The Hazel Dormouse (*Muscardinus avellanarius*) in Styria: Suitable Habitats and known Distribution

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Abstract: The hazel dormouse (*Muscardinus avellanarius*) is threatened by habitat loss and fragmentation due to land-use changes. This study assessed its distribution in Styria using GIS-based Habitat Suitability Index (HSI) modelling, field surveys with nest tubes at 30 sites, and the analysis of previous records. The HSI model identified 17.06 % of Styria as suitable or highly suitable habitat, with the highest suitability in the Alpine foothills. Distribution analysis revealed a lack of data in the Central Alps and Styrian Peripheral Mountains, highlighting the need for further systematic surveys. Field studies confirmed dormice at 27 sites, with population densities ranging from 1 to 10 individuals per hectare (I/ha), averaging 2.5 I/ha. While the Northern Alps contain large forests, the Alpine foothills are highly fragmented due to intensive agriculture. The results emphasize the importance of habitat connectivity, particularly hedgerows and riparian woodlands, for dormouse conservation.

Zusammenfassung: Die Haselmaus *(Muscardinus avellanarius)* in der Steiermark: Geeignete Lebensräume und bekannte Verbreitung. – Die Haselmaus (*Muscardinus avellanarius*) ist durch den Verlust und die Fragmentierung ihres Lebensraums infolge von Landnutzungsänderungen zunehmend bedroht. In dieser Studie wurde ihre Verbreitung in der Steiermark anhand einer GIS-gestützten Habitat-Suitability-Index-(HSI)-Modellierung, ergänzender Feldstudien mit Neströhren an 30 Standorten sowie einer Analyse vorhandener Nachweise untersucht. Das HSI-Modell ergab, dass 17,06 % der Steiermark als gut bis sehr gut geeigneter Lebensraum für die Haselmaus eingestuft werden können, wobei die höchste Eignung im Alpenvorland festgestellt wurde. Die Analyse der Verbreitungsdaten offenbarte jedoch erhebliche Informationslücken in den Zentralalpen und im Randgebirge, wodurch ein Bedarf an weiterführenden systematischen Erhebungen deutlich wird. In den Feldstudien konnte das Vorkommen der Haselmaus an 27 untersuchten Standorten bestätigt werden. Die Populationsdichten schwankten dabei zwischen 1 und 10 Individuen pro Hektar (I/ha), mit einem Durchschnittswert von 2,5 I/ha. Während die Nördlichen Alpen von ausgedehnten Waldgebieten geprägt sind, ist das Alpenvorland aufgrund intensiver landwirtschaftlicher Nutzung durch eine starke Fragmentierung gekennzeichnet. Die Ergebnisse dieser Untersuchung unterstreichen die zentrale Bedeutung der Habitatvernetzung für den Schutz der Haselmaus. Insbesondere Heckenstrukturen und Auwälder spielen eine entscheidende Rolle für den Erhalt dieser gefährdeten Art.

Keywords: Distribution in Styria, Habitat Suitability Model (HSI), Hazel dormouse, *Muscardinus avellanarius*, nest tubes.

Schlüsselwörter: Haselmaus, Habitateignungsmodell HSI, *Muscardinus avellanarius*, Neströhren, Verbreitung Steiermark.

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1. Introduction

Ongoing land-use and climate changes are causing significant transformations in the habitats and lifestyle of dormice (Ruf & Bieber 2020; Bennette & Richard 2021; Fedyń et al. 2021; Helvacı 2024). The hazel dormouse (*Muscardinus avellanarius*) is particularly affected in cultivated landscapes, where the intensification of agriculture and forestry often leads to the loss, degradation and fragmentation of its preferred habitats (Bright & Morris 1996; Bright et al. 2006; Juškaitis & Büchner 2010; Büchner & Lang 2014; Resch & Resch 2021a). These habitats include species-rich deciduous and mixed forests with open canopies that support a fruit-bearing shrub layer (Bright & Morris 1993; Juškaitis & Büchner 2010; Juškaitis et al. 2014; Resch et al. 2021a). Both, the colonization and extinction probability are strongly influenced by the distance between remaining habitat patches and the presence of hedgerows, which serve as corridors and facilitate movement (Bright et al. 1994; Bright & MacPherson 2002; Chanin & Gubert 2012; Ehlers 2012; Iannarilli et al. 2017). Due to its habitat preference, the hazel dormouse serves as a bioindicator for structurally diverse and intact ecosystems (Bright & MacPherson 2002). Moreover, it is considered a keystone species as conservation measures aimed at protecting its habitats benefit a wide range of other species within the same ecosystems (Bright et al. 2006). Despite its ecological importance and its protection under the EU Habitats Directive (Annex IV), the last Article 17 report (reporting years 2013–2018) classified the hazel dormouse as having an unfavourable conservation status in Austria (Council Directive 92/43/EEC of 21 May 1992). In addition, the impact of climate change on hazel dormouse ecology remains uncertain. It was long assumed that rising winter temperatures would negatively impact its hibernation (Pretzlaff & Dausmann 2012; Goodwin et al. 2018). However, recent research suggests that they adapt well through thermoregulatory and behavioural responses (Pretzlaff et al. 2020). As Cartledge et al. (2024) further showed for the United Kingdom, hazel dormouse habitats can also develop positively with climate warming. In Austria, this aligns to the ongoing shift from spruce forests to climate-resilient mixed deciduous forests (Karrer et al. 2022), which meets their habitat requirements and could therefore be beneficial.

