

The strange case of beaver return in Italy: origins and management

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Abstract

The Eurasian beaver (*Castor fiber*) became extinct in Italy between the end of the 16th century and the beginning of the 17th century. A few animals were recorded at the border with Austria in 2018 and 2020. Between 2021 and 2023, beavers were reported six Central and Southern Italy areas at more than 350-400 km from the nearest colonies. Following an official position by the Italian Mammal Society, this paper aims to explore the possible origin of these nuclei, suggests their removal and provide an analysis of the concerns and management recommendations. Given the distances between beaver locations in Central and Southern Italy and the rapid appearance of numerous small nuclei with few individuals in just a couple of years, the most plausible explanation is multiple unlawful releases. Unplanned and unauthorised reintroductions are unacceptable in terms of a sound wildlife management approach and represent a dangerous precedent stimulating further unlawful release of mammals. Therefore, we urge competent authorities to remove these animals from the field.

Introduction

Conservation translocation involves the deliberate movement of organisms from one site to another to gain a benefit for species and populations (IUCN/SSC, 2013). Among these actions, the boldest are reintroductions, where species are returned to part of their historical range from which they have disappeared (Armstrong and Seddon, 2008). Reintroductions can be an effective conservation tool but are complex to implement, even from a bureaucratic point of view, and they often present difficulties that can undermine their success (Berger-Tal et al., 2020). For this reason, the International World Union for Conservation of Nature (IUCN), the recognized global authority on the status of nature, produced specific guidelines for reintroductions and other conservation translocations (IUCN/SSC, 2013), including disease risk analysis related to movements of animals from one area to another (IUCN/SSC, 2014). Risks in a translocation also include the many ways the released animals will impact the biotic communities, the ecosystem functions, and the human activities in the destination areas. Consequently, according to IUCN guidelines, a previous consultation of the main stakeholders and local communities is also fundamental to assess their level of acceptance of the target species and avoid conflicts that might compromise the success of the whole operation. Therefore, these conservation operations must be carefully planned, involving experts from different scientific fields, and competent authorities.

Reintroduction projects play a crucial role in the large-scale recovery of formerly persecuted species. One such example is the Eurasian beaver (*Castor fiber*), a species that has suffered significant population declines due to human activity in Europe. Thanks to numerous reintroduction projects, the beaver is now making a widespread comeback (Halley et al., 2021). However, some of the reintroductions were unplanned and illegal actions. The Eurasian beaver became extinct in Italy between the end of the 16th century and the beginning of the 17th century (Pratesi, 1978; Amori, 1993; Salari et al., 2020). After more than 400 years, following the expansion of the reintroduced population in the Danube, the return of beavers in Italy was first documented in 2018 and in 2020 in north-eastern Italy (Pontarini et al., 2019; Pucci et al., 2021). In 2021, the presence of beavers was unexpectedly recorded at a few isolated and distant locations in Central Italy, in Tuscany and Umbria (Pucci et al., 2021; Mori et al., 2021), located more than 350 km from the northeastern Italian boundary with Slovenia and Austria. The authors of the articles reporting this discovery suggested the possibility that beavers did not arrive in Central Italy by natural dispersal but as the result of escape from captivity or voluntary releases. Consequently, the Italian Mammal Society (ATI - Associazione Teriologica Italiana, www.mammiferi.org) organised a workshop (Rome, 29 September 2021) to review the available data on the Eurasian beaver in Italy and neighbouring countries and evaluate possible pathways of arrival of the species in Central Italy. As a result of this workshop, ATI prepared and approved a position statement on this topic

(www.mammiferi.org/posizione-ufficiale-di-atit-sulla-gestione-dei-nuclei-di-castori-eurasiatici-in-centro-italia), which has been shared with the national and local bodies in charge of wildlife management. Afterwards, beavers were also discovered in southern localities: in 2023, new records were reported from the Abruzzi region and along the Volturno River at the border between Molise and Campania regions (Capobianco et al., 2023).

Following the position statement by the Italian Mammal Society this paper aims to explore the possible origin of the animals recorded in Central and Southern Italy and provide appropriate management recommendations based on the outcomes of the investigations.

The Eurasian beaver

The historical range of the Eurasian beaver extends from the Iberian Peninsula and Great Britain to eastern Siberia (Batbold et al., 2021). Following overexploitation for fur, meat and the oil produced by its peri-anal glands (*castoreum*), at the beginning of the 20th century, the species survived only with eight small and fragmented populations (Nolet and Rosell, 1998). In the 1900s, the species recovered in many European countries (Wróbel, 2020) and it is now listed as Least Concern in the IUCN red list (Batbold et al., 2021). Recovery has been promoted by legal protection – the species is listed in Annex II and IV of the Habitat Directive 92/43/EEC, except for the Finnish and Swedish populations, listed in Annex V – and the implementation of reintroduction projects at large geographical scales, coupled with the species capacity to disperse across the hydrographic network (Halley and Rosell, 2003; Halley et al., 2021).

An ecosystem engineer

The beaver is widely considered an "ecosystem engineer" (Brazier et al., 2020) because of its ability to significantly alter the hydrology, geomorphology, biogeochemistry, and ecosystems of rivers through feeding, denning, and dam construction activities (Larsen et al., 2021; Jones et al., 1994; Rosell et al., 2005; Wright et al., 2002). Landscape and ecosystem transformations produced by beavers are mainly due to the construction of dams, which stop the water flow and increase the extent of open water. These effects of dams are more pronounced in streams, side channels of large rivers, and floodplains (Butler and Malanson, 2005; Gurnell, 1998; Laland and Boogert, 2010; Westbrook et al., 2013). Beavers build dams to maximise food supply, create water bodies deep enough not to freeze completely during winter (at higher latitudes), and as protection from potential predators. Once

93 built, dams can be actively maintained for years or decades or abandoned and eventually get destroyed
94 by floods or filled with sediment (James and Lanman, 2012).

