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REVIEW

# Why are hazel dormice common while edible dormice are endangered in Lithuania? The importance of forest management for dormouse conservation

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**Abstract.** In many European countries, the hazel dormouse *Muscardinus avellanarius* is a rare and threatened species, while the edible dormouse *Glis glis* is common and abundant. In Lithuania, however, the hazel dormouse is widespread and common, but the edible dormouse is rare and endangered. This study aims to review the status of these two dormouse species in Lithuania and the importance of forest management for dormouse conservation in Lithuania and other European countries. Hazel dormice are prospering in Lithuania because forest management practices are favourable for this species. Small-scale clear-felling is a typical technique for harvesting timber in Lithuanian forests. In this way, a mosaic of forest plots is created, consisting of new clear-felled areas, regenerating clearings, young forest stands of different ages, and mature forest stands. Regenerating clearings on fertile soils are attractive to hazel dormice, and dormouse density can be much higher than in surrounding forest areas. However, these forest management practices are harmful to the edible dormouse as they gradually destroy mature oak-dominated forest stands, which are the primary edible dormouse habitat in Lithuania. The conservation status of different dormouse species may directly depend on forest management practices used in particular countries.

**Key words:** small-scale clear-felling, regenerating clearings, *Muscardinus avellanarius*, *Glis glis*

## Introduction

The hazel dormouse *Muscardinus avellanarius* and the edible dormouse *Glis glis* are widespread in Europe; both are arboreal species and often live sympatrically (Juškaitis 2014, Holden-Musser et al. 2016). The ecology of these species is more thoroughly investigated than other European dormouse species (Fedyń et al. 2021, Lang et al. 2022). However, the conservation status of these two dormouse species differs in many European countries.

Broadly, the hazel dormouse is considered a threatened species, included in Annex IV of the Habitats Directive of the European Union. Under Article 17 of this Directive, the conservation status of the species' population has been assessed by the European Commission as unfavourable-bad for the Atlantic bio-region and as unfavourable-inadequate for the Continental, Pannonian and Black Sea bio-regions for the reporting period 2013 to 2018. The conservation status of this species was assessed as unfavourable-bad in the UK, Belgium, the Netherlands, Denmark, Croatia and the Atlantic bio-region of France, and as unfavourable-inadequate in Germany, Austria, Hungary and the Continental bio-region of France (https://nature-art17.eionet.europa.eu/article17/species/

summary/?period=5&group=Mammals&subject=Muscardinus+avellanarius&region=STE). In many European countries, the hazel dormouse is included in national Red Lists (e.g. Belarus, Denmark, Estonia, Germany, UK, Latvia, Hungary) (see Juškaitis 2014).

In the current century, the hazel dormouse may have disappeared from Estonia and north-eastern Latvia, where this species was recorded in the 19th and 20th centuries (Pilāts et al. 2022). Currently, the worst situation for the hazel dormouse is recorded in the UK. Despite a high level of species protection and widespread conservation measures, including reintroductions (e.g. Bright et al. 2006, Mitchell-Jones & White 2009, Morris 2021), an overall ongoing decline of 78% in adult dormouse abundance has been recorded over 27 years, 1994-2020 (Goodwin et al. 2017, Scopes et al. 2023). Conversely, hazel dormouse populations are considered stable in central and southern Europe as well as in Lithuania and Sweden, situated at the northern edge of the species range (https://nature-art17.eionet.europa.eu/article17/species/summary/?period=5&group=Mammals&subject=Muscardinus+avellanarius&region=STE; Berglund & Persson 2012, Juškaitis 2018).

Unlike the hazel dormouse, the edible dormouse is not included in Annex IV of the Habitats Directive. This species is common in southern and central Europe. An increased abundance of the edible dormouse was recorded in Germany (Gatter & Schütt 2001, Koppmann-Rumpf et al. 2003) and the Czech Republic (Adamík & Král 2008). In England, a rapid increase in the distribution and abundance of an introduced population of the edible dormouse was confirmed recently (Trout et al. 2024). In years of high population density, the edible dormouse can even be considered a local forestry pest, causing tree damage by bark-stripping and, in orchards, damaging crops of various fruit trees, including apples, pears, peaches, vines, hazelnuts, etc. (Kryštufek 2010, Morris 2011, Holden-Musser et al. 2016). Traditional hunting of the edible dormouse continues today in Slovenia and Croatia (Kryštufek 2010).

