

Risk assessment template developed under the "Study on Invasive Alien Species – Development of risk assessments to tackle priority species and enhance prevention"
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Name of organism: *Neogale vison* (Schreber, 1777)

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¹ This template is based on the Great Britain non-native species risk assessment scheme (GBNNRA). A number of amendments have been introduced to ensure compliance with Regulation (EU) 1143/2014 on IAS and relevant legislation, including the Delegated Regulation (EU) 2018/968 of 30 April 2018, supplementing Regulation (EU) No 1143/2014 of the European Parliament and of the Council with regard to risk assessments in relation to invasive alien species (see <https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32018R0968>).

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SECTION A – Organism Information and Screening

A1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?

including the following elements:

- the taxonomic family, order and class to which the species belongs;
- the scientific name and author of the species, as well as a list of the most common synonym names;
- names used in commerce (if any)
- a list of the most common subspecies, lower taxa, varieties, breeds or hybrids

As a general rule, one risk assessment should be developed for a single species. However, there may be cases where it may be justified to develop one risk assessment covering more than one species (e.g. species belonging to the same genus with comparable or identical features and impact). It shall be clearly stated if the risk assessment covers more than one species, or if it excludes or only includes certain subspecies, lower taxa, hybrids, varieties or breeds (and if so, which subspecies, lower taxa, hybrids, varieties or breeds). Any such choice must be properly justified.

Response:

This Risk Assessment concerns the American mink *Neogale vison* (Schreber, 1777). It is a single taxonomic entity. The American mink belongs in the Class Mammalia, Order Carnivora, and Family Mustelidae. It is described in the genus *Mustela*; previously placed in the genus *Neovison* by Abramov (2000), but currently placed in the genus *Neogale* by Patterson et al. (2021), based on genetic (Harding and Smith 2009, Hassanin et al. 2021) and biogeographical data. Synonyms (both of which are used extensively in the recent scientific literature) are *Mustela vison* (Schreber, 1777) and *Neovison vison* (Schreber, 1777).

Common names are as follows: American mink (EN); американска норка (BG), Amerikanischer mink, Amerikanischer nerz (DE); minken, Amerikansk mink (DK); mink ehk ameerika naarits (EE); visón americano (ES); minkki (FI); vison d'Amérique (FR); Američka vidrica (HR); Amerikai nyérc (HU); visone americano (IT); Amerikas ūdele, arī nercs (LV); Amerikaanse nerts (NL); wizon Amerykański, norka Amerykańska, wizon (PL); vison-Americano (PT); nurca Americană sau vizonul (RO); mink (SE).

Wozencraft (2005) lists 15 recognised subspecies of American mink: *N. v. vison*, *N. v. aestuarina*, *N. v. aniakensis*, *N. v. energumenos*, *N. v. evagor*, *N. v. evergladensis*, *N. v. ingens*, *N. v. lacustris*, *N. v. letifera*, *N. v. lowii*, *N. v. lutensis*, *N. v. melampeplus*, *N. v. mink*, *N. v. nesolestes*, *N. v. vulgivaga*. There is some disagreement regarding the validity of all purported subspecies: for example, amongst the four Florida subspecies (Florida Fish and Wildlife Conservation Commission 2012), Humphrey and Setzer (1989) consider *N. v. evergladensis* (the Everglades mink) to be a disjunct population of *N. v. mink* (the common mink), whilst other authors consider *N. v. halilimnetes* (the Gulf salt marsh mink, described as a new species in 1989) to be a disjunct population of *N. v. lutensis* (the Atlantic salt marsh mink, Trani and Chapman 2007). There are also several different colour variants from

selective breeding in mink farms (from pure white to almost black). All subspecies and all colour variants are included in this assessment.

American mink will mate with European mink *Mustela lutreola* in captivity, but the embryos are usually reabsorbed and do not develop further (Ternovsky and Ternovskaya 1994, Amstislavsky et al. 2008). There is no evidence of copulation between the two mink species in the wild (Harrington and Maran 2025, both mink species belong to different genera) and therefore hybrids are not considered here.

A2. Provide information on the existence of other species that look very similar [that may be detected in the risk assessment area, either in the environment, in confinement or associated with a pathway of introduction]

Include both native and non-native species that could be confused with the species being assessed, including the following elements:

- other alien species with similar invasive characteristics, to be avoided as substitute species (in this case preparing a risk assessment for more than one species together may be considered);
- other alien species without similar invasive characteristics, potential substitute species;
- native species, potential misidentification and mis-targeting

Response:

Three native species in the risk assessment area - European mink, European polecat (*Mustela putorius*) and steppe polecat (*Mustela eversmanii*) - are morphologically similar, and similar in size, but American mink can be adequately distinguished from those species on the basis of facial markings. European mink have a white margin around their upper and lower lips, whereas American mink only have a lower white lip (both mink species may have white markings on their throat and chest) (Harrington and Maran 2025). Both species of polecat have a distinct facial 'mask' with an apparently darker band across their eyes and paler fur around their muzzle, above their eyes and on their ears (mink are uniformly dark and their ears are dark like the rest of their face and bodies) (Harrington and Maran 2025).

American mink also differ from European mink in cranial shape (but not size) and overall body size. Relative to American mink, European mink have a shorter facial region with a rounder forehead and wider orbits, a longer neurocranium with less developed crests and processes, and an antero-medially placed tympanic bullae with an anteriorly expanded cranial border (Gálvez-López et al. 2022). American mink tend to be larger than the European mink, (Sidorovich et al. 1999), but given considerable variation across the non-native range, body size is not a reliable distinguishing feature in the field.

Feral domestic ferrets (*Mustela putorius furo*) usually resemble polecats in facial markings and so can be distinguished from American mink in the same way. Occasionally, American mink recently escaped/released from fur farms are pale in coloration and these individuals may be difficult to distinguish from pale or albino feral domestic ferrets, but both are rare in established populations the wild.

A3. Does a relevant earlier risk assessment exist? Give details of any previous risk assessment, including the final scores and its validity in relation to the risk assessment area.

Response:

Bouros et al. (2016) provided a risk assessment for the EU28, concluding that the American mink poses a high risk (with high confidence). They summarize: *“A large number of scientific publications demonstrate the invasiveness of the American mink and its very high ecological impact (the species is the main cause of decline or extinction of several threatened species). The main risk for establishment comes from mink farms.”* Most of the information and data provided are still valid for the current risk assessment for the EU27, except for changes in the distribution, the number of mink farms and the transmission of SARS-CoV-2. This risk assessment is largely based on Bouros et al. (2016), with additional details and updates provided where relevant. Several countries within the risk assessment area have produced national-level risk assessments.

The most recent national-level risk assessment was for Poland where maximum impact on predation, competition, and the transfer of pathogens and parasites was supported with high confidence (Zalewski et al. 2018). Although the authors classified the overall impact of the species as “intermediate” they attributed this to the species small direct impact on humans and lack of impact on crops (due to the ecology of the species) but also stressed that some changes (e.g cascade effects) remain underexplored and thus that an increase in the overall assessment should be considered.

The impact assessment for Germany concluded that American mink is an invasive species, based on competition with, and predation on, native species (Nehring et al. 2015). Because of the wide distribution in the country it was assigned to the “Management List”, which means that *“Measures against such species should be aimed to minimise/mitigate the negative impact in e.g. protected areas, nature reserves or safeguard endangered native species.”* (Nehring et al. 2015).

The Belgian risk assessment for American mink concludes that *“the presence of breeding farms and holding by pet owners represent a high risk for future establishment in the wild as mink are reported to escape easily from captivity”* and that *“there is high confidence that establishment of feral populations of American mink in Belgium and neighbouring areas will contribute to the decline of native [species] because of predation”* (Branquart 2013).

In the Netherlands, a risk assessment was published by the Dutch Mammal Society in 2012, commissioned by the Netherlands Food and Consumer Product Safety Authority (Ministry of Economic Affairs), Team Invasive Exotics (Dekker 2012). Dekker (2012) reports that most by-catches of mink during muskrat control were close to fur farms, and that *“the largest distance between an observation and the nearest farm was 45 km”*. The impact assessment, performed with the Invasive Species Ecological Impact Assessment (ISEIA) protocol (Branquart 2007) concludes that the American mink in the Netherlands falls into the “watch list” category based on a high score for impact on native species, the colonisation of high conservation value habitat, and high dispersal potential.

All national-level risk assessments are still valid in their respective countries.

A4. Where is the organism native?

including the following elements:

- an indication of the continent or part of a continent, climatic zone and habitat where the species is naturally occurring
- if applicable, indicate whether the species could naturally spread into the risk assessment area

Response:

The species is native to North America: its natural range extends from Alaska and Canada through most of the United States, except Arizona and the dry parts of California, Nevada, Utah, New Mexico and western Texas (Reid et al. 2016).

It is a highly resilient opportunistic species, which can easily adapt to a variety of aquatic habitats, e.g. rivers, streams, channels, lakes, freshwater and saltwater wetlands or marshes, coastal areas and archipelagos (Dunstone 1993). In its native range, it is found across different climatic zones (arctic to sub-tropical) from the Yukon river in Alaska (8 miles north of the Arctic circle, Rausch 1953) to the Everglades and Big Cypress Swamp region in Florida (Humphrey 1992, Humphrey and Setzer 1989). The species can also be found in dry habitats if food is abundant (Arnold and Fritzell 1990) and occasionally in suburban settings (Department of Environmental Conservation, New York State, dec.ny.gov, accessed 28.09.2023).

The American mink cannot naturally spread from its native range into the risk assessment area.

A5. What is the global non-native distribution of the organism outside the risk assessment area?

Response:

Outside the risk assessment area, within Europe, the species is widespread (potential extent of occurrence estimated at > 50% of the total country area) in Iceland, Norway, and the UK (Vada et al. 2023) and in Belarus where it is present in every stream and in most waterbodies (pers. comm. V. Sidorovich, 13.11.2023). It is also present in Ukraine (where it is believed to be widespread in the forest and forest-steppe zone, Hegyeli and Kecskés 2014) and the centre of European (Western) Russia (the Caspian-Baltic watershed, Vada et al. 2023). This information, and responses to Qu. A6 and A8, are based on a recent assessment of the European distribution of American mink in Europe by Vada et al. (2023). The assessment summarises the existing scientific literature and databases available from across 32 European countries (original references are given in Vada et al. 2023); the information presented here has been cross-referenced and supplemented with additional original literature and personal communication with national experts where necessary. One mink record (based on the presence of tracks) was recorded in eastern Albania, in the upper Devoll river in 2011 (a region where there are no mink farms, Galanaki and Kominos 2022), there is also a single mink record from Serbia (from the River Danube, Hegyeli and Kecskés 2014, Vada et al. 2023). The American mink is not yet recorded from Switzerland (BAFU 2022).

In Asia, the species is established on Hokkaido, in northern Japan (Shimatani et al. 2010), in northern and northwest Mongolia (Saveljev et al. 2014, Lebedev et al. 2016), and Northeast China (Chen et al. 2023). There is little detailed information from the Russian Federation as a whole, but a distribution map published by Khlyap et al. (2011) suggests that the species occurs across most of the country from the west to the Far East and is absent only from some of the northern regions. Evidence of southward spread in this region is evidenced by recent records in the territory of the Uvs Nuur Hollow north of Mongolia (Oleinikov 2013, Saveljev et al. 2015).

Beyond Eurasia, the species is established in the south of South America. It is widespread in Argentina (including throughout most of the Tierra del Fuego Archipelago; Fasola and Valenzuela 2014) and Chile (including Chiloe Island, Navarino Island, and the Los Chonos archipelago; Crego et al. 2018, Suárez-Villota et al. 2023, Vergara and Valenzuela 2015). The species is thought to occur in almost all Chilean water bodies and islands between latitudes 38° and 55° S (Mora et al. 2018) and it was estimated that its expansion covered an area of 450 thousand km² of Argentina Patagonia (Fasola and Valenzuela 2014). The species has also (since 2010) been recorded in Uruguay (Laufer et al. 2022).

A6. In which biogeographic region(s) or marine subregion(s) in the risk assessment area has the species been recorded and where is it established? The information needs be given separately for recorded (including casual or transient occurrences) and established occurrences. “Established” means the process of an alien species successfully producing viable offspring with the likelihood of continued survival².

A6a. Recorded: List regions

A6b. Established: List regions

Comment on the sources of information on which the response is based and discuss any uncertainty in the response.

For delimitation of EU biogeographical regions please refer to <https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2> (see also Annex VI).

For delimitation of EU marine regions and subregions consider the Marine Strategy Framework Directive areas; please refer to <https://www.eea.europa.eu/data-and-maps/data/msfd-regions-and-subregions/technical-document/pdf> (see also Annex VI).

Response (6a):

The species has been recorded in Alpine, Atlantic, Boreal, Continental, Mediterranean, Pannonian and Steppic biogeographic regions (see Qu A8a). The absence of records of American mink in Hungary reported in Vada et al. (2023) suggests that the species has limited presence (if any) in the Pannonian region. Presence in the Mediterranean varies among countries (Vada et al. 2023), being extensive in Spain (Pödra and Gómez 2018) but relatively more localised in Italy (Mori and Mazza 2019) and Greece (Galanaki and Kominos 2022).

Across biogeographic regions, the species is found at altitudes ranging from 0 to 1500 m asl (e.g. Roesler et al. 2012), and has been recorded as high as 1700 m asl on Vourinos Mt in Kozani in northern Greece (Galanaki and Kominos 2022).

² Convention on Biological Diversity, Decision VI/23

Response (6b):

The species is established in Alpine, Atlantic, Boreal, Continental, Mediterranean and Steppic biogeographic regions (see Qu A8b).

A7. In which biogeographic region(s) or marine subregion(s) in the risk assessment area could the species establish in the future under current climate and under foreseeable climate change? The information needs be given separately for current climate and under foreseeable climate change conditions.

A7a. Current climate: List regions

A7b. Future climate: List regions

With regard to EU biogeographic and marine (sub)regions, see above.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5)
- what aspects of climate change are most likely to affect the risk assessment (e.g. increase in average winter temperature, increase in drought periods)

The assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

Response (7a):

Annex VIII provides a species distribution model (SDM) based on the accessible distributional data for the species. The model suggests that all biogeographic regions from the risk assessment area are suitable (Alpine, Atlantic, Black Sea, Boreal, Continental, Mediterranean, Pannonian, Steppic). The lowest suitability was found for the Steppic and the Mediterranean region, which was still very high (>0.75). (Note that Annex VIII also considers the Anatolian, Arctic and Macaronesian regions, which fall outside the scope of this question.)

Response (7b):

As derived from the SDM, climate change is expected to have no effect on suitability within most of the biogeographic regions in the risk assessment area (Annex VIII, climate change scenarios RCP 2.6, 4.5 and 8.5) (Alpine, Atlantic, Black Sea, Boreal, Continental, Mediterranean, Pannonian, Steppic). A gradual decrease in suitability is discernable (with increasing severity of the scenarios) for the Mediterranean and the Steppic regions, where especially parts of the Mediterranean become unsuitable under RCP 8.5 (<0.25).

A8. In which EU Member States has the species been recorded and in which EU Member States has it established? List them with an indication of the timeline of observations. The information needs be given separately for recorded and established

occurrences.

A8a. Recorded: List Member States

A8b. Established: List Member States

The description of the invasion history of the species shall include information on countries invaded and an indication of the timeline of the first observations, establishment and spread.

Response (8a):

The species has been recorded in 23 EU Member States: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy (including Sardinia), Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden (Macdonald and Harrington 2003, Bonesi and Palazón 2007, Dekker and Hofmeester 2014, Hegyeli and Kecskés 2014, Vada et al. 2023).

Note that in the case of Hungary, Bonesi and Palazón (2007) reported occasional sightings in winter in the area of Gödöllő, east of Budapest, whereas the ‘absence’ report in Vada et al. (2023) pertains to the period since 2013. Hegyeli and Kecskés (2014) also refer to ‘scattered’ observations of mink in Hungary.

The species has not been observed in Slovenia (Vada et al. 2023) and is not present in Croatia (Ministry of Economy and Sustainable Development 2023, <https://invazivnevrste.haop.hr/katalog>, accessed 28.09.2023) or in Cyprus (Margarita Hadjistylli, pers. comm., 16.11.2023).

There is no information on American mink in Malta.

Response (8b):

The species is considered to be established in 18 EU Member States: Austria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Poland, Portugal, Romania, Slovakia, Spain, Sweden (Macdonald and Harrington 2003, Bonesi and Palazón 2007, Roy et al. 2009, Zalewski et al. 2010, Hegyeli and Kecskés 2014, MAGRAMA 2014, Rodrigues et al. 2015, Vada et al. 2023). The species is locally abundant in Austria and Lithuania (Birnbaum 2013), in France (as of 2018) it occurred in three discrete but continually expanding populations in the south, west, and southwest (DREAL 2021), and in Greece its distribution is currently localized (Galanaki and Kominos 2022). In most other Member States where the species is established it is common or very common (Birnbaum 2013) and the most recent assessment of the species occurrence in Europe reported it to be widespread (potential extent of occurrence estimated at > 50% of the total country area) in Germany, Ireland, Latvia, Lithuania, Poland, Spain and Sweden (Vada et al. 2023 and references therein).

The species is not yet considered to be established in Bulgaria, but the number of mink observed in the wild has increased and evidence of young animals and litters suggests that they are reproducing (Koshev 2019). A two-year study using camera traps also shows that American mink, which have been regularly observed in the areas around the fur farms, demonstrate signs of adaptation and establishment (Nikova et al. 2023). Similarly, despite numerous escapes from fur farms and successful reproduction being reported (Adriaens et al. 2015), the species never established in Belgium (Van den Berge 2008, Van den Berge and

Gouw 2009). Currently there is a rapid response mechanism in place for any mink reported in the wild and fur farming was phased out.

In the Netherlands, there have been a very limited number of documented cases of reproduction in the wild (Dekker 2012, J. Dekker pers. comm. 08.11.2023) but this is an exception amongst most countries within the risk assessment area. Failure to establish in the Netherlands is attributed to the prevalence of systematic and intensive muskrat trapping in the country (Dekker 2012). The American mink is now considered to have been almost totally removed from the country, with only a handful of observations in 2023 (La Haye 2022, Glenn Lelieveld, pers. comm. 13.09.2023, J. Dekker, pers. comm. 06.11.2023).

In Luxembourg, a single individual mink was reported in the wild in 1993 and in 2013 a single dead animal was recorded but there is no evidence of an established population in the country (Bonesi and Palazón 2007, Vada et al. 2023).

The species was introduced to northern Europe (for fur farming) in the 1920s and 1930s (e.g. 1926 in France, 1928 in Poland) and was intentionally released into the wild in European Russia for harvesting in the 1930s and 1940s; modern intensive fur farming in Europe started in the 1950s (Birnbäum 2013) and has since expanded to southern European countries (e.g. Italy in the 1950s, Mori and Mazza 2019; Greece in 1972, Galanaki and Kominos 2022).

The following country-specific timelines are from Bonesi and Palazón (2007), unless otherwise stated. In Austria, American mink were first recorded in the wild in the 1980s and established small populations from the 1990s (north of the Danube in Lower and Upper Austria, along the Danube Lowlands, south of the Danube, and in south-eastern Styria and neighbouring province of Burgenland). In the Czech Republic, mink populations have been established in the wild since at least the 1960s (when they were first recorded in the wild), occurrence increased from 5% to 27% through the 1990s, and the population in 2007 was still expanding. Mink were first recorded in the wild in the 1940s in Denmark. The population of mink in Denmark was relatively low until the 1980s but increased eight-fold by the millennium; in recent decades, the Danish feral mink population has decreased, but mink are still widely distributed across the country (Rørbæk et al. 2023). In Estonia, the species began to establish in the country in approximately 1940, by the 1980s it was found across the entire south and west of the country, and through the 2000s it continued to spread in the north and east (Maran 2003). In Finland, mink were first recorded in the country in the 1930s and were widespread by the early 1990s (with the highest densities recorded in the east, Kauhala 1996). In France, feral American mink populations have been expanding since the 1960s (when they were first recorded in the wild); initially (by the 1990s) they established populations in Brittany but by the 2000s two additional populations centres had established in the central-west and the south-west (Bressan et al. 2022). In Germany the species was first observed in the wild in 1955, after which it spread rapidly through the northeast (Zschille et al. 2014). Mink are now widespread in several regions in Germany (Vada et al. 2023). In Greece, American mink have been established in the Ramsar wetland Lake Mikri Prespa since the late 1990s (no naturalised populations were documented prior to this, Galanaki and Kominos 2022); feral mink populations are now well established (but patchily distributed) in northwest Greece (in Kozani, Kastoria, Florina, and Grevena, Galanaki and Kominos 2022). There is recent (2020) evidence of reproduction in Kastoria; mink have also been recorded in central Greece in the Region of Thessaly (Trikala Prefecture) and in the Region of Central Macedonia (Pella and Imathia Prefectures) in the north, and one feral mink was found in Viotia (Dervenochoria) (also in central Greece) in 2020 (Galanaki and Kominos 2022). It is likely that mink are also present in North Macedonia (Galanaki and Kominos 2022). The

species was first confirmed to have escaped from fur farms in Ireland (in Co. Tyrone) in 1961 (Deane and Gorman 1969; although Smal [1988] refers to the possibility that mink had been present in the wild in Co. Donegal as early as 1956). By the end of the 1960s there were 31 records of mink sighted, trapped or shot in the wild, and their distribution continued to spread through the 1970s (Small 1988); the species is now widespread and well established in Ireland (Roy et al. 2009). Feral populations have been present in the northeast of Italy (from Friuli Venezia-Giulia to Veneto and Trentino Alto-Adige) since the 1970s, in central Italy (at the borders between Tuscany and Emilia-Romagna regions, near the northernmost part of the Apennine ridge) since the 1990s (Bonesi et al. 2013), and more recently in Lazio and Sardinia; individual animals in southern Lombardy seem not to have established (Dettori et al. 2016, Mori and Mazza 2019). In Sardinia and in central Italy, the species range is expanding, and in the latter kits have been observed although the population is still considered to be isolated and probably small (Mori et al. 2022). Mink were first recorded in Latvia and Lithuania in the 1940s and 1950s, respectively, and feral populations were widespread in both by the early 1990s. In Poland, mink have been present in the wild at least since the 1960s, by the 1990s they had colonised half the country, by 2016 75% of the country, and expansion (as of 2019) was still on-going (Skorupski 2015, Brzeziński et al. 2019). The first records (before 1980–1985) of the species were from a few locations in the north, but almost the entire lowland part of the country was colonised by 2000 (Brzeziński et al. 2019). The American mink was first reported in Portugal in 1985 on the River Minho on the border between northwest Portugal and Galicia, Spain; range expansion in Portugal appeared to be slow initially but by the 2010s mink were thought to be present in all hydrographic basins in the northwest region (Rodrigues et al. 2015). The species is reportedly common in the plain areas of Transcarpathia, a region bordering Romania and Hungary but there is little information about the presence of the species in Romania otherwise: Hegyeli and Kecskés (2014) suggest that recent (2000s) records of mink along the River Mures in Transylvania might indicate an established wild-living population, and unconfirmed sightings of the species elsewhere suggest that it might be present in other river basins in the Carpathians and Transylvannia Plateau. There are also isolated records of individual mink in the vicinity of the Danube Delta (first published in 2002, including the Ukrainian part of the delta, Hegyeli and Kecskés 2014), but no American mink were trapped or observed during a 2000 and 2011 survey in the Danube Delta Biosphere Reserve (Marinov et al. 2012). Thirteen records of American mink in Braşov County, Transylvania (in central Romania), between 2015 and 2017, were reported by Ionescu et al. (2019) but it is unclear whether these were individual animals or members of an established population. Mink were first recorded in the wild in Slovakia in the 1950s, predominantly in the central part of Slovakia. A study of the behaviour of American mink in nine localities in the Záhorie region, in western Slovakia, between 2016 and 2020, suggests that mink are now established in the wild (Poláčková et al. 2022). In Spain, mink were first recorded in the wild in the 1970s, the first wild feral populations of American mink were formed in the 1980s and since then a continuous expansion in their range has been observed: between 1985 and 2012 the distribution area of the species increased by 17 times, and by 2012, a quarter of continental Spain was occupied (Pödra and Gómez 2018). Mink were first recorded in the wild in Sweden at the end of the 1920s; their populations in the wild then followed a pattern of logistic growth from the late 1930s to the late 1970s, tripling in the early 1980s followed by a decline (Carlsson et al. 2010); currently they remain widespread.

In summary, in almost every country to which the species was introduced (for fur farming), it was observed in the wild within a few years of introduction (Dunstone 1993, Bevanger and Henriksen 1995, Bonesi and Palazón 2007, see Qu. B1.3a). Over the last 15 years, the species has continued to spread across the European continent and to increase its geographic range such that it now ranges across the entire continent and is reported in almost all EU Member

States (Vada et al. 2023). Confirmed mink-free areas are scarce and small. Compared to records provided by Bonesi and Palazón (2007), the species distribution has remained constant in 13 countries, increased in 10 countries, and decreased only in Portugal (Vada et al. 2023).

A9. In which EU Member States could the species establish in the future under current climate and under foreseeable climate change? The information needs be given separately for current climate and under foreseeable climate change conditions.

A9a. Current climate: List Member States

A9b. Future climate: List Member States

With regard to EU Member States, see above.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5)
- what aspects of climate change are most likely to affect the risk assessment (e.g. increase in average winter temperature, increase in drought periods)

The assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

Response (9a): Under current climate conditions, the species could establish in the future in all Member States where the species has been recorded (Qu. A8a). Inferred by projecting the species' worldwide distribution to the risk assessment area, a species distribution model (SDM, Annex VIII) attains high suitability (>0.85) for all Member States except for Cyprus (0.12) and Malta (0.00).

Response (9b): As derived from the SDM, climate change is expected to have no effect on suitability within most of the Member States in the risk assessment area (Annex VIII, climate change scenarios RCP 2.6, 4.5 and 8.5). For some of the Mediterranean Member States (Greece, Italy, Portugal, Spain), a gradual decrease in suitability is discernable (with increasing severity of the scenarios). Given the adaptability of the species, and the suitability of ecoclimatic zones across the risk assessment area (Qu. A7), establishment, in the future, in Member States where the species has not yet been recorded or is considered absent (Hungary, Slovenia, Croatia), or not yet established, is also possible.

A10. Is the organism known to be invasive (i.e. to threaten or adversely impact upon biodiversity and related ecosystem services) anywhere outside the risk assessment area?

Response:

The American mink is known to be invasive in several countries outside the risk assessment area where it is present: Belarus, European Russia, Iceland, Norway, UK, Argentina, and Chile.

The American mink is associated with a number of serious ecological problems in its non-native range (outside the risk assessment area), resulting from predation on, and competition with, native fauna. For example, the Global Invasive Species Database (2023) shows impacts on a total of 46 Red List assessed species. In most of Eastern Europe the American mink out-competed and displaced the Critically Endangered European mink (Maran 2007, Sidorovich 2011). In Iceland the species had negative impacts on several ground-nesting bird species (Atlantic puffin *Fratercula arctica*, black guillemot *Cepphus grille*, common eider *Somateria mollissima*, horned grebe *Podiceps auratus*, and water rail *Rallus aquaticus*, Stefánsson et al. 2016 and references therein) and in both Iceland and Norway the species may have had negative impacts on Arctic charr *Salvelinus alpinus* in small streams (Stefánsson et al. 2016 and references therein). In Norway the species has been reported to have negative effects on sea bird colonies (common eider and puffins) and riverine trout *Salmo trutta* (The Norwegian Directorate for Nature Management 2011 and references therein). In the UK, American mink is one of the main factors involved in the near extinction of the water vole *Arvicola terrestris*, and is responsible for the loss of colonies of ground-nesting sea birds on the coast of Scotland (common terns, *Sterna hirundo*, black-headed gulls, *Larus ridibundus*, and common gulls, *L. canus*, Fraser et al. 2017 and references therein). In Argentina, American mink have spread to remote plateau lakes where they predate Critically Endangered hooded grebes *Podiceps gallardoi* (Roesler et al. 2012). In addition, at least 12 of the 25 waterfowl species observed in the plateau lakes are sensitive to the presence of the mink, either being absent or having a lower abundance where mink are present: the great grebe *Podiceps major*, speckled teal *Anas flavirostris*, Chiloe wigeon *Anas sibilatrix* and red-gartered coot *Fulica armillata* were more abundant on water bodies without mink, flocks of the ashy-headed goose *Chloephaga poliocephala* were larger in areas without mink, and other species, such as the white-tufted grebe *Rollandia rolland*, coscoroba swan *Coscoroba coscoroba*, black-necked swan *Cygnus melanocoryphus*, cinnamon teal *Anas cyanoptera*, Andean duck *Oxyura ferruginea* and Andean gull *Larus serranus* were never observed in areas harbouring mink (Peris et al. 2009). Flightless steamer duck *Tachyeres pteneres* and upland goose *Chloephaga picta* nest survival have been severely reduced by mink predation on Navarino Island, Chile (Schüttler et al. 2009). In Argentina and Chile, introduced mink can also represent a health threat as a vector in parvovirus transmission between domestic pets and the Endangered native river otter *Lontra provocax* (Barros et al. 2022, Medina-Vogel et al. 2022). There are no data available to assess the impact of the species in Ukraine but there are serious concerns regarding its potential impact on severely depleted populations of the European mink (Volokh and Rozhenko 2011).

