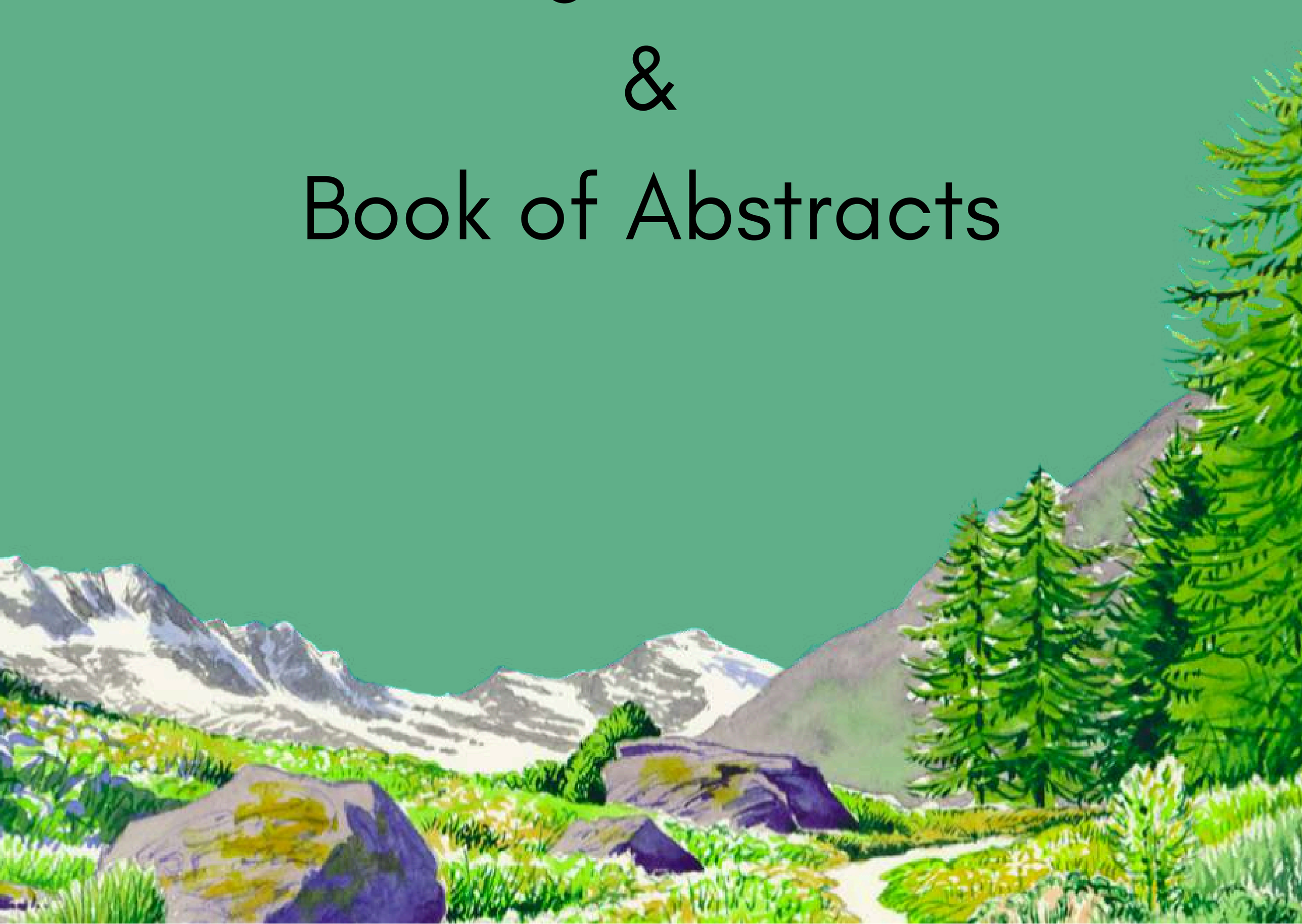
Région Autonome Vallée d'Aoste
Regione Autonoma Valle d'Aosta

PARCO NAZIONALE GRAN PARADISO

BioMA
Biodiversity Monitoring Association

ALPINE FLORA: BIODIVERSITY AND CONSERVATION

Programme & Book of Abstracts



SESSIONS

Ecology and climate change

Conservation and management of Alpine species

Event: 6th June 2025 - Cogne Town Hall, Via Bourgeois 38 - 8:15 am

ALPINE FLORA: BIODIVERSITY AND CONSERVATION

Scientific conference – Programme

9.00 - 9.15 **Eusebio Bergò S. – University of Torino**
Comparison of large-scale and habitat-specific approaches to assess long-term vegetation dynamics in alpine grasslands

9.15 - 9.30 **Testolin R. – University of Bologna**
GLOBALP: A Global Database of Alpine Vegetation

9.30 - 9.45 **Di Musciano M. – University of L'Aquila**
Beneath the surface: soil temperature as a driver of plant community changes in mountain ecosystems

9:45 - 10.00 **Angelini L. – MUSE – Science Museum in Trento**
Hay meadows as conservation priorities: resampling alpine meadow diversity after 10 years shows reduction in species-rich habitats

10.00 - 10.15 **Alexy R. – Alpine Ecology Lab, Grenoble Alpes University**
Did high-elevation summits serve as vegetation refugia during Pleistocene glaciations?

10.15 - 10.30 **Zemmer F. – Fondazione Edmund Mach**
Airborne pollen as an indicator of global change in Alpine ecosystems

10.30 - 11.00 **COFFEE BREAK**

11.00 - 11.15 **Tarascio M. – University of Pavia**
Long-term monitoring of flower production shows a decline in reproductive performance in cold adapted species at the southern edge of their distribution range

11.15 - 11.30 **Tognela M. – University of Pavia**
Trait-based insights into alpine plant responses to climate change

11.30 - 11.45 **Nascimbene J. – University of Bologna**
The lichen biota of the Dolomites in the face of climate change

11.45 - 12.00 **Brancaleoni L. – University of Ferrara**
Distribution of calcifuge and calcicole species in alpine grasslands of the western Alps. Effects of bedrock geology

12.00 - 12.15 **Pollo A. – University of Torino**
Rapid changes of Sphagnum-dominated mires in the Western Alps under climate change

12:15 - 12:30 **Perez M. – Italian Institute for Environmental Protection and Research (ISPRA)**
Bridging Satellites and Ground Truth for Future-Proof Habitat Monitoring

12.30 - 14.00 **LUNCH** (on your own)

14.00 - 14.15 **Mainetti A. – Gran Paradiso National Park**
Recent 5-years plant colonization in proglacial forelands has been faster than expected in GPNP

14.15 - 14.30 **Valle B. – University of Siena**
Studying glacial and periglacial moss flora: a taxonomic and functional approach

14.30 - 14.45 **Richiardi C. – ENEA, Saluggia (VC)**
Long-term habitat mapping in Gran Paradiso National Park (NW Italy): a remote sensing approach

14.45 - 15.00 **Doni L. – University of Genova**
Effects of climate change on the habitat suitability of grassland habitats in the Alps

15.00 - 15.15 **Adamo M. – University of Torino**
How much do we know about the genetics of plants endemic to the Alps?

15.15 - 15.30 **Guglielmo F. – Museo Regionale di Scienze Naturali della Valle d'Aosta Efisio Noussan**
SSR-based molecular markers to improve conservation strategies of *Astragalus alopecurus* Pall. in Aosta Valley

15.30 - 16.00 **COFFEE BREAK**

16.00 - 16.15 **Isocrono D. – University of Torino**
Lichen biodiversity and conservation in Aosta Valley

16.15 - 16.30 **Canella M. – Botanical Garden of Padova**
Linking functional traits and germination patterns in the steno-endemic *Saxifraga berica*

16.30 - 16.45 **Betuzzi F. – University of Genova**
Micromorphological and phytochemical diversity of different *Artemisia* species growing in the area of the Gran Paradiso National Park

16.45 - 17.00 **Azzolini S. – MUSE – Science Museum in Trento**
Ex situ and in situ conservation strategies for *Dracocephalum austriacum*

17.00 - 17.15 **Bonifazio C. – University of Genova**
Reproductive strategies and conservation of two SW Alps endemics

17.15 - 17.30 **Caccianiga M. – University of Milano**
Ex situ conservation and *in situ* monitoring of the endangered species *Dracocephalum austriacum* L. in Lombardy

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9:00 - 9:15 **Ecology and climate change**

Eusebio Bergò S.[1], Pollo A.[1], Oddi L.[1], Carollo G.[1], Siniscalco C.[1]

[1]University of Torino.