The edible dormouse is a species of conservation concern only along its northern range, with fragmented populations and low densities. It is a red-listed species in Latvia, Lithuania, Belarus and Poland (Juškaitis 2018). A reintroduction program of the edible dormouse was initiated and successfully implemented in several forests in Poland (Jurczyszyn 2001, Strejczek-Jaźwińska & Jaźwiński 2019).

To summarise, in many European countries, the status of the edible dormouse is promising, and its abundance is even increasing, while the status of the hazel dormouse is more unfavourable. The most contrasting status of these two dormouse species is documented in the UK, Germany, France and Croatia. In contrast to the examples presented and countries listed above, the hazel dormouse is widespread and common in Lithuania, but the edible dormouse is rare and endangered. The present paper aims to review the status of both dormouse species in Lithuania and the importance of forest management for dormouse conservation in Lithuania and other European countries. The term forest management means any anthropogenic pressures related to the direct use of forest resources (thinning, clear-felling, selective felling, and planting (Paillet et al. 2010)).

## Status of the hazel dormouse in Lithuania

Lithuania is situated on the northern edge of the hazel dormouse distribution range (Fig. 1). Despite this, the hazel dormouse is relatively common and widely distributed across almost all of the country. Although there are many 'white spots' in the distribution map of the hazel dormouse in Lithuania, most are related only to the lack of data because no large-scale dormouse survey has been carried out in Lithuania. In the best-investigated areas in central Lithuania, hazel dormice were recorded in every 10 × 10 km mapping square and in every forest inside the square (Fig. 1).

As a result of more intensive research during recent decades, the number of 10 × 10 km mapping squares containing hazel dormouse localities increased from 34 in 1988 to 181 in 2024. However, the latter number is probably an underestimate. It is predicted that hazel dormice should be present in more than 500 out of about 700 mapping squares covering the whole of Lithuania because mixed deciduous-coniferous forests suitable for hazel dormice are present in the majority of these squares (Juškaitis 2007b).

Hazel dormice are widespread in Lithuania because they have plenty of suitable habitat. Forest coverage increased steadily from less than 20% after the Second World War up to 33.8% in 2023, when the area covered by forest stands was 2,068,229 ha (https://osp.stat.gov.lt/statistikos-leidiniu-katalogas?publication=43140). One-third of Lithuanian forests are dominated by Scots pine *Pinus sylvestris*, and the majority of them are pure pine stands without any understorey, which are unsuitable habitats for the hazel dormouse.

However, the majority of the remaining Lithuanian forests are mixed forests dominated by Norway spruce *Picea abies*, birches *Betula pendula* and *B. pubescens* or other deciduous tree species, and they all are suitable habitats for the hazel dormouse (Juškaitis 2007a, b).

This situation means that at least half of Lithuanian forests – a minimum of about 1,000,000 ha – are suitable habitats for the hazel dormouse. It should be noted that these habitats are far from optimal habitats described for this species (Bright & Morris 1990, 1996), and the average dormouse population density – about one adult/ha in the pre-breeding season – is comparatively low (Juškaitis 2014). By analogy with Sweden, where there are at least 2,000,000 ha of suitable habitats for the hazel dormouse, the estimated average density of hazel dormouse populations is one adult/ha, and the national population should, therefore be at least 2,000,000 adults in spring (Berglund & Persson 2012), the total Lithuanian hazel dormouse population should be at least 1,000,000 adults in spring.

Habitat fragmentation might not represent a problem for hazel dormice in Lithuania. It is supposed that 20 ha is the minimum area necessary to support a viable population of the hazel dormouse if the woodland is isolated (Bright et al. 1994, Keckel et al. 2012). However, forest tracts larger than 50 ha compose 89% of the total Lithuanian forest area (Kuliešis et al. 2003).

