



Research Article

Rapid eradication of a small Eastern grey squirrel (*Sciurus carolinensis*) population in Italy

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Abstract

Rapid eradication is an effective management strategy when introduced populations are still localized. This report details the eradication of a small Eastern grey squirrel (*Sciurus carolinensis*) nucleus in Turin Province, northwestern Italy. The eradication began fifteen months after the first animal was discovered, allowing time to develop and approve the management plan. Following a trial period in August with no captures, from October 2012 to February 2013 16 grey squirrels were removed during monthly sessions from a 258-hectare area. A total of 8–10 cage traps were deployed over 32 days, with a monthly trapping effort of 40 to 70 trap-days and a total of 312 trap-days. Personnel costs amounted to 753 €, while transport expenses totalled 611 €. The overall eradication costs reached 2,077 €. The swift eradication of this grey squirrel nucleus prevented the species from colonizing the largest remaining lowland forest in northern Italy, which is currently home to the native red squirrel. The success of this action was due to the rapid response, which was supported by an existing LIFE project aimed at developing new approaches for grey squirrel management. This project provided trained personnel, materials, and protocols. To achieve similar rapid eradication success, it is crucial to have a well-organized system in place, with trained staff, resources, and intervention procedures ready to be deployed. Streamlining administrative procedures by allowing direct reference to national action plans can expedite rapid response efforts by reducing bureaucratic delays.

Introduction

Eradication is an effective action aimed at preventing the establishment and spread of invasive alien species (hereafter IAS). This management option is particularly effective within an early warning and rapid response system. Prompt detection of IAS is crucial because it enables intervention before significant populations are established, allowing for the quick removal of populations that are still limited and localized (Booy et al., 2020; Robertson et al., 2020). Removing IAS populations contributes to the global conservation goals required by the Convention on Biological Diversity (CBD, 1992). Successful eradications have been documented on both islands (Jones et al., 2016) and mainland areas (Robertson et al., 2017), yielding substantial benefits for species conservation and ecosystem restoration.

The Eastern grey squirrel (*Sciurus carolinensis*, hereafter grey squirrel) is a species native to North America that was introduced to Australia, South Africa and to Europe, in Great Britain, Ireland, and Italy (Bertolino, 2009). The establishment of the grey squirrel in these countries is the result of multiple releases for ornamental purposes or escapes of pets (Bertolino, 2009). In Europe, the grey squirrel outcompetes the native Eurasian red squirrel (*Sciurus vulgaris*, hereafter red squirrel) through exploitation competition for food resources (Wauters et al., 2002a,b). In Great Britain, the displacement of the red squirrel is exacerbated by a squirrelpox virus carried by grey squirrels, which is lethal to the native species (Tompkins et al., 2002; Romeo et al., 2018). In Italy, negative effects from the spillover of a parasitic helminth (*Strongyloides robustus*) from grey to red squirrels has been documented (Santicchia et al., 2020; Romeo et al., 2021; Wauters et al., 2023). Due to these harmful impacts, the grey squirrel was included in

the list of Invasive Alien Species of Union Concern (European Union list) under European Regulation 1143/2014 (Bertolino et al., 2014), which mandates the rapid eradication of newly occurring populations.

The eradication of the grey squirrel from Italy failed in 1997 when an initial trail was stopped by radical animal rights groups which took the wildlife managers to court (Bertolino and Genovesi, 2003). Since then, the species has greatly expanded its range and has been introduced to many other areas drastically increasing its range (Bertolino et al., 2014, 2016; Signorile et al., 2014). In 2011, management activities began in three Italian regions as part of a European LIFE project (LIFE09 NAT/IT/00095 EC-SQUARE), aiming to develop methods to remove grey squirrels in different socio-ecological contexts and limit the spread of the species (Bertolino et al., 2016). Monitoring activities established during this project led to the discovery in May 2011 of a small nucleus of grey squirrels within 'La Mandria' regional park, north of Turin (Fig. 1). This site was about 12.3 km from the northernmost known record of grey squirrels. To reach this new site, grey squirrels would have had to cross a highly urbanized area, including the Turin ring road (six lanes and fenced off). Due to these barriers, this nucleus was attributed to a new introduction or translocation of animals. Therefore, the park staff and managers from the LIFE project, with the support of the regional authority, implemented a rapid eradication. The aim of this work is to report on the successful eradication of this grey squirrel population and to estimate the effort required. Previous squirrel eradications have taken several years to complete (Adriaens et al., 2015; La Haye et al., 2023). Given the importance of a rapid response to invasions, providing an example of a successful rapid eradication can serve as a model to encourage similar actions.