To monitor these developments, a solid data foundation is necessary. However, in Styria, a lack of reliable data on its distribution was evident at the start of this project. Existing information was limited to results from local surveys (Blatt & Resch 2013; Resch et al. 2015; Resch & Resch 2018), outdated publications (Spitzenberger 1983, 2001) and incidental observations on citizen science platforms such as naturbeobachtung.at or iNaturalist.

To address this knowledge gap, the Naturschutzbund Steiermark initiated a conservation project with two main objectives: (1) assessing potential habitat availability through GIS-based modelling, and (2) determining the current distribution of the hazel dormouse via field studies and data research. This research provides a crucial basis for targeted conservation measures in Styria.

2. Methods

2.1. Habitat Suitability Index (HSI)

The habitat suitability map was developed to accurately represent habitat quality while ensuring broad applicability. The analysis was based on the widely recognized and established Habitat Suitability Index (HSI) model, which has been extensively applied in conservation since the 1980s (U.S. Fish and Wildlife Service 1980, 1981; Terell & Carpenter 1997; Blaschke 2004). The present calculation adheres to the principles of the HSI-model but employs, in line with Maringer & Slotta-Bachmayer (2006), Friembichler & Slotta-Bachmayer (2013) and Resch et al. (2021b), a classification system with a scale from 0 (not suitable) to 4 (very suitable), rather than the commonly used 0 to 1. Elevation, land use, vegetation type, vegetation period and Impact of global radiation were selected as habitat parameters (Habitat Suitability Values, HSV) and classified according to the known habitat requirements of the hazel dormouse (Tab. 1). The calculation of the HSI was performed by multiplying the individual HSV values using QGIS 3.x and a 10 × 10 m raster resolution (WGS 84/UTM Zone 33, EPSG 32633). To facilitate interpretation, the values were finally transformed into a composite scale ranging from 0 to 14 and categorized into five suitability classes: 0: Not suitable [HSI=0], 1–5: Low suitability [HSI=1], 6–8: Moderate suitability [HSI=2], 9–11: High suitability [HSI=3], and 12–14: Very high suitability [HSI=4]. Follow-up analyses were conducted based on the natural spatial landscape classification of Styria: Polygon shapefile based on Lieb (1991), CC-BY-4.0: Land Steiermark – data.steiermark.gv.at.

2.2. Field studies

Study sites: The survey was conducted at 30 study sites (Fig.1). They were selected based on their potential habitat suitability for the hazel dormouse. The selected areas were at least 1 ha in size, or (for linear elements such as hedgerows) at least 150 meters in length. If continuity was lacking, two sub-areas were selected; this applied to three of the chosen sites. Since habitat improvement measures were planned for confirmed hazel dormouse occurrences, areas owned by the Naturschutzbund Steiermark were preferred resulting in 26 of the 30 sites being located on their property. The surveys were carried out for two years: sites 1–13 were surveyed in 2022, and sites 14–30 in 2023.

Since dormice are rarely captured using conventional live traps (e.g., Longworth and Sherman traps), artificial nesting sites are preferred for data collection. In recent years, the use of "nest tubes" has proven to be an effective method for studying the hazel dormouse (Chanin & Woods 2003; Bright et al. 2006; Juškaitis & Büchner 2010; Juškaitis 2014). At each study area, we mounted two nest tubes at heights between 1.5 and 2 meters at 15 different spots. Monitoring was conducted in August/September (live trapping of dormice) and November/December (nest inspections). Flood events in August 2023 (BMLRT, 2023) particularly affected the southern study areas along the Murauwald (28MT, 29MW, and 30MU). In areas 28MT and 29MW, trees were uprooted, making access (live trapping in September and the removal of nest tubes in December) either impossible or only partially feasible.

Occupation Density: During the monitoring, grass nests of the hazel dormouse found in nest tubes were documented. Since wood mice (*Apodemus* sp.) also use artificial nesting sites, microscopic species identification based on hair samples (Teerink 1991; De Marinis & Agnelli 1993; Meyer et al. 2002; Tselikova & Chernova 2004) was performed for nests that could not be identified with certainty (e.g. leaf-nests). Occupation density was calculated as the proportion of occupied nests relative to the total number of artificial nesting sites available.