A11. In which biogeographic region(s) or marine subregion(s) in the risk assessment area has the species shown signs of invasiveness? Indicate the area endangered by the organism as detailed as possible.

Comment on the sources of information on which the response is based and discuss any uncertainty in the response.

For delimitation of EU biogeographical regions please refer to <https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2> (see also Annex VI).

For delimitation of EU marine regions and subregions consider the Marine Strategy Framework Directive areas; please refer to <https://www.eea.europa.eu/data-and-maps/data/msfd-regions-and-subregions/technical-document/pdf> (see also Annex VI).

Response:

The species has shown signs of invasiveness in the following biogeographic regions in the risk assessment area: Alpine, Atlantic, Boreal, Continental, and Mediterranean.

Details of the magnitude of impact on biodiversity, outside and within the risk assessment area, are provided in section B4.

A12. In which EU Member States has the species shown signs of invasiveness? Indicate the area endangered by the organism as detailed as possible.

Response:

There is direct evidence that the species is invasive in more than half of the EU Member States in which it has become established: Czech Republic (Sálek et al. 2005, Fischer et al. 2009), Estonia (Maran et al. 1998), Finland (Nordström et al. 2002, Banks et al. 2004, 2008, Ahola et al. 2006), France (DREAL et al. 2021), Greece, Ireland, Latvia, Lithuania, Poland (Brzeziński et al. 2012), Spain (Pödra et al. 2013, Zuberogoitia et al. 2013, Santulli et al. 2014, García et al. 2020), Sweden (see also Bonesi and Palazón 2007). Member States that are not included in this list (Austria, Denmark, Germany, Italy, Portugal, Romania, Slovakia) are omitted because data or specific studies on the impacts of the species within the Member State itself are lacking, but this does not imply that the species is not invasive in that Member State. The species could also become invasive in areas not yet colonized in these Member States (e.g., southern Portugal – Rodrigues et al. 2015) or in Member States where it currently is not established or absent (e.g. Bulgaria, Belgium). Based on current evidence, signs of the species' invasiveness are widespread across EU Member States within their invaded range.

Details of the impact of the species, and the magnitude of impacts on biodiversity, outside and within the risk assessment area, are provided in section B4.

A13. Describe any known socio-economic benefits of the organism.

Including the following elements:

- Description of known uses for the species, including a list and description of known uses in the risk assessment area and third countries, if relevant.
- Description of social and economic benefits deriving from those uses, including a description of the environmental, social and economic relevance of each of those uses and an indication of associated beneficiaries, quantitatively and/or qualitatively depending on what information is available.

If the information available is not sufficient to provide a description of those benefits for the entire risk assessment area, qualitative data or different case studies from across the risk assessment area or third countries shall be used, if available.

Response:

Eleven of the 27 EU Member States currently (as of 2023) produce mink skins (Bulgaria, Denmark, Finland, Greece, Latvia, Lithuania, Poland, Romania, Slovakia, Spain, Sweden). Mink skins are also produced in China and Russia (both major producers), and to a lesser extent in Belarus, Ukraine, Norway, and Iceland (FiFur 2023). The largest fur producers

within the risk assessment area are currently Poland, Greece, Lithuania, Finland, and Spain with annual production of mink skins (as of 2022) at 3.4, 1.4, 1.16, 0.5, and 0.45 million skins respectively; other Member States (Latvia, Romania, Sweden) with active mink fur farms produced between 225,000 and 360,000 skins in 2022, and some (Bulgaria, Slovakia) produced <100,000 (FiFur 2023; summarized in Table 1 with annual production for 2019 [pre-covid] provided for comparison). Denmark produced no furs in 2022 (due to the loss of its breeding stock during the covid pandemic; all farm mink were culled in 2020) although previously in 2020 they produced over five million (and over 17 million in 2018, FiFur 2023). Poland is currently the largest mink pelt producing country globally (FiFur 2023). Across Europe as a whole, the total number of operating mink farms in 2022 was ca. 1,000 (this represents a decline since 2015 when there were > 5,000 mink farms across Europe). Total annual mink production within the risk assessment area in 2022 was 7.6 million pelts (also reduced from > 40 million in 2015; www.fureurope.eu, www.furfreealliance.org). According to auction sale reports in February/March 2024 from Copenhagen Fur (www.kopenhagenfur.com/auction/) and SAGA furs (www.sagafurs.com/auction/), the average mink pelt price ranges between 17 and 82 Euros depending on the type (overall average for February 2024 reported by Copenhagen Fur = 37.1 Euros). The “top” prices reported per type were 20 – 174 Euros at Copenhagen Fur and 27 – 128 Euros, or up to 750 Euros for female “brown velvet” pelts, at SAGA furs. SAGA furs do not provide auction sale prices on their website from before 2022; for comparison, Copenhagen Fur report average prices of between 32 and 103 (overall average 55.9 Euros) for the 2015 auction at the same time of year (February).

Table 1. Annual mink skin production in member states in 2019 and 2022 (representing the most recent figures available, and comparable figures for the year before the covid pandemic – the latter is included for comparison because there were widespread closures of mink farms in several countries during the pandemic; it is not known whether production levels will increase to former levels). Data are from FiFur (2023).

Member State	2019	2022
Poland	5,750,000	3,400,000
Greece	1,200,000	1,400,000
Lithuania	1,234,000	1,160,000
Finland	1,000,000	500, 000
Spain	550,000	450,000
Latvia	455,000	360,000
Romania	100,000	225,000
Sweden	500,000	225,000
Bulgaria	120,000	90,000
‘Other’ (inc. Slovakia)	<4,000,000	<50,000
Denmark	12,150,000	0

Ireland and the Netherlands not included because mink farming is no longer permitted there (they produced 85,000 and 4,000,000 skins, respectively, in 2019)

In Poland, the majority of farms are located in two provinces: West Pomeranian and Greater Poland (Firlej et al. 2018, Iwanski et al. 2018). As of 2023, there are 166 active mink fur farms in Poland (Mathur 2023), compared with 1,130 in 2016 (Firlej et al. 2018). Industry development in Poland was largely due to investment by Dutch companies and North American agencies in the late 2000s (Iwanski et al. 2018). Firlej et al. (2018) reported that mink fur farms in 2016 (producing 8.5 million mink pelts, more than twice production in

2022) exported > 90% of their production at a value of 300 million euros and employed a total of 10,000 people. There are no published reports detailing the socio-economic importance of the industry in Poland at 2022-2023 production levels. A study carried out by ZOBSiE (financed by Open Cages, Fur Free Alliance and the Albert Schweitzer Foundation for Our Contemporaries) reports high turnover rate amongst employees on fur farms, argues that the industry has not had a positive impact on the labour market, and presents questionnaire survey results suggesting that local communities are not supportive of fur farming (Iwański et al. 2018).

In Greece, the number of mink farms fell to 92 in 2020 from 131 in 2018 (Tagaris 2022). The farms are located primarily in Western Macedonia (mostly in the Prefectures of Kastoria and Kozani) in the northwestern part of Greece (Semos et al. 2021, 2023). Fur garments are among Greece's top 10 exports (Tagaris 2022) but exports have been declining over recent years: exports to Russia (the primary market for Greek furs) were valued at 14 million euros in 2021, down from 55 million euros in 2017, and, as of March 2022, exports to Russia (and selling to Russian tourists in Greece) is banned under EU trade sanctions against Russia over the Ukrainian war (Tagaris 2022). The Kastorian Fur Association states that in the town of Kastoria alone the fur industry provides 60% of the 35,000 inhabitants with jobs, and there are over 2,000 companies in the area dependent on the fur industry; however, these figures include the breeding sector and the processing sector, which produces ready-to-wear garments (Gomez 2021). Fur garments are also produced from other animal species, with fur imported from foreign countries (Semos et al. 2021). The Greek fur industry buys 5-7% of world fur production and distributes 8-10% of ready-made garments (Semos et al. 2023) but the breeding sector itself (as a livestock activity) is supported by the Greek state via subsidies and other initiatives (Semos 2016).

In Finland, fur farms are concentrated in the west, primarily in the Ostrobothnia region. As of 2021, there were ca. 600 fur farms producing pelts with a net export value of 126 million euros (0.2% of total net export revenue for Finland) (Vinnari 2023, FiFur 2023). The following information is from a report by Animalia, Finland (Vinnari 2023): the Finnish fur farming sector directly employed 826 people in 2020, but this figure includes self-employed and seasonal workers, collectively, Finnish fur farms, Saga Furs Oyj, and the feed mills employ between 1,100 and 1,200 people, and fur farming is estimated to provide the primary source of income for approximately 200 entrepreneurs.

In Spain, the two mink farms previously within the Spanish European mink range in the north (Regional Government of Gipuzkoa province) are now closed (Madinabeitia 2021); some others are situated nearby (MAGRAMA 2014). These existing farms are permitted to continue production but building new American mink farms was prohibited in 2016 (under Royal Decree 1628/201). Spanish mink farms in 2022 produced ca. 450,000 mink pelts per year (FiFur 2023).

Fur production across Europe is also under considerable pressure from animal welfare groups: over the past two decades, 22 European countries (of which 16 are EU Member States) have either voted to ban the practice, prohibited the farming of particular species, or have introduced stricter regulations that have effectively curtailed the practice (furfreealliance.com, accessed 01.10.2023). Three Member States that currently produce mink skins (Latvia, Lithuania, Slovakia) have committed to phasing out mink farming by 2028, 2027, and 2025, respectively, and two (Poland, Romania) are currently undergoing parliamentary debate regarding the future of fur farming in their country (furfreealliance.com, accessed 01.10.2023). In Bulgaria, in 2022, the Ministry of Environment and Water issued a ban on

breeding of American mink, in response to numerous cases of escaped individuals from fur farms and the potential threat to biodiversity. However, the ban was appealed by the fur farm owners and is still not effective (BTA 2023). Changes in the legislation to ban the breeding of animals for fur production has been proposed to the Bulgarian Parliament for consideration. Several major luxury fashion companies (including, amongst others, Gucci, Calvin Klein, Ralph Lauren, Burberry, Michel Kors) have also moved away from using fur (Cernansky 2021), and fur has been banned from fashion weeks in Copenhagen, Amsterdam, and Helsinki (Sachdeva, 2022). There is currently a European Citizens' Initiative, 'Fur Free Europe', calling for an EU-wide ban on the keeping and killing of fur animals, that was debated in the European Parliament in October 2023 (Rojek 2023) and will be responded on by the end of 2023.

In addition, during the global Covid-19 pandemic in 2020 and 2021, detection of American mink on farms infected with the SARS-CoV-2 virus (the causative agent of Covid-19; see Qu B4.14), led to mass culls of mink on farms in the Netherlands, Denmark and Spain (e.g. World Health Organisation 2020, Hansen 2021). In the Netherlands, already planned out-phasing of fur farms was brought forward due to the SARS-CoV-2 related cull of the total stock, and farms were not re-opened (La Haye 2022). Further culls were undertaken in Spain and Finland on farms where mink were found to be infected with highly pathogenic avian influenza (H5N1) (Agüero et al. 2023, Lindh et al. 2023). In Finland, the Finnish Food Authority inspected all fur farms for avian influenza in autumn 2023; a total of 124,000 mink were culled (Finnish Food Authority,

<https://www.ruokavirasto.fi/teemat/lintuinfluenssa/#lintuinfluenssa-turkistarhoilla>).

Consequently, the number of countries involved in the production of mink fur, the number of farms, the number of skins produced, and the overall value of the fur industry across Europe (and globally, e.g. United States Department of Agriculture (USDA) 2023) has declined significantly in recent years.

Some countries (e.g. Denmark) are planning on resuming fur farming post-covid (Humane Society International 2022). Specifically, after a two-year ban, Denmark announced mink farming would be allowed again from January 2023. Recent news articles (The Animal Reader 2023) report that 2,000 mink were imported from Iceland to create a new breeding population (Iceland itself produced 83,000 mink pelts in 2022, FiFur 2023) and refer to plans to import further animals. However, only around 1% of Danish fur farmers (14 out of more than 1,200 mink farm companies prior to the culls) applied for State Aid to re-start business if the temporary ban was lifted (Humane Society International 2022).

Hunting/trapping of American mink may provide some benefit in countries in east and north Europe (within and outside the risk assessment area). In northwest Mongolia, indigenous people hunt American mink; their skins sell for up to 30,000 tugriks (equivalent to approx. 8 euros, as of 02.03.2023) and are mostly exported to China (Saveljev et al. 2014). The yearly hunting bag in Finland is ca 35,000 (2021) - 80,000 (2001) individuals (Finnish Game and Fisheries Research Institute 2014, Natural Resources Institute Finland (Luke) 2017), 38,000 in 2022 (Natural Resources Institute Finland (Luke) 2023), but the economic value of the catch is small. Nowadays, mink are trapped in the wild mostly because they are considered vermin, or to contribute towards removal efforts (e.g. Stien and Hausner 2018), not because of their fur.

SECTION B – Detailed assessment

Important instructions:

- In the case of lack of information the assessors are requested to use a standardized answer: “No information has been found.” In this case, no score and confidence should be given and the standardized “score” is N/A (not applicable).
- With regard to the scoring of the likelihood of events or the magnitude of impacts see Annexes I and II.
- With regard to the confidence levels, see Annex III.
- Highlight the selected response score and confidence level in **bold** but keep the other scores in normal text (so that the selected score is evident in the final document).

1 PROBABILITY OF INTRODUCTION AND ENTRY

Important instructions:

- **Introduction** is the movement of the species into the risk assessment area (it may be either in captive conditions and/or in the environment, depending on the relevant pathways).
- **Entry** is the release/escape/arrival in the environment, i.e. occurrence in the wild
- Introduction and entry may coincide for species entering through pathways such as “corridor” or “unaided”, but it also may differ. If different, please consider all relevant pathways, both for the introduction into the risk assessment area and the entry in the environment.
- For each described pathway, in each of the questions below, ensure that there are separate comments explicitly addressing both the “introduction” and “entry” where applicable and as appropriate. The classification of pathways developed by the Convention of Biological Diversity (CBD) should be used (see Annex IV). For detailed explanations of the CBD pathway classification scheme consult the IUCN/CEH guidance document³ and the provided key to pathways⁴.
- For organisms which are already present (recorded or established) in the risk assessment area, the likelihood of introduction and entry should be scored as “very likely” by default.
- Repeated (independent) introductions and entries at separate locations in the risk assessment area should be considered here (see Qu. 1.7).

Qu. 1.1. List relevant pathways through which the organism could be introduced into the risk assessment area and/or enter into the environment. Where possible give details about the specific origins and end points of the pathways as well as a description of any

³ <https://op.europa.eu/en/publication-detail/-/publication/f8627bbc-1f15-11eb-b57e-01aa75ed71a1>

⁴ <https://circabc.europa.eu/sd/a/0aeba7f1-c8c2-45a1-9ba3-bcb91a9f039d/TSSR-2016-010%20CBD%20pathways%20key%20full%20only.pdf>

associated commodities.

For each pathway answer questions 1.2 to 1.8 (copy and paste additional rows at the end of this section as necessary). Please attribute unique identifiers to each question if you consider more than one pathway, e.g. 1.2a, 1.3a, etc. and then 1.2b, 1.3b etc. for the next pathway.

In this context a pathway is the route or mechanism of introduction and/or entry of the species.

The description of commodities with which the introduction of the species is generally associated shall include a list and description of commodities with an indication of associated risks (e.g. the volume of trade; the likelihood of a commodity being contaminated or acting as vector).

If there are no active pathways or potential future pathways this should be stated explicitly here, and there is no need to answer the questions 1.2-1.9.

Response:

There are two active pathways relevant to the introduction and entry of mink into the risk assessment area, these are:

- a. Escape from confinement: Fur farms
- b. Escape from confinement: Pet/aquarium/terrarium species

Until 1971, American mink were also deliberately released for hunting purposes in many localities in the former Soviet Union (Heptner et al. 1967, Maran et al. 1998). However, the “Hunting” pathway is not considered active in the risk assessment area and will not be assessed.

PATHWAY a: Escape from confinement: Fur farms – Description of pathway

Introduction: The species was introduced to Europe from its native North America in the 1920s for fur farming (Gerell 1967, Dunstone 1993). Farms were established in several Member States within the risk assessment area, and in other European countries, initially in the 1920s and the 1930s, continuing in the 1950s, 1960s, and 1970s (particularly in southern Member States). New farms in new locations continue to be established at the present time in countries where mink farming is still permitted, and mink are transported within, and between, Member States to provide stock for new farms. Fur farms produce raw pelts for sale and export; some Member States (e.g. Greece) also produce and export finished garments made of mink fur. The risk of introduction and entry is associated with live animals held in farms. Based on production figures, the number of live mink held in farms across Europe as a whole, is in excess of 7 million (previously, in 2015, there were > 40 million mink held in farms across Europe, FiFur 2023, www.furfreealliance.org).

Entry: Since the first establishment of farms, mink have escaped from these facilities. Mink continue to escape from farms in Member States and in other neighbouring countries, and, in addition, are occasionally released in large numbers by animal rights activists or others (e.g. Greece in the 2010s). Escapes during transport within, or between, Member States are also a risk.

The species has already been introduced to, and entered, several Member States within the risk assessment area (see Section A). Introduction to, and entry into, additional Member States remains a possibility.

PATHWAY b: Escape from confinement: Pet/aquarium/terrarium species – Description of pathway

Introduction through this potential pathway is associated with the potential availability of American mink for sale in pet shops, or through private vendors, as exotic pets for private owners. Entry into the environment could occur via escape of the animal or intentional release by the owner. Globally, across taxa, many exotic pets escape or are intentionally released by owners (Lockwood et al. 2019 and references therein).

PATHWAY a: Escape from confinement: Fur farms (Questions 1.2 – 1.8)

Qu. 1.2a. Is introduction and/or entry along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)?

RESPONSE	intentional unintentional	CONFIDENCE	low medium high
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Response:

Introduction into the risk assessment area under this pathway is intentional. Entry into the environment may be either intentional (via deliberate release by animal rights activists or others) or unintentional (via escaped animals either from the farm itself or during transport between different farms).

Qu. 1.3a. How likely is it that large numbers of the organism will be introduced and/or enter into the environment through this pathway from the point(s) of origin over the course of one year?

Including the following elements:

- discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction and/or entry based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in subsequent establishment whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely moderately likely	CONFIDENCE	low medium high
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	likely very likely		
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Response:

The species has already been introduced to the risk assessment area via this pathway in 23 Member States. The species was introduced to northern Europe for fur farming in the 1920s and 1930s and was intentionally released into the wild in European Russia for harvesting in the 1930s and 1940s. Modern intensive fur farming in Europe started in the 1950s (Birnbaum 2013) and has since expanded to southern European countries, e.g. Italy and Spain in the 1950s (Mori and Mazza 2019) and Greece in 1972 (Galanaki and Kominos 2022). Mink farms in Latvia first opened in 1944, in Slovakia in the 1950s (Bonesi and Palazón 2007), and in Poland, mink farming on a large scale began in 1953 (Birnbaum 2013). Establishment of new farms in Member States where the species has not yet been introduced remains a possibility and is likely given the current situation whereby some Member States (where fur production companies are currently located) have banned fur farming and other Member States continue to permit it. For example, in Greece, breeding American mink is supported via subsidies by the Greek state which creates investment opportunities for new farming units (Semos 2016). The number of individuals already present and held in fur farms within the risk assessment area and neighboring European countries collectively exceeds 7 million (formerly, in 2015, > 40 million, FiFur 2023, Fur Europe 2015, www.furfreealliance.org).

Continual escapes and releases from mink farms have been the origin of American mink entry into the environment in several Member States, including Finland, Denmark, Estonia, Spain, Italy (Kauhala 1996, Ruiz-Olmo et al. 1997, Hammershøj et al. 2005, Maran 1991), and in other European countries (e.g. the UK, Macdonald and Harrington 2003). In many Member States and other European countries, mink entered the environment concurrently with their introduction (via farms), in the vicinity of mink fur farms, or during a period when mink fur farming was at its peak. The following country-specific examples are from Bonesi and Palazón (2007), unless otherwise stated; information on the presence of fur farms and dates of closures is from The Fur Free Alliance (furfreealliance.com, accessed 26.09.2023). In Austria, American mink established small populations in the vicinity of fur farms (now closed) in Lower Austria via escapes in the 1990s. The population of mink in Denmark was relatively low until the 1980s but increased eight-fold by the millennium; in the mid-2000s, there were more than 2,000 mink farms in Denmark. Additionally, there are studies showing strong genetic evidence for a high percentage of escaped farm mink in the free-ranging population in Denmark (Hammershøj et al. 2005). In Finland, mink were observed in the 1940s (following initial sightings in the wild in the 1930s) mainly in the vicinity of fur farms; analysis of their spread between 1951 and 1993 based on game inquiries carried out by the Finnish Game and Fisheries Research Institute provided evidence of a clear connection between the increase of mink populations in Finland and in Scandinavia and mink farming (Kauhala 1996). In France, feral American mink populations have been expanding since the 1960s when the number of farms reached a peak of 600 (in 1959, DREAL et al. 2021), mink initially (by the 1990s) established populations in Brittany where most of the mink farms (now closed) were concentrated (Bressan et al. 2022). In Germany the species was first observed in the wild in 1955, after which it spread rapidly through the northeast supported by repeated farm outbreaks (Zschille et al. 2014). In Greece, three significant intentional releases by activists were carried out in 2008, 2009, and 2010 but accidental escapes also occur, and feral mink populations are now well established in the northwest of the country around the core areas of fur farms (in Kozani, Kastoria, Florina, and Grevena, Galanaki and Kominos 2022). One feral mink was also found in Viotia (Dervenochoria) (in central Greece) in 2020 where one fur

farm operates (Galanaki and Kominos 2022). In Greece the distribution of American mink is currently localized, predominantly around fur farms (Galanaki and Kominos 2022). In Hungary, mink are not known to be common but occasional sightings are reported in winter in the area of Gödöllő, east of Budapest, where most remaining farms are located. In Ireland mink were first reported in the wild in 1961 with a self-sustaining population established by the 1980s (Smal, 1991). Early sightings were close to the locations of the fur farms (mostly in the east and south of the country) but the species has since spread throughout the island of Ireland (Roy et al. 2009). In Portugal, the first feral American mink reports (in 1985) were from animals that were most likely to have escaped from a farm located in the Spanish part of the Minho river on the Spanish-Portuguese border (Vidal-Figueroa and Delibes 1987). In central Romania, there were several escapes in 2015 from a recently established farm (Zs. Hegyeli, unpublished); records of 13 American mink in the wild between 2015 and 2017 (Ionescu et al. 2019) were also all within 9 km of farms in Braşov County, Transylvania, central Romania. In Spain, the first wild feral populations of American mink were formed in the 1980s (when the number of farms reached a peak of 400, located predominantly in Galicia): in northwest Galicia, the origin of the mink population is associated with escapes of mink from damaged cages during the cyclone “Hortensia” (in 1984), and in northeast Catalonia, two local population centres are linked to a fire at a farm near Barcelona in 1983 and damage caused by activists at a farm near Teruel (Ruiz-Olmo et al. 1997).

Overall, the likelihood of mink escaping from farms depends on the construction quality of the farm, farm security measures, and human (farm worker) behaviour. Previous experience suggests that escapes are highly likely: for example, a mink escaped from a farm in Oregon, USA, under quarantine conditions during a global pandemic period when security surveillance would likely have been at its highest (Oregon Department of Agriculture News 2020). The number of escaping mink at any given time depends on the total number of mink in the farm, and the level of biosecurity at the farm, and may involve only individuals on any single occasion. The precise numbers of mink escaped or released (and survived) (either during a single or several events over time) are not known but are often sufficiently large to establish a population in the wild.

Animal rights activists have been responsible for releases in many countries. Intentional releases are not frequent, but when they happen, the number of liberated mink is usually large or very large (hundreds or thousands of mink), and the likelihood that a feral population will be established is very high. No farm can be fully protected from such actions. In recent years deliberate release from fur farms by animal rights activists has become a regular hazard in Europe – for example 6,000 mink were released from a fur farm in the Netherlands in 2003 (Reynolds et al. 2004), there have been several cases in Spain (Palazón and Ruiz-Olmo 1997, e.g. ABC News 2001), and particularly large releases in Greece in 2008, 2009, and 2010 (Galanaki and Kominos 2022). Releases also occurred in France (Dearing 2009 cited in Galanaki and Komnos 2022), in Italy, e.g. in the 1990s (Lapini 1991) and in the 2000s (Iordan et al. 2016), Finland in 2007 (Reuters 2007), Ireland in 2010 (Irish Times 2010), and Denmark in 2011 and 2014 (The Local 2014). These large releases do not take place every year (although Greece suffered three in consecutive years), and the probability of such a release occurring in any particular year cannot be calculated with any certainty because it is a random event; however, the likelihood of such a release occurring somewhere in the risk assessment area where mink are not yet established (in any one year) is, in part, dependent on the number of farms in these areas.

Data on transport of American mink (volume, frequency, and routes taken, including whether transport is within or between Member States) are not readily available, but it is estimated that

1% of the annual production, mainly breeding animals, are transported live (Fenollar et al. 2021). Similarly, records of previous escapes during transport are lacking. Consequently, the likelihood of escape during transport cannot be quantified. Nevertheless, transport of live American mink between farms presents a feasible risk and so is relevant to this risk assessment and should be evaluated. The volume subject to transport is unknown but might number a thousand or more (as in recent imports of 2,000 American mink to farms in Denmark, sourced from Iceland, The Animal Reader 2023). Risks would be greatest during transfer of animals from their cages to the transport vehicles or vice versa, either at the source or recipient farm.

A number of studies provide evidence that American mink in the environment have come from mink fur farms. These broadly include studies showing that feral mink in the early stages of invasion occur close to farms, that their appearance in the wild coincides with fur farm activity/events (either new farms opening, large scale releases, or changes in production indicative of increasing number of animals held on farms, see Qu. B1.3a), or that mink in the wild can be identified as being of farm origin. The following are some key examples of mink in the wild being identified as being of farm origin (note that whilst we draw on examples from across Europe the findings are applicable across the risk assessment area).

A recent assessment (2010–2020) of mink occurrence in Greece found that 56% of records of mink in the wild were within 5–10 km of fur farms (Galanaki and Kominos 2022). Deliberate releases have been documented as the main cause of entry into the wild and subsequent establishment in Spain: 4 out of 6 populations were formed due to escapes (Ruiz-Olmo et al. 1997) and Bartolommei et al. (2013) attribute the appearance of American mink in central Italy in the late 1990s to the mink farms in the area (from which the owners confirmed that escapes and releases had occurred). In Poland, the rate of expansion of American mink from its appearance in the environment in the 1980s to 2016, was correlated with an increase in pelt production (Brzeziński et al. 2019) and genetic data explicitly show that in Poland the inflow of farmed mink into wild living populations is still ongoing (Zalewski et al. 2010, 2011). In Russia, wild populations of the species located close to mink farms, have haplotypes typical of domesticated minks (i.e. are of farm origin, Korablev et al. 2017). In a recent assessment of the status of American mink populations across Europe, Vada et al. (2023) concludes that findings of genotypes of farmed mink and their hybrids in free-ranging individuals in the mink populations near fur farms, objectively testify to the unintentional invasion of the introduced animals and their contribution to the gene pool of feral populations. Additional studies, in this case based on morphology and evidence of antibiotic treatment (i.e. whilst on farms), provide further evidence: among the feral mink on the mainland in Denmark, 28.4% of males and 21.6% of females were found to be escapees (Pagh et al. 2019).

In conclusion, as the American mink is small, elusive and fast (as are most other mustelids), mink farming, and any associated transport between farms, always carries a risk of escapes (from cages and farms during routine management, during accidental events, e.g. destruction of farm infrastructure by storm or flooding, or from cages, farms, or transport vehicles during transport between farms). The probability of a mink avoiding (i.e. surviving) recapture once it has escaped the cage/farm would depend on how quickly they were detected, and the trapping effort put into place. Once outside farms, although escapees from farms can be relatively easy to trap, capture in reality would depend on realization by farm workers that an escape had occurred, subsequent trapping effort put into place, and the time delay between escape and initiation of trapping efforts. These principles would apply whether mink had escaped, been released, or escaped during transport: large scale releases would likely be quickly detected but would require significant trapping effort and a quick response to ensure a large proportion

were recaptured and returned to farms (it is highly unlikely that all escapees during a large scale escape/release would be recaptured).