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Methods

Study area

Grey squirrels were reported in the municipality of La Cassa (Province of Turin), inside La Mandria Regional Natural Park (Fig. 1). This park covered 6,570 hectares and preserves one of the last and largest surviving lowland forests (*Quercus-carpinetum*) of the Po Valley, which covers much of northern Italy. The forest, interspersed with meadows and bodies of water, hosts the red squirrel. The area where grey squirrels were observed lies at the western border of the park, outside the extensive forest, in a region consisting of small and fragmented woodlands, pastures, and crops, and is close to small villages.

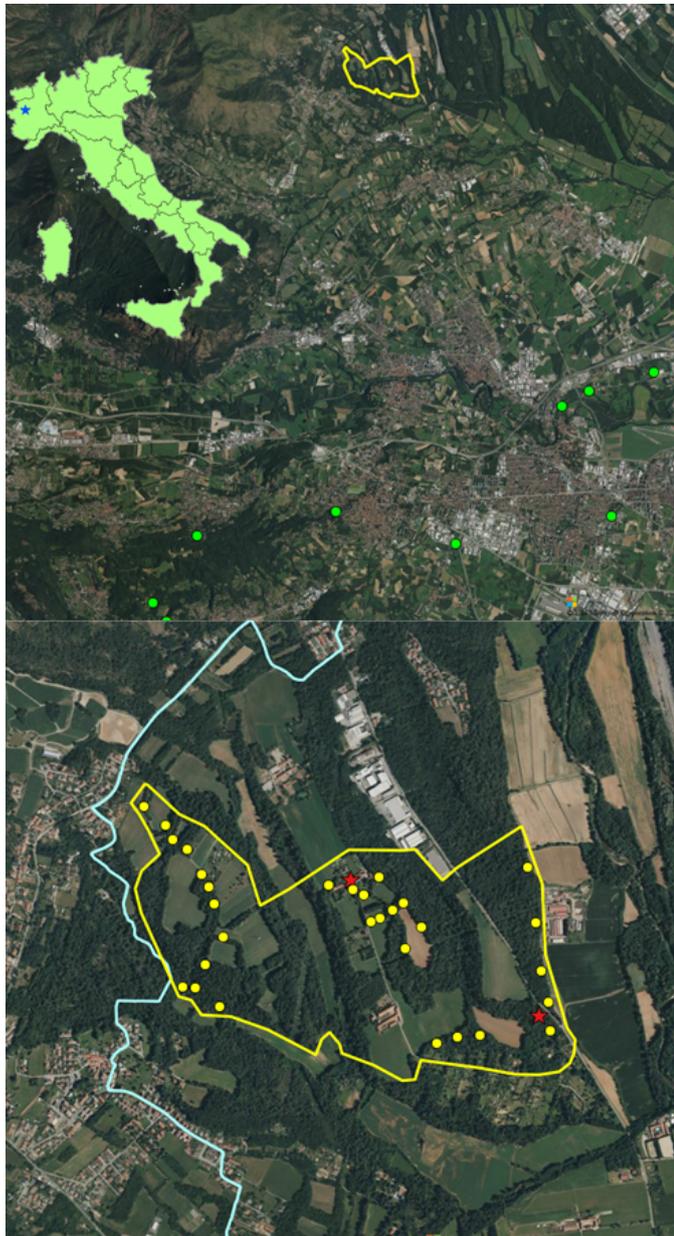


Figure 1 – Above: Location of the study area in Italy (blue insert in the outline of Italy on the left) and area of eradication (yellow line) with respect to the area of previous grey squirrel presence (green dots). Below: trapping area (yellow line) with points of the first grey squirrels recorded (red star) and location of the traps (yellow dots; different traps were activated in different periods); in light blue the perimeter of the park. Images produced with QGIS and Microsoft Bing layers.