Comparison of large-scale and habitat-specific approaches to assess long-term vegetation dynamics in alpine grassland

The Alps are a biodiversity hotspot heavily impacted by climate and land-use changes. Monitoring species and ecosystem responses using past data is crucial for guiding conservation efforts.

We conducted a vegetation plot resurvey in the Gran Paradiso National Park to examine four decades of ecological changes in the alpine grasslands of the western Italian Alps. This is the first resurvey in the area, aiming to investigate: (1) variations in species diversity and composition, (2) changes in vegetation structure, and (3) grassland responses to environmental shifts.

Previous resurvey studies in the Alps have either analyzed alpine vegetation as a whole or distinguished vegetation types based on research goals. To assess whether these approaches yield similar or different insights, we examined the grasslands both collectively and by habitat type.

Vegetation data were classified into four habitats based on the EUNIS system. Snow-bed vegetation was the most affected, undergoing species composition, structural, and environmental changes leading to its transition into surrounding grasslands. Mountain hay meadows and acidophilous alpine grasslands showed encroachment by woody plants, while calcareous alpine grasslands remained the most stable.

Analyzing grasslands as a whole provided a broad perspective on vegetation trends but lacked the resolution to fully capture within-habitat dynamics. This highlights the importance of integrating broad-scale and habitat-specific analyses to better understand ongoing ecological transformations.

9:15 - 9:30 **Ecology and climate change**

Testolin R.

University of Bologna.

GLOBALP: A Global Database of Alpine Vegetation

The GLOBALP vegetation database (GIVD ID 00-00-007) is the first global collection of vegetation plots from alpine regions, with a particular focus on non-European mountains. Currently, it houses 2,796 records of a wide range of alpine vegetation formations, from North America (United States), South America (Peru), Africa (Tanzania, South Africa), Asia (Tajikistan, Kyrgyzstan, Nepal, Mongolia, Russia), and Oceania (Indonesian Papua, Papua New Guinea). Plot sizes range from 1 to 500 m^2, and geographic coordinates are recorded using GPS, estimated from maps, or based on localities, with varying levels of precision. The database includes both published and novel data, providing comprehensive coverage of zonal vascular vegetation above the natural climatic treeline. Each plot contains a full list of vascular plant species and their respective cover values. GLOBALP is part of sPlot - the largest repository for plant community data in the world - and is already contributing to research projects in biogeography, macroecology, and conservation biology.

9:30 - 9:45 **Ecology and climate change**

Di Musciano M.[1], Ricci L. [1], Theurillat J.P.[2], Cutini M.[3], Sabatini F[1]., Cangelmi G. [1], Frattaroli A.R.[1]

[1]University of L'Aquila; [2]Centre Alpien de Phytogéographie, [3]University of Roma Tre.

Beneath the Surface: Soil Temperature as a Driver of Plant Community Changes in Mountain Ecosystems

Alpine ecosystems are experiencing rapid transformations due to global warming, yet emerging evidence suggests that microclimatic conditions play a decisive role in re-shaping plant communities. Indeed, soil temperature and related variables have a strong influence on species growth and germination. In this study, we explore how belowground temperature influence plant community dynamics across an elevational gradient in the Central Apennines (Italy). We conducted vegetation surveys across 84 nested plots (from 2.25 cm^2 to 4 m^2) repeatedly over a 20-year period (2005–2025). Concurrently, we collected continuous soil temperature data from 40 dataloggers installed at 10 cm depth. From these measurements, we derived key climatic indicators (mean annual soil temperature, snow cover duration, length of the growing season, and cumulative growing degree days) and modelled them across the study area using boosted regression trees (BRT) using topographic variables (elevation, aspect, and wetness index) as environmental covariates. To quantify vegetation change, we applied trajectory analysis, and tested the influence of soil climatic variables on compositional changes. Our results reveal that the observed temporal patterns are scale-dependent: while the smallest plots display stochastic shifts, larger plots (≥0.25 m^2) show directional trends associated with specific microclimatic gradients. Notably, areas with extended snow cover and lower mean annual temperature exhibited the strongest community changes and a marked increase in species richness. These findings underscore the importance of microclimate in driving vegetation change in high-elevation ecosystems and highlight the susceptibility of cold-adapted plant assemblages to ongoing environmental changes.

9:45 - 10:00 **Ecology and climate change**

Angelini L.[1,] Salvatori M.[1]

[1]MUSE – Science Museum - Trento.

Hay meadows as conservation priorities: resampling alpine meadow diversity after 10 years shows reduction in species-rich habitats

Alpine valley floors have been increasingly subjected to infrastructure development and intensive agriculture -particularly orchard cultivation- with the concomitant reduction of extensive meadows, extremely rare remnants of the traditional landscape. Due to the elevation gradient of these processes, progressive landscape transformations are to date mainly concentrated in mid-elevation areas, where extensive grasslands still persist but are under threat of farming intensification and rapid land-use change. Given the ecological and landscape importance of open habitats-along with their high biodiversity and currently uncertain conservation status, it is essential to understand ongoing dynamics and guide their management towards conservation and, where possible, restoration.

In this study we assessed the changes of vegetation types within hay meadows in Trentino, southeastern Alps, by sampling 67 vegetation plots covering a total of 7.15 hectares during summer 2024. Surveys closely followed the cadastral framework and classification system of Scotton et al. (2012), allowing for direct comparison with data collected by the Fondazione Museo Civico di Rovereto between 2013 and 2015.

Our preliminary results indicate a marked decline in both the extent and ecological quality of species-rich meadows over the past decade. This trend is probably driven by an increase in nutrient-enriched conditions, leading to homogenization and biodiversity loss. The study contributes to a broader understanding of grassland transformation in Alpine regions and sets the stage for more detailed ecological analyses, including data on additional taxonomic groups.

10:00 - 10:15 **Ecology and climate change**

Alexy R.

Alpine Ecology Lab, Grenoble Alpes University.

Did high-elevation summits serve as vegetation refugia during Pleistocene glaciations ?

The European Alps were heavily glaciated during the Pleistocene, prompting debates about plants' glacial refugia. While most alpine vegetation likely survived in lower mountain ranges adjacent to or disconnected from the Alps, or in other European lowlands, a century-old alternative hypothesis suggests some plants persisted on rocky peaks protruding from ice-covered areas.

Such refugia would typically be located in the highest crystalline reliefs of the central continuous core of the alpine arc. While it has received some empirical support from both botanical and phylogeographic studies; this so-called "nunatak hypothesis", which posits that some plant species persisted in fragmented populations within heavily glaciated mountain areas for hundreds of thousands of years, remains a debated scenario of glacial refugia.

Therefore, we aimed to test whether alpine nunataks served as vegetation refugia through glacial periods, and to advance this debate by harnessing environmental niche modelling, phylogeography with spatially explicit demographic analyses, and integrating up-to-date paleo-geomorphological evidence of glacier cover, while giving a special focus on plant species that are strict specialists to high-elevation environments.

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10:15 - 10:30 **Ecology and climate change**

Zemmer F. [1,2], Cristofori A. [1,2], Cristofolini C. [1], Gottardini E. [1,2]

[1]Fondazione Edmund Mach, [2] National Biodiversity Future Centre.

Airborne pollen as an indicator of global change in Alpine ecosystems

Alpine protected sites are sanctuaries of biodiversity conservation. Yet, impacts of global change threaten ecosystem stability, making the detection of early signals of change critical for designing effective conservation strategies. Aerobiology offers a promising approach to indirectly assess impacts on plant communities and ecosystems.

In this study, airborne pollen was collected using Sigma-2 passive samplers across four protected Alpine sites in Trentino, northern Italy: Rifugio Val di Fumo (1906 m a.s.l., Parco Naturale Adamello-Brenta), Rifugio Altissimo (2057 m a.s.l., Parco Naturale Locale Monte Baldo), Rifugio Rosetta (2577 m a.s.l., Parco Naturale Paneveggio Pale di San Martino), and Rifugio Cevedale (2608 m a.s.l., Parco Nazionale dello Stelvio).