95 The beaver is a generalist herbivore, feeding on woody plants, forbes, ferns and aquatic vegetation.
96 Among woody species, it prefers the genera *Salix* and *Populus*, which is capable of gnawing and
97 felling even large mature trees (Haarberg and Rosell, 2006). Beaver trophic activity can also
98 significantly affect ecological successions and the structure and composition of plant communities
99 (Anderson et al., 2006).

100 The extensive landscape-scale environmental transformations induced by the presence of the beaver
101 involve both positive and negative effects, which have been extensively analysed in the scientific
102 literature. The main positive effects include the stabilisation of water flows and reduction of flood
103 risk (Neumayer et al., 2020), marked improvements in water quality (Larsen et al., 2021; Wegener et
104 al., 2017), the creation of an interconnected matrix of wetland habitats which enhances biodiversity
105 (Rosell et al., 2005), and increases tourist attractiveness (Auster et al., 2020). The main negative
106 impacts include excavation activities on hydraulic reticulation dams and increased risk of flooding
107 (Larsen et al., 2021), impacts on agricultural activities and resulting social conflicts (Campbell-
108 Palmer et al., 2016), reduced movement and spawning opportunities for fish (Kemp et al. 2012),
109 impacts on vegetation (Rosell et al., 2005; Mikulka et al., 2022, e.g., Natura 2000 habitat 92A0), and
110 the spread of zoonoses (Girling et al., 2019).

111 The extent to which beaver impacts are considered to be positive or negative also depends on
112 conservation and consequently management priorities for the landscape characterising a certain area,
113 which in turn rely heavily on the extent of changes the species can cause in specific natural and
114 anthropogenic contexts (Larsen et al., 2021), but also in consideration of the conflicts with human
115 activities affected by beaver presence.

116 **Beaver illegal reintroductions in Europe**

117 Reintroductions of Eurasian beavers in Europe started in 1922. Early reintroductions aimed to
118 establish populations for fur harvesting, but the conservation aim became prominent in the following
119 decades (Halley and Rosell, 2003). First, reintroductions were conducted through hard release without
120 planning, but later operations were properly planned. The present distribution of the Eurasian beaver
121 results from dozens of reintroductions in at least 28 countries and natural spread (reviewed by Halley
122 and Rosell, 2003; Halley et al., 2021). However, at least, twelve of these reintroductions were illegal
123 (Table 1): 2 in Belgium, 5 in England, 2 in Scotland, and 3 in Spain. The following is a brief analysis
124 of these illegal situations.

Belgium

In Belgium, 101 beavers (4 from the Elbe and 97 from Bavaria) were unofficially released in different areas of Wallonia, mainly in the Ardennes and Namur, between 1998-2000 (Verbeylen, 2003). The Bavarian beaver population is estimated at 35,000 animals, and it has been the primary source for most reintroductions throughout Europe since the 1970s (Halley et al., 2021). In 2000, beavers started to spread in Flanders, and the Ministry of the Flemish Government asked for a feasibility study as part of a future reintroduction project (Niewold and Rossaert, 2002). However, before any decision was taken, in 2003, 20 Bavarian (Germany) beavers were released in at least 6 locations along the rivers Dijle and Laan: this reintroduction was planned illegally, without preparing or informing the local population and other stakeholders, and without permission (Verbeylen, 2003).

England

Unlicensed releases of beavers in England took place along the River Otter in Devon, where these animals have been present since at least 2008, with the first confirmed reproduction occurring in 2014 (Girling et al., 2019; Halley et al., 2021). Initially, the government had planned to remove the beavers. However, in 2015, they accepted a proposal from the Devon Wildlife Trust for a five-year trial aimed at evaluating the impact of beavers on the landscape, which also included efforts to reinforce the beaver population (Brazier et al., 2020). In 2020, the government made the decision to allow the River Otter beaver population to remain in the wild. Further illegal releases of beavers leading to the establishment of populations occurred in the Tamar River, the Kent Stour, and the Wye on the Welsh border, as well as in the Somerset levels (Halley et al., 2021).

In 2015, the UK Mammal Society approved a Position statement on beaver reintroduction (www.mammal.org.uk/2015/08/position-statement-beaver-reintroduction) welcoming the return of the beaver to Great Britain. Still, it did not support unlicensed releases, emphasising that these pose a risk to human and animal health, could damage the interests of nature conservation, and may also compromise the beavers' welfare. Following the recognition of legal protection status, the Mammal Society has produced a new Position Statement (20th October 2022, <https://www.mammal.org.uk/2022/10/14284/>) welcoming the return of this native species across Britain and the recent increased legal protection in Scotland and England.

The Eurasian beaver has a protected status in England from 1 October 2022. To reduce damage to people, land management and the environment, a 5-step approach to beaver management was developed (DEFRA, 2022). The last step includes the possibility of lethal control.

Scotland

157 In 1995, the Scottish Natural Heritage started investigating the possibility of a beaver reintroduction
158 project, which was authorised and started as a trial between 2009 and 2014 at Knapdale forest (Coz
159 and Young, 2020). However, parallel to this official reintroduction, two accidental escapes or illegal
160 releases occurred in 2001 in Tayside, eastern Scotland, on the River Tay and River Earn catchments
161 and in 2017 on the River Beaulieu near Inverness in the Highlands (Coz and Young, 2020).

