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Species richness is a poor guide to conservation value: a case study of plant diversity in the natural habitats of Synohora National Nature Park

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Abstract

Species richness is widely used to rank habitats for conservation, but it is unclear whether it reflects the features that make a habitat irreplaceable or vulnerable. This descriptive case study examined seven EUNIS habitats of Synohora National Nature Park (Gorgany, Ukrainian Carpathians): *Abies* and *Picea* woodland (G3.1), *Fagus* woodland (G1.6), mixed *Abies–Picea–Fagus* woodland (G4.6), Carpathian *Larix* and *Pinus cembra* forests (G3.25), conifer scrub close to the tree limit (F2.4), subalpine deciduous scrub (F2.3) and acid alpine and subalpine grassland (E4.3). Abundance–cover data from seven permanent and 43 temporary plots yielded 116 vascular plant species, analysed with diversity indices, similarity measures and ordination. Richness ranged from 9 species in G3.25 to 45 in G1.6; G4.6 and E4.3 each had 39. Richness was positively related to Shannon diversity (Spearman $\varrho = 0.76$) but not to the number of Red Data Book species ($\varrho = -0.36$, $p = 0.43$), which was highest in E4.3 (five) and G3.25 (three); with $n = 7$ these relationships are indicative only. Four of six woody habitats, including all three high-elevation ones, showed insufficient tree regeneration. Seventy-four species (64 %) occurred in one habitat only, and the two richest habitats partly duplicated each other: G1.6 and G4.6 together held 61 species, whereas G1.6 plus E4.3 held 76. In this system, richness indicates how many species a habitat contributes, but not how rare, distinct or threatened it is, and should not be used alone to set monitoring priorities. Thirty-nine diagnostic species are proposed for field identification.

Keywords: Ukrainian Carpathians, Synohora National Nature Park, habitat conservation, species richness, Red Data Book, Bray–Curtis dissimilarity, diagnostic species

1. Introduction

Habitat-based conservation is the backbone of nature protection in Europe. The EU Habitats Directive (Council of the European Communities, 1992) and the Bern Convention (Council of Europe, 1979), through its Emerald Network, protect habitat types that are defined, in practice, by characteristic combinations of plant species (Chytrý et al., 2020). Plant species composition is therefore both the tool used to identify a habitat in the field and a basis for judging its conservation status, including in national forest inventories (Kovac et al., 2020; Borghi et al., 2024). In the

Ukrainian Carpathians, habitat identification follows regional catalogues (Prots & Kagalo, 2012; Kuzemko et al., 2018), but it is complicated by the strong mosaic of climatic, soil, biotic and anthropogenic conditions (Kyyak et al., 2021).

Once habitats are identified, managers must decide which to prioritise. Species richness is the easiest metric to obtain and is often used for this purpose, but its link with conservation value can be weak. In boreal plant communities, richness was a surrogate for the occurrence of rare plants but not for conservation value (Crisfield et al., 2020), and the relationship between richness and rarity differed among habitats of European conservation value in Ireland (Perrin & Waldren, 2020). Habitat-level threat is assessed with separate criteria, as in the European Red List of Habitats (Janssen & Rodwell, 2016). In forests, understorey vegetation is an important functional component (Landuyt et al., 2019), and its richness is related to light availability (Dormann et al., 2020) and, according to other studies, to light heterogeneity (Helbach et al., 2022), to the identity of the dominant trees (Petersson et al., 2019) and to stand structure and management (Bricca et al., 2023). These drivers are not necessarily related to the rarity, distinctiveness or vulnerability of a habitat. Richness might therefore be expected to peak in structurally complex forests of the lower mountain belt and to be low in harsh high-elevation habitats, whatever their conservation importance.

The Carpathians are a hotspot of species protected under the Habitats Directive (Halada et al., 2024), and their high-elevation habitats host rare plants that are sensitive to climate change (Kobiv, 2017, 2018) and to changes in grazing pressure (Mitka et al., 2022). At the same time, Norway spruce forests, which dominate the Gorgany range, are affected by drought, bark beetle outbreaks and shifting climatic suitability (Dyderski et al., 2018; Hlásny et al., 2021; Prykhodko et al., 2020; Senf & Seidl, 2021; Shparyk, 2019). Despite this, few quantitative comparisons of the plant diversity of the natural habitats of Gorgany are available, and it is unknown whether the habitats that are richest in species are also those that are most in need of protection.

This study uses a standardised vegetation survey of seven natural habitats in Synohora National Nature Park to address three questions. (1) How do richness, evenness and dominance differ among habitats? (2) Does richness track conservation-relevant attributes: the number of Red Data Book species, tree regeneration and floristic distinctiveness? (3) Do the habitats form floristically distinct units, and which species identify them in the field? The aim is descriptive and regional: to provide quantitative baseline data for Gorgany and to examine, for these seven habitats, the hypothesis that richness describes the contribution of a habitat to the species pool but not its rarity, distinctiveness or vulnerability.