Pollen was morphologically identified using optical microscopy, supported by identification manuals and reference slides prepared from local flora. Vegetation was assessed at multiple spatial scales around each sampler. Pollen season metrics were analyzed to infer flowering phenology, while pollen taxa richness and abundance provided insights into biodiversity and pollen-plant relationships. By tracing the plant sources of airborne pollen, this approach may detect signals of environmental change across local, regional, and long-distance scales.

11:00 - 11:15 **Ecology and climate change**

Tarascio, M.[1] & Abeli, T.[1]

[1] University of Pavia.

Long-term monitoring of flower production shows a decline in reproductive performance in cold adapted species at the southern edge of their distribution range

Recent climate warming has significantly impacted alpine environments, with surface temperatures increasing faster than the global average. These changes are altering the phenology, physiology, and distribution of alpine plants, particularly at the species trailing range edge where plants are expected to face greater stress. This study investigates the effects of climate warming on three cold adapted plant species (*Leucanthemopsis alpina, Senecio incanus, and Viscaria alpina*), focusing on both phenological responses and plasticity at the southern boundary of their range in the northern Apennines (Italy). Using 20 years of data, we observed significant fluctuations in inflorescence production, influenced by mean summer temperature, precipitation and snow cover persistence, showing high phenotypic plasticity. Overall, the three species showed a stable trend of inflorescence production, during the monitoring period, despite yearly fluctuations. However, in the last 10 years, a significant decrease in flower production was observed. On one hand, the long-term stability of these populations is likely due to local adaptation to harsher conditions in the southern edge of their distribution range. On the other hand, the more recent decline indicates that climate change is exceeding the plasticity and adaptation potential of these populations.

11:15 - 11:30 **Ecology and climate change**

Tognela M.[1], Lodetti S.[1,] Porro F.[1], White F.G.[2], Saretto M.A.[3], Rossi G.[1], Mondoni A.[1]

[1]University of Pavia, [2]IGG Institute of Geosciences and Earth Resources, National Research Council of Italy, [3]Free University of Bozen-Bolzano.

Trait-based insights into alpine plant responses to climate change

The rate of temperature increase in European alpine environments exceeds the global average, posing a threat to alpine plant species adapted to low temperatures and short growing seasons. As a result, shifts in species distribution, phenology, and physiology of several alpine plants have been widely documented, with some species thriving under changing conditions while others declining or facing extinction. Understanding the underlying mechanisms that drive the resistance or the vulnerability of alpine flora is crucial for biodiversity conservation. In this context, functional ecology offers a powerful tool to assess plant population dynamic under climatic shifts. However, most studies rely on trait data from online databases, often overlooking the geographical and intraspecific variation.

In this study, we collected both vegetative and regenerative traits for 50 species exhibiting contrasting population dynamics in the Northern Apennines site of the GLORIA project, monitored by the Universities of Pavia and Parma since 2001. Our goal was to identify which traits - and their interactions - can predict alpine plants' response to climate change. To this end, we correlated the collected traits with the temporal species population dynamics occurred in the GLORIA Northern Apennines. Our results show that population dynamics of the last 20 years were significantly correlated to plant reproductive height, highlighting the key role of reproductive traits in shaping alpine plant assemblages in the near future.

This study is part of the SENTINEL project (The reSponsEs of italian mouNTaIN Ecosystems to cLimate change), funded by the Italian Ministry of University and Scientific Research (MUR).

11:30 - 11:45 **Ecology and climate change**

Nascimbene J.[1], Francesconi L.[1]

[1]University of Bologna.

The lichen biota of the Dolomites in the face of climate change: the Dolichens project

Mountain ecosystems are critically affected by climate change and many species that currently miss protection may face severe extinction risk. This is the case of poikilohydric organisms like lichens since their physiology is directly coupled to environmental conditions. Despite their relevant ecological roles and widespread use as bioindicators, lichens are often underrepresented in conservation policies, mostly due to insufficient data. The Dolomites are one of the lichenologically best-known areas in Italy. However, the data collected over the years were scattered in various sources, hampering their accessibility and use for research and conservation. The Dolichens project was launched to address this gap by aggregating over 77,000 occurrences spanning from 1820 to 2024 for 2071 infrageneric taxa, into an accessible online database (https://italic.units.it/dolichens). Targeted field surveys related to the Dolichens project have significantly contributed to covering previously unexplored areas, leading to the discovery of several species new to Italy, and even the science. This inventory provides a comprehensive resource for tracking lichen diversity in the Dolomites over two centuries and sets a basis for forthcoming taxonomic, biogeographical, and ecological studies. For example, untill now, we compiled the updated checklist of the lichenized fungi of the Paneveggio-Pale di San Martino Natural Park and used species distribution models to investigate range shifts of 272 lichens under different climate change scenarios. Results underscore the importance of repositories such as the Dolichens database, in tracking biodiversity, assessing ecological changes, and informing strategies to address the challenges posed by global change for vulnerable organisms like lichens.

11:45 - 12:00 **Ecology and climate change**

Brancaleoni L.[1], Cazzavillan A.[1], Marrocchino E.[1] & Gerdol R.[1]

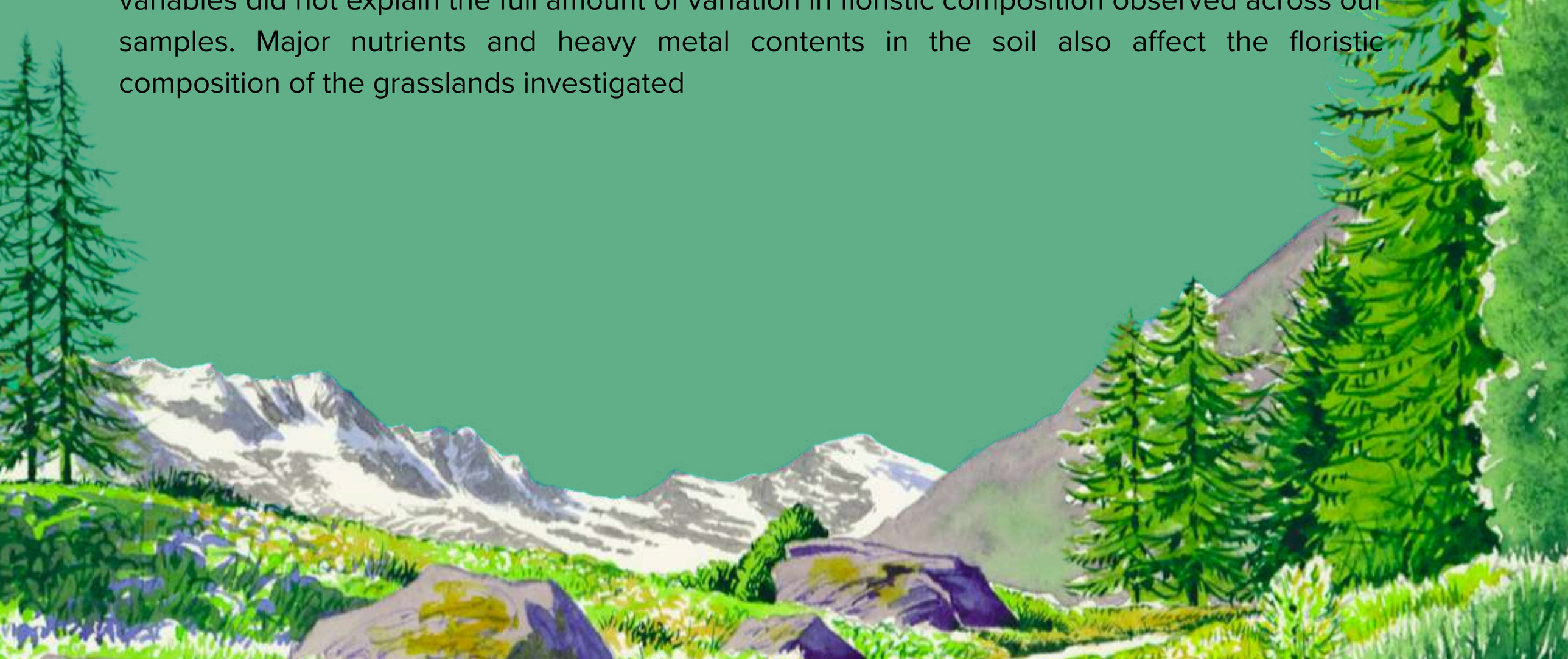
[1]University of Ferrara.

