Department of Environmental Biology, Sapienza University of Rome

31st CONFERENCE OF THE EUROPEAN VEGETATION SURVEY

May 21 – 25, 2023, Rome (Italy)

EUROPEAN VEGETATION SURVEY: METHODS AND APPROACHES IN A CHANGING ENVIRONMENT

Book of abstracts

Rome (Italy)

2023

Organizer

Department of Environmental Biology, Sapienza University of Rome

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Plenary presentations

Outline of plant life in Albania

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Albania is a small country of exceptional biodiversity. What is exceptional (at the European level) about this biodiversity is not so much in the numbers as the extensive presence of relict and paleoendemic elements. The flora of Albania includes species such as *Pinus peuce*, whose more close relatives are in North America, *Forsythia europaea*, a species belonging to a genus which is mainly distributed in East Asia, or the rare *Dioscorea balcanica*, related to subtropical species.
Albania is exceptional not only for his flora but also for its political history. Albania has a very old language and population. Albanian language represents its own branch in the Indo-European language, with many peculiar grammatical features, and the population is probably related to the ancient Illyrians that inhabited the east coast of Adria at the times of Romans. Albania was, for most of its history, part of big empires, the Roman, the Byzantine and the Ottoman empires. It gained its independence in 1912, and after a short period of relationships with Italy, after the second World War a communist regime of exceptional strictness began. In this period all the relationship with other European countries were broken and Albania was completely isolated. After the fall of the regime in 1990, a period of unrest followed. Fear, blood, and uncertainty were the norm for Albanian people in those terrible days. Only gradually, normality came back and eventually in 2014 it became officially candidate to the European Union.
The long period of political isolation of Albania had dramatic consequences for the botanical exploration of Albania. The foundations of Albanian botany were laid down at the beginning of the 20th century by Antonio Baldacci, an Italian botanist that described the diversity of the Albanian flora with several travels to this country, and Friedrich Markgraf, a German botanist who outlined the main features of plant geography of Albania. After this seminal contribution, a long period of silence followed, with rare exceptions. Consequently, Albania was, until recently, very poorly known. By the opening of the country to the rest of the world, a generation of intrepid Albanian botanist began to collaborate with foreign scientists and the knowledge of Albanian flora and vegetation rapidly rose. Nonetheless, much has still to be done. Probably, dozens of endemic plant species have yet to be discovered or recognized, and the phytosociological knowledge, although largely improved, lacks sometimes in details.
In this context, it is interesting the story of the Albanian phytosociological database, in the framework of EVA project. In ten years of exploration by

Giuliano Fanelli and Michele De Sanctis in collaboration with the outstanding Albanian colleagues Ermelinda Mahmutaj, Ermelinda Gjeta, Lulëzim Shuka, Petrit Hoda, Marjol Meco and others, a database of about 2000 relevés were gathered, exploring all the main parts of this rough and mountainous country. On the base of this base of data, it was possible to revaluate the main features of Albanian phytogeography, which were laid down as said above by the studies of Markgraf.

The main feature of Albania is the fact that in this country the Mediterranean and the Central European regions meet. This transitional nature results in two main lines, dividing the flora and vegetation of Albania: a line that divides the inner part of Albania with a Submediterranean-Central European character, and the Mediterranean coastal belt; and a second line that divides the North from the South, the latter with important relationships with Northern Greece.

Markgraf recognized four altitudinal belts: the Mediterranean, with vegetation dominated by maquis or shiblijak; the Supramediterranean belt, with *Quercus cerris-Quercus frainetto* trockenwälder, the montane belt with beech or pine forest and the alpine belts with alpine grasslands mainly dominated by different species of *Selseria*.

The composition of the flora is characterized by the co-presence of Mediterranean, Eurasiatic, European and Balkan species in equal proportions. The Mediterranean species decrease with altitude but remain important in all parts of Albania. The endemic element is not exceptionally represented but it must be taken into account that probably many more endemic species will be discovered in the future. The endemic element is mainly related to one of the outstanding features of Albania, the presence of large extensions of serpentines, with many endemic and subendemic species such as *Bornmuellera baldaccii*, *Festucopsis serpentinii*, *Sanguisorba albanica*, *Euphorbia glabriflora*, *Forsythia europaea* etc. In the south, very important centres of endemisms are the coastal limestone massifs, in particular the Llogora-Çika and Tomorr, with exceptional endemics such as *Astragalus autranii*, *Sanguisorba albanica* and *Reichardia albanica*.

Albania is trendy. The inclusions of the Albanian botany in the European context goes hand in hand with the opening of the country to the European Union and the development of an important ecotourism and environmental movement in Albania. Tourists are beginning to flock into Albania, either to visit the cool capital Tirana or to climb the beautiful mountains.

Classification and biogeography of European forests: a complicated relationship

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Keywords: Biomes, Forests, Formations, Phylogeography, Phytosociology, Vegetation classification

Forests and woodlands are the predominant zonal vegetation of Europe. Most of them belong to one of three main biomes: mediterranean evergreen, temperate deciduous and boreal coniferous. However, when going into more detail, things become complicated. Transitional areas (e.g., the submediterranean and hemiboreal zones), high montane and subalpine forests, azonal habitats (e.g., alluvial forests) and seral stands are treated in very different ways and on different hierarchical levels in the literature. In my talk, I discuss what we might (or should) expect from a classification of forests, and whether or not the current phytosociological systems meet these expectations. After giving a short history of forest classification in the Braun-Blanquet approach, the inconsistent treatment of the vegetation layers is identified as one of the main problems in the floristic classification of forests. Based on a numerical classification of a large data set of Central European forests, I show that the higher levels of the Braun-Blanquet system can basically be reproduced by taking only the shrub and tree layer into account. However, all past and current classifications suffer from arbitrary exceptions to this rule, leading to inconsistencies and blurring the main biogeographical patterns.

In the last part of my talk, I will present some new findings on the historical biogeography of European forest herbs. These results suggest that species having a high fidelity to beech forests under the current climatic conditions have partly survived the last glacial period in coniferous forests. Given that the upper levels of a vegetation system should be more stable over time than the lower levels, this is another argument for giving the tree species a higher weight in the classification of the European forests.

Novelties and issues in vegetation classification

On affiliation of communities with *Rhynchospora fusca* in Latvia

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Keywords: dune slacks, mires, *Rhynchospora fusca*, vegetation classification

Rhynchospora fusca is a suboceanic boreo-temperate species. In Latvia, four sites are known, and all are state protected. The study aims to describe and classify plant communities with *R. fusca* in Latvia. Formal definitions of fen alliances were used in classification at the alliance level and cluster analysis was used to classify vegetation at the association level. Similarly, as in other parts of its distribution range, *R. fusca* grows in a shallow nutrient-poor lake, fen, and periodically flooded humid dune slacks. In the lake, it forms monodominant stands in 10-15 cm water accompanied by *Myrica gale, Carex lasiocarpa*, and other sedges and bordering *Eleocharis multicaulis* community. In the humid dune slacks, *R. fusca* is accompanied by acidophilous species such as *Andromeda polifolia, Vaccinium oxycoccos, Calluna vulgaris, Eriophorum vaginatum*, and *Eriophorum angustifolium*. The moss layer was absent or weakly developed. *Sphagnum palustre* and *Sphagnum subsecundum* were the most common bryophytes. The dune slacks are overgrowing with *Myrica gale*. In the fen, *R. fusca* is occasionally found in *Rhynchospora alba* community bordering *Cladietum marisci*. Frequent associates were *Myrica gale, Carex lasiocarpa, Menyanthes trifoliata, Vaccinium oxycoccos*, and *Utricularia intermedia*. *Sphagnum teres, Sphagnum contortum, Campylium stellatum*, and *Scorpidium scorpioides* are abundant in the moss layer. The lakeshore community was assigned to *Magnocaricion elatae*, but the fen community – to *Sphagno warnstorfi-Tomentypnion nitentis*. The affinity of the dune slack community remains unclear. The main threats include past drainage in the dune slacks causing expansion of *Myrica gale*. In the future all communities may be influenced by climate change, mainly by increased summer temperatures. causing the decrease of water level.

Acknowledgements: This research was partly supported by the University of Latvia project `Biological diversity – impacts, functions, and protection (Nr. AAP2016/B034, ZD2015/AZ81). The participation at the EVS conference is financed by the ERDF project `Latvijas Universitāte un institūti Eiropas pētniecības telpā – ekselence, aktivitāte, mobilitāte, kapacitāte" Nr. 1.1.1.5/18/I/016.

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The national vegetation check-list of France

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Keywords: Phytosociology, check-list, France

In France, various national programmes using sigmatist phytosociology have shown the need for a common and shared language and thus a syntaxonomical standard. The last work to exhaustively list the vegetation units present in France (to the alliance level) was the *Prodrome des végétations de France*, published 18 years ago. A follow-up at the association level is currently in progress in the form of monographs for each class.

Unfortunately, because of the slow rate of publication of this follow-up and the different author's visions, there is still no updated and consensually elaborated exhaustive list of France syntaxa. The national vegetation check-list of France aims to produce such a list based on occurrence statuses at the departmental level for each of the units identified.

To do this, the regional check-lists of the different National Botanical Conservatories are aggregated within a system derived from the previous national work. The list of units and its architecture are then reviewed and validated collectively; points of uncertainty are recorded as footnotes.

The check-list is currently validated (including departmental chorology) down to the alliance and sub-alliance level. It includes a bit less than 500

alliances for the territory. Some are widespread (*Phragmition communis*), others much rarer (*Cnidion venosi* or *Anthyllidion hermanniae*).

This collaborative alliance check-list is only a first step: an important work on synonymy and nomenclature validation remains to be done at the association level. Additional information such as ecology or diagnostic taxa will be incorporated. Finally, the national vegetation check-list of France should also be compared to EuroVegChecklist and FloraVeg.eu to identify possible discrepancies and constructively address them.

Acknowledgements: This research is funded by the French Ministry of Ecological Transition and the French Biodiversity Agency as part of their support and cooperation with the National Botanical Conservatories.

"Good" and "problematic" alliances of the *Molinio-Arrhenatheretea* class in the European context

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Most European countries have their own classification schemes of the *Molinio-Arrhenatheretea* class, which may differ significantly in the methodical approaches used and national syntaxonomic traditions. The EuroVegChecklist includes 48 alliances, but the status of some of them is debatable. We wondered whether all of these syntaxonomic units are sufficiently delimited floristically and ecologically and whether they really deserve a separate status. For this purpose, we analyzed more than 300,000 relevés extracted from the European Vegetation Archive (project #87) and developed a classification expert system for *Molinio-Arrhenatheretea* vegetation to the level of alliances and orders. Thanks to this, all alliances were divided into groups that: 1) are clearly distinguished by the expert system and their original assignment does not significantly differ from that determined by the expert system (e.g. *Cynosurion, Molinion, Potentillion anserinae*); 2) are distinguished by the expert system, but the original assignment is significantly different (e.g. *Trifolion montani*), 3) are present in the dataset, according to their original assignment, but are not distinguished by the expert system (e.g. *Triseto flavescentis-Polygonion bistortae, Brachypodio-Centaureion nemoralis*); 4) have no relevés in EVA and the analyzed dataset (e.g. *Astrantion maximae, Artemision ponticae, Conioselinion tatarici*). Alliances belonging to group 1 can obviously be considered as "good", that is, have a clear ecological and floristic separation, which is also supported by ordination. Alliances belonging to groups 2 and 3 at this stage are classified as problematic, but we do not reject them, that is, we do not consider them as "bad", although we do not rule out that some of them will be merged with other alliances. As for the alliances assigned to group 4, we search for published relevés and digitize them. Adding them to the total dataset will allow us to find out their status in the future.

Carici stantis-Dupontietea fulvae – a new class of Arctic wetland vegetation

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Keywords: Arctic, Siberia, wetland

Various researchers of the Siberian Arctic noted that wetland vegetation in the high latitudes occupies insignificant areas and is presented by successional communities in swamping water bodies or overgrowing freshly drained alluvial banks. In this regard, Arctic wetland vegetation was either ignored or just mentioned in brief comments. Some attention was paid traditionally to communities of Dupontia fulva (=Arctophila fulva) considered in the class Phragmito-Magnocaricetea Klika in Klika et Novák 1941 (hereinafter Ph.-Mag.) or Scheuchzerio-Caricetea nigrae (Nordh. 1936) Tx. 1937 (hereinafter Sch.-Car.), or even in a separate class Arctophiletea fulvae Pestryakov et Gogl. 1989. Communities of other large aquatic grasses and sedges were included in the class Sch.-Car.

The data collected in recent years in the Arctic of Middle Siberia (Krasnoyarsk Krai) and East Siberia (Yakutia), i.e., 212 relevés, made it possible to revise the syntaxonomic position of wetland communities. Such communities develop in similar habitats that are characteristic of Ph.-Mag. at lower latitudes, with the exception of permafrost soils and the absence of most diagnostic species of the Ph.-Mag. At the same time, Arctic communities are often dominated by predominantly or even exclusively Arctic species (e.g., Dupontia fulva, D. fisheri, Pleuropogon sabinii, etc.).

Based on the presence of a group of diagnostic species (besides those mentioned above, these are Caltha arctica, Coptidium pallasii) and on their confinement to permafrost habitats, we propose a new class Carici stantis-Dupontietea fulvae that replaces the Ph.-Mag. in the Arctic. The new class includes two orders, corresponding to the arctic tundra subzone, and more southern regions to the forest-tundra. Along the southern boundary of the new class, communities of a transitional type (combining diagnostic species of both wetland classes) are observed.

Can we classify plant communities from space?

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Keywords: Syntaxonomical units, Diagnostic species, Remote sensing, NaturaSat

Remote sensing is one of the essential tools in ecology and nature conservation for effective spatio-temporal monitoring of changes in ecosystems. As imaging resolution, multispectral and hyperspectral data availability, and advanced data processing techniques improve, remote sensing offers more profound insights into land cover categories. However, due to the complicated and complex character of plant communities, it was impossible to reach the detailed scale defined by diagnostic plant species composition following the Braun-Blanquet approach with existing methodologies and satellite data. Here we show the concept of natural numerical networks as a novel tool for identifying plant communities using satellite images that break this limitation.

The natural numerical network is a new deep learning algorithm based on the numerical solution of nonlinear forward-backward diffusion equations on complete graphs. The first network was calibrated to identify four syntaxonomical units in Western Slovakia automatically. The result of classification is a relevancy map, where the values of habitat affinity to trained units in each pixel are computed. For testing the classification success, 150 relevés were chosen from the database. Using the NaturaSat software, the homogenous area around each relevé was obtained by automatic segmentation, and relevancy values for each unit were computed. The number and cover of diagnostic species were computed for relevés and compared with their relevance values to confirm whether we can classify vegetation units using the presented approach.

Acknowledgements: This research was supported by the European Space Agency grant No. 4000140486/23/NL/SC/rp, grant VEGA 02/0097/22, and Geobotany private research company.

Syntaxonomical diversity of class *Digitario sanguinalis-Eragrostietea minoris* in Bulgaria

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Overview: Till now there were no consistent in depth phytocenological studies of class *Digitario sanguinalis-Eragrostietea minoris* in the country. This research focuses on the thermophilous plant communities on ruderal and anthropogenically disturbed places, found in lowlands and semi-mountainous regions in Bulgaria.

Materials and methods: During the period 2018-2022, 448 phytocoenological relevés using the Braun-Blanquet approach were collected. The used plot size was 8-16 m^2. In addition, we collected data for some abiotic factors such as slope, altitude, bedrock and inclination. All relevés were contributed to the Balkan Vegetation Database (EU-00-013). The nomenclature of species was standardized according to the Euro+Med PlantBase. The hierarchical clustering was performed by the PC-ORD software package using Bray-Curtis dissimilarity and flexible beta clustering algorithm. The species cover values were square root transformed and clusters were standardized to equal size. The diagnostic species were determined by calculating the Phi-coefficient and only the statistically significant values evaluated by Fisher's exact test ($P<0.05$) were considered.

Results and discussion: The syntaxonomical diversity of class *Digitario sanguinalis-Eragrostietea minoris* was represented by 1 order

(*Eragrostietalia*), 3 alliances (*Spergulo arvensis-Erodion cicutariae, Chenopodion botryose* and *Eragrostion*), 8 associations (*Cynodontetum dactyli*, *Portulacetum oleraceae, Eragrostio-Euphorbietum maculatae, Tribulo-Tragetum, Digitario sanguinalis- Eragrostietum minoris, Setario pumile- Echinocloetum cruris-gali, Setario-pumile – Sorghetum halepense, Chenopodietum botryos*) and 1 plant community (*Setaria viridis-Hibiscus trionum*). These grass-rich communities are characterized by predominance of annual and biannual heliophytes and thermophytes. Such ruderal vegetation is found on wastelands, ditches, crop fields, city squares, parking spots, railways and other similar places.

Conclusion: This is the first analysis of the syntaxonomy and ecology of class *Digitario sanguinalis-Eragrostietea minoris* in Bulgaria. We found 1 alliance, 7 associations and 1 community new for the territory of Bulgaria.

Classification of Armenian dry grasslands and thorn-cushion communities

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Keywords: *Astragalo-Brometea*, *Festuco-Brometea*, phytosociology, semi-desert, steppe, Western Asia

Dry grasslands and thorn-cushion communities of Armenia are very diverse, but no formal plot-based classification system for them has been proposed yet. There are only a few studies of these communities from adjacent countries in the Southern Caucasus. The vegetation of Armenia is rather unique due to the border between two biogeographical regions crossing the country: Euro-Siberian and Irano-Turanian (Takhtajan 1986; Manafzadeh et al. 2017). Thus, the species belonging to these two regions are both common in the country, and, consequently, the vegetation types of these two regions meet here.

We sampled 111 relevés of dry grassland and thorn-cushion communities within five administrative regions of the country (Shirak, Aragatsotn,

Gegharkunik, Vayots dzor, Ararat) and an elevational range from 1338 to 2400 m a.s.l. To be able to identify the high-level syntaxonomical units, we used relevés from the neighboring regions for comparison, focusing on the original diagnoses of the high-level units of the similar vegetation types (206 from Northern Caucasus (Russia), 230 from Anatolia (Turkey), and 51 from Alborz Mountains (Iran). In total, 598 relevés were used. After unifying the species taxonomy, removing species determined only to the genus level, and merging species in aggregates, the final dataset contained 1559 vascular plant taxa.

Based on the results of a Modified TWINSPAN classification, we distinguished three class-level and eight order-level units in the joint dataset. The relevés from Armenia were classified into two classes, four orders, six alliances, and 11 association-level units.

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When will we be done with the vegetation classification?

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Keywords: methodology, phytosociology, vegetation classification

Phytosociology is a school of vegetation study that provides one of the irreplaceable perspectives on vegetation. It emphasizes combinations of species that recur in space, focuses on their standardized description, and attempts to identify their controlling factors. Classification is an important tool to simplify the complex patterns of vegetation variability and to present it in a clear way. An inevitable consequence of the simplification associated with classification is that there are alternative ways to classify the same vegetation. It is usually not possible to select the best solution because of the equivalence of different solutions or because of the multitude of criteria used to evaluate the classification results. Thus, if the resulting classification is just one of the suitable solutions, the results of classification studies should perhaps be presented in an appropriate, pluralistic manner. I believe that particularly syntaxonomic syntheses still owe much to their users in this respect. Looking at the perspectives of the EVS, I suggest we also should work towards the understanding of plurality of the different classifications to keep phytosociology alive at a time when its role is somewhat marginalised in some traditional countries. This effort might include an emphasis on the view that broad-scale syntheses are complementary, rather than superior, to fine-scale classification exercises. We should also encourage the development of alternative classifications for the same areas, based for example on different methodological approaches. Also, matching new relevés to existing classifications might be done in a pluralistic way, enriching rather than unifying our viewpoints. Thus, we will probably never be done with vegetation classification – but this is perhaps what phytosociology needs to maintain a creative and authentic relationship of experts and the wider public to the variability of vegetation in space as one aspect of a diverse living world.

Factors influencing diversity in plant communities

Habitat specialist species drive fine-scale diversity-area relationships (DARs) in southern European Atlantic coastal dunes

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Keywords: coastal dunes, fine scale, gradient, taxonomic diversity, phylogenetic diversity, phylogenetic structure, β-diversity

Diversity-area relationships (DARs) have mostly focused on species richness but other diversity components, such as phylogenetic diversity, may help understand how biodiversity patterns change across spatial scales. In this work, we sampled vascular plant composition in nested plots of seven grain sizes (0.0001-100 m^2) on southern European Atlantic coastal dune communities (embryo, mobile and fixed dunes) in order to analyse DARs. This was done separately for the whole species pool and for the subset of specialists. We asked: do fine-scale SAR and PDAR patterns and taxonomic and phylogenetic β-diversity change along the dune gradient?; how do specialist species influence these patterns?

Diversity indices included taxonomic diversity (TD, by means of species richness), Faith's index of phylogenetic diversity (PD) and its standardised effect sizes (PD.SES) to remove the influence of species richness on PD. A phylogenetic tree was assembled for the calculation of these phylogenetic indices. z-values were calculated for TD, PD and PD.SES using linear regressions of the power-law function in double log space.

TD and PD increased with plot size in the three habitats along the gradient, with fixed dunes accumulating more TD and PD. Both embryo and mobile dunes had mean positive PD.SES values at all grain sizes and their curves showed a similar pattern, while PD.SES in fixed dunes turned from negative at the smallest grain sizes to positive at the biggest ones. Results were similar for total species and for specialists, suggesting that the latter drive DARs in these habitats. Mean z-values for TD and PD ranged from 0.16 to 0.25 and increased from embryo to mobile to fixed dunes, with higher values for total species in the case of TD and similar values for total species and specialists regarding PD. Mean z-values for PD.SES were close to 0 and negative in embryo and mobile dunes and close to 0 and positive in fixed dunes, both for total species and specialists.

Potential of vegetation databases in macroecological studies – drivers of plant species richness and composition in semi-natural grasslands

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Keywords: vegetation plot, spatial analysis, redundancy analysis, human pressure, landscape structure

In the face of climate change and declining area of semi-natural grasslands in agricultural landscape, information about macroecological drivers of grassland diversity is of key importance for effective conservation of these ecosystems. In studies at a large spatial extent, data related to vegetation and its potential drivers are often characterised by low resolution or scarceness. However, growing availability, quality, and accuracy of databases enables us to overcome methodological challenges. Here, we examined the effects of environmental gradients, landscape, human pressure, habitat continuity in time, and spatial structure on plant species richness and composition in semi-natural grasslands at a regional extent (ca 20,000 km^2). For this purpose we used data from the Polish Vegetation Database, as well as environmental, socio-economical, and historical data from freely available national and international databases. The analyses were performed using boosted regression trees and multivariate approach for over 700 georeferenced relevés (vegetation plots) distributed across an area of ~20,000 km^2. We found that variables associated with human pressure, landscape, soil parameters, and spatial structures significantly affected species richness patterns. Species composition patterns were affected by different sets of drivers, which represented climate, long-term habitat continuity, and topography. In this study, we also stressed that identification of individual grasslands patches and patch complexes with high conservation value (in terms of species richness and composition) would be crucial in planning conservation areas network, at a landscape scale. Vegetation databases could make this information widely available. The approach presented here, which utilised phytosociological data and environmental databases, could be used in other macroecological studies on different habitat types and for different regions.

Environmental and historical factors influencing understory community diversity of *Pinus nigra* forests in Europe

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Keywords: Alpha diversity, beta diversity, community assembly, functional biogeography, pine forest, plant traits

Pinus nigra is one the most abundant and widespread pine species in the Mediterranean Basin, with a distribution range resulting from the interplay of environmental factors and historical processes. Understanding the relative importance of these factors and processes for diversity and composition of the understory plant community across the distribution of *P. nigra* forests requires a multifaceted approach that integrates taxonomic and functional alpha and beta diversity. We assessed the effects of climate (aridity and climatic seasonality), history (distance from current native range), and local factors (terrain ruggedness index and canopy cover) on alpha and beta taxonomic and functional diversity using linear models and distance-based redundancy analysis. Climate was the main driver of diversity and composition at different scales, highlighting the vulnerability of understory communities to climate change. Historical factors affected the diversity of local communities through the interplay of dispersal limitation. Local diversity is reduced under high canopy cover and in more homogeneous landscape. Comparing the drivers of the different diversity facets at continental scale enhances our understanding of vegetation response to environmental gradients.

Drivers of plant diversity

Unique microclimate and resource availability may support species persistence in microrefugia

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Keywords: Climate change, microrefugia, dolines

Microrefugia are often located within topographically complex areas where they provide stable environmental conditions for climate-change-sensitive species. The unique microclimate (e.g., cold-air pooling) of such safe havens is in the focus of most studies concerning the distributions of species, instead of other environmental factors, such as resource availability (e.g., soil moisture and soil nutrients). Furthermore, there is little knowledge about the relationships among topography-related microhabitat diversity, microclimate, resource availability and vegetation patterns in contemporary and potential future microrefugia. Karst landscapes cover about 20% of the Earth's terrestrial surface, providing topographically complex environments. The most typical landforms of these landscapes are topographic depressions, such as dolines, which may function as microrefugia. Here we investigated the effects of microclimatic conditions and resource availability (various soil properties) on plant species persistence within and adjacent to 30 large dolines distributed in two distant karst regions in Central Europe. Sampling sites were established in four microhabitats in each doline (south-facing slope, north-facing slope, bottom, and the surrounding plateau) for vegetation and soil sampling and microclimatic measurements. We used mixed-effects models and non-metric multidimensional scaling for our analysis. Our results highlighted that both microclimate and resource availability may be crucial in structuring vegetation patterns in topographic

depressions in karst landscapes. We found, for instance, that the cool and moist north-facing slopes and bottoms of dolines maintained several climate-change-sensitive species, while the nutrient-rich doline bottoms provided important microhabitats for nutrient-demanding species. Identifying climate-smart conservation priorities and strategies is required to maintain or increase the resistance and resilience of such microrefugia.

Acknowledgements: This research was supported by the NKFI K 124796, FK 142428 grants. The authors are also grateful for the support of the Bolyai János Research Scholarship and the New National Excellence Program of the Ministry for Culture and Innovation from the source of the National Research, Development and Innovation Fund (AAH: ÚNKP-22–3-SZTE-405, KF: ÚNKP-22–3-SZTE-402, ZB: ÚNKP-22–5-SZTE-538)

Temporal changes in forest plant diversity in Europe: What species are winning and losing?

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Keywords: biodiversity change; biogeography; forestREplot; global change; phylogeny; plant functional traits

Changes in the global environment have led to the extinction of local species and the colonization of new ones, resulting in losses and gains of evolutionary lineages with unique characteristics. The question arises as to whether these losses and gains occur randomly across the tree of life. To answer this question, we analyzed changes in plant phylogenetic diversity (losses and gains) in European temperate forest understories over a period of approximately 40 years. We also examined the phylogenetic structure of the species lost and gained in these areas and investigated how changes in macroclimate and nitrogen deposition affected these changes.

Although there was only a slight decline in phylogenetic diversity, losses and gains of species were concentrated within specific lineages. For example, consistent losses were found in the Fabaceae, Orchidaceae, and Rubiaceae families, while consistent gains were found in the Fagaceae, Betulaceae, and Rosaceae families. We found that plots experiencing declines in annual precipitation but little change in minimum winter temperatures lost a considerable amount of phylogenetic diversity. On the other hand, plots with low nitrogen deposition that experienced warmer summers gained more phylogenetic diversity.

The lost and gained species within the plots were phylogenetically random subsets of surrounding habitat species pools, indicating that closely related plant species did not share traits affecting their ability to colonize new environments or making them vulnerable to extinction. Furthermore, environmental changes did not appear to affect the phylogenetic structure of lost and gained species. In conclusion, recent environmental changes in temperate forests have altered patterns of phylogenetic diversity, with losses and gains identifying specific branches of the tree of life and ecological strategies that may expand or contract under global change.

