



Diversity and Coverage of Melliferous Plants in Northwest Bulgaria Across EUNIS Habitat Types

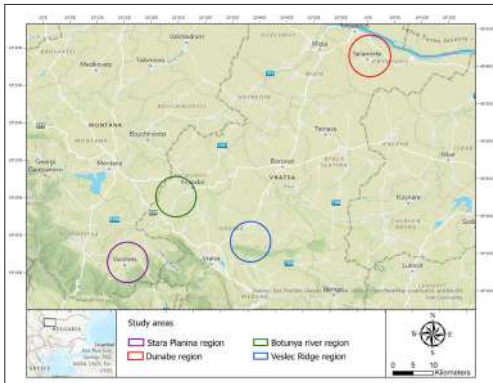
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Introduction

Melliferous plants provide nectar and pollen keeping pollinators fed throughout the year. That steady food supply supports both wild pollinators and managed honeybees, linking the importance of the healthy ecosystems to the livelihoods of beekeepers. But we still don't know enough about where these plants are and how diverse they are in different habitats, which makes it hard to target conservation and restoration efforts. This knowledge is especially important in anthropogenic landscapes, where fewer flowering resources can quickly weaken pollinator communities and the services they provide.

Study area



Bulgaria is located in the eastern Balkans (Fig. 1), where diverse natural conditions shape its vegetation. The country sits in a climatic transition zone between Cfb (warm-temperate, fully humid with warm summers) and Csa (summer-dry Mediterranean influence), with elevations from sea level to 2,925 m and 28% of the territory above 600 m. Northwestern Bulgaria has a temperate-continental character, and at low elevations key stations such as Vidin and Pleven are classified as Cfa (humid subtropical: no dry season, hot summers) under the Köppen system; toward the higher Fore-Balkan, conditions grade into continental subtypes Dfa/Dfb. According to the 2012 Conspectus of the Bulgarian Vascular Flora, 4,102 plant species occur across temperate and mixed deciduous forests, coniferous forests, grasslands, Mediterranean scrub, and alpine zones. The four representative areas examined span roughly 20–1,300 m above sea level.

Methodology

312 km²
Total study area (4 × 78 km²) in Northwestern Bulgaria.
All fieldwork conducted in 2023.

348
Phytosociological descriptions (relevés).
Vegetation recorded with the Braun-Blanquet cover-abundance scale.
Melliferous species filtered from a literature-based list for Bulgaria.

68% of relevés auto-classified with EUNIS-EbY in R.
32% resolved using EUNIS Habitat Factbooks by matching field data to diagnostic, constant and dominant species.
Tax. reliability: 10,084/10,717 plots (98%) uniquely assigned to EUNIS habitat, 7,810 to Level 3 (Broukheide, Tichý, Chytrý & Jansen, 2021).

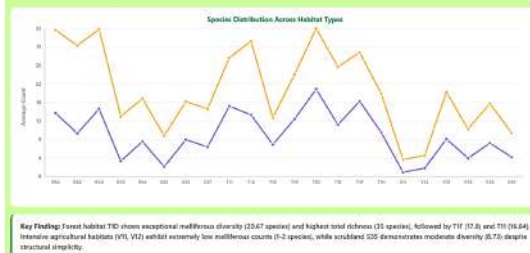
Workflow: Field observations → Phytosociological descriptions & mapping → R-based habitat assignment (EUNIS-EbY & Factbooks) → Quarterly & cover of melliferous flora.

Results

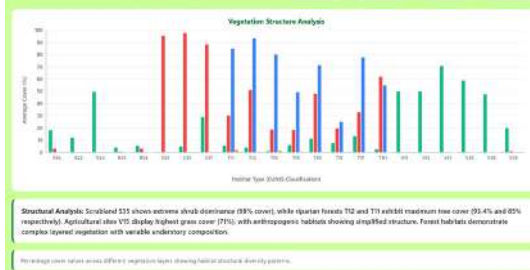
24 types of habitats were identified at level 3 of the EUNIS classification. Of them, five are grasslands, three shrublands, nine forests, and six are anthropogenic habitats.

EUNIS Habitat Classification Legend			
 Forest Habitats (T-series)		 Scrub Habitats (S-series)	
T11	Temperate Salix and Populus riparian forest	S20	Temperate Rubus roseus
T12	Corylus and Quercus major deciduous forest	S21	Temperate and submediterranean rose scrub
T13	Temperate and submediterranean Thermophilous deciduous forest	S22	Corylus avellana scrub
T14	Pagan forest on acid soils		
T15	Alnus glutinosa-Alnus incana forest on open and inland soils		
T16	Southern European mountain deciduous and Populus riparian forest		
T17	Spruce forest		
T18	Broadleaved deciduous plantation of non-rare native trees		
 Grassland Habitats (G-series)		 Anthropogenic Habitats (V-series)	
G10	Semi-dry perennial cerise-grassland (meadow steppe)	V10	Temperate mesophilous grassland with annuals
G20	Low and medium altitude hay meadow	V20	Dry perennial anthropogenic herbaceous vegetation
G30	Submediterranean moist meadow	V30	Mixed perennial anthropogenic herbaceous vegetation
G40	Short or mid-montane to alpine hay meadow	V40	Bare field, fallow or recently abandoned arable land
G50	Perennial equilium vegetation	V50	Intensive uncultivated crops
		V60	Mixed crops of market gardens and horticulture
		V70	Vineyard
		V80	Broadleaved fruit and nut tree orchard