Distribution of calcifuge and calcicole species in alpine grasslands of the western Alps. Effects of bedrock geology

The seminal studies on alpine vegetation have mainly focused on compositional differences between alpine plant communities on calcareous rocks, hosting calcicole plant species and siliceous rocks, hosting calcifuge plant species. Calcicole plants are mostly found on sedimentary carbonate-rich rocks such as limestone and dolomite while calcifuge plants are mostly found on acidic crystalline rocks such as granite. Several mountain regions are geologically formed of a much wider range of bedrock types besides pure calcareous and pure siliceous bedrocks, including among others mafic-ultramafic rocks (commonly called serpentines), calcite-containing schists (commonly called calc-schists) and metamorphic rocks, the latter often showing strong variation in terms of protolith origin and hence geochemical composition. Most of these bedrock types present intermediate geochemical features between calcareous and siliceous bedrocks. Such petrographic variation can in turn affect soil chemistry and vegetation composition of plant communities settled on different bedrock types. This is especially the case of the Western Alps, since this sector of the Alps exhibits the by far largest petrographic variety across the whole Alpine chain.

We surveyed thirty sites across a vast area in the Western Alps, from Colle della Lombarda (Maritime Alps) to Tête de Ferret (Pennine Alps). These sites span the whole range of bedrock types occurring in the Western Alps: limestone, dolomite, calc-schist, slate, serpentine, mica-schist, gneiss and granite. At each site we sampled vegetation composition of alpine grasslands in three to seven 1 □1 m square plots, with 129 plots in total. All plots were located at 2500 ± 100 m above sea level, thus restricting the sampling area to the mid-alpine vegetation belt. At each plot we collected a bedrock sample from natural outcrops and a sample of about 100 g of top soil. Those samples served for determining (i) element concentrations in the bedrock; (ii) pH and concentrations of major nutrients in the soil, respectively.

Multivariate statistical analyses of compositional data, related to bedrock chemistry and soil chemistry revealed that CaCO3 and SiO2 concentrations in the bedrock as well as soil pH played the main role in driving compositional variation in alpine grasslands. However, these variables did not explain the full amount of variation in floristic composition observed across our samples. Major nutrients and heavy metal contents in the soil also affect the floristic composition of the grasslands investigated



12:00 - 12:15 **Ecology and climate change**

Pollo A.[1], Oddi L.[1], Eusebio Bergò S.[1], Piccini I.[2], Miserere L.[1], Buffa G.[1], Siniscalco M.[1]

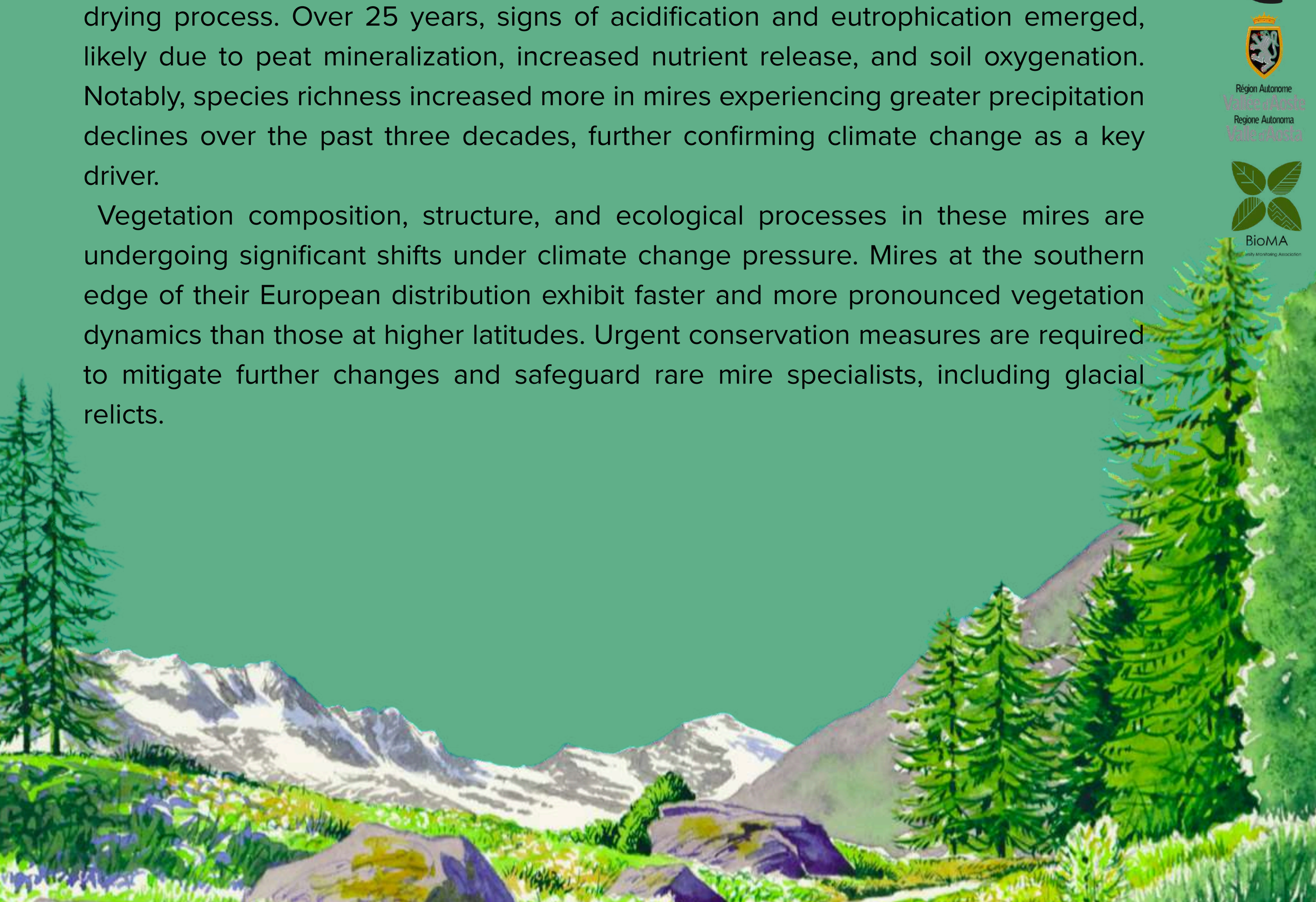
[1]University of Torino, [2]Poznań University of Life Sciences.

Rapid changes of Sphagnum-dominated mires in the Western Alps under climate change

Mires are essential habitats providing key ecosystem services such as carbon storage, water regulation, and biodiversity conservation. Although traditionally considered stable ecosystems with little floristic change over decades to millennia, climate change is driving rapid transformations. In the Alps, where mires are rare and particularly vulnerable, climate warming occurs at an accelerated rate compared to the global average.

This study investigated vegetation changes in Sphagnum-dominated mires in the Western Alps over one and two decades. A total of 139 plots across 14 sites were resurveyed, comparing historical data from 1998 and 2011 with new surveys conducted in 2023. Climate data analysis confirmed increasing air temperatures, decreasing precipitation, and rising evaporation. In response to these climatic trends, both shorter- and longer-term resurveys showed an increase in species richness and diversity, particularly among vascular plants. Woody and generalist species expanded, while mire specialists, including Sphagnum species, declined or became locally extinct, suggesting a lowering of the water table and an ongoing drying process. Over 25 years, signs of acidification and eutrophication emerged, likely due to peat mineralization, increased nutrient release, and soil oxygenation. Notably, species richness increased more in mires experiencing greater precipitation declines over the past three decades, further confirming climate change as a key driver.

Vegetation composition, structure, and ecological processes in these mires are undergoing significant shifts under climate change pressure. Mires at the southern edge of their European distribution exhibit faster and more pronounced vegetation dynamics than those at higher latitudes. Urgent conservation measures are required to mitigate further changes and safeguard rare mire specialists, including glacial relicts.



12:15 - 12:30 **Ecology and climate change**

Perez M.[1], Carli E.[1,] Agrillo E.[1], Alessi N.,[1] Casella L.[1], Cucca B.[1,] Marchetti G.[1,] Pezzarossa A.[1], Pretto F.[1], Angelini P.[1]

[1]Italian Institute for Environmental Protection and Research (ISPRA).