Trapping and handling

Squirrels were captured using 8–10 mesh wire cage live traps (Tomahawk, model 202, LxWxH=50×15×15 cm). Traps were distributed opportunistically according to sightings provided by residents (Fig. 1). Eight traps were initially activated from August 8–11, but no squirrels

were captured. Consequently, trapping was suspended and resumed in October with 10 traps after a more extended pre-baiting period. Traps were placed on the ground and baited with hazelnuts and walnuts for a couple of weeks before activation. Traps were activated early in the morning and checked at midday and in the evening. Trapped grey squirrels were transferred to a cloth bag and placed in an airtight container. Here, the grey squirrels were dispatched with an overdose of carbon dioxide. Red squirrels were immediately released. The grey squirrel carcasses were then transferred to the University of Varese for parasitological analysis. During the capture period, there was no damage to the traps.

The cost of the intervention was assessed by summing the expenses for materials, staff labour, and travel. Personnel costs were calculated by multiplying their hourly rates (26.81 €/hour and 21.66 €/hour, depending on their level) with the hours worked on the project. Transportation costs were estimated based on the average cost per kilometer at a rate of 0.35 €/km, which includes vehicle depreciation, per km traveled. The project benefited from the presence of an active LIFE project on the management of the grey squirrel, in which Region Piedmont was a partner. Since this project already provided for coordination costs and for the training of personnel to capture and manipulate the squirrels, we did not evaluate these costs. Although the LIFE project provided the materials, we evaluated the cost of purchasing them by consulting the payment receipts. Similarly, park managers conducted monitoring in the years following the removal during their daily patrols to establish specific post-eradication monitoring. In addition, several camera traps were also active for other projects and were potentially able to detect grey squirrels.

Results

Trapping was conducted in an area of 258 ha, defined based on reports of grey squirrel sightings and landscape features such as woodland edges. Sightings of grey squirrels were primarily reported to the park warden by local residents, who were aware of the threat that grey squirrels pose to the native red squirrel. Fifteen months after the first report of grey squirrels in the area, trapping was initiated in August 2012. After this initial trial period, the traps were activated in five monthly periods from October 2012 to February 2013. In total, 16 grey squirrels, 11 males and 5 females, and 3 red squirrels were captured during 32 days with traps activated (Tab. 1, Fig. 2). Data on the age of the animals are not available. Monthly trapping effort varied over time and increased from 40 to 70 trap-days (Fig. 2 above) for a total of 312 trap-days. Since the area was small and easily reachable by car, checking the cages took about 15–30 minutes, with an additional 15 minutes required if a grey squirrel was captured. The operations were conducted by 1–2 park rangers depending on the daily availability of personnel. Capturing the first animal required 72 trap-days in two trapping periods (Tab. 1), subsequently trapping efforts ranged from 9 to 35 trap-days to remove one squirrel, with a tendency to increase (Fig. 2 below). After February 18, 2013, no more grey squirrels were reported in the area by local residents and by the park rangers patrolling the park daily.