## Status of the edible dormouse in Lithuania

Until 1990, the presence of the edible dormouse in Lithuania was known only from two animals collected in 1936 and stored in the Kaunas T. Ivanauskas Museum of Zoology (Juškaitis 2018). Surveys for rare dormouse species (edible dormouse,

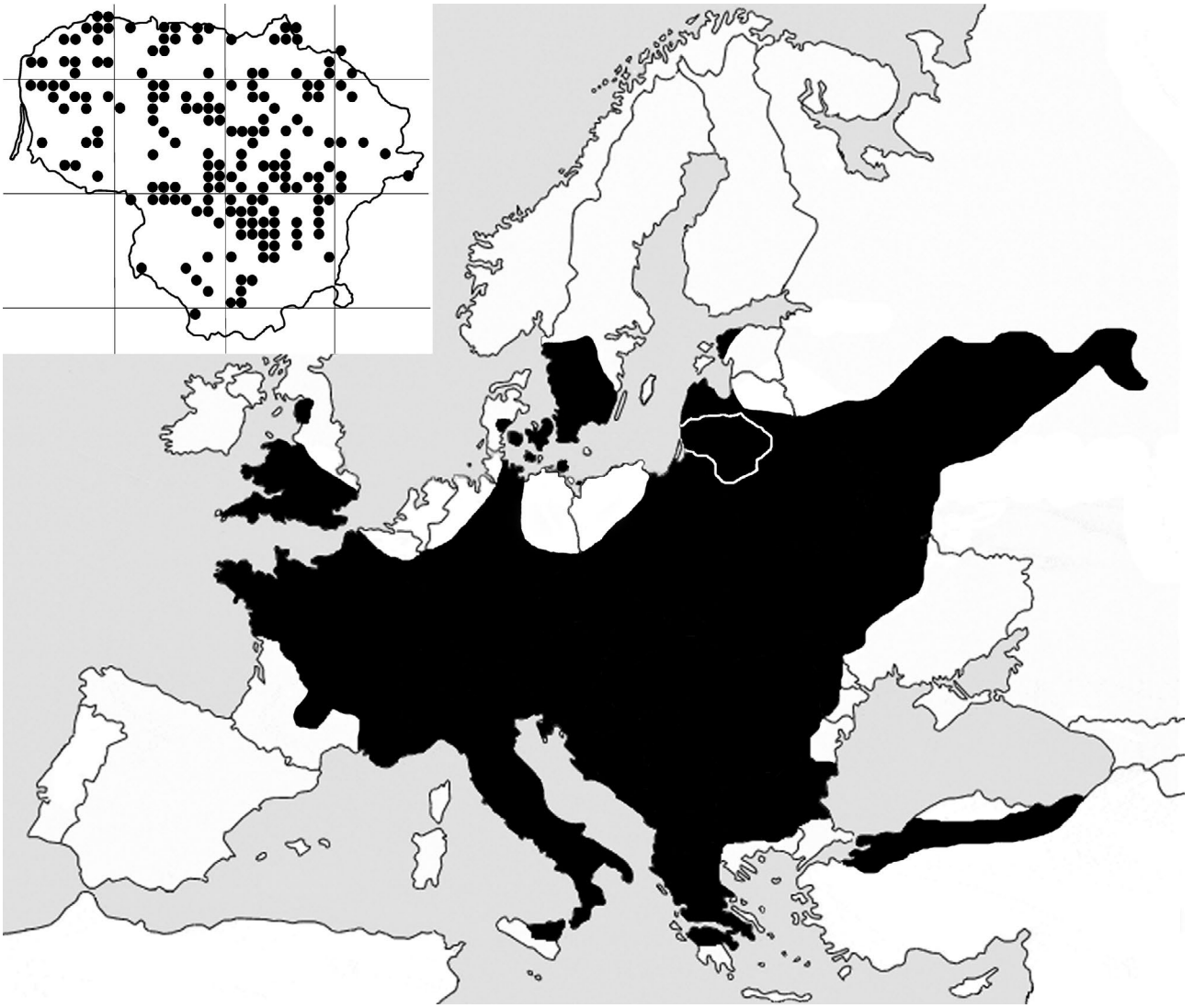

**Fig. 1.** Distributional range of the hazel dormouse (according on Juškaitis 2014), geographical situation of Lithuania (white outline) and localities of the hazel dormouse in Lithuania, depicted on 10 × 10 km mapping squares of the national grid 'Lithuania-94' (top left corner).