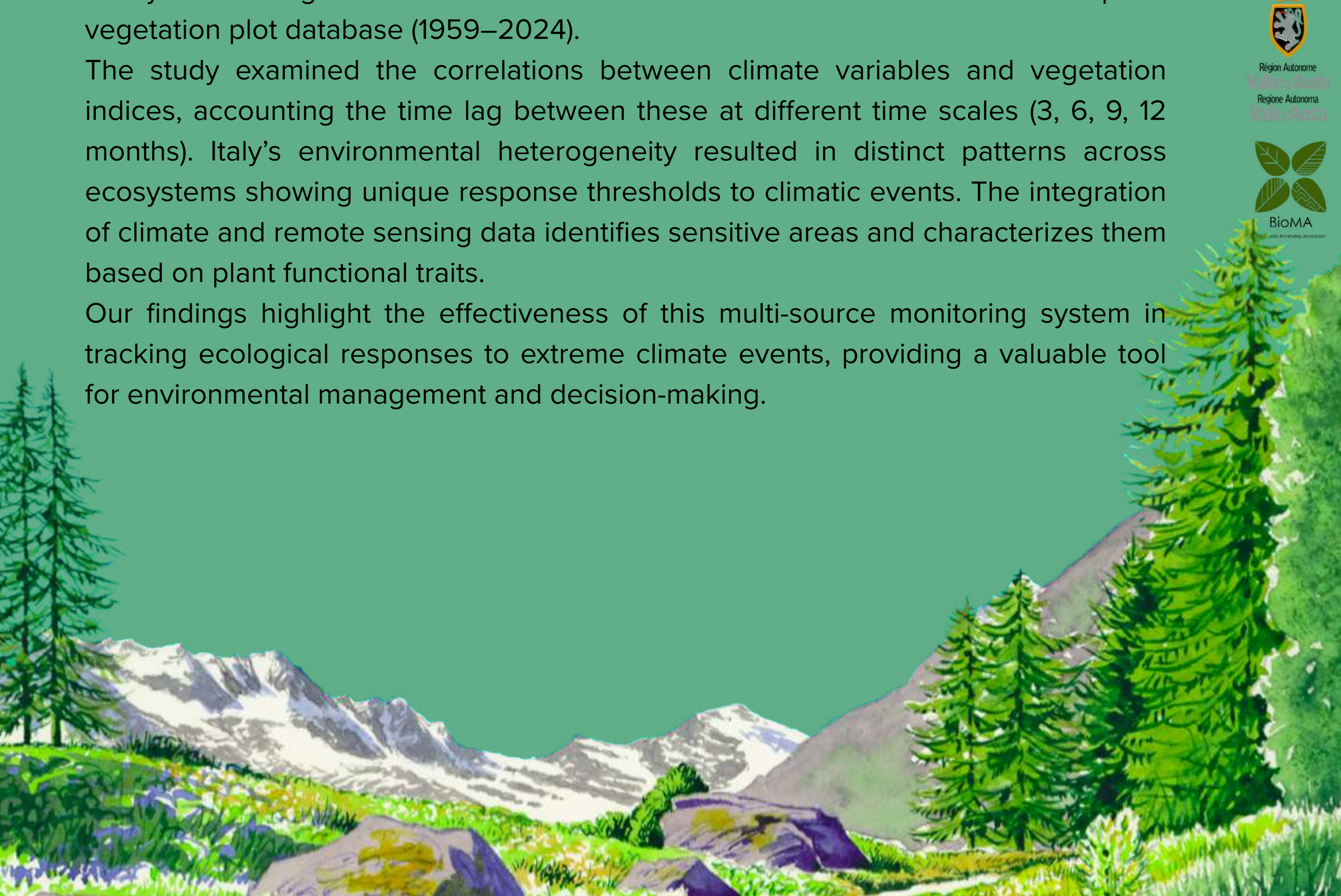
Bridging Satellites and Ground Truth for Future-Proof Habitat Monitoring

Climate anomalies (e.g., extreme drought and rising temperatures) have increased in frequency over recent decades, posing significant threats to habitat conservation and ecosystem stability. By analyzing the relationships between climatic variables (temperature, precipitation, and drought indicators), satellite-derived vegetation indices, and ground-truth vegetation data, we aim to provide key insights into how climate anomalies impact different habitat types. This approach helps identify spatial and temporal patterns of extreme event impacts on plant communities from a functional perspective.

As part of the PNRR DigitAP project, funded by MASE, this study supports local authorities in detecting areas most vulnerable to climate anomalies within Italian National Parks. To this end, ISPRA developed a biodiversity monitoring framework integrating climate data, vegetation indices, and field surveys. Climate anomalies were assessed using ISPRA's BIGBANG hydrological model (1952–2024). Vegetation indices were derived from MODIS and Sentinel-2, while CLC datasets analyzed ecosystem changes. Plant functional traits were extracted from a multi-temporal vegetation plot database (1959–2024).

The study examined the correlations between climate variables and vegetation indices, accounting the time lag between these at different time scales (3, 6, 9, 12 months). Italy's environmental heterogeneity resulted in distinct patterns across ecosystems showing unique response thresholds to climatic events. The integration of climate and remote sensing data identifies sensitive areas and characterizes them based on plant functional traits.

Our findings highlight the effectiveness of this multi-source monitoring system in tracking ecological responses to extreme climate events, providing a valuable tool for environmental management and decision-making.



14:00 - 14:15 Ecology and climate change

Mainetti A.[1], Nota G.[2], Lonati M.[2]

[1]Gran Paradiso National Park, [2]University of Torino.

Recent 5-years plant colonization in proglacial forelands has been faster than expected in GPNP

Proglacial vegetation communities are undergoing significant changes due to rapid glacier retreat and global warming, which may alter plant colonization patterns. This study investigates short-term vegetation changes in two alpine chronosequences in the Gran Paradiso National Park (north-western Italian Alps) and compares current vegetation trajectories with those predicted by the chronosequence approach. We re-surveyed permanent plots along the chronosequences (spanning 5 to 165 years from deglaciation) over a 5-year period. The number and cover of total, pioneer, and alpine grassland species were analyzed, and the slopes of the chronosequence and permanent plot trajectories were calculated.

The results showed an increase in the number and cover of total, pioneer, and grassland species over the 5-year study period, which was consistent with our expectations. However, we also observed a significant acceleration in plant colonization, with species richness and cover increasing 21 and 45 times faster, respectively, than predicted by the chronosequence. These dramatic changes in proglacial plant communities' vegetation dynamics are likely caused by the increased temperatures and longer growing seasons in the Alps.

These findings highlight the rapid response of proglacial vegetation to contemporary climate change, with plant colonization rates significantly exceeding those inferred from longer-term chronosequence data. The study emphasizes the importance of incorporating short-term monitoring data to accurately predict future vegetation changes in these dynamic alpine environments.

14:15 - 14:30 **Ecology and climate change**

Valle B.[1], Onelli E.[2] Moscatelli A.[2], Malvezzi L.[2,] Baccolo M.[2], Della Janna A.[2,] Gobbi M.[2], Ligi O.[3,] Maestrini C.[2], Roveda F.A.[2], Villa A.[2], Caccianiga M.[2]

[1]University of Siena, [2]University of Milano, [3] MUSE- Science Museum - Trento.

Studying glacial and periglacial moss flora: a taxonomic and functional approach

Glacial and periglacial environments represent highly selective ecosystems where bryophytes are among the main plant components; however, little is known about their occurrence on these landforms. This research investigates bryophyte biodiversity of two rock glaciers with contrasting lithology and a glacier foreland in the Italian Alps, to highlight their biodiversity and distribution. Qualitative work was performed on the two rock glaciers (Cima Uomo,Trento, on carbonatic bedrock; Lazaunkar, Bolzano, on crystalline bedrock) aiming at a comparison between the two rock glaciers and with the surrounding landforms. On the Sforzellina Glacier foreland (Sondrio) species composition at fine scale was analyzed along the young (> 30 years after deglaciation) glacier foreland. Our findings indicate differences in bryophyte assemblages between rock glaciers and glacier foreland, reflecting habitat-specific constraints and successional trajectories. Rare high-altitude species were found especially on crystalline bedrock, where the main colonizers are species producing bulbils like Pohlia filum.