2. Materials and methods

2.1. Study area

The study was carried out in 2023–2026 in Synohora National Nature Park (10,866 ha) in the upper Bystrytsia Solotvynska basin, central Gorgany, Ukrainian Carpathians (Fig. 1). Elevation ranges from 670 m (Stara Huta village) to 1,837 m (Mt Velyka Syvulia). Forests cover almost 93 % of the park; Norway spruce (*Picea abies*) accounts for more than 68 % of the forest area, European beech (*Fagus sylvatica*) for 17 %, mountain pine (*Pinus mugo*) for 7 % and silver fir (*Abies alba*) for 5 %, whereas stands with Swiss stone pine (*Pinus cembra*) as the main species cover only 3.9 ha (Obrizan, 2022). Alpine and subalpine meadows, subalpine scrub and screes are also present.

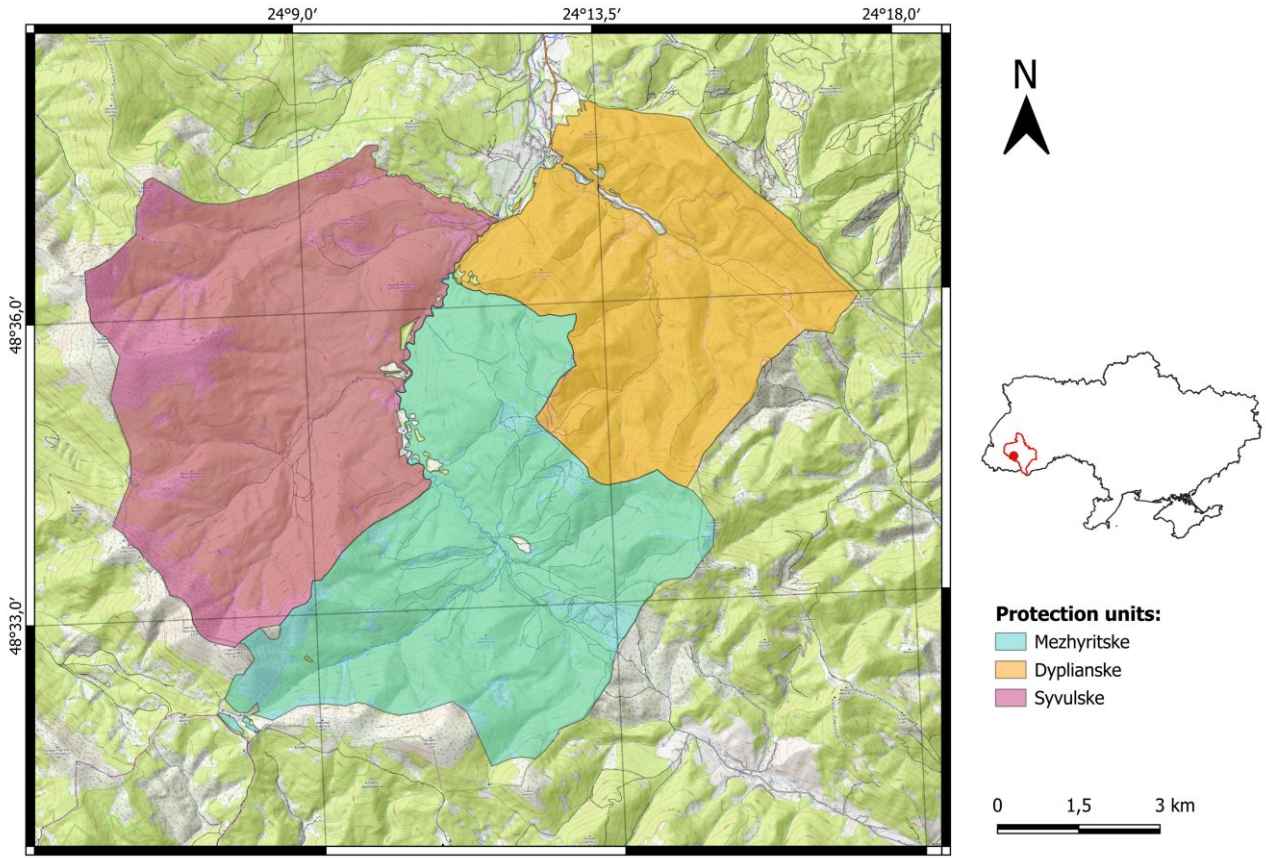


Fig. 1. Synohora National Nature Park: its three protection units (Mezhyritske, Dyplianske and Syvulske) and its location in Ukraine (inset).
Source: compiled by the author.