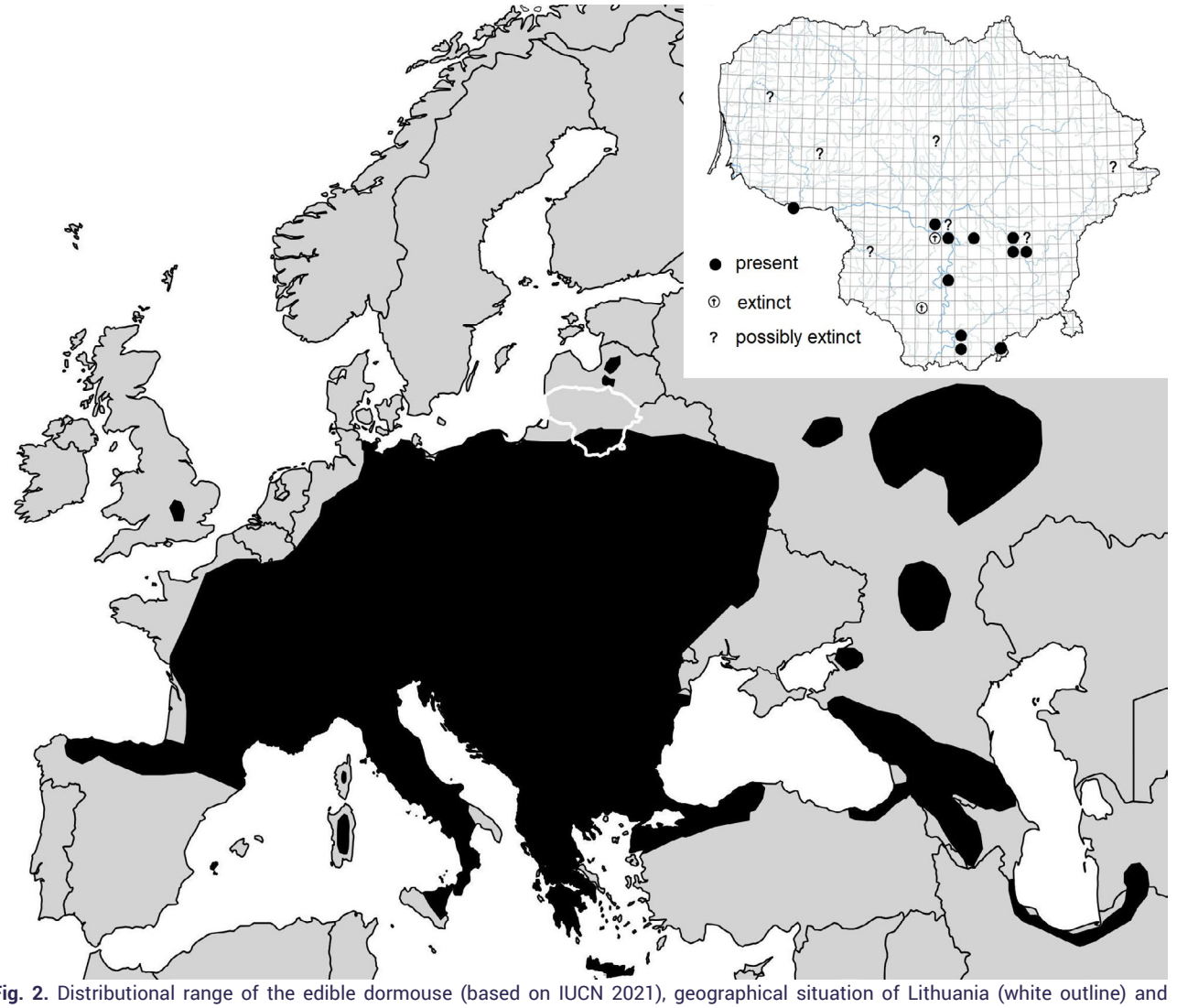


**Fig. 2.** Distributional range of the edible dormouse (based on IUCN 2021), geographical situation of Lithuania (white outline) and localities of the edible dormouse and their status in Lithuania (top right corner).

forest dormouse *Dryomys nitedula* and garden dormouse *Eliomys quercinus*) were conducted in 1990 and 2001-2002. Historical records (Kaunas T. Ivanauskas Museum of Zoology and publications), as well as personal communications about possible observations of the edible dormouse and potential suitable habitat (mature oak-dominated forests), were verified. Wooden nest boxes were set up in suitable localities in spring and inspected in autumn. As a result, some localities of the edible dormouse have been confirmed. Thanks to these and subsequent research, 11 populations of the edible dormouse occurring in isolated forests are known in Lithuania at present (Fig. 2). They all are concentrated in the southern part of the country, mainly along the two largest Lithuanian rivers – the Nemunas and Neris (Juškaitis & Augutė 2015).