Acknowledgements: JPC was funded by the Agency for Management of University and Research Grants of the Government of Catalonia (grant 2020-BP-00013). TD was funded through the EU Horizon 2020-funded eLTER PLUS project (Grant Agreement No. 871128). FM was funded by the Slovak Research and Development Agency under project APVV-19-0319. MChu, RH, MK, MM, OV, and PP were funded by the Czech Academy of Sciences (project RVO 67985939). MC was funded by the Czech Science Foundation (grant 19-28491X).

Climate relict plants and syntaxonomical classification: a case study from Sicily (Italy)

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Keywords: micro-refugia, narrow endemics, *Ptilostemon greuteri*.

Ptilostemon greuteri (Asteraceae) is one of the most intriguing narrow endemic plant species of the Mediterranean Basin. At first glance, the largest individuals of this species remind the most remarkable and weird cases of herbaceous genera (e.g., *Echium*, *Senecio*) turned woody on insular or insular-like mountain ecosystems. This woody thistle is only known from two populations mostly growing on NNE-facing calcareous cliffs and ledges on the NW coast of Sicily (Italy) and can be considered a climate relict. To better understand its ecology and better address conservation efforts, we investigated the plant communities where *P. greuteri* lives, then analysed which species and life forms are most frequently associated with it. The analysis of vegetation plots sampled along four orthogonal transects showed that *P. greuteri* is positively associated with species ascribed to different syntaxa, united by a preference for shady environmental conditions. Our results confirm that relict species are difficult to frame into

a syntaxonomical classification, because in most cases they represent the last remnants of a vegetation type that has disappeared.

Acknowledgements: This research was supported by the Audemars Piguet Foundation through a conservation project for *Ptilostemon greuteri*.

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Global review of woody plant encroachment: effects on plant diversity and management concerns

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Keywords: woody plant encroachment, land use changes, shrub expansion, dynamics, management, diversity

The increase in density and biomass of shrub species in grasslands is a global trend related to climate change, land use changes and abandonment of grasslands. This phenomenon, known as woody plant encroachment (WPE), leads to various effects on grasslands, such as a loss of plant diversity and changes in soil ecology. In the present study, we carried out a literature review with the aim of 1) exploring the global distribution of existing studies on WPE and 2) analyzing WPE studies focused on vegetation dynamics and floristic diversity. We conducted a literature search and categorization of the selected references, a total of 752.

There has been a remarkable increase in the number of studies in the last decade and a lot of them are related to vegetation and global change. Most of these studies correspond to North America and Africa, and with respect to biomes, to savanna and steppe. Out of 752 references, 303 study vegetation-related aspects. Most of them quantify the increase of WPE, assess vegetation dynamics and floristic composition changes, or evaluate management practices. Few studies analyze the effects of shrub invasion on taxonomic, functional or phylogenetic diversity.

In general, studies measuring WPE show an increase of shrubland over the last decades, which is associated with an increase in atmospheric CO_2 concentration, global warming, fire frequency and grazing regime. Most of these studies conclude that this increase leads to a loss of diversity and a change in composition and structure. The dynamics of the grassland-shrub ecotone follow different patterns depending on the location, and many factors influence the increase of woody plants over herbaceous plants, such as the characteristics of the encroaching woody species, plant interactions and climatic or edaphic conditions. Studies evaluating management methods conclude that a combination of different management techniques is the best way to halt the spread of shrub species.

Acknowledgements: This research was supported by the University of the Basque Country (UPV/EHU) and the Basque Government (IT1487-22). (Spain)

Seed dispersal-distance classes and dispersal modes for the European flora

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Keywords: Dispersal distance category, dispersal mode, Europe, plant trait, semiquantitative scale

Although the dispersal ability of plants is one of the key features in the spatial dynamics of species reflected also in the structure of plant communities, it is also one of the traits for which we still lack data for most species. Therefore, we compiled a comprehensive dataset of seed dispersal-distance classes and major dispersal modes for most European vascular plants.
In our dataset, we classified species to seven dispersal-distance classes based on the morphology of dispersal units (i.e. diaspores or propagules), life form, prevailing dispersal mode, seed release height, seed mass, and habitat preferences. Each class thus contains species with similar dispersal ability. The seven dispersal-distance classes can be further used as a semi-quantitative trait. To evaluate our assignments into dispersal-distance classes, we further related them to the estimated dispersal distances based on a different approach.
Seed dispersal dataset contains information about dispersal-distance classes and the most efficient dispersal modes for almost 10,000 most frequent and locally dominant European vascular plant species. It will become open and easily accessible within the FloraVeg.EU online database and can be used in functional biogeography, dynamic vegetation modelling and ecological studies that account for plant dispersal from local to continental scales.

Acknowledgements: This research was supported by the 2019-2020 BiodivERsA joint call for research proposals, under the BiodivClim ERA-Net COFUND program, and with the funding organizations Swiss National Science Foundation SNF (project: FeedBaCks, 193907), Agence nationale de la recherche (ANR-20-EBI5-0001-05), and the Technology Agency of the Czech Republic (SS70010002).

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Zelkova carpinifolia: An ancient relict tree from a phytosociological perspective

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Keywords: Caucasus, Colchis, forest vegetation, Hyrcanian Region, phytosociology, relict, syntaxonomy

Zelkova carpinifolia is a remarkable relict tree of the Arcto-Tertiary Geoflora in southwestern Eurasia. Its distribution encompasses Colchic and Hyrcanian refugia and a few isolated stands beyond (Kozlowski et al. 2018). In 2022, we recorded a dataset of vegetation-plot records of forests dominated by *Z. carpinifolia* in Colchis (W Georgia) and merged it with analogical plots from the Hyrcanian Region (N Iran; Gholizadeh et al. 2020). The Colchic distribution of *Z. carpinifolia* concentrates in a small inland area (~600 km^2) of the largely deforested lowland around Kutaisi. It occurs mainly in remnant forests on old river terraces and hillslopes (Nakhutsrishvili 2013). Colchic types appeared relatively xeric, *Carpinus orientalis* and *Quercus* spp. were its most common canopy companions. Other xerophytes and xeromesophytes frequently grew in the understory. Contrary, Hyrcanian types displayed a higher portion of mesophytes and local endemics. Colchic stands occurred on moderately acidic to neutral soils (mean pH 6.2), often deep, loamy or with an admixture of gravel and silt. *Z. carpinifolia* in Colchis favours higher light availability and drier substrates and thus prefers forest edges, sunny slopes and various convex relief forms. Colchic and Hyrcanian stands are developed under a climate with summer drought periods and relatively warm winters. In the context of other dry deciduous forests in the Euxinian Province, Georgian *Z. carpinifolia* stands exhibited a unique species composition, together with Colchic *Carpinus orientalis* forests (Novák et al. 2021).

Z. carpinifolia belongs among the flagship species of the Caucasian nature conservancy (Akhalkatsi 2019, Gegechkori 2020). According to our observations, overgrazing still represents a severe threat to most of its Colchic stands, coupled with several other factors. Therefore, various aspects

of *Z. carpinifolia* ecology and biology should be investigated to increase the effectiveness of its in-situ conservation.

Acknowledgements: We thank Ketevan Batsatsashvili, David Kikodze and Gregor Kozlowski for providing relevant literature. This research was supported by the Czech Science Foundation (project 19-28491X).

Environmental and socio-economic correlates of vascular plant species richness in Poland

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Keywords: biodiversity drivers, biogeography, macroecology, native species, neophytes, red list species

Understanding spatial patterns of species diversity distribution is among major goals in ecology. The ongoing biodiversity loss due to global socio-economic changes, landscape transformation, and intensification of agriculture resulting in habitat loss and degradation, gives an extra impulse to study the biodiversity drivers. Here, using a new data set (Szymura et al. 2023), we examine environmental and socio-economical correlates likely influencing vascular plant species richness in Poland, Central Europe (ca. 312,000 km2). We analyzed species richness of native species, neophytes, archeophytes, and species with high conservation value in a 10x10 km spatial grid (2,866 squares examined), with an assessment of potential sampling effort effect. The modeling was done using a joined model approach with boosted regression trees and random forests algorithms, which enabled to examination explanatory power of species richness drivers and also modeled the changes of the species richness along values of the explanatory variables.

We found that species richness of particular species groups (e.g. archeophytes, neophytes) correlates with different explanatory variables. Species groups also differed in explained variation by environmental and socioeconomic drivers variability. Besides the differences, among the most important correlates were size of farms and human population density. Our results showed that species richness decreases with increasing farm size, and this trend was observed also for neophytes. The effect of population density was less straightforward as richness of the native and high

conservation value species increases with population density up to particular density thresholds. This study also indicates the high importance of bio-climatic, soil, and topographic correlates for species richness patterns. Particularly we found that soil calcium content correlates with high conservation value species richness, but rather not with other species groups.

Acknowledgements: This research was supported by the National Science Centre, Poland, project number 2019/35/B/NZ8/00273.

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Natura 2000, EUNIS and vegetation classification approaches

Mapping Natura 2000 Habitat distribution at regional scale

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Keywords: Habitat Directive, Random Forest, Vegetation databases

A distribution model of Annex I Habitat types of the Habitat Directive (92/43/CEE), at the regional scale (i.e. Latium region, Italy), was developed and applied to provide a baseline mapping.
An initial database of 8615 vegetation plots was analysed and filtered by means of an expert-based process followed by fuzzy analysis to assign Habitat type codes. Finally, a field campaign was carried out to fill gaps in specific Natura 2000 sites and/or Habitat types.
The resulting 6686 Habitat plots dataset was then grouped according to the highest level of the Habitat hierarchy – i.e., macro-categories (1xxx-9xxx units in the Annex 1 list). The spatially explicit occurrences of the macro-categories were used to produce a map of the Habitat types, by means of a Random Forests supervised machine learning algorithm, with an overall accuracy close to 80%. This procedure integrates the Habitat occurrences data with information generated from Sentinel-2 MSI satellite imageries (vegetation and spectral indices and spectral signatures over time) and environmental variables (i.e. climatic, topographic and soil properties).
We provided a standardized and reproducible methodology to produce a probabilistic Habitat distribution map, which can be used to support monitoring and assessment procedures at local and national scale.

Adapting the EUNIS Expert System to regional classifications: a case study in the Cantabrian Mixed Forest ecoregion

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Keywords: Cantabrian Mixed Forests, European habitats, EUNIS, Vegetation classification

The new version of the EUNIS habitat classification will become the reference list for aggregating habitat information at the European level. Accordingly, regional habitat maps and vegetation databases will need to link their classification systems to EUNIS typologies in the best way possible. Assigning vegetation plots to EUNIS types has been successfully implemented at the European scale with the Expert System algorithm (Chytrý et al. 2020), but we still need to understand how this procedure applies to regional data sets. Here, we present a procedure to assign vegetation data to EUNIS habitats at the regional level in the Cantabrian Mixed Forest ecoregion. We used 28,775 vegetation plots of the ecoregion stored in SIVIM (Font et al. 2010) and applied the Expert System to assign the plots to EUNIS typologies of forests and shrublands. The number of plots assigned to EUNIS level-III types was relatively low and the assignment was inaccurate. Thus, we kept the Expert System at EUNIS level II and then analysed each group separately. Within each level-II group, we conducted a semi-supervised classification to differentiate habitat types in agreement to regional classifications used in vegetation maps and phytosociological systems. During the process, we assigned plots not classified by the Expert System at EUNIS level II to each habitat type, including new types when necessary. Our approach allowed us to assign all forest and shrubland plots to EUNIS units at different levels (mostly IV and V), making them useful for both regional management and European-scale analyses.

Acknowledgements: This research was supported by the Atlantic Botanic Garden, SV-20-GIJON-JBA

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- National vegetation monitoring of protected biotopes using an advanced sampling design

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Keywords: Long-term monitoring, permanent plot, unequal probability sampling, spatial stratified balancing, multi-stage, design-based statistics, dry grasslands, alluvial areas, wetland, fen, bog

Often the aim of national vegetation monitoring is to provide reliable estimates for predefined indicators both for the total area and for regions and ecological stratifications within the area. Sampling techniques such as grid sampling, stratification and cluster sampling are usually used to achieve broad sample coverage, high estimation precision and low survey costs.

In Switzerland, the monitoring programme of protected biotopes of national importance (WBS) was established in 2011 and aims by means of repeated vegetation surveys of permanent plots to estimate trends in nature conservation quality of these biotopes. Vegetation surveys are done in dry meadows and pastures, alluvial areas, fens and bogs. To select sites of national importance and plots within sites, we used a multi-stage unequal probability sampling design to better cover small regions (e.g., southern Alps, Jura mountains) and rare vegetation types (e.g., Stipo-Poion). The sampling efficiency, i.e., the precision of the estimates, was ensured by an additional spreading of the samples (sites and plots) over the geographic and environmental space.

We will demonstrate the principles and the efficiency of the advanced sampling design and present exemplary results of state and change estimates for three types of indicators (species number, plant indicator values, area of target vegetation types).

Acknowledgements: This research was supported by the Swiss Federal Office for the Environment (FOEN; contract number 00.5040.PZ / R242-1677)

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Forest classification and diversity

Past projections of marcescent oaks predicts future range-shifts of vulnerable species

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Keywords: biodiversity conservation, forecast, hindcast, Mediterranean forests, SDMs, *Quercus*

Mediterranean woodlands are amongst the most threatened forest ecosystems worldwide and are predicted to be severely hit by climate change. This region hosts a group of narrowly distributed marcescent oaks that evolved under Mediterranean-type climate regimes, distinguishing a continental-scale ecotone between the temperate deciduous and the typical evergreen forests of the Mediterranean basin. This group of species distributions patterns are deeply related to recent past range shifts since the Last Glacial Maximum (LGM). Therefore, analyzing their past range dynamics may help us to predict how vulnerable species are to climatic fluctuations and how they will respond in the face of future climate changes. We used Species Distribution Models (SDMs) and explored the range dynamics of eight submediterranean oaks, considering six past periods since the LGM, current climate conditions, and future climatic scenarios (2070 and 2100).

We compiled 12450 occurrence records and downscaled climate datasets from PaleoClim and CHELSA to obtain the potential distribution of each species, through an ensemble-modelling approach. Dynamics between past and future range shifts were analysed through linear regression. SDM performance ranged from good to excellent, and we obtained positive correlations between past and future range shifts. These changes were generally higher for eastern Mediterranean species and the amelioration periods generally recorded higher associations between past-future dynamics for the same group of species. Vulnerable oaks (*Q. kotschyana*, *Q. vulcanica*, *Q. canariensis* and *Q. lusitanica*) suffered higher range shifts and loss of suitable area in parallel to future-projected suitability, into areas utterly outside their biogeographic outreach. Studying past distribution range shifts of oaks helps to better predict future dynamics in the face of climate change. The implications of our results contribute to the broader conservation efforts of Mediterranean forests.

Global change drivers affect the functional diversity of temperate forest understories

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Keywords: Global changes, herb layer, bud bank, clonal trait, seed mass, specific leaf area.

In macroecology, a shift from coarse- to stand-scale explanatory factors would represent a significant step forward in understanding the effect of global changes on functional diversity (FD). Plants are multifunctional organisms and different traits may respond differently to environmental conditions. Selecting plant traits mirroring independent axes of functional specialization is therefore compelling to understand how environmental and human-induced changes can affect plant functioning. Here we aim to assess how modelled macro- to micro-climate, as well as stand-scale measured soil properties, forest structural parameters, and the type of management, affect the FD of forest understories at the macroecological scale using a multifunctional approach. We used a probabilistic sampling representative of the managed forests of Italy. Twelve predictors were selected and grouped into climate, soil, forest structure, and management variables. We used five traits capturing independent functional dimensions to calculate the standardized effect size of FD for all traits (multitrait) and single traits. Multiple regression models were used to assess the effect of predictors on FD. Climate and soil were the main drivers of FD of specific leaf area, plant size, seed mass, and bud bank, while multi-trait FD and clonal lateral spread did not significantly respond to the predictors. Among the forest structural variables, only the amount of deadwood affected specific leaf area and seed mass, while forest management exerted a very limited effect. Future warmer and more seasonal climate might reduce the diversity of resource economics and persistence strategies of forest understory plant communities. Soil eutrophication and acidification might mainly affect the diversity of regeneration strategies by both seeds and bud bank. Multifunctional approaches are fundamental to disentangling the effect of

global changes on FD since independent functional specialization axis are modulated by different drivers.

Acknowledgements: Data were gathered within the Italian ICP Forests - CON.ECO.FOR. network, managed by the Carabinieri Command for the Protection of Biodiversity and Parks - Studies and Projects Office (CUFAA). S.Ch., J.T., G.C., M.C., A.A., S.Ca., and R.C. were supported by the LIFE MODERn(NEC) project (LIFE20 GIE/IT/000091). S.Ch., G.C., and R.C. were furtherly supported by the RE.DI. (REducing risks of natural DIsasters) Consortium.

Basin-scale analysis of floodplain forests: effects of mesoclimate and water regime on their diversity

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Keywords: Riparian forest, Azonal vegetation, Temperate Climate, Mediterranean Climate, Functional diversity, Ellenberg Indicator Values, Disturbance Indicator Values

Riparian forests are included within azonal vegetation types by the Euroveg checklist due to their local characteristics as soil humidity and flooding. Nevertheless, climate is clearly affecting the species composition and diversity of these forests, as demonstrated by Biurrun et al. (2016) for the Iberian Peninsula, where four alliances differ regarding several climatic parameters. One of these alliances, *Alnion incanae*, is present in the upper sections of several tributaries of the Ebro river, from the Cantabrian Range to the Pyrenees. In this work we focus on the floodplain forests of this alliance at the basin scale, with the aim at assessing the effect of mesoclimate and water regime in their diversity. The study area is the basin of the river Irati (Navarre, Spain), located in a climatic transition zone, with a temperate climate and forests with *Fraxinus excelsior* in the northern part and a submediterranean climate and forests with *F. angustifolia* in the south. In addition, some rivers of the area come from the Pyrenees, with pluvio-nival water regime while others raise in the Basque-Cantabrian Mountains, with pluvial regime. We sampled 45 vegetation plots distributed across the four main rivers of the basin. Plots of 20 m x 10 m were arranged paralel to the river, and the four corners were marked with sticks for further resurvey. All the vascular plants present in the plot were considered and their percentage cover estimated. Cover of the tree, shrub herb and cryptogam layers was also estimated, as well as the litter and dead wood. We will first classify the plots using Twinspan, in order to go more in depth in the differentiation of forest types. Further, we will compare their functional composition regarding a set of selected traits (SLA, seed mass, life-forms). We will also compare their ecological features by means of Ellenberg indicator values as well as their degree of adaptation to disturbance by means of Disturbance indicator values.

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Fine-grain beta diversity of Basque-Navarran temperate forests (Spain)

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Keywords: Forest, Fine-grain diversity, Z-value, Species-area relationship.

Disentangling the spatial and environmental drivers influencing vegetation communities holds a special interest among researchers. Species-area relationships (SARs), described as the increase of species richness with area and one of the fundamental laws in ecology, is hitherto broadly used to compare spatial diversity patterns in a wide range of organisms (Dembicz *et al.,* 2021). In addition, several studies have also tested the fitness of the different functions and how ecological context affects them, undoubtedly acknowledging that the power function ($S = c\ Az \Leftrightarrow \log S = \log c + z \log A$) has the best performance in a wide array of cases. Eventually, SARs, is also a suitable tool to allow extrapolation and standardization of species richness to different scaled units. Nevertheless, most of the research outcomes regarding the empirical evidence on small-grain SARs in continuous habitats have centered in open habitats such as grasslands in the Palaearctic region (Dengler *et al.,* 2019), completely ignoring forest ecosystems, known as the habitats holding the largest terrestrial biomass.

Therefore, this study pretends to continue the trend of describing the diversity drivers of the habitats in the Palaearctic region, with the main goal of setting how forest type and climatic factors affect the fine-grain diversity in forests. In order to achieve this purpose, we have used 73 nested-plot series with grain sizes ranging from 1 cm^2 to 200 m^2 located in several forest habitats of the subcantabric region of the Basque Country and Navarra. We conducted this nested-plot sampling for the herb layer of the forest, using the shoot presence method, with two nested series with seven sizes in each 100 m^2-half of the big plot, a rectangle of 20 m x 10 m. We calculated the *z*-value of the power function of SAR and used it as a measure of fine-grain beta diversity. We further tested the changes across forest types and effects of climatic factors on beta diversity.

Acknowledgements: this research has been financially supported by the European Union-Next Generation EU grant and the Basque Government (IT1487-22).

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How much are we stepping on the Iberian native forests?

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Keywords: Native forests, Vegetation, Nature conservation, Human footprint, Spain, Portugal

Human activities are among the major causes of native forests decline. Establishing concrete conservation priorities and restoration goals for these communities is challenging as information is scattered, detailed maps are usually missing, and their high ecological value is hard to synthesize.
Using life-forms and simple rules about cover values, we determined the dominant tree species for 14745 relevés of Iberian native forests, obtaining 69 different dominance types. We mapped the environmental envelope associated to each dominance type, using high-resolution variables known to determine vegetation distribution, namely, climatic variables, soil variables, and hydrologic variables. Inside each of these modelled areas, we extracted data on the human footprint as a measure for multiple pressures associated to the different human activities. Additionally, to estimate the maximum area ever realized by each dominance type during the Holocene epoch, we used estimates of forest cover at the landscape level from the great forest expansion period (circa 8250 calibrated BP, in the Iberian Peninsula).
Contrasting the current footprint size with the maximum realized areas, we were able to classify each dominance type into four major risk classes. We discuss the relevance of each class from a nature conservation perspective and point towards appropriate actions needed in each class.

Acknowledgements: This work was supported by National Funds from FCT - Portuguese Foundation for Science and Technology, under the project UIDB/04033/2020. TMH was funded by the European Social Fund (POCH) and by National Funds (MCTES), through a Fundação para a Ciência e a Tecnologia postdoctoral fellowship (SFRH/BPD/115057/2016).

It's a matter of class. The uncomfortable syntaxonomic position of the Italian "thermophilous" oak forests

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Keywords: Biogeography, Epiontology, EuroVegChecklist, Syntaxonomic classification criteria, thermophilous oak forests

The attribution of a plant community to a syntaxonomic class is not always an easy choice, and above all the forest communities seem to be often subject to different interpretations regarding their classification at the class level. In the Italian peninsula, the most widespread deciduous oak forests are those dominated by *Quercus cerris* and *Q. pubescens* s.l. and their classification has often been a source of debate. *Q. pubescens*-dominated forests find their coenological optimum within the South facing slopes where traditional agricultural land-use practices occur. According to Brullo & Marcenò (1985), southern Italy downy-oak species are not to be referred to *Quercus pubescens* Willd. but to other strictly steno-Mediterranean pubescent-oak taxa (e.g. *Q. virgiliana* (Ten.) Ten., *Q. dalechampii* Ten., *Q. congesta* C. Presl...) having their optimum in the meso-Mediterranean bioclimate. For this reason, these authors classified the related forests in the *Quercetea ilicis*. Other authors (e.g. Blasi et al. 2004) considered all the downy-oak associations as belonging to the *Querco-Fagetea* by virtue of the deciduous character of the guide species. Eventually, the EVC (Mucina et al. 2016) considered all the pubescent oak forests as an evolution (or a relict) of paleo E-European steppe-forests, therefore to be classified in the *Quercetea pubescentis*. For their part, *Quercus cerris*-dominated forests represent an important component of the forest heritage of the Italian peninsula. They show a wide distribution, especially within the Apennine range. In this case, the EVC classifies them in the class *Quercetea*

pubescentis as well, framing them within a single order and four alliances. On the other hand, Biondi et al. (2014) classifies them in the class *Querco-Fagetea* within two orders and six alliances. In this paper, we focus on the most suitable criteria to be considered for an appropriate interpretation and classification of these "thermophilous" oak forests at the rank of class.

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Functional traits and vegetation ecology

Edaphic and topographic filtering of plant life forms in Mediterranean mountaintop communities: a case study from the Madonie Mountains, Sicily

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Keywords: Communities, Life-form, Mediterranean, Mountains, Soil, Topography

Environmental drivers filtering life forms at local scales are poorly investigated in general, and studies devoted to this topic in the Mediterranean mountains are still missing. We investigated the role of edaphic and topographic gradients in vegetation above 1900 m a.s.l. on Pizzo Carbonara (Madonie Mountains, Northern Sicily), a carbonate massif extensively affected by karst erosion that gave rise to a system of sinkholes and windy ridges alternating on the summit plateau. We sampled 42 vegetation plots, georeferenced with a sub-metric GPS. Different topographic variables were derived from the regional technical map of Sicily, with 2 m resolution, using QGIS. Additionally, several chemical and biochemical soil parameters were analysed for each plot. The species were split into three life-form groups: chamaephytes, hemicryptophytes, and therophytes. Data were analysed using different response variables: species richness, vegetation cover, and species composition. For the first two response variables, a Generalised Linear Model (GLM) was run. The compositional data were processed by distance-based redundancy analysis (db-RDA) through variation partitioning. Results show that life forms are subject to differential filtering by edaphic and topographic variables. These

topographic conditions affect the relative performance of the co-occurring vascular plant species, and consequently, the structure and composition of local plant communities.

Species sorting along succession is mediated by leaf economics, regeneration niche traits and clonality

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Keywords: succession, colonization, functional traits, life histories, phylogenetic ecology

Species realized niches are determined by successional conditions and their colonization-related skills. Recently, two indexes have been developed to capture these niche dimensions or gradients for a subset of Central European plant species: an estimated optimum of abundance after disturbance and the Index of Colonization Potential. Here, we show how functional and phylogenetic differences of *Festuco-Brometea* (dry grasslands) species from the Czech Republic drive the species sorting along these two gradients. First, we identified the main axes of trait variation through ordination. Then, we ran both random forests and linear regressions to show that traits explain a moderate amount of variation of species sorting along these two axes. The explanatory traits were related to the leaf economics, regeneration niche, plant size and clonality. We also analyzed the relevance of phylogeny in explaining the two gradients and showed that the Index of Colonization Potential and many traits, but not the successional preferences, have a strong phylogenetic signal. However, phylogenetic relatedness does not explain the patterns found by phylogeny-agnostic analysis. We also analyzed the multivariate explanation of traits as they are filtered by succession and colonization preferences. We identify a meaningful pattern of plant size, seed mass, and phenology, explained by successional preferences, and clonality, certain dispersal types and plant size explained by colonization abilities. We conclude that the dry grasslands species pool holds a significant successional and colonization gradient generating a continuum of life histories.

Local conditions and topography shape plant functional diversity along mountain slopes

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Keywords: Central Apennines, Functional traits, Elevational gradient, Field sampling, Forest ecology

The central Apennines on the Italian peninsula are a region of great interest to forest ecologists, as their refugial status during the repeated Pleistocene glacial events and traditional timber and pasture management retained a high plant diversity. As elevation increases, the mesoclimate changes from temperate with a dry summer season to cold with a wet summer season, altering the forest composition and structure. To understand how the environment impacts community assembly by filtering plants with specific trait strategies along this gradient, we conducted a transect-based field sampling on northern and southern slopes. From the valley bottom to the climatic treeline at ~2,000 m, we recorded vascular plant diversity, forest structure and soil characteristics at 150 m intervals. We used 10 functional traits characterising species competitiveness, dispersal, and stress tolerance to compute community-weighted means and functional richness based on trait hypervolumes. We then modelled the relationship between trait means, functional richness and (a)biotic site conditions.

Our data suggest that functional richness is highest at the valley bottom in mixed broadleaf coppices. With the transition into beech-dominated high forests, functional richness reaches its minimum mid-slope, but increases again toward the treeline. This convex relationship seems to contradict the commonly observed linear decline of diverging trait strategies with elevation. We explain this pattern with a reduced dominance of *Fagus sylvatica* at high elevations, where the trees' height and diameter decrease, leading to more open canopies. This could allow alpine plants to encroach into the impoverished subalpine beech forest. Although slopes with a southern orientation showed a positive impact on species richness, we

could not find a similar effect for functional richness. By analysing community weighted means, we confirmed and extended results from previous forest studies, in that beech forests filter plants with acquisitive leaf traits and rhizomatic storage organs, whereas communities in the low-elevation mixed *Ostrya carpinifolia* and *Quercus* forests are characterised by higher lateral spread rates and conservative leaf traits.