Population Density: Population density was estimated based on the number of captured individuals (representing the minimum number of individuals present) at the 15 spots. The area to be considered as "catchment area" was calculated using buffers around the trapping spots. Based on known home-range-data from literature (Juškaitis & Büchner 2010; Juškaitis 2014) in this study, a value of r = 25 m was used. Areas such as meadows, paved roads, railway lines, and water bodies were excluded. If nests were found but no individuals were captured, five nests were equated to one individual.

Population Status: The population status was assessed according to Meinig (2006). This classification scheme considers populations as "medium– poor" if only single individuals are detected, as "good" if multiple individuals (2–5) of both sexes are found per 1 ha, and as „very good" if more than five individuals, including juveniles, are detected.

Tab. 1: Summary of Habitat Suitability Values (HSV) – data sources, classification and ecological relevance, including references.

Tab. 1: Zusammenfassung der Habitat-Eignungswerte (HSV) – Datenquellen, Klassifizierung und ökologische Relevanz, einschließlich Referenzen.

HSV	Type and source of data	Categorization	References
Elevation	Digital Terrain Model (DTM) with 10m resolution, derived from airborne LiDAR data (2022); raster data, CC-BY-4.0: Land Steiermark – data.steiermark.gv.at	HSV=0 >2000 m; HSV=1: 1200–1999 m; HSV = 2: 190–1200 m	Distribution of hazel dormouse records in Austria across elevation and vegetation zones (Spitzenberger 1983), elevation diagram (Spitzenberger 2001), and the highest recorded hazel dormouse occurrence in Austria at 1,935 m (Resch & Resch 2023).
Land Use	Cadastre/DKM land use areas (2022), scale 1:1000, vector data, Land Steiermark – A17 Statistics and Geoinformation	HSV = 0: Alpine areas, industrial areas, permanent crops/gardens, buildings, parking lots, agricultural land, vineyards, forestry roads, water bodies, low-vegetation areas, cemeteries, extraction sites, rock/glacier areas, rail and road infrastructure, and recreational areas; HSV = 1: Shrubland, forests, wetlands, riparian zones, roadside areas, and bushy vegetation.	The hazel dormouse prefers structurally diverse mixed deciduous forests with ample sunlight and a fruit-rich understory. In the Alps, it follows riparian woodland corridors up to the upper forest and dwarf pine zones. It is rarely found in buildings, except near forests. While forests without a shrub layer are considered suboptimal, occasional sightings occur in undergrowth-free deciduous plantations and pure spruce stands (Berg 1996; Bright et al. 2006; Büchner & Lang 2014; Fedyń et al. 2021; Juškaitis & Büchner 2010; Juškaitis 2014; Juškaitis et al. 2016; Resch & Resch 2021; Resch et al. 2021a, Resch et al. 2023; Wolten 2009).
Vegetation	CORINE Land Cover (2018), scale 1:100,000, vector data, CC-BY-4.0: Umweltbundesamt GmbH & European Union, Copernicus Land Monitoring Service (2018), European Environment Agency (EEA), funded by the European Union	HSV = 1: all built-up areas, agriculture; HSV = 2: heathlands and moorlands, inland wetlands; HSV = 3: Deciduous forests. HSV = 4: Forest/shrub transition zones, mixed forests.	
Vegetation Period	Based on the average vegetation period duration (≥10°C), derived from 50 × 50 m^2 temperature raster data (Climate Atlas Styria, 2010, dataset Veg-d10). Data source: CC-BY-4.0, Land Steiermark	HSV = 0: Vegetation duration; HSV = 1: < 92.5 days (half of the maximum); HSV = 2: > 92.5 days.	The hazel dormouse relies on a steady food supply of flowers and fruits from spring to hibernation in winter (Bright & Morris 1993, 1996; Bright et al. 2006; Juškaitis 2014; Juškaitis et al. 2016). Vegetation duration and global radiation were used to account for this.
Global Radiation	Sum of incoming solar radiation on a horizontal surface during the vegetation period (1989–2018), derived from FORSITE climate data – Styria dataset: glohoriVP. Unit: [$kWh/m^2/a$], raster data	HSV = 1: < 487 $kWh/m^2/a$; HSV = 2: 487–772 $kWh/m^2/a$; HSV = 3: > 772 $kWh/m^2/a$.	