However, edible dormice have become extinct in the two localities where they were discovered in 1936. One locality was flooded when the Kaunas hydroelectric power plant was built on the River Nemunas. Extinction of edible dormice at another locality occurred due to the felling of mature forest stands. For the same reason, edible dormice are presumably extinct from other forests where they were observed previously, but concrete evidence is lacking (Fig. 2). Cattle grazing in the past could be a reason for the extinction of both edible and hazel dormice in the Dūkštų ąžuolynas forest which is the current largest oak-dominated forest in Lithuania.

In Lithuania, the edible dormouse is formally protected by laws. It is included in the Red Data Book of Lithuania as an endangered species (IUCN category EN) and in the List of strictly protected species of Lithuania. A conservation plan for the edible dormouse was approved in 2017 (Ministry of Environment of the Republic of Lithuania 2010, 2017, Rašomavičius 2021).


**Fig. 3.** An example of a Lithuanian commercial forest with a mosaic of clear-felled plots (grey colour), regenerating clearings (light green colour) and forest stands of different ages (dark green colours). The typical width of felling strips is 100 m (credit Google Earth Image © 2024 Maxar Technologies).

## Impact of forest management measures on hazel and edible dormouse populations in Lithuania

Small-scale clear-felling is a typical technique for harvesting timber in Lithuanian forests (Fig. 3). Clear-felling destroys dormouse habitats completely (Fig. 4a). However, young hazels *Corylus avellana*, alder buckthorns *Frangula alnus*, raspberries *Rubus ideus*, dwarf honeysuckle *Lonicera xylosteum* and pioneer trees like birch and aspen *Populus tremula* start to re-grow quickly (Fig. 4b). Foresters usually plant young Norway spruce or Scots pine trees, less often young pedunculate oak *Quercus robur*, although many clearings, especially in private forests, are left for natural regeneration (Brukas et al. 2013). Such regenerating clearings are favoured habitats for hazel dormice.

A long-term case study in a regenerating clearing showed that dormice had already started to use it in the second year after clear-felling. Dormouse abundance increased in the third year and reached its maximum in the 7$^{th}$-9$^{th}$ years after clear-felling. Hazel dormice concentrated in this plot and around it. The average dormouse density in the regenerating clearing was significantly higher than the rest of the study site (Juškaitis 2020).

In regenerating clearings, hazel dormice can find suitable food, such as the fruits of raspberries, alder buckthorn and dwarf honeysuckles. The fruit of alder buckthorn is an important food source for all dormouse species because the fruiting period of this plant lasts from August until November (Juškaitis & Baltrūnaitė 2013). Young spruce and oak trees are favourite nest sites for hazel dormice. In the fourth- and fifth years following clear-felling, 23 and 18 dormouse nests were found in an area of 5 ha, i.e. 16.2 nests/ha and 11.8 nests/ha, respectively (Juškaitis & Remeisis 2007).

It should be noted that such favourable conditions for hazel dormice are temporary because regenerating clearings are thinned every three or four years, and young tree stands are formed (Fig. 4c). Thinning of the re-growing woody vegetation during the first decade after clear-felling has only a temporary negative impact on hazel dormouse abundance (Juškaitis 2020). Immediately after thinning, these habitats are less suitable for dormice because the density of trees and shrubs is reduced. The following year, truncated shrubs re-grow, and these habitats again become suitable for hazel dormice. However, this process is not continuous. After thinning young forest stands older than ten years old, these habitats again become unfavourable to hazel dormice (Juškaitis 2008, 2020). The canopies of young trees shade the understorey as they grow, and shaded shrubs are sparse and fruit poorly. For some years, such young forest stands are entirely unsuitable or suboptimal for hazel dormice


**Fig. 4.** Managed forest plots in a commercial forest in Lithuania: a) recently clear-felled area; b) regenerating clearing (5th year after clear-felling), c) recently thinned regenerating clearing (13th year after clear-felling), d) mature mixed forest stand.

until the understorey develops again (Fig. 4c). Nevertheless, new small plots are clear-felled each year, resulting in the formation of new regenerating clearings suitable for hazel dormice after a few years.