Qu. 1.4a. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

High survival and reproduction rates of American mink on farms is ensured by farmers because their business (production of fur) depends on successful breeding and growth of animals. At this point, animals are under the care of farmers and so are fed and protected from mortality but are also confined. The following data are from Canadian mink farms but are illustrative. The greatest losses are usually due to early loss of preweaned kits – this can be as high as 20 – 25%, but a study of 21 mink farms in Ontario reported overall kit mortality of between 4.5 and 10% (Compo et al. 2017). An earlier study reported mortality rate of females during the lactation period to be between 0.2% to 10.1%, with a median of 1.9% (Schneider and Hunter 1993), and one farm reported an overall annual mortality rate (excluding preweaning losses) of 6.8% (n= 369 deaths) among females and 2.2% (n= 68 deaths) among males (Schneider and Hunter 1993) (i.e. even accounting for kit loss annual survival rates are highly likely to exceed 90%). Female mink on farms usually give birth to 5 or 6 young, sometimes 7 (Felska-Błaszczuk et al. 2019) and, theoretically, up to 12 (Turner 2023). The mean litter size \pm SE for captive-born females in Denmark was 5.9 ± 0.9 (range in that study was 1-10 kits, Pagh et al. 2021). Litter size as large as 17 has been reported for farmed mink but 10 or more are infrequent (Dunstone 1993).

The survival rate of escaped American mink individuals is unknown, but would depend on the animal being able to find food and shelter, and to avoid predation and other common causes of mortality (e.g. road traffic accidents). At this point, there are no specific threats during passage along the pathway other than ‘normal’ threats that might be encountered by any medium sized predator. However, because these animals are captive bred, individual short term survival probability is likely to be relatively low due to naivety and lack of natural ‘survival skills’ that would normally be learnt in the wild (e.g. Jule et al. 2008). On the other hand, animals that have recently escaped from farms would theoretically be in good body condition, since the aim of farms is to keep animals in ‘optimal’ health for production and fur condition (e.g. Finley et al. 2012), and therefore might be better able to sustain an initial period of hunger (e.g. Evans 1969) if they are able to avoid mortality. Crucially, although the average probability of an individual surviving outside the farm is likely low, variability is likely to be high and chance effects (e.g. encountering a car on a road, or a larger predator) would have a significant influence on the outcome. This is important either where escapes of individual or small numbers of animals are frequent or where large numbers are released, per individual survival probability might be low but the probability of a small number of potential founder specimens surviving is likely to be high.

Survival probability once escaped would be the same regardless of the route by which it occurs (escape or release from farms, or during transport). Mink survival after an accident during transport is likely to vary considerably. If mink are able to escape, their individual survival chances would be no different to that of an individual that had escaped via any other means (escape or release from farms).

Reproduction in the wild following successful escape would depend, in part, on the time of year of the escape, the sex of the escapee animal, and (in the case of females) their status at the time of escape. A pregnant female escapee could give birth to 1–12 young (based on litter sizes in captivity, above) in the wild within two months, assuming that they were already pregnant and escape in March and then give birth in May. Even a naïve female escapee could presumably be mated provided that a wild male is encountered during the mating season (usually December to March, Dunstone 1993). A mated female in the wild (based on reported litter sizes in the wild) could be expected to give birth to at least 2–4 young, up to 5–6 (and potentially even as many as 7, or reportedly 11) in May of the same year (Dunstone 1993, Sidorovich 1993, Fournier-Chambrillon et al. 2010, Melero et al. 2015, Pagh et al. 2021, Qu. B2.7) assuming it survived and carried kits to term.

Qu. 1.5a. How likely is the organism to survive existing management practices before and during transport and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

Individual animals are held as breeding stock on farms until they are between 0 and 4 years old: on farms in Canada, for example, the average number of years that breeding females were kept was 2.7 (range 2 to 4, median = 3), while for breeding males, it was 1.5 years (range 0 to 3, median = 1) (Compo et al. 2017). At any one time, a farm might hold hundreds or thousands of live mink. Exchanges between farms would also involve live animals because they are intended either for breeding or to be ‘grown’ into adult sized animals before they are killed for their pelts. Their survival while they are confined is an inherent aspect of the fur production process.

Qu. 1.6a. How likely is the organism to be introduced into the risk assessment area or entry into the environment undetected?

Please note that “detection” here is considered as any system or event that may actively contribute to record the presence of a species in a way that appropriate management measures could be potentially undertaken by relevant authorities.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

American mink are already present in Europe, both in the wild and in captivity (in fur farms). Introduction into new areas/Member States would be associated with new farms being established but this would presumably be readily detected (unless farms were established in remote areas without seeking required permits/registration if required by national legislation). Entry into the environment in new areas, however, is highly unlikely to be detected. Specific methods are needed to detect the presence of escaped mink in the wild. Direct observations are not likely when only a few specimens escape, and American mink signs (footprints, faeces) can easily be confused with those of other small mustelids (polecat, martens, etc.). Mink rafts (floating footprint tunnels, Reynolds et al. 2004, Harrington et al. 2009a) are the most efficient method of detecting American mink in the field but these systems tend to be established only when a feral mink population is already known to be present (e.g. Harrington et al. 2009a). Moreover, the species high capability of dispersion means that the time period when escaped animals can be detected near fur farms is short. In many countries with feral American mink, experience has suggested “mink can be present for some time in appreciable numbers without being detected” (e.g. Clark 1970). An example is provided by the Isles of Lewis in the Outer Hebrides, Scotland, where mink were first reported in 1969 but the last fur farm (the only possible source of mink on the island) had closed down eight years earlier (Cuthbert 1973).

Qu. 1.7a. How isolated or widespread are possible points of introduction and/or entry into the environment in the risk assessment area?

RESPONSE	isolated widespread ubiquitous	CONFIDENCE	low medium high
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Response:

Existing mink farm locations provide possible points of entry into the environment within the risk assessment area - these can be considered widespread in that they are distributed across the risk assessment area from Spain to Bulgaria and Romania, and north to Sweden and Finland. Within this wide distribution area, there are approximately 1,000 mink farms still operating that are, by the nature of their relatively small number, relatively isolated. Within countries, farms are often clustered in particular regions e.g. in Greece, farms are predominantly in the northwest, and in Finland, they are predominantly in the west, in the region of Ostrobothnia (see Section A). In the absence of regulation, it is possible that the number of mink farms would increase again (in 2015, there were more than 5,000 mink farms across Europe, see Section A) but their overall distribution would remain patchy with ‘gaps’ in countries that have banned fur farming (see Section A).

Theoretically, mink could be introduced to any member state, or to any new area within Member States, where mink farming is still permitted.

Qu. 1.8a. Estimate the overall likelihood of introduction into the risk assessment area and/or entry into the environment based on this pathway?

RESPONSE	very unlikely	CONFIDENCE	low
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	unlikely moderately likely likely very likely		medium high
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Response:

Available data confirm that escapes from fur farms are rather common and that escaped mink are able to establish in the wild (Kauhala 1996, Ruiz-Olmo et al. 1997, Hammershøj et al. 2005, Zuberogitia et al. 2013, Dekker and Hofmeester 2014). Therefore, escapes from fur farms can be considered to be the main cause of introduction and entry of the American mink where the species is currently established, and there is a high likelihood that it will continue to be the main pathway for introduction of the species in new areas within the risk assessment area (see for example Qu.1.3a).

PATHWAY b: Escape from confinement: Pet/aquarium/terrarium species (Questions 1.2 – 1.8)

Qu. 1.2b. Is introduction and/or entry along this pathway intentional (e.g. the organism is imported for trade) or unintentional (e.g. the organism is a contaminant of imported goods)?

RESPONSE	intentional unintentional	CONFIDENCE	low medium high
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Response:

Introduction into the risk assessment area under this pathway is intentional (as a result of import or breeding of animals for sale or private ownership). Entry into the environment may be either unintentional (pet animals escaping from owners or pet shops) or intentional (deliberate release by animal owners).

Qu. 1.3b. How likely is it that large numbers of the organism will be introduced and/or enter into the environment through this pathway from the point(s) of origin over the course of one year?

Including the following elements:

- discuss how likely the organism is to get onto the pathway in the first place. Also comment on the volume of movement along this pathway.
- an indication of the propagule pressure (e.g. estimated volume or number of individuals / propagules, or frequency of passage through pathway), including the likelihood of reinvasion after eradication
- if relevant, comment on the likelihood of introduction and/or entry based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in subsequent establishment whereas for others high propagule pressure (many thousands of individuals) may not.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

The number of escaped and released mink from/by private owners would be notably lower than the number of escapes from farms because large numbers are unlikely to be kept by private owners. However, there are no mechanisms in place to minimize the number of escapes, as most pet mink owners remain unknown.

Documented evidence of introduction from this pathway is only anecdotal, yet the risk of this being an active pathway exists. There has already been a case of a pet mink escaping into the wild near Athens (Dmitris Bakaloudis, pers. comm. 05.09.2023). In the event that the American mink increases in popularity as a pet in the future, the number of escaped and released individuals is likely to increase. Large numbers released overall in any one area could occur if there are several concurrent escapes or releases. There is evidence of the existence and popularity of pet mink on various channels on social media. A simple google search for “my pet mink” results in 40 videos of owners with their pet mink, and the hashtag “petmink” is associated with over 1,000 posts on social media. “My Pet Mink” community created on Facebook is another sign of growing interest within the general public in having mink as a pet (<https://www.facebook.com/mypetmink/info>). Some people also train mink to hunt muskrats and brown rats in the United States (<http://modernfarmer.com/2014/05/farm-confessional-minks-escape-farms-train-hun>, accessed 28.09.2023).

The volume of movement along this pathway is unknown. Propagule pressure is likely to be in the order of 1 to 2 individuals but there is a risk that even low numbers may be able to establish a population if they are male and female, or if the female escaping/released is already pregnant.

Qu. 1.4b. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

The survival rate of animals in captivity is likely to be relatively high since it is in the interest of the owner to maintain the animal alive; in reality, survival would vary dependent on the skills and knowledge of the owner. The likelihood of reproduction and increase while in captivity would similarly be entirely dependent on the intentions of the owner.

The survival rate of escaped/released American mink from private owners in the wild is probably rather low due to domestication in captivity (Hammershøj 2004). Survival also depends on the point of escape (the probability of survival may be higher for escapees in the countryside, for example, than in cities) and keeping conditions (level of domestication). Otherwise, the likelihood of surviving, reproducing, and increasing along this pathway would be the same as for escapes from fur farms when propagule pressure (the number of individuals escaping) is low, as in Qu. 1.4a.

Qu. 1.5b. How likely is the organism to survive existing management practices before and during transport and storage along the pathway?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

While kept in captivity there are no management practices that would prevent survival.

Qu. 1.6b. How likely is the organism to be introduced into the risk assessment area or entry into the environment undetected?

Please note that “detection” here is considered as any system or event that may actively contribute to record the presence of a species in a way that appropriate management measures could be potentially undertaken by relevant authorities.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

The species is already present in the risk assessment area but it still may enter into other new areas and Member States. Whilst the owner is likely to be aware of the escape, there is no specified body to alert to the presence of the animal in the wild, and in the case of a release (which may be illegal in many countries) the owner is unlikely to admit to releasing the animal. Once in the wild specific methods are needed to detect the escaped animal. Direct observations or finding signs of the escaped animal are not likely. Moreover, the species high capability of dispersion means for those animals that do leave the area the time period when they can be detected near the location of their escape/release may be short.

Qu. 1.7b. How isolated or widespread are possible points of introduction and/or entry into the environment in the risk assessment area?

RESPONSE	isolated widespread	CONFIDENCE	low medium
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	ubiquitous		high
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Response:

The number and location of mink pet owners is currently unknown, but across the risk assessment area as a whole are almost certainly relatively rare and isolated. This may change in the future if their popularity as an exotic pet increases – however, even popular exotic pets are rather specialized and so it is likely that owners would remain relatively isolated.

Qu. 1.8b. Estimate the overall likelihood of introduction into the risk assessment area and/or entry into the environment based on this pathway?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

It is currently impossible to quantify the likelihood of introduction into the risk assessment area and/or entry into the environment based on this pathway because the number of private owners and the frequency of escapes and releases are unknown. However, it is known that mink have already been introduced into the risk assessment area as privately owned pets, and, whilst propagule pressure via this pathway is expected to be low similar scenarios with other species suggest that the risk of this pathway in establishing viable populations should not be underestimated.

An important parallel demonstrating the potential feasibility of this pathway is the case of feral ferrets and raccoons in the risk assessment area, which have established feral populations in the wild. Some reasons for their release are the expense or time involved in keeping them (as is the case for many unwanted pets).

Qu. 1.9. Estimate the overall likelihood of introduction into the risk assessment area or entry into the environment based on all pathways and specify if different in relevant biogeographical regions in current conditions.

Provide a thorough assessment of the risk of introduction in relevant biogeographical regions in current conditions: providing insight in to the risk of introduction into the risk assessment area.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

The species has already been introduced in the risk assessment area, through the two pathways discussed above. Due to escapes and releases, episodes of entry into the

environment have been frequent. Therefore, the overall likelihood of introduction and entry into new areas in Europe (including potentially all biogeographical areas where they do not yet occur) as result of direct or indirect human actions is very high. Present wild populations of American mink originate mostly from fur farms in Europe. Farms create opportunities for escapes and deliberate releases. Possible accidents during transport as well as escapes or releases of pet mink may also contribute to the introduction and entry of more individuals in the wild and may augment animals from farms. Currently, the distribution of American mink already established across Europe (see Section A) means that new populations in new areas may arise either from escapes/releases from farms or private owners, or as a result of natural (unaided) dispersal and spread of feral populations. It is not always possible to distinguish between escapes, deliberate releases and expansion of already-established populations. But the effect of regular escapes and deliberate releases (from either farms, or private owners) act as mutually supportive processes in the establishment of new feral populations and increases in the distribution and relative abundance of existing feral populations.

Qu. 1.10. Estimate the overall likelihood of introduction into the risk assessment area or entry into the environment based on all pathways in foreseeable climate change conditions?

Thorough assessment of the risk of introduction in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5)
- what aspects of climate change are most likely to affect the likelihood of introduction (e.g. change in trade or user preferences)

The thorough assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment of likely introduction within a medium timeframe scenario (e.g. 30-50 years) with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

The likelihood of introduction and entry is not affected by climate change and remains the same as for Qu. 1.9.

2 PROBABILITY OF ESTABLISHMENT

Important instructions:

- For organisms which are already established in parts of the risk assessment area or have previously been eradicated, the likelihood of establishment should be scored as “very likely” by default.
- Discuss the risk also for those parts of the risk assessment area, where the species is not yet established.

Qu. 2.1. How likely is it that the organism will be able to establish in the risk assessment area based on similarity of climatic and abiotic conditions in its distribution elsewhere in the world?

RESPONSE		CONFIDENCE	
	very unlikely		low
	unlikely		medium
	moderately likely		high
	likely		
	very likely		

Response:

The species is already established in the risk assessment area. The species is considered to be established in 18 EU Member States: Austria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Poland, Portugal, Romania, Slovakia, Spain, Sweden (Macdonald and Harrington 2003, Bonesi and Palazón 2007, Roy et al. 2009, Zalewski et al. 2010, Hegyeli and Kecskés 2014, MAGRAMA 2014, Rodrigues et al. 2015, Vada et al. 2023) (see Qu. A8b above).

Qu. 2.2. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in the risk assessment area? Consider if the organism specifically requires another species to complete its life cycle.

RESPONSE		CONFIDENCE	
	very isolated		low
	isolated		medium
	moderately		high
	widespread		
	widespread		
	ubiquitous		

Response:

The species occupies all kind of freshwater habitats (rivers, streams, canals, wetlands, lakes) and also coastal areas and archipelagos (Dunstone 1993) in most of Europe. Therefore, suitable habitat types for the establishment (survival, development and increase) of American mink are available and widely distributed throughout the risk assessment area.

The American mink is also adaptable and opportunistic in its diet and able to find suitable prey (small mammals, amphibians, fish, crayfish and birds) almost everywhere (Dunstone 1993, Sidorovich et al. 1998). For example, a recent study on Navarino Island, Chile, found that mink use habitats > 800 m from water sources and thus that mink can also survive and establish populations in terrestrial habitats at least seasonally (Crego et al. 2018). In Denmark, the American mink has further widened its range to urban areas. There have been sightings of mink by the canals in the center of Copenhagen and an interview study showed that the species had been seen within a year in 58% of the 145 harbors investigated (Meier 2005). The American mink does not require another species for critical stages in its life cycle, reproduction and spread (except for prey).

Qu. 2.3. How likely is it that establishment will occur despite competition from existing species in the risk assessment area?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

Although intra-guild competition does occur between American mink and other semi-aquatic species, competitive pressure will not prevent establishment of American mink populations.

Studies in Belarus and the UK demonstrate that American mink are able to coexist with Eurasian otters (*Lutra lutra*, that are larger, dominant competitors) through avoidance behaviours, either by using different habitats (spatial avoidance) or by adopting different activity patterns (temporal avoidance, Harrington et al. 2009b, 2020). Although, there has been much discussion of the impact of otters on American mink populations in the scientific literature, and a few studies have reported a correlation between otter population recovery and mink population decline e.g. in the UK and Finland (Bonesi et al. 2004, McDonald et al. 2007, Urho et al. 2014), there is no evidence of a causal link between these two processes (Harrington et al. 2020). There are several areas/countries where American mink have established populations in the presence of otters and/or polecats (e.g. Portugal, Rodrigues et al. 2015, Spain, Põdra and Gómez 2018, Belarus, Sidorovich 1997, Scotland, Fraser et al. 2015, amongst others) and the majority of experts regard these apparent patterns to be coincidental (Bouros et al. 2016).

There has been some suggestion that foxes (*Vulpes* spp.) might impact American mink populations in the northern parts of their European range through competition for food and harassment e.g. the red fox *Vulpes vulpes* in Sweden (Carlsson et al. 2010) and the Arctic fox *Vulpes lagopus* in Iceland (Magnusdottir et al. 2014) but there is no clear causal evidence of an impact of either species and no evidence that canids impact American mink elsewhere. If either of these species do impact mink populations, then their impact is likely to be limited, may be spatially restricted and not sufficient to limit mink establishment.

Qu. 2.4. How likely is it that establishment will occur despite predators, parasites or pathogens already present in the risk assessment area?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

Predation risk by white-tailed sea eagles *Haliaeetus albicilla* may limit individual mink movements between islands in the archipelago of SW Finland, but the possible negative implications of this on the mink population can only be speculated (Salo et al. 2008). Eurasian eagle-owls *Bubo bubo* can also be predators of mink in introduced regions (Sidorovich 2011). However, whilst there are a few published reports of predation on mink, there is no evidence that any predation that might occur has a population-level impact on American mink. Across Europe American mink currently co-exist with several larger carnivores (Sidorovich 1993, for example, provides an overview of the predator community in Belarus).

Mink are infected by ticks and several parasites (e.g. *Toxoplasma gondii*, *Yersinia* spp., and *Coccidia* spp.) but these organisms are not usually of clinical significance (e.g., Harrington et al. 2012a, Martínez-Rondán et al. 2017).

American mink are susceptible to Aleutian mink disease virus (AMDV, Yamaguchi and Macdonald 2001) and infection with AMDV may be associated with poor body condition in wild mink (Zalewski et al. 2021) and reduced reproductive output (litter size reduced by 8% compared with uninfected individuals, and offspring survival to Sept/Oct reduced by 14%) (Zalewski et al. 2023).

However, neither predators, parasites, nor pathogens prevented the establishment of American mink in countries across Europe or in other world regions (e.g. Russia. China, or South America, see Section A).

Qu. 2.5. How likely is the organism to establish despite existing management practices in the risk assessment area? Explain if existing management practices could facilitate establishment.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

The species has already established in almost all European countries and confirmed mink-free areas in Europe and within the risk assessment area are scarce and small (Vada et al. 2023). This situation has occurred despite existing management practices (hunting, agricultural predator control practices, etc.) in the risk assessment area. The only exception is in the Netherlands, where American mink failed to establish, and their lack of establishment is attributed to intense, systematic, on-going trapping for another invasive alien species, the muskrat *Ondatra zibethicus* (Dekker 2012, Dekker and Hofmeester 2014).

The current species-specific management approach whereby mink control efforts tend to be implemented when mink are known to be present and breeding in the area, and/or have been observed to have caused a significant impact on native biodiversity, by default means that current “management” (in the vast majority of cases) facilitates establishment because escapees are “allowed” to settle, breed, and establish in the wild before any action is taken.

Qu. 2.6. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in the risk assessment area?

RESPONSE		CONFIDENCE	
	very unlikely		low
	unlikely		medium
	moderately likely		high
	likely		
	very likely		

Response:

In general, the eradication of invasive alien mustelids is a difficult task. The most common reasons for this are probably the lack of opportunity (i.e. a lack of trapping density/effort), active avoidance (if individuals find but refuse to enter a trap, “trap shyness”), or both (Zuberogoitia et al. 2006, King et al. 2009). Removal efforts may also fail due to the lack of eradication experience and insufficient financial support (Zabala et al. 2010). In addition, American mink present high reproductive plasticity: reproduction rate (litter size and the proportion of females breeding) can increase markedly when density is low (as might be the case during intensive trapping, Sidorovich 1997, Melero et al. 2015, pers. obs. Asun Gomez and Madis Podra) and its pregnancy duration may vary from 30–75 days depending upon environmental conditions (Larivière 1999). Such a response decreases the probability of success of eradication campaigns, especially when trapping effort is insufficient or methods used are inadequate. American mink are also exceptionally mobile hence potentially able to recolonise cleared areas quickly (Bryce et al 2011), although this mobility and a tendency of animals to re-occupy the best sites can be exploited in control efforts (Oliver et al. 2016).

That being said, in some cases local or regional eradication has been achieved. For example, in Norway effective local control and eradication programmes have been carried out and have been successful after the Norwegian action plan against the American Mink was implemented in 2011 (Stien and Hausner 2018). Continuous removal of American mink in the outer archipelago of SW Finland has resulted in an essentially mink-free area of over 800 km² (with land area less than 10%; Salo 2014). The Hebridean Mink Project successfully eradicated mink from 1,100 km² of the southern islands of the Hebridean Archipelago in Scotland (Roy 2011) and mink were also successfully removed from an area of > 29,000 km² in central Scotland (Bryce et al. 2011). New trapping methods, developed in the UK (mink rafts; Reynolds et al. 2004, 2013), have demonstrated that effective control or even local eradication is possible with reasonable effort. The method is currently used in several areas in Europe and gives significantly better results compared to traditional trapping with baited cage-traps (Harrington et al. 2009a, Bryce et al. 2011, Tragsatec 2015). The raft method exploits the mink’s natural curiosity and behaviour as it hunts along river/lakeside banks (Reynolds et al. 2004).

Qu. 2.7. How likely are the biological characteristics of the organism to facilitate its establishment in the risk assessment area?

Including the following elements:

- a list and description of the reproduction mechanisms of the species in relation to the environmental conditions in the risk assessment area
- an indication of the propagule pressure of the species (e.g. number of gametes, seeds, eggs or propagules, number of reproductive cycles per year) of each of those reproduction mechanisms in relation to the environmental conditions in the risk assessment area.
- If relevant, comment on the likelihood of establishment based on propagule pressure (i.e. for some species low propagule pressure (1-2 individuals) could result in establishment whereas for others high propagule pressure (many thousands of individuals) may not.
- If relevant, comment on the adaptability of the organism to facilitate its establishment and if low genetic diversity in the founder population would have an influence on establishment.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

The species is able to use, settle, and reproduce in habitats and environments that are relatively abundant across the risk assessment area. That the biological characteristics of the species are suitable to facilitate its establishment within the risk assessment area is evidenced by the species presence across Europe and its establishment over the last few decades (see Section A, and this Section Qu. 3). Establishment has not been limited to areas where propagule size was large, suggesting that whilst propagule size might logically be expected to influence the rate at which initial population growth occurs, it does not necessarily influence population establishment per se.

American mink in the wild usually live to between < 1 and ca. 3 years old but potentially older: a female mink in North Uist, Scotland was 6 years old (Bonesi et al. 2006). American mink mate and reproduce once a year but give birth to relatively large litters even in the wild, producing average litter sizes in the wild (aged > 1 month) of 5.8 (in Belarus, Sidorovich 1993), 5.5 in Scotland (Melero et al. 2015) and 7.5 (in France/Spain, Fournier-Chambrillon et al. 2010) (slightly smaller – 2-4 – in England, Dunstone 1993). The species is therefore able to establish sizeable populations relatively quickly. In Denmark, a recent study found that the mean litter size of wild-born females (7.6 ± 0.9 , range 5–11, in that study) was even larger than that of escaped free-living captive-born females (i.e. those that have recently escaped from farms, 5.9 ± 0.9 , range 1–10, Pagh et al. 2021) and the percentage of reproducing females was 81% (Pagh et al. 2021). Further, demographic studies carried out in Belarus showed that the reproduction rate of American mink increased during the expansion phase of the population (Sidorovich 1993). A similar tendency was observed in Scotland (Melero et al. 2015).

The shape and size of the American mink skull reflects masticatory-muscle volume, muscle force and bite force, and, relative to other similar species (e.g. the European mink) supports the dietary range of American mink and suggests that the species is able to take a wider range of potentially bigger and tougher prey species than their native European counterpart (Gálvez-López et al. 2022). This and their behavioural flexibility (see Qu. 3) allows population establishment in a range of habitats, across a range of climatic and environmental conditions.

In addition, the species differs from several other domesticated species in that it is able to regain the larger brain size of the wild phenotype (which is presumably adaptive for wild living), i.e. relative brain size can recover in feral animals, even after almost a century of domestication and less than 50 years in the wild (Pohle et al. 2023).

Qu. 2.8. If the organism does not establish, then how likely is it that casual populations will continue to occur?

Consider, for example, a species which cannot reproduce in the risk assessment area, because of unsuitable climatic conditions or host plants, but is present because of recurring introduction, entry and release events. This may also apply for long-living organisms.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

For American mink this situation appears to be rare but has occurred in the Netherlands where intensive trapping for another species appeared to prevent establishment of American mink populations (Dekker 2012, Dekker and Hofmeester 2014) but their presence persisted (due to recurring introduction and entry) until mink farms in the country had been closed (La Haye 2022, Glenn Lelieveld, pers. comm. 05.09.2023).

Qu. 2.9. Estimate the overall likelihood of establishment in the risk assessment area under current climatic conditions. In addition, details of the likelihood of establishment in relevant biogeographical regions under current climatic conditions should be provided.

Thorough assessment of the risk of establishment in relevant biogeographical regions in current conditions: providing insight in the risk of establishment in (new areas in) the risk assessment area.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

The species has already established in the risk assessment area in a range of biogeographical regions and countries (see Section A).

Continuous escapes from fur farms provide a sufficiently high number of founder specimens to make the establishment of feral populations in new areas not yet occupied highly probable. The fact that populations establish by individuals escaped from fur farms is evidenced by the number of countries currently occupied by feral American mink and the current extent of the invaded range of the American mink. Genetic analyses of feral and farm mink have also confirmed the presence of escapees from farms in wild populations (Zalewski et al. 2010, 2011, Zuberogitia et al. 2013). Pregnant females escaping could give birth to young animals in the wild, or males and females escaping during the mating season (March) could mate in the wild, producing an independent wild-born generation within 3-4 months.

Qu. 2.10. Estimate the overall likelihood of establishment in the risk assessment area under foreseeable climate change conditions. In addition, details of the likelihood of establishment in relevant biogeographical regions under foreseeable climate change conditions should be provided.

Thorough assessment of the risk of establishment in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk.

With regard to climate change, provide information on

- the applied timeframe (e.g. 2050/2070)
- the applied scenario (e.g. RCP 4.5)
- what aspects of climate change are most likely to affect the likelihood of establishment (e.g. increase in average winter temperature, increase in drought periods)

The thorough assessment does not have to include a full range of simulations on the basis of different climate change scenarios, as long as an assessment of likely establishment within a medium timeframe scenario (e.g. 30-50 years) with a clear explanation of the assumptions is provided. However, if new, original models are executed for this risk assessment, the following RCP pathways shall be applied: RCP 2.6 (likely range of 0.4-1.6°C global warming increase by 2065) and RCP 4.5 (likely range of 0.9-2.0°C global warming increase by 2065). Otherwise, the choice of the assessed scenario has to be explained.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response:

The projected current climatic suitability in the Species Distribution Model (Annex VIII) indicates that most parts of the continent are suitable, except for some parts of the Mediterranean (southern Iberia, Sicily, Malta, Aegean Islands, Cyprus) that appear to be too dry. Under climate change scenarios RCP 2.6, 4.5 and RCP 8.5, by the 2070s, some Mediterranean areas become gradually less suitable (see Qu. A9 and Annex VIII).

3 PROBABILITY OF SPREAD

Important instructions:

- Spread is defined as the expansion of the geographical distribution of an alien species within the risk assessment area.
- Repeated releases at separate locations do not represent continuous spread and should be considered in the probability of introduction and entry section (Qu. 1.7).

Qu. 3.1. How important is the expected spread of this organism within the risk assessment area by natural means? (List and comment on each of the mechanisms for natural spread.)

including the following elements:

- a list and description of the natural spread mechanisms of the species in relation to the environmental conditions in the risk assessment area.
- an indication of the rate of spread discussed in relation to the species biology and the environmental conditions in the risk assessment area.