162 In 2012, the Minister for the Environment announced a policy of tolerance towards beavers in
163 Tayside, pending a decision on the future of beaver reintroduction in Scotland, which was scheduled
164 for 2015 (Campbell et al., 2012). During this time, the Scottish government initiated a trapping and
165 relocation effort for beavers inhabiting a river near Beaulieu due to their illegal release. However, this
166 project was temporarily suspended following the unfortunate deaths of two of the relocated animals
167 (BBC News, 2017). Then, in 2016, government ministers decided to allow beavers to remain in
168 Scotland and initiated a process to reinforce the beaver population in Knapdale through additional
169 translocations of these animals (Dowse et al., 2020).

170 The Eurasian beaver received protected species status in Scotland on 1 May 2019. At the same time,
171 a Beaver Management Framework was adopted to balance the desire to allow the beaver populations
172 to continue to expand their range naturally whilst mitigating significant detrimental impacts
173 (NatureScot, 2021). The management framework considers a range of actions to minimise damage
174 produced by beavers, including their licensed killing. From May 2019 to December 2022, a total of
175 352 beavers were killed under licence: 87 in 2019 (from May to December, NatureScot, 2020), 115
176 in 2020 (NatureScot, 2021), 87 in 2021 (NatureScot, 2022), and 63 in 2022 (NatureScot, 2020)

177 **Spain**

178 In Spain, 18 beavers from northern and southern European countries were illegally released in 2003
179 into the Aragón River (Navarra; Spain). Though the Eurasian beaver is listed in the Habitat Directive
180 (92/43/EEC), and since it was not present in Spain when the directive was adopted, initially, the
181 Spanish territory was not considered to be included in the natural range of the species. Therefore, the
182 provisions of the Habitat Directive were considered not applicable to the Eurasian beaver in the
183 country. The local authority, supported by the position of the European Commission, started an
184 eradication project. A total of 216 beavers were removed from 2008–2017; however, the eradication
185 was unsuccessful (Calderon et al., 2023). As a result of this failure, in 2018, the European
186 Commission considered naturalised the species in Spain and requested the government to fulfil the
187 Habitat Directive provisions ensuring the protection of the species (European Parliament 2018). In
188 2020, with an order from the Spanish national government, the species was included in the list of
189 species with special protection (www.boe.es/eli/es/o/2020/11/20/ted1126).

190 The presence of a second nucleus was recently reported in the Tormes River (a tributary of the Douro
191 River), 332 km away in straight line and 611 km distance along the riverbanks from the nearest known
192 range and attributed to an independent illegal release (Calderon et al., 2023). A third nucleus was
193 reported in 2023 by Burón et al., (2023) in Guadalquivir river, in Villatorres and Torreblascopedro
194 municipalities (province of Jaén)

195 Italian beavers

196 Although Italy is not included in the historical range of the Eurasian beaver described by Batbold et
197 al. (2021), the species was known to occur in the country in the early Mediaeval times, with a
198 stronghold in the Po Valley, from where it disappeared during the 16th century or the beginning of
199 the 17th century (Pratesi 1978; Amori, 1993; Salari et al., 2020). Across the last four centuries, the
200 Eurasian beaver has never been observed in Italy. Its return dates back to 2018 when one individual
201 was observed in small tributaries of the Danube drainage system in the Municipality of Tarvisio
202 (province of Udine, north-eastern Italy) as a result of natural dispersal from Austria (Loy et al., 2019;
203 Pontarini et al., 2019). In Austria, the large population results from numerous reintroductions planned
204 in 1970-90 and from the dispersal of animals from Germany (Halley et al., 2021). In November 2020,
205 the Eurasian beaver was also camera-trapped in Val Pusteria (near Sesto Pusteria, province of
206 Bolzano), close to the Austrian border (Pucci et al., 2021).

207 In 2021, beavers were documented along two distinct river basins in Tuscany (Central Italy; Pucci et
208 al., 2021) (Fig. 1). The first area was about 15 km long and encompassed both the Ombrone and
209 Merse rivers in the municipalities of Civitella-Paganico (province of Grosseto) and Murlo,
210 Monticiano, Montalcino (province of Siena), the second was near Sansepolcro (province of Arezzo).
211 These areas are separated by over 110 km in a straight line and by 350-400 km from the nearest
212 beaver population. After further monitoring, beavers were confirmed to be present also in the Umbria
213 region (Fig. 1) in Val Tiberina (the Tevere river valley) in the two provinces of Perugia
214 (municipalities of Città di Castello and Deruta) and Terni (municipalities of Guardea and Alviano)
215 (Mori et al. 2021). In 2021, a roadkilled individual was found in the Marche region, close to the
216 border with Tuscany (Mercatello sul Metauro, province of Pesaro Urbino). A monitoring project in
217 Tuscany and Umbria estimated the presence of a few dozen animals in 2022 (Mori et al., 2023).

218 In 2023, the presence of the species was confirmed in Abruzzi region along the Aterno River, close
219 to the city of Aquila and in the municipality of Vittorito, and in South Italy along the Volturno River
220 at the border of Molise region (municipality of Monteroduni-Roccaravindola, province Isernia) and
221 Campania region (Capriati a Volturno, province of Caserta) (Capobianco et al., 2023).

Origins of Central and Southern Italy beavers

The beavers observed in Central and Southern Italy could have four possible origins: a cryptic residual population, a dispersal from other areas, an escape from captivity or an unlawful release.