2.2. Habitat selection and field survey

Habitats were identified using the Carpathian habitat catalogue (Prots & Kagalo, 2012), starting from the habitats previously mapped in the park (Synohora National Nature Park, 2025), and classified according to EUNIS; the revised EUNIS classification, which uses different codes (Chytrý et al., 2020), was not applied. Seven habitats were selected for study. Throughout the paper they are referred to by their EUNIS (2012 version) codes and names (European Environment Agency, 2012): G3.1 *Abies* and *Picea* woodland; G1.6 *Fagus* woodland; G4.6 Mixed *Abies–Picea–Fagus* woodland; G3.25 Carpathian *Larix* and *Pinus cembra* forests; F2.4 Conifer scrub close to the tree limit; F2.3 Subalpine deciduous scrub; and E4.3 Acid alpine and subalpine grassland. In the study area, G3.1 is dominated by *Picea abies*, G1.6 by *Fagus sylvatica*, G4.6 by *Abies alba*, G3.25 by *Pinus cembra*, F2.4 by *Pinus mugo* and F2.3 by *Alnus viridis*. Sites were accepted if the dominant species matched the habitat type, the elevation was appropriate, the dominant trees were old (or, in non-forest habitats, the dominant had remained unchanged for a long period), all key species of the catalogue were present, and there were no introduced or invasive species and no critical anthropogenic damage (Kuzemko et al., 2018; Prots & Kagalo, 2012).

Fieldwork was carried out on seven permanent research plots (one per habitat; 0.02–0.35 ha, depending on the density of the key species; boundaries marked with posts) and on 43 temporary plots in the same habitats. On each plot, every vascular plant species was recorded and its abundance–cover estimated visually on the Braun-Blanquet scale (Braun-Blanquet, 1964). Species were identified in the field and verified in the laboratory with a microscope, reference floras, the plant-identification applications PlantNet, Flora Incognita, PictureThis and Blossom, and consultation with colleagues; herbarium specimens are kept at Synohora National Nature Park

depository. For each habitat, the mean abundance–cover index of a species over all plots was calculated and used in the analysis. In forest and scrub habitats, stand characteristics (site class, relative stocking, dead wood and regeneration by height classes) were measured on the permanent plots following the park monitoring protocol (Synohora National Nature Park, 2022).

2.3. Data analysis

Braun-Blanquet classes were converted to percentage cover using class midpoints (r = 0.1; + = 0.5; 1 = 3, class range 1–5 %; 2 = 15, 5–25 %; 3 = 37.5, 25–50 %; 4 = 62.5, 50–75 %; 5 = 87.5 %, 75–100 %). Using 2.5 % instead of 3 % for class 1 changed H′ by no more than 0.07 and did not alter the ranking of habitats. For each habitat, species richness (S, the number of species recorded), the Shannon index (H′; Shannon, 1948), the Simpson diversity index (D; Simpson, 1949) and Pielou's evenness (J; Pielou, 1969) were calculated:

$$p_i = \frac{c_i}{\sum_{i=1}^{S} c_i} \quad (1)$$

$$H' = -\sum_{i=1}^{S} p_i \ln p_i \quad (2)$$

$$D = 1 - \sum_{i=1}^{S} p_i^2 \quad (3)$$

$$J = \frac{H'}{\ln S} \quad (4)$$

where c_i is the cover of species i and p_i is its share of the total cover. The effective number of species, $e^{H'}$ (the Hill number of order 1; Jost, 2006), and the share of the total cover held by the most abundant species (a measure of dominance) are also reported. For each habitat type, the number of species listed in the Red Book of Ukraine was calculated (Ministry of Environmental Protection and Natural Resources of Ukraine, 2021).

Floristic similarity between habitats was measured with the Jaccard index and, for cover data, with Bray–Curtis dissimilarity (Bray & Curtis, 1957; Jaccard, 1912):

$$J_{AB} = \frac{a}{a+b+c} \quad (5)$$

$$BC_{AB} = \frac{\sum_i |c_{iA} - c_{iB}|}{\sum_i (c_{iA} + c_{iB})} \quad (6)$$

where a is the number of species shared by habitats A and B, b and c are the numbers of species unique to A and to B, and c_{iA}, c_{iB} are the covers of species i in A and B. Habitats were ordinated with non-metric multidimensional scaling (NMDS) on the Bray–Curtis matrix in two dimensions, and the fit was judged by Kruskal's (1964) stress using the thresholds of Clarke (1993). The same matrix was clustered with the unweighted pair-group method with arithmetic mean (UPGMA; Sokal & Michener, 1958), and the dendrogram was evaluated by the cophenetic correlation (Sokal & Rohlf, 1962). Because each habitat is represented by one aggregated vector (n = 7), differences among habitats were not tested; associations between habitat-level variables were assessed with Spearman's rank correlation and are interpreted as descriptive, since power at n = 7 is low. To compare conservation strategies, species were accumulated over habitats in two orders: from the richest habitat downwards, and by greedy complementarity (Margules & Pressey, 2000), adding at each step the habitat that contributed most species not yet covered. Calculations were carried out in Python 3.13 (NumPy 2.5, SciPy 1.18, scikit-learn 1.9).

3. Results and discussion

3.1. Richness, evenness and dominance

In total, 116 vascular plant species were recorded. *Picea abies* was the only species present in all seven habitats; 74 species (64 %) occurred in a single habitat, 21 in two and 21 in three or more. The four woodland habitats (G3.1, G1.6, G4.6, G3.25) together held 75 species, the two scrub habitats (F2.4, F2.3) 35 and the grassland E4.3 39. Richness ranged from 9 species in G3.25 to 45 in G1.6 (Table 1, Fig. 2a). Within the lower belt, G1.6 (45) and G4.6 (39) were considerably richer than G3.1 (24).