The description of spread patterns here refers to the CBD pathway category “Unaided (Natural Spread)”. It should include elements of the species life history and behavioural traits able to explain its ability to spread, including: reproduction or growth strategy, dispersal capacity, longevity, dietary requirements, environmental and climatic requirements, specialist or generalist characteristics.

RESPONSE		CONFIDENCE	
	minimal		low
	minor		medium
	moderate		high
	major		
	massive		

Response:

Once in the environment, the American mink is well adapted to spread and colonise large areas unaided by natural means. The species has traits that make it an effective invader: it is an opportunistic predator with a high reproduction rate, it is capable of adapting to a number of habitat types, and juveniles can disperse over long distances from their natal territories on land and in water (including underwater, and from one river catchment to another).

The life history of American mink is well studied in a number of countries. Some of the following comes from work in the UK and Belarus, so outside the risk assessment area, but the information from these studies is applicable across Europe. American mink spreads by a combination of population growth and dispersal in a system whereby young of the year (born in May) reach independence and disperse from their natal territory at the age of approximately three months in August/September (Dunstone 1993). Both sexes disperse from their natal territory and establish independent territories (Dunstone 1993). Sub-adult and adult American mink in wild populations live in a spatially organized social system where both males and females live in home ranges that they defend against same-sex neighbours, and male home ranges overlap one or two female home ranges (Yamaguchi et al. 2004, Harrington and

Macdonald 2008). Mink are generalist predators (Sidorovich 2000a, Sidorovich et al. 2001, 2010, Chibowski et al. 2019), that are able to use a variety of semi-aquatic/riparian habitat types (Sidorovich and Macdonald 2001, Yamaguchi et al. 2003), and hunt and travel either on land or in water (Dunstone 1993, Harrington et al. 2012b). Mink can dive to at least 3 m in rivers and might dive over 100 times in a day (Harrington et al. 2012b, Lapini 2003) but are also able to use habitats almost 1 km away from the water (Crego et al. 2018). The suitability of environmental/climatic conditions across much of the risk assessment area means that American mink are potentially able to spread and occupy a considerable and largely contiguous range across Europe (much of which is already occupied, see Section A). At low densities (i.e. during colonization) population growth may be further facilitated by an increase in both the litter size and proportion of females breeding (see Qu. B2.7, Sidorovich 1993, Melero et al. 2015).

The effectiveness of the spread of American mink by natural means has been evidenced in several countries in Europe. In Finland, American mink colonized the whole country between the 1950s and 1970s (Kauhala 1996), and in some areas the annual frequency of occurrence increased from 20% to 80% in just a few years. As a consequence, the annual mink catch also increased ca. 7-fold between the 1970s and 1990s. It took 25 years from the first observations of the American mink in the wild to full occupation of mainland Estonia (Maran 1991). In Spain, the known distribution area has increased nearly 17-fold in less than 30 years, from 75 UTM squares (10x10 km) in 1985 (Ruiz-Olmo et al. 1997) to 1277 UTM squares in 2012 (MAGRAMA 2014, Põdra and Gómez 2018), such that American mink now occupy the majority of central and northern Spain. Rapid expansion has also been observed in Ireland (Roy et al. 2009).

Outside the risk assessment area, in the UK, expansion in one particular river valley where American mink occupancy was closely monitored increased from 7% of 161 survey sites occupied in 1975, to 25% of sites by 1990 (although all mink farms in the area had closed by the late 1980s), and to 46% sites in 1995, and they continued to spread into the upper reaches of the river basin in the early 2000s (Macdonald and Harrington 2003). Similarly, the species managed to settle in a greater part of Norway (occupying an estimated 80–85% of the country) in 35 years (Bevanger and Henriksen 1995, The Norwegian Directorate for Nature Management 2011).

The common feature of the species' spread in all of these countries is the establishment of small isolated populations close to fur farms. This phase is commonly followed by rapid expansion of these small populations into other areas due to extremely efficient dispersal.

Observed average dispersal distances of juvenile mink in the UK were ca. 19 km, maximum inferred dispersal distances (at low mink population density) in Scotland were around 55 km for males and 40 km for females (Oliver et al. 2016) and the longest dispersal recorded in Sweden was 45 km (Gerell 1970). Some much more extensive dispersal events have been recorded: in Scotland, some individuals dispersed over 130 km from their natal territories (Lambin et al. 2011) and 20% of dispersers in a later study (based on genetic analysis) were inferred to have travelled more than 80 km (Melero et al. 2018). Mink can also cross open bodies of water up to 5 km wide (Bevanger and Henriksen 1995) and have occupied islands more than 10 km from the mainland in Iceland by 'island hopping' (Skirnisson et al. 2004, Bonesi et al. 2006).

It is possible that American crayfish (another invasive species that are a key food resource for American mink where they occur), may further facilitate invasion of American mink in some areas (e.g. Portugal, Rodrigues et al. 2015).

Qu. 3.2a. List and describe relevant pathways of spread other than "unaided". For each pathway answer questions 3.3 to 3.9 (copy and paste additional rows at the end of this section as necessary). Please attribute unique identifiers to each question if you consider more than one pathway, e.g. 3.3a, 3.4a, etc. and then 3.3b, 3.4b etc. for the next pathway.

including the following elements:

- a list and description of pathways of spread with an indication of their importance and associated risks (e.g. the likelihood of spread in the risk assessment area, based on these pathways; likelihood of survival, or reproduction, or increase during transport and storage; ability and likelihood of transfer from the pathway to a suitable habitat or host) in relation to the environmental conditions in the risk assessment area.
- an indication of the rate of spread for each pathway discussed in relation to the species biology and the environmental conditions in the risk assessment area.
- All relevant pathways of spread (except “Unaided (Natural Spread)”, which is assessed in Qu. 3.1) should be considered. The classification of pathways developed by the Convention of Biological Diversity shall be used (see Annex IV).

Response:

Repeated escapes or releases at separate locations do not represent continuous spread and are considered in the probability of introduction and entry section (Section B1.2–1.8). There are anecdotal reports of individual mink transported on small boats in the Outer Hebrides of Scotland (P. Robertson, pers. comm. 14.11.2023), but considering the lack of specific data and the infrequency of such events, it is not considered further. Once in the environment mink spread by natural means, there are no other relevant human assisted pathways.

Qu. 3.3a. Is spread along this pathway intentional (e.g. the organism is deliberately transported from one place to another) or unintentional (e.g. the organism is a contaminant of translocated goods within the risk assessment area)?

RESPONSE	intentional	CONFIDENCE	low
	unintentional		medium high

Response: N/A

Qu. 3.4a. How likely is it that a number of individuals sufficient to originate a viable population will spread along this pathway from the point(s) of origin over the course of one year?

including the following elements:

- an indication of the propagule pressure (e.g. estimated volume or number of specimens, or frequency of passage through pathway), including the likelihood of reinvasion after

eradication

- if appropriate, indicate the rate of spread along this pathway
- if appropriate, include an explanation of the relevance of the number of individuals for spread with regard to the biology of species (e.g. some species may not necessarily rely on large numbers of individuals).

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: N/A

Qu. 3.5a. How likely is the organism to survive, reproduce, or increase during transport and storage along the pathway (excluding management practices that would kill the organism)?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: N/A

Qu. 3.6a. How likely is the organism to survive existing management practices during spread?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: N/A

Qu. 3.7a. How likely is the organism to spread in the risk assessment area undetected?

Please note that “detection” here is considered as any system or event that may actively contribute to record the presence of a species in a way that appropriate management measures could be potentially undertaken by relevant authorities.

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: N/A

Qu. 3.8a. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host during spread?

RESPONSE	very unlikely unlikely moderately likely likely very likely	CONFIDENCE	low medium high
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Response: N/A

Qu. 3.9a. Estimate the overall potential rate of spread based on this pathway in relation to the environmental conditions in the risk assessment area. (please provide quantitative data where possible).

RESPONSE	very slowly slowly moderately rapidly very rapidly	CONFIDENCE	low medium high
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Response: N/A

Qu. 3.10. Within the risk assessment area, how difficult would it be to contain the organism in relation to these pathways of spread?

RESPONSE	very easy easy with some difficulty difficult very difficult	CONFIDENCE	low medium high
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Response:

With respect to natural spread within the risk assessment area, preventing American mink from moving into new areas after it has established in the wild is a very difficult task. In mountainous areas, or in areas with artificial barriers (roads, industrial areas, etc.), the invasion of American mink may be limited to some extent and it may be easier to control its expansion. However, landscape features such as mountains may slow down but they will not stop colonisation; spread and colonisation rates may also be further enhanced by continued introduction and entry into the environment over time (Zalewski et al. 2009, Fraser et al. 2013).

The use of rafts/floating platforms that are used for detection and control (Reynolds et al. 2004, 2013) would not be ideal for capturing dispersing mink and preventing spread (unless they are permanently set up with either lethal or live traps), but have been successful to keep areas free from colonization despite continued spread from neighbouring populations (e.g. in

the Netherlands). Lethal traps carry significant risk of non-target captures and live traps require checking every 24 hours when they are set (for welfare reasons), i.e. resource requirements would be very high if rafts are not used in a targeted manner.

Qu. 3.11. Estimate the overall potential rate of spread in relevant biogeographical regions under current conditions for this organism in the risk assessment area (indicate any key issues and provide quantitative data where possible).

Thorough assessment of the risk of spread in relevant biogeographical regions in current conditions, providing insight in the risk of spread into (new areas in) the risk assessment area.

RESPONSE	very slowly slowly moderately rapidly very rapidly	CONFIDENCE	low medium high
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Response:

Several European studies have quantified the rate of spread of American mink populations. In northern Spain, a continuous expansion in the range of American mink was observed between 1985 and 2012, whereby the distribution area of the species increased by 17 times, with an average annual increment in distribution area over the 27 years of 16.5% and no significant variation among populations (Põdra and Gómez 2018). Recorded linear expansion rates vary from about 2.5 to 22.5 km per year in Portugal (Rodrigues et al. 2015), from 5.5 to 9 km per year in Argentina (Fasola et al. 2011) and 8 to 27.3 km per year (mean 14 km per year) in Scotland (Fraser et al. 2015). From Scotland, comparable data are also available for radial and areal expansion rates, which ranged (for radial expansion) from 1 to 23 km per year (mean 10 km per year) and (for rate of expansion by area) from 101 to 2,866 km² per year (mean 1,327 km² per year) (Fraser et al. 2015). In Iceland, the average minimum advance of the dispersal front was estimated to be approximately 20 km per year (Hersteinsson et al. 2012).

Data from Catalonia, Spain, demonstrate that expansion rates may also increase over time: the species expanded from occupying one 10×10-km cell located in northern Montseny in the 1970s to 159 cells of the same size in 2014 (Palazón et al. 2016). At the start of the invasion, the average expansion rate was 0.39 cells per year but this increased to 0.91 cells per year after 2009 (Palazón et al. 2016). Similarly, in Portugal, following an initial phase of slow expansion (55 km in 20 years), mink expanded their range quite rapidly in only two years (45 km) (Rodrigues et al. 2015). In Poland, the rate of expansion over time showed accelerating and decelerating patterns: from 1980 to 1992 the rate of expansion accelerated up to 20,000 km² per year, then decelerated down to about 6,000 km² per year, and again increased in the years 2006–2008 to nearly 14,000 km² per year and then decreased in the following years to 3,000 km² per year (Brzeziński et al. 2019). The cumulative area reached 270,000 km² after 35 years of invasion, which gives about 7,700 km² per year on average (Brzeziński et al. 2019). In Poland, these patterns of increasing and decreasing rate of spread were correlated with mink farm activity (see Qu. B1.8a) but this was not the case in Portugal.

In summary, American mink have invaded a large part of Europe during a few decades and for many of the populations invasion rate has increased over time (Bonesi and Palazón 2007, Vada et al. 2023). Therefore, it is likely that the species will further colonize areas that are

currently vacant unless prevention measures are undertaken. The presence of natural barriers or urban habitats may slow down the dispersal rate but cannot stop the invasion. Similarly, whilst some studies (e.g. Brzeziński et al. 2019) have shown that expansion may be faster where there is more aquatic habitat, mink are not limited to aquatic habitats where other prey resources are available (as was found in Navarino Island, Chile, Crego et al. 2018, see Qu. 3.12).

Note that at this point in time, the species' spread is currently unaffected by closures of fur farms but continues through natural means (Vada et al. 2023).

Qu. 3.12. Estimate the overall potential rate of spread in relevant biogeographical regions in foreseeable climate change conditions (provide quantitative data where possible).

Thorough assessment of the risk of spread in relevant biogeographical regions in foreseeable climate change conditions: explaining how foreseeable climate change conditions will influence this risk, specifically if rates of spread are likely slowed down or accelerated.

RESPONSE	very slowly slowly moderately rapidly very rapidly	CONFIDENCE	low medium high
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Response:

Potential rate of spread under foreseeable climate change conditions is difficult to predict. There are uncertainties involved in all modelling exercises: for example, even under current climate conditions the species’ spread in Sardinia was significantly underestimated by modelling (Dettori et al. 2016).

The current distribution of American mink in both its native and non-native range illustrate the species ability to adapt and thrive in a wide range of climatic conditions, as evidenced within the risk assessment area by its presence from Scandinavia to the Mediterranean (see Section A). Ultimately, the species’ ability to persist in and colonise new areas depends on the availability of resources.

In Iceland, a decrease in the distribution of American mink coincided with widespread breeding failures of several Icelandic seabird species, associated with reduced availability of the sandeel (Ammodytidae) that has crashed in many areas in the North Atlantic, e.g. the North Sea, most likely because of climate change. The sandeel is not a part of mink diet and seabirds are only a small part of it; nevertheless, Stefánsson et al. (2016), Magnusdottir et al. (2014), and other authors suggest that climate change might have cascaded through the food web to the American mink, causing reduced access to optimal prey, thereby contributing to the reduction in population size.

In other areas, where there is a wider variety of potential prey, the flexibility of American mink appears to allow them to adapt. The most likely immediate climate change scenario in Europe is perhaps drought and increasingly dry areas, particular in Mediterranean regions. The spread of American mink in Patagonia, across the steppe-arid environment, often assumed to be an obstacle for mink colonization (Fasola and Roesler 2018) suggests that it

will be able to cope in arid environments provided that prey are available. Further evidence of significant niche expansion potential is provided by a study on Navarino Island, Chile, where camera trapping revealed that mink occupied and were active at sites up to 880 m from water sources during summers and used more terrestrial habitats than expected (where they preyed on small mammals and birds) (Crego et al. 2018).

Using habitat suitability and dynamic connectivity modelling Goicolea et al. (2023) predicted that American mink are likely to experience average declines in habitat of 41% and average declines in connectivity of 32% by the end of the century under three different shared socio-economic and emissions pathways (an optimistic and sustainable scenario, a medium–high emissions scenario, and high fossil-fuel development) under the GFDL-ESM4 (National Oceanic and Atmospheric Administration, Geophysical Fluid Dynamics Laboratory, Princeton, NJ 08540, USA) Global Climatic Model. However, this assumes suitability and connectivity provided by aquatic habitats, whereas habitat use and movements in Patagonia and Chile demonstrate that mink may be capable of adapting to more terrestrial habitats, and can certainly move across dry lands.

4 MAGNITUDE OF IMPACT

Important instructions:

- Questions 4.1-4.5 relate to biodiversity and ecosystem impacts, 4.6-4.8 to impacts on ecosystem services, 4.9-4.13 to economic impact, 4.14-4.15 to social and human health impact, and 4.16-4.18 to other impacts. These impacts can be interlinked, for example, a disease may cause impacts on biodiversity and/or ecosystem functioning that leads to impacts on ecosystem services and finally economic impacts. In such cases the assessor should try to note the different impacts where most appropriate, cross-referencing between questions when needed.
- Each set of questions starts with the impact elsewhere in the world, then considers impacts in the risk assessment area (=EU excluding outermost regions) separating known impacts to date (i.e. past and current impacts) from potential future impacts (including foreseeable climate change).
- Only negative impacts are considered in this section (socio-economic benefits are considered in Qu. A.7)
- In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer “No information has been found on the issue”. This is necessary to avoid confusion between “no information found” and “no impact found”. In this case, no score and confidence should be given and the standardized “score” is N/A (not applicable). Note that in principle, even if no information is available for the risk assessment area, this does not apply to Qu. 4.2 and 4.3, because the information on impact can be inferred from regions outside the risk assessment area. If no information is available from regions outside the risk assessment area either, then this should be discussed explicitly.

Biodiversity and ecosystem impacts

Qu. 4.1. How important is the impact of the organism on biodiversity at all levels of organisation caused by the organism in its non-native range excluding the risk assessment area?

including the following elements:

- Biodiversity means the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems
- impacted chemical, physical or structural characteristics and functioning of ecosystems

RESPONSE		CONFIDENCE	
	minimal		low
	minor		medium
	moderate		high
	major		
	massive		

Response:

In South America, the American mink has had a negative impact on mammals and birds (ground-nesting birds in coastal areas, woodpeckers in woodlands; Jaksic et al. 2002, Jiménez et al. 2014). In Argentina, the potential impact of the American mink on the endangered Hooded Grebe *Podiceps gallardoi* (a Critically Endangered species of the highland plateau lakes in Patagonia that is naïve to mammalian predators) has been described as “catastrophic” (BirdLife International 2023, Roesler et al. 2012). In 2011, 33 Hooded Grebes’ nests were destroyed and incubating adults killed by an American mink over just 2 days, resulting in the loss of 4% of the grebe’s global population (Roesler et al. 2012). Two other surplus killing events in 2012 in two different lakes produced an extra loss of almost 50 individuals overnight, including adults, chicks, and juveniles (Fasola and Roesler 2016). In Chile, American mink predate on protected native fauna such as straight-billed curlew *Limosa haemastica* and monito del monte *Dromiciops gliroides* (Suárez-Villota et al. 2023). Flightless steamer duck *Tachyeres pteneres* and upland goose *Chloephaga picta* nest survival have also been severely reduced by mink predation on Navarino Island, Chile (Schüttler et al. 2010). On Navarino Island, Crego et al. (2018) raise concerns regarding the behavioral flexibility exhibited by the species there (diurnal activity away from aquatic habitats) that can, through adaption to suboptimal habitats, lead to ecological disruptions that are more severe than previously predicted based on the ecology of the species in its native habitat.

According to Global Invasive Species Database (2023) *Lontra felina* (EN) and *L. provocax* (EN) are threatened by the American mink in Chile. While no details are reported for *L. felina*, it seems that for *L. provocax* there is no evidence of a negative effect of the mink, although several studies have investigated competition between these mustelids and river otters (Medina 1997, Aued et al. 2003, Fasola et al. 2009, Valenzuela et al. 2013). Current studies in the marine part of the range suggest a negative effect of otters over mink through habitat (Valenzuela et al. 2013) and temporal segregation (Medina-Vogel et al. 2013). The invasive mink is a potential vector of CDV to otters given their behavioural similarities and sharing of latrines (Sepúlveda et al. 2014).

In Russia, the American mink has had a significantly negative impact on populations of the Critically Endangered European mink, which is rapidly becoming less abundant in comparison with American mink. For instance, in the Vologda and Kostroma regions the proportion of European mink skins in the hunting bag of the two mink species decreased from 50–70% to 1–10% in the 5–7 years until 2006 (Maran et al. 2016). For the whole of Russia recent records refer only to the capture of single European mink individuals or to local populations consisting of some tens of individuals (Skumatov and Saveljev 2006). In Belarus, a detailed ecological study of the ecology and behaviour of the two species was able to track the displacement of the European mink by the competitively superior American mink in the Upper Lovat River valley in the northeast of Belarus (Sidorovich and Macdonald 2001, Maran et al. 2017), and European mink are now believed to be extinct in Belarus (Harrington and Maran 2025).

The American mink is one of the main factors involved in the near extinction of the water vole *Arvicola terrestris* in the UK (Woodroffe et al. 1990, Aars et al. 2001, Strachan et al. 2011, Wijas et al. 2019) and is responsible for the loss of important colonies of ground-nesting sea birds (common terns, *Sterna hirundo*, black-headed gulls, *Chroicocephalus ridibundus*, and common gulls, *Larus canus*) on the coast of Scotland (Craik 1997; Clode and Macdonald 2002).

In Iceland, the American mink is believed to have had negative impacts on colonies of Atlantic puffin *Fratercula arctica* and black guillemot *Cepphus grylle*, affected the distribution and perhaps number of ducks, regularly caused damage in common eider *Somateria mollissima* breeding colonies, probably also caused declines in the horned grebe *Podiceps auritus* population, and in conjunction with habitat destruction by wetland drainage is believed to have caused the extinction of the water rail *Rallus aquaticus* in the 1970s (Stefánsson et al. 2016).

Qu. 4.2. How important is the current known impact of the organism on biodiversity at all levels of organisation (e.g. decline in native species, changes in native species communities, hybridisation) in the risk assessment area (include any past impact in your response)?

Discuss impacts that are currently occurring or are likely occurring or have occurred in the past in the risk assessment area. Where there is no direct evidence of impact in the risk assessment area (for example no studies have been conducted), evidence from outside of the risk assessment area can be used to infer impacts within the risk assessment area.

RESPONSE		CONFIDENCE	
	minimal		low
	minor		medium
	moderate		high
	major		
	massive		

Response:

Through ecological competition American mink affects several native carnivores. Crucially, in several countries, the American mink is considered the main reason for the disappearance of the Critically Endangered European mink (Harrington and Maran 2025, Maran et al. 1998, 2011, 2016, 2017, Sidorovich and Macdonald 2001). It is essential to realize that the European mink has a much narrower ecological niche than the American mink, both in habitat selection and food selection (Maran and Henttonen 1995). The much reduced and fragmented range of the European mink means that it is now in serious danger of imminent extinction (Maran et al. 2011). In Spain, one of the European mink's last strongholds, it has been estimated that if American mink control stopped, the European mink would be extinct in no more than 10 years (Põdra et al. 2013, Zuberogoitia et al. 2013). The mechanism involved in this case is interspecific aggression (evidence summarised in Maran et al. 2017); however, experience in Spain suggests that American mink will also actually kill as well as aggressively displace European mink, although they do not eat them (Põdra et al. 2013). Consequently, several experts have concluded that even low numbers of American mink are prohibitive to future restoration attempts for the European mink (Põdra et al. 2013, Zuberogoitia et al. 2013, Santulli et al. 2014, García et al. 2020, DREAL et al. 2021).

The American mink may also affect other small mustelids such as the European polecat (Barrientos 2015, Brzeziński et al. 2021, 2022) and stoat (Sidorovich 2000b, Sidorovich and Solovej 2007). The mechanism underpinning the decline in stoats is most likely a reduction in the density and distribution of their main prey, the riparian voles (the water vole *Arvicola terrestris* and the root vole *Microtus oeconomus*), due to excessive predation by mink (Sidorovich and Solovej 2007). Polecats in some regions have also declined significantly following the introduction of American mink (Melero et al. 2012, Sidorovich and Macdonald 2001) with a male-biased sex ratio suggesting that female polecats are susceptible to

interspecific aggression as European mink are (Barrientos 2015, Sidorovich 2000b). In the Białowieża Primeval Forest, Poland, however, European polecats appeared to be unaffected by the arrival of American mink (Martínez-Cruz et al. 2022), suggesting that unlike for the European mink, there appears to be some variation among sites (summarized in Croose et al. 2018).

American mink predation seriously damages waterfowl, small mammal, amphibian and fish populations across mainland Europe and on a number of isolated islands (Macdonald et al. 2002, Nordström et al. 2002, 2003, Ahola et al. 2006, Fischer et al. 2009, Roy et al. 2009, Melero et al. 2012, Brzeziński et al. 2020, Jaatinen et al. 2022), and it may launch small-scale trophic cascades, e.g. affecting plant biodiversity through its predation on voles, which are the main grazers on the small islands in the archipelago of SW Finland (Fey et al. 2009).

In the archipelago of SW Finland, the numbers of seabirds nesting in colonies (razorbills and black guillemots) declined dramatically after the invasion of American mink in the 1970s. Subsequently, American mink eradication experiments in the Baltic Sea resulted in the return of regionally extinct bird species, or in the increase in the number of rare species in the area (Nordström et al. 2002), indicating that the invasion of American mink is detrimental (but potentially reversible) to species that are already rare and/or endangered. In Ireland, the American mink is identified as an ongoing threat to the conservation status of burrow-nesting seabirds such as puffin *Fratercula arctica*, Manx shearwater *Puffinus puffinus* and storm petrel *Hydrobates pelagicus*. Cummins et al. (2019) concluded that if mammalian predators (including American mink amongst others) “...are left unchecked and allowed to occupy further seabird islands, then significant declines in seabird breeding populations and range declines are inevitable. A programme of eradication projects in association with the creation of biosecurity plans for our important offshore colonies is urgently required.” Drastic decreases of coot and grebe density were also observed in Poland (Brzeziński et al. 2012). In northern Greece, a breeding colony of Pygmy cormorants *Phalacrocorax pygmeus* on Kastoria lake was abandoned in 2011 following a large release of American mink from nearby mink fur farms in 2010, and the colony has not recovered since then (Toskos 2011). Heavy predation by mink on waterfowl, amphibians, the grass snake *Natrix tessellata*, and stone crayfish *Austropotamobius torrentium* has also been observed in various regions of the Czech Republic (Fischer et al. 2009 and references therein). Mink on small isolated islands in the SW archipelago in Finland also had a significant impact on the bank vole *Clethrionomys glareolus*, field vole *Microtus agrestis*, and common frog *Rana temporaria* (Banks et al. 2004, 200, Ahola et al. 2006, Salo et al. 2010).

Qu. 4.3. How important is the potential future impact of the organism on biodiversity at all levels of organisation likely to be in the risk assessment area?

See comment above. The potential future impact shall be assessed only for the risk assessment area. A potential increase in the distribution range due to climate change does not *per se* justify a higher impact score.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

American mink colonisation into new areas may cause significant additional effects on native, threatened, or endemic species, which would be even more concerning in the case of introductions to island ecosystems.

The European mink is of most immediate concern. This species currently persists in small isolated populations in areas that are largely free of (although continually encroached by) American mink – thus, further spread of American mink north in Spain, invasion in France, or in Romania would present a serious threat to the persistence of those populations (Hegyeli and Kecskés 2014, Maran et al. 2017, DREAL et al. 2021) and would likely cause the extinction of European mink in Europe.

In Italy, the distribution of the American mink is currently relatively limited but is expanding (see Section A). Further expansion in the northeast raises concerns regarding the impact of predation on the endemic Italian water vole *Arvicola italicus* (Mori and Mazza 2019). Mori et al. (2022) also suggest that on-going expansion in the Northern Apennine ridge should be closely monitored to protect future impacts on two species of endangered native freshwater crustacean species (the white-clawed crayfish *Austropotamobius pallipes* complex and the freshwater crab *Potamon fluviatile*) which may represent important prey for the American mink and are already threatened by an invasive and uncontrolled population of northern raccoons *Procyon lotor*. In Sardinia, there is a risk of impacts on a number of endemic freshwater amphibians found on the island (Dettori et al. 2016).

A potential impact of the American mink on the Pyrenean desman *Galemys pyrenaicus* has been suggested by several authors (Gisbert and García-Perea 2014, Pedroso and Chora 2014, Biffi et al. 2016, Charbonnel et al. 2016) but has never been properly investigated (Biffi et al. 2019).

Qu. 4.4. How important is decline in conservation value with regard to European and national nature conservation legislation caused by the organism currently in the risk assessment area?

including the following elements:

- native species impacted, including red list species, endemic species and species listed in the Birds and Habitats directives
- protected sites impacted, in particular Natura 2000
- habitats impacted, in particular habitats listed in the Habitats Directive, or red list habitats
- the ecological status of water bodies according to the Water Framework Directive and environmental status of the marine environment according to the Marine Strategy Framework Directive

RESPONSE		CONFIDENCE	
	minimal		low
	minor		medium
	moderate		high
	major		
	massive		

Response:

Within the risk assessment area, American mink competition/predation has directly caused changes in the conservation status of the European mink, listed on the IUCN Red List as Critically Endangered since 2011 and recorded as extinct in 19 countries across Europe and central Asia. The European mink is protected by the Bern Convention on the Conservation of European Wildlife and Natural Habitats, the Habitats Directive Annex II and IV, and national legislation in several Member States.

Across Europe and across taxa there is evidence of an effect of American mink invasion on at least three globally Endangered or Critically Endangered species: *Austropotamobius pallipes* (EN), *Galemys pyrenaicus* (EN), and *Mustela lutreola* (CR) (Global Invasive Species Database 2023, Genovesi et al. 2012). The conservation status of several other threatened and endemic species within the risk assessment area is also at risk as a result of potential predation impacts (see Qu. 4.2, Table 2).

Table 2: Species impacted by American mink in the risk assessment area and their global and European conservation status.