A cryptic residual population

The first hypothesis implies that one or more cryptic populations of European beavers survived undiscovered in Central or South Italy for more than 300 years. This hypothesis is extremely unlikely. In fact, the size of these residual populations should have been sufficient to ensure their permanence for a long time. Moreover, the stable presence of beavers in an area is easily detectable due to their recognisable signs of presence, especially trees or stems of larger bushes felled by double-conically gnawing, gnawing traces on still-living woody plants, canal digging, burrows, lodges and bank dens, dams (Campbell-Palmer et al., 2021). Natural areas in Central Italy (e.g. Apennines) were much more anthropised in the past and nowadays rivers and wetlands are frequented and intensively monitored for fishing, biodiversity inventories, and coypu management. Therefore, it is unrealistic that an existing beaver population could be present in the area without being reported for more than 300 years.

A recent study (Attili et al. 2023) discovered that the beaver populations established in Central Italy have two haplotypes currently found in western and eastern European populations. These findings confirm that these populations were likely established from a genetically mixed stock of animals and do not support their origin from a hidden local population.

Dispersal from neighbouring countries

The closest extant Eurasian beaver populations occur in France, Switzerland, and Austria (Halley et al., 2021). The animals reported in Tuscany are at about 350 km the crow flies from the animals observed in eastern Italy, and about 480 km from the nearest French populations. Beavers prefer to disperse through watercourses as corridors, although they can also travel overland. Therefore, individuals dispersing from the French border or eastern Italy to Tuscany and Umbria regions would have travelled hundreds of kilometres. Further, beavers from eastern Italy should have crossed, unnoticed, the largely unsuitable, human populated, Po Valley, whereas animals dispersing from France, would then have crossed the many catchments of the northern Apennines. In these areas, human pressure is much lower, and the environment seems to be suitable for beavers, where the current is not too fast. It is, therefore, likely that any dispersing beavers would have first become

252 established in the northern Apennine rivers. This is confirmed by the model produced by Falaschi et
253 al. (2023), which indicates large parts of the Apennines are highly suitable for beavers.

254 The distance travelled by dispersing beavers leading to settlement and breeding averages 9 km/year
255 with a maximum of 80 km (Fustec et al., 2001). To reach the areas in Central Italy, the animals would
256 have had to overcome a distance at least 5-6 times greater. The presence of undetected beaver
257 populations in Central and Northern Italy, acting as a stepping-stone towards Tuscany and Umbria
258 and then in regions further south, is again unlikely. In 2022, the Italian Mammal Society funded a
259 monitoring project in Emilia-Romagna region, i.e. an area connecting the central and northeastern
260 parts of Italy. Two fieldworkers monitored all rivers between Modena, the Republic of San Marino
261 and the Po Delta looking for beaver signs (Fig. 2). In total, 150 points along 23 watercourses were
262 checked without finding any sign (Leoncini and Viviano, 2022).

263 However, the beavers were recorded at multiple and isolated locations in Tuscany, Umbria, Abruzzi,
264 and at the border between Molise and Campania. These nuclei are each composed of a few animals
265 (Mori et al. 2023). The colonisation of many areas in Central and Southern Italy, even hundreds of
266 kilometres away from each other, without the presence of a source area with a large and consistent
267 population, is a dynamic that is difficult to explain.

268 **Illegal reintroduction (release or escape)**

269 According to the EAZA database for the current and former vertebrate inventories of zoos and other
270 public collections (www.zootierliste.de/en, accessed on 03.02.2023), Eurasian beavers are kept in
271 captivity in two areas in the provinces of Arezzo (over 100 km north to the Ombrone-Farma-Merse
272 river basins) and Pavia (North Italy). Communicating the escape of captive individuals of wildlife
273 species is mandatory for private citizens (the Italian Decree Law n. 150/1992) or zoological gardens
274 (the Italian Decree Law n. 73/2005). An illegal escape implies the owners of the beavers should have
275 communicated this event to local authorities. However, local authorities were unaware of the species'
276 presence both in the rivers of Tuscany and Umbria and in Abruzzi, Molise and Campania. Moreover,
277 as no authorisation for the captive breeding of beavers has been requested, beavers would have been
278 detained without any authorisation, which is another illegal situation. Beavers have been detected
279 almost simultaneously (from 2021 to 2022) in many areas spanning about 300 km along Central and
280 Southern Italy, therefore, should be the result of multiple and almost simultaneous escapes from
281 unknown enclosures, or from a single escape with subsequent migration to different and distant areas.
282 In any case, this hypothesis would imply several animals being kept in captivity without any
283 notification to the competent authorities. This hypothesis seems to be scarcely plausible, also
284 considering that an individual escaped from captivity in northern Tuscany in the early 2000s was
285 rapidly detected and poached (Pucci et al., 2021).

286 The alternative hypothesis of a deliberate release implies another violation of existing laws about
287 wildlife kept in captivity, which prevents private individuals from releasing animals in the wild
288 without specific authorisation from the competent authorities and related to the conservation of the
289 species (e.g. for restocking or a reintroduction project). Anyway, the appearance in several regions
290 of numerous nuclei with few individuals suggests multiple illegal releases planned and implemented
291 in a few years, making this hypothesis the most realistic.

292 **Genetic investigation**

293 Beavers released in Central and Southern Italy are from unknown origin. Theoretically, genetic tools
294 can be implemented to investigate their origin. Previous studies have shown that the scattered relict
295 populations in Eurasia at the beginning of the 20th century were genetically differentiated, sharing a
296 few or no mitochondrial DNA haplotypes (Durka et al., 2005; Ducroz et al., 2005). More recent
297 reintroductions, realised in several regions of Europe, have partially altered this phylogeographic
298 signal (Frosch et al., 2014). Nonetheless, sequencing the mitochondrial control region and comparing
299 it to publicly available sequences (i.e. GenBank) from other reference populations can allow
300 associating the beavers present in Italy to a restricted set of current populations (see Attili et al. 2023
301 for a first approach). This activity, however, would not allow distinguishing between natural and
302 human-mediated dispersal, even if it turns out that the most likely source population was one of the
303 closest geographically (i.e. France, Switzerland, Austria). The suspected beavers can derive from a
304 local captive nucleus of foreign origin. The only way to exclude (or confirm) this option genetically
305 would be to compare beavers in Italy with reference animals from the captive natal stock.