In this way, in Lithuanian commercial forests, a mosaic of plots is created comprising new clear-felled areas, regenerating clearings, young forest stands of different ages, and mature forest stands (Figs. 3, 4). In this mosaic, hazel dormice can find forest plots varying from completely unsuitable to highly favourable.

Some other forest management operations affecting hazel dormice are also carried out in commercial forests of Lithuania. Selective felling of mature trees has no evident negative impact on dormouse abundance. Subsequently, it has a positive influence on the development of the shrub layer in open spaces created by felling. However, the felling of the entire understorey of a hazel stand was shown to impact hazel dormice negatively (Juškaitis 2008). In the first year, dormouse density decreased to 0.1 adults/ha, and no litters of juveniles were found in nest boxes set up in the affected plots. Dormouse abundance gradually recovered only in the sixth year after felling (Juškaitis 2008).

To summarise, most forest management operations employed in Lithuania (small-scale clear-felling, thinning, felling of understorey) have a temporary negative effect on habitat suitability for the hazel dormouse, but later-developing habitats that are more favourable for this species regenerate in the affected plots (Juškaitis 2008, 2020).

In contrast to the hazel dormouse, current Lithuanian forest management practices negatively affect the edible dormouse. The edible dormouse is considered a species of climax forests (Morris 2011, Holden-Musser et al. 2016). In Lithuania, which is situated outside the range of the European beech *Fagus sylvatica*, mature mixed forests with old pedunculate oak trees and old hazels are the main habitats for edible dormice (Juškaitis & Augutė 2015). It could be supposed that edible dormice were much more

widespread and abundant than hazel dormice in Lithuania some centuries ago when mature oak-dominated forests occupied much larger areas, and human influence on forests was minimal (Verbyla et al. 2003). Gradual small-scale clear-felling is harmful to edible dormice because the entire mature forest is cut down in a few decades. Edible dormice became extinct, but hazel dormice remained abundant after small-scale clear-felling in the Staciškės forest, where the edible dormouse was recorded in 1936. The same could have happened in some other mature oak-dominated forests in which edible dormice were observed by naturalists in the 20$^{th}$ century but not recorded currently (Fig. 2).

Lithuanian edible dormouse populations are comparatively small, and any forest management measures can potentially affect them. Edible dormice travel mainly in the canopy stratum, and every gap in the canopy due to the thinning of forest stands adversely affects their movement. Only clear-felling of some small forest plots, which are not suitable habitats for edible dormice, could be favourable for these animals when raspberries, glossy buckthorn and hazels re-grow, which are favourite food sources for edible dormice (Juškaitis et al. 2015). Currently, most of the known populations of edible dormouse in Lithuania are situated in protected areas where forest felling restrictions help them persist.

## Forest management and dormouse status in other European countries

The conservation status of different dormouse species may directly depend on forest management practices used in a particular country. For this reason, their conservation status can differ between neighbouring countries. In general, hazel dormice respond positively to intensive forest management practices. In all parts of its distribution, they prefer the early successional stages of woody vegetation created by clear-felling or coppicing (reviews in Juškaitis 2014, Buckley 2020). For this reason, the hazel dormouse showed a marginally significant negative response to habitat protection status in Romania. Most dormice were captured in unprotected areas with ongoing forest exploitation, and no dormouse was captured in long-term protected areas (Benedek et al. 2022).

In Sweden, clear-felling is a standard method in forest management (Brukas et al. 2013, Lundmark 2020), and hazel dormouse populations appear to be relatively large and stable in this country (Berg & Berg 1999, Berglund & Persson 2012). Hazel dormice are found at relatively high densities in intensively managed woodlands in Denmark, although their distribution is restricted to only a few isolated locations (Mortensen et al. 2022).

Studies in many woodlands across the UK have shown that proper woodland management is crucial for hazel dormouse populations. Coppice-with-standards management maintains a suitable habitat for hazel dormice, and a decline in such woodland management could be a significant factor in the present scarcity of these dormice (Bright & Morris 1990). Replacement of ancient woodland by conifer plantations was deleterious to the hazel dormouse in the UK (Bright & Morris 1996), and now attempts at restoration of these habitats are carried out by removal of coniferous trees (Trout et al. 2012, 2018). Hazel dormouse populations may benefit from reinstatement or increased frequency of management practices, such as coppicing and glade management, that maintain successional and diverse habitats within woodlands (Goodwin et al. 2018). The long-term trend indicates a decline in dormouse populations where woodland management is absent (White 2012).