Acknowledgements: The data acquisition and processing part of this research was supported by Alessandro Bricca, Irena Axmanová, Gianluigi Ottaviani and Gonzalo Velasco.

Resurveing Europe in a changing environment

Significant decline in habitat specialists in dry grasslands of South Moravia over four decades

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Keywords: abandonment, conservation management, succession, vegetation change, vegetation resurvey

Semi-dry grasslands are among the most species-rich and valuable plant communities in the world, harbouring many specialised and threatened species. Most of these grasslands were traditionally maintained by grazing and haymaking. After the cessation of traditional management, protected areas were established, and conservation management was introduced to protect the most valuable habitats. However, recent changes in traditional land use, eutrophication and climate warming have had negative effects on the biodiversity of these grasslands. We asked whether plant species composition and richness change over time and whether the decline in habitat quality and plant diversity is less severe or absent in protected areas. We conducted two resurvey studies over 40 years in South Moravia (Czech Republic). One study focused on acidophilous dry grasslands and heathlands, and the other on basiphilous semi-dry grasslands.

We identified significant changes in species composition in both acidophilous and basiphilous communities. Species richness, the proportion of habitat specialists and Red-List species decreased, while competitively stronger species with higher demands on nutrients, juveniles of woody plants and alien species increased. In the acidophilous grasslands, we also detected an increase in annual species and the negative impact of the invasive grass *Arrhenatherum elatius* on habitat quality. In the basiphilous semi-dry grasslands, there was a significant increase in species with higher demands on moisture, causing a transition to more mesophilous communities. These negative trends occurred both within and outside protected areas but were more pronounced outside. The main factor behind the changes appears to be the cessation of traditional management and natural succession supported by eutrophication.

Acknowledgements: KK is a Brno Ph.D. Talent Scholarship Holder – Funded by the Brno City Municipality. This research was further supported by the Technology Agency of the Czech Republic (project no. SS02030018, DivLand), Czech Science Foundation (project no. 19-28491X), and European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement No 101090344.

ReSurveyEurope: a database of resampled vegetation plots in Europe

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Keywords: Global change, Europe, Resurvey, Vegetation change, Vegetation database, Vegetation plot

ReSurveyEurope is a community initiative that establishes a new repository of data from resurveyed vegetation plots in Europe. ReSurveyEurope collects vegetation plots from all habitats. The first call for data provision was issued on 6 October 2020. All databases in ReSurveyEurope are stored and managed using the Turboveg program versions 2 and 3 at Masaryk University in Brno. Version 1.0 of ReSurveyEurope contains 274,396 observations (i.e. individual surveys of each plot) from 77,020 plots sampled in 442 independent resurvey projects included in 256 datasets. Of these, 62,431 (80%) are permanent plots, i.e. marked or geo-tagged plots, which allow for high spatial accuracy in resurvey. The remaining 15,873 (20%) plots are from resampling studies, in which plots from the initial survey were not exactly relocated. Four datasets, which together account for 28,470 (35%) plots, provide only presence/absence information on plant species, while the remaining 49,834 (65%) plots contain abundance information (e.g. percentage cover or cover-abundance classes such as the Braun-Blanquet scale). The oldest plots were sampled in 1911 in the Eastern Alps, while most plots were sampled between 1950 and 2022. Of those plots that could be classified to EUNIS habitat types, 50% were from grasslands, 21% changed their broad habitat type over time, 16% were from forests and 13% were from other habitat types.

ReSurveyEurope is devoted to an inclusive and transparent governance and data usage approach based on slightly adapted rules of the well-established European Vegetation Archive (EVA).

Acceleration of understorey vegetation changes in the Western Carpathians forests during the last 60 years

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Keywords: alpha diversity, forest communities, herb layer, plot resurvey, species turnover

Acceleration of anthropogenic impacts on the biosphere has been observed since the 1950s. Along with an exponential growth of environmental factors, an increasing impact on plant communities is expected. In temperate forests, several drivers of vegetation change were already identified, particularly climate warming and eutrophication. However, acceleration of changes has not been proven yet. To solve this hypothesis, we repeatedly re-surveyed 127 plots in the Western Carpathian forests (including oak, oak-hornbeam, beech, mixed mountain and spruce forests). Plots were established about 1966, firstly re-surveyed in about 2005, and secondly in about 2021. We compared diversity and species composition similarity measures of forest understories divided by time span (years) between the re-survey periods, getting the mean change per year.

Alpha diversity measures (species richness, H´, J´) did not change in the herb understorey. Significant decrease as well as its acceleration was observed in the total herb cover. Mean annual decrease was 0.3% in the first period (1966 and 2005) and 1.0% in the second (2005–2021). Rapid and accelerating changes were also detected in the species composition change when the Bray-Curtis index increased annually by 0.015 up to 2005 and by 0.032 in the latest period. Mean species turnover reached 50 % (according to Jaccard index from presence/absence data) between 2005 and 2021.

We conclude that forest vegetation dynamics accelerates in the Western-Carpathians, manifested by increased rates of compositional and cover change. These findings have serious consequences for vegetation and habitat classification as well as for nature conservation.

Acknowledgements: This research was supported by the Scientific Grant Agency VEGA, project 1/0624/21.

Climate change effects on plant communities' distribution

Introducing VegTrends: an EU-funded project to assess long-term trends in European vegetation and evaluating the effectiveness of protected areas

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Keywords: temporal changes, resurveying studies, protected areas effectiveness

Many terrestrial habitats across the globe are currently assessed as "threatened", and the extent to which existing protected areas effectively safeguard biodiversity is debated. With many ecosystem services depending on plants, reliable estimates of long-term vegetation change are needed as a benchmark for future monitoring and reporting, as well as to plan and undertake effective conservation measures. We hereby present VegTrends, a new EU-funded project aimed at i) providing a multi-habitat and multi-faceted assessment of temporal vegetation changes across plant communities and species; ii) evaluating the effectiveness of protected areas in conserving European habitats. Building on an unprecedented number of previously-disconnected datasets now included in the ReSurveyEurope database, VegTrends will allow producing the first comprehensive and representative report of temporal trends in the vegetation of European open habitats accounting for the effects of protection status (Natura2000 + Emerald Network). Besides assessing compositional shifts and quantifying changes in taxonomic, functional and phylogenetic diversity metrics, we will analyse trends in biological variables defining changes in conservation status (e.g. richness and cover of habitat specialist, threatened and alien species) and investigate whether they differ based on protection status. Moreover, we will identify driving mechanisms (turnover vs nestedness, gain vs loss) and test for the exceptionality of observed changes. This will allow

pinpointing habitats and species that underwent the strongest changes, with important implications for habitat conservation.

Go north: Do mountain plant species shift their ranges towards northern aspects in response to climate change?

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Keywords: alpine plant species, range shift, climate change, microrefugia, aspects, northness

In response to climate change many plant species shift their ranges towards cooler higher elevations to track their temperature niches, although they are lagging behind climate warming (e.g., Rumpf et al. 2018). On the other hand, rugged mountain topography provides a wide range of microclimatic niches within the same elevation which may serve as microrefugia in a warming world (Körner & Hiltbrunner 2021) - particularly northern expositions are notably cooler than other aspects (Winkler et al. 2016).

Here we assess horizontal range dynamics of 183 vascular plant species of the Eastern Alps on 1,576 semi-permanent non-forested plots surveyed between 1911-1970 and resurveyed 2014-2015 (dataset from Rumpf et al. 2018). On average, these 183 species shifted significantly towards northern aspects. However, horizontal shifts were only significant in ~15% of the species, 85% of which moved to the north. Only 2% of the species shifted both upwards and towards the north. Changes in northness were idiosyncratic and not related to the species' ecological indicator values (Landolt et al. 2010) for temperature, soil moisture or nutrients. We conclude that for a small subset of mountain plant species horizontal range shifts to cooler northern aspects may thus constitute an alternative (rather than complementary) strategy to escape rising temperatures.

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Limited impact of microtopography on alpine plant distribution

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Keywords: Alpine vegetation, Climate change, Ecological indicator values, Microrefugium, Spatial mass effect, Spatial resolution, Species distribution models, Topography

High topographic variability has a strong impact on the distribution of plants in alpine landscapes. It has been hypothesized that through regulating near-surface temperature above the tree line it may sustain cold microrefugia for alpine plants and hence relax the need of shifting upward when climate warms. However, the effectiveness of these microrefugia relies on the premise that plant distribution in alpine landscapes is mainly controlled by fine-scale topographic variation rather than coarse-scale one.

We tested this assumption by relating the distribution of 79 plant species and 10 community attributes across 900 1 m² plots in a landscape of the Austrian Alps spanning 1,677 elevational metres to 13 topographical descriptors at resolutions between 1 and 301 m. We found that the spatial distribution of most species and most community traits were better explained by topographic variation at coarser scales (> 20 m). The pattern is stronger in the case of the distribution of individual species than in case of community properties, where the effect of the fine-scale topography is relatively stronger. Fine-scale topography is more clearly reflected in moisture than in temperature requirements of species. The elevational gradient, not topographic variation at any scale, is the single most important driver of species distribution and variation of community-attribute in the area studied.

We hypothesise that our results reflect an underestimated impact of neutral, dispersal-related processes on alpine plant distribution. Mass effects and dispersal limitation can override environmental filtering at fine scales and will thus compromise the survival of cold-adapted plants in small and fragmented refugia under climate warming.

Acknowledgements: This work was funded by European Union's Horizon 2020 research and innovation programme (grant agreement No 883669).

Restoration ecology: methods and approaches

Have agriculturally semi-improved lowland grasslands the ability to revert back to their semi-natural state with appropriate management based on solely their seed-bank?

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Keywords: Seedbank, Habitat Restoration, Grassland, Biodiversity Restoration, Ireland

Ireland's largest terrestrial habitat is grassland, though much of this grassland has been agriculturally improved (O'Neill et al., 2013) and as a result, the original species assemblages have been lost, therefore, habitat restoration is the desired option for biodiversity enhancement. When spontaneous restoration is being considered, the health of a habitat's seedbank can directly correlate with restoration success, particularly when remnant habitat is not present (Prach et al., 2001). How a seedbank may degrade over time depends on the type of habitat that was present. Grassland is generally a stable habitat, and as such, seeds within the seedbank may degrade quickly after land use change (Bossuyt et al. 2008). However, a grassland seedbank study has not been completed to date in Ireland.

The seedling emergence method was used to assess the seedbank within the lowland grasslands of Killarney National Park, Co. Kerry. Soil seed samples were collected from lowland fields during October 2022 and seeds grown. The species present in the seed bank throughout the park grasslands have been estimated. A vegetation survey was completed in July 2022 to compare diversity of existing vegetation versus this seedbank.

The preliminary results indicate that the seedbank has been somewhat degraded, however, there were species within the seedbank that were not recorded in the vegetation survey. These included graminoid species such as *Trisetum flavescens* and other oat grasses. There were also additional common ruderals within the seedbank. No rare target species were germinated from the seed samples collected. Conversely, species such as *Rhinanthus minor* were absent from the seed bank, yet present in the vegetation survey.

This study will inform semi-improved lowland grassland biodiversity restoration projects and shed light on the self-restorative capacity of these grasslands. It will also indicate if the most common methods used to evaluate seedbanks in mainland Europe are as effective in Ireland.

Acknowledgements: This research is funded by the National Parks & Wildlife Service of Ireland and Munster Technological University.

Sincere thank you to the staff of Killarney National Park and Shannon ABC and Brandon Bioscience for their continued support.

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Safeguarding plant species diversity in a crowded country – challenges and solutions

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Nature is facing huge challenges worldwide and the future of many endangered plant species is pitch dark if no direct action is taken. With crises like the biodiversity crisis, the climate crisis, the water crisis and the nitrogen crisis omnipresent, it is not an easy task to turn the tide. This clearly holds for the Netherlands, with more than 17 million inhabitants living in an area of just a little more than 40,000 square kilometres. Here, more than one third of the 1,500 indigenous plant species are on the National Red List of Vascular Plants, of which 70 are critically endangered, meaning that they easily may get extinct on the national level. To prevent that from happening, quite a number of restoration programmes have been carried out in the last decennia and more are scheduled in the near future. These programmes focus on improving the former environmental conditions to counteract the impact of eutrophication, acidification, desiccation and fragmentation, and more are scheduled for the near future. The Dutch government has set aside no less than 26 billion euros to restore nature as quickly as possible, with 2030 as a target. In the light of this, the role of gene banks has come under attention: if we succeed to restore the abiotic conditions, we have to be sure that the species are still present, preferably *in situ* but otherwise *ex situ*. Already in 1992, at the Convention on Biodiversity in Rio de Janeiro and repeated at the COP meeting in Montreal last year, it was decided to set up national genebanks as a backup for nature ánd as a tool for strengthening or reintroducing plant populations. At the IAVS meeting in Bremen in 2019, we launched the Dutch Living Archive as an important tool of the overall rescue plan; this time, we will focus on restoration plans for a set of species, discussing both options and foot traps. We selected three examples out of a total of about one hundred plant species for which 'action plans' are set up in the Netherlands. There is no single roadmap for reinforcing existing impoverished populations and reintroducing species at former sites where the site conditions have been improved. How to operate will be illustrated

for three strongly endangered plant species in the Netherlands: *Geum rivale*, *Daphne mezereum* and *Puccinellia rupestris*. For reaching maximal results in reinforcement and reintroduction, universities and other research institutes have to collaborate with nature conservation agencies as well as policy makers at different levels.

Synthesis of litter raking experiments in Europe: the impact on forest understories

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Keywords: biomass removal, permanent plots, conservation management, litter raking, species diversity, temperate woodlands

The practice of litter raking has been widespread in forests throughout Europe and has left a significant legacy on forest ecosystems. Recently, litter raking has been considered as a conservation tool to restore declining plant species diversity due to increased nitrogen deposition and abandonment of traditional management. To address this, several experiments have been set up since the 1990s to monitor how forest ecosystems respond to history-inspired management interventions. We compiled a dataset of 156 permanent forest vegetation plots from the Czech Republic, Poland, Slovakia, Germany and Switzerland. We investigated whether there is a general pattern in the effect of litter raking on the diversity and composition of understorey vascular plants. Specifically, we focused on changes in species richness, taxonomic heterogeneity and Ellenberg indicator values for nutrients and soil reaction. We found a consistent increase in species richness, mostly beginning in the third year of the experiment. The response of taxonomic heterogeneity to litter raking measured as a distance from the centroid was highly variable between sites, with both increases and decreases. In general, based on Ellenberg indicator values, species composition shifted towards flora with lower nutrient levels and lower soil

reaction but the changes were not consistent between sites. This trend was stronger on sites with originally acidophilic and oligotrophic flora, such as acidophilous oak forests. The results of this study suggest that the response of understorey species diversity and composition to litter raking may vary depending on the initial site conditions, such as soil and vegetation type. The results may also help to select sites suitable for litter raking as a conservation management tool.

Acknowledgements: This study was supported by long-term research development project RVO 67985939 to the Institute of Botany of the Czech Academy of Sciences and by the project "Application of traditional knowledge to halt biodiversity loss in woodlands" (TO01000132) financed by the Technology Agency of the Czech Republic and Norway Grants 2014–2021.

Successful grasslands restoration on site invaded by *Solidago*

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Keywords: plant invasion control, restoration process, vegetation changes

Invasive species spreading control and restore ecosystems, like semi-natural grasslands are among the EU's biodiversity strategy targets. Successful restoration of lands invaded by alien plant species has to consider three stages: invasive species removing, habitat restoration, and further management. Among species that have a strong negative impact to biodiversity and frequently invade grasslands in Central Europe are *Solidago gigantea* and *S. canadensis*.

We present results of eight years experiment aimed to restore semi-natural grassland, testing different methods of removing invasive *Solidago* species and seed application. Three kinds of removal treatments (herbicide spraying, rototilling, turf stripping) and two seed addition methods (direct sowing of a fast-growing grass species mixture, and spreading of fresh hay collected from a semi-natural meadow) were examined. The experimental plots were mowed twice a year, and the vegetation composition was assessed every year. Obtained results show that lands degraded by invasive species can be restored to valuable grasslands, but the process needs time. The effectiveness of herbicide treatment was not superior to other *Solidago* removal methods, indicating that methods that are less harmful to the environment can be used. The use of fresh hay as a seed source was not only beneficial to biodiversity but also most effective in suppressing the invasive species. The recommended method of management is regular mowing twice a year.

It should be emphasized that a realistic evaluation of restoration outcomes should be performed from a longer time perspective. The short-term observations document only the temporal stages of vegetation succession, which could differ substantially after 8 years, resulting in misleading conclusions regarding the excellent effect of herbicides or commercial seed

mixtures of fast-growing grasses on long-term restoration success (Szymura et al. 2022).

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Miyawaki Mini-Forests based on Vegetation Science

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Keywords: Restoration of natural forest, Evergreen broad-leaved forest, Deciduous forest, European sclerophyll Quercus

The original idea and models for the mini-forests envisioned by Akira Miyawaki came especially from Autobahn forests and conserved *Urwald* in Germany and the Netherlands, where he had studied the potential natural forests according to the Tüxen school of phytosociology. The diversity of natural forests is high in Europe, but Prof. Miyawaki also added his agricultural experience to the idea of potential natural forests. The most stable forests occur on stable topography, with mesic, rich soil and good drainage. In Europe these are *Quercus* and *Fagus* forests, along with forests dominated by *Ulmus* or *Carpinus* on alluvial areas and valley slopes. In Japan, Miyawaki created natural forests in the evergreen broad-leaved forest region. His method involves: 1) potted saplings (Miyawaki's idea) of dominant species of the potential natural forest; 2) soil preparation on the planting sites; 3) dense, random, mixed-species plantings; 4) planting activity by local students and townspeople, for environmental education; and 5) mulching with rice straw, weeds or bark chips to reduce evaporation and soil erosion, add nutrients, foster soil animals, and suppress weeds. Dense planting encourages competition and coexistence among seedlings, encouraging early growth. Such forests also serve as habitats for mammals and birds, mitigate disasters (fire, tsunami, flood, etc.), and protect against wind, salt spray, sand, noise, dust, etc., all of which treat various SDG goals. There is a Miyawaki mini-forests in Istanbul (Sango Co.), and Prof. B. Schirone (Tuscia, Italy) will describe his experiences in a talk at the IAVS meeting in Coffs Harbour. Restoration methods of evergreen broad-leaved and deciduous forests differ in planting density, due to sapling shape. European sclerophyll *Quercus* needs greater density and admixture with deciduous *Quercus*.

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Miyawaki method of afforestation and vegetation science

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Keywords: Miyawaki method, Forests, Vegetation science

Miyawaki's reforestation method is at present the most sophisticated among the current approaches to forest and environment restoration. According to it, large amounts of seedlings of native late successional trees should be planted in plots on fertilized, artificially recovered organic topsoil. It basically mimics natural succession enabling the planted stands to grow and mature much more quickly than with traditional afforestation methods. Urban deforested areas became early target-scenarios of these plantations, basically fostering the body of knowledge on topics related to the planning, design and the establishment of urban and peri-urban woody vegetation. Basic foundations of the method involve the knowledge of local succession, soil dynamics and potential natural vegetation.

Nevertheless, criticism is raised concerning the high costs, frequent failure in dry areas and loss of diversity. The core paradigm "natural potential vegetation/native, late successional trees", apparently is the crucial point. Criticism to the method does basically come from disregarding these basic requirements. Moreover, the computing of diversity before and after the establishment of the stands is highly misleading. The interpretation of changes in diversity after the establishment of the plantation, often is biased by the obvious disappearance of what is a stock of ruderal or early successional species, once in situ, which is evaluated as bad result, ignoring local natural vegetation dynamics and that most extant late successional old growth forest stands in the temperate and Mediterranean forests can be extremely species poor in the understorey.

The Scientific Community of Vegetation Science must re-emphasize the basic geobotanical foundations of the method and watch over its development, in order to prevent conceptual bias, misinterpretations of failures or misleading developments of the technique and revert to Miyawaki's original solid ground in geobotany and phytogeography.

Patterns and drivers of plant invasion

Effectiveness of methods used to *Solidago* stands reclamation –preliminary results

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Keywords: grasslands, biological invasion, eradication methods, legume, semi-natural meadow, *Solidago* species

One of the most common invasive plant genera in Europe and Asia, with a strong environmental impact, is *Solidago* of North American origin. Member states of the European Union are required to prevent the introduction, control, or eradication of invasive alien species due to the significant environmental impact of biological invasions (European Community, 2014). Two steps are required for the long-term successful eradication of invasive species: the removal of invasive plant species and the ensuing restoration of the habitat (Reid et al. 2009). The presented study aims to find the best, environmentally friendly method to control *Solidago* invasion and restore the semi-natural meadow on the site invaded by *Solidago*. For this purpose, the two-factorial experiment was established in 2020 using: (1) different methods of seed introduction [sowing the seed mixture of pasture grasses (4 species); pasture grasses with legumes (6 species); seeds from the semi-natural meadow (37 species); and application of fresh hay (47 species)], as well as (2) different frequency of mowing (once, twice, and three times). The experiment area was mowed and the soil was prepared using a rototiller prior to seed application. The species compositions with coverage were recorded before the first mowing in two years (2021 and 2022). The cover of *Solidago* in 2021 and 2022 significantly decreased by mowing twice and three times and the highest change in seeds from the semi-natural meadow with one-time mowing was observed. The species richness was influenced by a combination of factors: seed introduction methods and mowing regimes. The highest species richness was observed in the semi-natural meadow with mowing three times. The results revealed that all the mowing regimes and seed introduction methods are effective in *Solidago* stand reclamation, reducing an average of 80% of *Solidago* coverage from the beginning to after three years.

Acknowledgements: This research was supported by the 'UPWR 2.0: international and interdisciplinary programme of development of Wrocław University of Environmental and Life Sciences', co-financed by the European Social Fund under the Operational Program

Knowledge Education Development, under contract No. POWR.03.05.00-00-Z062 / 18 of June 4, 2019 and Wrocław University of Environmental and Life Sciences (Poland) under the Ph.D. research programme 'Innovative Doctorate' no N070/0008/21.

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Harmonized lists of alien floras for European countries

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Keywords: Alien species, Database, Europe, Invasion status, Residence time, Vascular plants

Alien plant species are considered a major driver of the rise of novel ecosystems and a serious threat to biodiversity. To study their ecology and dynamics at large scales, high-quality checklists are needed. Although several attempts to compile large databases of alien plants have been made, especially in Europe, they were constrained by the limited availability of regional checklists or they focused on selected groups of alien plants (e.g. GloNAF on naturalized aliens). We assembled >100 alien plant checklists for European countries and identified large gaps in their completeness and comparability.

To overcome these inconsistencies, we started to update the lists of alien vascular plants for individual countries based on several sources available. We considered regional checklists (including unpublished ones), large databases, namely DAISIE, GloNAF and the Euro+Med PlantBase, and occurrence data from the GBIF and EVA database of vegetation plots. We carefully standardized all these input data to the same nomenclature following the Euro+Med Plantbase concept or POWO in case of taxa not included in Euro+Med. We created a database, in which each species is assigned a native or alien status within 55 countries or regions (large islands were treated separately). If available, we also provide the residence-time status (archaeophyte, neophyte), invasion status (casual, naturalized, invasive), and region of origin (e.g. North America, tropical Asia). If the sources differed in status assigned to the same taxon, we treated such cases individually with the help of regional experts.

Our comprehensive database will enable large-scale syntheses focused on alien plants in Europe. We plan to make it open and regularly update the information in the recently developed FloraVeg.EU database, comprising characteristics of the European flora and vegetation. We also plan to further contribute our data to the Euro+Med and GloNAF databases.

Acknowledgements: This research was supported by the Czech Science Foundation (EXPRO grant no. 19-28491X). JCS considers this work a contribution to Center for Ecological Dynamics in a Novel Biosphere (ECONOVO), funded by Danish National Research Foundation (grant DNRF173) and his VILLUM Investigator project “Biodiversity Dynamics in a Changing World”, funded by VILLUM FONDEN (grant 16549).

Ecological indicators for vegetation analysis and nature conservation

Ellenberg ecological indicators for the Iberian Peninsula flora

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Keywords: Ellenberg indicator indices, Iberian Peninsula, Juice software.

The ecological indicators of Ellenberg (EIVs) for species and subspecies have been compiled for the Iberian flora. Indicator values for light (L), temperature (T), moisture (F), soil reaction (R), nutrient availability (N) and salinity (S) were assigned to 2500 species using the nine-degree, or 12-degree for moisture and 10-degree for salinity using the ordinal scales proposed by Heinz Ellenberg for the flora of Germany. We have used the original Ellenberg indicators (Ellenberg et al. 1991) as a baseline, together to datasets from other reference floras from close countries: Jiménez-Alfaro et al. (2021) from the Cantabrian Range; Julve et al. (2012) from France; Pignatti et al. (2005) and Guarino et al. (2012) from Italy; Böhling et al. (2002) for the South of Greece and Landolt et al. (2010) for Switzerland.
We have used the reciprocal averaging method (Chytry et al. 2018) to fill values of the EIVs for the species of different vegetation datasets obtained from SIVIM (Font et al. 2012). Until now we have revised: therophytic vegetation, high-mountain vegetation, *Quercus pyrenaica* forest, saline vegetation and shrublands and scrublands. The total number of plots have been 45000 aprox. and they were analyzed by Juice v.7.1 (Tichý 2002, Tichý et al. 2023) and some cases also with the R package FD, function *functcom* (Laliberté et al 2014). Taxa with an initial EIV in the floras of reference but absent from the vegetation plots were left without EIVs. We finally calculated Spearman correlations between the final EIVs and those reported in the original floras to test whether they retained a similar ecological meaning. The Kernel probability was also used to analyze the probability of variables to reach a determined value. The results showed a final list of species with new indices and also species that were present in the comparison floras that now have a value for those EIVs.

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Using ecological indicator values for vegetation classification. Why not?

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Keywords: Vegetation classification, ecological indicator values, habitats, alliances

Vegetation classification traditionally uses the phytosociological approach, whereby species-by-plot matrices are directly subjected to analyses. The resulting groups are interpreted ecologically, which is often mirrored in the English names of syntaxa; for instance, the *Arrhenatherion elatioris* is circumscribed as "Mesic mown meadows on mineral-rich soils in the lowland to submontane belts of temperate Europe". Hence, particularly at the level of alliances and/or habitat types, classification based on ecological properties seems feasible, and classifying vegetation using mean ecological indicator values could be a worthwhile complement to the traditional phytosociological approach. I present first results, potential pros, cons and open questions concerning vegetation classification using indicator values. I analysed 1200 10-m^2 relevés of Swiss open land vegetation that had been assigned to habitat types (alliances) using three different phytosociological methods. As a first proof of concept, I trained a linear discriminant analysis (LDA) model with six mean indicator values and ¾ of the relevés that had been consensually assigned to the same vegetation types by all three phytosociological methods. This LDA model correctly predicted the vegetation type of 85% of the ¼ consensus relevés used as test data. Another approach is mapping relevés within the multidimensional ecological space created by the indicator values. Thereby, ecologically extreme vegetation types like raised bogs can easily be delimited, whereas vegetation types that often overlap floristically also overlap in the indicator value space. Critical feedback and ideas on how to further implement and evaluate indicator-value-based classification approaches are highly welcome.