306 **Risks of illegal and unplanned reintroductions**

307 Available data indicate beyond a reasonable doubt that the presence of Eurasian beavers in Central
308 and Southern Italy is the result of multiple voluntary but illegal releases with the aim of reintroducing
309 the species in this area, as it has already happened in other European countries. Although related to a
310 species of European conservation concern, an unplanned and unauthorised reintroduction is
311 unacceptable in terms of a sound wildlife management or conservation biology approach.

312 Reintroductions can be an effective conservation tool, but they can also have adverse ecological,
313 sanitary and economic impacts, which can cause a negative social perception and reaction. These
314 concerns should be identified and discussed in advance by involving local communities and
315 authorities. International (IUCN/SSC, 2013) and national (AA.VV., 2007) guidelines require to
316 motivate the intervention with respect to the strategy for the conservation of the target species and to
317 assess its feasibility. Deciding when a reintroduction is an acceptable option includes a balance of the
318 conservation benefits against the costs and risks of both the translocation and alternative conservation

319 actions. A consultation of the main stakeholders and local populations is also fundamental to
320 assessing the new species' acceptability. The EU Habitat Directive at art. 22 requires a consultation
321 of the public before reintroducing species included in Annex IV of the Directive, such as the beaver.
322 This is even more necessary for an ecosystem engineer like the beaver in highly populated areas.

323 Reintroducing a species that has been absent from a certain territory for centuries is challenging from
324 an ecological and social point of view. Over such a long period of time, ecosystems have probably
325 changed considerably due to human impact. Moreover, people have probably forgotten that the beaver
326 or other species were part of the local natural ecosystem and may consider them as introduced, even
327 though they are native (Coz and Young, 2020).

328 Reintroductions can also pose epidemiological risks, such as introducing new pathogens or
329 amplifying those already present, with possible unpredictable effects on both animal and public health
330 (Kosmider et al. 2013; Daszak et al., 2000; Chinchio et al., 2020). Eurasian beavers are potential hosts
331 for various infectious diseases and parasites, including those typical of common European rodents
332 (Girling et al., 2019). For this reason, a risk analysis was performed in Great Britain to inform projects
333 of conservation translocation of the species (Girling et al., 2019; Donald et al., 2020). Therefore, from
334 a sanitary point of view, neither an illegal release nor an escape from captivity of a species that has
335 been absent from a territory for centuries is acceptable.

336 Finally, despite the economic value of ecosystem services delivered by beavers can be substantial
337 (Thompson et al., 2020), it is worth mentioning that in France, since the 90s, they required high
338 attention on wildlife, forestry and hydraulic impacts (Rouland et al., 1990; AA.VV., 2012; Le Lay et
339 al., 2017) also as a result of the strong economic damages they can cause. Likewise, in the Czech
340 Republic, Poland and Bavaria (Germany), three areas characterised by high species densities, yearly
341 damages are approx. 187,000, 130,000 and 450,000 euros, respectively. In Denmark, where beavers
342 were reintroduced in 1999, managing and mitigating conflicts with human activities costs around
343 90.000 € per year (Janiszewki and Hermanowska, 2019).

344 According to the Italian Presidential Decree n. 357/1997 (recently modified by Decree n. 102/2019),
345 a specific authorisation by the competent regional administration is needed for releasing species listed
346 in Annex D of the Decree (Annex IV of the Habitat Directive), even if for conservation purposes, and
347 an adequate consultation of the public is also prescribed. Moreover, the National Institute for
348 Environmental Protection and Research (ISPRA), needs to evaluate the motivations and feasibility of
349 the project. Specific criteria for reintroducing and restocking native species listed in Annex D are
350 defined in Annex I of the ministerial Decree of 02/04/2020. IUCN guidelines and European and
351 national legislation agree in requiring technical procedures prior to a reintroduction project,
352 highlighting that a social acceptance of translocations plays a crucial role, and these activities cannot
353 be left to individual initiatives that are not subject to third-party oversight.

354 The possible reintroduction of Eurasian beavers had to be evaluated carefully because of the potential
355 environmental impacts of the species on rivers from which they have been absent for many centuries,
356 and cascade effects are unpredictable. A recent modelling paper (Falaschi et al., 2023) identified the
357 areas where beaver populations are most likely to spread in the near future in Italy. However, such
358 ecological assessments have not been conducted in the face of the illegality of the reintroduction. In
359 any case, the study from Falaschi et al. (2023) identified the main areas of potential human-beaver
360 conflicts, and one is located in Central Italy, where illegal reintroductions occurred.

361 **Managing illegal reintroduction**

362 There have been at least twelve cases of illegal reintroductions resulting in the establishment of
363 Eurasian beaver populations in Europe. Removal efforts of a couple of these populations in Spain and
364 Scotland have proven unsuccessful. In Spain, for instance, between 2008 and 2017, 216 beavers were
365 removed in regions including La Rioja, Navarra, and Aragon, yet attempts at eradication ultimately
366 failed (Calderon et al., 2023). In the case of Navarra, the estimated cost of removing 100 animals
367 amounted to €131,000. Unfortunately, detailed information regarding the removal efforts is
368 unavailable, making it challenging to assess the reasons behind the failure. For this reason, the project
369 is unsuitable as a reference for future removal attempts. In some instances, as in England, illegally
370 released beavers have been tolerated, essentially legitimizing their presence. From the perspective of
371 those who planned the actions, these illegal releases may be viewed as successful, potentially serving
372 as inspiration for similar actions in other countries, such as Italy. The passive acceptance of unplanned
373 reintroductions only encourages further emulation.