This is consistent with the reported effect of dominant tree species on understorey communities (Bricca et al., 2023; Petersson et al., 2019), although the present data cannot separate tree identity from light conditions, which were not measured. E4.3, with 39 species, was as rich as G4.6.

Table 1

Plant diversity indices of the natural habitats of Synohora National Nature Park

Habitat	S	H′	D	J	$e^{H'}$	Dominant share, %	RDB
G3.1 *Abies* and *Picea* woodland	24	2.369	0.849	0.746	10.7	34.1	2
G1.6 *Fagus* woodland	45	2.910	0.903	0.764	18.4	24.4	1
G4.6 Mixed *Abies–Picea–Fagus* woodland	39	2.928	0.917	0.799	18.7	17.9	0
G3.25 Carpathian *Larix* and *Pinus cembra* forests	9	1.677	0.768	0.763	5.4	38.2	3
F2.4 Conifer scrub close to the tree limit	11	1.260	0.605	0.526	3.5	57.0	2
F2.3 Subalpine deciduous scrub	27	1.546	0.596	0.469	4.7	61.4	0
E4.3 Acid alpine and subalpine grassland	39	2.518	0.892	0.687	12.4	16.4	5

Note: S – species richness; H′ – Shannon index; D – Simpson index; J – Pielou evenness; $e^{H'}$ – effective number of species; Dominant share – cover of the most abundant species as % of total cover; RDB – species of the Red Data Book of Ukraine. Habitat names follow EUNIS (European Environment Agency, 2012).

Diversity indices ranked the habitats largely as richness did, with exceptions at the low end of the gradient. Shannon diversity was highest in G4.6 (2.93) and G1.6 (2.91) and lowest in the two scrub habitats (1.26 in F2.4 and 1.55 in F2.3), and richness and H′ were positively correlated ($\rho = 0.76$, $p = 0.049$). Evenness, however, was lowest in the scrub habitats (J = 0.47–0.53), where a single woody species held 57 % (*Pinus mugo*, F2.4) and 61 % (*Alnus viridis*, F2.3) of the total cover. As a result, F2.3 ranked fourth of seven in richness (27 species) but sixth in effective species number ($e^{H'} = 4.7$), and its 27 species functioned like fewer than five equally common ones. In contrast, E4.3 combined high richness with moderate dominance (three species tied as the most abundant, each with 16.4 % of the cover) and an effective number of 12.4.

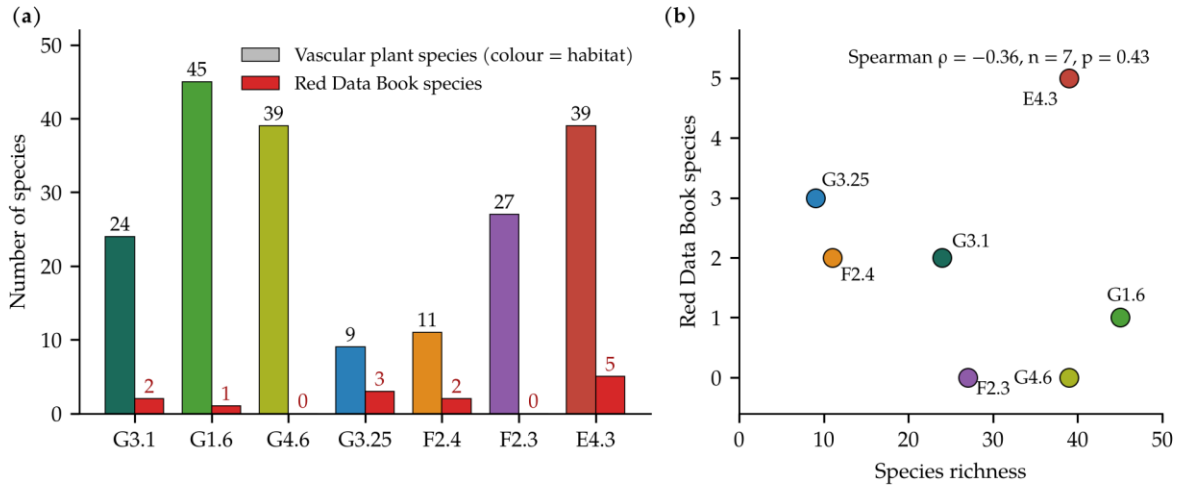


Fig. 2. Species richness and Red Data Book species in the seven habitats (a) and their relationship (b). Source: author's calculations.