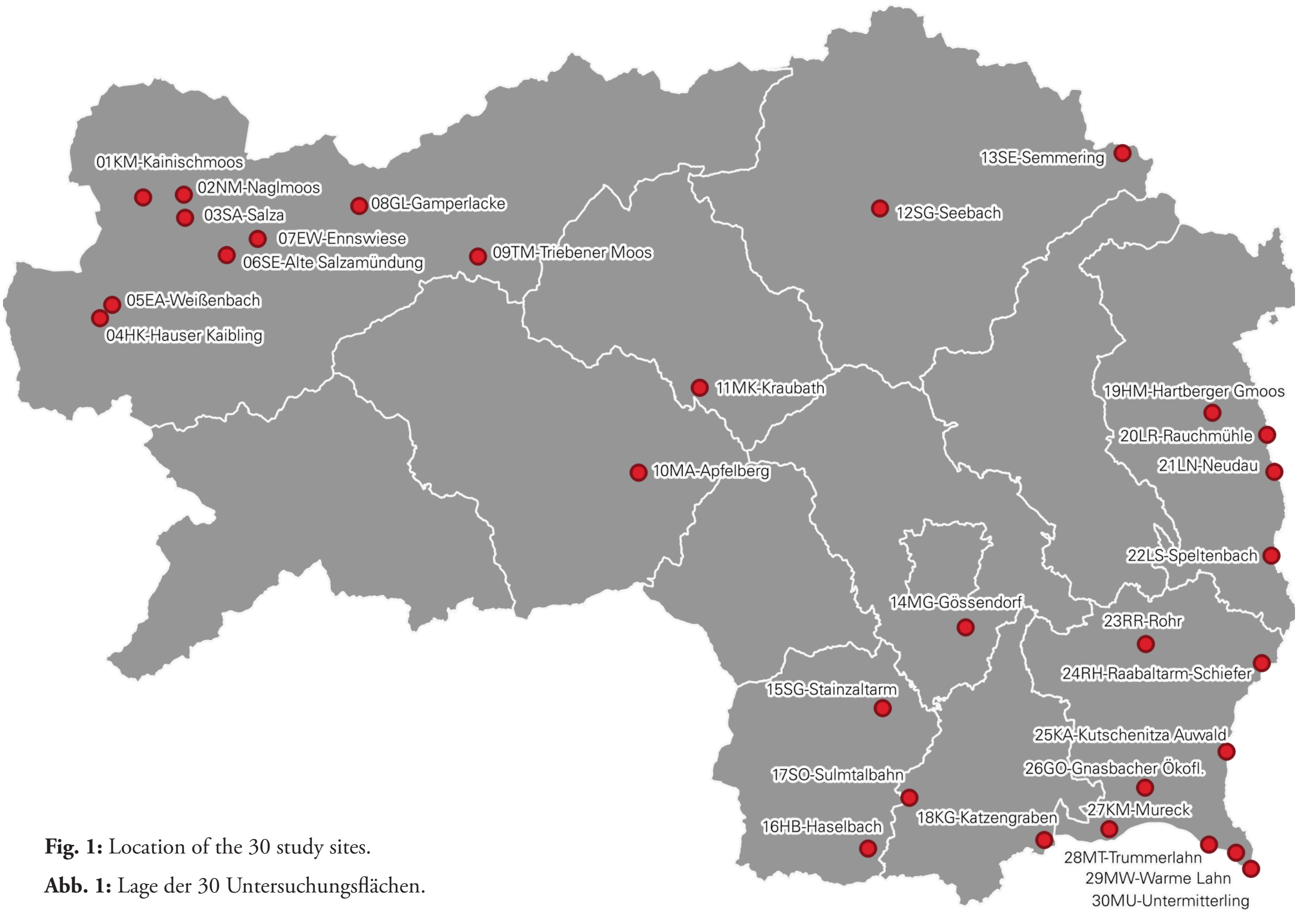

Fig. 1: Location of the 30 study sites.

Abb. 1: Lage der 30 Untersuchungsflächen.

2.3. Data reserach

To achieve our goal to obtain a comprehensive overview of the hazel dormouse distribution, we conducted a distribution analysis including museum specimens and verified photographic evidence. The following data sources were consulted:

- Publications including record type descriptions: Spitzenberger (1983)
- Databases: baumschlaefer.at (Österreichische Bundesforste & apodemus 2025), GeoMaus (Resch & Resch 2025), naturbeobachtung.at (Naturschutz bund Österreich 2025), GBIF.org (2025): including iNaturalist (2025), observation.org (2025) and Univer sity of Natural Resources and Life Sciences – Roadkill (2024)
- Requests for hazel dormouse records from the Universalmuseum Joanneum in January 2025 and Nature Conservation Department in October 2023, including additional recordings of the hazel dormouse from Resch & Resch (2024), which had not yet been incorporated into this database.

Duplicates were sorted out. Remaining points from the years 1900–2024 were georeferenced with an accuracy of 2 decimal digits (corresponds to an inaccuracy of 1,100 m) in WGS 84 (World Geodetic System 1984) and visualized in a distribution map including our project data.