374 From a management point of view, if the competent authorities will tolerate these illegally released
375 Eurasian beavers, the risk of other deliberate and illegal releases of mammals will likely increase.
376 Rewilding is the large-scale restoration of ecosystems to preserve species, habitats and natural
377 processes. Therefore, it is a form of ecological restoration that includes removing human
378 constructions and disturbance, creating corridors and reintroducing missing species to reinstate
379 natural processes. However, poorly planned rewilding can have disastrous consequences for wildlife
380 and people (Carver et al., 2021). Also, some in the scientific community have expressed concerns
381 about some poorly designed rewilding initiatives triggering human-wildlife conflicts if the needs of
382 stakeholders and the socio-economic contexts are ignored (e.g. large carnivores, Drouilly and
383 O’Riain, 2021).

384 Considering what is illustrated in this article, we strongly criticise actions such as the one we believe
385 may have led to the reappearance of the Eurasian beaver in Central and Southern Italy. The end of
386 having the beaver after many centuries of absence cannot in any way justify the means, such as illegal
387 releases. Justifying these releases for conservation purposes would lead to accepting any species

388 release on the Italian territory: who decides what is right and what is wrong if one accepts illegality?
389 Emulation may lead to the release of other species. What if the next species released is an invasive
390 alien species?

391 We also express concern that in the near future, illegally introduced Eurasian Beaver populations in
392 Italy may divert human and economic resources (national and international) from the conservation of
393 native biodiversity and, in particular, freshwater ecosystems, which are among the most threatened
394 on a global scale (Dudgeon et al., 2006) and require a remarkable conservation effort, as envisioned
395 by the Kunming-Montreal Global Biodiversity Framework (Targets 2 and 3).

396 Considering that the Eurasian beavers present in Central and Southern Italy are likely the result of
397 unplanned and unauthorised releases and following the official position of the Italian Mammal
398 Society, we urge competent authorities to remove these animals from the field. Though the Italian
399 law on wildlife (Law n. 157/1992, art. 2) protects all native populations of mammals and birds living
400 permanently or temporarily in the national territory (Bertolino et al., 2023), the removal of the beavers
401 in Central and Southern regions could be authorised by the Italian Ministry for the Environment as
402 they originated from an illegal act (Italian Presidential Decree n. 357/1997).

403 Assessing the feasibility of a removal plan for beaver populations in Italy requires consideration of
404 both the species' biology and the effectiveness of removal methods. However, it's essential to
405 recognize that social and political factors play a pivotal role in determining the actual realisation of
406 such projects. While producing a comprehensive feasibility report falls beyond the scope of the
407 present paper, we have highlighted certain positive factors that may facilitate animal removal and the
408 challenges that could hamper its implementation (see Table 2). Given that beavers are aquatic species,
409 monitoring their presence and implementing removal measures can be directed in well-defined,
410 limited areas. As linear landscape features, rivers, can be easily divided into removal and monitoring
411 zones. Beavers leave conspicuous signs of their presence, ensuring the possibility of detecting the
412 species even at very low densities. The detection of the species in areas with a very small number of
413 animals during intensive monitoring in Italy confirms its detectability. These factors support the
414 technical feasibility of removing the small populations of beavers in Italy.

415 The main challenges, however, lie in the fragmentation of the local authorities who hold regional
416 responsibility for wildlife management and the likely opposition from organized citizen groups.
417 Beaver populations are distributed across five regions in Central and Southern Italy. Because wildlife
418 management in Italy is a regional competence, the national government cannot directly enforce
419 removal plans. While the national wildlife institute (Istituto Superiore per la Protezione e la Ricerca
420 Ambientale) advocates for the removal of the species, the involvement of various regional offices,
421 each dependent on local political backing, adds complexity to the coordination of a national plan. The
422 governance of the removal operation can be very critical if this objective is not fully shared and

423 supported by decision-makers in all regions, with the risk of successful actions in some areas and
424 stalled or ineffective efforts in others. As the beaver is a charismatic species, opposition to its removal
425 can be expected locally and nationally. Animal welfare is an issue when it comes to the removal of
426 animals. Acting now would involve the removal of a few dozen animals, which offers the possibility
427 of evaluating different intervention techniques, lethal and not. It can be observed that established
428 beaver populations are often managed to reduce their impact on human activities, and management
429 also includes the authorised culling of animals, as demonstrated in Scotland following legal and
430 illegal reintroductions. The lethal removal of even a few animals per year still leads to the killing of
431 many animals in the long term. Opposition can be particularly fervent when dealing with charismatic
432 species, as they can be used as icons to capture the public's imagination and get support for opposition
433 campaigns. Therefore, effective communication of the reasons behind removal interventions is
434 crucial. Emphasizing the need to counter illegal animal releases and that decisions on reintroduction
435 and wildlife management and, more in general, on nature restoration cannot be left to private action
436 but must be the result of a participatory process, are key points to convey.

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439 Associazione Teriologica Italiana) in 2021 in Rome. It reflects the discussion in the workshop and
440 the following Position paper ([https://www.mammiferi.org/wp-content/uploads/2021/11/Posizione-
441 ATIt-sul-Castoro-in-centro-Italia.pdf](https://www.mammiferi.org/wp-content/uploads/2021/11/Posizione-ATIt-sul-Castoro-in-centro-Italia.pdf)) that represent the official position of ATIt on the presence of
442 the Eurasian beaver in Central and Southern Italy.