Species Name	IUCN Red List status	Habitat Directive	Bird Directive
European mink (<i>Mustela lutreola</i>)	Critically Endangered	Annex 2 Annex 4	
White-clawed Crayfish (<i>Austropotamobius pallipes</i>)	Endangered	Annex 2	
Pyrenean desman (<i>Galemys pyrenaicus</i>)	Endangered	Annex 2 Annex 4	
Atlantic puffin (<i>Fratercula arctica</i>)	Vulnerable (Endangered in Europe)		
Horned grebe (<i>Podiceps auritus</i>)	Vulnerable (Near Threatened in Europe)		Annex I
Velvet Scoter (<i>Melanitta fusca</i>)	Vulnerable		Annex II/2
Common eider (<i>Somateria mollissima</i>)	Near Threatened (Endangered in Europe)		Annex II/2 Annex III/2
Freshwater crab (<i>Potamon fluviatile</i>)	Near Threatened		
Water vole (<i>Arvicola amphibius</i> , = <i>A. terrestris</i>)	Least Concern		
Black guillemot (<i>Cepphus grylle</i>)	Least Concern		
Bank vole (<i>Clethrionomys glareolus</i>)	Least Concern		
Common gulls/Mew Gulls (<i>Larus canus</i>)	Least Concern		Annex II/2
Black headed gulls (<i>Larus Chroicocephalus ridibundus</i>)	Least Concern		Annex II/2
Pygmy cormorants (<i>Microcarbo pygmaeus</i>)	Least Concern		
Field vole (<i>Microtus agrestis</i>)	Least Concern		
Root vole (<i>Microtus oeconomus</i>)	Least Concern	Annex 4	
Stoat (<i>Mustela erminea</i>)	Least Concern		
European polecat (<i>Mustela putorius</i>)	Least Concern	Annex 5	
Grass snake (<i>Natrix tessellata</i>)	Least Concern	Annex 4	
Common frog	Least Concern	Annex 5	

(<i>Rana temporaria</i>)			
Water rail (<i>Rallus aquaticus</i>)	Least Concern		Annex II/2
Brown trout (<i>Salmo trutta</i>)	Least Concern		
Arctic charr (<i>Salvelinus alpinus</i>)	Least Concern		
Common terns (<i>Sterna hirundo</i>)	Least Concern		Annex I
Storm petrel (<i>Hydrobates pelagicus</i>)	Least Concern		Annex I
Manx shearwater (<i>Puffinus puffinus</i>)	Least Concern		
Italian water vole (<i>Arvicola italicus</i>)	No record		
Stone crayfish (<i>Austropotamobius torrentium</i>)	Data deficient	Annex 2	

The conservation value of protected areas has declined accordingly in many areas (islands, wetlands etc.). Globally, the American mink is found in 1,251 protected areas (and is the second most common invading mammal in protected areas, Liu et al. 2020). In Greece, 88% of fur farms (and associated risk of further entry) are within 10 km of protected areas (Galanaki and Kominos 2022). Other protected areas in the risk assessment area are at risk of encroachment of American mink (e.g. the Foreste Casentinesi National Park in Italy, Mori et al. 2022) or are already colonized (e.g. the Donau-Auen National Park in Austria, Zulka et al. 2021).

Considering the distributional information used for the Species Distribution Model (Annex VIII), which includes point data with high, but also grid data with low spatial accuracy, the species is present in or close to hundreds of Natura 2000 sites across all Member States, with Denmark, France, Spain, and Sweden being most affected (Table 3).

*Table 3: Presence of American mink in or near Natura 2000 sites (designated under the Bird Directive, Habitats Directive, or both, double-counting is excluded) across Member States. Because of the low spatial resolution of some occurrences, the numbers are combined into classes and have indicative value only. *The relatively small number of Natura 2000 sites in Finland is considered a data artefact and not corresponding to the real situation; it is assumed that American mink is present in > 100 Natura 2000 sites in Finland.*

Number of Natura 2000 sites	Member States
> 100	Denmark, France, Spain, Sweden
50-100	Germany, Ireland,
10-50	Estonia, Finland*, Italy, Poland, Portugal, Slovakia
< 10	Austria, Czech Republic, Latvia, Lithuania, Bulgaria

Relatively little is known of the impact of American mink on fish and macro-invertebrate populations. A recent study in Finland demonstrated that predation by mink can cause high mortality among juvenile brown trout *Salmo trutta* in small streams (Vehanen et al. 2022). In Iceland, unconfirmed claims by farmers and fishermen suggest negative impacts on local populations of Arctic charr *Salvelinus alpinus* in small streams (Stefánsson and references therein). In the Czech Republic, Fischer et al. (2009) suggested that the American mink could

be an important mortality factor for stone crayfish *Austropotamobius torrentium* at a local scale. It is possible that the American mink affects aquatic biodiversity more broadly and therefore, by virtue of potentially altered aquatic community structure, could be expected to cause a decline in the ecological status of water bodies according to the Water Framework Directive across the risk assessment area.

Qu. 4.5. How important is decline in conservation value with regard to European and national nature conservation legislation caused by the organism likely to be in the future in the risk assessment area?

- See guidance to Qu. 4.3. and 4.4.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

In the future, given the expected spread of American mink, and the likelihood of sustained competition/predation pressure from the species, significant declines in conservation value within the risk assessment area could potentially be caused through impacts on any of the species referred to in Qu. 4.2. Those species that are already threatened (e.g. the white-clawed crayfish and Pyrenean desman) or are endemic (e.g. the Italian water vole) might be most vulnerable but impacts elsewhere on previously common species (e.g. the water vole in the UK) suggest that any species could be at risk, especially on island ecosystems.

Given the current highly perilous state of the Critically Endangered European mink in the risk assessment area there is a very real risk that the American mink could be the cause of the first mammalian extinction in Europe since the 18th century (European Parliament 2021).

Ecosystem Services impacts

Qu. 4.6. How important is the impact of the organism on provisioning, regulating, and cultural services in its non-native range excluding the risk assessment area?

- For a list of services use the CICES classification V5.1 provided in Annex V.
- Impacts on ecosystem services build on the observed impacts on biodiversity (habitat, species, genetic, functional) but focus exclusively on reflecting these changes in relation to their links with socio-economic well-being.
- Quantitative data should be provided whenever available and references duly reported.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

American mink affects aquatic, semi-aquatic, and riparian biodiversity in its non-native range and therefore, by virtue of potentially altered community structure may have impacts on Cultural Services in these environments by reducing the qualities of the ecosystem that make it attractive for recreation. Bird watching in particular (and eco-tourism) may be impacted in coastal areas where American mink predation results in declines, and collapsed colonies, of ground-nesting birds (Moore et al. 2000). American mink is likely to have some negative impact on Provisioning Services, provided by various sectors who rear terrestrial and aquatic animals for food (nutritional) or other purposes, including domestic poultry and waterfowl production, aquaculture, commercial recreational fish ponds, and game bird rearing. Impacts on Regulation Services (e.g. pest and disease control, maintaining nursery populations and habitats) cannot be ruled out.

Qu. 4.7. How important is the impact of the organism on provisioning, regulating, and cultural services currently in the different biogeographic regions or marine sub-regions where the species has established in the risk assessment area (include any past impact in your response)?

- See guidance to Qu. 4.6.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

American mink affects aquatic, semi-aquatic, and riparian biodiversity in the risk assessment area and therefore, by virtue of potentially altered community structure may have impacts on Cultural Services in these environments by reducing the qualities of the ecosystem that make it attractive for recreation. Bird watching in particular (and eco-tourism) may be impacted in coastal areas where American mink predation results in declines, and collapsed colonies, of ground-nesting birds (Moore et al. 2000). American mink is likely to have some negative impact on Provisioning Services, provided by various sectors who rear terrestrial and aquatic animals for food (nutritional) or other purposes, including domestic poultry and waterfowl production, aquaculture, commercial recreational fish ponds, and game bird rearing. Impacts on Regulation Services (e.g. pest and disease control, maintaining nursery populations and habitats) cannot be ruled out.

Qu. 4.8. How important is the impact of the organism on provisioning, regulating, and cultural services likely to be in the different biogeographic regions or marine sub-regions where the species can establish in the risk assessment area in the future?

- See guidance to Qu. 4.6.

RESPONSE	minimal minor moderate	CONFIDENCE	low medium high
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	major massive		
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Response:

As for Qu. B4.7 – these impacts might be expected to increase in the future with further expansion and spread of American mink populations in all biogeographic regions, but could also decrease locally in areas of declining suitability. Impacts probably are reversible, local and temporary, and effect few services.

Economic impacts

Qu. 4.9. How great is the overall economic cost caused by the organism within its current area of distribution (excluding the risk assessment area), including both costs of / loss due to damage and the cost of current management.

- Where economic costs of / loss due to the organism have been quantified for a species anywhere in the world these should be reported here. The assessment of the potential costs of / loss due to damage shall describe those costs quantitatively and/or qualitatively depending on what information is available. Cost of / loss due to damage within different economic sectors can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage. As far as possible, it would be useful to separate costs of / loss due to the organism from costs of current management.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

There are limited data available on the actual economic costs caused by the American mink outside of the risk assessment area. However, it is known that the American mink may impact various economic sectors – primarily poultry and domestic waterfowl, fish farming, and game bird rearing operations by preying on fish, chickens and other farm birds, and reared game birds (Harrison and Symes 1989).

In the UK, mass killings (sometimes in excess of 100 birds) of pheasant poults and reared mallards in pens were reported in the mid-1980s; during the same period, 16% of trout farmers surveyed regarded mink damage (predation/damage to fish, and damage to cages/netting) as a serious problem (Harrison and Symes 1989). At the time, Harrison and Symes (1989) concluded that there were no major economic costs associated with the American mink in the UK but that local, individual costs might be significant. In the late 2000s, 35% of fish farms in Wales perceived mink to have a detrimental impact on their business (Kelly et al. 2013). On the Outer Hebridean Islands in Scotland, prior to eradication of the American mink there, mink caused significant damage to salmon farming interests, particularly during the parr and smolt stages, where they ate fish, damaged the netting allowing some fish to escape or simply damaged fish which reduced their subsequent value;

on occasion they were reported to bite and kill, or release (via damaged nets) large numbers of fish - in one incident, mink were responsible for the escape of 14,500 smolts (costing £11,600 at the time, Moore et al. 2000). Mink were also believed to be a major contributory factor in the decline in free-range chickens on Lewis and Harris: the observed 90% reduction in the number of crofts keeping chickens was estimated to equate to a loss to the islands' economy of nearly £600,000 per year as a result of reduced egg production.

In Bulgaria, killing or injury of over 50 domestic or pet animals by mink has been reported. Furthermore, mink are observed to settle near fishponds and aquaculture facilities where they catch fish and damage the nets causing mass escape of the fish and economic losses (Koshev 2019).

Economic impacts on eco-tourism are also possible where tourism is heavily dependent on bird watching (and American mink predation results in declines, and collapsed colonies, of ground-nesting birds, Moore et al. 2000). These types of losses are extremely difficult to quantify.

The only national-level cost for the damage caused by American mink that we were able to find was for Chile, where the authors estimated a total cost to the Chilean economy of 9.5 million USD per year and 417 million USD projected over the next two decades (predominantly due to the negative impacts on biodiversity, Araos et al. 2020).

The cost of management has been reported for two major American mink removal initiatives in Scotland. Between 2001 and 2006, the Hebridean Mink Project (HMP) successfully eradicated invasive mink from 1,100 km² of the southern islands of the Hebridean Archipelago, in Scotland at a cost of £1.6 million (Roy and Robertson 2017). Subsequent extension of the HMP to include the two northern islands, covering a total area of 3,050 km², cost a total of £5.26M over 16 years (Macleod et al. 2019). Long-term efforts to control American mink in northern Scotland, beginning with an area of 30 km² in 2004 extending to > 29,000 km² by 2018 – 2022, cost a total of £2.8 million (although the cost-effectiveness of this project was achieved by the use of a workforce of 866 unpaid “citizen-conservationist” volunteers, crudely valued at an additional £1.4 million, Lambin et al. 2019). Based on experience to date and the known costs of trapping equipment, Martin and Lea (2020) estimate that a GB-wide mink eradication campaign would be likely to cost in the high tens of millions of pounds sterling.

Combining costs of damage and management, Cuthbert et al. (2021) report American mink to be the third highest contributor to the monetary cost of invasive species in the semi-aquatic environment worldwide.

Qu. 4.10. How great is the economic cost of / loss due to damage (excluding costs of management) of the organism currently in the risk assessment area (include any past costs in your response)?

- Where economic costs of / loss due to the organism have been quantified for a species anywhere in the EU these should be reported here. Assessment of the potential costs of damage on human health, safety, and the economy, including the cost of non-action. A full economic assessment at EU scale might not be possible, but qualitative data or different case studies from across the EU (or third countries if relevant) may provide useful information to inform decision making. In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer “No information has been found on the issue”. This is necessary to avoid confusion between

“no information found” and “no impact found”. In this case, no score and confidence should be given and the standardized “score” is N/A (not applicable). Cost of / loss due to damage within different economic sectors can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

As in various countries outside the risk assessment area (see Qu. 4.9), the American mink is likely to have economic impacts within the risk assessment area on various sectors including domestic poultry and waterfowl production, aquaculture, commercial recreational fish ponds, game bird rearing, and potentially eco-tourism (where, for example, ground-nesting seabird colonies are a major tourist attraction). However, there are limited data available on the actual economic cost of American mink damage in the risk assessment area.

In Ireland, in the late 2000s, over 70% of finfish farmers considered mink a pest and 60% reported suffering economic losses to the species (Kelly et al. 2013 and references therein). Monetary losses for the finfish industry in Ireland were estimated as follows: mean yearly loss on fish farms = Euro 849.40 (range 40-22,400), mean yearly losses to the industry = Euro 47,566 (range 2,240-112,000), given an industry value of approximately 60 million Euro, this equates an economic loss of 0.07% of the income generated by finfish (Kelly et al. 2013).

Not much is known about direct economic losses caused by mink elsewhere. In Germany, several exceptional instances have been reported: of 250 one-year-old carp that were eaten, or 10 koi, or 40 goldfish (Reinhardt et al. 2003). In general, a mink can be expected to take up to five kilograms of trout in the course of a winter from trout hatcheries, at a cost of 3.07 Euro/kg (Reinhardt et al. 2003).

Qu. 4.11. How great is the economic cost of / loss due to damage (excluding costs of management) of the organism likely to be in the future in the risk assessment area?

- See guidance to Qu. 4.10.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

There are no data on projected costs of damage that we are aware of; however, costs should be expected to rise as American mink numbers increase and spread, and the extent of damage increases proportionally. Costs for the re-introduction of European mink can be significant

(e.g. LIFE00 NAT/EE/007081, LUTREOLA,
<https://webgate.ec.europa.eu/life/publicWebsite/project/details/1630>).

Qu. 4.12. How great are the economic costs / losses associated with managing this organism currently in the risk assessment area (include any past costs in your response)?

- In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer “No information has been found on the issue”. This is necessary to avoid confusion between “no information found” and “no impact found”. In this case, no score and confidence should be given and the standardized “score” is N/A (not applicable).

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

Reliable estimates of costs for the management of the American mink can be extracted from the LIFE database, because there are LIFE projects which were financed since the early 2000s for protecting native fauna in the EU (see <https://webgate.ec.europa.eu/life/publicWebsite/search>). For example, between 2000 and 2002, four LIFE Nature projects were funded in Cataluña, La Rioja, Álava and Castilla and León regions in Spain (LIFE00 NAT/E/7331, LIFE00 NAT/E/7335, LIFE00 NAT/ E/7299, LIFE02 NAT/E/8604) for a total of 1,883,656 Euro (Scalera and Zaghi 2004). Their objective was to develop a collaborative framework to protect the only relatively healthy population of the native European mink in Western Europe. Another important project aimed at the control of the American mink was carried out in the Western Isles to protect important birds in SPAs (LIFE00 NAT/UK/7073) for a total amount of 2,762,834 Euro (Scalera and Zaghi 2004). LIFE ATIAS project (LIFE18/NAT/GR/000430) (2019-2024) addresses the threat of invasive alien species in Northern Greece, using early warning and information systems for mammals, for a total budget of 1,988,770 €. The main aim of the project is eradication or at least containment of the spread of the feral population of the American mink before it can severely damage biodiversity in Greece (<https://lifeatias.gr/>).

The yearly estimated costs for mink trapping in the Archipelago National Park, SW Finland were around 10,000 Euro in 2009 (J. Högmander, pers. comm.). Methods included traps and scent dogs. Removal began in 1992 in one area which has since expanded to cover over 800 km² of the outer archipelago. This area can be considered mink-free, but if mink removal ceases it would be rapidly invaded again. Most islands are not isolated enough to prevent mink from re-entering. The Finnish archipelago project has been running for over 20 years. Other, short-term projects in Finland before 2009 have had costs < 30,000 Euro. It should be noted that most mink control activities in Finland are performed by voluntary hunters (either during “normal” trapping practices or dedicated campaigns), but the efficiency and spatial scale of these trapping schemes is unknown (Pälvi Salo, pers. comm.). Annual eradication costs using professional hunters in the archipelago area are estimated to be ca. 100 000 Euros (based on the SOTKA-project run by Metsähallitus, including both American mink and

raccoon dog (<https://julkaisut.metsa.fi/julkaisu/luonnonhoidollinen-vieraspetopyynti-saaristossa-sotka-hankkeen-tuloksia/>).

Protection of ground-nesting birds from mammalian predators (including mink) is an important element of two ongoing LIFE projects in Ireland (*Corncrake LIFE* and *LIFE on Machair*). Predator control is managed jointly for both LIFE projects by Nest Protection Officers who are typically paid €240–€250 per day. The overall cost for predator control across the two programmes, which between them cover a significant area along the west coast of Ireland, is in the order of €350,000 per annum (John Carey, Project Manager, Corncrake LIFE, pers. comm.).

The InvaCost database (Diagne et al. 2020) provides post-invasion management costs for Navarra, Spain, over 12 years (2008–2020) at > 300,000 Euro (ca. 25,000 Euro per year) and for Finland (for 2009) at 47,000 Euro (without further details). In another study from Spain, the cost of eradicating the species from an area of 174 km² was estimated to cost in the range of Euro 58,300 to 172,500 (Zuberogoitia et al. 2010).

National-level costs for mink management have been estimated for four countries in the risk assessment area: Germany (see Qu. 4.13), Finland, Spain, and Ireland (note that we present original costs from different time periods that are not directly comparable without adjusting for different levels of inflation).

Zabala et al. (2010) estimated the cost of eradicating mink from Spain. They modelled costs based on experience gained from small scale eradication programmes. They estimated that the cost of removing mink from the five population centres in Spain covering 633 x 10 km squares in Spain would cost between 3 and 13 million Euro over a year (Zabala et al. 2010). This estimate was solely based on the removal of the species from river systems (and not coastlines) using live-traps. A more recent estimate is provided by the Spanish Strategy for mink eradication and control (MAGRAMA 2014) which estimates minimum yearly costs of mink control at Euro 1.8 million, although the most recent methods of trapping (using mink rafts) are not considered.

In Ireland, Kelly et al. (2013) estimate that finfish farms each spend, on average, 761.20 Euro a year (range 17.30–5,190) controlling American mink.

The cost of control activities (trapping, monitoring) can be reduced using more effective methods. The studies carried out in UK (not within the risk assessment area but relevant in terms of methodology) and results from Spain demonstrate that the detection and capture of American mink is significantly more economic using the mink rafts method (Reynolds et al. 2004, Harrington et al. 2009a, Tragsatec 2015). Rafts can save manpower primarily by pre-defining where and when to direct trapping effort. Rafts can be operated by citizen conservationists who call upon a trained person only when a mink is caught, making it possible to have control over very large spatial scales (Bryce et al. 2011). Efficiency is improved even further with the use of ‘smart’ rafts that send a phone signal to alert a trapper when there is a mink in the trap (removing the requirement, and resources required, to check the traps daily, Martin and Lea 2020). Although their use is limited in fast flowing or tidal waters so they are not suitable in highland or coastal sites.

Qu. 4.13. How great are the economic costs / losses associated with managing this organism likely to be in the future in the risk assessment area?

- See guidance to Qu. 4.12.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

It is difficult to estimate precise costs particularly over large scales, and whilst some estimates exist in the literature, they do not always use the most cost-effective methods. What is certain is that the costs will increase if mink continue to proliferate and spread in Europe.

For example, Kelly et al. (2013) estimate the cost of eradicating the species from Ireland based on its distribution at the time (410 x 10 km squares) as between Euro 41.1 million and 53.6 million over five years. But if eradication was left to the point when mink were present across the whole of Ireland (84,043 km²) they suggest that the cost would double to between Euro 84 and 111 million.

In Germany, eradication in 2002 was estimated to cost between 12.9 and 43 million Euro. In the event of mink spreading to all of Germany, the costs were predicted to quadruple to between 49 and 163 million Euro (Reinhardt et al. 2003).

Social and human health impacts

Qu. 4.14. How important is social, human health or other impact (not directly included in any earlier categories) caused by the organism for the risk assessment area and for third countries, if relevant (e.g. with similar eco-climatic conditions).

The description of the known impact and the assessment of potential future impact on human health, safety and the economy, shall, if relevant, include information on

- illnesses, allergies or other affections to humans that may derive directly or indirectly from a species;
- damages provoked directly or indirectly by a species with consequences for the safety of people, property or infrastructure;
- direct or indirect disruption of, or other consequences for, an economic or social activity due to the presence of a species.

Social and human health impacts can be a direct or indirect consequence of the earlier-noted impacts on ecosystem services. In such case, please provide an indication of the interlinkage.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

The American mink may be a threat for human health and welfare, particularly through the transmission of zoonoses. The following outlines briefly what is known currently of zoonoses in American mink – to date, no cases of human mortality (or significant health or welfare impact) have been reported as a direct consequence of spread of pathogens and diseases by the American mink. However the diversity of zoonoses involved together with specific cases (e.g. SARS-CoV-2, the virus responsible for covid-19) and relevant impacts, mean that American mink (particularly in high density captive environments) represent a moderate risk.

Like other alien mammals (see review by Capizzi et al. 2018), American mink can act as vectors of both alien and native pathogens, and as host of either native or alien parasites (which in turn can be acting as vectors of either native or alien pathogens). In this way American mink may introduce new pathogens, alter the epidemiology of local pathogens, become reservoir hosts, and increase disease risk for humans (along with other species, see Prenter et al. 2004, Dunn 2009) by harbouring and spreading important pathogens or parasites. For example, it is documented that American mink can serve as hosts for a number of zoonosis including leptospirosis, trichinellosis, toxoplasmosis and Hepatitis E (Barros et al. 2014, Krog et al. 2013, Hurníková et al. 2016, Zheng et al. 2016).

The potential impact (depending on the associated pathogens) of the American mink as host for zoonotic diseases was summarised by Purse et al (2020), these authors identified Influenza A (Spain), Ascaridinae, *Cryptosporidium* sp., *Leptospira* spp. (*L. interrogans*, *L. borgpetersenii*), and *Pterygodermatites* (*Paucipectines*) spp. (Chile), *Echinococcus* sp. and *Toxocara* sp., (Poland), *Toxoplasma gondii* (Spain) (Gholipour et al. 2017, Kołodziej-Sobocińska et al. 2020, Ramírez-Pizarro et al. 2019, Barros et al. 2014, Ribas et al. 2018). Another recent review by Warwick et al. (2023) listed the following zoonotic and cross-species infections associated with fur farmed American mink: *Salmonella* spp., Carnivore amdoparvovirus/ *Parvovirus* spp., Influenza A virus, *Eimeria* spp., *Isospora* spp., *Cryptosporidium* spp., *L. infantum*, Microsporidia/ *Enterocytozoon bieneusi*.

The role of the American mink in the transmission cycle of zoonotic parasites such as *Leishmania infantum* and *T. gondii* in Europe is also described by Bezerra-Santos et al. (2023). In particular , *L. infantum*, described as a protozoan that infects several domestic and wild hosts worldwide, was detected in American mink in Greece and Spain (Dantas-Torres et al. 2012, Tsakmakidis et al. 2019, Azami-Conesa et al. 2021, Ribas et al. 2018), suggesting that this species may be a potential reservoir host for the parasite in Europe. In addition, *T. gondii*, was detected in American mink in Spain (Ribas et al. 2018), and *Trichinella* spp. in American mink in Poland (Hurníková et al. 2016).

A recent review suggested that 49% of the pathogens known to infect the American mink have zoonotic potential (Tedeschi et al. 2022).

Because of their use in mink farms, their role as zoonotic reservoirs at the interface with humans, pets and livestock, is also well known. For example, in mink farms with frequent contacts between minks and humans, Aleutian mink disease parvovirus may play a role in human health: two mink farmers in Denmark have been infected (Jepsen et al. 2009).

In October 2022, mink at a fur farm in Galicia, Spain, tested positive for H5N1 – the first documented case of highly pathogenic avian influenza H5N1 clade 2.3.4.4b in fur farm mink in Europe (Agüero et al. 2023). None of the farm workers were infected, but there was evidence suggesting possible spread of H5N1 from mink to mink (as in the later case in Finland, below, Lindh et al. 2023) – this is an uncommon trait of the virus, which is usually

only passed on through infected birds (Hulme 2023). The virus had a mutation (T271A) in the PB2 gene, with unknown biological impact, but potentially a major concern for global public health (Agüero et al. 2023). In July 2023, H5N1 was detected in 26 fur farms across the South and Central Ostrobothnia regions of Finland, where samples confirmed signs of mammal adaptation in the PB2 genes (mutations T271A and E627K, Lindh et al. 2023) (this number has risen to 71 farms as of autumn 2023; Finnish Food Authority, <https://www.ruokavirasto.fi/teemat/lintuinfluenssa/#lintuinfluenssa-turkistarhoilla>) with 124,000 mink being culled. Dead animals exhibited no obvious cause of disease but had lesions in the lungs and signs of septicaemia. Follow-up investigation by the Finnish Food Authority (FFA) revealed symptoms characteristic of HPAI H5N1 virus infection in mammalian species (lethargy, neurological signs, diarrhoea, rapid death) occurring among the fur animals on affected farms. Subsequently, the causative agent was confirmed by PCR at FFA to be HPAI H5N1 virus clade 2.3.4.4b. The virus was most likely introduced from wild birds scavenging for food in farm areas (Lindh et al. 2023). Nothing is known of H5N1 on mink farms elsewhere (e.g. in Poland) (H5 is not a notifiable disease on mink farms) (Hulme 2023).

The complex (and potentially hugely serious) nature of the interactions between Invasive Alien Species and zoonotic disease was highlighted during the covid-19 global pandemic, as evidence in relation to SARS-CoV-2, farmed mink, and the potential for spillback of pathogens from mink to humans and other animals was obtained rapidly from on-going priority disease monitoring and research (Purse et al. 2020; Roy et al. 2022).

SARS-CoV-2-infected mink were reported on fur farms across Europe - namely in the Netherlands, Denmark, France, Greece, Italy, Spain, Sweden, Poland, Lithuania, Bulgaria - and North America - i.e. United States and Canada (OIE 2021, Warwick et al. 2023). In fur farm in Bulgaria in 2023 during routine testing of 118 minks, 98 individuals or 83% of all tested animals were positive for COVID-19 (<https://wahis.woah.org/#/in-review/5293>). Whole-genome sequencing of the virus isolated from mink on farms in the Netherlands provided evidence of both human-to-mink and mink-to-human transmission of the virus (Munnink et al. 2021, Fenollar et al. 2021). Further sequencing of samples from humans infected with mink-related SARS-CoV-2 in Denmark revealed that the virus had accumulated mutations with potentially adverse consequences for human health (Larsen et al. 2021, Fenollar et al. 2021). There were also reports of SARS-CoV-2-infected mink in the wild: an infected mink found in Utah near a fur farm in December 2020 represented the first case of a non-captive animal infected with this coronavirus. Another case (of a mink escaped from a fur farm and successfully recaptured) was reported in Oregon (Oregon Department of Agriculture News 2020). This situation should be of particular concern, considering the studies demonstrating the overlap in habitat use between free-ranging mink populations and farm animals (Hammershøj et al. 2005, Valnistry et al. 2020). A further case was reported in Spain with the capture of two American mink in the wild reportedly with SARS-CoV-2 infection, although in this case far from fur farms and with very low viral load (Aguiló-Gisbert et al. 2021; a larger study of mink in northern Spain failed to detect evidence SARS-CoV-2 infection, Villanueva-Saz et al. 2022). The clinical and pathological characteristic of the SARS-CoV-2 outbreaks in mink farms, documented in the Netherlands, was an acute interstitial pneumonia coupled with acute alveolar damage (Molenaar et al. 2020). Infected mink released in the wild can infect other species, including domestic species such as cats and dogs (Fenollar et al. 2021). Infectivity pattern analysis has illustrated that mink and bat coronaviruses have similar infectivity patterns with 2019-nCoV and confirm that mink may be one of the candidate reservoirs of SARS-CoV-2 (Guo et al. 2020). Because of the evidence of SARS-CoV-2 outbreaks in mink farms across several Member States, many facilities have

been closed and the animals dispatched as a precautionary principle, except in Greece, where the policy is to allow infected mink to recover (Gomez 2021).