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Ecological Indicator Values for Europe (EIVE): overview, aims and next steps

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Keywords: bioindication, ecological indicator value, Europe, light, moisture, niche position, niche width, nitrogen, pH, temperature

Ecological indicator value (EIV) systems of plants, which allow to assess the conditions of plots on the basis of species composition, are widely used in ecological studies of vegetation in Europe. Until recently there were many regional systems developed for a territory. However, these systems are inconsistent in scaling and plant taxonomy, which hinders their use for large-scale studies across the continent. Our goal was to create an indicator value system for all Europe based on the assessments in the regional systems. **Study area**: Europe (and closely adjacent regions). **Methods**: We used 31 regional EIV systems that have data on at least one of the five

ecological niche dimensions: soil moisture (M) - 31 source systems, soil nitrogen (N) - 24, soil reaction (R) - 28, light (L) – 33, and temperature (T) - 23. We combined and unified the regional scales by harmonizing the scaling in an iterative approach. We derived consensus values of niche position and niche width for each combination of taxon x niche dimension. Thus, we got the European values scale, where 0 is the minimum value of the factor, and 10 is the maximum available in Europe. All analyses were performed in R. Taxon names were harmonised to the Euro+Med Plantbase. We validated our T values by correlating them with species niche data derived from GBIF. **Results**: In January 2023, we published the Ecological Indicator Values for Europe (EIVE) 1.0 with niche position and niche width for 14,835 taxa of vascular plants (14,714 for M, 13,748 for N, 14,254 for R, 14,054 for L, 14,496 for T). **Future plans**: Currently, we are working on EIVE 1.5 to cover also bryophytes, lichens and macro-algae plus some new and updated systems for vascular plants. Beyond that, future plans include adding further niche dimensions with the same consensus approach, combining EIVE with the European Vegetation Archive (EVA) as well as preparing additional regional versions of EIVE for major parts of Europe.

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Bryophytes diversity and vegetation communities

Forest bryophyte patterns along the north-western Dinaric altitudinal gradients (Croatia)

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Keywords: alpha diversity, distribution patterns, elevation, spruce forests, species turnover

Bryophytes are a diverse group of land plants, but due to difficulties in their identification, they have rarely been included in biodiversity surveys. As they are found from sea level to mountain summits, they are ideal candidates for altitudinal studies. Analysis of bryophyte diversity was undertaken to elucidate the richness and floristic composition of the eight forest altitudinal belts along two Dinaric mountains. A total of 185 species (40 liverworts and 145 mosses) were encountered. The lowest total number of bryophytes is in the lowest holm oak (Fraxino orni-Quercetum ilicis Horvatić (1956) 1958) altitudinal belt and the highest in the complex of spruce communities (Vaccinio-Piceion Oberd. 1957). Patterns of alpha diversity were best described by the cubic regression function with diversity maxima approximately between 1.100 and 1.200 m a.s.l. The most prominent species turnover appears between boreal spruce and subalpine beech belts and between subalpine beech and pine Krummholz belts. Bryophytes exhibit the highest abundances in spruce and mixed beech and fir communities and the lowest in thermophilic (Oriental hornbeam and holm oak) communities. The diagnostic species of low-altitude thermophilic forests are *Rhynchostegium confertum*, *Rhynchostegiella tenella*, *Fissidens taxifolius*, *Leptodon smithii*, *Zygodon rupestris*, *Frullania cesatiana*, *Orthotrichum diaphanum* and *Scorpiurium circinatum*, of mixed beech and fir forests *Exsertotheca crispa* and *Ulota crispa*, of spruce forests *Rhytidiadelphus loreus*, *Plagiothecium laeutum*, *Chiloscyphus polyanthos*, *Polytrichum formosum*, *Dicranum tauricum*, *Buxbaumia viridis* and *Herzogiella seligeri*, of subalpine beech forests *Paraleucobryum sauteri*, *Leskurea saviana* and *L. incurvata*, while of pine Krumholtz vegetation *Rhytidiadelphus triquetrus*. The altitudinal zonation of bryophytes demonstrates that these plants respond to elevational gradient in terms of species richness, floristic composition and phytogeographical patterns.

Bryophyte diversity in relation to substrate characteristics in aspen (*Populus tremula)* forests along forest age chronosequence

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Keywords: Bryophytes, Aspen forests, Substrate

Aspen forests are important habitats for many organism groups, including bryophytes. Old-growth aspen forests provide a variety of rare bryophyte species. Bryophyte communities in aspen forests are threatened by forestry activities, especially low cutting age in commercial aspen forests. It is important to understand how bryophyte communities change with the forest age. The aim of the study was to explore bryophyte diversity in relation to substrate characteristics along aspen forest chronosequence. The study was carried out in aspen forest stands representing three age classes – young, middle, and old-growth forests. Bryophytes were studied on three substrate groups – ground, logs, and living trees. On each substrate bryophyte cover as well as substrate characteristics were evaluated. Diameter and tree species were evaluated for the living trees. The presence of bark, decay stage, diameter, and tree species were recorded for logs. The cover of forest litter was evaluated for ground plots. Our study gives a detailed analysis of the importance of each substrate to bryophyte diversity along aspen forest chronosequence.

Acknowledgements: The study was supported by Fundamental and applied science research project of the Latvian Council of Science: “Bryophyte and lichen successional and spatial patterns in deciduous forests” (No. lzp-2020/1-0314).

Ecological preferences of aquatic bryophytes and their communities – insights from Croatian watercourses

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Keywords: Dinaric Ecoregion, Karstic rivers, Ecological responses, Land use, Macrophytes, Water quality

An extensive survey of aquatic vegetation in Croatian watercourses was conducted to assess the ecological status according to the Water Framework Directive. Macrophyte cover and abundance were assessed along 100 m-long transects using the extended Braun-Blanquet scale. The survey yielded 80 bryophyte species from 208 sites on 144 different watercourses. Direct multivariate ordination of vegetation data paired with 18 environmental variables revealed that freshwater bryophytes and their assemblages were segregated along the gradients of water chemistry and the proportion of natural and urban area within the catchment. Furthermore, the ecological responses of individual species were explored with generalized additive models. The majority of the species preferred watercourses with unaltered catchments, clean, well-oxygenated water with low nutrient and organic matter content, as well as low electrical conductivity. However, the most frequent and widely distributed species, such as *Fontinalis antipyretica*, *Rhynchostegium riparioides*, *Cratoneuron filicinum*, *Fissidens crassipes*, *Cinclidotus fontinaloides* and *C. riparius*, had a wide ecological tolerance. Several species with narrow ecological niches, indicative of good water quality were identified as well, while only *Riccia fluitans* and *Leptodyctium riparium* had optima in hypereutrophic waters with high electrical conductivity and organic content and were frequently associated with a high share of intensive agriculture within the catchment area. When only bryophyte-dominated sites were considered, five communities segregated along the gradient of several climatic, physiographic and water chemistry parameters were recognized. The geographical patterns of the bryophytes and their communities revealed that clean, fast and cold karstic rivers with larger substrates and larger catchment areas, which are characteristic of the Dinaric Ecoregion, provide the most suitable habitats supporting their greatest diversity.

Poster session

Adaptation strategies of *Rhododendron ferrugineum* L. in high altitude environments: An analysis of some ecophysiological traits

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Keywords: Alpine vegetation, Leaf eco-physiological traits, Plant ecology, Climate change

Surveys concerned with patterns of biodiversity change along environmental gradients have always been in scientific focus. In particular, functional leaf traits have been used in plants to assess how effectively they can manage different resources. Specific leaf area (SLA) and leaf dry matter content (LDMC) were used to assess these changes in the subalpine ericoid Rhododendron ferrugineum in the Sharri Mountains. Variations in abiotic conditions over short vertical distances can affect leaf functional traits and plant phenology. Here, we tested the relationship between leaf size, SLA, LDMC, and total chlorophyll content at three randomly selected sites (1910 m a.s.l., 2080 m a.s.l., and 2220 m a.s.l.) in the Sharri Mts. in Kosovo, over two periods in June and July. We assessed these ecophysiological variables and analyzed the obtained results using ANOVA analysis. It was found that total chlorophyll content, leaf size, SLA as well as LDMC varied significantly along the altitude factor but showed no variation(s) with respect to the two sampling periods. SLA, leaf size and total chlorophyll content were higher at the altitude of 2200 m a.s.l. compared to the other two sampling sites. Our study highlights the importance of examining both seasonal and elevational gradients to understand plant adaptation strategies. Overall, our results indicate that the plasticity of ecophysiological traits underscores the wide distribution of R. ferrugineum in the high mountains of Europe.

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Phytosociological analysis of the *Elyno-Seslerietea* from Sharri Mts., Kosovo

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Key words: Syntaxonomy, Vegetation classification, Grasslands ecology, Balkans, EuroVegChecklist

Elyno-Seslerietea is a large vegetation class of alpine and subalpine limestone grasslands in the European mountains. This class occurs in the more continental parts of the Balkans, as *Seslerietalia tenuifoliae* in the western part along the Dinaric Alps and as *Onobrychido-Seselerietalia* in the continental regions of the central and southern Balkans. Our analysis is based on 110 new relevés and 299 literature relevés assigned to the same class from the Balkans. The communities thriving in the Sharri Mts. are classified to the order *Onobrychido-Seslerietalia*. We note two alliances, *Anthyllido-Seslerion klasterskyi*, the alliance of alpine vegetation and *Seslerion nitidae*, that encompass subalpine vegetation. Of the alpine alliances *Anthylido-Seslerion klasterskyi* we found *Carici laevis-sempervirens* Rajevski 74 nomen inept. We inverted (Art. 42 ICPN) the name to *Caricetum sempervirens-kitaibeliani* Rajevski 74 nom. invers. From the alliance *Seslerion nitidae* we found three new associations: 1. *Festuco-Bryoerythrophylletum recurvirostrae* ass. nova prov.; 2. *Poeto-Cerastietum cerastioidae* ass. nova prov. and 3. *Helianthemo-Festucetum pancicianae* ass. nova prov. We also reviewed the nomenclature of some other associations from this alliance, as: 1. *Helianthemo-Festucetum adamovicii* Rajevski 74 nom. invers, which we further divided into two subassociations: *Helianthemo-Festucetum adamovicii* Rajevski 74 nom. invers. (*alchemilletosum velebiticae* and *bromopsietosum erectae*) and 2. *Helianthemo-Festucetum adamovicii* Rajevski 74 nom. invers. With two new subassociations (bromopsietosum erectae and alchemilletosum velebiticae), based on the data of our original relevès. New data on (sub)alpine vegetation in the Sharr Mts. will be of considerable importance for the establishment of protected areas and will contribute to our

understanding of the functioning of grassland ecosystems and provide information that can be used for conservation, land management and sustainable development.

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Restoration approaches for steppe vegetation losses in Ukraine due to russian military aggression: a program

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Keywords: russian military aggression, losses of steppe vegetation, restoration

Russian military aggression in Ukraine has caused catastrophic environmental damage amounting to ecocide. Approximately 300 protected territories covering over 3.5 million hectares and providing habitats for around 30 protected plant and animal species, have been decimated. Ukraine's steppe ecosystems, which make up 8% of the world's reserve of chernozems, were already largely plowed, with less than 1% preserved as protected areas, and are now on the brink of destruction. In response, an urgent search for alternative ways to restore these losses has begun.

The proposed Program aims to compensate for the losses of Ukrainian steppes by reserving significant areas of low-productivity and degraded plowed soils for further restoration of steppe vegetation. Based on our research and analysis of over 300 sources, the program includes the following steps:

1. Developing a legislative basis for steppe vegetation restoration;
2. Identifying, inventorying, and classifying land plots for future steppe reserves of various typological and regional variances;
3. Step-by-step large-scale conservation of eroded lands in the steppe and forest-steppe zones of Ukraine, optimization of agricultural landscapes, and restoration of vegetation on degraded lands;
4. Developing a digital database of steppe localities in Ukraine, including those planned for conservation, using GIS technology;
5. Studying the self-development of the steppes and their adaptation to global warming;
6. Developing strategies and biotechnical measures for post-plowing restoration;
7. International projects on steppes restoration involving academic, educational institutions, environmental organizations, and the public;
8. Identifying financing sources for the program, including state, private, and reparations from the Russian federation;
9. Establishing a scientific advisory council on steppes restoration;
10. Developing monitoring and control mechanisms for program implementation.

Vegetation restoration of military tank range in Kryvyi Rih (Central Ukraine)

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Keywords: Active military training, Abandoned land, Plants communities, Derivative group

Spontaneous revegetation of the destroyed land is the basic role in improving the environmental condition. The goal of the researches is to reveal the specifics of the Vegetation restoration on military tank range. The territory of military tank range are located within Adopted Sites of Emerald Network of Ukraine, site name «Middle Inhulets river valley».
The main factors that influence on forming vegetation of military tank range are relief, frequency and degree of disturbance of vegetation and soil cover by military equipment. The mosaic structure of ecotypes determines the detailed contour of the vegetation.
The ruderal vegetation are presented of the class *Artemisietea vulgaris* Lohmeyer et al. in Tx. ex von Rochow 1951, mainly by associations - *Agropyretum repentis* Felföldy 1942, *Calamagrostietum epigei* Kostylev in Solomakha et al. 1992 nom. rejic. propos. (art. 31), *Convolvulo arvensis-Agropyretum repentis* Felföldy 1943 etc. Plants communities of *Convolvulo-Brometum inermis* Eliáš 1979 associations are formed in places of significant disturbance of soil cover.
Monodominant plant communities form by *Carduus acanthoides* L., *Descurainia sophia* (L.) Webb ex Prantl in place of explosions of artillery shells.
Plant communities of the class *Festuco-Brometea* Br.-Bl. et Tx. ex Soó 1947 are formed on the territory where military exercises have not been conducted for a long period of time. The vegetation cover is mosaic and represented by the derivative group DC *Festuca valesiaca* + *Koeleria cristata* [*Festucion valesiacae* Klika 1931] and association *Salvio nemorosae-Festucetum valesiacae* Korotchenko et Didukh 1997.
Korotchenko et Didukh 1997. These secondary steppe groups will be formed under the influence of anthropogenic load. Plant communities dominated by *Stipa capillata* L. and *Stipa lessingiana* Trin. & Rupr. are formed on the territory of the military tank range bordering the slopes of the gully system.

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Evaluation of the ecological and topological structure of habitats of the Dniester Canyon (Ukraine)

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Keywords: symphytosociology, topological differentiation of habitats, vegetation

Study area. Dniester Canyon (Ukraine).
Materials and methods. An algorithm for describing and evaluating the ecological and topological structure of habitats of the Dniester Canyon is suggested. As a main unit for these purposes, we used the catena level, which shows the distribution of habitats in the landscape. For the typification of selected territorial units, we used the sigma-syntaxa approach (Rivas-Martínez, 2005). For their identification we used the dataset of 622 relevés of different vegetation types from Dniester Canyon. For the statistical analysis we used R programming language and Past. Ecological evaluation is done using the phytoindication methodology (Didukh 2011).
Results. The habitat diversity of the Dniester Canyon is mainly characterized by forests of the *Carpino-Fagetea sylvaticae* class. The remnants of thermophilic and acidophilic forests of the *Quercetea pubescentis* class are unique to this region. The steppe vegetation of the *Festuco-Brometea* class shows the highest phytosociological diversity. The dominants of such communities are often rare species, such as *Stipa capillata*, *S. pennata*, *S. pulcherrima*, *Sesleria heufleriana*, *Chamaecytisus podolicus*, etc. The chasmophitic vegetation is confined to the outcrops of carbonate outcrops of the canyon and is classified into the classes *Sedo-Scleranthetea*, *Asplenietea trichomanis*, *Verrucarietea nigrescentis*. Floodplain forests and shrubs, forest fringe vegetation, meadows, and aquatic communities have a limited distribution within the canyon. The complexity of the structure of the habitats in the Dniester Canyon is explained primarily by the variety of natural conditions (orographic, geomorphological, geological, edaphic, and climatic).

The ecological and topological structure of the habitats of the Dniester Canyon is presented by 16 sigma-syntaxa: one sigma-class, two sigma-orders, and 12 sigma-associations. The analysis on the level of sigma-syntaxa displays the α, β, γ-diversity of the study region, and shows the integrity of the environmental conditions despite the highly fragmented natural habitat system.

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Alysso-Sedetalia order communities in the Carpathian-Pannonian region, western Ukraine, and Moldova

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Key words: *Alysso-Sedetalia* order, calciphilous vegetation, Carpatho-Pannonian region.

This study aims to revise previous syntaxonomic concepts and provide a unified classification of the *Alysso-Sedetalia* order communities in the Carpatho-Pannonian region, western Ukraine, and Moldova.

We focused on plant communities dominated by annuals, succulents, bryophytes, and lichens. We extracted relevés from EVA (Chytrý et al. 2016) and Ukrainian Grassland Database (Kuzemko 2012). We also selected nomenclatural types of 25 associations described within the *Alysso-Sedetalia* order in the study area.

To obtain a selection of relevés of the target plant communities, we classified the initial dataset of 10211 relevés using an expert system. We conducted the HCR resampling (Lengyel et al. 2011) on the relevés belonging to the *Sedo-Scleranthetea* class and got a dataset of 633 relevés. Then we used the modified TWINSPAN algorithm (Roleček et al. 2009) to obtain 20 clusters. We removed 10 clusters that did not represent the *Alysso-Sedetalia* order.

Ten clusters of *Alysso-Sedetalia* were interpreted at the association level: *Aurinio petraeae-Sedetum hispanici* (3 relevés); *Alyssetum muralis* (3 relevés); *Sempervivetum soboliferi* (11 relevés); *Poo compressae-Saxifragetum tridactylitae* (30 relevés); *Allio montani-Sedetum sexangularis* (14 relevés); *Alysso-Sedetum* (87 relevés); *Aurinio saxatilis-Allietum podolici* (87 relevés); *Saxifrago-Veronicetum praecocis* (65 relevés), *Cerastietum pumili* (45 relevés); and *Erodio cicutarii-Brometum hordeacei* (28 relevés).

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Phytoindicative assessment of the vegetation cover reaction in Ukraine on possible climatic changes

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The study area: Ukraine.
Materials and methods:
The data of more than 3000 relevés were analyzed in the JUICE software. We used the TWINSPAN modified algorithm for cluster analysis of the dataset. Based on the phytoindication methodology, we calculated changes in the point indicators of climatic factors: thermoregime, cryoregime, continentality, ombroregime and edaphic; additionally, we have conducted DCA analysis (Detrended Correspondence Analysis) to assess the impact of environmental factors on plant communities.
Results:
The correlation sequences between environmental factors were determined, which have non-linear features and change depending on the regional characteristics of the four bioclimatic zones of Ukraine.
We established that the indirect effect of changing the characteristics of the leading ecological factors is more important than the direct one and causes cascade processes that cause various fluctuating, successional and synevolutionary changes in the vegetation cover. The nature of these changes depends on the resilience and resistance of the communities, which we assessed by the indicators of Grime's types of ecological strategies. Based on the analysis of about 300 associations of different vegetation classes in Ukraine, we established that the critical limits are increasing the annual temperature from 2 to +2,5 °C, above which more than half of syntaxa fall into the zone of possible risk, 30-40% of syntaxa fall into the area of possible habitat extinction (this zone is characterized by the irreversible changes that are signs of a catastrophic state). Notably, 70 % of 170 rare species listed in the Red Data Book of Ukraine (2009) fall into the zone of condition changes; 30% of rare species fall into the extinction zone, which indicates a severe loss of biodiversity. The situation threatens species and communities in extreme conditions or on the edge of their range without retreating.

Effects of drought-induced holm oak dieback on emissions of biogenic volatile organic compounds in a Mediterranean forest

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Keywords: Biogenic Volatile Organic Compounds (BVOCs), climate change, drought, *Quercus ilex* L. crown defoliation, Mediterranean forests, Vegetation cover and composition

Climate change is impairing tree physiology and growth, causing an increase in tree dieback in many Mediterranean forests. These desiccation phenomena are leading to changes in land cover and plant community composition. Mediterranean plants are capable to emit large amount of Biogenic Volatile Organic Compounds (BVOCs), whose emission and biosynthesis is strongly affected by environmental conditions. This study evaluates the seasonal changes in understory species composition in two forest stands in Southern Tuscany (Maremma Regional Park, Alberese, Grosseto, Italy) characterized by different levels of *Quercus ilex* L. crown defoliation (low and high defoliation, LD and HD) and the relationship with BVOCs emissions over three years. We found significant changes in the understory plant community following *Q. ilex* crown defoliation and mortality, observing an increment in the number of shrubs both in HD and LD stands. The environmental sampling of BVOCs fully reflected the changes in vegetation cover and composition, with a reduction in the amount of monoterpene emissions due to the increasing rates of defoliation and mortality of *Q. ilex* trees. Our results suggest that terpene emissions from Mediterranean forests would be modified by an increase of *Q. ilex* dieback, with important consequences for functioning of this forest ecosystem and its atmospheric chemistry.

Two new phytosociological associations from the summit plateau of Pizzo Carbonara (Madonie Mountains, Northern Sicily)

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Keywords: Classification, Mediterranean Region, Mountaintop vegetation, Phytosociology

Madonie Mountains cover an area of approximately 984 km2 and represent the westernmost portion of the so-called “Sicilian Apennine”, a tectonically complex mountain range located along the northern coast of Sicily. The Madonie Regional Natural Park, established in 1989, represents a hotspot in the framework of Mediterranean plant biodiversity, hosting several endemic species and being a refuge area for several boreal and nemoral species that migrated southwards during the repeated glacial events of the Pleistocene. Most significant scientific contributions on the vegetation of Madonie Mts. were published in the 1970s and 1980s. During summer 2022, we sampled 42 vegetation plots in the oromediterranean calciphilous grasslands colonising the summit plateau of Pizzo Carbonara, above 1900 m a.s.l. Vegetation data from these plots and from phytosociological scientific literature were analysed together, with the aim to classify the grassland communities at the association level. Using Modified TWINSPAN and Non-Metric Multidimensional Scaling (NMDS), we defined seven associations along an altitudinal gradient, from 1200 to 1979 m a.s.l. Five of these associations were already described in the past and are confirmed, while the other two are described as new. The first new association (*Helianthemo tomentosi-Festucetum crassifoliae*) occurs on windy ridges of the highest peaks of Pizzo Carbonara (above 1900 m a.s.l.) and is ascribed to the *Cerastio-Astragalion nebrodensis*, a phytosociological alliance grouping the endemite-rich xeric calcicolous hemicrypto-chaemaephytic oromediterranean vegetation of the Madonie Mountains. The second new association (*Androsaco breistrofferi-Potentilletum calabrae*) occupies the bottom of the sinkholes scattered throughout the summit areas of Pizzo

Carbonara, well above 1800 m a.s.l., and is ascribed to the *Plantaginion cupanii*, an alliance grouping mesophilous hemicryptophytic communities colonising leached or acidic compacted soils. A detailed description of the ecological preferences of both new associations is presented.

New data on vegetation of "Padule di Fucecchio" area, one of the largest inland marsh in Italy

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Keywords: Wetlands, Vegetation, Syntaxonomy, Conservation, Tuscany

The "Padule di Fucecchio" area is one of the largest inland marsh in Italy. About 2,000 hectares wide, it spreads in central Tuscany between the provinces of Florence and Pistoia. It is one of the wetlands of international importance listed in the Ramsar Convention and hosts several protected natural areas of European and local interest, due to the naturalistic richness and the peculiarities of its hydrogeology and landscape. The studies on its flora, even if rather dated, are numerous and several specimens are deposited in the Tuscan herbariums (Garbari 1980; Tomei et al. 2001). On the contrary, surprisingly, studies on plant communities are very scarce and out of date. For these reasons, a vegetation survey concerning aquatic and marshy vegetation has been carried out in the last two years. As it could be predicted, the preliminary data analysis show that a large part of the aquatic and marsh plants of relevant conservation value have disappeared or have greatly reduced their diffusion, in favor of alien species, which have also become an important or predominant part in plant communities. Nevertheless, several vegetation types with high naturalness have been detected and reported in the area for the first time, such as for example *Schoenoplectetum lacustris, Caricetum ripariae, Phalaridetum arundinaceae*. In addition, several communities dominated by species of the genus *Bolboschoenus* have been detected and are being defined through comparison with international data (Hroudová et al. 2009). Particular communities of ephemeral environments dominated by native and alien species (e.g., *Cyperus* sp.pl., *Amaranthus blitum, Lindernia dubia*) have been widely detected in the study area and their syntaxonomic definition is underway.

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Impact of holm oak dieback on alpha diversity in a Mediterranean forest

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Keywords: holm oak forest, drought-induced dieback, alpha diversity, canopy cover, Ellenberg index

The impact of holm oak dieback on understory vegetation composition was investigated in the Maremma Park (Tuscany, IT). Seasonal inventories of shrub and herbaceous species were conducted from summer 2019 to summer 2022 on two stands of an area of about 600 m^2, characterized by different degrees of holm oak crown defoliation (high and low defoliated, HD and LD). Species richness, Shannon-Wiener and Pielou indices (alpha diversity) were calculated. Species inventories were also used to assess the biological spectrum and estimate habitat explanatory factors using Ellenberg's indicator values (EV).

We hypothesized that the reduction in canopy cover of holm oak trees would result in loss of alpha diversity. Canopy cover was halved from summer 2019 to summer 2022 in both areas, and the higher light availability due to canopy gap resulted in an increase in species richness for both stands in 2021. However, in 2022, species richness decreased in both areas, probably because of the large amount of dead holm oak wood on the ground.

During the study, the Shannon-Wiener and Pielou indices did not significantly change between the stands; however, the LD stand maintained a higher variety of life forms than the HD stand (phanerophytes, hemicryptophytes, and therophytes). High temperature and light EV values suggested that both HD and LD areas are suited for species preferring warm conditions and high light intensity. Further, EV highlighted a certain anthropic disturbance of the HD stand, which counted more nitrophilous species than the LD stand. These results may be due to the presence of some medicinal herbaceous plants (e.g., *Atropa belladonna* L., and *Datura*

stramonium L.) introduced by humans in the Middle Ages, whose diffusion may have recently been favoured by the holm oak decline. In conclusion, although no reduction in alpha diversity has been observed during the study period, holm oak dieback has altered species composition in the understory vegetation.

Monitoring holm oak forest dieback combining tree physiological and visual assessment data with remote sensing

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Keywords: Holm oak, remote sensing, chlorophyll fluorescence, crown visual assessment, dieback.

In the context of climate change, drought and heatwaves affect Mediterranean ecosystems by deteriorating tree health, leading to species die-off, with consequences for biodiversity and ecosystem functioning. Therefore, it is crucial to identify effective tools for monitoring forest dieback after extreme climatic events. We monitored changes in tree health status induced by severe drought in a holm oak forest located in Southern Tuscany by integrating field measurements and Sentinel 2 data over two years (2020-2021).

We analysed the relationships between field-assessed crown defoliation and satellite-derived Normalized Difference Vegetation and Water Indices (NDVI and NDWI) in six holm oak forest plots characterized by different degrees of defoliation and tree mortality. In addition, chlorophyll fluorescence and the DUALEX® chlorophyll index were monitored in two of these plots showing contrasting degrees of defoliation. The relationships between physiological indicators of plant stress and remote sensing indices were evaluated.

A strong relationship was observed between NDVI and NDWI indices and crown visual assessment for the plot characterized by the highest holm oak mortality rate. Although the high spatial resolution of Sentinel 2 (10 m) allowed for the detection of general vegetation decline after the extreme summer drought of 2017, these indices were ineffective for the detailed analysis of forest stands characterized by a patchy dieback. Positive correlations among NDVI, NDWI and physiological parameters were observed in plots with lower defoliation in all seasons.

In conclusion, Sentinel-2 satellite indices are efficient tools for monitoring holm oak forest status only when tree health conditions are severely and homogeneously impaired. Our study highlights the importance of multiscale analyses that integrate *in situ* physiological measurements and satellite data to effectively monitor holm oak forest health status and responses to extreme climatic events.