In Italy, a strong effect of forest management on the presence and abundance of dormice was found. Re-growing coppices were the most suitable stands for hazel dormice, whereas recent coppices were the most unsuitable, with an ephemeral presence of a few individuals. Old coppices and high forest stands were both able to sustain local hazel dormouse populations but at lower densities (Sozio et al. 2016). In central Italy, edible dormice occurred in all the surveyed high forests, while no sign of their presence was detected in coppices with a short (< 18 years) rotation cycle (Capizzi et al. 2003). In contrast, in southern Italy, where the harvesting cycle was relatively short, with forest patches being coppiced after around 15 years, the edible dormouse was the most frequently captured dormouse species in comparatively young 10-15-year-old coppice-with-standards forest stands (Martini et al. 2024). The presence of mature trees consisting of taller coppice shoots with greater diameters (approximately 100 standards per hectare left after coppicing) may explain the suitability of such habitat for the edible dormouse.

In Poland, several forest-cutting systems are used. However, the most popular approaches, like large-scale shelterwood compartment systems or shelterwood strip systems, seem harmful to edible dormouse populations (Figarski 2010, Fedyń et al. 2021). Edible dormice avoided the most extensively

managed forest patches, and preservation of mixed forest stands with old deciduous trees and dense understory layer is crucial for these arboreal rodents in managed forests (Iwinska et al. 2020). The extinction of both edible and hazel dormice in central and locally in north-western Poland could be due to extensive deforestation in the past (Jurczyszyn & Wołk 1998).

Some aspects of the impact of forest felling on the absence of edible dormice were revealed by mapping this species in the Czech Republic. Dormice were not recorded at a range of sites that look suitable for this species. Adamík et al. (2019) indicate that this could be an example of dormouse extinctions in the past, e.g. due to the large-scale conversion of deciduous forests to spruce plantations and, later again, re-planting to deciduous stands. Meanwhile, edible dormice survived at some sites that are likely to be on inaccessible terrain that might have been difficult to clear in the past (Adamík et al. 2019).

Current German forest management policy, supporting high forest practices and increased average tree stock age, offers better habitats for the edible dormouse, and this species is considered a winner from the modern forestry policy in Germany (Gatter & Schütt 2001). However, this process could lead to further deterioration of the situation for the hazel dormouse in this country, where it is a red-listed species (Schulze 1996, Juškaitis & Büchner 2013, Meinig et al. 2020). Hence, the status of these two dormouse species in Germany is opposite to that in Lithuania, reflecting the different forest management practices in these countries.

## Conclusions

The hazel dormouse and the edible dormouse show different habitat requirements, and these two dormouse species need different forest management strategies for their conservation. Both small-scale clear-felling and coppicing maintain a heterogeneous successional composition of woodlands, which is favourable for hazel dormice but harmful for edible dormice. Mortellitti et al. (2009) stressed the necessity of different conservation strategies for these two dormouse species. If habitat restoration is the objective, then the edible dormouse should be the target species, whilst the hazel dormouse is less sensitive. Relatively mature forests with rich understory will guarantee habitat for both dormouse species (Mortelliti et al. 2009, Juškaitis & Šiožinytė 2008). However, achieving such a goal requires specialised forest management practices that are incompatible with efficient timber production in commercial forest plantations but that could be implemented in protected areas.

Many measures have been proposed for the conservation of the hazel dormouse (e.g. Bright et al. 2006, Juškaitis & Büchner 2013, Lang et al. 2013), but few for the edible dormouse (e.g. Figarski 2010, Fedyń et al. 2021). Further research is necessary on harmonising forest management practices to conserve both dormouse species living in sympatry. This goal is especially relevant in the northern parts of the range of these species.

Practically nothing is known about the impact of timber harvesting on the animals per se. Do they leave the clear-felled patch and move to nearby sites? If clear-felling occurs in winter, heavy machinery will impact the fossorial hibernacula and lead to elevated mortality of hibernating dormice (Trout et al. 2012). This outcome is especially true for small dormouse populations, and future research should focus on resolving these questions.

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