3. Results

3.1. Habitat Suitability Index (HSI)

According to the habitat model, 17.06 % of Styria would provide good or very good habitats (HSI = 3 or 4). An additional 24.84 % is considered suitable. In contrast, 58.10 % of the area is categorized as either not suitable (40.37 %) or poorly suitable (17.73 %). Based on the landscape classification of Styria by Lieb (1991), the Alpine foothills have the highest habitat suitability. They cover an area of 1,046 km² of well-suited (HSI = 3) and highly suitable (HSI = 4) habitats (corresponds to an area of 35 % of the entire Alpine foothills). This is followed by the Styrian Peripheral Mountains (901 km², 23 %), the Northern Alps (605 km², 15 %), and the Central Alps (134 km², 4 %). When considering smaller units, suitable habitats are primarily found in the Riedelland, Grazer Bergland and Koralpe (Tab. 2, Fig. 2).

The habitat suitability model was assessed through statistical analysis of known hazel dormouse occurrences (data source: Nature Conservation Department, 25.10.2023). A 25 m buffer was applied to 64 occurrence points, eliminating those within less than 25 m of each other, resulting in 31 distinct points. These were then compared to 31 randomly generated points (each also buffered by 25 m) using a U-test. HSI values (0–4) were assigned to all points, with the dominant value selected in cases of overlapping areas. The test revealed a significant difference between occurrence and random points, with higher HSI values at occurrence points ($U = 290$, $z = 2.77$, $p = 0.005$).

3.2. Occupancy Density, Population Density, Population Status

In 27 out of the 30 study sites, the presence of the hazel dormouse was confirmed. Population densities ranged between 1 and 10 individuals per hectare (I/ha), with an average of 2.5 I/ha. Deviations from this were observed in the areas Triebener Moos, Kirchgraben-Mureck, Katzengraben, Alte Salzamündung-Enns and Murauwald-Apfelberg with densities below 1 I/ha, and in the area Semmering-Erzlhof where a density of 14,2 I/ha was recorded. The population status was classified as „very good“ in 4 cases, „good“ in 6 cases, and „medium to poor“ in 19 cases (Tab. 3).

3.3. Distribution analysis (Data research and field studies)

For Styria, a total of 177 records of the hazel dormouse were obtained: 27 from field studies and 150 from data research in publications, databases and institutions (museum specimen or photo): Spitzenberger 1983 (11), baumschlaefer.at (3), GeoMaus (4), naturbeobachtung.at (10), Joanneum Graz (5), Nature Conservation Department (95) and GBIF.org (11): observation.org (1), University of Natural Resources and Life Sciences – Roadkill (1) und iNaturalist (9).

4. Discussion

With evidence from 27 of the 30 survey sites, the results show that the hazel dormouse is regularly found in its known primary habitats. The documented population densities ranged between 1–10 individuals per hectare (I/ha) with an average of 2.5. This corresponds to published data were also densities between 1–10 (max. 15) were reported (review in Juškaitis & Büchner 2010; Juškaitis 2014; Juškaitis et al. 2015). In addition, previous studies in the Austrian Alps (Blatt & Resch 2013, 2015; Resch et al. 2019; Resch et al. 2021a) have reported similar population densities ranging from 0.4 –4 I/ha. Furthermore, our findings align with the National Dormouse Monitoring Programme in England, which reported average population densities ranging from 1.75 to 2.5 individuals per hectare across 83 monitored sites (Bright et al. 2006).

This study aimed to improve the database by deliberately choosing survey sites deemed suitable for the hazel dormouse and where its presence was considered likely. The high number of records does not allow conclusions about its overall conservation status. Due to the preference for selecting Naturschutzbund Steiermark-owned areas, the study sites were unevenly distributed across Styria. So statistical analyses on their presence in e.g. natural region categories are not feasible, but in combination with the calculated Habitat Suitability Index and supplementary data research, they provide sample-based insights into the population status of selected regions.

Tab. 2: Subareas containing suitable habitats (= HSI 2,3,4) larger than 50 km², with information on spatial extent [km²] and the percentage distribution of individual HSI categories (0 = Not suitable, 1 = Low suitability, 2 = Moderate suitability, 3 = High suitability, 4 = Very high suitability).

Tab. 2: Teilgebiete mit geeigneten Lebensräumen (= HSI 2,3,4), welche größer als 50 km² sind, mit Angaben zur Flächenausdehnung [km²] und prozentualer Verteilung der einzelnen HSI-Kategorien (0 = Nicht geeignet, 1 = Wenig geeignet, 2 = Geeignet, 3 = Gut geeignet, 4 = Sehr gut geeignet).