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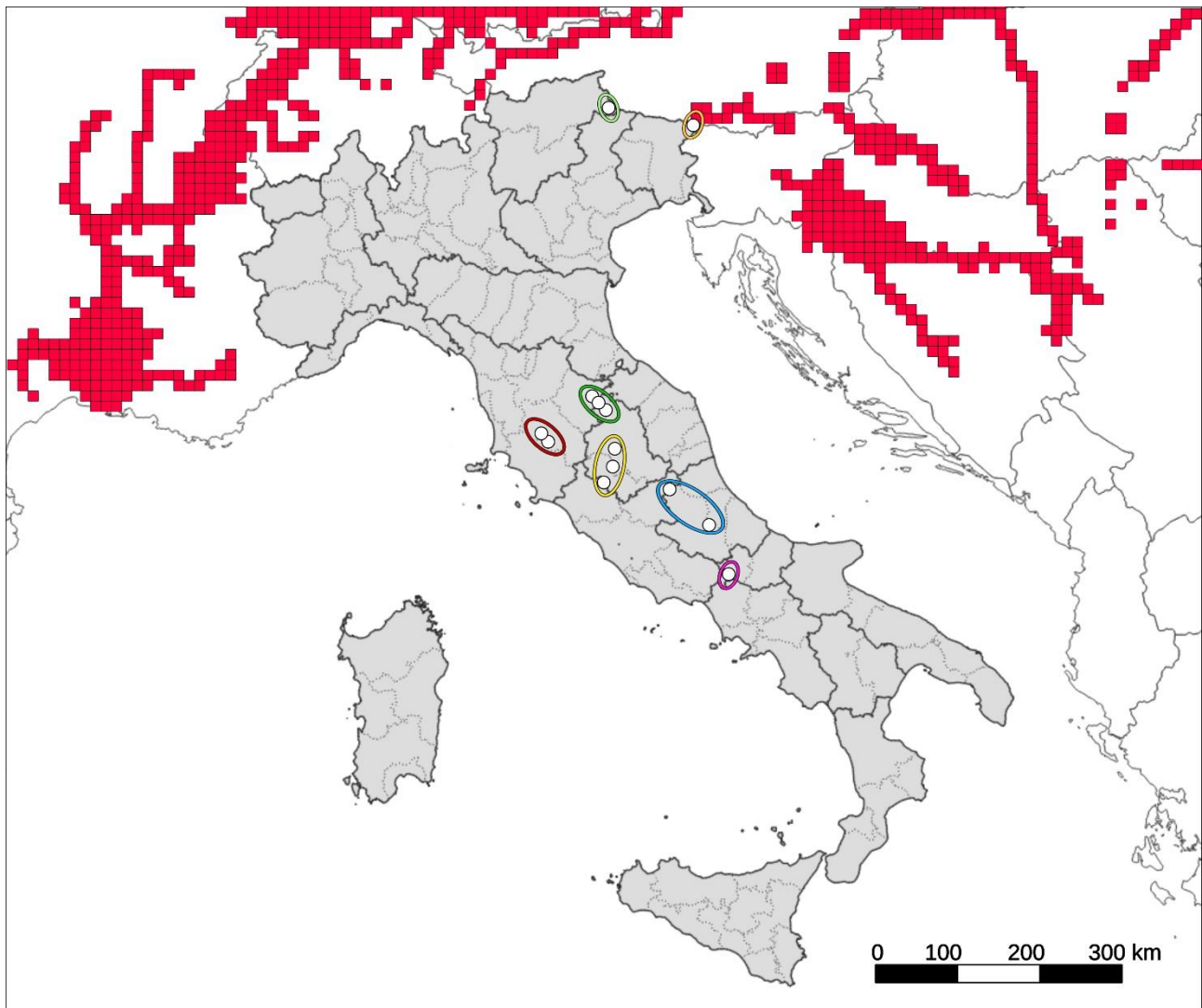
Table 1. Areas in Europe with beaver presence resulting from illegal releases.

Country	Location	Date of release / first observation	No. of animals released	Area of origin of the released animals	Source
Belgium	Wallonia	1998-2000	101	Germany	Verbeylen, 2003
	River Dijle, River Laan (Flanders)	2003	20	Germany	Verbeylen, 2003
England	River Otter (Devon)	2008		Germany	Brazier et al., 2020, Campbell-Palmer et al., 2020
	Tamar River				
	Kent Stour			Norway	Halley et al., 2021
	Wye river on the Welsh border				
	Somerset				
Scotland	River Tay, River Earn, Tayside	2001			Coz and Young, 2020
	River Beaulieu (Highlands)	2017			Coz and Young, 2020 Coz and Young, 2020
Spain	Aragón River (Navarra)	2003	18	northern and southern Europe	Calderon et al., 2023
	Tormes River, near the Douro River	2022			Calderon et al., 2022
	Guadalquivir river (Villatorres, Torreblascopedro)	2023			Burón et al., 2023
Italy	Ombrone and Merse rivers (Tuscany)	2021			Pucci et al., 2021
	Sansepolcro (Tuscany)	2021			Pucci et al., 2021
	Perugia province (Tevere river valley, Umbria)	2021			Mori et al. 2021