3.2. Richness and conservation-relevant attributes

The number of species listed in the Red Data Book did not follow richness (Fig. 2). E4.3 held five such species, G3.25 three, G3.1 and F2.4 two each, G1.6 one, and G4.6 and F2.3 none (Table 1). The correlation between richness and the number of Red Data Book species was weak and negative (ϱ = −0.36, p = 0.43), and the proportion of Red Data Book species in the species list declined with richness (ϱ = −0.66, p = 0.10): it was 33 % in G3.25 and 18 % in F2.4, but 2 % in G1.6. With seven habitats these coefficients are not statistically significant, but the pattern is clear for the extremes: the two richest woodland habitats (G1.6 and G4.6) held one and no Red Data Book species, and the two poorest habitats (G3.25 and F2.4) held three and two. Because the Red Data Book of Ukraine includes many high-elevation Carpathian species, a negative association with the richness of lower-belt forests is partly expected from the construction of the list.

Table 2

Stand characteristics of woody habitats and tree regeneration

Habitat	Dominant woody species (share in stand)	Site class	Relative stocking	Tree regeneration
G3.1 *Abies* and *Picea* woodland	*Picea abies* (100 %)	I	0.90	Sufficient
G1.6 *Fagus* woodland	*Fagus sylvatica* (80 %), *Abies alba* (20 %)	I	0.98	Sufficient
G4.6 Mixed *Abies*–*Picea*–*Fagus* woodland	*Abies alba* (80 %), *Fagus sylvatica* (10 %), *Picea abies* (10 %)	I	1.48	Insufficient (<10 thousand ha^{-1})
G3.25 Carpathian *Larix* and *Pinus cembra* forests	*Pinus cembra* (60 %), *Picea abies* (40 %)	IV	0.77	Insufficient (≈6 thousand ha^{-1})
F2.4 Conifer scrub close to the tree limit	*Pinus mugo* (50 %), *Picea abies* (30 %), *Pinus cembra* (20 %)	Va	1.42	Seed regeneration insufficient
F2.3 Subalpine deciduous scrub	*Alnus viridis* (90 %)	V	0.51	Insufficient (<1 thousand ha^{-1})

Note: Site class – productivity class of the stand (I = most productive, V = least productive). Relative stocking – ratio of the stand basal area to that of a fully stocked normal stand of the same age and site class; values above 1.0 (G4.6, F2.4) are unusually high confirm the calculation method. The sampled G4.6 stand is dominated by *Abies alba* (80 %) and represents the fir-rich end of the habitat; G3.1 was sampled in a pure *Picea abies* stand. Source: Chronicle of nature of Synohora National Nature Park (2022, 2025; unpublished institutional reports) and measurements on permanent plots. Habitat names follow EUNIS (European Environment Agency, 2012).

Regeneration showed a similar pattern (Table 2). Tree regeneration was classified as sufficient only in G3.1 and G1.6, and as insufficient in G4.6 (<10 thousand individuals ha^{-1}), G3.25 (about 6 thousand ha^{-1}), F2.4 (insufficient seed regeneration) and F2.3 (<1 thousand ha^{-1}). Thus four of six woody habitats, including all three high-elevation ones, had a regeneration deficit, and one of them (G4.6) is among the two richest habitats. This assessment rests on one permanent plot per habitat and is indicative only. E4.3 is a grassland habitat, in which the absence of tree regeneration is expected and is not interpreted as a threat; it is therefore not included in Table 2. Stand productivity followed the elevation gradient rather than richness: site class I in the three lower-belt woodland habitats (G3.1, G1.6, G4.6) and classes IV–V in the high-elevation woody habitats (G3.25, F2.4, F2.3).

3.3. Floristic distinctiveness of habitats

Floristic overlap among habitats was low. The mean Jaccard similarity over the 21 habitat pairs was 14.0 % (range 1.8–42.9 %; Table 3), and 14 of 21 pairs had a Bray–Curtis dissimilarity of at least

0.90. Only two pairs exceeded 25 % similarity: G3.25 and F2.4 (42.9 %, shared *Pinus cembra*, *Empetrum nigrum*, *Lycopodium annotinum* and *Vaccinium myrtillus*) and G1.6 and G4.6 (37.7 %). The NMDS ordination had a stress of 0.045, which is classed as excellent (Clarke, 1993) (Fig. 3a). However, stress values are inherently low when only seven objects are ordinated, so the dissimilarity matrix and the dendrogram (cophenetic correlation 0.87) were also used. UPGMA joined G1.6 and G4.6 at a dissimilarity of 0.64, then G3.1 and G3.25 at 0.75, and added F2.4 at 0.83; these two groups merged at 0.91, E4.3 joined at 0.93 and F2.3 was the most isolated unit (0.97; Fig. 3b). A presence–absence analysis with Jaccard distances retained the pairs G1.6–G4.6 and G3.25–F2.4, but placed G3.1 with the G1.6–G4.6 group and E4.3 with F2.3, so the grouping of G3.1 is less stable than that of the other habitats.