Natural unit	Primary natural unit	HSI 0 [km²]	HSI 1 [km²]	HSI 2 [km²]	HSI 3 [km²]	HSI 4 [km²]	HSI 0 [%]	HSI 1 [%]	HSI 2 [%]	HSI 3 [%]	HSI 4 [%]
Oststeirisches Riedel-land	Alpine foothills	1287	0	143	0	730	60	0	7	0	34
Mountains Graz Ost	Styrian Peripheral Mountainss range	193	30	144	2	213	33	5	25	0	37
Weststeirisches Riedelland	Alpine foothills	318	0	54	0	213	54	0	9	0	36
Mountains Graz West	Styrian Peripheral Mountainss range	96	0	63	0	188	28	0	18	0	54
Koralpe	Styrian Peripheral Mountainss range	152	115	195	2	155	25	19	32	0	25
Ybbstaler Alps	Northern Alps	42	31	130	22	116	12	9	38	6	34
Ennstaler Alps	Northern Alps	121	65	164	19	104	26	14	35	4	22
Hochschwabgruppe	Northern Alps	186	140	229	28	83	28	21	34	4	12
Joglland	Styrian Peripheral Mountains range	216	2	133	0	89	49	1	30	0	20
Gleinalpe	Styrian Peripheral Mountains range	75	144	276	2	79	13	25	48	0	14
Totes Gebirge	Northern Alps	211	124	83	12	48	44	26	17	2	10
Fischbacher Alps	Styrian Peripheral Mountains range	132	120	303	4	54	21	20	49	1	9
Eisenerzer Alps	Northern Alps	119	149	164	18	38	24	30	34	4	8
Windische Bühel	Alpine foothills	89	0	12	0	56	56	0	8	0	36
Mürzsteger Alps	Northern Alps	91	118	220	14	29	19	25	47	3	6
Stubalpe	Styrian Peripheral Mountains range	130	141	169	7	34	27	29	35	1	7
Wölzer Tauern	Central Alps	493	444	170	12	28	43	39	15	1	2
Mürztaler Alps	Northern Alps	99	73	374	1	35	17	12	64	0	6
Dachstein	Northern Alps	153	108	109	8	23	38	27	27	2	6
Murberge	Central Alps	86	154	105	7	19	23	42	28	2	5
Seckauer Tauern	Central Alps	197	306	213	9	17	27	41	29	1	2
Wechsel	Styrian Peripheral Mountains range	76	44	99	0	21	32	18	41	0	9
Seetaler Alps	Central Alps	112	161	104	3	12	29	41	26	1	3
Gurktaler Alps	Central Alps	95	249	91	7	8	21	55	20	2	2
Schladminger Tauern	Central Alps	407	184	64	5	7	61	28	10	1	1

Tab. 3: Overview of Results: Occupancy Density (OD [%]), Population Density (PD [individuals per hectare, I/ha]), Population Status.

Tab. 3: Übersicht der Ergebnisse: Besatzdichte (OD [%]), Populationsdichte (PD [Individuen pro Hektar, I/ha]), Populationsstatus.

ID	Study site	OD (%)	PD	Population Status
01KM	Kainischmoos	33|0	2.6|0	good|–
02NM	Naglmoos	33	1.6	medium – poor
03SA	Salzamündung–Aussee	37	1.6	medium – poor
04HK	Hauser Kaibling	13	2.3	medium – poor
05EA	Ennsauwald–Weißenbach	33	4.2	very good
06SE	Alte Salzamündung–Enns	23	0.8	medium – poor
07EW	Ennswiese–Trautenfels	17	1.3	medium – poor
08GL	Gamperlacke	47	1.1	medium – poor
09TM	Triebener Moos	27	0.5	medium – poor
10MA	Murauwald–Apfelberg	13	0.9	medium – poor
11MK	Murauwald– Kraubath	83	8.6	very good
12SG	Seebach–Grassnitz	7	1.2	medium – poor
13SE	Semmering–Erzlhof	95|90	14.2|4.5	very good|good
14MG	Murauwald–Gössendorf	0	0	–
15SG	Stainzaltarm Grafendorf	20	2.5	medium – poor
16HB	Haselbach	27	5.1	medium – poor
17SO	Sulmtal–Otternitzwinkel	20	6.3	medium – poor
18KG	Katzengraben	17	0.8	medium – poor
19HM	Hartberger Gmoos	20	1.2	good
20LR	Lafniz–Rauchmühle	7|38	2.2|3.5	medium – poor|-good
21LN	Lafnitz–Neudau	43	1.3	medium – poor
22LS	Lafnitz–Speltenbach	37	2.8	good
23RR	Raabaltarm–Rohr	27	1.3	medium – poor
24RS	Raabaltarm–Schiefer	37	1.7	medium – poor
25KA	Kutschenitza Auwald	57	2.2	good
26GO	Gnasbacher Ökoflächen	20	1.8	medium – poor
27KM	Kirchgraben–Mureck	7	0.7	medium – poor
28MT	Murauwald–Trummerlahn	0	0	–
29MW	Murauwald–Warme Lahn	0	0	–
30MU	Murauwald–Untermitterling	33	1.3	medium – poor