Shading vs. biomass production: maintaining scattered trees in temperate pastures brings more benefits than losses

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Keywords: Agroforestry system, Biomass, Carbon sequestration, Ecosystem service, Grazing, Herbage nutritive value, Tree-grass interaction

In open ecosystems, such as pastures, scattered trees create environmental heterogeneity, resulting in a variety of microhabitats and increasing biodiversity. Scattered trees also play an essential role in carbon sequestration, and enhance the well-being of grazing livestock as well by providing shade during the hottest period of the year. However, trees of European wood-pastures are in jeopardy as some potential disservices can also be linked to them, which leads to an unfavorable valuation of trees. Furthermore, the current legal environment is inadequate to secure their existence. In this study, instead of the well-documented ecosystem services, we aimed to document and quantify the potential negative effects of trees. We used a grazing-exclusion experiment to assess the effect of scattered trees on herbage production in wood-pastures from semi-arid continental to humid montane areas in the temperate deciduous forest ecoregion. We found that trees have a suppressive effect throughout the year, although herbage nutritive value, as indicated by herbage nitrogen content, seems to be improved in spring. We upscaled the locally detected negative effect on herbage yield to entire wood-pastures, and we found that the loss remained below 3%, which can be amply compensated by the gains in livestock production due to advanced access to shade. Although scattered trees

undoubtedly suppress herbage production in wood pastures, this cost is overridden by their beneficial effects, thus the negative attitude of land managers and decision makers towards trees may be based on mistaken observations. Our results proved that traditionally low tree cover proportions do not comprise current land use, therefore, protecting old scattered trees and establishing young ones is highly recommended.

Acknowledgements: This research was supported by the National Research Development and Innovation Office of Hungary (grant numbers: PD 132131, FK 134384, FK 142428, PD 137632, KKP144068, K 137573). The authors are also grateful for the support of the Bolyai János Research Scholarship and the New National Excellence Program of the Ministry for Culture and Innovation from the source of the National Research, Development and Innovation Fund (AAH: ÚNKP-22–3-SZTE-405, KF: ÚNKP-22–3-SZTE-402, ZB: ÚNKP-22–5-SZTE-538).

Rare steppe plant communities of Ukraine

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Key words: rare plant communities, classification, steppe.

In 1987, for the first time in the Ukrainian conservation activity, the idea of protecting rare plant communities identified by the dominant approach was implemented. All theoretical principles of this concept were presented in the Green Data Book of Ukraine (2009). In Ukraine, the flat steppe areas, except those located in nature reserves, have been plowed up. Therefore, it is concentrated by small-scale patches along the slopes of river valleys, ravines, and gullies. Rare steppe plant communities are represented by 37 associations of the classes Festuco-Brometea, Festucetea vaginatae, Sedo-Scleranthetea, Festuco-Puccinellietea, Rhamno-Prunetea, Drypidetea spinosae, Erico-Pinetea. The rarest communities belong to associations Asphodelino-Juniperetum foetidissimae, Bromopsio tauricae-Asphodelinetum tauricae, Genisto albidae-Stipetum lithophilae, Minuartio auctae-Festucetum pallentis, Paronychio cephalotae-Onosmatetum polyphyllae, Poetum versicoloris, Ranunculo zapalowiczi-Helictotrichonetum desertori, Stipo brauneri-Bromopsietum cappadocicae. Currently, most of them are in the area of hostilities or under occupation. In this regard, new successions are predicted, which will lead to high uncertainty of processes, the likelihood of new unexpected changes in ecosystems, expansion of both native and invasive species, changes in dominant species, and the appearance of a significant number of transformed plant communities.

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Syntaxonomy of plant communities dominated by *Elaeagnus angustifolia* in Ukraine

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Elaeagnus angustifolia is one of the highly invasive woody species that is actively spreading in Ukraine nowadays and has a high ability to form plant communities. We aimed to make phytosociological classification of *E. angustifolia*-dominated stands in Ukraine and compare their synecological characteristics. We collected 245 phytosociological vegetation plots, analyzed them and identified four associations and one community due to their floristic differences and environmental conditions. Association ***Lactuco tataricae-Elaeagnetum angustifoliae*** represents halophylous stands on the flat areas with turf-meadow or sandy soils and inhabits previously covered areas by salt meadows or salt steppe grasslands in the Black Sea and Azov Sea regions. Association ***Plantago arenariae-Elaeagnetum angustifoliae*** is known only across Lower Dnipro Arenas and occurs in the lowland areas between dunes on sandy soils. ***Balloto nigrae-Elaeagnetum angustifoliae*** unites species-rich mesophylous stands with a higher ratio of nitrophylous plants, which tend to riparian zones with turf-meadow or loamy soils in the steppe zone of Ukraine. ***Leymo sabulosi-Elaeagnetum angustifoliae*** represents species-poor stands that are located on spits of sandy or sandy-pebbly seacoasts across the Azov Sea coast. *E. angustifolia* stands with the dominance of *Elytrigia repens* in the herb layer we identified as ***Elytrigia repens-Elaeagnus angustifolia*** community. This vegetation occupies meadow solonchaks and is characterized by a high proportion of graminoids and ruderal plants resulting from grazing overpressure.
The current spread of *E. angustifolia*-dominated vegetation in Ukraine is related to anthropogenic pressure. At the landscape level, *E. angustifolia* is actively naturalizing in different habitat types, from river floodplains and sand steppes to halophytic and coastal grasslands.

New phytosociological findings in southern France

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Keywords: Natura 2000, coastal vegetation, *Limonio virgati-Plantaginetum crassifoliae, Nerio oleandri-Tamaricetea africanae*

Knowledge of vegetations and their fine scale mapping are essential for Natura 2000 implementation. We studied three Natura 2000 coastal sites, located in the Gulf of Lion (southern France) in order to have a complete view of the vegetation occurring in these sites and to see if it corresponds to habitats of community interest. As habitats of community interest identification relies heavily on phytosociological identification, we carried out many field relevés according to the Braun-Blanquet method. We analysed these relevés jointly with data from SIMETHIS-Flore-CBNMed database (EU-FR-006). It appears that a large majority of the vegetation units were already known in the surroundings, but some relevés seem to be more interesting. We discovered new sites for the *Limonio virgati-Plantaginetum crassifoliae* Gesti & Vilar ex Mercadal 2022, extending its known distribution range. Two groups of relevés do not match anything known and should probably be described as two new associations. Finally, relevés of thickets dominated by *Tamarix gallica* L. raise some questions on how they should be classified: they are traditionally assigned to *Nerio oleandri-Tamaricetea africanae* Braun-Blanq. & Bolòs 1958 class but they don't fit in well. We can see that while southern France is the cradle of sigmatist phytosociology, many vegetations are still to be discovered and many questions stay unanswered.

Acknowledgements: This research was supported by the French Ministry of Ecological Transition

Subalpine tall-herb vegetation (class *Mulgedio-Aconitetea*) in Bulgaria

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Keywords: Alpine, Balkans, Phytosociology, Subalpine, Syntaxonomy, Vegetation classification

Bulgaria contains diverse and geographically separate mountain areas. The Stara Planina Mts. are directly linked to the Carpathians, whereas other mountains, such as Rila and Pirin, are more connected to the southern Balkan. This contributes to the regionally rich vegetation of the class *Mulgedio-Aconitetea*. This class is poorly studied in the Balkans, and the previous classification of the diversity of the *Mulgedio-Aconitetea* in Bulgaria (Tzonev et al. 2009) containing only two alliances, *Cirsion appendiculati* (order *Adenostyletalia alliariae*) and *Rumicion alpini* (order *Senecioni rupestris-Rumicetalia alpini*), seems incomplete.

We have compiled ~350 vegetation plots, which derive from our field sampling or are part of the Bulgarian vegetation database (EU-BG-001). The compiled data cover all the main mountain ranges. Our concept of the *Mulgedio-Aconitetea* follows Mucina et al. (2016) and excludes *Betulo carpaticae-Alnetea viridis*. Our goal is to (1) classify the vegetation types of the class *Mulgedio-Aconitetea* in Bulgaria to the level of association and to (2) identify the gaps in available data.

Some vegetation types, such as *Rumicion alpini* (ord. *Senecioni rupestris-Rumicetalia alpini*), are widespread, while others, such as *Adenostylion alliariae* (ord. *Adenostyletalia alliariae*) and *Calamagrostion villosae* (ord. *Calamagrostietalia villosae*) are rare and show certain geographical patterns.

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Raised bog vegetation response to the change of site hydrology

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Keywords: peatlands, raised bogs, vegetation change

Intact raised bog vegetation diversity is provided by the site micro-topography - hummocks, hollows, lawns and pools. Plant communities from the *Oxycocco-Sphagnetea* class occupy hummocks that are permanently above water level, while hollows and pools that have waterlogged conditions are assigned to *Scheuzerio palustris-Caricetea nigrae* class. Due to drainage, the characteristic raised bog vegetation changes, as a result the typical intact mire species are replaced by the indicators to degradation. The species gradient from relatively dry hummocks through the flat lawns close to the water level to waterlogged hollows and pools is lost. Raised bog vegetation shift was studied in Sudas-Zviedru Mire in Latvia. The aim of the study was to follow vegetation response after restoration activities. Changes in the vascular plant and bryophyte cover and site hydrology, resulting in water level raise in drainage-influenced areas of peatlands were analysed in permanent vegetation plots and include daily water level data. Vegetation plots were established in 2015 within the LIFE Wetlands project and continued within LIFE PeatCarbon project in 2022. Vegetation studies show that restoration results in the succession of plant communities towards the targeted raised bog vegetation of wetter conditions. This was evident from the decreased abundance of species benefiting from drainage and the corresponding increase of species characteristic for wetter habitats. As there was a distinct rise of the water level, also the vegetation recovery was immediate followed by re-appearance of *Sphagnum cuspidatum* in the hollows, accompanied by other bog species. Most important is the development of *Sphagnum* communities as they play a crucial role in raised bog carbon accumulation. After the rise of the water level because of peatland restoration activities there is a trend of natural bog vegetation establishment.

Mapping habitats in Nature 2000 sites through photointerpretation of images from drones and field surveys

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Keywords: drones, habitat mapping, Nature 2000, photointerpretation, UAVs

So far, vegetation monitoring has been conducted mainly in the field, with time-consuming methods and logistical difficulties. But recently, however, remote sensing is becoming a suitable source of data for vegetation classification with satellite and aerial photointerpretation as most common approaches.

These approaches can though produce errors when applied to heterogeneous vegetation on small scales and when pixel size is not small enough to avoid combination of different vegetation.

Unmanned aerial vehicles (UAV), which can reach high resolution with pixel size of a few centimetres, represent a solution to monitor vegetation dynamics, partially replacing field work, reducing costs and acquiring images with high temporal resolution. However, few studies have used UAV images to classify vegetation.

Through UAV images photointerpretation and comparison with field surveys we updated habitat cartography of 5 Nature 2000 sites in Aosta Valley. The aim was to define and test a protocol for UAV images detection considering the vegetation phenology to guarantee t3he acquisition of the best images. The design and classification of polygons were done verifying phytocenosis, the main species that make up the layers and phenological trends through field surveys. Old and updated maps were compared to quantify the increased information details obtained from high-resolution images and the validity of the method.

Results show a resolution increase in the habitat cartography, the correct definition of best conditions and times of the year for image acquisition, and the need of field verifying of real vegetation conditions for its correct classification.

Acknowledgements: this research was supported as part of project COBIODIV, financed by the ALCOTRA 2014/2020 (FESR) Italy-France trans frontiers cooperation program.

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Forest diversity of the Cantabrian Mixed Forests ecoregion: EUNIS types and related phytosociological units

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Keywords: Forests, Cantabrian Mixed Forests, Vegetation classification, EUNIS, European habitats, temperate deciduous forests, broadleaved evergreen forests, coniferous forests

The Cantabrian Mixed Forests ecoregion, located in the northern Iberian Peninsula, displays a great diversity of forest communities due to several drivers such as high climatic heterogeneity and the existence of glacial refugia, both enhanced by a complex topography. The ecoregion is dominated by broadleaved deciduous forests ranging from warm-temperate to boreal-like typologies, with the co-existence or even the local dominance of broadleaved evergreen forests or coniferous forests. The aim of this study is to synthesise the diversity of forests occurring in the ecoregion, applying to them the EUNIS classification. We used the EUNIS expert system to differentiate broadleaved deciduous, broadleaved evergreen and coniferous evergreen forests from vegetation relevés stored in SIVIM. We then followed a semi-supervised approach based on TWINSPAN and the k-means algorithm to select the optimal number of groups in agreement with regional knowledge. We obtained 22 different types of forests: 12 broadleaved deciduous, 6 broadleaved evergreen and 4 evergreen coniferous. Our forest types contrasted with classical phytosociological classification, which was unequally matched to the different forests, some of them related to more than 10 associations while others were related to no one. Regarding floristic composition, NMDS showed a clear differentiation between broadleaved deciduous and evergreen forests, while coniferous forests displayed a more scattered pattern. However, all of them were found to be highly diverse, with some of them hosting more than 30 species on an average relevé. Overall, the Cantabrian Mixed Forests represent around 40% of the forest types occurring in the Iberian Peninsula and the Balearic Islands, highlighting the great forest diversity of this ecoregion.

Acknowledgements: This research was supported by the Severo Ochoa PhD program of the Principality of Asturias.

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Ruderal communities *Calamagrostis epigejos* in Ukraine

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Keywords: ruderal vegetation, Artemisietea vulgaris, ecological differentiation

Ruderal communities with *Calamagrostis epigejos* are listed within the association *Rubo caesii-Calamagrostietum epigeji* COSTE 1985. However, in the territory of Ukraine, communities with the participation of C. epigejos were described in different ecological conditions and species composition. They are characterized as tall plants, coenoses of dry and wet areas, dominated by *Calamagrostis epigejos*, *Convolvulus arvensis, Elytrigia repens, Melandrium album, Achillea submillefolium, Poa angustifoli, Rubus caesius*.

This allows us to classify them as a class of thermophilic ruderal vegetation. The analysis of *C. epigejos* communities (63 relevés) from different habitats showed a significant differentiation of three groups. The first of them is dominated by nitrophilous and mesophytic species: *Urtica dioica, Aristolochia clematitis, Poa pratensis, Galium aparine, Anthriscus sylvestris, Alopecurus pratensis*. The second cluster is dominated by xerophytic species: *Erigeron canadensis, Artemisia dniproica, Agrostis gigantea, Berteroa incana, Potentilla argentea, Viola arvensis, Veronica spicata, Carex hirta*. The third cluster is characterized by xeromesophytes *Artemisia vulgaris, Daucus carota, Hypericum perforatum, Cichorium intybus, Dactylis glomerata*. Analysis of the studied communities *Aristolochia clematitis* + *Urtica dioica*, *Artemisia dniproica* + *Erigeron canadensis*, *Artemisia vulgaris* + *Daucus carota* and comparison with other syntaxons of the class showed their clear differentiation, which allows them to be separated into an alliance *Rubo caesii-Calamagrostion epigeji* Dengler et al., 2003.

These communities are spread over the entire territory of Ukraine, mainly in the northern and central parts. They form as a continuum on the edges of forests, in the coastal zone of rivers and reservoirs, in the lower part of beams, along roads.

Methodological approaches to assessing military damage to natural habitats in Ukraine

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Military operations as a result of the military aggression of the Russian Federation in Ukraine have led to large-scale direct and indirect losses of Ukrainian ecosystems. Damage assessment is based on the characteristics of the type and extent of damage, stability (resistance) and vulnerability (restoration rate) of different habitat types. The proposed approach to damage assessment includes several steps. The first step is to compile a list of damaged habitat types, their areas and damage classification. The second step includes collecting, recording and documenting relevant information, which involves assessing the extent (size, structure and valuable components) of losses, the possibility, degree and time of their restoration to a certain stable state, the need for additional restoration measures, the possibility of indirect negative phenomena, etc. to minimize negative consequences. At this stage, remote sensing methods come to the fore, and in some cases, methods of field interpretation and data verification when they can be used without direct risk to the researcher's safety. The last step includes analyzing the information obtained at the previous stage and converting it into quantitative (scoring) units. According to the degree of habitat damage, five categories are distinguished: A - cannot be restored and require recultivation (80% of points); B - require special measures for restoration (60-79%); C - natural recovery is possible with control or adjustment of regulatory processes (30-59%); D - damage is minor, the ecosystem is capable of self-restoration within a certain time (0-39%); E - damage is local (fragmentary), the structure and functioning are maintained and will be restored within a short time. The developed methodology will be used to quantify losses in monetary terms for the purpose of compensation.

The main drivers of changes in natural, rocky plant communities

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Keywords: climate change, eutrophication, Central Europe, Ellenberg Indicator Values for Europe

Changes caused by global warming and atmospheric nitrogen deposition are observed in forest, grassland and alpine ecosystems worldwide. Still scarcely little is known about the impact of these global phenomena on the natural rocky plant communities.
We used 214 pairs of replots (collected between 1989 and 2022) of rocky plant communities stored in the VESTA database (Świerkosz, Reczyńska 2022). The changes in the species composition, basic plant traits and environmental conditions expressed by Ellenberg Indicator Values for Europe - EIVEs (for nutrients, temperature and moisture) (Dengler J. et al. 2023) were analyzed using ordination techniques and generalized additive models (GAM). We assumed that the longer time span between the surveys the more pronounced changes in compositional and functional structure as well as environmental conditions of rocky communities.
The results of the analyses revealed that species composition of studied communities has not changed significantly over the last 30 years. The changes in environmental conditions calculated as the difference in the EIVEs values at each site between the resurvey and baseline survey did not show such strongly significant relationships with the time span that we expected. Time span between surveys significantly influenced only on changes in EIVEs for temperature (ΔTemp) on neutral and ultrabasic substrates and moisture (ΔMoist) on acidic bedrock. Much more significant impact on changes in nutrients (ΔNutr), moisture and temperature had change in light availability (ΔLight) - ΔNutr and ΔMoist decreased significantly with light availability regardless of the type of bedrock, whereas ΔTemp showed a converse trend but only on neutral and ultrabasic rocks. It also appears that the lower baseline values of EIVEs the greater their change. This suggests that for example the eutrophication or thermophilization effect is stronger in habitats with a lower share of nitrophilic or thermophilous species, respectively, during the baseline survey. Similarly, variation in plant traits (specific leaf area - SLA, leaf dry

matter content - LDMC and seed mass - SM) was mainly influenced by change in light availability and bedrock type.

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Alien plants of Europe: an overview of available national and regional inventories

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Keywords: Alien species, Database, Europe, Residence time status, Invasion status, Vascular plants

The detailed knowledge of the alien species pool in Europe including residence time and invasion status of introduced plants is crucial for macroecological research of plant invasions. The development of inventories of alien floras in many European countries started in the 1990s based on the collation and expert evaluation of available floristic records. Subsequently, continental-scale databases containing regional data on alien plants were developed, such as DAISIE, GloNAF and Euro+Med PlantBase. However,

there are still gaps and inconsistencies among existing databases in terms of revision, completeness, taxonomy, data quality and consistency of species categorizations.

We compiled 111 recently published articles and online national or regional alien plant inventories for 56 European territories (countries or large islands and archipelagos with distinct history and biogeography). We unified species nomenclature, residence and invasion status categories and other information provided, using a standardised methodological approach. The highest numbers of aliens were reported from Belgium (2289 species), Norway (1750), United Kingdom (1713) and the Czech Republic (1561). The full categorization of invasion status was available only for 24 (43.6%) European territories.

In total, we identified 7208 alien plant species of which 553 were hybrids and cultivars. According to their residence time, 93 plant species were assessed exclusively as archaeophytes in all countries where reported, 565 as archaeophytes and neophytes in different parts of Europe, 3919 species were exclusively neophytes, and 2588 species received undefined alien status. We identified 2436 alien species with casual status, 2414 that were classified as naturalized and 1045 species that reached the invasive status in at least one of the European territories. Country-based species status data obtained from the published checklists will become part of the recently developed FloraVeg.EU online database.

Acknowledgements: This research was supported by the Czech Science Foundation (EXPRO grant no. 19-28491X). JCS considers this work a contribution to Center for Ecological Dynamics in a Novel Biosphere (ECONOVO), funded by Danish National Research Foundation (grant DNRF173) and his VILLUM Investigator project “Biodiversity Dynamics in a Changing World”, funded by VILLUM FONDEN (grant 16549).

Vegetation as tool to improve grassland management in protected areas

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Keywords: grassland management, biodiversity, sheep pastures

Nowadays substantial decrease in grasslands in Europe is observed, and majority of semi-natural grassland habitats are protected in Natura 2000 network. Unfortunately, the existing systems of protected areas and ecological corridors are not suited for grasslands protection, but focused on forest ecosystems (Szymura and Szymura 2019). It caused further degradation of grasslands due to intensification of cultivation or abandonment. It is urgent need to establish the methods of grassland value assessment, and protocol of management ensuring biodiversity preserving, at least in protected areas. Extensive pasturage of animals is in a line with the principles of sustainable development, but its new rules should be developed taking into account the climate and economic changes.

The aim of the study was to create methodology of analysis and establishment of protocol which guarantee determining of optimal grassland management in protected areas, like National Parks in changing climatic and socio-economic conditions.

A vegetation analysis was the basis for the model, and sampling plots were established on the basis of digital elevation model (DEM), topographic wetness index (TWI), and diurnal anisotropic heating index (DAH). The study was conducted in Stołowe Mountains National Park, located in SW Poland. In this protected area forest vegetation dominate, mostly coniferous, whereas grasslands cover only 8%, and have a form of islands in forest landscape. The most of the studied grasslands were used as arable lands before II WW (Szymura et al. 2016), and after cessation of cultivation the grasslands vegetation spontaneously developed. According to National park management plans the grasslands were mowed once per year, in July. Nowadays the extensive sheep pasture management has been introduced. Based on the created methodology and protocol of management the plan of pasturing in accordance to suitable development, and nature protection was developed.

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Monitoring and evaluation of Malta's coastal wetlands in a global change context: a case study using a multimethod approach

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Keywords: Drone monitoring, Habitat Directive, Halophilous vegetation, Landscape changes, Natura 2000, Phytosociology, Salt marsh, Vascular flora

Mediterranean coastal wetlands are important ecosystems that provide a variety of ecological services such as coastal protection, habitat for fish and bird species, and carbon sequestration (Tomaselli et al. 2022). As regards the Maltese Islands' saline, these wetlands are sparsely spread along the shoreline and are frequently affected by anthropogenic influences. Consequently, the Maltese Islands lack pristine saline marshlands (Henwood 2006; Lanfranco et al. 2009) and the most extant have been artificially engineered. One such wetland is il-Magħluq ta' Marsaxlokk, which forms part of the Natura 2000 site, il-Ballut ta' Marsaxlokk.

This is a case study to investigate the plant species cover and diversity of il-Ballut ta' Marsaxlokk, which aims to contribute to the knowledge on participatory management in protected areas. Despite its high ecological importance, this site has been subjected to several stresses including habitat loss due to sea erosion. In order to evaluate the plant biodiversity of the wetland, a multimethod approach investigation was carried out. Photointerpretation and on-site surveys were used to identify habitats, which were then classified in accordance with CORINE Biotopes, Directive 92/43/EEC, and EUNIS codes. In addition, phytosociological relevés retrieved from literature and unpublished data were processed. The diversity was quantified through three indices: species richness, Shannon's diversity index, and Simpson's diversity index. Our preliminary results suggest

that over time there has been a reduction of the halophilous plant communities. With several threats such as climate change and human activities, frequent monitoring of wetlands like this one will be increasingly important for long-term conservation in accordance with the objectives of the Habitats Directive.

Acknowledgements: The authors would like to thank the Environment & Resources Authority (2023) for drone images of Il-Ballut ta' Marsaxlokk.

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Vegetation mapping of Mt. Etna (Sicily)

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Keywords: Climate change, Diachronic analysis, GIS, Phytosociology, Habitat conservation

Vegetation mapping represents an important and useful tool for implementing sustainable development policies and in the decision-making process regarding the management of protected areas. The study area is Mount Etna (Sicily), the highest (3,357m a.s.l.) active volcano in Europe. This huge polygenic basaltic volcano represents for some species and plant communities the southernmost geographical range, which appears to be more affected by climate change. Besides several field activities, all literature data concerning the vegetation map of Mt. Etna were considered (Hoffman et al. 1960; Pirola et al. 1960; Poli 1965; Poli et al. 1983; 2000; Brullo et al. 2001, 2005). Main aim of our research is to update the vegetation map of Mt. Etna through an expert evaluation approach. Based on satellite photo interpretation, the vegetation polygons were defined by means of GIS software. The resulting map was validated by several field surveys, performed with the phytosociological method, in order to analyse structure, floristic composition, serial and catenal contacts and distribution patterns. This ongoing study allowed us: to perform an in-depth update of the vegetation map, to quantify the Habitats Directive coverage, to identify the areas deserving plant conservation priority, and to evaluate the effects of climate change on the *Betula etnensis*-populations over the last 80 years.

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Database of floodplain forest and shrub vegetation of Ukraine

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Keywords: database, floodplain, Ukraine

Floodplain forests and scrublands are communities conditioned by strong impact of water. Inside this group, communities are developed depending on factors such as type of flooding, water table level, substrate ability to retain water etc. These factors are changing along short gradients, which make the classification of this type of vegetation challenging.
The database currently includes 4400 vegetation plots representing 4 classes - *Alnetea glutinosae, Salicetea purpureae, Alno glutinosae-Populetea albae, Franguletea*. 59% of plots (2590) have been sampled during field seasons since 2014 and contain accurate geographical coordinates and data on sampling sites. We also digitalized relevés from the literature sampled from 1997 and included unpublished plots contributed by different authors (totally 54 contributors). All digitalized relevés have been georeferenced with precision and contain all information presented in the original sources (locality, country, relevé area, total/tree/shrub/herb cover, bedrock, reference, etc).
About 25% of plots represent *Alnetea glutinosae* class, 30% – plant communities of *Alno glutinosae-Populetea albae* class. The *Salicetea purpureae* class represents about 35% of all data, Franguletea - 10 %. The plot sizes vary in very wide ranges – from 1 to 150 м^2.
The main aims of this database are to compile vegetation-plot data from all over Ukraine to conduct a large-scale phytosociological synthesis, ecological studies to provide and implement conservation strategy of floodplain forests. It will enable us to find out the patterns of territorial distribution of these vegetation and habitat types, to identify the leading factors of their ecological differentiation, to give a sozological evaluation, as well as to observe the vegetation dynamics trends in space and time, especially in conditions of human impact growth. The database will be registered in the Global Index of Vegetation-Plot Databases (GIVD) and European Vegetation Archive.

Changes in functional plant groups as a cause of natural ecological restoration on burned Mediterranean abandoned field

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Keywords: functional ecology, induced fire, therophytes

Several research papers emphasize that both species composition and land cover in Mediterranean ecosystems generally recover rapidly after fire. Mediterranean species have ecological strategies for the post-fire period, such as the ability to resprout, seed bank persistence, or the ability to grow or disperse.
Here an abandoned agricultural field (AAF) near Biograd na moru (Croatia) was burned by an induced fire. Fifteen rings (diameter 0.2 m^2) were established, five for each variant: I. unburned (UB), II. medium intensity (MB) and III. high intensity (HB), and observed within 12 months. The results showed that the functional group (FG) of grasses dominated in the variant MB, in contrast to the dominance of legumes in the variant HB. Compared to AAF, the number of forbs FG slightly decreased in both burn variants (MB, HB). The dominant strategy was competitors (C), followed by ruderal plants (R), whose numbers increased slightly after burning in the MB and HB variants, while stress tolerants decreased significantly in both variants. The total cover of renewed vegetation was higher on HB than on MB.
These preliminary results indicate that the intensity of HB does not promote grass survival in the first year after fire, while legumes and forbs are more resistant to higher fire intensity and therefore have a higher chance of survival.

Acknowledgements: This research was supported by the Croatian science foundation under the project “Influence of Summer Fire on Soil and Water Quality” (IP-2018-01-1645).

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Initial results for a long-term grassland management experiment in the Botanical Garden of the University of Latvia

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Keywords: Grassland management; Mowing experiment

The loss of natural or semi-natural grasslands in Latvia, similar to the trends throughout Europe, has been observed in recent decades. Mostly it is a result of land use change – intensification of agriculture, succession of grasslands to bushes and forests, cessation of regular mowing or grazing. Today, of all habitat types of the European Union importance, which occupy about 10% of the entire country, only 1% belongs to grasslands. Of these, the dominant area is taken by Fennoscandian lowland species-rich dry to mesic grasslands and Northern boreal alluvial meadows.