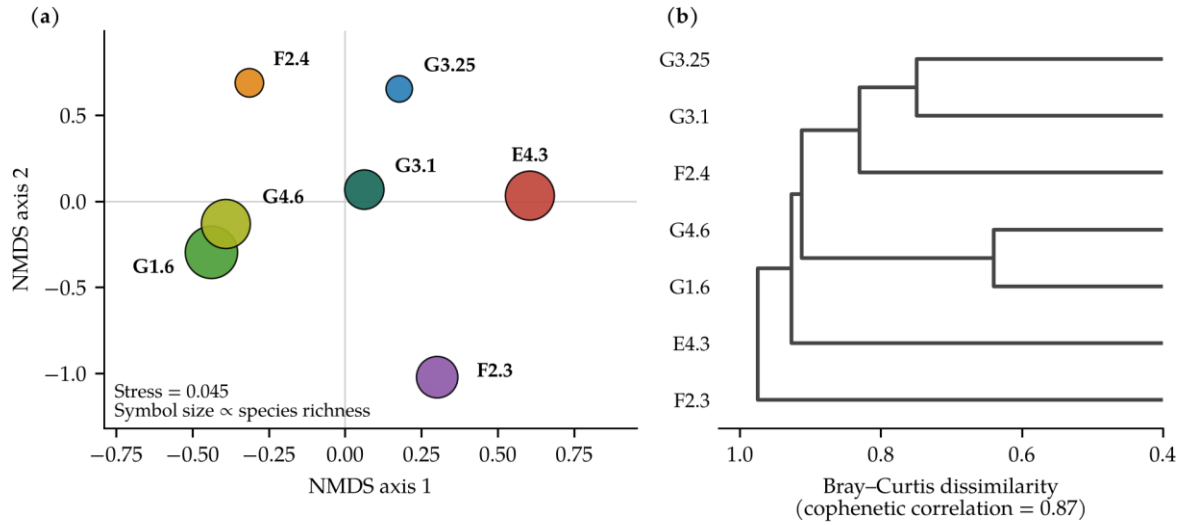


Fig. 3. NMDS ordination (a) and UPGMA dendrogram (b) of the habitats based on Bray–Curtis dissimilarity of cover data.
Source: author's calculations.

Table 3

Floristic similarity (Jaccard index, %, below the diagonal) and Bray–Curtis dissimilarity (above the diagonal) between habitats

	G3.1	G1.6	G4.6	G3.25	F2.4	F2.3	E4.3
G3.1	–	0.84	0.84	0.75	0.91	0.95	0.87
G1.6	21.1	–	0.64	0.99	0.99	0.97	0.95
G4.6	21.2	37.7	–	0.94	0.87	0.97	0.92
G3.25	13.8	3.8	4.3	–	0.75	0.99	0.92
F2.4	16.7	1.8	4.2	42.9	–	0.99	0.98
F2.3	13.3	9.1	10.0	5.9	8.6	–	0.98
E4.3	14.5	10.5	14.7	11.6	11.1	17.9	–

Richness was a good predictor of the number of species that a habitat contributed exclusively (ϱ = 0.88, p = 0.008): 21 species were found only in E4.3, 17 only in G1.6 and 14 only in F2.3, compared with one in G3.25. Richness was not related to mean Bray–Curtis dissimilarity from the other habitats (ϱ = 0.14, p = 0.76). The richest habitats partly duplicated each other. Accumulating species from the richest habitat downwards, the two richest habitats (G1.6 and G4.6) covered only 61 species (53 % of the flora), whereas adding E4.3 to G1.6 covered 76 species (66 %), and the complementarity order G1.6, E4.3 and F2.3 reached 91 species (78 %). G1.6 alone held 39 % of the recorded flora.

3.4. Diagnostic species

Diagnostic species were selected by expert judgement, following the catalogue principle that key

species must be present (Prots & Kagalo, 2012). Each species was assigned to the habitat in which it is most characteristic; only *Vaccinium myrtillus* is listed for two habitats (G3.25 and F2.4), which have few species (Table 4). Formal fidelity measures such as the phi coefficient (Chytrý et al., 2002) or the indicator value (Dufrêne & Legendre, 1997) were not calculated because plot-level data were not used. *Adenostyles alliariae*, listed earlier for E4.3, was recorded in the data only in G1.6 and was replaced by *Nardus stricta*, which was restricted to E4.3. All 40 listings (39 species) were then recorded in their habitat. Sixteen listings (40 %) refer to species restricted to one habitat among the seven (e.g., *Homogyne alpina*, *Soldanella hungarica* and *Luzula sylvatica* in G3.1, *Sanicula europaea* in G1.6, *Veratrum album*, *Arnica montana* and *Nardus stricta* in E4.3), and nine refer to species occurring in four or more habitats (e.g., *Picea abies*, *Abies alba*, *Rubus hirtus* and *Vaccinium myrtillus*). The latter are diagnostic only in combination with others. Dominant trees are included because the catalogue requires them, but they discriminate poorly between habitats in mosaic landscapes (*Picea abies* occurs in all seven).