The research includes also the development of a functional approach for mosses, aiming to assess their ecological strategies. A selected group of moss species from various habitats was analyzed using a starting set of 32 morpho-functional traits, including leaf and stem dimensions and specific plant area. Principal Component Analysis identified two major axes of variation —plant size and resource-use efficiency— paralleling functional dimensions observed in vascular plants.

This work provides new insights into the adaptive strategies of mosses in glacial settings. It also contributes to trait-based approaches for non-vascular plants, to better understand how bryophyte communities respond to environmental change in Alpine regions.

14:30 - 14:45 **Ecology and climate change**

Richiardi C.[1,2], Siniscalco C.[2], Adamo M.[3]

[1]ENEA - Saluggia (VC), [2] University of Torino, [3]National Research Council (CNR), Institute of Atmospheric Pollution Research.

Long-term habitat mapping in Gran Paradiso National Park (NW Italy): a remote sensing approach

Conventional habitat mapping remains challenging for high resources needed, remote areas accessibility and, not last, not applicable to reconstruct long-term ecological dynamics. This study proposes a novel approach based on a hierarchical habitat classification framework, tailored to enable habitat monitoring using a single baseline map, such as those required under the Natura 2000 Directive, alongside freely accessible Landsat imagery and basic ancillary data (e.g., Digital Elevation Models). The methodology was applied across Gran Paradiso National Park (NW Italy), spanning 1985–2023. Seasonal composites were created for both the growing and senescence periods using an enhanced Best Available Pixel approach, which incorporated terrain correction and cloud masking. Pure pixels, statistically identified from the baseline map, enabled the creation of a robust training set used in a Random Forest classification to generate hierarchical habitat and land cover maps annually. Validation against high-resolution maps confirmed the method's robustness. It supports fine-scale monitoring of habitat transitions, even in data-scarce alpine contexts. Key findings include a steady decline in grasslands (–10 ha/year) and a corresponding increase in shrublands (+10 ha/year) and rocky habitats (+8.6 ha/year), trends relevant to climate-driven vegetation shifts and land-use legacies. This approach is especially suitable for large habitats where changes are gradual, making it ideal for protected areas. It offers a cost-effective, scalable solution for long-term biodiversity monitoring. Future applications could expand to diverse landscapes and incorporate deep learning or multi-source remote sensing.

14:45 - 15:00 **Ecology and climate change**

Doni. L[1], Biffoni G.[1,] Guerrina M.[1], Rota F.[2], Casazza G.[1]

[1]University of Genova, [2]Swiss Federal Institute for Forest, Snow, and Landscape Research WSL.

Effects of climate change on the habitat suitability of grassland habitats in the Alps

The European Alps are characterised by an exceptional variety of habitats. Among these, grasslands are a hotspot of biodiversity supporting highly diverse and often specialized flora. However, ongoing climatic changes towards warmer temperatures are inducing changes to suitable habitat conditions for biodiversity. Consequently, mountain grasslands are envisioned to be particularly vulnerable to a warming climate where many species may need to migrate to survive to such changes. The aim of our study is to predict changes in habitat suitability of grasslands habitats (Annex I, 92/44/EEC), namely 6110*,6210(*), 6230*, 6240*, where we expect their distribution boundaries to differently decrease, shift or increase across different regions in the Alps. We used point-data of diagnostic species of each habitat (GBIF), 19 bioclimatic variables for current (1981-2010) and future (2071-2100) time periods (CHELSA), 6 soil variables (SoilGrid) and the topographic roughness index (DEM). For model predictions, we used the above data to run five different species distribution model (SDMs) techniques (GLM, GBM, ANN, FDA, MARS) to account for model-based uncertainties. Our results confirm shift in habitat suitability for thermophilous habitats (6110*, 6210(*)) gaining range in Central and Eastern Alps whereas they lose it in the Southern Alps. We detected instead a decreased for habitats composed by species more adapted to colder climates (6230*) only gaining range in the Northern and Central Alps. Ultimately, we observed a loss in habitat suitability for xerophilous habitat (6240*) across the Alps possibly caused by changes in the precipitation regimes which intensively affect its current restricted range of distribution.

15:00 - 15:15 **Conservation and management of Alpine species**

Adamo M.[1], Boria S. V.[1], Dexter G. K.[1], Mucciarelli M.[1]

[1]University of Torino.

How much do we know about the genetics of plants endemic to the Alps?

Biodiversity loss, accelerated by increasing land use and climate change, poses critical ecological, economic, and societal challenges. Genetic diversity, a cornerstone of biodiversity, is pivotal for adaptation and long-term survival of species. However, the implementation of this diversity in conservation efforts remains largely underestimated compared to ecosystem and species diversity. This study is an attempt to assess the current state of genetic research on endemic plants of the European Alps. This biodiversity hotspot has unique taxa confined to a small geographic range. Using the Web of Science database, 689 studies on Alpine endemic plants were selected for focusing on topics encompassing phylogeny, cytogenetics, and population genetics. Only one-third of these studies directly address conservation goals. A Genetic Monitoring Effort Index (GMEi) was applied to assess the coverage of the topic and to highlight principal trends. This survey has revealed that recent advancements in genetic techniques, such as high-throughput sequencing, have allowed much information of importance in conservation biology. However, genetic studies are still limited by high costs and the need of specialized expertise. Results indicate an urgent need to study genetics of alpine endemic flora in more detail, particularly for species with limited available data, to bridge gaps in knowledge and inform conservation strategies. A coordinated effort to integrate genetic insights into conservation planning, supported by enhanced research incentives and interdisciplinary collaboration, is essential to preserve this invaluable floristic heritage

15:15- 15:30 **Conservation and management of Alpine species**

Guglielmo F.[1], Chabloz J.[1] Tutino S.[1], Mainetti A.[2], Comino C.[3], Portis E.[3]

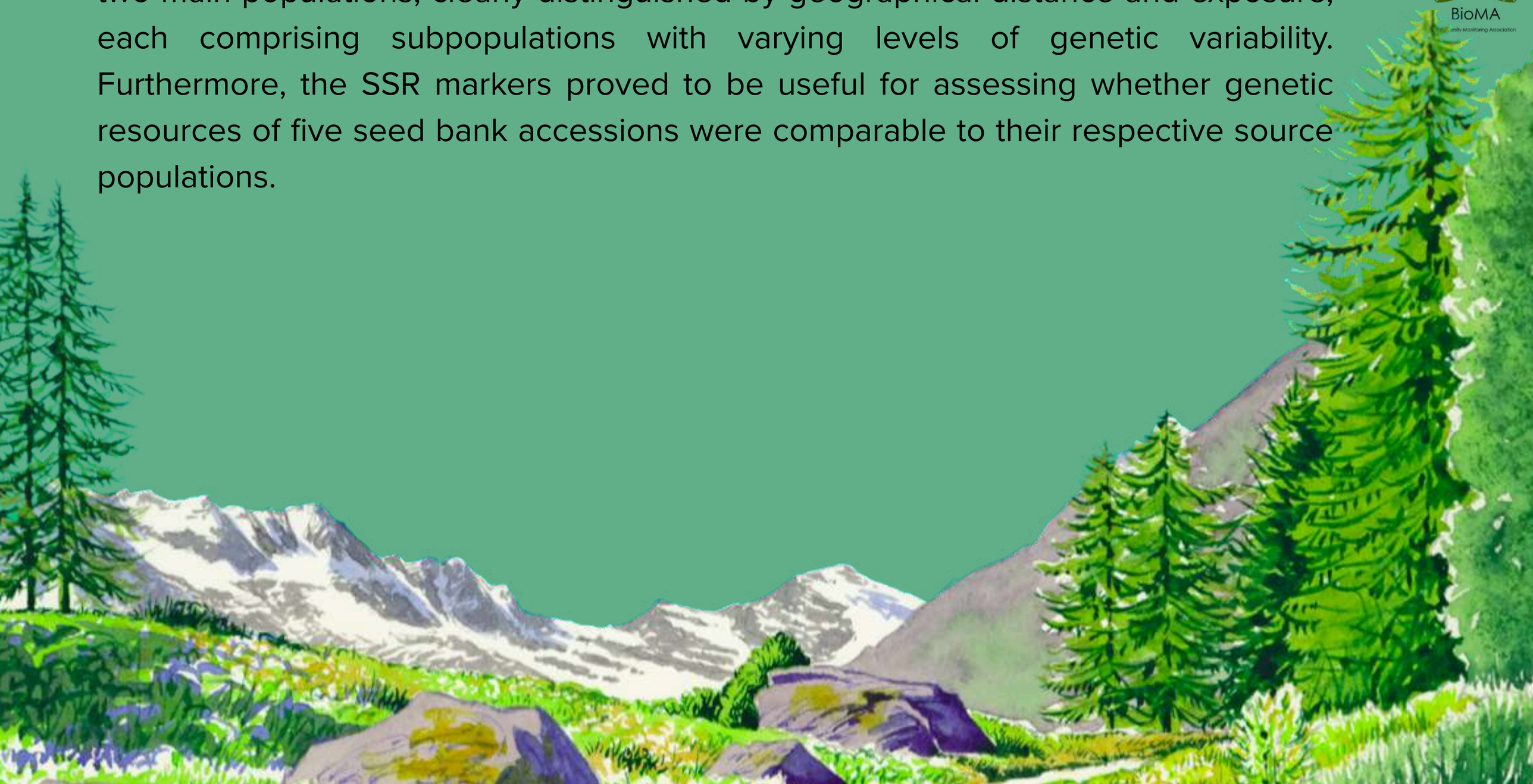
[1]Efisio Noussan regional Museum of natural Sciences, [2]Gran Paradiso National Park, [3]University of Torino.