In order to restore grasslands and species associated with these habitats, different management projects have been implemented in Latvia. In one of them, a 7-year activity was started in the Botanical Garden of the University of Latvia. It aims to restore the grassland in former orchard. Six regimes will be tested in 30 experimental plots, combining different mowing intensities, removal of the sod layer and application of grassland-related seed material. Repeated monitoring of vascular plant and bryophyte species showed that, compared to the control plot, any management activity has a positive effect on species diversity. From a total of 32 species in regularly mowed lawns, the number has doubled to 74 species in maintained plots. Pairwise Manova test, Shannon diversity index, indicator species analysis and Decorana ordination were used to compare the effects of different techniques on species composition. The results confirm that annual mowing, collecting of mowed material, planting of grassland-related species seeds combined with removal of dense graminoid sod improves lawn quality already two years after management. Although only half of 20 species sown survived to the second year of experiment, the project's activities show promising results. In addition, the role of botanic gardens in supporting miniature habitats has been proven.

Acknowledgements: This research was supported by the European Comission LIFE LatViaNature LIFE19 IPE/LV/000010.

Ecological characterization of forest site types (FST) in Slovenia

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Keywords: Forest site types, vegetation, ecology, phytoindication, Slovenian forestry

Forest sites are an essential basis for forest management in Slovenia. In forest management, their characteristics are assessed on the basis of the forest plant communities found there. For forest management purposes in Slovenia, forest sites have recently been defined by forest site types (FST), which include floristically and ecologically similar forest communities and can therefore be treated similarly in silvicultural terms. The typology is now a widely accepted system for naming forest communities and forest sites in Slovenian forestry. In sustainable forest management, knowledge about forest sites and their ecological characteristics is particularly important as this type of forest management attempts to adapt as much as possible to the natural characteristics of the forest sites and to the natural species and structural composition of forest stands, as well as to the natural development patterns of forest stands. The growth of forest trees and forest stands depends on forest sites, which include all the growth factors of a particular area, so it is obvious that forest sites are also an important framework for forest growth studies.

In recent study, we provide a synthetic overview of ecological conditions in the FSTs of Slovenia based on an extensive database of phytocenological inventories. Data on elevation and terrain characteristics were taken directly from the phytocenological relevés, while other ecological conditions were assessed indirectly using Ellenberg phytoindication values of the recorded plant species. We also analysed the species diversity of each FST. Ecological conditions of FSTs were represented and compared using ecograms, and floristic similarity of FSTs was determined using detrended correspondence analysis (DCA). In the ordination space of the DCA analysis the realised ecological niches of the woody species of the forest vegetation layer in Slovenian forests were also presented.

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The importance of soil pH maps for the accuracy of the plant distribution models: insights from two spatial scales

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Keywords: LUCAS, MaxEnt, Random Forest, rock alkalinity map, SoilGrids250m, soil pH, species distribution models, vascular plants

Soil pH is a crucial factor that affects the distribution of plant species, particularly at a fine scale. However, it is frequently overlooked in species distribution models. The aim of this study is to investigate the effects of topsoil pH and rock alkalinity maps on the accuracy of distribution models for vascular plant species at continental and regional scales (Europe and the Czech Republic).
The plant species were selected to represent different site preferences along the soil pH gradient, using their Ellenberg indicator values for reaction. We modelled species distribution across continental and regional scale with the MaxEnt algorithm, and further with the Random Forest algorithm at regional scale. The change in predictive power of the model was evaluated by comparing the model calibrated using only climatic variables from the CHELSA database with the model that also included soil pH 1, from LUCAS and 2, SoilGrids250m.
Soil pH was found to be one of the most significant predictors for the distribution of vascular plants at the regional scale, while climate was the primary factor controlling the distribution of plants at the continental level. However, even at the continental scale, soil pH was more important for plants in areas with homogeneous climatic conditions.
While inclusion of soil pH improved the predictive power of the models for most acidophytes, basiphytes and neutrophytes, we found different pattern for generalists. For this group, the climate-only models were more accurate, particularly at the continental scale.
The models with rock alkalinity achieved better predictive power than the climate-only models, but they were inferior to the soil pH models. The differences in accuracy between the individual types of models varied depending on the modelling method used, with Random Forest models showing better predictive performance (tested only at regional scale).

Gradual long-term degradation of vegetation in a suburban forest

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Keywords: Re-survey study, Invasive species, Biodiversity loss, Vegetation changes, Soil acidification, Soil sorption capacity decrease, Traditional forest management

Klánovický forest is protected as a special area of conservation according to the Habitats Directive. This nature reserve near Prague extends across ca 300 ha of former agricultural land surrounding extinct Mediaeval villages and has undergone relatively large changes in tree species composition and forest management. To assess vegetation changes, I resurveyed part of 130 semi-permanent plots recorded in the area in three periods (1964, 1988–1992, 2002–2015) based on accurate maps and personal communication with their authors and ascertained the current plant species composition and chemical properties of the forest soil. Despite probable sampling bias, it seems that the vegetation relevés have captured three important facets of woodland herb layer degradation: (i) the disappearance of heliophilous plant species (e.g. *Hieracium* sp. div.) still present in the 1960s, (ii) the expansion of brambles (*Rubus fruticosus* agg.) during the 1980s (shrubification) associated with the closure of the hornbeam canopy, and (iii) the current invasion of non-native species (e.g. *Prunus serotina*) spreading from abandoned buildings and plantations. In addition, the soils in the forest have suffered a drastic loss of basic ions. Based on the resurvey, I conclude that sustainable forest management is needed to halt the biodiversity loss. I recommend (i) the elimination of non-native tree plantations, particularly of red oak to reduce the spread of its invasion by propagules from adult trees, (ii) thinning dense shrubs under old sessile oak in infertile places to release light for heliophilous plant and animal species and avoid an explosion of nitrophilous vegetation, and (iii) introducing the traditional practice of coppicing in part of the forest.

Acknowledgements: The presentation of this research was supported by the project "Application of traditional knowledge to halt biodiversity loss in woodlands" (TO01000132) financed by the Technology Agency of the Czech Republic and Norway Grants 2014–2021.

Identifying climatically analogue areas to future climate of Hungary from the point of view of vegetation

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Keywords: climate analogue, vegetation, bioclimatic variables

Effects of climate change on vegetation are often modeled by correlative models trained on the present vegetation-environment relationships and extrapolated into the future. Extrapolation is less risky if the training area involves situations that are similar to the expected future conditions, i.e. climatically analog areas. The motivation of our study was to identify such areas for future Hungary for more effective climate change impact modeling. We compared the current climate of the Balkan Peninsula and the lowland part of mainland Italy with the future climate projections of Hungary for the 2071–2100 period according to 4×2 global and regional climate models obtained from Euro-Cordex. We focused on eight indicators of the annual climate distribution that are determinants of bioclimatic variables, which are widely used in correlative models to describe climate features relevant for vegetation. The inverse Euclidean distance of the standardized bioclimatic variables was calculated as a measure of analogy between all the point pairs. The resulting multidimensional climate analogy space was then aggregated into statistical measures and map representations.

We found that the main challenge in finding analogs lies in the periods underlying bioclimatic variables that involve precipitation patterns. We identified global climate models, which project non-analog climates. However, in the majority, it was possible to identify analog areas. Future projections appear to bear a similar climate pattern to either the Po Plain and Slovenia or the border area of Croatia and Bosnia-Herzegovina (depending on the climate model) for the western part of Hungary. While eastern Hungary is expected to change less or to become similar to the current climate of Serbia and that of the Danube floodplain of Romania.

Acknowledgments: This research was supported by the Eötvös Loránd Research Network, Hungary, grant no. SA-64/2021.

Plant diversity and invasions across habitats of Murter Island (Croatia)

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Keywords: Vascular plants, Alien species, EUNIS habitats types, Biodiversity, Adriatic island

Murter is an island placed in the northern part of Dalmatia region on the Adriatic Sea. The island covers the area of 17.58 km^2. Karst is the most dominant landscape type, while fields, vineyards and olive groves are mostly abandoned and overgrown by woody vegetation. Tourism is the main human impact on the island of Murter that continuously leads to landscape changes and biodiversity loss. The goal of the research was to determine human impact on vascular plant diversity and alien species number among detected habitat types of Murter island. Another objective was to explain a connection between human impacts, plant diversity and degree of invasion.

For the habitat determination 269 literature relevés were used. Relevés were classified into different EUNIS habitat types using the expert system (Chytrý et al. 2020). Ecological indicator values were used for ecological interpretation of studied habitat types (Tichý et al. 2023). To check the differentiation of the habitat types and to explore relationship with environmental variables Non-Metric Multidimensional Scaling (NMDS) was applied. Disturbance indicator values were used to estimate anthropogenic impact on studied habitat types (Midolo et al. 2023).

In the studied area 15 habitat types were identified. Alien species were present in 25 % of the relevés and represented 5 % of the total number of species. The average highest α-diversity of vascular plants was determined at Mediterranean tall perennial dry grassland and Dry perennial anthropogenic herbaceous vegetation as well as in plots with moderate disturbance. Studied habitats are resilient to moderate human disturbances but a strong disturbance leads to negative consequences such as an increase in number of alien species. The best management strategy in the researched area is moderate grazing because it secures a great plant diversity and reduces the number of alien species.

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Growth of different common beech and sessile oak provenances under drought stress in relation to different soil phosphorus concentrations

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Keywords: drought, common beech, sessile oak

One of the main limiting factors in plant growth and development in recent decades is drought. In the last two decades alone, several extreme, record-breaking droughts have been recorded in Europe - for example in 2003, 2005 and 2018-2020. (Kasper et al. 2022). In order to be able to predict how certain species, especially those that occupy large areas, will react to drought and in what way the negative impacts of drought could be mitigated through forest management, this issue has been increasingly researched in recent years (Kasper et al. 2021; Kahmen et al. 2022). We studied provenance-specific growth response of *Fagus sylvatica* L., one of the most important and widespread broadleaved tree species in Europe, and *Quercus petraea* (Matt.) Liebl. to experimentally applied drought under different soil phosphorus concentrations. Saplings originating from two provenances (wet and dry) of each species in a mixed composition were grown in four mesocosms at the nursery. Those four mesocosms were subjected to different treatments. A significant influence of drought and different phosphorus concentrations on above-ground and below-ground growth and biomass allocation in both species was determined. In beech, neither drought nor phosphorus affected the above-ground biomass, but these two factors interacted to affect the below-ground biomass, especially the fine, physiologically active roots. In the case of oak, which is a more drought-resistant species than beech, the drought significantly reduced stem diameter, height growth, leaf area and biomass. Differences between the provenances indicate that both species show a significant provenance-specific acclimation potential, which should be kept in mind when managing forests with regard to predicted climate changes.

Acknowledgements: This research was supported by the Croatian Science Foundation as part of the research project "IP-2020-02-5204 Phenotypic response of provenances of

common beech and sessile oak to long-term drought in interaction with different phosphorus concentrations in the soil"

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Do you have a network of plots to collect data for the Habitats directive reporting in your country? Please let us know!

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Keywords: Habitats directive, Conservation status, Sampling design, Monitoring network, Grassland, Vegetation

In France, within the national project PRéSur, we search to set up a monitoring network of the conservation status of agropastoral habitats of community interest (HCIs). The main objective of this network is to produce objective, quantitatively comparable and enough precise data to allow building indicators, and finally obtain comparable assessment results for the Habitat directive reporting.

To set up an adequate monitoring network, we ask two main questions:

(i) how to design the network of plots?
(ii) how to size the network of plots?

For the design, we started from our main objective, i.e. collect data to produce assessment results for the Habitat directive reporting. Consequently, from an original dataset of 22 830 phytosociological relevés, we first stratified the sampling of plots by the object to assess (i.e. the HCIs) and by the spatial scales necessary for the restitution of the assessment results (i.e. national and biogeographic region scales). Then, we secondly stratified the sampling of plots (i) to avoid the spatial autocorrelation between plots, (ii) to optimize the field logistic for the future data collections, and (iii) to priorize complementaries (e.g. mutualisation of costs) between this monitoring network and others already existing.

For the size, we tried to determine the minimum number of plots necessary to obtain results that are statistically sensitive enough. For this, we used power tests for several indicators (moisture level, trophic level, etc.) and we applied these tests on the phytosociological alliances and sub-alliances composing the agropastoral HCIs. Due to the lack of data observed or measured directly in situ, we used mainly bio-indicator values of plants to construct the indicators, and due to the strong variability of the most of HCIs, the phytosociological alliances and sub-alliances have been recognized as the ideal objects for the assessment of differences among the indicators and consequently to apply the power tests.

Acknowledgements: This research is financially supported by the Office Français de la Biodiversité.

What do we know about the vegetation of South-European alpine fens with high endemism?

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Keywords: Phytosociological alliances, Mediterranean mountains, Relict mires, Vegetation classification

Floristically specific fens with high endemism occur in the large massifs of high mountains of Southern Europe that form isolated islands in the Mediterranean climate region. In the EUNIS habitat classification, they form a separate habitat type called “Relict mires od Mediterranean mountains” that contain isolated fens of Sierra Nevada (S Spain; *Festucion frigidae* Rivas-Martinéz et al. 2002), Corsica (*Caricion intricatae* Quézel 1953; Syn.: *Bellidio-Belion nivalis* Gamisans 1975) and the SE Balkan (*Narthecion scardici* Horvat ex Lakušić 1968). Recently, the new alliance *Pinguiculo vulgaris-Plantaginion gentianoidis* de Foucault 2022 was described for the entire South-Eastern Europe and Turkey, but without a direct comparison to *Narthecion scardici*. A distinct group of endemic species also characterises Cantabrian and Pyrenean alpine fens, but no endemic alliance is described from this area; the planned vegetation synthesis could quantify whether these fens are indeed less distinct than the Balkan, Sierra Nevadan or Corsican ones or whether there is a room for a separate alliance. The fens in

Central System Mountain Range in Spain have an intermediate position towards Sierra Nevadan ones. Some other high-mountain areas in S Europe located at the same latitudes show much lower endemism in fens (e.g., Apennines). This pattern draws attention to the possible role of current and past climate. Our poster aims to summarise the existing knowledge of the target vegetation, emphasising our current field research. We highlight the directions of future research that should include broad-scale vegetation syntheses, continuation in basic taxonomic research and regional vegetation surveys, and analysing of the relationships between the richness of narrow-range endemic species and edaphic, climatic, and biogeographic variables. The expected results would allow modelling of the future distribution of these unique mires and set the appropriate conservation strategies.

The variation of vegetation eco-physiological responses in mining areas with different scenarios of reclamation: Central Europe, Poland

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Keywords: Novel ecosystems, Functional traits, Environmental stress

We present preliminary results of studies on eco-physiological responses of chosen species occurring in novel ecosystems of hard coal-mine spoil heaps to environmental stresses. The response of vegetation to environmental stress factors depending on the reclamation method was studied. A large spoil heap (112 ha) in Upper Silesia, South Poland (Central Europe), was selected as a model site for research. On 120 study plots, in two variants: 1) active reclamation by topsoiling (TS) and 2) passive reclamation from the natural succession (NS) research was conducted. Chosen of physiological traits of 3 plant functional groups (grasses, legumes and forbs) on TS and NS were measured. It has been shown that the chlorophyll index was significantly lower in forbs than in grasses in both subsoil types. We did not find significant differences in the flavonol index for plants in both habitats. The maximum recorded fluorescence was significantly lower in grasses on TS than grasses on NS and legumes and forbs populations in both subsoil types. The average values of quantum yield of electron transport φEo (at t = 0), were significantly lower in forbs and legumes populations than in grasses populations. The results confirmed drought on spoil heaps and high temperature in NS sites as the main environmental stressors that shape the response of photosynthetic apparatus (PSA) and gas exchange (gs) of grasses, forbs and legumes in studied habitats. Plants of the forbs and legumes population showed significantly lower gs from forbs and legumes in TS than NS plants. Authors found that studied groups of species cope with environmental stressors by a slightly different mechanism while growing on coal mine heaps depending on the way of reclamation.

Acknowledgements: This research was supported by the National Science Centre, Poland (Grant No. 2020/39/B/ST10/00862).

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Coexistence of native and alien plant and tick species along roadsides: introduction to a project

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Keywords: Alien plants, Native flora, Roadside vegetation, Tick

The biodiversity loss is more rapid than ever before, and mainly it is caused by human activity [1]. Roadsides are the special man-made habitats which can serve as a refugia for native plants in agro-landscape. However, alien species are also closely related to man-made habitats, and one of the main vector of their distribution are transport systems: roads, railways, airports or ports [2]. Roadsides are specific habitats that face hard and frequent management pressure for traffic-safety reasons. The frequent management could be one of the factors which reduce alien species establishment in these habitats. However, the current trend is to reduce the frequency of mowing on roadsides, which in general would have a positive effect for native flora or pollinators but could also accelerate alien plant invasions [3, 4]. In addition, the reduction of mowing has raised concerns in society that the tick population will increase drastically due to infrequent mowing [5].
During this study, we will test the role of roadsides as a refugia, habitats and dispersal corridors for native and alien flora, as well as a hotspot for tick diversity. This project will reveal how the distribution of native and alien plant species is related to environmental factors such as traffic intensity, soil chemistry or management frequency. At the same time, this project will determine if there is any link between the abundance and diversity of ticks and environmental variables specific to roadsides as well as community functional diversity. The study will combine data from fieldwork and various databases and provide new insights into roadsides as an important player in shaping biodiversity and invasions.

Acknowledgements: This research is supported by the Research Council of Lithuania (Nr. S-MIP-23-1).

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Spatial patterns of vascular plant species richness in Poland - a data set

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Keywords: Diversity maps, Floristic and vegetation databases, Sampling bias

Knowledge on the spatial patterns of species richness is essential for theoretical studies and nature conservation. A key element for the recognition of species richness is to prepare a comprehensive data set. It is important to use data from different sources, however, it can be challenging due to differences in nomenclature, and the type and magnitude of biases in the source databases. This study presents a stepwise process of joining and harmonizing the data from the *Atlas of Distribution of Vascular Plants in Poland* (ATPOL) and the *Polish Vegetation Database* (PVD) in order to study spatial patterns of vascular plant species richness in Poland.

The ATPOL data were derived from mapping the occurrence of vascular plants, using the cartogram method in 10 × 10 km squares (henceforth, squares). Each floristic record in ATPOL is assigned the code of a square. ATPOL provided records of 3,053 taxa in 3,280 squares. The PVD stores 117,328 georeferenced vegetation plots. Data on taxa occurrences were derived from each plot based on its georeferenced location and assigned to particular squares. PVD provided records of 2,625 taxa in 2,593 squares. The nomenclature of taxa was harmonised using Euro+Med PlantBase, and taxa aggregations were created as needed. Cultivars and ephemerophytes, and taxa recognized at the genus level only were excluded. However, taxonomically difficult genera (e.g. *Alchemilla, Hieracium, Pilosella, Rubus, and Taraxacum*) were considered at the genus level for species richness mapping. The procedures of data filtering and taxonomic harmonisation resulted in the data set including 2,160 species in 3,283 squares.

The species were divided into groups according to their status and frequency of distribution, and the statistics for each square were obtained. For purposes of analysis, sampling bias was assessed. The data set promotes

theoretical analysis on species richness and reinforces the planning of nature conservation.

Acknowledgements: This research was supported by the National Science Centre, Poland, project number 2019/35/B/NZ8/00273

Immediate effects of fertilization on ground vegetation in forest stands and a deciduous tree plantation in Latvia

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Keywords: Ammonium nitrate, Wood ash, Ground vegetation, Forest, Plantation, Organic soil, Mineral soil.

This study examines how the ground vegetation in forest stands and in a plantation of deciduous trees is affected by fertilization with ammonium nitrate and wood ash depending on soil conditions and tree species. The dominant tree species of the forest stands were *Pinus sylvestris* L., *Picea abies* (L.) H. Karst., and *Betula pendula* Roth, whereas the species growing in the plantation were *Betula pendula* Roth, *Alnus glutinosa* (L.) Gaertn., and *Cerasus avium* (L.) Moench. Fertilization was carried out in 2013-2017. The ground vegetation was assessed two years following the fertilization and the ground cover for each species was visually estimated. A comparison was made between fertilized and unfertilized plots regarding species diversity, richness, composition, and Ellenberg indicator values (EIVs). In addition, Detrended Correspondence Analysis (DCA) was performed with soil chemical parameters, EIVs and Shannon diversity index (H') as explanatory variables.

Regarding forest stands, our findings indicate that the overall species composition in both the control and fertilized plots is typical of the forest site types studied. However, the differences in species diversity and richness were most noticeable in silver birch stands. The DCA shows that, for the most part, environmental gradients (moisture, continentality, reaction, temperature) have a greater impact on species composition than the application of ammonium nitrate and wood ash.

The fertilized parcels of the plantation had a greater occurrence and larger coverage of several nitrophilous species, compared with the control. The DCA showed that only sweet cherry-growing parcel had a significant difference in species composition between the control and fertilized plots. Furthermore, significant differences in the number of species and H' values also were only observed for sweet cherry. Light was identified as the most influential factor regarding species diversity.

Acknowledgements: This research was supported by the European Regional Development Fund project No. 1.1.1.1/21/A/031 “Evaluation of factors affecting greenhouse gas (GHG) emissions reduction potential in cropland and grassland with organic soils”

A Study of the Impact of Spatial Characteristics on Functional Species Diversity in Core and Edge Areas

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Keywords: Edge effect, Forest fragmentation, Functional species diversity

The long history of forest fragmentation in Central Europe has resulted in a mosaic landscape consisting of forest remnants surrounded by a matrix of agricultural, urban and other developed land. Humans have not only affected the area and the relative distance between the rest of the forest but also their physical and biological composition through the influence of the external environment and biota on the forest interior.

We investigate the impact of spatial characteristics in various habitats on functional species diversity of forest patches in the core and the edge area. We study if the effect differs among forest habitat types (turkey oak, oak-hornbeam, hardwood floodplain and alder forests), depending on their position within the forest fragment (core vs. edge area), and spatial configuration (shape area, perimeter, shape index). In the western part of Slovakia we analysed 49 forest fragments. For all fragments we computed the dissimilarities between each paired “edge” and “core” plots. This dissimilarity was used as a dependent variable in a set of GLM models. Fragmentation indices (perimeter, shape area, shape index) were used as explanatory variables. Dissimilarities in herb layers differ significantly between the edge and the core of individual habitat types. We have found that the biggest differences between the edge and the core area in the herb layer are within the alder fragments and the smallest ones within the turkey oak forest remnants.

Acknowledgements: This research was supported by the VEGA 2/0097/22

Grassland vegetation in urban landscape: patterns of ecosystem functions and habitat characteristics

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Keywords: species traits, bioindication, principal component analysis (PCA), generalized linear model (GLM)

Urban grasslands (UGs) serve as places for leisure, sport, and recreation for local citizens. They also support biodiversity, improve the quality of soil, water and air. The goal of this study was to test the effects of UGs location in the city (centre, peripheries), patch size (small, medium, large), and function (lawns, road verges, river embankments, parks) on their: 1. ecosystem functions (community-weighted means of plant species traits); 2. habitat characteristics (community-weighted means of Ellenberg Indicator Values and Disturbance Indicator Values); and 3. spatial distribution patterns (landscape metrics). We investigated vascular plant species composition on 244 UGs in Wrocław, Silesia, Poland. Our results revealed that UGs in city centre were more scattered, and their vegetation was dominated by ruderals, annuals, and hemicryptophytes adapted to intensive disturbance, high light intensity, high soil pH, and high soil salinity. UGs in peripheries were better spatially connected, the vegetation was dominated by perennial plants adapted to high soil nutrient concentration (N) and high soil moisture (M). We also found that vegetation on lawns and road verges, regardless of their location, was similar to UGs in the city centre. The UGs vegetation at river embankments was characterised by a high proportion of perennials and clonal species producing more biomass and adapted to higher N and M. UGs in parks were characterised by a higher proportion of autochoric and stress-tolerant species, also adopted to higher N and M. We found significant interactions between tested factors, such as UGs size and location, and

function. The study highlighted two main factors shaping UGs vegetation. Firstly, direct human pressure including landscape fragmentation, disturbance intensity, soil salinisation and calcification. Secondly, soil nutrient availability, and soil moisture gradients shaping vegetation composition and, in turn, ecosystem functions of UGs.

Acknowledgements: This research was supported by the project "UPWR 2.0: international and interdisciplinary programme of development of Wrocław University of Environmental and Life Sciences", co-financed by the European Social Fund under the Operational Program Knowledge Education Development, under contract No. POWR.03.05.00-00-Z062 / 18 of June 4, 2019 and by the National Science Centre, Poland, grant no. 2019/35/B/NZ8/03358.

Political borders in the traditional mountain grassland management context (the case study from Ukrainian and Romanian villages of Maramures and Bukovina regions)

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Keywords: Carpathians, Vegetation, Plant diversity, Landscape, Traditional agriculture, Agriculture policy

Mountain meadows within central Eastern Carpathians are known as species-rich grasslands with unique traditional low-intensity grassland management. However, little is known about the drivers of its high floristic richness and, what is particularly interesting, the importance of social factors such as political borders.
Our study area is located at the border between Ukraine and Romania, in the historical regions of Maramures and Bukovina, where grassland vegetation and management practices were considered. Plant diversity was recorded at 7 spatial scales within 6 nested plot series per village. The effect of the political regime on taxonomic composition we calculated separately for vascular plants and bryophytes in the RDA and CCA, respectively.
In total, we recorded 383 species within 48 releves. The mean number of vascular and non-vascular plants was similar or considerably less within Ukrainian villages. The political border was found as one of the strongest drivers for vascular plants composition within studied villages (4.0% of the explained variation as a conditional effect), while for the bryophyte's richness it wasn't significant (as a simple effect it explains 2.6%) as opposed to the valued topographic and soil-related factors.
Our results emphasize the role of the political regime in the species composition of mountain grasslands. Agriculture policy, including use of chemical fertilizers, may show one of the differences between villages separated by political boundaries. Nevertheless, to assess traditional low-intensity grassland management, other factors may also act significantly and therefore should be taken into account.

Acknowledgements: This research was supported by the APVV-0226 project and VEGA 02/0065/23. We also thank Government Office of the Slovak Republic for the opportunity to continue substantive work for Ukrainian scientist (Scholarships for excellent researchers threatened by the war conflict in Ukraine: 09I03-03-V01-00018).

How EU CAP subsidies affect species composition of mesic meadows in Slovakia, Central Europe

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Keywords: agricultural subsidies, Common Agricultural Policy, habitat of European and national importance, management, resampling

The most species-rich permanent grasslands, which are the results of the coevolution of nature and human activities, are currently undergoing radical management changes, significantly influenced by the implementation of the Common Agricultural Policy in Slovakia since the country joined the European Union in 2004. The aim of this study is to assess the effectiveness and impact of agri-environmental schemes (AS) on the species-rich grasslands implemented since 2004 on the current state of the habitats, using the resampling of phytosociological relevés.

Vegetation resampling was carried out during the vegetation seasons in 2021 and 2022. Relevés (originated in 1998–2003 before Slovakia joined EU) were obtained from the Slovak Vegetation Database and personal databases of the authors. For each relevé, we determined the implementation of AS in three reference years (2009, 2014, 2021), and they were divided into four categories (1 – no AS, 2 – AS in one reference year, 3 – AS in two reference years, 4 – AS in all reference years). Field resampling was performed according to the Zürich-Montpellier school on plots of the same size as the original relevés (16–25 m^2). The phytosociological relevés were stored in TURBOWIN and harmonised using the program JUICE. Temporal changes were analysed by indirect and direct gradient analyses using Canoco 5.

The results show significant changes in the species composition of *Arrhenatherion* grasslands in all four groups. The number of ruderal species, trees, shrubs and generalists is increasing, in contrast to the decreasing number of species of more oligotrophic species-rich communities. For sites with AS received for a longer time (categories 3 and 4) the changes are less pronounced, while in categories 1 and 2 they are highly significant. In conclusion, implementing AS will not prevent undesirable changes in plant diversity of mesic grasslands, but it can slow down habitat degradation.