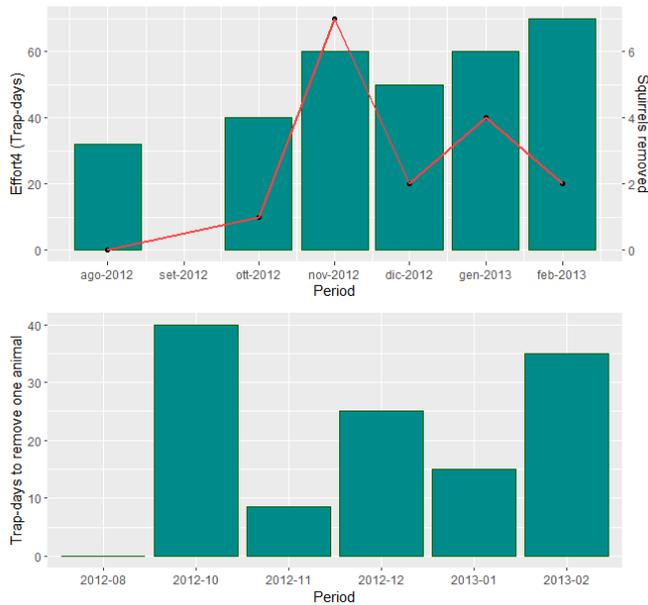
The overall costs of the eradication summed up to 2077.00 € (Tab. 2). Personnel costs (trapping hours) amounted to 753.00 €, materials 713.00 €, and transport 611.00 €, including the travel for trapping when traps were active and bringing the animals to the University of Varese, where post-mortem analyses were carried out.

Discussion

Early detection and rapid response are a crucial component of any effective invasive species management program and are considered among the most cost-effective methods for controlling invasive alien species, second only to prevention. A prompt and coordinated eradication response can significantly reduce environmental and economic impacts when new invasive species are detected. This approach is cost-effective compared to a long-term control program after the species is established (Panzacchi et al., 2007; Medina et al., 2019). Here,

Table 1 – Trapping periods with trapping efforts and grey squirrels removed; red squirrels were immediately released.

Period	Start date	End date	Trap-days	Grey squirrels			Red squirrels
				Total	Males	Females	
I	08/08/2012	11/08/2012	32	0	0	0	0
II	01/10/2012	05/10/2012	40	1	0	1	2
III	18/11/2012	23/11/2012	60	7	6	1	0
IV	03/12/2012	07/12/2012	50	2	0	2	1
V	13/01/2013	18/01/2013	60	4	3	1	0
VI	15/02/2013	20/02/2013	70	2	2	0	0
Total			312	16	11	5	3

**Figure 2** – Above: Trapping efforts (trapping-days) of the six trapping periods (bars) and number of animals removed (red line). Below: Number of trapping-days necessary to catch one squirrel.**Table 2** – Costs of eradicating the Eastern grey squirrel from La Cassa (Piedmont region, Italy).

Coordination	
Experts from LIFE09 NAT/IT/00095 EC-SQUARE	No cost
Materials	713,00€
10 Tomahawk Live traps	415,00€
Bait	50,00€
Euthanasia kit	248,00€
Personnel	
Trapping hours	753,00€
Transport	
Transport from and to park headquarters	456,00€
Transport animals to Varese University	155,00€
Post-eradication survey	
Park wardens during their daily patrol	No cost
Total cost	2.077,00€

we provide an example of the rapid eradication of a small nucleus of grey squirrels in Italy. This species is listed in the European Union list, which mandates that member states act quickly when new colonies are discovered. In general, alien squirrels can establish from just a few individuals (Bertolino, 2009; Bertolino and Lurz, 2013; Waut-

ers et al., 2023). Since regional authorities were partners in the LIFE project, they were already aware of the necessity to limit the spread of grey squirrels. Consequently, the regional park authorities supported the eradication efforts. This paper demonstrates that with the necessary political and administrative support, it is possible to eradicate the initial propagule of a new alien squirrel colonization with limited cost and effort.

Despite this commitment, the eradication effort commenced a year after the first sighting of the grey squirrel. This delay was due to the time required to complete the administrative procedures, including the preparation and approval of the eradication plan, as required also for species listed under the Union list. In Italy, the authorization process involves several steps: drafting an eradication plan, obtaining approval from ISPRA (the Italian Institute for Environmental Protection and Research, the national technical control body for wildlife management), and securing permissions from provincial or regional administrations. These procedures typically require several months to finalize. Although national action plans exist for species on the European Union list, they do not streamline local-level procedures. To enhance response times, particularly for Union-listed species, it is essential to simplify authorization processes. For instance, permitting direct reference to the national action plan without the need to prepare a separate management plan at the local level.

