europe's most threatened mammals, having undergone a severe decline in population size and range over the last century. In Romania, the Danube Delta supports the country's only confirmed extant wild population, a single, isolated group of moderate genetic diversity. While this population remains viable, its isolation leaves it acutely vulnerable to stochastic threats such as disease outbreaks, extreme weather events, environmental pollution and the impacts of climate change.

Creating additional, self-sustaining populations would reduce extinction risk by providing demographic and geographic resilience, while also contributing to Romania's commitments under the EU Habitats Directive and the EU Biodiversity Strategy for 2030. Habitat modelling confirms the presence of extensive, well-connected riparian habitat in parts of the southern Carpathians, particularly along the Mureş River, offering opportunities for reintroduction within the species' historical range. However, connectivity is locally constrained by habitat gaps, infrastructure, and road networks. These factors must be addressed in site selection and mitigation planning.

The main threats to the species (habitat loss and degradation, historical over-exploitation, and competition from invasive American mink) remain significant but are locally manageable. Experience from other European mink reintroductions demonstrates that American mink control, where they are present, is an essential pre-condition for success. In addition, habitat suitability must be rigorously assessed in candidate release areas, with particular attention to long-term functional connectivity.

Population Viability Analysis (PVA) results indicate that a 'harvest-only' (wild to wild) translocation from the Danube Delta would yield low survival probability for reintroduced populations if limited to relatively small founder sizes (c. 60). A hybrid strategy, combining a limited harvest of wild individuals from the Danube Delta with supplementary releases from a captive breeding programme, offers a more promising pathway. Modelling suggests that removing 60 individuals over three years is unlikely to compromise the source population's viability, provided that removals are coupled with robust, ongoing monitoring. However, this result needs to be caveated with the considerable uncertainties highlighted below. Supplementation with captive-bred animals substantially improves reintroduction success probability and long-term population size.

Despite these positive projections, important uncertainties remain in demographic parameters, survival rates and the true Danube Delta population size. The available evidence suggests a current population of approximately 500 individuals, but this estimate carries wide confidence intervals due to limited survey coverage and low detection rates. Improvements in survey methodology, such as including camera trapping and non-invasive genetic sampling, are needed to refine these estimates before any harvesting is undertaken.

Socioeconomic and cultural considerations are also critical. Local awareness of the European mink, its distinction from the invasive American mink and its ecological value is likely to be low. Fisheries interests, in particular, may perceive the species as a competitor. Effective community engagement, clear communication, and demonstration of potential socio-economic benefits (eg, eco-tourism) will be essential for building support and reducing conflict risk.

Overall, reintroduction to suitable areas of the southern Carpathians represents a viable and strategically important conservation action for European mink, but success depends on meeting strict ecological, genetic, and social prerequisites.

11 Recommendations



Based on the results of the work carried out for this feasibility study, we recommend the following next steps:

1 Source population monitoring and management

- Use capture-mark-recapture combined with one or more non-invasive method (eg, camera trapping, hair tubes, environmental DNA) to improve detection probability and effective population size estimates ensuring coverage of diverse habitats and multiple seasons.
- Set a precautionary threshold: reconsider the feasibility of removals if improved population estimates are below current PVA baseline (~500 individuals).
- Maintain and monitor the Danube Delta population before, during, and after any harvesting to ensure no significant decline in size or genetic diversity.

2 Pre-reintroduction ecological actions

- Conduct targeted American mink monitoring and control (where required) in and around proposed release sites, eg, using cameras and mink rafts (monitoring) and deploying cage traps where American mink are detected (control).
- Complete detailed habitat suitability and connectivity assessments at fine spatial scales at release sites.
- Address connectivity barriers along the Mureş River and monitor the impact of road crossings.
- Implement mitigation measures for road mortality risk, particularly in high-crossing density areas such as Hodac.
- Establish baseline biodiversity monitoring to evaluate ecological impacts of reintroduction.

3 Captive breeding programme

- Expand or establish Romanian-based capacity for captive breeding of European mink to reduce reliance on wild harvests.
- Integrate genetic management to maximise diversity and minimise inbreeding depression.
- Consider managed gene flow with other European populations to bolster adaptive potential.

4 Reintroduction strategy

- Adopt a hybrid release model:
- Translocate up to 60 wild individuals from the Danube Delta over three years (once steps 1 and 2 satisfactorily completed).
- Supplement annually with captive-bred animals to increase founder numbers and genetic diversity.
- Prioritise release timing and techniques shown to maximise post-release survival (eg, soft-release enclosures, pre-release acclimatisation).
- Plan for adaptive management: adjust harvest and release rates in response to real-time monitoring feedback.

5 Socioeconomic and cultural engagement

- Undertake a full social feasibility study to assess local perceptions, awareness, and potential conflict points, particularly with fisheries.
- Develop clear, accessible materials for targeted education and outreach campaigns explaining the species' endangered status, ecological role, and differences from American mink.
- Involve local communities, land managers and relevant authorities in project planning and early implementation to build ownership and trust.
- Explore opportunities for eco-tourism and other nature-based economic benefits linked to European mink recovery.
- Work with fishing communities to address concerns about potential conflicts, backed by evidence and dialogue.

6 Long-term monitoring and evaluation

- Implement a standardised, multi-year post-release monitoring protocol, combining population surveys, genetic sampling, and health assessments.
- Measure success against predefined biological and social indicators (eg, population growth rate, range expansion, community support).
- Publish results to contribute to broader European mink conservation knowledge and best practice.

7 Research and adaptive management

- Data Improvement — Invest in long-term population studies to refine demographic parameters, improve PVA reliability, and track genetic diversity.
- Adaptive Framework — Embed decision points within the project to allow changes to harvest rates, release numbers, and threat management in response to monitoring data.
- Long-term Vision — Integrate reintroduced populations into a broader European metapopulation framework, facilitating gene flow between regions to counteract inbreeding and maintain evolutionary potential.

In summary, the ecological potential, combined with Romania's remaining high-quality riparian habitats, provides a rare and urgent opportunity to expand the range of the European mink. By coupling ecological feasibility with strong social engagement, rigorous monitoring, and adaptive management, reintroduction into the southern Carpathians could significantly reduce extinction risk and contribute to the recovery of the species across Europe.



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