Qu. 4.15. How important is social, human health or other impact (not directly included in any earlier categories) caused by the organism in the future for the risk assessment area.

- In absence of specific studies or other direct evidences this should be clearly stated by using the standard answer “No information has been found on the issue”. This is necessary to avoid confusion between “no information found” and “no impact found”. In this case, no score and confidence should be given and the standardized “score” is N/A (not applicable).

RESPONSE		CONFIDENCE	
	minimal		low
	minor		medium
	moderate		high
	major		
	massive		

Response:

American mink in farms have the potential for a massive impact on human health in the future in the risk assessment area. In farms, mink pose a risk for the emergence of future disease outbreaks and the evolution of future pandemics (Peacock and Barclay 2023).

Mink in farms are kept at high densities in wire cages that allow for rapid spread of airborne viruses (Peacock and Barclay 2023). These conditions, along with the low genetic diversity of farmed mink, allow for virus adaptation to animals that would be unlikely to occur in nature. Besides the evident risks with SARS-CoV-2, there is a risk within mink fur farms of the creation of a reservoir for influenza A viruses with the potential for serious zoonotic events (Kessler et al. 2021). Referring to the H5N1 case in a mink farm in Spain, Peacock and Barclay (2023) suggest that “we narrowly escaped a larger disaster”. Further, since farmed mink can contract human or swine, and avian influenza A viruses (AIVs), they could potentially act as ‘mixing vessels’ allowing reassortment of circulating influenza viruses (Hulme 2023). De Vries and de Haan (2023) raise concerns that adaptation of avian viruses to mink may provide a first step towards potential human-to-human transmission.

No human infections have been detected thus far in the current fur farm outbreak in Finland and, globally, there is no verified transmission of HPAI H5N1 virus infection from another mammal to humans. However, these outbreaks (see Qu 4.14) raise concerns for the future, not only in Spain and Finland but in the global context (EFSA et al. 2023, Lindh et al. 2023). No firm conclusions can yet be drawn on the current risks for fur animal-to-human or human-to-human transmission but there is a concern (based on well-established evidence) that prolonged replication of the HPAI H5N1 virus in a high-density mammalian population, such as in fur farms, might lead to viral forms that could more easily spread among humans (Lindh et al. 2023 and references therein).

Other impacts

Qu. 4.16. How important is the organism in facilitating other damaging organisms (e.g. diseases) as food source, a host, a symbiont or a vector etc.?

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

American mink can transmit diseases (e.g. Maran and Henttonen 1995, Mañas et al. 2001, 2016) of relevance to several native wildlife species and is therefore a potentially important vector. This is relevant in the wild (in terms of increasing pathogen prevalence as a result of the presence of an invasive species, e.g. Chinchio et al. 2020) and in captivity (in terms of the risk presented by infected escaping animals). In the wild, mink may also act as a bridging host between domestic species (e.g. domestic dogs) and wildlife; in this case, canine distemper virus (CDV) and canine parvovirus are of potential concern (Barros et al. 2022). The invasive mink is a potential vector of CDV to otters given the spatial and behavioural overlap between the two species (Sepúlveda et al. 2014). The possibility that wild populations might provide conditions for establishment of the SARS-CoV-2 virus in the environment has also been raised (Harrington et al. 2021, Delahay et al. 2021). Therefore, there is a possible indirect impact of the American mink as a disease reservoir, which could have a deeper impact on the survival of native European species, particularly small carnivores (such as other mustelids) through the transport of pathogens. Disease transmission could be critical for the European mink, in particular.

American mink are susceptible to Aleutian mink disease (AMD) caused by the Aleutian mink disease virus (AMDV, Mañas et al. 2001). AMD is an economically significant disease in mink farms (Vahedi et al. 2023) and AMDV also poses a health risk for other members of the family Mustelidae, including European mink, weasels, badgers and other animal species (Mañas et al. 2016, Zaleska-Wawro et al. 2021). AMD virus of American origin has been found in several native mammal species in Europe (Knuuttila et al. 2015). The diversity of AMD virus strains indicates several introductions into Finland (Virtanen et al. 2019). Prevalence of AMDV in wild populations is often high: 23.8% of 164 wild American mink in Iceland were confirmed to be infected with Aleutian mink disease virus (AMDV) with significant deterioration of body and spleen parameters in infected individuals (Panicz et al. 2021). Additionally, the prevalence of virus in the feral population was higher closer to fur farms. Amongst 144 free-ranging mink hunted in Sweden, 46.1% were found to be positive for AMDV antibodies and 57.6% were positive for AMDV DNA (Persson et al. 2015). In 1,735 feral American mink in Spain, overall prevalence was 32.4% but was up to 47% in some areas (Mañas et al. 2016). Harrington et al. (2012a) reported prevalence of 66% in England, and Hossain-Fared (2013) reported prevalence of > 90% in Canada. The potential negative impact of AMD on the European mink has been discussed, but Mañas et al. (2016) did not find evidence for that.

The species is also susceptible to water-borne parasites (Nugaraitė et al. 2019). A study of wild American mink in Biebrza and Narew national parks in Poland revealed moderate infestation with parasites, including: Coccidia, Echinostomatidae, Taenidae, and Capillariidae parasites suggesting that mink play an important role as a reservoir for parasites potentially

increasing pathogen prevalence and increasing the risk of infection for endemic mustelids, and are potentially a risk factor in the case of accidental transmissions to farm mink (Klockiewicz et al. 2023). Flukes belonged to *Isthionorpha melis* and tapeworms to *Versteria mustelae*. This study was the first isolation of *V. mustelae* in mink in these areas.

Other recent findings include: 90% of 22 animals in Spain tested positive for *Leishmania infantum* a parasite that produces leishmaniasis an endemic disease in the Mediterranean Basin that affects humans and domestic and wild mammals (Azami-Conesa et al. 2021). Leptospirosis assays on 33 mink kidney samples from Chiloé Island, Chile revealed a prevalence of 18% in 42% of the localities sampled (6 individuals from 5 localities) (Suárez-Villota et al. 2023).

Qu. 4.17. How important might other impacts not already covered by previous questions be resulting from introduction of the organism?

RESPONSE		CONFIDENCE	
	minimal		low
	minor		medium
	moderate		high
	major		
	massive		

Response:

A recent review has shown that fur farms, including for American mink, may also cause significant environmental problems in relation to greenhouse gas emissions, toxic chemicals, and eutrophication (Warwick et al. 2023). Because most data refer to fur farms in general, and cannot be attributed a low confidence score is given.

Qu. 4.18. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in the risk assessment area?

RESPONSE		CONFIDENCE	
	minimal		low
	minor		medium
	moderate		high
	major		
	massive		

Response:

The expected negative impact of the American mink (in the wild) towards biodiversity within the risk assessment area is major everywhere in Europe. There is no evidence that predators, competitors, parasites or pathogens present in Europe have limited the establishment, spread, or persistence of American mink, or caused population-level effects. Although a few studies have reported a correlation between otter (*Lutra lutra*) population recovery and mink population decline, e.g. in UK and Finland (Bonesi et al. 2004, McDonald et al. 2007, Urho et al. 2014) there is no evidence of a causal link between these two processes and a majority of experts regard this correlation of coincidental character. In Spain, the limiting effect of otter has not been observed: the expansion of American mink has occurred in parallel with the

recovery of otter (Põdra and Gómez 2018). Some of the misperceptions of the relationship between these two species are discussed in Harrington et al. (2020).

Qu. 4.19. Estimate the overall impact in the risk assessment area under current climate conditions. In addition, details of overall impact in relevant biogeographical regions should be provided.

Thorough assessment of the overall impact on biodiversity and ecosystem services, with impacts on economy as well as social and human health as aggravating factors, in current conditions.

RESPONSE	minimal minor moderate major massive	CONFIDENCE	low medium high
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Response:

The evidence gathered demonstrates the major impact of this species on biodiversity in its non-native range and in the risk assessment area, resulting in at least moderate decline in conservation value (although note the extremely precarious status of the Critically Endangered European mink which teeters on the brink of extinction due to competition and predation by the American mink, Maran et al. 2017). The species also has minor impacts on Ecosystem Services, predominantly Cultural services (through the species impact on native biodiversity) but also Regulatory services (as a result of the associated need for pest and disease control). It has major economic impacts affecting various economic sectors (poultry, waterfowl, gamebirds) due to predation, coupled with the high cost of management in its current non-native range and the risk assessment area. The impact of the species on human health (associated with the transmission of zoonoses) is currently judged to be moderate but the potential risks associated with the species susceptibility to (and potential role in transmission of) the SARS-CoV-2 and avian flu viruses mean that the impact could be much higher and should be considered to be rapidly changeable. The species role in facilitating transmission of pathogens of potential importance to native wildlife is also considered to be moderate currently. There is no evidence for any natural control of the species at a population level due to either native predators, parasites, or pathogens.

Qu. 4.20. Estimate the overall impact in the risk assessment area in foreseeable climate change conditions. In addition, details of overall impact in relevant biogeographical regions should be provided.

Thorough assessment of the overall impact on biodiversity and ecosystem services, with impacts on economy as well as social and human health as aggravating factors, under future conditions.

- See also guidance to Qu. 4.3.

RESPONSE	minimal minor moderate major	CONFIDENCE	low medium high
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	massive		
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Response:

In the future, there is a significant possibility of much greater impacts of the species associated with the potential extinction of the European mink, as well as potentially other threatened species (which would justify the impact being classified as ‘massive’). In addition, the role of the American mink in farms in the transmission of future SARS and/or influenza viruses could lead to massive impacts on human health within the risk assessment area, and beyond.

RISK SUMMARIES			
	RESPONSE	CONFIDENCE	COMMENT
Summarise Introduction and Entry*	very unlikely unlikely moderately likely likely very likely	low medium high	The overall likelihood of new introductions and entries into new areas in the risk assessment area as result of human activity is very high. Present wild populations of American mink originate mostly from fur farms in Europe. Farms are also the principal cause for the formation of new populations in the future, as they leave opportunities for escapes and deliberate releases. Possible escapes or releases of pet minks may contribute to further introductions and entries into the wild. Lack of escape prevention measures in existing farms will support feral mink populations with additional animals.
Summarise Establishment*	very unlikely unlikely moderately likely likely very likely	low medium high	The species is already established in the risk assessment area, from the North (Finland, Sweden) to the South (Portugal, Spain). Climate conditions can be considered as suitable in the area still free of American mink. The species can be successfully kept and bred in captivity (fur farms) and it may establish in a variety of habitats in the wild: rivers, streams, canals, wetlands, lakes and coastal areas. There is no evidence that the existence of competitors, predators or diseases will prevent the establishment of new populations. Moreover, the species is difficult to detect due to its elusive nature and high capability to disperse and reproduce. The large and

			viable feral populations in Europe, combined with existing fur farms, produce a high number of founders which can easily establish in new areas.
Summarise Spread*	very slowly slowly moderately rapidly very rapidly	low medium high	American mink has invaded a large part of Europe within a few decades and many of the populations show an increasing trend. Therefore, it is very likely that the species will continue spreading and rapidly colonizing areas that current remain unoccupied. Landscape barriers may slow the speed of invasion. However, feral mink may disperse distances of over 100 km per year and they are able to travel long distances in unsuitable habitat, including open bodies of water. The existence of mink farms in areas with no or only few feral mink might initiate new invasion processes.
Summarise Impact*	minimal minor moderate major massive	low medium high	The American mink is an invasive mammal with one of the highest impacts on native species in Europe, negatively affecting more than two dozens of native species. Through ecological competition and predation it provokes the decline of threatened species (e.g. European mink, Pyrenean desman, Atlantic puffin, Horned grebe) and drives them towards extinction (local extinctions have already occurred in the risk assessment area). The American mink may be a threat for wildlife, animal and human health and welfare through the transmission of zoonoses, including SARS-CoV-2 and H5N1. Impacts on ecosystem services are likely small. The continuous expansion of mink populations suggests that the impacts on

			native species will continue to increase in the future. The economic cost of control activities is high. However, local removal, e.g. in protected areas and on islands of conservation concern have been successful and have completely eradicated mink populations.
Conclusion of the risk assessment (overall risk)	low moderate high	low medium high	A large number of scientific publications demonstrate the invasiveness of the American mink and its very high ecological impact (the species is the main cause of decline or extinction of several threatened species). The main risk for introduction and entry into the wild as well as establishment comes from mink farms.

*in current climate conditions and in foreseeable future climate conditions

Distribution Summary

Please answer as follows:

- Yes if recorded, established or invasive
- if not recorded, established or invasive
- ? Unknown; data deficient

The columns refer to the answers to Questions A5 to A12 under Section A.

For data on marine species at the Member State level, delete Member States that have no marine borders. In all other cases, provide answers for all columns.

Member States

	Recorded	Established (currently)	Possible establishment (under current climate)	Possible establishment (under foreseeable climate)	Invasive (currently)*
Austria	X	X	X	X	*
Belgium	X		X	X	
Bulgaria	X		X	X	
Croatia			X	X	
Cyprus					
Czech Republic	X	X	X	X	X
Denmark	X	X	X	X	*
Estonia	X	X	X	X	X
Finland	X	X	X	X	X
France	X	X	X	X	X
Germany	X	X	X	X	*
Greece	X	X	X	X	X
Hungary	X		X	X	
Ireland	X	X	X	X	X
Italy	X	X	X	X	*
Latvia	X	X	X	X	X
Lithuania	X	X	X	X	X
Luxembourg	X		X	X	
Malta					
Netherlands	X		X	X	
Poland	X	X	X	X	X
Portugal	X	X	X	X	*
Romania	X	X	X	X	*
Slovakia	X	X	X	X	*
Slovenia			X	X	
Spain	X	X	X	X	X
Sweden	X	X	X	X	X

* Member States that are not included in this column (Austria, Denmark, Germany, Italy, Portugal, Romania, Slovakia) are omitted because data or specific studies on the impacts of the species within the Member State itself are lacking, this does not imply that the species is not invasive in that Member State.

Biogeographical regions of the risk assessment area

	Recorded	Established (currently)	Possible establishment (under current climate)	Possible establishment (under foreseeable climate)	Invasive (currently)
Alpine	X	X		X	X
Atlantic	X	X		X	X
Black Sea			X	X	
Boreal	X	X		X	X
Continental	X	X		X	X
Mediterranean	X	X		X	X
Pannonian	X		X	X	
Steppic	X	X		X	

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ANNEX I Scoring of Likelihoods of Events

(taken from UK Non-native Organism Risk Assessment Scheme User Manual, Version 3.3, 28.02.2005)

Score	Description	Frequency
Very unlikely	This sort of event is theoretically possible, but is never known to have occurred and is not expected to occur	1 in 10,000 years
Unlikely	This sort of event has occurred somewhere at least once in the last millenium	1 in 1,000 years
Moderately likely	This sort of event has occurred somewhere at least once in the last century	1 in 100 years
Likely	This sort of event has happened on several occasions elsewhere, or on at least once in the last decade	1 in 10 years
Very likely	This sort of event happens continually and would be expected to occur	Once a year

ANNEX II Scoring of Magnitude of Impacts

(modified from UK Non-native Organism Risk Assessment Scheme User Manual, Version 3.3, 28.02.2005)

Score	Biodiversity and ecosystem impact	Ecosystem Services impact	Economic impact (Monetary loss and response costs per year)	Social and human health impact, and other impacts
	<i>Question 4.1-5</i>	<i>Question 4.6-8</i>	<i>Question 4.9-13</i>	<i>Question 4.14-18</i>
Minimal	Local, short-term population decline, no significant ecosystem impact	No services affected ⁵	Up to 10,000 Euro	No social disruption. Local, mild, short-term reversible effects to individuals.
Minor	Local, short-term population loss, Localized reversible ecosystem impact	Local and temporary, reversible effects to one or few services	10,000-100,000 Euro	Significant concern expressed at local level. Mild short-term reversible effects to identifiable groups, localised.
Moderate	Local to regional long-term population decline/loss, Measureable reversible long-term damage to ecosystem, little spread, no extinction	Measureable, temporary, local and reversible effects on one or several services	100,000-1,000,000 Euro	Temporary changes to normal activities at local level. Minor irreversible effects and/or larger numbers covered by reversible effects, localised.
Major	Long-term irreversible ecosystem change, spreading beyond local area, population loss or extinction of single species	Local and irreversible or widespread and reversible effects on one / several services	1,000,000-10,000,000 Euro	Some permanent change of activity locally, concern expressed over wider area. Significant irreversible effects locally or reversible effects over large area.
Massive	Long-term irreversible ecosystem change, widespread, population loss or extinction of several species	Widespread and irreversible effects on one / several services	Above 10,000,000 Euro	Long-term social change, significant loss of employment, migration from affected area. Widespread, severe, long-term, irreversible health effects.

⁵ Not to be confused with “no impact”.

ANNEX III Scoring of Confidence Levels

(modified from Bacher et al. 2017)

Each answer provided in the risk assessment must include an assessment of the level of confidence attached to that answer, reflecting the possibility that information needed for the answer is not available or is insufficient or available but conflicting.

The responses in the risk assessment should clearly support the choice of the confidence level.

Confidence level	Description
Low	There is no direct observational evidence to support the assessment, e.g. only inferred data have been used as supporting evidence <i>and/or</i> Impacts are recorded at a spatial scale which is unlikely to be relevant to the assessment area <i>and/or</i> Evidence is poor and difficult to interpret, e.g. because it is strongly ambiguous <i>and/or</i> The information sources are considered to be of low quality or contain information that is unreliable.
Medium	There is some direct observational evidence to support the assessment, but some information is inferred <i>and/or</i> Impacts are recorded at a small spatial scale, but rescaling of the data to relevant scales of the assessment area is considered reliable, or to embrace little uncertainty <i>and/or</i> The interpretation of the data is to some extent ambiguous or contradictory.
High	There is direct relevant observational evidence to support the assessment (including causality) <i>and</i> Impacts are recorded at a comparable scale <i>and/or</i> There are reliable/good quality data sources on impacts of the taxa <i>and</i> The interpretation of data/information is straightforward <i>and/or</i> Data/information are not controversial or contradictory.

ANNEX IV CBD pathway categorisation scheme

Overview of CBD pathway categorisation scheme showing how the 44 pathways relate to the six main pathway categories. All of the pathways can be broadly classified into 1) those that involve intentional transport (blue), 2) those in which the taxa are unintentionally transported (green) and 3) those where taxa moved between regions without direct transportation by humans and/or via artificial corridors (orange and yellow). **Note that the pathways in the category “Escape from confinement” can be considered intentional for the introduction into the risk assessment area and unintentional for the entry into the environment.**



ANNEX V Ecosystem services classification (CICES V5.1, simplified) and examples

For the purposes of this risk assessment, please feel free to use what seems as the most appropriate category / level / combination of impact (Section – Division – Group), reflecting information available.

Section	Division	Group	Examples (i.e. relevant CICES “classes”)
Provisioning	Biomass	Cultivated <i>terrestrial</i> plants	<p>Cultivated terrestrial plants (including fungi, algae) grown for <u>nutritional purposes</u>; <u>Fibres and other materials</u> from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials); Cultivated plants (including fungi, algae) grown as a <u>source of energy</u></p> <p><i>Example: negative impacts of non-native organisms to crops, orchards, timber etc.</i></p>
		Cultivated <i>aquatic</i> plants	<p>Plants cultivated by in- situ aquaculture grown for <u>nutritional purposes</u>; <u>Fibres and other materials</u> from in-situ aquaculture for direct use or processing (excluding genetic materials); Plants cultivated by in- situ aquaculture grown as an <u>energy source</u>.</p> <p><i>Example: negative impacts of non-native organisms to aquatic plants cultivated for nutrition, gardening etc. purposes.</i></p>
		Reared animals	<p>Animals reared for <u>nutritional purposes</u>; <u>Fibres and other materials</u> from reared animals for direct use or processing (excluding genetic materials); Animals reared to provide <u>energy</u> (including mechanical)</p> <p><i>Example: negative impacts of non-native organisms to livestock</i></p>
		Reared <i>aquatic</i> animals	<p>Animals reared by in-situ aquaculture for <u>nutritional purposes</u>; <u>Fibres and other materials</u> from animals grown by in-situ aquaculture for direct use or processing (excluding genetic materials); Animals reared by in-situ aquaculture as an <u>energy source</u></p> <p><i>Example: negative impacts of non-native organisms to fish farming</i></p>
		Wild plants (terrestrial and aquatic)	<p>Wild plants (terrestrial and aquatic, including fungi, algae) used for <u>nutrition</u>; <u>Fibres and other materials</u> from wild plants for direct use or processing (excluding genetic materials); Wild plants (terrestrial and aquatic, including fungi, algae) used as a <u>source of energy</u></p> <p><i>Example: reduction in the availability of wild plants (e.g. wild berries, ornamentals) due to non-native organisms (competition, spread of disease etc.)</i></p>
		Wild animals (terrestrial and aquatic)	<p>Wild animals (terrestrial and aquatic) used for <u>nutritional purposes</u>; <u>Fibres and other materials</u> from wild animals for direct use or processing (excluding genetic materials); Wild animals (terrestrial and aquatic) used as a <u>source of energy</u></p> <p><i>Example: reduction in the availability of wild animals (e.g. fish stocks, game) due to non-native organisms (competition, predations, spread of disease etc.)</i></p>

	Genetic material from all biota	Genetic material from plants, algae or fungi	<p><u>Seeds, spores and other plant materials</u> collected for maintaining or establishing a population; Higher and lower plants (whole organisms) used to <u>breed new strains or varieties</u>; Individual genes extracted from higher and lower plants for the <u>design and construction of new biological entities</u></p> <p><i>Example: negative impacts of non-native organisms due to interbreeding</i></p>
		Genetic material from animals	<p>Animal material collected for the purposes of maintaining or establishing a population; Wild animals (whole organisms) used to breed new strains or varieties; Individual genes extracted from organisms for the design and construction of new biological entities</p> <p><i>Example: negative impacts of non-native organisms due to interbreeding</i></p>
	Water⁶	Surface water used for nutrition, materials or energy	<p>Surface water for <u>drinking</u>; Surface water used as a material (<u>non-drinking purposes</u>); Freshwater surface water, coastal and marine water used as an <u>energy source</u></p> <p><i>Example: loss of access to surface water due to spread of non-native organisms</i></p>
		Ground water for used for nutrition, materials or energy	<p>Ground (and subsurface) water for <u>drinking</u>; Ground water (and subsurface) used as a material (<u>non-drinking purposes</u>); Ground water (and subsurface) used as an <u>energy source</u></p> <p><i>Example: reduced availability of ground water due to spread of non-native organisms and associated increase of ground water consumption by vegetation.</i></p>
Regulation & Maintenance	Transformation of biochemical or physical inputs to ecosystems	Mediation of wastes or toxic substances of anthropogenic origin by living processes	<p><u>Bio-remediation</u> by micro-organisms, algae, plants, and animals; <u>Filtration/sequestration/storage/accumulation</u> by micro-organisms, algae, plants, and animals</p> <p><i>Example: changes caused by non-native organisms to ecosystem functioning and ability to filtrate etc. waste or toxics</i></p>
		Mediation of nuisances of anthropogenic origin	<p><u>Smell reduction</u>; <u>noise attenuation</u>; <u>visual screening</u> (e.g. by means of green infrastructure)</p> <p><i>Example: changes caused by non-native organisms to ecosystem structure, leading to reduced ability to mediate nuisances.</i></p>
	Regulation of physical, chemical, biological conditions	Baseline flows and extreme event regulation	<p>Control of <u>erosion</u> rates; Buffering and attenuation of <u>mass movement</u>; <u>Hydrological cycle and water flow regulation</u> (Including flood control, and coastal protection); <u>Wind</u> protection; <u>Fire</u> protection</p> <p><i>Example: changes caused by non-native organisms to ecosystem functioning or structure leading to, for example, destabilisation of soil, increased risk or intensity of wild fires etc.</i></p>
		Lifecycle maintenance , habitat and gene pool protection	<p><u>Pollination</u> (or 'gamete' dispersal in a marine context); <u>Seed dispersal</u>; Maintaining <u>nursery populations and habitats</u> (Including gene pool protection)</p> <p><i>Example: changes caused by non-native organisms to the abundance and/or distribution of wild pollinators; changes to the availability / quality of nursery habitats for fisheries</i></p>

⁶ Note: in the CICES classification provisioning of water is considered as an abiotic service whereas the rest of ecosystem services listed here are considered biotic.

		Pest and disease control	Pest control; Disease control <i>Example: changes caused by non-native organisms to the abundance and/or distribution of pests</i>
		Soil quality regulation	Weathering processes and their effect on soil quality; <u>Decomposition and fixing processes</u> and their effect on soil quality <i>Example: changes caused by non-native organisms to vegetation structure and/or soil fauna leading to reduced soil quality</i>
		Water conditions	Regulation of the <u>chemical condition</u> of freshwaters by living processes; Regulation of the chemical condition of salt waters by living processes <i>Example: changes caused by non-native organisms to buffer strips along water courses that remove nutrients in runoff and/or fish communities that regulate the resilience and resistance of water bodies to eutrophication</i>
		Atmospheric composition and conditions	Regulation of <u>chemical composition</u> of atmosphere and oceans; Regulation of <u>temperature and humidity</u> , including ventilation and transpiration <i>Example: changes caused by non-native organisms to ecosystems' ability to sequester carbon and/or evaporative cooling (e.g. by urban trees)</i>
Cultural	Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through <u>active or immersive interactions</u> ; Characteristics of living systems that enable activities promoting health, recuperation or enjoyment through <u>passive or observational interactions</u> <i>Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that make it attractive for recreation, wild life watching etc.</i>
		Intellectual and representative interactions with natural environment	Characteristics of living systems that enable <u>scientific investigation</u> or the creation of traditional ecological knowledge; Characteristics of living systems that enable <u>education and training</u> ; Characteristics of living systems that are resonant in terms of <u>culture or heritage</u> ; Characteristics of living systems that enable <u>aesthetic experiences</u> <i>Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that have cultural importance</i>
	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic and other interactions with natural environment	Elements of living systems that have <u>symbolic meaning</u> ; Elements of living systems that have <u>sacred or religious meaning</u> ; Elements of living systems used for <u>entertainment or representation</u> <i>Example: changes caused by non-native organisms to the qualities of ecosystems (structure, species composition etc.) that have sacred or religious meaning</i>
		Other biotic characteristics that have a non-use value	Characteristics or features of living systems that have an <u>existence value</u> ; Characteristics or features of living systems that have an <u>option or bequest value</u> <i>Example: changes caused by non-native organisms to</i>

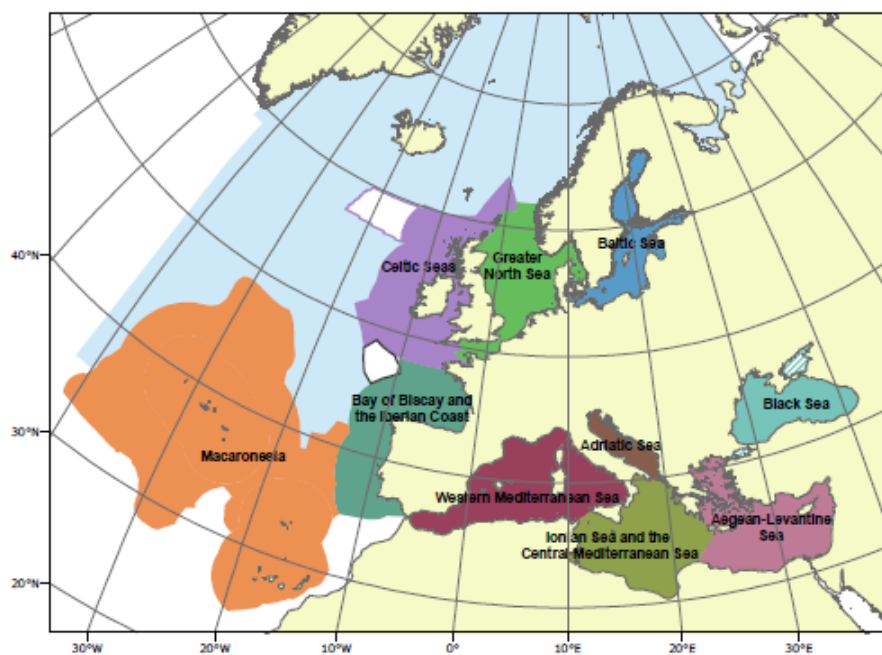
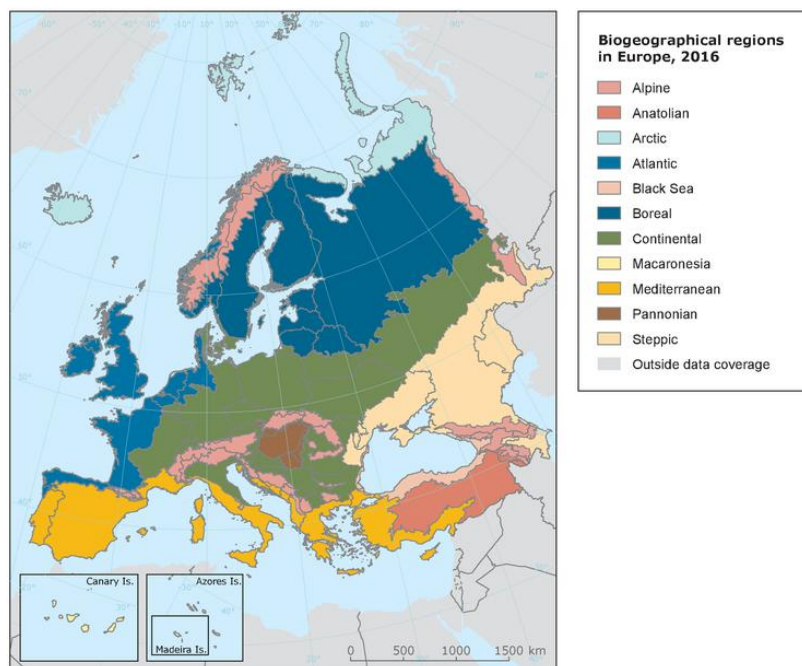
			<i>ecosystems designated as wilderness areas, habitats of endangered species etc.</i>
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ANNEX VI EU Biogeographic Regions and MSFD Subregions

See <https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2> ,
http://ec.europa.eu/environment/nature/natura2000/biogeog_regions/

and

<https://www.eea.europa.eu/data-and-maps/data/msfd-regions-and-subregions-1/technical-document/pdf>



ANNEX VII Delegated Regulation (EU) 2018/968 of 30 April 2018

see <https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32018R0968>

ANNEX VIII Projection of environmental suitability for *Neogale vison* establishment in Europe

Steph Rorke, Tim Adriaens, Wolfgang Rabitsch

31 October 2023

Aim

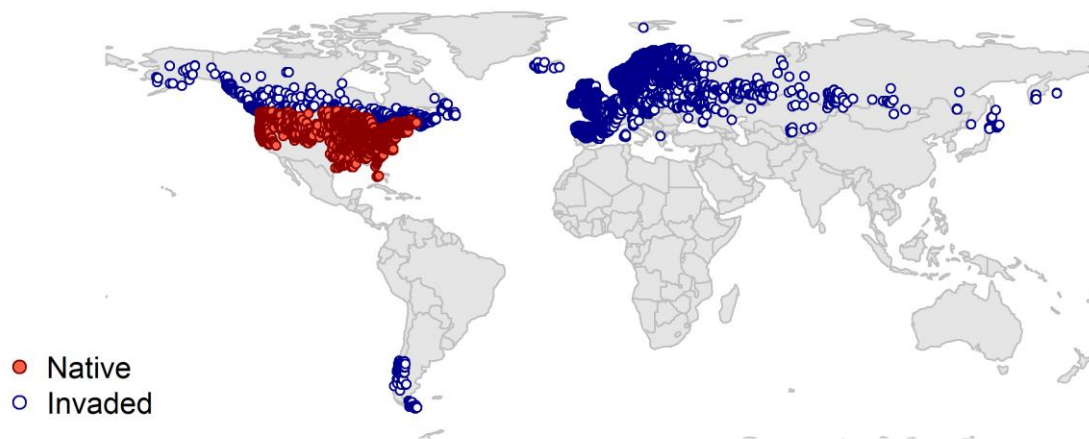
To project the suitability for potential establishment of *Neogale vison* in Europe, under current and predicted future climatic conditions.