In 2024, 11 years after successfully eradicating a small group of grey squirrels inside La Mandria Regional Natural Park, the species has not reappeared in the management area. The limited number of animals removed, the distance from the main colony of grey squirrels, and the absence of a recolonization of the area, confirm that this was an isolated nucleus, likely the result of a new release or the translocation of animals from other colonies in Italy. Despite this successful control campaign, due to the lack of management of the largest Piedmont colony, the grey squirrel is now making a comeback. There were two sightings in the park: one 2.7 km northeast of the trapping area in 2023 and another 2.8 km southeast in 2024. Until 2024, the grey squirrel had not yet been observed in the eradication area.

The success of the rapid eradication of grey squirrels is linked to several factors considered crucial in such efforts. The activity started quickly after the initial report. Management was facilitated by an existing LIFE project in the same region, aimed at developing new approaches to grey squirrel management. This project provided access to trained personnel, an established trapping protocol, and necessary materials (e.g. traps, euthanasia kits). Rapid response is essential as it prevents animals from spreading and reproducing. The project lasted 6 months with a cost of 2077.00€. Trapping efforts escalate rapidly with the spread of alien mammals across larger areas (Robertson et al., 2017). For example, eradicating a local population of Pallas's squirrel (*Callosciurus erythraeus*) from a 15-hectare urban area in Belgium required five consecutive capture campaigns from 2005 to 2011. A total of 248 animals were removed using live trapping and euthanized with carbon dioxide, costing 207.000€, including post-eradication monitoring (Adriaens et al., 2015). Similarly, removing 249 Pallas's squirrels from an urban area in the Netherlands involved live trapping, surgical sterilization, and relocation to animal parks across Europe from 2011 to 2015, costing 331.376€ (La Haye et al., 2023). In our case, removing 16 grey squirrels with 8-10 live traps over a 258-ha area required 312

trap-days over 6 months. The traps were activated for 32 days, with a daily commitment of half an hour to check the traps, plus an additional 15–30 minutes if one or more squirrels were caught. The reduced time to check the traps was due to their location along an accessible road.

The opposition from stakeholders (Bertolino and Genovesi, 2003) and restricted access to private properties could impact the effectiveness of eradication efforts, highlighting the importance of gaining support from the local population (Bertolino et al., 2021). In our case, residents played a crucial role in facilitating removal activities by reporting sightings of grey squirrels, which helped detect them even at low densities, adjust trap placement accordingly, and allowing traps to be set on their properties. The LIFE project supported a nationwide and locally distributed information campaign (Lioy et al., 2019). This campaign raised awareness among the population about the extinction risks that grey squirrels pose to native red squirrel conservation. Being locally present and familiar to the people, the conservation of the red squirrel likely motivated residents to collaborate in preventing the spread of the grey squirrel population that could threaten the local red squirrels. The LIFE project also provided materials and expertise necessary to implement the eradication project, reducing the time of reaction. At the end of this and a successive project (LIFE13 BIO/IT/000204 U-SAVEREDS), an Alien Squirrel Emergency Team (ASET), made-up by managers and squirrel experts, was established.

The translocation of animals within countries' boundaries where alien squirrels have been introduced is a key pathway for their spread. Genetic studies and monitoring projects have demonstrated this for the grey squirrel in Italy (Signorile et al., 2016) and Great Britain (Stevenson-Holt and Sinclair, 2015; Wauters et al., 2023), as well as for Pallas's squirrel in Argentina (Guichón et al., 2020) and Barbary ground squirrel (*Atlantoxerus getulus*) in the Canary Islands (Medina et al., 2019). The inclusion of the grey squirrel in the European Union list prohibits its trade and translocation. However, given the species' widespread distribution in Italy, the possibility of future illegal translocations cannot be ruled out. The established ASET has the aim to fill in the gap between the reporting of alien squirrels and the active management, supporting local authorities and management agencies with expertise and providing materials for first intervention. This initiative will facilitate future early detection and rapid response interventions against alien squirrels. ☞

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