Table 4

Diagnostic species lists of the habitats and their occurrence among the seven habitats

Habitat	Diagnostic species	Listed	Recorded in habitat	Restricted to one habitat	In ≥4 habitats
G3.1	*Picea abies, Cicerbita alpina, Dryopteris expansa, Homogyne alpina, Luzula sylvatica, Oxalis acetosella, Prenanthes purpurea, Soldanella hungarica, Symphytum cordatum, Trientalis europaea*	10	10	4	2
G1.6	*Fagus sylvatica, Carex sylvatica, Galium intermedium, Sanicula europaea, Stellaria nemorum, Mercurialis perennis*	6	6	2	0
G4.6	*Abies alba, Cardamine bulbifera, Circaea alpina, Lamium galeobdolon, Lonicera nigra, Orthilia secunda, Rubus hirtus*	7	7	3	2
G3.25	*Pinus cembra, Empetrum nigrum, Lycopodium annotinum, Vaccinium myrtillus*	4	4	0	1
F2.4	*Pinus mugo, Melampyrum sylvaticum, Vaccinium myrtillus, Vaccinium vitis-idaea*	4	4	2	1
F2.3	*Alnus viridis, Dryopteris filix-mas, Rosa pendulina, Rubus idaeus*	4	4	1	2
E4.3	*Arnica montana, Diphasiastrum alpinum, Gentiana asclepiadea, Nardus stricta, Veratrum album*	5	5	4	1
Total	**39 species (*Vaccinium myrtillus* is listed twice)**	**40**	40	16	**9**

Note: "Restricted" – recorded in only one of the seven habitats. *Adenostyles alliariae*, previously listed for E4.3, was recorded only in G1.6 and was replaced by *Nardus stricta*. Dominant trees are listed because the habitat catalogue requires them, not because they discriminate between habitats.

3.5. Why richness is a poor currency for conservation priorities

The central result is a divergence between two views of the same seven habitats. By richness, the ranking is G1.6 > G4.6 = E4.3 > F2.3 > G3.1 > F2.4 > G3.25. By attributes related to rarity and vulnerability, the picture differs for the woody habitats: the two poorest habitats (G3.25 and F2.4) held the highest proportions of Red Data Book species, showed insufficient regeneration and depended on one or two dominant species. These results agree in part with earlier work. Crisfield

et al. (2020) found that richness was a surrogate for the occurrence of rare plants but not for conservation value, and Perrin and Waldren (2020) found that richness–rarity relationships differed among habitats. In the present data, richness did not even track the number of Red Data Book species, which differs from the first finding; possible reasons are the concentration of Red Data Book species in high-elevation habitats, the small number of habitats and the aggregated data. Studies of forests suggest that understorey richness is related to light, tree identity and stand structure (Bricca et al., 2023; Dormann et al., 2020; Petersson et al., 2019). These factors were not measured here and cannot explain the present pattern, but it is consistent with the idea that richness reflects the permissiveness of the environment, which is highest in the lower mountain belt, more than the scarcity of the species that grow in it.

Three observations illustrate why a ranking by richness could misdirect priorities. First, richness hides dominance: F2.3 had 27 species but functioned like a community of fewer than five equally common ones, and its low evenness reflects strong dominance by one species. Second, species-poor habitats can be floristically similar to other habitats yet important for other reasons. G3.25, the poorest habitat (nine species, only one exclusive), is floristically close to F2.4 and G3.1 (a pattern consistent with, but not a formal test of, nestedness), so its value does not lie in a unique flora. It may lie in the rarity of *Pinus cembra* as the main species (3.9 ha in the park), in the Red Data Book species the habitat holds and in its regeneration deficit; none of these is captured by a diversity index. Habitat-level threat is assessed separately, for example in the European Red List of Habitats (Janssen & Rodwell, 2016), and the status of forest habitats is assessed with structural and functional indicators in addition to composition (Borghi et al., 2024; Kovac et al., 2020). Third, richness is a poor guide to complementarity (Margules & Pressey, 2000): the two richest woodland habitats overlapped considerably (G1.6 and G4.6, Jaccard 37.7 %), whereas E4.3 and F2.3, which ranked lower than or equal to G4.6 in richness, together contributed 35 exclusive species.

In a national park all natural habitats are protected, so these findings are relevant to priorities for monitoring and zoning rather than to the choice of habitats to protect. Monitoring effort allocated by richness alone would have covered 61 species in two habitats, whereas a complementarity-based choice would have covered 76. This matters in the Carpathians, where high-elevation habitats are expected to be vulnerable to warming and changes in land use (Kobiv, 2017, 2018; Mitka et al., 2022) and lower-belt spruce forests are under pressure from drought and bark beetles (Hlásny et al., 2021; Prykhodko et al., 2020; Senf & Seidl, 2021). Monitoring and zoning priorities in a park such as Synohora should consider several criteria in parallel: the occurrence of Red Data Book species, the regeneration of the dominant tree species, the rarity of the habitat in the park and the region, and its complementarity to other habitats. Richness and diversity indices remain useful for tracking change within a habitat over time, but not for ranking habitats against each other. The diagnostic species in Table 4 provide a tool for identifying the habitats in the field and for repeating the survey, which is the first step in such monitoring.