Data for modelling

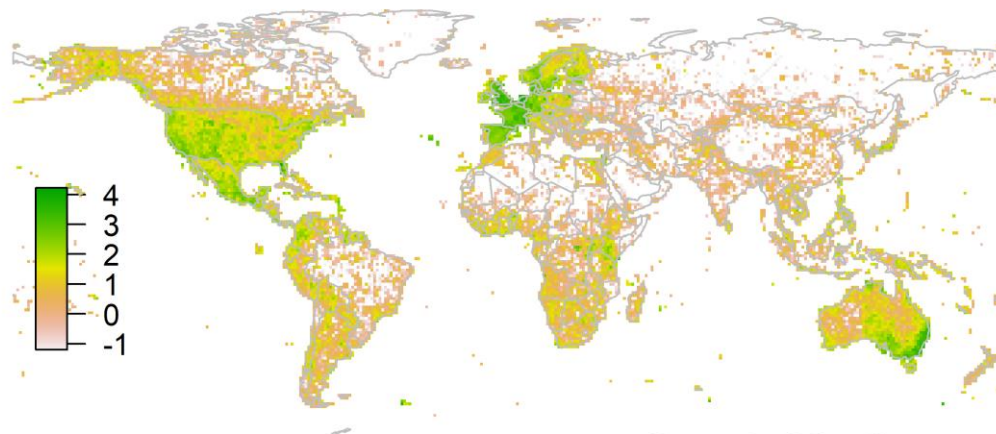
Species occurrence data were obtained from GBIF (50300 records), TA_GB (15490 records), iNaturalist (11077 records), OpenObs (2843 records), TA_SLK (143 records), TA_IT_1 (45 records), and additional records from the risk assessment team. We scrutinised occurrence records from regions where the species is not known to be established and removed any dubious records or where the georeferencing was too imprecise (e.g. records referenced to a country or island centroid) or outside of the coverage of the predictor layers (e.g. small island or coastal occurrences). The remaining records were gridded at a 0.25 x 0.25 degree resolution for modelling, yielding 7306 grid cells with occurrences (Figure 1a). As a proxy for recording effort, the density of Mammalia records held by GBIF was also compiled on the same grid (Figure 1b).

Figure 1. (a) Occurrence records obtained for *Neogale vison* and used in the modelling, showing native and invaded distributions. (b) The recording density of Mammalia on GBIF, which was used as a proxy for recording effort.

(a) Species distribution used in modelling



(b) Estimated recording effort (log10-scaled)



Climate data were selected from the 'Bioclim' variables contained within the WorldClim 2.1 database (Fick & Hijmans 2017), originally at 5 arcminute resolution (0.083 x 0.083 degrees of longitude/latitude) and aggregated to a 0.25 x 0.25 degree grid for use in the model. The data are based on mean 1970-2000 climate and are used as the "current" climate scenario in the present study.

Based on the biology of *Neogale vison*, the following climate variables were used in the modelling:

- Temperature seasonality (Bio4)
- Temperature annual range (Bio5-Bio6) (Bio7)
- Mean temperature of the warmest quarter (Bio10)
- Precipitation seasonality (Bio15)

- Precipitation of the wettest quarter (Bio16)

To estimate the effect of climate change on the potential distribution, equivalent modelled future climate conditions for the 2070s under the Representative Concentration Pathways (RCP) 2.6, 4.5 and 8.5 were also obtained. These represent low, medium and very high emissions scenarios, respectively. Future bioclimatic variables were obtained as averages of outputs of 25 global climate models, downscaled and calibrated against the WorldClim baseline (see <https://worldclim.org/data/cmip6/cmip6climate.html>).

Species distribution model

A presence-background (presence-only) ensemble modelling strategy was employed using the BIOMOD2 R package version 4.2-2 (R Core Team 2022, Thuiller et al. 2023). These models contrast the environment at the species' occurrence locations against a random sample of the global background environmental conditions (often termed 'pseudo-absences') in order to characterise and project suitability for occurrence. This approach has been developed for distributions that are in equilibrium with the environment. Because invasive species' distributions are not at equilibrium and subject to dispersal constraints at a global scale, we took care to minimise the inclusion of locations suitable for the species but where it has not been able to disperse to (Chapman et al. 2019). Therefore the background sampling region included:

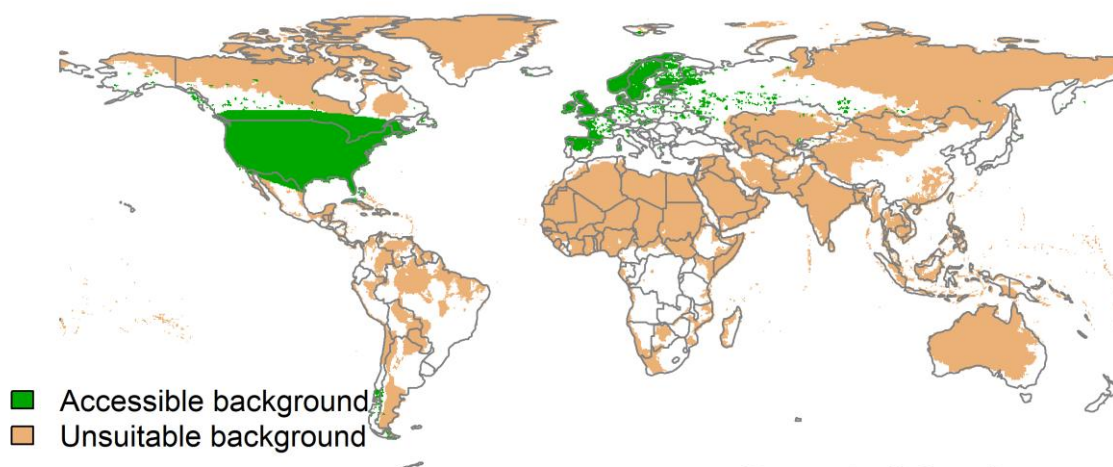
- Firstly, regions where we have an *a priori* expectation of high unsuitability for the species so that absence is assumed irrespective of dispersal constraints (see Figure 2). The following rules were applied to define a region expected to be highly unsuitable for *Neogale vison* at the spatial scale of the model:
 - Minimum temperature of the coldest month (Bio6) < -27.00
 - Mean temperature of the warmest quarter (Bio10) > 26.52
 - Precipitation of the wettest quarter (Bio16) < $\log_{10}(116.91 + 1)$

Altogether, 2.3% of occurrence grid cells were located in the unsuitable background region.

- Secondly, the background sampling region included the area “accessible” by native *Neogale vison* populations, in which the species is likely to have had sufficient time to disperse to all locations, but has failed to establish. Based on presumed maximum dispersal distances, the accessible region was defined as a 400km buffer around the native range occurrences.
- Thirdly, the background included a 30km buffer around the non-native occurrences, encompassing “accessible” regions likely to have had high propagule pressure for introduction by humans and/or dispersal of the species, but where it has failed to establish.

Within the unsuitable background region, 10 samples of 1000 randomly sampled grid cells were obtained (i.e. ten times the number of occurrence grid cells). In the accessible background (comprising the accessible areas around native and non-native occurrences as detailed above), the same number of pseudo-absence samples were drawn as there were presence records (7306), weighting the sampling by a proxy for recording effort (Figure 1(b)) - reflecting higher confidence in records showing a true picture of presence and absence of the species in regions with higher recording effort.

Figure 2. The background from which pseudo-absence samples were taken in the modelling of *Neogale vison*. Samples were taken from areas expected to be highly unsuitable for the species (the unsuitable background region), and additionally from a 400km buffer around the native range and a 30km buffer around non-native occurrences (together forming the accessible background). Samples from the accessible background were weighted by a proxy for recording effort (Figure 1(b)).



Each dataset (i.e. combination of the presences and the individual background samples) was randomly split into 80% for model training and 20% for model evaluation. With each training dataset, seven statistical algorithms were fitted with the default BIOMOD2 settings and rescaled using logistic regression:

- Generalised linear model (GLM)
- Generalised boosting model (GBM)
- Generalised additive model (GAM) with a maximum of four degrees of freedom per smoothing spline
- Artificial neural network (ANN)
- Multivariate adaptive regression splines (MARS)
- Random forest (RF)
- Maxent

Since the total background sample was larger than the number of occurrences, prevalence fitting weights were applied to give equal overall importance to the occurrences and the background. Normalised variable importance was assessed and variable response functions were produced using BIOMOD2's default procedure.

Model predictive performance was assessed by the following three measures:

- AUC, the area under the receiver operating characteristic curve (Fielding & Bell 1997). Predictions of presence-absence models can be compared with a subset of records set aside for model evaluation (here 20%) by constructing a confusion matrix

with the number of true positive, false positive, false negative and true negative cases. For models generating non-dichotomous scores (as here) a threshold can be applied to transform the scores into a dichotomous set of presence-absence predictions. Two measures that can be derived from the confusion matrix are sensitivity (the proportion of observed presences that are predicted as such, quantifying omission errors), and specificity (the proportion of observed absences that are predicted as such, quantifying commission errors). A receiver operating characteristic (ROC) curve can be constructed by using all possible thresholds to classify the scores into confusion matrices, obtaining sensitivity and specificity for each matrix, and plotting sensitivity against the corresponding proportion of false positives (equal to $1 - \text{specificity}$). The use of all possible thresholds avoids the need for a selection of a single threshold, which is often arbitrary, and allows appreciation of the trade-off between sensitivity and specificity. The area under the ROC curve (AUC) is often used as a single threshold-independent measure for model performance (Manel et al. 2001). AUC is the probability that a randomly selected presence has a higher model-predicted suitability than a randomly selected absence (Allouche et al. 2006).

- Cohen's Kappa (Cohen 1960). This measure corrects the overall accuracy of model predictions (ratio of the sum of true presences plus true absences to the total number of records) by the accuracy expected to occur by chance. The Kappa statistic ranges from -1 to +1, where +1 indicates perfect agreement and values of zero or less indicate a performance no better than random. Advantages of Kappa are its simplicity, the fact that both commission and omission errors are accounted for in one parameter, and its relative tolerance to zero values in the confusion matrix (Manel et al. 2001). However, Kappa has been criticised for being sensitive to prevalence (the proportion of sites in which the species was recorded as present) and may therefore be inappropriate for comparisons of model accuracy between species or regions (McPherson et al. 2004, Allouche et al. 2006).
- TSS, the true skill statistic (Allouche et al. 2006). TSS is defined as sensitivity + specificity - 1, and corrects for Kappa's dependency on prevalence. TSS compares the number of correct forecasts, minus those attributable to random guessing, to that of a hypothetical set of perfect forecasts. Like Kappa, TSS takes into account both omission and commission errors, and success as a result of random guessing, and ranges from -1 to +1, where +1 indicates perfect agreement and values of zero or less indicate a performance no better than random (Allouche et al. 2006).

An ensemble model was created by first rejecting poorly performing algorithms with relatively extreme low AUC values and then averaging the predictions of the remaining algorithms, weighted by their AUC. To identify poorly performing algorithms, AUC values were converted into modified z-scores based on their difference to the median and the median absolute deviation across all algorithms (Iglewicz & Hoaglin 1993). Algorithms with $z < -2$ were rejected. In this way, ensemble projections were made for each dataset and then averaged to give an overall suitability, as well as its standard deviation.

Projections were classified into suitable and unsuitable regions using a "lowest presence threshold" (Pearson et al. 2007), setting the cut-off as the lowest value at which 98% of all presence records are classified correctly under the current climate (here 0.17). In order to express the sensitivity of classifications to the choice of this threshold, thresholds at which 95% and 99% of records are classified correctly (here 0.26 and 0.13 respectively) were used in the calculation of error bars in Figures 9 and 10 below in addition to taking account of uncertainty in the projections themselves (cf. part (b) of Figs. 5,7,8). In other words, the upper error bars in Figs. 9 and 10 show proportions classified as suitable with a threshold of 0.13 (at which 99% of presence records are classified

correctly), and are based on projected suitabilities plus the standard error in projections, while the lower error bars show proportions classified as suitable with a threshold of 0.26 (at which 95% of presence records are classified correctly), and are based on projected suitabilities minus the standard error in projections.

We also produced a limiting factor map for Europe following Elith et al. (2010). For this, projections were made separately with each individual variable fixed at a near-optimal value. These were chosen as the median values at the occurrence grid cells. Then, the most strongly limiting factors were identified as the ones resulting in the highest increase in suitability in each grid cell.

Results

The ensemble model suggested that suitability for *Neogale vison* was most strongly determined by Temperature seasonality (Bio4), accounting for 38.4% of variation explained, followed by Temperature annual range (Bio5-Bio6) (Bio7) (25.8%), Mean temperature of the warmest quarter (Bio10) (17.1%), Precipitation of the wettest quarter (Bio16) (10.5%) and Precipitation seasonality (Bio15) (8.3%) (Table 1, Figure 3).

Table 1. Summary of the cross-validation predictive performance (AUC, Kappa, TSS) and variable importance of the fitted model algorithms and the ensemble (AUC-weighted average of the best performing algorithms). Results are the average from models fitted to 10 different background samples of the data.

Algorithm	AUC	Kappa	TSS	Used in the ensemble	Variable importance (%)				
					Temperature seasonality (Bio4)	Temperature annual range (Bio5-Bio6) (Bio7)	Mean temperature of the warmest quarter (Bio10)	Precipitation of the wettest quarter (Bio16)	Precipitation seasonality (Bio15)
ANN	0.670	0.283	0.292	no	41	43	9	3	3
GAM	0.550	0.140	0.145	no	22	24	39	13	2
GBM	0.755	0.376	0.382	yes	31	11	22	17	19
GLM	0.730	0.338	0.346	yes	37	31	15	12	5
MARS	0.744	0.341	0.348	yes	44	36	14	4	2
MAXENT	0.747	0.356	0.362	yes	42	27	16	8	7
RF	0.567	0.249	0.260	no	29	18	22	15	17
Ensemble	0.752	0.361	0.365		38	26	17	10	8

Figure 3. Partial response plots from the fitted models. Thin coloured lines show responses from the algorithms in the ensemble, while the thick black line is their ensemble. In each plot, other model variables are held at their median value in the training data. Some of the divergence among algorithms is because of their different treatment of interactions among variables.

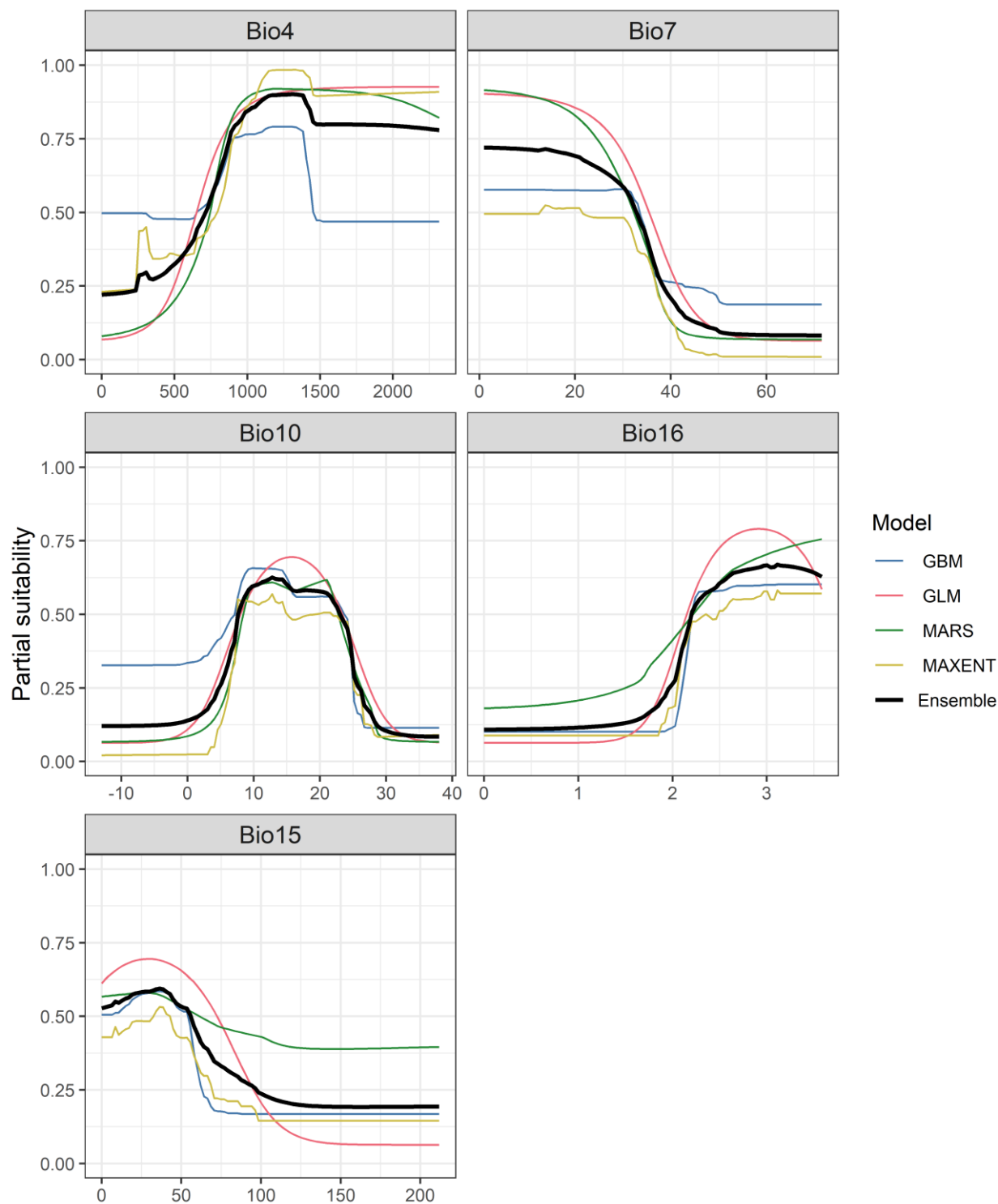


Figure 4. (a) Projected global suitability for *Neogale vison* establishment in the current climate. For visualisation, the projection has been aggregated to a 0.5 x 0.5 degree resolution, by taking the maximum suitability of constituent higher resolution grid cells. Values > 0.17 are likely to be suitable for the species, with 98% of global presence records above this threshold. Values below 0.17 indicate lower relative suitability. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

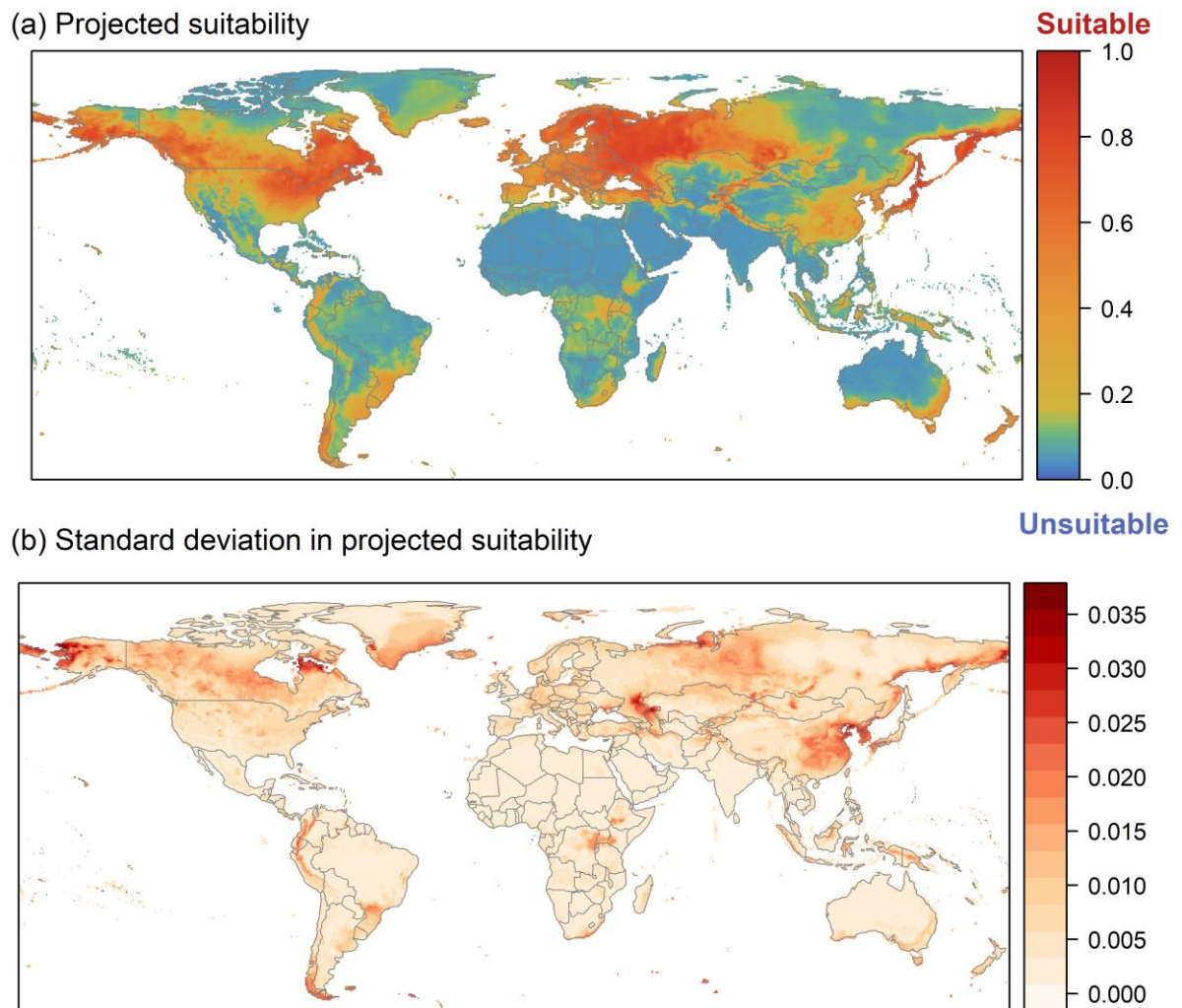


Figure 5. (a) Projected current suitability for *Neogale vison* establishment in Europe and the Mediterranean region. Values > 0.17 are likely to be suitable for the species, with 98% of global presence records above this threshold. Values below 0.17 indicate lower relative suitability. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

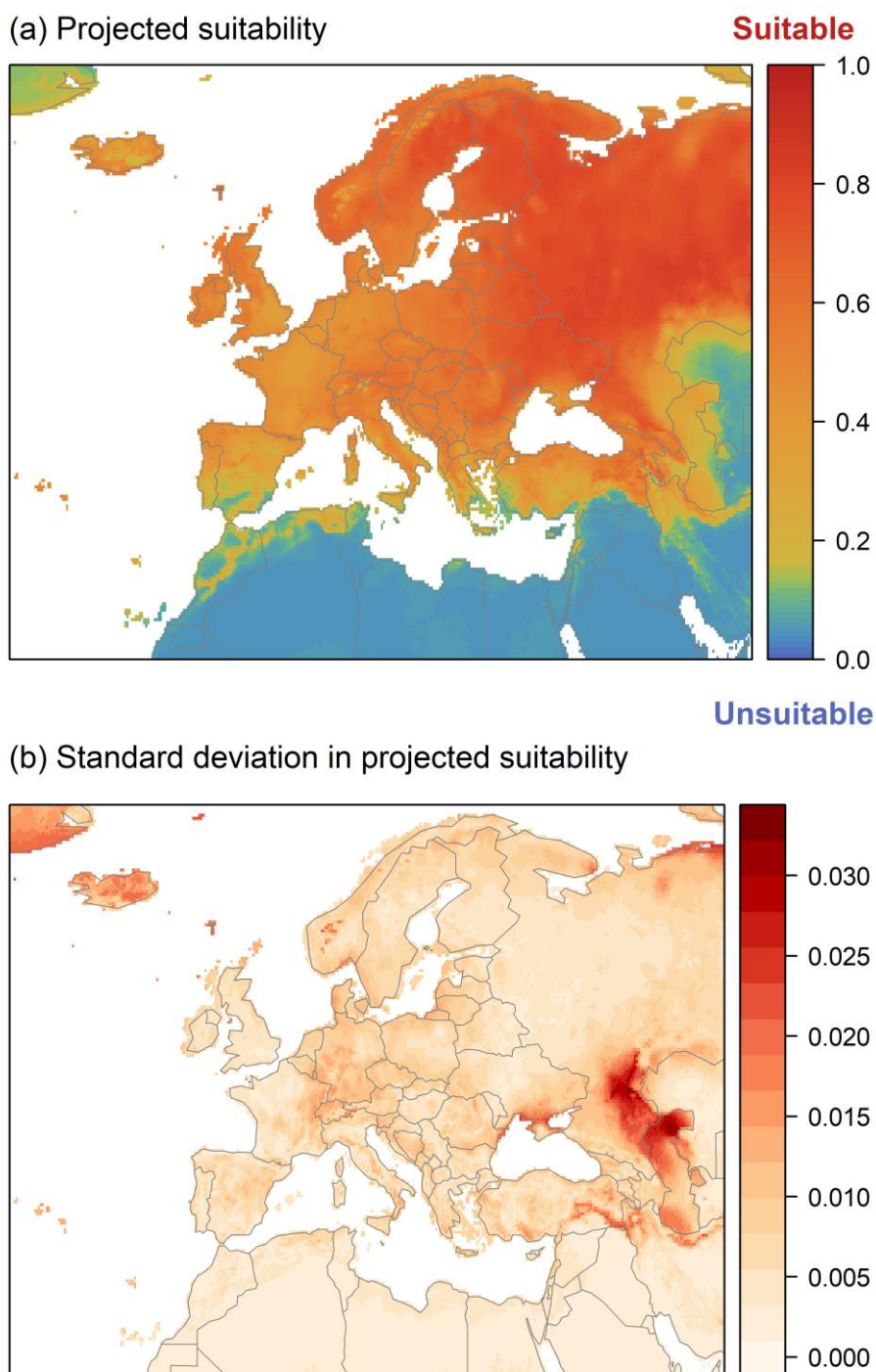


Figure 6. The most strongly limiting factors for *Neogale vison* establishment estimated by the model in Europe and the Mediterranean region in current climatic conditions.