Acknowledgements: This research was supported by the Scientific Grant Agency of the Ministry of education, science, research and sport of the Slovak Republic and the Slovak Academy of Sciences VEGA no. 2/0132/21

Snowbed vegetation of Europe

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Keywords: arctic-alpine vegetation; climate, diagnostic species, diversity drivers; environmental gradients; *Salicetea herbaceae*

Snow cover is an essential part of the climate system and one of the most critical drivers affecting plant community distribution patterns across the landscape. Snow interacts with other climate and environmental components at hemispheric, regional, local, and micro scales, generating steep environmental gradients and determining the presence of specific snow bed communities, distributed in the alpine areas of temperate high mountains and the Arctic.
The main aim of our contribution is to understand the main drivers influencing species pools and community diversity of snowbeds across European regions. Based on national data sets, we put together all available relevés from European mountains the Arctic and run supranational analyses to search the main types of European snowbeds at the level of alliances and associations, if applicable. We identified diagnostic, constant, and dominant species of individual units, as well as the main gradients in species composition based on selected traits (growth forms, life forms, life history, etc.). We also recognized the affinity of certain chorological elements to particular vegetation units. To interpret the obtained results, the climatic data were used to link the results with average temperatures and precipitations during the vegetation season.
Acknowledgements: This research was supported by the VEGA 02/0097/2022 and ESA 4000140486/23/NL/SC/rp

Modelling of Sinai desert vegetation

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Keywords: Desert vegetation, Sinai, Modelling, Classification

Aims: Sinai is a global hotspot for desert vegetation; however, there is no well-developed vegetation map for its vegetation. We aim to provide suitability maps of Sinai desert vegetation based on an extensive database and formal classification. We further aim to describe the distribution of the vegetation communities and their relation to the environmental parameters.

Methods: We retrieved the vegetation observation coordinates from a comprehensive database of Sinai vegetation. We acquired the environmental parameters (the predictors) from different verified sources to build abiotic layers for the vegetation plots coordinates in QGIS v3.2. Then we used the predictors and the coordinates of vegetation plots in modelling the desert vegetation suitability maps using Maxent V. 3.4. We used 50% of the data for modelling and the other 50% for testing.

Results: We produced four suitability maps representing the main desert vegetation groups of Sinai and 25 suitability maps representing the groups of the desert vegetation communities. The maps correspond to the expected distribution of the vegetation communities and we interpreted them based on the environmental parameters included.

Conclusion: We present suitability maps of Sinai desert vegetation first of its kind, based on a comprehensive database and modern tools for vegetation mapping.

The impact of landscape and local land use changes on grasslands of the Czech Republic over the past 200 years

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Keywords: central European grasslands, endangered species, historical continuity, land use, plant species richness

One of the important factors determining grassland species composition and species richness is the landscape structure and its past changes. Despite this fact, there are still only a few local or regional studies assessing this relationship.
Here we explore how the habitat continuity and the local and landscape-scale land use and its changes affect recent species composition and species richness of central European grasslands in the example of the Czech Republic. We used recent vegetation plots from the Czech National Phytosociological Database and a set of historical land-use maps (1840, 1870, 1950, 1990 and 2006), where we distinguished 9 land-use categories. For each plot, we applied a 300 m buffer to assess changes at local scale and a 1 km buffer to assess landscape scale.
Generalized Linear Models showed high importance of grassland continuity for species richness and number of endangered species in both meadows and mesic pastures (*Molinio-Arrhenatheretea*) and dry grasslands (*Festuco-Brometea*) in the mid-elevations (300–600 m a.s.l.). However, no impact was detected for pioneer vegetation of sandy and shallow soils (*Koelerio-Corynephoretea*). We also found a negative effect of the area of continuous forest on grassland species richness, especially in higher altitudes characterized by the highest forest expansion. We recently detected an increase in the grassland area around broad-leaved dry grasslands localities, while we revealed its continual decline around intermittently wet to wet grasslands both locally and on the landscape scale.
During the second half of the 20th century, many valuable and preserved grasslands, harbouring large species diversity, disappeared or drastically reduced their area. Surviving fragments were at risk of random extinctions or disappearance of rare species. Nowadays, there are some newly established or restored grasslands, but our results reveal almost no spatial connection to remaining fragments of continuous grasslands.

Acknowledgements: This research was supported by the Technology Agency of the Czech Republic (SS02030018).

Dynamism and conservation of seminatural forest habitats: cork oak forests of central Italy

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Keywords: Quercus suber, Seminatural habitat, Regeneration, Conservation

The forest habitats listed in the 92/43/CEE Habitat Directive include several seminatural formations that are favoured or maintained in equilibrium by human action, mainly for productive purposes. Some of these coenoses are undergoing transformation due to decreasing human interest and the consequent triggering of dynamic processes. To study this phenomenon, we have analysed the case of cork oak forests on the Tyrrhenian side of Central Italy, which are part of the "9330 forests of Quercus suber" habitat of the Habitat Directive. The choice is appropriate due to the current characteristics of these populations: they cover a limited area and have a fragmented distribution, they have been created by man to exploit the cork and they have mostly run wild. The ecological characteristics and dynamic processes underway have been analysed through a multi-disciplinary approach in order to draw up possible conservation strategies. Through the processing of climate, stational, structural, regeneration and soil data we have shown how habitat is linked to silvicultural management that encourages the renewal and affirmation of cork, in the absence of which there are clear signs of transformation towards uneven-aged mixed forests. By analysing the ecological niche we have identified the potential distribution of the species, as well as the most suitable areas for potential intervention. In conclusion, cork oak woodlands can be viewed as a system on the edge of radical change and at clear risk of collapse, driven by rapid and turbulent socioeconomic and climatic changes. Cork production is still profitable in many places and motivates some protection, if not investment, in new stands. In that sense, cork oak can be considered not only an emblematic but also an archetypal Mediterranean plant. It is also an ecologically and economically emblematic tree for Mediterranean landscapes, where people and nature have interacted for millennia.

Regulating ecosystem services: The role of forests in enhancing the air quality

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Keywords: Ecosystem Services, SEEA-EA, PM10, PM2.5, Forests, GIS, Air Quality

Air pollution is among the main issues plaguing our century. The pollutants released in the atmosphere by ever-increasing human activities are altering natural ecosystems and affecting human health. Particulate matter (PM) is one of the most threatening pollutants in the European Union, and Poland has the worst PM concentration among European countries. Polish policymakers are applying several strategies to improve the air quality; however, the achievement of the target appears to be distant due to the massive use of coal to produce energy and heat.
Although strong actions are needed to limit sources of pollution, proper forest management could be a useful tool to decrease the number of pollutants in the atmosphere through the Ecosystem Services they provide. Several studies recognized the important role of forests in improving air quality and reducing emissions in the atmosphere.
In this study, we aimed to assess the role of forests, in both biophysical and monetary terms, in enhancing air quality and human well-being by removing particulate matter in the Tuchola forest (Poland). Tuchola is a Biosphere and UNESCO-MAB Reserve, representing one of the biggest Polish forest complexes. Following the most recent System of Environmental-Economic Accounting-Ecosystem Accounting (SEEA-EA) framework, we assessed the ability of trees in removing PM10 and PM2.5, applying an accounting model based on remote sensing data. We also analyzed the impact of a devastating hurricane in 2017, assessing the destroyed forest area and the related ability lost to remove air pollutants after the hurricane crossing.

The results will boost the scientific knowledge of the ecosystem services provided by forests while encouraging policymakers to develop strategies to preserve such ecosystems.

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The flora diversity under taxonomic, phylogenetic and functional trait aspects of sub- and alpine semi-natural grassland habitats

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Keywords: Semi-natural grasslands, Plant community, Taxonomy, Phylogeny, Functional traits

Semi-natural grassland habitats have been formed through millennia of pastoral activities. They have allowed the development of a wide range of ecological niches, with the capacity of hosting a high biodiversity. However, on-going land-use changes trigger modification in the floristic composition of such habitats, resulting in a decline of species richness. The aim of this study is to explore changes in plant community composition (α-β diversity) in relation to changes in agro-pastoral activities. Taxonomic, phylogenetic and functional trait diversity metrics are used to analyse the data under different grazing pressures and time since grazing ceased. The preliminary results show how taxonomic (SR) and phylogenetic diversity (PD' *Faith*) are higher in grazed sites. However, intensive grazing causes a reduction of diversity similar to abandoned pastures. NRI analysis shows how, in intensively grazed and recently abandoned sites (<10 years), community composition is shaped by grazing, which acts as a filter. On the other hand, in extensively grazed and older abandoned sites (>10 years), plant community composition is more driven by species competition dynamics. PhyloSor community dissimilarity matrix showed differences mainly among heavily grazed sites and all the other site conditions. The nestedness and turnover analyses revealed that the main driver of community changes in composition is linked to species replacement. In particular, different successional stages in abandoned sites are associated with significant events of species turnover. This study has stimulated us to examine the role of environmental and intra-specific relationships in community composition in this study system. To this end, a pool of traits reflecting disturbance responses of species has been selected to clarify the factors affecting community dynamics.

Acknowledgements: This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie GA No. 101034449

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Linking Lichen Biodiversity to Forest Habitats Structure: A cross-taxon approach

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Keywords: Habitat Monitoring, LBI, Forests Structural Data

Lichens are important indicators of forest ecosystem health. Monitoring lichen diversity can provide valuable insights into the forest habitats degree of conservation. One of the commonest approaches to monitoring lichen diversity is to use the Lichen Biodiversity Index (LBI), that considers lichen species richness and abundance (ANPA 2001).
To understand the relationship between lichen diversity and forest structure, we surveyed and measured habitat variables in addition to lichens. Habitat monitoring including canopy cover, understory vegetation, and tree species composition (Angelini et al. 2016, Carli et al. 2023). These variables can directly, or indirectly, affect lichen diversity and abundance, as different lichen species have different ecological requirements, including habitat fragmentation (Potenza et al. 2022). In this context, considering differences in the LBI in relation to structural and ecological aspects of forest ecosystems, we obtained a more comprehensive insight of the conservation status of forest ecosystems. Since the LBI monitoring network is homogeneously distributed on the Italian peninsula, we suggest using it for assessing forest habitat types conservation status, forest management practices impacts, and ensure the long-term health and sustainability of forests.

Acknowledgements: This work was supported by the ARPA Basilicata [Agreement between ARPA Basilicata and ISPRA on Ecosystems Monitoring by innovative indicators development (30/11/2021)]

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Identifying habitat types based on Sentinel 2 data in the Toolik Lake region, Alaska

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Keywords: Arctic tundra, Vegetation units, Toolik lake, Remote sensing, NaturaSat

In a changing world with increasing pressure on natural resources, land cover maps and monitoring have substantial importance. The most visible impact of the on-going climate change is observed in the Arctic regions. At the same time, mapping and monitoring arctic habitats is extremely difficult due to the large amount of remote areas. Therefore, variable remote sensing approaches are necessary in such regions.
The NaturaSat software integrates various image processing techniques together with vegetation data, into one multipurpose tool that is already in use in Central Europe, allowing extraction of the habitat borders with pixel accuracy of the Sentinel-2 optical data, classification of plant communities in segmented areas by satellite image characteristics and monitoring their area and quality dynamic changes. The first application of the software in the Arctic region was done in the Toolik Lake region, Alaska.
Toolik Lake Area Vegetation map (Walker & Maier 2008) originally consists of 14 vegetation units, distributed in 1448 polygons. Considering the character of Sentinel-2 data, and the fact that only optical data were used (without any supplementary data as geological or pedological maps), habitat types were connected into following groups: Barrens, Erect shrubs, Prostrate shrubs, Moist graminoid tundra, Wet graminoid tundra and water bodies. Simplified version of the Vegetation map was imported into the NaturaSat software. Polygons larger than 2000 m^2 were included into the analyses. Since the map was published in 2008, recently some vegetation unit borders have changed due to the shrubification or succession. To obtain “core area” of habitats, polygons were processed by the Adjust function that allows automatic movement of habitat borders into real borders identified in satellite data by edge detector. For the final dataset, spectral characteristics

of all bands were computed and compared by statistical methods, to verify the possibilities of automatic recognition of arctic tundra habitats.

Acknowledgements: This research was supported by the European Space Agency grant No. 4000140486/23/NL/SC/rp

Species diversity of the Ukrainian flora ferns in chasmophytic habitats of the Ukrainian Crystalline Massif

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Keywords: ferns, Ukraine, Ukrainian Crystalline Massif, biotopes.

Rock outcrops are a unique habitat type, connecting the abiotic conditions features with specific plant cover. The ferns play a valuable role in such biotopes. Unlike most plants, they are adapted and tolerate extreme conditions. The ferns vanish first due to the anthropic transformation of the habitats. Therefore, they need individual attention and protection. In the plain part of Ukraine, rock outcrops are represented within the Ukrainian Crystalline Massif (UCM) – a blocky uplift of the crystalline foundation of the East European platform.

We studied the species diversity of the ferns in the rock habitats of the UCM. We analyzed 182 relevés made within UCM. We used the Expert System for automatic vegetation classification of the plots to EUNIS habitat types (Chytry et al. 2020) run in the JUICE software (Tichý, 2002).

We identified 3 habitat types: R12, R16, and U33. The last one (U33 Temperate, lowland to the montane siliceous inland cliff) is characterized by the biggest number of fern species – 8 species. Generally in Ukraine, more than 30 fern species (Vasheka & Bezsmertna 2012) occur in rocky habitats, but within UCM, this number counts 13 species. For those territories, the most typical species are *Asplenium trichomanes*, *Cystopteris fragilis*, and *Polypodium vulgare*.

The unique finds relate to 2 species of the *Woodsia* genera in the UCM. For instance, In Ukraine, there are only 4 localities of *W. alpina* (Bezsmertna et

al., 2022). Perhaps, some localities can be lost because they are situated close to the war frontline (Zaporizhzhia and Donetsk regions).

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Vegetation-soil relationships on consolidated limestone of Serbia

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Keywords: Leptosols; Phaeozems, *Saturejion montanae*; *Festucion valesiacae*,

Understanding the relationships between soil features and grassland vegetation have significant importance for agriculture and nature conservation. The aim of this study was to analyse the soil physical and chemical characteristics influencing plant species composition and species richness of grassland vegetation developed on the consolidated limestone in eastern Serbia. The analyses have been carried out on 22 phytosociological relevés, corresponding mixed soil samples (0-10 cm depth) and 8 soil profiles. The collected soils samples were classified according to the World Reference Base for Soil Resources (2015). Numerical classification distinguished two grassland vegetation types: Balkan endemic steppe alliance *Saturejion montanae* and steppe fescue grasslands on deep calcareous soils, alliance *Festucion valesiacae*. The grasslands of both vegetation types are developed on Leptosols and Phaeozems. According to the results of the Detrended Correspondence Analysis, the most important soil parameters affecting the species composition of steppe grasslands were humus, soil exchange capacity, the content of calcium, total acidity, base saturation, altitude, soil depth and pH.

National vegetation database of Montenegro

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Keywords: database, EVA, GIVD, Montenegro, relevé, vegetation

The Vegetation Database of Montenegro (GIVD ID EU-ME-001) is national database established in 2019 at Faculty of Natural Sciences and Mathematics (University of Montenegro) in Podgorica. A digitized collection of vegetation relevés comprises different vegetation types which have been sampled on the territory of the Montenegro.
So far, 3293 published (50.9%) and unpublished (49.1%) vegetation plots are stored in Vegetation Database of Montenegro. In total, it contains 2733 taxa (vascular plants, mosses, lichens, algae), while 2612 taxa is referred to vascular plants. The largest amount of vegetation data in the field was collected during two periods: from 1960 to 1969 and after the year 2020. The oldest relevé dates from đ1940 (Muravjov, the vegetation of Bjelasica mountain). The majority of vegetation plots (63.4%) have precise date of sampling. All plots are georeferenced; for most of the relevés coordinates are determined a-posteriori, because only 35% relevés have originally published coordinates. Range of the plots size is from 0.12 m^2 to 7000 m^2, while most of the relevés have plot size from 26 to 100 m^2. For 8.7% of relevés the data on plot size is missing. More than half of vegetation plots was sampled in sub-montane and montane areas. Highest number of relevés was originally classified to forest vegetation types (classes *Quercetea pubescentis* and *Carpino-Fagetea sylvaticae*) and grasslands (*Molinio-Arrhenatheretea* and *Festuco-Brometea*).
The database is part of the European Vegetation Archive (EVA) and has a semi-restricted access mode.

Quercus trojana forests on the Balkan and Apennine Peninsula

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Keywords: Macedonian oak, Natura 2000, *Quercetum trojanae*

Macedonian oak (*Quercus trojana* Webb) is a medium-sized, semi-evergreen tree whose forests are distributed in southeastern Europe (Balkan and Apennine peninsulas) and southwestern Asia (Asia Minor). *Quercus trojana* forests are also classified in Natura 2000 habitat type 9250 *Quercus trojana woods*.

We collected all available relevés (mostly unpublished) from Italy, Croatia, Montenegro, Albania, Kosovo, Northern Macedonia and Greece (280 relevés) and performed a numerical analysis (classification and ordination) of the resampled dataset.

There are four associations of Macedonian oak: two from the Balkan Peninsula: *Quercetum trojanae* (with four new subassociations - *typicum* (MK, AL, GR, MNE), *chrysopogonetosum grylii* (GR), *festucetosum callieri* (GR), and *seslerietosum autumnalis* (MNE)), and *Ruto graveolens-Quercetum trojanae* (Kosovo), and two already known associations from the Apennines: *Teucrio siculi-Quercetum trojanae* and *Euphorbio apii-Quercetum trojanae*. With an exception of *Ruto graveolens-Quercetum trojanae* which is classified to the *Fraxino orni-Ostryion*, other associations are assigned to the *Carpinion orientalis* alliance.

Conservation status of Quercus trojana forests differs between the countries. In Greece, it is considered as favourable (FV), while in Italy as unfavourable-inadequate (U1). In Croatia these forests are not included in the Natura 2000 Habitat list, while other non-EU countries do not report their conservation status yet. In Montenegro, these forests are listed in the

Field guide for identification of habitats of European interest. According to our observations, major part of the stands are under zoo-anthropogenic pressure, which significantly reduced their representativeness.

Acknowledgements: This research was supported by the ARRS project P1-0236.

Combining species distribution models and palaeobotanical records to investigate the present and past distribution of *Arbutus* sp. pl. in the Western Paleartic region

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Keywords: Occurrence records, fossil data, ecological modelling, postglacial, demographic history

Four species of *Arbutus* (*A. unedo*, *A. andrachne*, *A. canariensis*, and *A. pavarii*) are currently recorded in the Mediterranean Basin, along the Atlantic coast of Europe and in Macaronesia, being an important representative of the Mediterranean broadleaved evergreen element. By combining current occurrence data, fossil records, and Species Distribution Models (SDMs), we inferred the postglacial dynamics of *Arbutus* and the bioclimatic constraints that shaped its demographic history.
We applied an ensemble-modelling approach (BIOMOD2) to obtain current and past predicted distributions for the four species of *Arbutus*. The SDMs were based on double-checked occurrence records from the literature and bioclimatic variables retrieved from the CHELSA database. The bioclimatic variables were analysed through Spearman correlation selecting three subsets with moderate/low correlation (|r|<0.7) for model development. Past distribution maps (last 30 ka at 1000-year intervals) were obtained from >1300 chronologically controlled pollen and macrofossil records, further used to calibrate model projections for each period using the downscaled PaleoClim database.
Results show excellent model performance for the two dominant species (TSS>0.91 for *A. unedo* and >0.93 for *A. andrachne*). Temperature and

precipitation seasonality are the drivers that better explain the current distribution of *A. unedo* and *A. andrachne*. Both species show an asymmetric distribution, mostly driven by annual rainfall, with *A. unedo* showing high climatic affinity for Atlantic regions, while *A. andrachne* exhibits a preference for inland areas.

Our work indicates that the combination of fossil records and modelling techniques is an effective tool to depict the Quaternary demographic history of tree taxa, to explain the modern biogeography of the Mediterranean evergreen ecosystems, to anticipate potential range shifts in relation to the ongoing climate change, and to raise hypotheses to inform phylogeographic research.

TracEve - Tracing the evergreen broad-leaved species and their spread

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Keywords: evergreen broad-leaved, forests, global changes, protected areas, remote sensing, vegetation

An ongoing spread of evergreen broad-leaved species has been reported in the Southern European forests. Global changes have been indicated as drivers of this environmental transformation. This joint Italy-Austria project aims to understand the spatio-temporal magnitude of this phenomenon, as well as its effects on diversity. We will set out a latitudinal study including evergreen woody species-rich and -poor protected areas in Mediterranean and Temperate forest vegetation. The main project goal is to study the spread of evergreen species by combining vegetation data collected in the field with satellite time series (Landsat, Sentinel 2) by implementing machine-learning procedures. Here, we present the hierarchical structure of the vegetation sampling schema which will be conducted in a selection of protected areas representative in terms of broad-leaved forest cover along a latitudinal gradient of the Italian Peninsula. For each area, a defined number of cells (1 km of resolution) will be selected to consider the landscape complexity based on informative strata such as forest cover, elevation, observed or predicted forest diversity. In each cell, two random sites (30 m of resolution) will be accounted for to consider local scale complexity based on a fine-scale elevational gradient and patterns of forest distribution. An additional preferential site will be selected to consider rare species aggregations based on field observations and surveys. Within each site, we will systematically select four plots (10 m of resolution) where we will collect vegetation data and information about the cover of broad-leaved evergreen woody species, including information about the vertical layers. To track back the possible future changes in forest composition, we will arrange a data set

to test machine-learning procedures combining historical and newly collected data. The final aim is to obtain a robust approach to be transferred to central European forests, beyond national borders.

This work has been conducted within the TracEve project I6452-B (https://www.uibk.ac.at/en/projects/traceve/), which has received funding from the FWF Austrian Science Fund in cooperation with the Autonomous Province of Bolzano-Bozen as a Joint-Project South Tyrol – Austria 2022.

Back to the lake: 100 years of flora and vegetation changes in the of Lake Pantano (Basilicata Southern Italy)

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Keywords: macrophyte, N2000, Ramsar Convention, vegetation monitoring, wetlands

The lake “Pantano di Pignola” located in the Basilicata Region, (Southern Italy) is part of “Natura 2000” network, one of the Italian sites of the Ramsar Convention, an Important Bird Area and it is also protected as a Regional Nature Reserve. Despite its importance at regional scale for wetlands conservation, information regarding flora and vegetation of the lake is scarce, fragmented and not updated. Starting from a specific monitoring of the macrophytic vegetation carried out during the period 2015-2022, we tried to reconstruct the vicissitudes of this biotope over the last 100 years. The accurate work of O. Gavioli describes the state of flora and vegetation of this area before reclamation. In the 1970s the lake reappeared as an artificial basin serving the nearby, in development, industrial site. However, the artificial reservoir was never brought to full capacity and underwent a process of renaturalization, with the formation of a wetland area of conservation concern, declared as of Regional interest in the 1980. Lastly, in the 1990s, in an attempt to reconcile naturalistic needs and the use of the water resource for industrial purposes, the lake basin was divided into two sectors with the construction of internal embankments. The state of the environment before the latter artificialization of the basin was documented by a detailed study that remained largely unpublished conducted in 1987 by researchers of the University of Basilicata.
After the restoration of the reservoir, many of the coenoses described by Gavioli in the 1930s quickly reformed but, the depth of the lake decreased from 5 to 2 m, some macrophytes became locally extinct (e.g *Aldrovanda vesciculosa*) and some habitats disappeared (e.g. Magnocaricion); after the 1990s, were rapidly invaded by helophytes and hygrophilous shrubs and trees, resulting in a consistent decrease in free water surface; macrophytes vegetation experienced strong changes, with the disappearance of communities with *Potamogeton lucens* and *Stuckenia pectinata*, documented by the 1987 surveys, and the absolute prevalence, in the more recent data of communities dominated by *Potamogeton natans*, *Ceratophyllum demersum* and *Persicaria amphibia*. We consider that knowledge of changes that have occurred in the past, in relation to

environmental changes, and the current dynamics should be carefully considered to address management actions of this site.

Consequences of anthropogenic influence and climate changes on the vegetation of high-altitude lakes of the Ukrainian Carpathians and ways of their preservation

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Keywords: successional series of plant communities, Potamogeton alpinus, Warnstorfia fluitans, Svidovets massif, Gorgany

High mountain lakes are excellent objects for studying the consequences of anthropogenic influence and climate change. The largest number of lakes are located on the Svydovets and Chornogora massifs, which are the hotspots of biodiversity. They are placed between 1460-1597 m above sea level. Some of them suffer from the excessive influence of tourists (Gereshaska, Dragobratske, Ivor), while others remain outside the limits of such influence due to their inaccessibility (Apshynets, Vorozheska). In anthropogenically altered lakes, the process of their overgrowth with the formation of oligotrophic swamps has been disturbed, the communities of the Potametea class have disappeared, communities of Carex rostrata dominate (Felbaba-Klushyna et al., 2023). On undisturbed lakes, oligotrophic swamps are formed and all series of communities are present, starting from very rare communities of the class Potametea to communities of the class Oxycocco-Sphagnetea. Changes in the temperature regime in the highlands are not reflected on them. Considering the vulnerability of these objects, their extremely important hydrological role and the ineffectiveness of existing protection methods, it is necessary to give these lakes the status of Ramsar sites and to include the Svidovets massif in the Carpathian Biosphere Reserve.

Vegetation types in dolines on Kras plateau (SW Slovenia)

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The object of research was characteristic karstic features: dolines. They range from a few meters to about several hundred meters in diameter, their depth generally varies from a few meters to a few tens of meters. Different forest types appear here, because ecological conditions are influenced by terrain concavity.

They are small, so it is not possible to sample relevés in the sense of Braun-Blanquet school, which should be at least 100 m^2. Nevertheless, we tried to establish which forest types appear in these small geomorphological features.

We used the transect method to study and analyze the pattern of forest types at the microscale level. For the analysis of the microscale pattern, we used microplots sampled in transects made in the herb layer. The size of the plots was 2 m x 2 m.

Besides, we collected all available relevés of forest communities from the Kras plateau (233 relevés) and established forest types. We found out that there are 16 forest types present in the region. Then we constructed an expert system for classification of forest types in the region.

We used this expert system for classifying the microplot matrix (286 microplots x 124 species). 129 microplots were classified within one of forest types, the rest of plots were unclassified or classified within two or more forest types. Six forest types were established in doline.

Then we used unsupervised k-means clustering and 6 established forest types have been used as a priori groups. After classification we got 7 clusters, presenting the ecological gradient in dolines, as *Asaro-Carpinetum betuli* in the bottom, *Seslerio-Quercetum petraeae* on gentle slopes, *Paeonio-Tilietum platyphylli* on ravines on lower slope, *Frangulo rupestris-Prunetum mahalebis* and *Qstryo-Quercetum pubescentis* on upper slopes and tops and *Seslerio-Quercetum cerridis* on deeper soil, most often on the top. We also found the seventh cluster, representing the chasmophytic communities appearing on extreme steep slopes and rocks.

Changes in diversity of grassland vegetation in Veľká Fatra Mts (Slovakia) during the last decades

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Keywords: Diversity, Functional traits, Grasslands, Re-sampled relevés, Species richness

Phytosociological research of grassland communities was carried out in the Veľká Fatra Mountains in central Slovakia between 1980 and 2005. We resurveyed a total of 78 grassland relevés between 2018 and 2020 to describe changes in species composition and the structure of grasslands. A temporary shift in species composition was assessed in the context of main gradients in species composition, obtained by detrended correspondence analysis (DCA) with passively plotted average ecological indicator values. Canonical correspondence analysis (CCA) was used to analyse the relationship between grassland species composition and time. Paired t-test was used to compare differences in species richness between re-sampled and historical plots and to identify increases or decreases in the number of specific species groups (herbs, graminoids, trees, Red List species, species with selected biological traits and ecological strategies). Wilcoxon matched-pair test was used to explore differences in ecological indicator values.
Changes in management intensity throughout the past few decades have caused transformative changes in the species composition of grasslands. Direct gradient analysis revealed that time had a significant influence on species composition. Statistical comparison of ecological indicator values revealed noticeable differences in light and nutrients, expressed in a higher representation of nutrient-demanding and shade-tolerant species in re-sampled relevés. The abandonment or reduction of grazing/mowing intensity resulted in a significantly higher number and coverage of tree and shrub species and a higher number of graminoids. Additionally, species richness significantly increased in re-sampled relevés, likely due to the penetration of woody plants and nutrient-demanding species in the early successional stages.