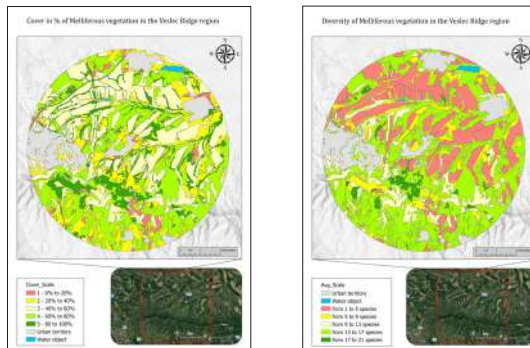
Melliferous Plants vs Total Species by Habitat



Melliferous Plants Cover by Habitat Type



- **Grasslands:** highest diversity. Peaks: **R1A = 35 spp** (15 melliferous); **R34 = 35 spp** (16 melliferous); **R34** has the highest mean melliferous cover = 50%.
- **Shrublands:** act as nectar corridors in farmed landscapes (e.g., **S35** along field edges); supply forage in late winter-early spring. Lower richness but high melliferous plants cover; important for colony build-up and crop pollination.
- **Forests:** key forage overall. **T1E, T1F, T1H** are main honey sources; others provide supplementary flow. Riparian and lime-dominated (plus some invasive honey plants) = highest value; conifer plantations = lowest.
- **Anthropogenic habitats:** strongly depend on agricultural practice. Ecotones host wild flora but are under pressure from field enlargement. Crops may be melliferous plants, yet uniform vegetation limits the diversity × area needed risking pollination deficits and arguing for minimum habitat-diversity thresholds.



(Left: percent cover of melliferous vegetation; Right: species richness.)

Conclusion & Discussion

Priority Habitats for Conservation

S35, T1F, T11, T1D, R34

Strategic Landscape Planning

Integrate temporal dynamics: Couple crop flowering calendars with melliferous bloom periods to optimize spatial placement and seasonal-relevance. Design riparian networks linking habitat patches via hedgerows and riparian strips to ensure continuous nectar flow throughout the growing season.

Habitat Conservation & Enhancement

Protect key habitats: Maintain high-value melliferous habitats within 2-3 km of crop fields. Focus on priority types: Establish buffer zones with melliferous field margins and actively protect existing shrub patches to bridge seasonal forage gaps in agricultural landscapes.

Map existing melliferous habitats and assess connectivity

Identify priority conservation areas and corridor opportunities

Develop crop-pollinator calendar models for region

Implement habitat enhancement and monitoring protocols

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Melliferous plants play a vital role in supporting pollinator populations by providing essential floral resources and contributing to both ecosystem stability and beekeeping productivity. Habitat fragmentation and degradation due to anthropogenic pressures threaten these floral resources. The lack of systematic, habitat-specific data complicates conservation strategies for pollinators, such as *Apis mellifera* L. In Northwestern Bulgaria, four representative regions (78 km² each), totaling an area of 312 km². Fieldwork was conducted in 2023 to gather data on melliferous plants in grassland, forest, shrub, and anthropogenic habitats. The Braun-Blanquet methodological approach was used for data collection. During the fieldwork, a total of 348 phytosociological descriptions were completed across the four areas, identifying 25 habitat types at EUNIS classification level 3. The results indicate that Semi-dry perennial calcareous grassland (R1A) and Southern European Mountain Betula and Populus tremula forest on mineral soils (T1D) support the highest diversity of melliferous plants. Temperate and sub-Mediterranean thorn scrub (S35) and Alnus glutinosa-Alnus incana forest on riparian and mineral soils (T12) provide the greatest vegetation cover. Shrub habitats function as ecological corridors, enhancing spatial connectivity and resource availability. In contrast, anthropogenic habitats vary in their floral availability, linked to management practices. Habitats dominated by invasive species and the transition of natural areas into continuous agricultural lands have been identified as significant threats to the long-term viability of melliferous vegetation. Analyses revealed significant variation in the richness of melliferous species across habitats. Visualization (in GIS environment) highlighting fragmented, high-value habitats as priority areas for conservation. Habitats such as R1A and S35 are particularly important for stabilizing seasonal floral resources, which directly impact pollinators and honey yields. Given these findings, there is an opportunity to target the protection of an abundance of floral resources by providing land managers with strategies to assist pollinators. Integrating habitat connectivity into land-use planning has the potential to further enhance ecosystem resilience and support pollinator populations.