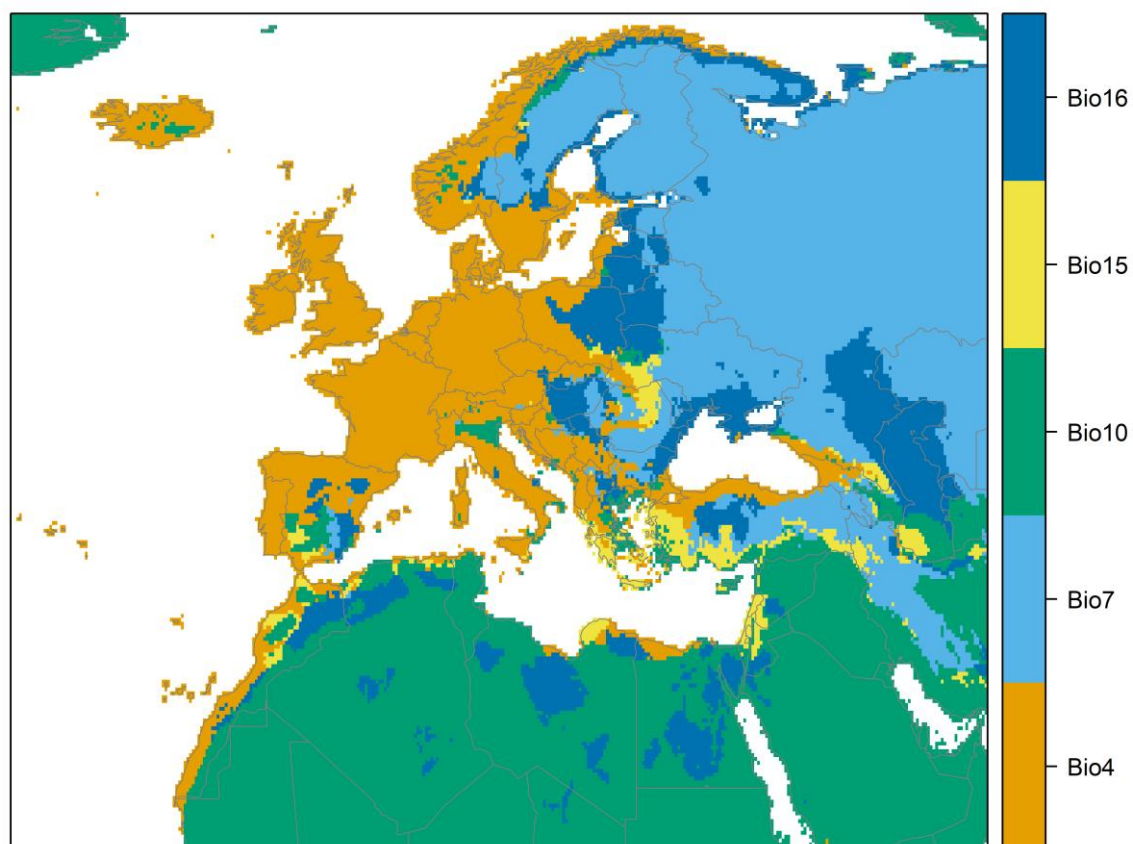


Figure 7. (a) Projected suitability for *Neogale vison* establishment in Europe and the Mediterranean region in the 2070s under climate change scenario RCP2.6. Values > 0.17 are likely to be suitable for the species, with 98% of global presence records above this threshold under current climate. Values below 0.17 indicate lower relative suitability. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

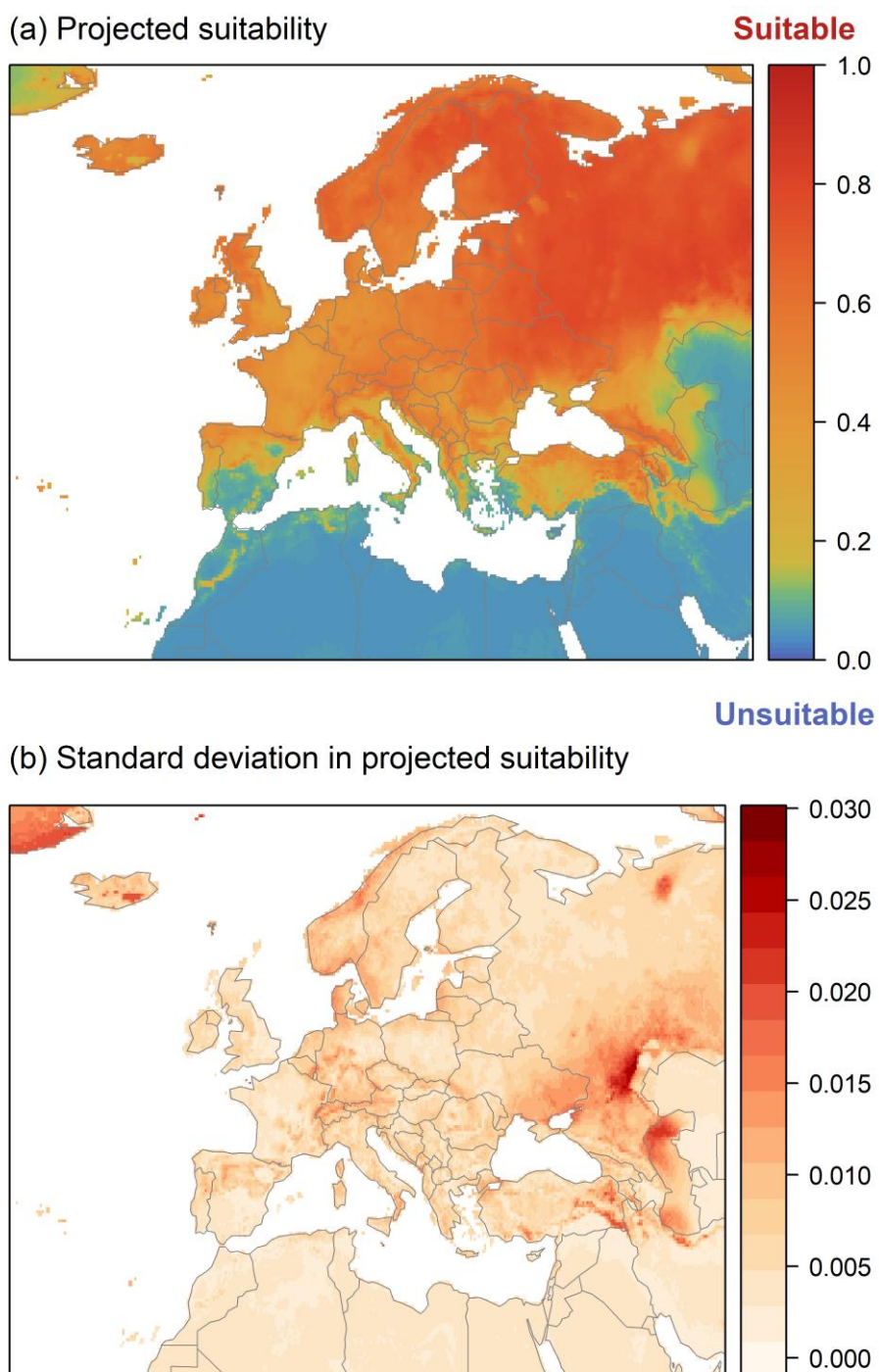


Figure 8. (a) Projected suitability for *Neogale vison* establishment in Europe and the Mediterranean region in the 2070s under climate change scenario RCP4.5. Values > 0.17 are likely to be suitable for the species, with 98% of global presence records above this threshold under current climate. Values below 0.17 indicate lower relative suitability. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

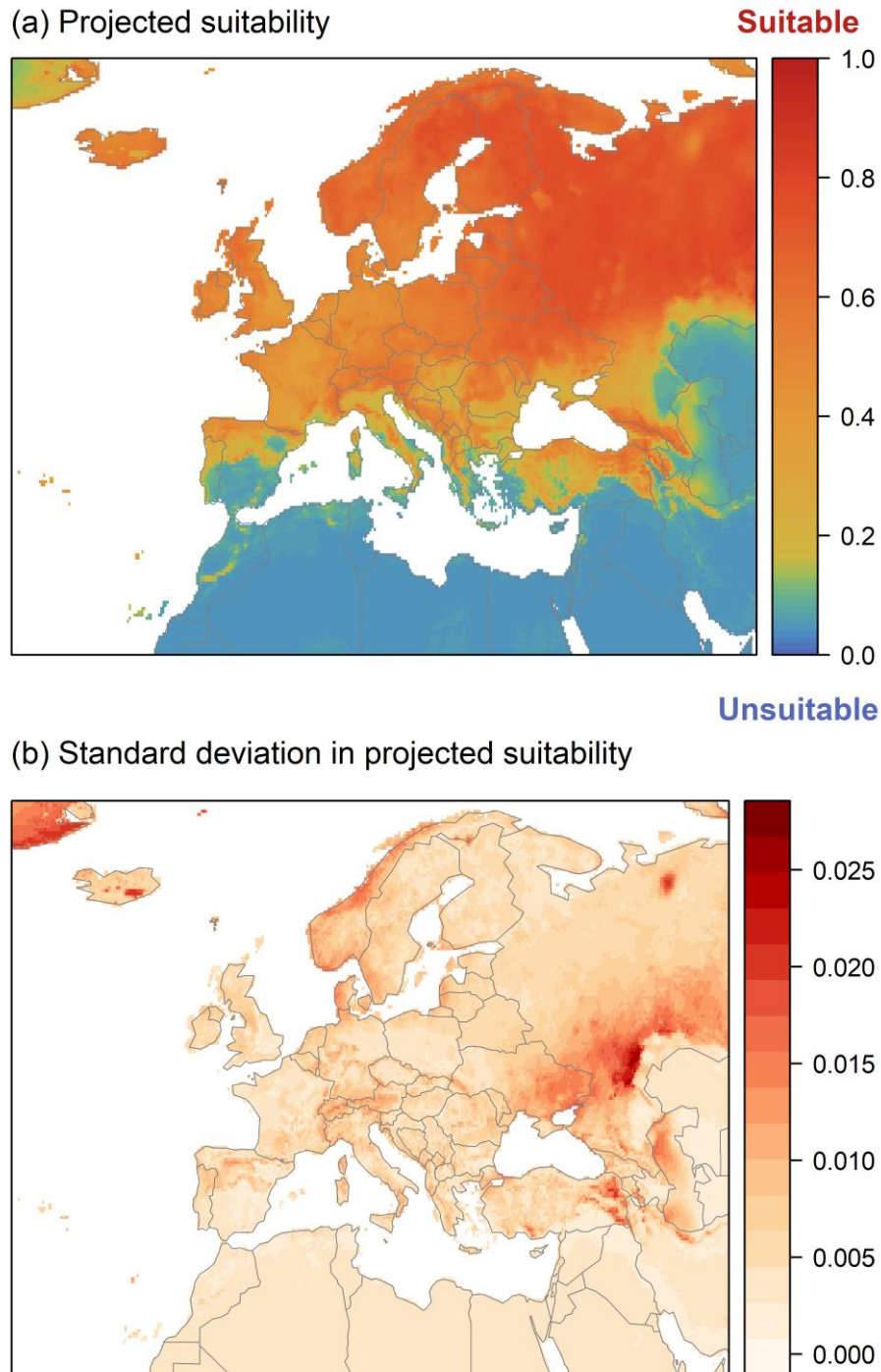


Figure 9. (a) Projected suitability for *Neogale vison* establishment in Europe and the Mediterranean region in the 2070s under climate change scenario RCP8.5. Values > 0.17 are likely to be suitable for the species, with 98% of global presence records above this threshold under current climate. Values below 0.17 indicate lower relative suitability. (b) Uncertainty in the ensemble projections, expressed as the among-algorithm standard deviation in predicted suitability, averaged across the 10 datasets.

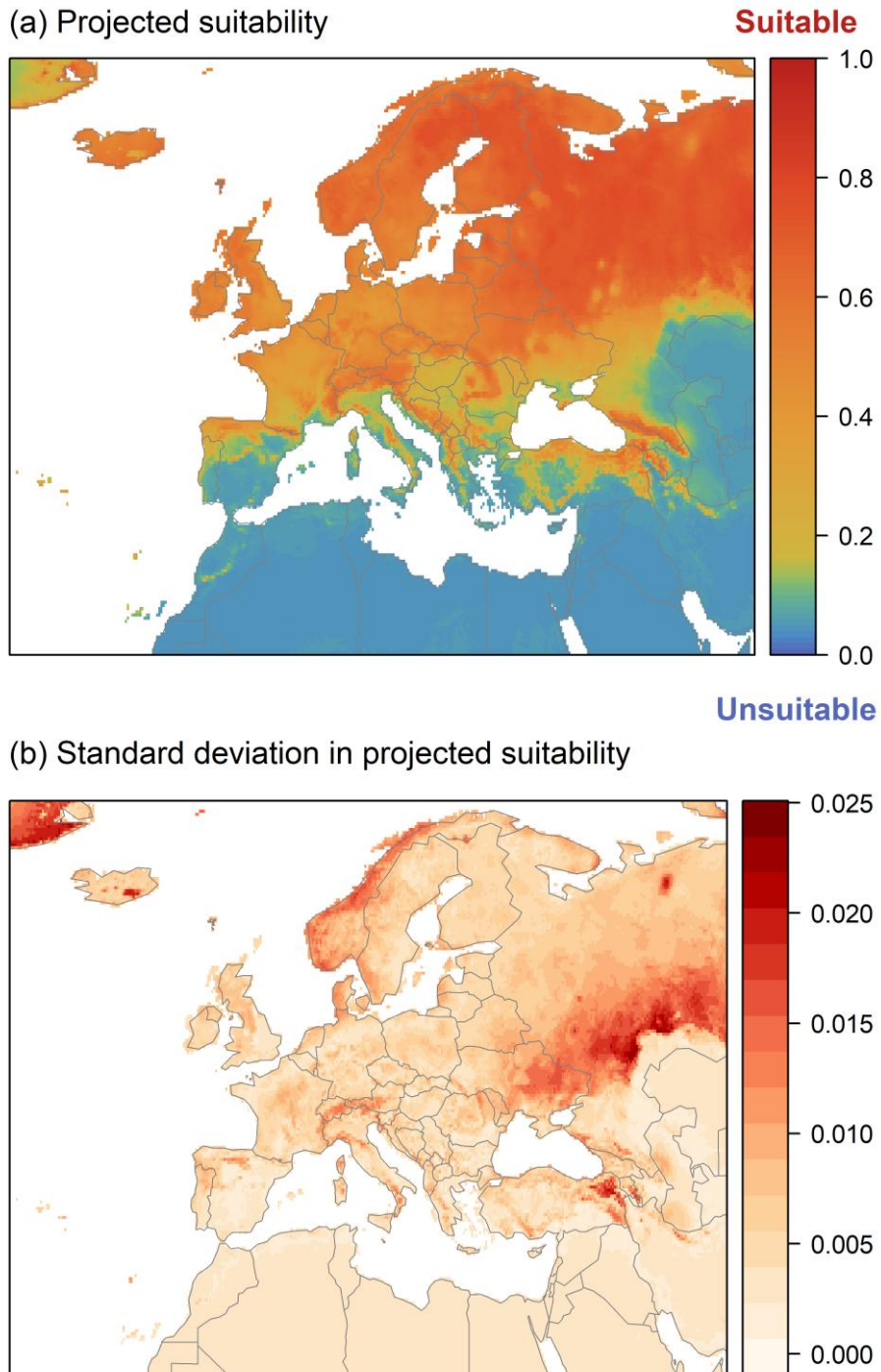


Figure 10. Variation in projected suitability for *Neogale vison* establishment among Biogeographical Regions of Europe (<https://www.eea.europa.eu/data-and-maps/data/biogeographical-regions-europe-3>). The bar plots show the proportion of grid cells in each region classified as suitable (with values > 0.17) in the current climate and projected climate for the 2070s under two RCP emissions scenarios. Error bars indicate uncertainty due to both the choice of classification threshold (cf. p.5/6) and uncertainty in the projections themselves (cf. part (b) of Figures 5, 7,8 and 9). The location of each region is also shown. The Arctic and Macaronesian regions are not part of the study area, but are included for completeness.

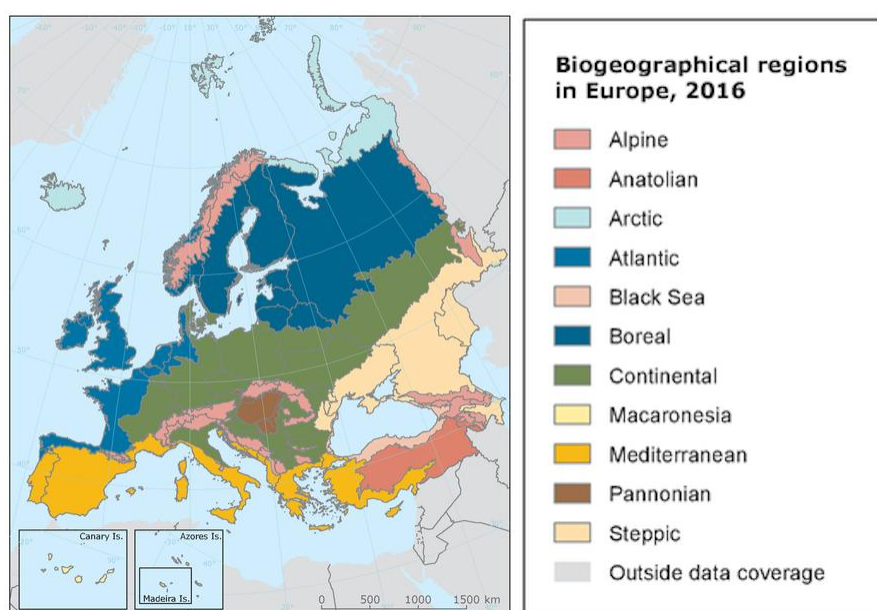
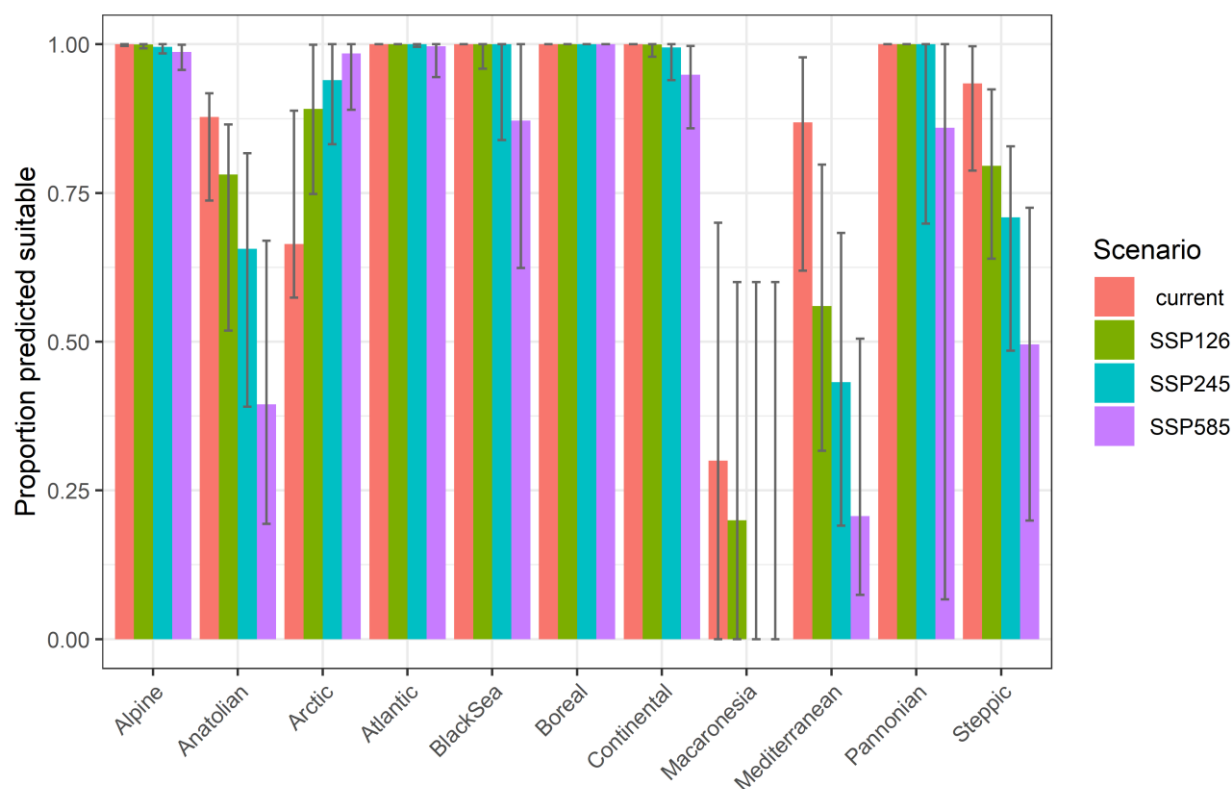


Table 2. Variation in projected suitability for *Neogale vison* establishment among Biogeographical regions of Europe (numerical values of Figure 10 above). The numbers are the proportion of grid cells in each region classified as suitable in the current climate and projected climate for the 2070s under two RCP emissions scenarios. The Arctic and Macaronesian biogeographical regions are not part of the study area, but are included for completeness.

	current climate			2070s RCP2.6			2070s RCP4.5			2070s RCP8.5		
	lower	central estimate	upper	lower	central estimate	upper	lower	central estimate	upper	lower	central estimate	upper
Alpine	1.00	1.00	1.00	0.99	1.00	1.00	0.98	1.00	1.00	0.96	0.99	1.00
Anatolian	0.74	0.88	0.92	0.52	0.78	0.87	0.39	0.66	0.82	0.19	0.39	0.67
Arctic	0.57	0.66	0.89	0.75	0.89	1.00	0.83	0.94	1.00	0.89	0.98	1.00
Atlantic	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.94	1.00	1.00
Black Sea	1.00	1.00	1.00	0.96	1.00	1.00	0.84	1.00	1.00	0.62	0.87	1.00
Boreal	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Continental	1.00	1.00	1.00	0.98	1.00	1.00	0.94	0.99	1.00	0.86	0.95	1.00
Macaronesia	0.00	0.30	0.70	0.00	0.20	0.60	0.00	0.00	0.60	0.00	0.00	0.60
Mediterranean	0.62	0.87	0.98	0.32	0.56	0.80	0.19	0.43	0.68	0.07	0.21	0.50
Pannonian	1.00	1.00	1.00	1.00	1.00	1.00	0.70	1.00	1.00	0.07	0.86	1.00
Steppic	0.79	0.93	1.00	0.64	0.80	0.92	0.48	0.71	0.83	0.20	0.50	0.73

Figure 11. Variation in projected suitability for *Neogale vison* establishment among European Union countries and the UK. The bar plots show the proportion of grid cells in each country classified as suitable (with values > 0.17) in the current climate and projected climate for the 2070s under two RCP emissions scenarios. Error bars indicate uncertainty due to both the choice of classification threshold (cf. p.5/6) and uncertainty in the projections themselves (cf. part (b) of Figures 5, 7,8 and 9).

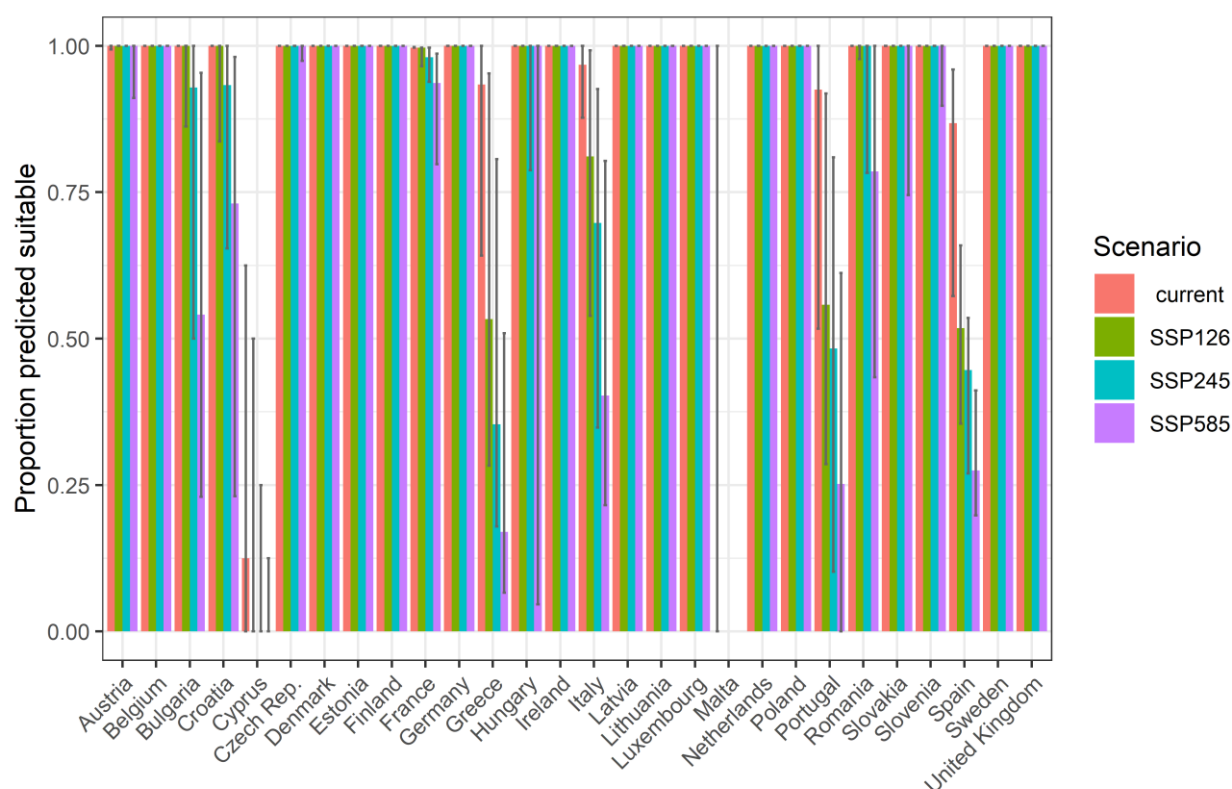


Table 3. Variation in projected suitability for *Neogale vison* establishment among European Union countries and the UK (numerical values of Figure 11 above). The numbers are the proportion of grid cells in each country classified as suitable in the current climate and projected climate for the 2070s under two RCP emissions scenarios.

	current climate			2070s RCP2.6			2070s RCP4.5			2070s RCP8.5		
	lower	central	upper	lower	central	upper	lower	central	upper	lower	central	upper
Austria	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.91	1.00	1.00
Belgium	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Bulgaria	1.00	1.00	1.00	0.86	1.00	1.00	0.50	0.93	1.00	0.23	0.54	0.95
Croatia	1.00	1.00	1.00	0.84	1.00	1.00	0.65	0.93	1.00	0.23	0.73	0.98
Cyprus	0.00	0.13	0.63	0.00	0.00	0.50	0.00	0.00	0.25	0.00	0.00	0.13
Czech Rep.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	1.00	1.00
Denmark	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Estonia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Finland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
France	1.00	1.00	1.00	0.97	1.00	1.00	0.94	0.98	1.00	0.80	0.94	0.99
Germany	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Greece	0.64	0.93	1.00	0.28	0.53	0.95	0.18	0.35	0.81	0.07	0.17	0.51

Hungary	1.00	1.00	1.00	1.00	1.00	1.00	0.79	1.00	1.00	0.05	1.00	1.00
Ireland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Italy	0.88	0.97	1.00	0.54	0.81	0.99	0.35	0.70	0.93	0.22	0.40	0.80
Latvia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lithuania	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Luxembourg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Netherlands	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Portugal	0.52	0.93	1.00	0.29	0.56	0.92	0.10	0.48	0.81	0.00	0.25	0.61
Romania	1.00	1.00	1.00	0.98	1.00	1.00	0.78	1.00	1.00	0.43	0.79	1.00
Slovakia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.74	1.00	1.00
Slovenia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	1.00	1.00
Spain	0.57	0.87	0.96	0.35	0.52	0.66	0.27	0.45	0.54	0.20	0.27	0.41
Sweden	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
UK	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Caveats to the modelling

To remove spatial recording biases, the selection of the background sample from the accessible background was weighted by the density of Mammalia records on the Global Biodiversity Information Facility (GBIF). While this is preferable to not accounting for recording bias at all, it may not provide the perfect measure of recording bias.

There was substantial variation among modelling algorithms in the partial response plots (Figure 3). In part this will reflect their different treatment of interactions among variables. Since partial plots are made with other variables held at their median, there may be values of a particular variable at which this does not provide a realistic combination of variables to predict from.

Other variables potentially affecting the distribution of the species, such as types of land cover were not included in the model.

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