SSR-based molecular markers to improve conservation strategies of *Astragalus alopecurus* Pall. in Aosta Valley

Astragalus alopecurus (Fabaceae) is one of the most emblematic wild plant species of Aosta Valley, since its impressive aspect, historical reputation, biogeographical characteristics as well as its rarity. Indeed, this perennial species occurs rather restrictively in temperate Asia and in Southern Europe, where its distribution is mainly limited to the Western Alps with several fragmented sites in Italy, exclusively in Aosta Valley, and in France, i.e. Hautes-Alpes and Alpes-de-Haute-Provence. As a species of relevant conservation interest, A. alopecurus is listed in Annex II and IV of the Habitats Directive 92/43/EEC as well as in Appendix I of Bern Convention. Although in Aosta Valley A. alopecurus is a strictly protected plant species, a deeper knowledge of its genetic variability and population structure is essential to guide effective in situ and ex situ conservation actions.

This study aimed at developing SSR-based molecular markers for *A. alopecurus* characterization to be applied for (i) population genetic studies in natural habitats and (ii) investigation on genetic resources within ex situ conserved accessions.

Starting from 4.172 reads obtained through a partial whole genome sequencing of A. alopecurus, 11 SSR markers were identified through in silico analysis and validated via PCR, then optimized for multiplex-PCRs. This molecular protocol was applied to 78 individuals collected from 11 sites of Aosta Valley and three outgroup samples from Hautes-Alpes. A total of 88 alleles were detected, revealing the presence of two main populations, clearly distinguished by geographical distance and exposure, each comprising subpopulations with varying levels of genetic variability. Furthermore, the SSR markers proved to be useful for assessing whether genetic resources of five seed bank accessions were comparable to their respective source populations.



16:00 - 16:15 **Conservation and management of Alpine species**

Isocrono D.[1] & Tania C.[2]

[1]University of Torino, [2]University of Brescia.

Lichen biodiversity and conservation in Aosta Valley: Exploring ecological patterns through an integrated dataset

Lichens are valuable bioindicators and key components of biodiversity, yet their distributional patterns at regional scales remain largely underexplored.

In this study, we present a comprehensive analysis of lichen biodiversity in the Aosta Valley (Northern Italy), based on a dataset of over 6,000 records derived from field sampling, herbarium collections, and literature. Each record documents the presence of a lichen species at a specific locality.

We integrated this dataset with a suite of environmental variables—including geomorphology, lithology, vegetation type, and topography—to explore spatial and ecological drivers of species richness and composition and highlight environmental gradients most strongly associated with lichen diversity.

Our results reveal significant correlations between substrate types, vegetation structure, and the distribution of sensitive or rare taxa, offering new insights into potential responses of lichens to landscape-level and environmental changes. This work underscores the importance of integrating historical and contemporary data to inform conservation strategies and improve our understanding of biodiversity patterns at regional scales.

16:15 - 16:30 **Conservation and management of Alpine species**

Canella M. [1,2,3], Natale S.[1,2], Boscariol V.[1,2,4], Pasinato A.[1], La Rocca N.[1,2], Dal Grande F.[1,2,3]

[1]University of Padova, [2] National Biodiversity Future Center, [3] Botanical Garden of Padova, [4]University of Palermo.

Linking Functional Traits and Germination Patterns in the Steno-Endemic *Saxifraga berica* (Bég.) D.A. Webb

Saxifraga berica (Bég.) D.A. Webb is a chasmophyte endemic to the Berici Hills (NE Italy), with a highly restricted distribution (ca. 20 sites, <1 km^2) and small population size (<1000 individuals), making it vulnerable to extinction. Understanding how functional traits relate to germination success is essential for the conservation of such narrow-ranged species. In this study, we explore the relationship between morpho-physiological and eco-physiological traits and germination performance in *S. berica*. Sixty individuals were sampled across six sites representing the species' microhabitat variability, including sun-exposed cliffs and shaded caves. We measured a suite of traits—leaf area, dry matter content, pigment concentration, seed morphology, and photosynthetic efficiency—directly in the field using portable devices, thus capturing the real-time physiological performance of plants in their native environment. This in-situ approach avoids artifacts common in controlled conditions and enhances ecological realism.

Seed germination (final germination % and mean germination time) was assessed under standardized conditions. Principal Component Analysis (PCA) revealed functional clusters of individuals differing significantly in germination behaviour. These results show that trait variability is ecologically meaningful and may reflect adaptive responses to local environmental conditions.

By linking germination patterns to functional traits, this study contributes to the quantitative modelling of ecological niches—an essential step for predicting species responses to environmental change and for designing science-based conservation actions. Our findings offer critical insights into the reproductive ecology of a threatened steno-endemic and support the development of targeted management strategies aimed at enhancing population resilience.

16:30 - 16:45 **Conservation and management of Alpine species**

Betuzzi F.[1], Malaspina P.[1], Mainetti A.[2], Polito F.[3], De Feo V.[3] and Cornara L.[1]

[1]University of Genova, [2]Gran Paradiso National Park, [3]University of Salerno.

Micromorphological and phytochemical diversity of different *Artemisia* species growing in the area of the Gran Paradiso National Park

The genus *Artemisia*, widespread in the temperate regions of the northern hemisphere, is characterized by high levels of polymorphism. The morphological and phytochemical diversity can promote adaptative mechanisms to cope with harsh climatic conditions such as drought, variations in temperature and high solar radiation.

The study of the micromorphological features and of the essential oils (EOs) composition can help distinguish between the different Artemisia species and highlight the adaptation of plants to different habitats.

In this work, we selected two *Artemisia* species (*A. chamaemelifolia* Vill. subsp. *chamaemelifolia*, *A. absinthium* L.), growing wild at high altitude in the valley of Cogne (Aosta, Italy). In Italy, *A. chamaemelifolia* is present only in Aosta Valley and Piedmont and it is included as “Near Threatened” in the Italian Red List. On the contrary, *A. absinthium* is diffused in all regions of Italy except Sicily and Sardinia.

The aim of our research was to investigate the micromorphology of the aerial portions of these species by light and scanning electron microscopy and to characterize their EOs by GC-MS. In addition, to evaluate how environmental conditions influence the phenotypic traits and the production of secondary metabolites, we compared the alpine *A. absinthium* with the same species collected in Southern Italy (Salerno, Italy) in the coastal area.

Overall, we observed that all *Artemisia* samples shared similar micromorphological features, with little differences concerning the abundance of covering trichomes and distribution of secretory tissues. On the contrary, the EO composition was significantly affected by both genotype and environmental factors.

16:45 - 17:00 **Conservation and management of Alpine species**

Azzolini S.[1], Parisi C.[1], Moret F.[1] , Bonomi C.[1]

[1]MUSE- Science Museum - Trento.

Ex situ and in situ conservation strategies for *Dracocephalum austriacum*: from germplasm collection to propagation and translocation into the wild.