3.6. Limitations

This study has several limitations. (1) Sampling and scale: each habitat is represented by a single aggregated vector from one permanent plot and a number of temporary plots that is not specified per habitat, so within-habitat variance is not available and n = 7 limits the power of all correlations, which are therefore treated as descriptive. Richness is a pooled value whose magnitude depends on sampled area and effort, which differed among habitats (plot areas 0.02–0.35 ha). Rarefaction or extrapolation (Chao et al., 2014; Gotelli & Colwell, 2001) was not possible with aggregated data, and the effective number of species was used as a complement that is less sensitive to effort; the ranking by richness may nevertheless partly reflect sampling. (2) Conservation criteria: Red Data Book counts rely on a single national list (Didukh, 2009) that has since been amended (Ministry of Environmental Protection and Natural Resources of Ukraine, 2021). The correspondence of the

habitats to Annex I types of the Habitats Directive and their European Red List status (Janssen & Rodwell, 2016) were not assessed, and regeneration was judged from one plot per habitat. (3) Taxonomic coverage: bryophytes and lichens, which are important in high-elevation habitats (mosses dominate the ground layer of G3.25), were not recorded, and the mean Braun-Blanquet indices give much weight to r and + records when converted to cover. (4) Diagnostic species were selected by expert judgement and should be tested with fidelity measures (Chytrý et al., 2002; Dufrêne & Legendre, 1997) using plot-level data. (5) Light and stand structure were not measured, and comparison with the regional geobotanical literature of Gorgany and neighbouring massifs is limited. Lastly, the ordination reveals differences in composition among habitats but is not a test of the habitat typology. Future work should replicate plots within habitats, deposit plot-level data in an open repository and test the diagnostic species on independent plots.

4. Conclusions

Seven natural habitats of Synohora National Nature Park hold 116 vascular plant species, 64 % of which occur in one habitat only. Richness ranges from 9 species (G3.25) to 45 (G1.6) and is highest in the lower-belt woodland habitats G1.6 and G4.6 and in the grassland E4.3.

Richness is positively related to Shannon diversity and to the number of species exclusive to a habitat, but not to the number of Red Data Book species, tree regeneration or compositional dissimilarity; with seven habitats these results are indicative only. The poorest habitats hold the highest proportions of Red Data Book species, and four of six woody habitats show insufficient regeneration.

The richest habitats partly duplicate each other (G1.6 and G4.6 overlap by 37.7 %), and the combination of G1.6 and E4.3 captures more of the flora (66 %) than G1.6 and G4.6 together (53 %). Richness should therefore not be used alone to rank habitats; multi-criteria evaluation and complementarity should be considered when setting monitoring priorities.

A list of 39 diagnostic species is proposed for field identification of the seven habitats; 16 of the 40 listings refer to species restricted to one habitat, whereas widespread species such as *Picea abies* must be used in combination with others.

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Видове багатство – ненадійний показник охоронної цінності: кейс-дослідження різноманіття рослин природних оселищ НПП «Синьогора»

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Анотація. Видове багатство широко використовують для ранжування оселищ за охоронною цінністю, проте не з'ясовано, чи відображає воно ознаки, що роблять оселище незамінним або вразливим. Описове дослідження охопило сім оселищ за класифікацією EUNIS у Національному природному парку «Синьогора» (Ґорґани, Українські Карпати): ліси Abies і Picea (G3.1), ліси Fagus (G1.6), мішані ліси Abies–Picea–Fagus (G4.6), карпатські ліси Larix і Pinus cembra (G3.25), хвойні чагарники поблизу верхньої межі лісу (F2.4), субальпійські листопадні чагарники (F2.3) та ацидофільні альпійські й субальпійські луки (E4.3). Дані про рясність-покриття із семи постійних і 43 тимчасових ділянок охопили 116 видів судинних рослин. Оселища порівняно за індексами різноманіття, подібністю Жаккара, несхожістю Брея–Кертіса та ординацією. Видове багатство коливалося від 9 видів у G3.25 до 45 у G1.6; G4.6 і E4.3 мали по 39. Багатство позитивно корелювало з індексом Шеннона (ϱ Спірмена = 0,76), але не з кількістю видів Червоної книги України (ϱ = −0,36; p = 0,43), найбільшою в E4.3 (п'ять) і G3.25 (три); за n = 7 ці зв'язки лише орієнтовні. У чотирьох із шести деревних оселищ, зокрема в усіх трьох високогірних, природне відновлення деревних порід недостатнє. Сімдесят чотири види (64 %) трапилися лише в одному оселищі, а два найбагатші оселища значною мірою дублюють одне одного флористично: G1.6 і G4.6 разом мали 61 вид, тоді як G1.6 разом з E4.3 – 76. У цій системі видове багатство показує, скільки видів оселище додає до флори парку, а не наскільки воно рідкісне, відмінне чи перебуває під загрозою, і саме по собі не може визначати пріоритети моніторингу. Запропоновано перелік із 39 діагностичних видів для польової ідентифікації оселищ.

Ключові слова: Українські Карпати, НПП «Синьогора», охорона оселищ, видове багатство, Червона книга України, несхожість Брея–Кертіса, діагностичні види