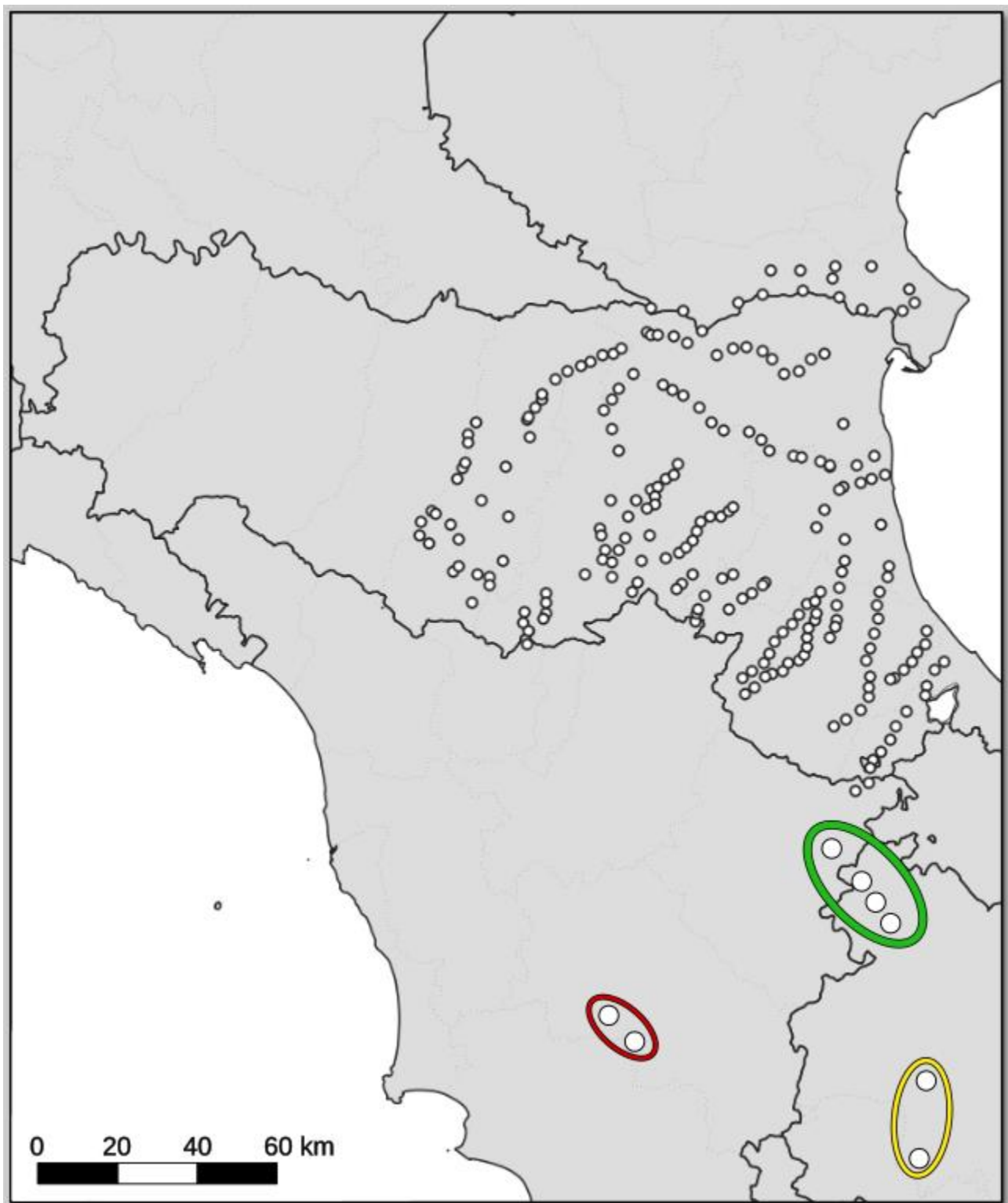
664	Terni province (Tevere	2021	Mori et al. 2021
665	river valley, Umbria)		
666	Aterno River (Abruzzi)	2023	Capobianco et
667			al. 2023
668	Volturno River (between	2023	Capobianco et
669	Molise and Campania)		al. 2023

Table 2. Positive factors (pros) that may facilitate beavers' nuclei removal in Central and Southern Italy and the challenges (cons) that could hamper the implementation of management plans.

Pros	Cons
<ul style="list-style-type: none"> The nuclei are still geographically restricted. 	<ul style="list-style-type: none"> Nuclei are located in 5 regions.
<ul style="list-style-type: none"> Every nucleus has probably no more than a few dozen of animals. 	<ul style="list-style-type: none"> Since wildlife management is a regional competence, it will be necessary to activate more action plans, albeit coordinated with each other.
<ul style="list-style-type: none"> The beaver is a semi-aquatic species; therefore, its distribution is linear along the rivers. This favors the concentration of the removal effort in limited areas. 	<ul style="list-style-type: none"> Political support from multiple regional authorities is needed, but the goal of removal may not be shared by the decision-makers of all regions
<ul style="list-style-type: none"> The signs of presence are evident, and the species can be detected even at very low density. 	<ul style="list-style-type: none"> Being a charismatic species, opposition to removal at local and national levels is predictable.



685 Figure 1. Beaver records reported for Italy and distribution of the species in neighbouring countries.
686 The different areas where beavers are present in Central and Southern Italy are represented as separate
687 ellipses. Points in Tuscany and Umbria (red, green and yellow ellipses) were provided by Emiliano
688 Mori, the others are from Pontarini et al. 2018, Pucci et al. 2021, Capobianco et al. 2023.



689 Figure 2. Areas monitored for beaver's presence in the Emilia-Romagna and Veneto regions, and in
690 the Republic of San Marino (from Leoncini and Viviano 2022, as small white dots). The different
691 areas where beavers are present in Tuscany and Umbria Regions are represented as separate ellipses.