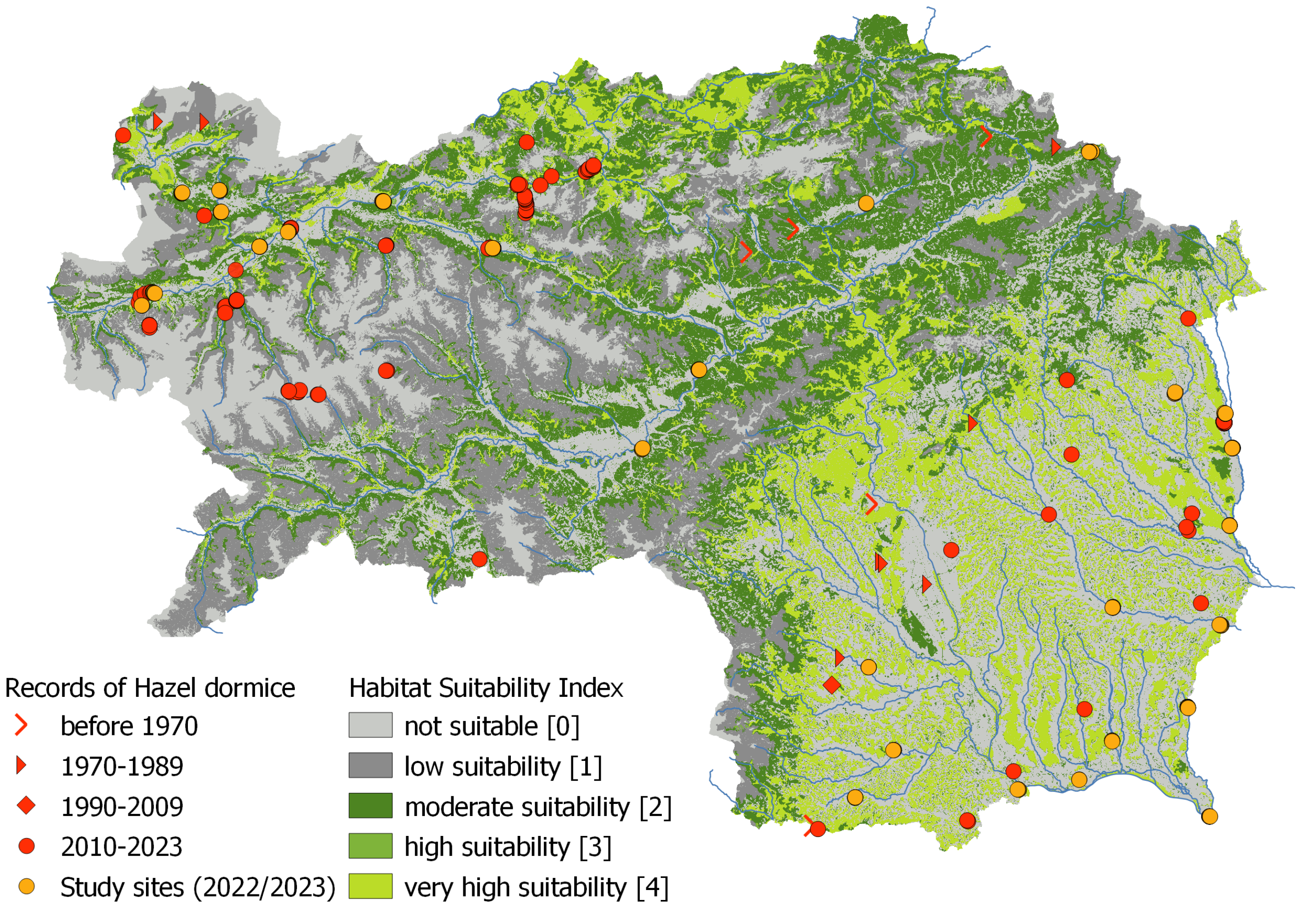

Fig. 2: Potential habitats (Habitat-Suitability-Index) and occurrences (confirmed records) of the hazel dormouse in Styria.

Abb. 2: Potenzielle Lebensräume (Habitat-Suitability-Index) und Vorkommen (bestätigte Nachweise) der Haselmaus in der Steiermark.