Acknowledgements: This research was supported by the Scientific Grant Agency of the Ministry of education, science, research and sport of the Slovak Republic and the Slovak Academy of Sciences VEGA no. 2/0132/21

Management of Spreading Pasqueflower *Pulsatilla patens* (L.) Mill. habitat in microreserve located in Eastern part of Latvia

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Keywords: protected species, habitats

Specific form of the state level protection form – microreserve, was established in 2008 to protect large and vital Spreading Pasqueflower finding within 8.4 ha of total area. Protected plant site is located in the Eastern part of Latvia. Very high vitality of Pasqueflower individuals is explained due to local hurricane on 2001. After the storm target area was open and sandy, so Pasqueflowers could spread rapidly with seeds among young and small Scots pine *Pinus sylvestris* trees. Within next years after the storm, this finding was one of the most vital in all the State.
Target habitat and microreserve surroundings are rich also in another Latvia and European Union protected vascular plant species, such as: Fastigiate gypsophila *Gypsophila fastigiata* and one subspecies of Sand pink *Dianthus arenarius ssp. borrusicus*. All those species are ecologically connected to light, sunlit forests and are so called regular disturbance dependant species. Accordingly, in shaded areas these plant species have mainly low vitality, weak flowering, occur mainly in vegetative stage. Lack of necessary ecological disturbances since 2001 caused decrease in amount and vitality of Pasqueflowers in the microreserve. Habitat is covered by 23 years old Scots pine young generation stand. Canopies of pine trees make more shade to ground cover vegetation causing spread and competition of herbaceous plants, shrubs and mosses. Step by step, rare and protected disturbance dependant plants decrease. Till now no management except protection was made in the microreserve. Detailed field surveys since 2012 is made in the site to monitor Pasqueflower amount and vitality. Since 2012 to 2021 flowering plants of Pasqueflowers decrease in 72 %, thus target habitat becomes less suitable for Pasqueflower existence and development. Thus, explains need for active management which imitates necessary natural disturbances. Management of Pasqueflower habitat takes place since January of 2022:

- optimisation of light conditions maintaining partly opened and sunlit structures, thinning out and extensively branching pine trees, removing expansive leaf trees and shrubs;
- thinning of expansive shrubs and mosses in ground cover, controlled burning of brunch piles and mineralisation of soil – to develop bare sand patches.

Implemented activities will support development of Spreading Pasqueflower with seeds and favourable conservation status of target habitat which is object of regular surveillance.

Acknowledgements: This research was methodologically supported by the European Commission Cohesion fund cofinanced project Nr.5.4.3.0/20/I/001 results and done within Integrated LIFE project LIFE IP LatViaNature activities as a knowledge transfer.

Response of herbaceous vegetation in *pro* senescence forest management of "Cansiglio Orientale" Natural Reserve (Pordenone, Italy)

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Keywords: forest gap, species composition, fagus sylvatica, forest management

The aim of this study is to analyze the response of herbaceous vegetation to gap opening in "Cansiglio Orientale" Natural Reserve (IT3310006) (Pordenone, Italy). The study is carried on in the context of a LIFE Natura Project (LIFE SPAN-Saproxylic habitat Network - LIFE19 NAT-IT-000104). The project proposes management solutions inspired to the concept of "Îlots de sénescence" (Mason et al., 2016) which envisages, among other things, to open gaps in a productive forest matrix (25 gaps in the Italian site for a total of about 4 ha). In *ex ante* survey (2021-22) 25 phytosociological relevés (250m^2) were made in the center of each future gap. Cluster analysis on matrix (25 relevés x 63 species) shows three clusters whose Ellenberg Indicator Value results significantly different for light (L) and soil reaction (R) (ANOVA $p<0.01$, Tukey's Test *letter* for significance between groups $p<0.05$). The clusters show the following values: L=3.5*a* R=5.1*a* in cluster I (pure *Fagus sylvatica*), L=3,5*a* R=4.7*ab* in cluster II (*F. sylvatica*, *Abies alba* and, occasionally *Picea abies* mixed stand) and L=4*b* R=2.8*b* in cluster III (*P. abies* dominant). Multi-level pattern analysis (indispecies package, R cran) showed species-site group association with *Actea spicata, Cardamine trifolia* and *Fagus sylvatica* in cluster I and II, differing only for the *A. alba* presence in cluster II. Considering other diagnostics species (Poldini et Nardini, 1993) such as *Cardamine pentaphylla, Saxifraga rotundifolia, Petasites albus*, probably cluster I and II are two *facies* of the same coenosis, referable to *Cardamini pentaphyllae-Fagetum* (Mayer et Hofmann 1969). Slightly different in terms of soil reaction, the first *facies* spreads on the upper belt and the second ones on the north-west slope (1100-1500 m a.s.l.). The cluster III, significantly associated to *P. abies, Phegopteris connectilis, Ranunculus lanuginosus, Senecio ovatus* showed more open canopy and acidic soil reaction: these are the *P. abies* forest of the Cansiglio plane (900-1000 m a.s.l.). In order to protect the gaps from grazing, 18 of them will be protected by electric fences while for the remaining 7 it was decided to use wooden

fences. In addition to flora every spring-summer in the gaps will be monitored flying insects, birds and bats. The *ex post* survey will be carried out in 2026.
Change in herbaceous species, difference between electric and wooden fences and relations between plants and animal species responses will be investigated.

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Which alien plant species are invading the Mediterranean mountains habitats? A case study in Gran Sasso massif

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Keywords: IAPs, Italy, altitudinal gradient, soil temperatures, EUNIS habitats

The Invasive Alien Plants (IAPs) are a growing threat to biodiversity, causing significant ecological losses, especially in Mediterranean mountain regions where it is a poorly known issue. In this context, in summer season 2022, the first monitoring site of the MIREN project (Haider et al, 2022) was established in Italy. The main objective is to investigate the occurrence and the distribution of IAPs along the altitudinal gradient in the Central Apennines. Vegetation was sampled along a road extending from 500 m a.s.l. to 2000 m a.s.l. in Gran Sasso massif (Italy), in 20 plots placed every 100 m of altitude. In each plot the cover of all vascular plant species was recorded. In addition, each vegetation plot was assigned to an EUNIS Habitat code, based on the species composition and cover (Chytry et al., 2020). Lastly, 10 sensors (iButton) were installed to measure soil temperature (Lembrechts et al., 2020).

Results highlighted that Gran Sasso massif is already affected by the processes of introduction and dispersion of IAPs, that currently were found until the beginning of the mountain beech forest. In particular, *Ailanthus altissima* reaches 1190 m a.s.l. and *Robinia pseudoacacia* 1144 m a.s.l., according with it was observed in other Mediterranean mountains (Vitasović-Kosić et al., 2020, Lapiedra et al., 2015). EUNIS habitats most affected by the IAPs spread were: "*Carpinus* and *Quercus* mesic deciduous forest" (EUNIS T1E) and "Deciduous self-sown forest of non-site-native trees" (EUNIS T1J). This last habitat showed a wider temperature range with high maximum temperatures during summer season 2022, in comparison with the other EUNIS forest habitats with native trees. This research established a new set of permanent plots for a long-term ecological monitoring of IAPs invasiveness in Mediterranean mountain habitats.

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Monitoring coastal dune vegetation in Abruzzo Region for nature conservation and management actions

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Keywords: dune plants, EUNIS habitat, EU habitat, Natura 2000 network, ecological guilds, Ellenberg indicators

Italian coastal environments and dune habitats modifications have been described by several authors (e.g. Del Vecchio et al., 2016; Pirone et al. 2014; Stanisci et al. 2014; de Francesco et al. 2022), specifically Adriatic coast is one of the most urbanized areas of the Mediterranean (Romano and Zullo 2014). At the end of the 1800s, the construction of the Adriatic railway changed the coastal landscape, causing the disappearance of numerous wooded areas and dune areas (Cianfraglione, 2014).
Afterwards, as a result of the explosion of tourism, an intense soil consumption began to take place and is still going on (Munafò, 2022).
Aim of this work is to identify a set of sites along the Abruzzo coast, inside and outside the Natura 2000 network and regional protected areas, where vegetation was analyzed and will be periodically monitored to analyze the ecological effects of land use and climate change, alien species invasion and coastal erosion. The data collected will also be useful for supporting the nature conservation and management actions implemented in the context of LIFE CALLIOPE project activities.
By aerial-photo interpretation, residual coastal vegetation patches were mapped and verified by vegetation sampling. The cover of all vascular plant species was recorded in 20 plots (2x2 m) and, after a cluster analysis, we classified the vegetation relevés in EUNIS and EU habitats. The ecological characteristics of each coastal dune habitat type were tested by comparing some ecological groups (e.g. diagnostic, alien and ruderal species) and Ellenberg bio-indicator values. Statistical analyses were performed in the R statistical computing program (R Core Team 2020).
Results highlighted that the residual shifting and transition dune plant communities host several ruderal and alien species, but when the perennial beach-grasses occur the diagnostic species cover is higher. We also

registered high Ellenberg nutrients values in transition and grey dunes vegetation, likely related to human trampling. The study provided useful insights for an array of actions to preserve the biodiversity of the Adriatic coastal dunes.

Acknowledgements: This research was supported by the LIFE17 NAT/IT/000565 CALLIOPE project, co-financied by European Commission.

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Mapping urban ecosystems in a small city of an Italian inner area

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Keywords: urban ecosystems, habitat mapping, Carta della Natura, biodiversity monitoring.

In the context of the PNRR National Biodiversity Future Centre project, a research task is oriented to increment knowledge on urban biodiversity in some Italian large and small cities, and to provide useful insights to protect and increase space for nature in cities. This will provide the increase of biodiversity connectivity, the mitigation of heatwaves, stormwater in flood events, as well as vital recreational space to support the mental, physical and social wellbeing of local residents (van den Bosch et al. 2017).

The present work explores the potential of the "Carta della Natura" approach, an official document of knowledge and territorial planning in Italy which gives particular attention to the conservation and enhancement of the natural heritage (Cardillo et al., 2017), as a support for biodiversity monitoring and planning in urban areas.

We choose as a case study the city of Campobasso, a representative example of small cities widely widespread in Italian and European inner areas. We specifically developed a detailed habitat map (with a scale range of 1:5.000/1:10000) of the functional urban area of Campobasso municipality (Dijkstra *et al*., 2019), classified according to the new Carta della Natura scheme. The habitat map was created using as a baseline the Carta della Natura of Molise region (made at a coarser scale, 1:25.000), through interpretation of aerial and satellite imagery, supported by field data and literature review (Ceralli, Laureti, 2021, Paura *et al.*, 2010). The minimum mapping unit is of 3.000 square metres, with a minimum width of 10 metres.

We present preliminary results stressing the usefulness of the Carta della Natura project on urban contexts and show some examples evidencing the high potential of detailed mapping of habitat as a baseline for the assessment of urban biodiversity that can be implemented on several cities in Italy and Europe.

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Plant functional types of Mediterranean temporary ponds – towards a standardized assessment

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Keywords: Heterophylly, isoetid growth form, plant size, seed size, tolerance of flooding, vernal pools

Interpreting the functional diversity of plant communities and ecosystem functioning reflects the filtering role of abiotic and biotic factors. Therefore, functional types spectrum provides a powerful tool in ecosystem convergence studies. Our study aimed to identify plant functional types (PFTs) of Mediterranean temporary ponds (MTPs) and understand their relationship with the underlying environmental gradients, along the annual dynamics of MTPs. We asked: i) are diagnostic PFTs distinct from those of more terrestrial vegetation? ii) are diagnostic PFTs specific of different hydrological phases and vegetation belts of MTPs? iii) Which are the environmental drivers underpinning PFTs and the zonation of plant communities within MTPs? The study was conducted in the coastal plain of southwest Portugal between 2006 and 2008. Plant surveys were carried out in 9 well-preserved MTPs in early spring and late spring, in each vegetation belt with four-square-meter *relevés*. Ten plant traits easily measurable at the individual plant scale were registered, allowing for a rapid and cost-effective evaluation. Traits were characteristic of phenological states (e.g., germination, growth, reproduction) and presumably adaptive to habitat stress (e.g., presence of aerenchyma or heterophylly). We also quantified four plant attributes to complete the characterization of the functional groups: flowering time, position/relative depth, syntaxonomic status, and geographic affinity. Data were analysed using multivariate statistical methods. Results allowed identifying eight PFTs associated with different vegetation belts and hydrological phases of MTPs, clearly reflecting ecosystem functioning. The most significant plant traits were: hydrophylly, plant size, persistence, seed size, carbohydrate storage capacity, and presence of aerenchyma. Moreover, the environmental factor that drives plant communities in MTPs and its spectrum of PFTs is the hydroperiod. These results represent an important contribution for standardizing PFTs in different Mediterranean regions, with applications on the conservation status assessment of MTPs.

River zoning in the framework of the project "Nature-based solutions for the management of the Guadaíra river": study and prioritisation as a basis for ecological restoration.

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Keywords: river degradation, sewage impacts, restoration strategies.

The project "Nature-based solutions (NbS) for the management of the Guadaíra river" aims to improve conservation state of the Guadaíra basin, with a great diversity of natural, rural and urban or peri-urban landscapes, being the only connection between the foothills of the Betic mountain range, the estuary of the Guadalquivir river and Doñana (Andalusia), constituting an irreplaceable ecological corridor of main ecological importance. The high anthropogenic pressure in the area means that the quality of the water, the aquatic and riparian biota, as well as the river landscape itself, has deteriorated considerably. One of the objectives is to identify the areas of the basin that need, as a matter of priority, concrete measures for impact correction and restoration. A prerequisite of any environmental restoration project is knowing the critical areas where to concentrate actions to stop, and if possible reverse, ecological degradation as effectively as possible. To this end, the riverbed has been covered on foot, zoning, geo-referencing and classifying the main impacts on water, vegetation and animal life (mainly birds). An assessment was made of the state of conservation of the riverbank vegetation using the Riverbank Forest Quality Index (Munné *et al*., 2003), the physiographic structure of the basin, and the composition of plant species, which made it possible to identify the areas with special requirements for action. It is concluded that the most effective solutions would be: passive restoration using SbN for the purification of waste water in isolated population centres using artificial wetlands, reducing the pollutant load entering the Guadaíra River; active ecological restoration of the riverbanks, currently dominated by invasive alien species; Enclosure of vehicle access to the riverbed to reduce degradation of the riverbanks and solid waste pollution; and the recovery of riparian forests with native species, increasing biodiversity and resilience of the system; In summary, active ecological restoration and the implementation of NbS can improve water quality and protect the ecosystem of the Guadaíra river basin.

Acknowledgements: Research supported by the project Nature-based solutions for the management of the Guadaíra river, promoted by the ministry of Economic Transformation, Industry, Knowledge and University (Junta de Andalucía) under the ERDF Operational Programme 2014-2020. Thematic Objective 1 "Strengthening research, technological development and innovation" and the financial programming of the measure A1123060E0 "Research and innovation activities in public research centres and centres of competence, including networking".

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Integrating Ground-Based with Remote Sensing Data and Deep Learning Algorithm to Monitor of Endangered Oak Forest Habitats

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Keywords: Earth observation, habitat mapping, numerical methods, Natura 2000, remote sensing

Protecting forest communities like Pannonian-Balkanic turkey oak–sessile oak forests, Euro-Siberian steppic woods with *Quercus* spp., and Pannonic woods with *Quercus petraea* and *Carpinus betulus* are part of the Natura 2000 network and protected areas in Slovakia, and thus require proper identification and regular monitoring. These forests are dominated by *Quercus cerris* and *Quercus petraea* and form part of a large complex of oak forests in the hilly plains and foothills of SE and Central Europe. In this study, we combine ground-based data, vegetation databases, and remote sensing data to develop a new approach for monitoring these habitats using a specialized software called NaturaSat. Automatic segmentations were performed from points that represented the coordinates of phytosociological relevés and, in the case of areas supplemented using the databases, from the centre of a homogeneous area of forest strands.

Our goal was to test the feasibility of distinguishing similar forest habitats dominated by oaks based only on multispectral data from Sentinel-2. We achieved a training success rate of 97.6% using a deep learning algorithm called a natural numerical network. The result of the training was the creation of relevance maps, which result in the detection of new forest areas of the target habitats. These areas were subsequently verified in the field. This approach can be used to monitoring of selected habitats and tracking habitat changes over time. Our approach represents an innovative way to connect ground-based and remote sensing data and could significantly contribute to the preparation of documents and maps for nature conservation.

Acknowledgement: This research was financially supported by the projects APVV-19-0460 and VEGA 2/0119/19, VEGA 2/0097/22 and European Space Agency.

Side event

“Gathering of Natura 2000 Practitioners for the Restoration, Conservation and Management of Standing Freshwater Habitats”

The habitat 3170 in the Lazio Natura 2000 network: Distribution, characteristics, and perspectives

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Keywords: temporary ponds, *Isoëtes*, *Isoëto-Nanojuncetea*

Several knowledge gaps affect our understanding of the priority habitat 3170, as well as a lack of a common view on its ecological characteristics, indicator species and geographical distribution (Bagella, 2023). This habitat often includes communities of a few square meters, making extremely difficult estimating its spatial representativeness both on local and global scales. Furthermore, the cover data from the standard data forms of Natura 2000 network suggest the existence of huge interpretative gaps in Italy, and the distribution of this habitat outside protected areas is almost unknown at present. These issues must be solved to best respond to the new EU Biodiversity Strategy for 2030. To do this, we have launched a multidisciplinary study, including a GIS-based framework to identify the potential presence of the habitat, the analysis of water and sediment quality, and the evaluation of flora-vegetation and fauna (e.g., macrobenthos and amphibians), focusing on the Lazio region. Three different plant communities were described. The first one, typical of the deepest temporary pools, is characterized by *Isoëtes velata*, accompanied by *Juncus articulatus, Agrostis canina, Glyceria notata* and *Callitriche* ssp., and a rich set of macrobenthos and amphibians. The other two coenoses show the presence of iconic species of the *Isoëto-Nanojuncetea* class (*Isoëtes durei* and *I. histrix*), but are typical of two different, specific ecological setting. The first of these is undoubtedly to be assigned to habitat 3170 and colonizes small shallow temporary ponds, early drying, with *Cicendia filiformis, Isolepis cernua, Juncus* ssp., and *Lythrum hyssopifolia*, which in the spring period are replaced and/or implemented by species of *Stipo-Trachynetea*. The last community colonises minimal areas of a few dm^2 characterized by high levels of edaphic humidity during early Spring and a physiognomic dominance of bryophytes, where only *Isoëtes durei* and *I. histrix* are characteristic species of the *Isoëto-Nanojuncetea*. These “very shallow” temporary ponds do not allow the presence of macrobenthos and amphibians. These results represent an important step forward in defining

the distribution of habitat 3170 in the Lazio region, offering new perspective from a coenological, ecological and faunal point of view.

Acknowledgements: This research was supported by the La Sapienza University funding for scientific research - year 2022.

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Mediterranean Temporary Ponds in the face of global changes

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Keywords: global changes, hydrological regimes, plant traits

Mediterranean Temporary Ponds (MTPs) are among the most precious habitats in the
Mediterranean bioclimatic because they shelter rare and isolated organisms from different taxa and are included in Annex 1 of the HD under code 3170*. Nevertheless, their conservation is highly precarious to such an extent to be considered a disappearing ecosystem (Bagella, 2023).
Plants living in MTPs show specific strategies which make them capable of tolerating different flooding conditions and can survive dry periods thanks to seed bank in the sediments. However, drastic changes in the hydroperiod length and water availability due to climate changes could result in adverse impacts (Čížková et al., 2013). In this study, we evaluate the responses of vascular plants of MTPs to different hydrological regimes to identify those most sensitive to their variations. We performed field surveys in Sardinian (Italy) MTPs and indoor experiments. In the field, we analyzed the distribution of plant species along the three concentric belts typical of MTPs (central belt, intermediate belt and outer). In indoor experiments, we evaluated the effects of different hydrological regimes on the life cycle using soil core collection from three MTPs. Our results highlighted the relevance of a clear pattern within the ponds related of the hydroperiod length. Some key species, such as *Isoetes histrix*, *Laurentia gasparrini*, *Exaculum pusillum* and *Cicendia filiformis* revealed a clear distribution pattern along the three belts. Conversely, the indoor experiments showed that species, such as *Crassula vailantii*, can adapt the length of their life to the different hydrological conditions while others such as *Helosciadium crassipes*, *Middendorfia borysthenica*, *Ranunculus ophioglossifolius* fail to close the cycle with seed production if conditions are not favourable. Based on the results obtained, it will be possible to identify the species most sensitive to climate change to target the conservation efforts effectively.

Acknowledgements: This research was supported by the project Clip-on, Fondazione di Sardegna 2019

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Monitoring the Mediterranean temporary ponds plant species in the Natura 2000 sites of Palo Laziale and Foglino Woodlands, Lazio region, Italy

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Standing freshwater habitats are among Europe's less-known and most endangered ecosystems. Mediterranean temporary ponds (code 3170*) are peculiar environments determined by a characteristic alternation of desiccation and submergence phases. However, regardless of its priority conservation interest, this habitat is often under an "unfavourable-inadequate" (U1) or "unfavourable-bad" (U2) conservation status over the European countries. Habitat misidentification/misinterpretation is a widespread issue that, together with direct and indirect human-related pressures such as climate change, eutrophication, trampling, and inappropriate water and landscape management, complicates conservation efforts. LIFE PRIMED (LIFE17NAT/GR/000511), an EU-funded project, promoted an interdisciplinary and multi-scale study in the Natura 2000 sites of Bosco di Palo Laziale and Bosco di Foglino (Rome) to investigate the ecological interdependencies of a group of Mediterranean temporary ponds. Micro-scale field data collection, laboratory analysis and data processing tackled the habitat's biotic and abiotic domains. Vegetation structure and composition, soil chemical-physical properties, micro-terrain features characteristics and climate parameters were assessed and eventually used as predictors. Different habitat configurations were revealed in the two sample sites, with most of them having distinctive ecological patterns. Such an ecosystem-based approach was used to identify the habitat's ecological features and establish a baseline that was at the cornerstone for the design and sizing of the Project’s restoration and conservation actions. Its replication in similar contexts is advisable to allow conservation practitioners to face restoring and managing such twisted habitat types.

Plant functional types of Mediterranean temporary ponds – towards a standardized assessment

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Keywords: Heterophylly, isoetid growth form, plant size, seed size, tolerance of flooding, vernal pools

Interpreting the functional diversity of plant communities and ecosystem functioning reflects the filtering role of abiotic and biotic factors. Therefore, functional types spectrum provides a powerful tool in ecosystem convergence studies. Our study aimed to identify plant functional types (PFTs) of Mediterranean temporary ponds (MTPs) and understand their relationship with the underlying environmental gradients, along the annual dynamics of MTPs. We asked: i) are diagnostic PFTs distinct from those of more terrestrial vegetation? ii) are diagnostic PFTs specific of different hydrological phases and vegetation belts of MTPs? iii) Which are the environmental drivers underpinning PFTs and the zonation of plant communities within MTPs? The study was conducted in the coastal plain of southwest Portugal between 2006 and 2008. Plant surveys were carried out in 9 well-preserved MTPs in early spring and late spring, in each vegetation belt with four-square-meter *relevés*. Ten plant traits easily measurable at the individual plant scale were registered, allowing for a rapid and cost-effective evaluation. Traits were characteristic of phenological states (e.g., germination, growth, reproduction) and presumably adaptive to habitat stress (e.g., presence of aerenchyma or heterophylly). We also quantified four plant attributes to complete the characterization of the functional groups: flowering time, position/relative depth, syntaxonomic status, and geographic affinity. Data were analysed using multivariate statistical methods. Results allowed identifying eight PFTs associated with different vegetation belts and hydrological phases of MTPs, clearly reflecting ecosystem functioning. The most significant plant traits were: hydrophylly, plant size, persistence, seed size, carbohydrate storage capacity, and presence of aerenchyma. Moreover, the environmental factor that drives plant communities in MTPs and its spectrum of PFTs is the hydroperiod. These results represent an important contribution for standardizing PFTs in different Mediterranean regions, with applications on the conservation status assessment of MTPs.

What's behind the criteria for the designation of Mediterranean Temporary Ponds (3170*)? The embarrasing case of the Doñana temporary ponds

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Keywords: Doñana temporary ponds, wetlands, ground water, conservation

The Doñana region (SW Spain) covers nearly 3000 km^2 and extends along the Atlantic coast from the estuary of the Tinto river to that of the Guadalquivir river, and inland from the coastline to the Guadiamar river valley. It shelters one the most important wetland areas in Europe and gathers an impressive record of biodiversity which is partly inherited from its unique location on the path between two continents, and partly from a glorious past as a true wilderness during centuries. Nearly 40% of this region is under specific protection plans. The Doñana National Park is a UNESCO World Heritage Site, a Biosphere Reserve, and a Ramsar Site though it has remained on the Montreux Record of Ramsar Sites under threat since 1990. Wetlands are located on both protected and non-protected areas, as well as on the two main geomorphological units, the silty-clay floodplain (marshland), and the aeolian sand systems (mobile and stable dunes). Amid the dunes, depressions of any size and depth are eventually flooded, sometimes after decades, when the water-table rises over the surface during heavy rainy periods. Unlike lagoons, the Doñana ponds have no surface or groundwater connection to the sea though they have some oceanic influence from airborne sea salt deposition. Collectively, this network of groundwater-fed ponds can gather over 3,000 temporary water bodies of extraordinary importance for amphibians, macroinvertebrates, and aquatic macrophytes.

In 2017, a high-ranking technical official reported to the police some irregularities concerning a major reduction in the number of temporary water bodies to be designated as 3170* by the administrative authorities of the National Park. A judicial investigation was open in 2020, and although the magistrate has recently shelved the case, the investigation has unravelled the implication of some park management officials with a ring of spurious uses of these ponds for cattle rising within the Doñana protected areas.

Monitoring 3170* Mediterranean Temporary Ponds habitats in Southeastern France to identify impacts of global change

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Keywords: Mediterranean, ponds, global change, southeastern France, RESEDA-Flore

Temporary ponds are considered to be one of the most typical habitats found in the mediterranean region. Species found in those ecosystems fit the mediterranean climatic and environmental conditions. Despite sharing common ecological characteristics, temporary ponds can be diversified, and display a variety of species. They are also among the most vulnerable habitats in the mediterranean region, as they are relatively small and particularily sensitive to disturbances. They are all the more threatened that the french mediterranean area is subjected to many types of threats and pressures, such as tourism and artificialization. The richness of these habitats and their vulnerability led to their integration in the natural habitat types of community interest list in Annex I of the "habitat directive". As part of the first program of the RESEDA-Flore network, a monitoring of ten different sites with around 20 mediterranean temporary ponds was initiated by the CBNMed and a monitoring protocol was finalized in 2021. The monitoring aims to study the evolution of several indicators of global change on the habitat including hydroperiod, water levels and floristic composition. A first set of data was collected in 2022. Results indicate that 2022 was a relatively dry year. Floristic composition can be linked to local perturbations and environmental conditions.

Acknowledgements: This work was supported by the Prince Albert II *of* Monaco Foundation, the *Ministère de la Transition écologique et de la Cohésion des territories* and the Provence-Alpes-Côte d'Azur region.

Linked reference:

TURPIN,L. ; DIADEMA,K. ; LALANNE,A. ; LE BERRE,M. ; PAPUGA,G. ; ARGAGNON,O. *Prioritization of natural habitats: a methodological framework applied to the French Mediterranean*. Journal for nature conservation 67(3) : 126185

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