One of the target species of the Life Seedforce project (LIFE20/NAT/IT/001468 - Using SEED banks to restore and reinFORCE the endangered native plants of Italy) is *Dracocephalum austriacum*. The goal of the project is to reverse the unfavorable conservation status of this species in Trentino through a series of ex situ and in situ conservation actions. These include seed collection, propagation of individuals in nurseries, habitat improvement actions, and the translocation of individuals into the wild.

Accurate census with reference to existing published data conducted during last spring using colored flags outlined that the existing populations were larger than expected. A detailed analysis of a single individual has made it possible to better understand the growth form of the species, which differs from what is reported in most publications.

The seedset of this species has been measured and rarely exceeded 20% so the species was short listed for a Trophic dependeces analisys: the first step was a assesment of the pollinators.

The Genetic diversity was also analysed in order to better understand the populations' heterozigosity levels and to more effectively plan translocations into the wild.

During the propagation activity, a process of trial and error led to the development of a detailed protocol for the ex situ propagation of this species, which will be valuable for future conservation efforts.

17:00 - 17:15 **Conservation and management of Alpine species**

Bonifazio C.[1], Briozzo I.[1], Casazza G.[1], Daglio S.A.[1], Franconi R.[1], Giugia D.[1], Guerrina M.[1], Longobardi M.[1], Minuto L.[1]

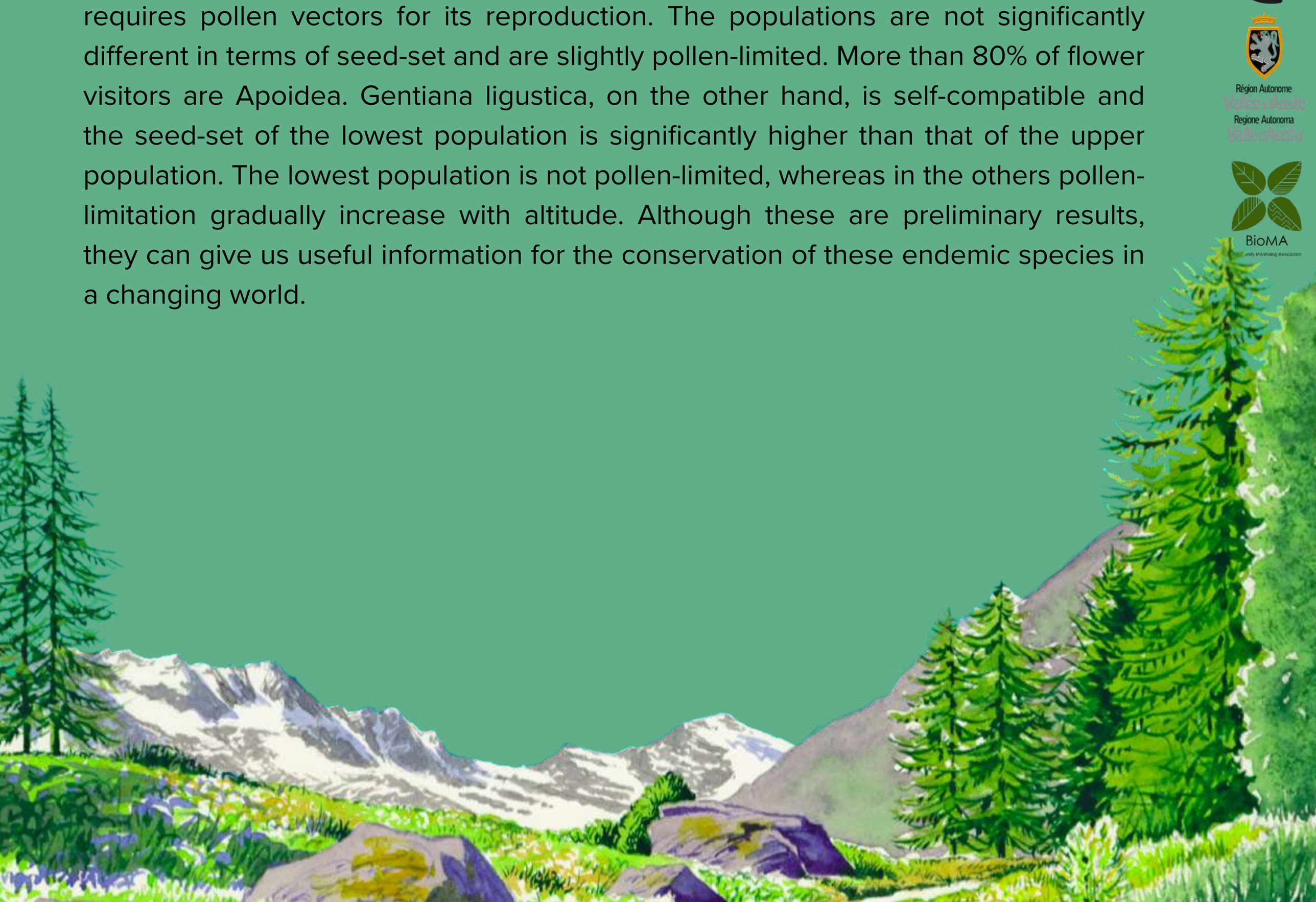
[1]University of Genova.

Reproductive strategies and conservation of two SW Alps endemics: *Campanula sabatia* De Not. and *Gentiana ligustica* R. Vilm. & Chopinet

Reproductive biology is a crucial aspect for the persistence of populations and its study is therefore of great relevance for conservation purposes. Special attention must be paid to endemic plant species, which today are increasingly at risk due to anthropogenic impact and climate change. As study species we chose Gentiana ligustica R. Wilm & Chopinet and Campanula sabatia De Not., two endemic species of SW Alps that occurr between the Alpine and Mediterranean biogeographical regions and are listed in the annex II and IV of the Habitat Directive.

For each species we selected three populations on an altitudinal gradient and tested the flowers for self-compatibility and pollen-limitation of the populations. Mature fruits were harvested and seeds were counted. Observations on flower visitors of C. sabatia were performed throughout the flowering period. Observations on flower visitors of G. ligustica will be carried out using cameras in the next flowering season.

Our results suggest that C. sabatia is a self-incompatible species and; consequently, requires pollen vectors for its reproduction. The populations are not significantly different in terms of seed-set and are slightly pollen-limited. More than 80% of flower visitors are Apoidea. Gentiana ligustica, on the other hand, is self-compatible and the seed-set of the lowest population is significantly higher than that of the upper population. The lowest population is not pollen-limited, whereas in the others pollen-limitation gradually increase with altitude. Although these are preliminary results, they can give us useful information for the conservation of these endemic species in a changing world.



17:15 - 17:30 **Conservation and management of Alpine species**

Beretta M.,[1] Mangili F.[1], Pozzi C.[1], **Caccianiga M.**[1]

[1]University of Milano.

Ex situ conservation and *in situ* monitoring of the endangered species *Dracocephalum austriacum* L. in Lombardy

Dracocephalum austriacum L. (Lamiaceae) is a rare species listed in the annex II of the EU Habitats Directive, linked to continental dry grasslands. In Italy is restricted to Lombardy, Trentino-Alto Adige, Piedmont and is endangered (EN) under the IUCN classification. Lombardy hosts only one population at Livigno (Sondrio).

Our research aims at the establishment of a protocol for its ex-situ reproduction and an evaluation of the status of the extant Lombardy population.

Four sowings were performed at the Città Studi Botanical Garden (Milan) in 2021-2024 with 207 achenes from plants already in cultivation from the Swiss population of Ardez, and 27 achenes from Livigno. Different treatments (with and without vernalization) and environmental conditions were employed. An overall 49% of germination rate for the Swiss provenance and 36% for the Livigno provenance were observed. Vernalization did not affect the germination rate, higher under heated conditions. Seedling mortality was higher for Livigno provenance (78,5% vs. 44%). Plants in cultivation flower readily and produce viable achenes.

Monitoring on the Livigno population recorded 60 individuals with only two blooming in 2020, and 90 individuals with 21 blooming in 2022; previously (2015) 119 individuals with 105 blooming were observed. Although no visible threat could be assessed, a decreasing seems to occur.

Our results are promising for the establishment of a cultivation protocol. The lower performance of the Livigno plants may indicate a lower reproductive success which, together with the scarcity of available wild individuals, may hinder from obtaining a satisfying number of individuals in cultivation.