The Northern Alps: Offer numerous high [HSI=3] and very high suitable [HSI=4] habitats for the hazel dormouse (605 km², 15 % corresponds to an area of 15 % of the entire Northern Alps), particularly in the eastern part, where sun-exposed mixed mountain forests of beech, spruce, and fir, as well as hardwood-rich moist slopes (Kilian et al. 1993) are prevalent. These habitats align with the species' known requirements for a high diversity in tree species and structural heterogeneity (Juškaitis & Büchner 2010, Büchner & Lang 2014, Juškaitis et al. 2014, 2016). Particularly suitable areas within the Northern Alps include the Ennstal Alps (287 km² at least moderately suitable), the Ybbstal Alps (267 km²), the Mürztal Alps (411 km), and the Hochschwab Massive (340 km²). The Eisenerz and Mürzsteg Alps additionally offer significant habitats, each exceeding 200 km². This is also confirmed by the field study, in which we recorded a very high population density of 14.2 I/ha at the Semmering–Erzlhof study site. In the western Northern Alps (Totes Gebirge, Dachstein Massive), suitable habitats are less common (<150 km²). Here, submontane to low montane beech-dominated mixed forests, riparian woodland, and shrub-rich moorland prevails (Kilian et al. 2013), aligning with habitat usage observed in previous research (Blatt & Resch 2013, 2015, Resch et al. 2015, 2023). This was confirmed by field studies with records at Kainischmoos, Nagelmoos and Salzamündung–Aussee. High-elevation spruce-fir forests and karstic plateaus with steep rocky slopes (Kilian et al. 1993) are considered unsuitable habitats, although individual animals can occasionally be detected in these environments (Büchner & Lang 2014).

Central Alps: Due to their high proportion of spruce forests, the Central Alps provide comparatively fewer highly and very highly suitable habitats (134 km², 4 %). However, deciduous mixed forests on fresh to moist slopes, dominated by sycamore maple, ash and grey alder, as well as small riparian forests and tree-lined banks of smaller streams and larger rivers such as the Enns and Mur (Kilian et al. 1993), are considered primary habitats for the hazel dormouse in Central Europe (Büchner & Lang 2014; Juškaitis & Büchner 2010; Blatt & Resch 2014). In these habitats, the species reaches high population densities, as observed in this study at the Ennsauwald–Weißenbach site with 4.2 I/ha and Murauwald–Kraubath with 8.6 I/ha. Small mammal camera trap surveys in the Niedere Tauern (Resch & Resch 2024) indicate that the hazel dormouse also inhabits high-altitude environments, using dwarf shrub heathlands and mountain pine (*Pinus mugo*) stands as suitable habitats which constitutes a type of habitat that has received little attention so far. The habitat model classified these areas as largely unsuitable or only marginally suitable due to their elevation and the lack of a distinct shrub and tree layer. Further research is needed to determine whether, and at what population densities, these secondary habitats are occupied.

Styrian Peripheral Mountains: compared to the Northern and Central Alps this area has a relatively high proportion of highly and very highly suitable habitats, covering 901 km² (23%). This is primarily due to the high share of deciduous mixed forests. Natural forest communities such as oak-hornbeam forests, mixed deciduous forests with sycamore maple, ash, elm, and small-leaved lime tree, as well as riparian forests with silver willow, grey alder, or black alder-ash stands along streams (Kilian et al. 2023), provide structurally diverse habitats with abundant food resources from spring to autumn, making them well-suited for the hazel dormouse (Bright & Morris 1993, 1996; Bright et al. 2006; Juškaitis 2014; Juškaitis et al. 2016). Particularly large areas of highly suitable habitat are found in the Koralpe (154 km²) as well as the western and eastern Mountains of Graz (401 km²). Despite this habitat classification and the presence of suitable natural forest communities, there are very few confirmed records. Only three recent records exist: Lafnitztal, Rabenwaldkogel and Radlpass (Fig. 2).

Alpine foothills: This area has the highest proportion of highly and very highly suitable habitats (1,046 km², 35 %). Its low elevation, the extended vegetation period and many sun-exposed locations create ideal conditions for the hazel dormouse. However, intensive land use for industry, agriculture, road infrastructure and urban development has led to substantial habitat fragmentation. Nonetheless, if habitat conditions are favourable, even small forest patches can support hazel dormouse populations (Ramakers et al. 2014; Büchner 2008). The high proportion of very highly suitable habitats in the Eastern (730 km²) and Western Styrian Riedelland (213 km²) indicates that the remaining deciduous mixed forests serve as important dormouse habitats, despite their often small size. In addition, this study recorded a good population status in Hartberger Moos, Kutschenitza Auwald, and Lafnitz-Speltenbach, and a very good population status in Sulmtal-Otternitzwinkel. Habitat size is here a crucial factor for survival. The risk of local extinction increases as forest patches shrink, regardless of habitat quality (Mortelliti et al. 2014). Although reproductive events have been observed in small forests under 2 ha (Capizzi et al. 2002; Büchner 2008), a minimum area of 20 ha is considered necessary for stable populations (Bright et al. 1994). Hedgerows play a key role: if well-structured, they serve as habitats (Wolton 2009; Resch & Resch 2020, 2021), facilitate movement, connect fragmented landscapes, and reduce genetic isolation (Bright et al. 1994; Naim et al. 2014; Bani et al. 2017). The documented occurrence of the hazel dormouse in riparian woodland corridors in the study areas Stainzaltarm Grafendorf, Haselbach, and Gnasbacher Ökoflächen further emphasizes the ecological significance of these landscape elements.

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