BOOK OF ABSTRACTS

This Book of Abstracts provides a comprehensive overview of the session content and is structured into three main sections:

I. Session Description – an introduction to each session, including its objectives and expected outputs
II. Session Program – a detailed schedule for each session, including speakers and timing
III. List of Abstracts – a complete compilation of all accepted abstracts

I. SESSION DESCRIPTION

ID: B7

Ecosystem services in polar, boreal, and alpine regions: advancing knowledge for shared futures

Hosts:

	Name	Organisation	E-mail
Host (s):	Miguel Villoslada	University of Eastern Finland	miguel.villoslada@uef.fi
	Rositsa Yaneva	Forest Research Institute - Bulgarian Academy of Sciences	r.s.yaneva@gmail.com
Co-host(s):	Benjamin Burkhard	Leibniz University Hannover	burkhard@phygeo.uni-hannover.de
	Timo Kumpula	University of Eastern Finland	timo.kumpula@uef.fi
	Miglena Zhiyanski	Forest Research Institute – Bulgarian Academy of Sciences	miglena.zhiyanski@gmail.com
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Abstract:

Cold and polar regions - including the Arctic, Antarctic, sub-Antarctic, boreal, and high-altitude alpine ecosystems - are at the forefront of global environmental change. These landscapes face rapid warming, intensified human pressures, and socio-economic transformations, making them critical indicators of the planet's ecological health. Ecosystem services provide a vital lens to understand and support both ecological integrity and human wellbeing. However, cold regions remain underrepresented in science, policy, and decision-making, partly due to challenges in capturing seasonal dynamics, ecological shifts, and socio-cultural values.

This session is structured into two complementary sub-sessions:

- Sub-session 1: Nature-Based Solutions in Polar Regions

Focusing on the Arctic, Antarctic, and sub-Antarctic zones, this sub-session explores how nature-based solutions can protect biodiversity, enhance ecosystem resilience, and support human wellbeing. Discussions will address climate change impacts, fragile ecological balances, and strategies for securing the long-term provision of ecosystem services. Contributions highlighting the integration of scientific knowledge, policy initiatives, and global efforts are particularly welcome.

- Sub-session 2: Perspectives on Ecosystem Services in Boreal and Alpine Regions

This sub-session examines boreal and high-altitude alpine ecosystems, where climate change, resource use, and socio-economic transformations directly affect both nature and people. Presentations will showcase innovative approaches to assessing and managing ecosystem services, including advanced monitoring, modelling, and participatory knowledge co-production with Indigenous and local communities. Emphasis will be placed on pathways to strengthen resilience, equity, and inclusivity, and on lessons these regions offer for broader sustainability transitions.

Together, these sub-sessions provide an integrated perspective on ecosystem services in cold regions, fostering dialogue on bridging ecological processes, societal needs, and policy priorities to advance shared, nature-positive futures.

Goals and objectives of the session:

1. Understand the shared challenges faced by Arctic, boreal, and alpine ecosystems under accelerating environmental and socio-economic changes, and examine their implications for ecosystem services supply and use.
2. Map the state-of-the-art in ecosystem services knowledge across cold regions, highlighting advances in methodologies, interdisciplinary approaches, and emerging innovations to address data and knowledge gaps.
3. Explore pathways for resilience, equity, and inclusivity, identifying how ecosystem services perspectives can contribute to just and sustainable futures in cold regions while informing Europe's broader nature- and people-positive transition.
4. Present recent advances in polar ecosystems research and empirical evidence on ecosystem functions, resilience, and services.
5. Discuss how nature-based solutions can be applied to deliver ecological, social, and economic co-benefits in rapidly changing polar regions.

Planned output / Deliverables:

- Share experiences conducting ecosystem research under challenging polar conditions.
- Explore opportunities to leverage natural processes for ecological, social, and economic co-benefits.
- Identify knowledge gaps and synergies across national and international initiatives.
- Discuss frameworks for integrating ecological, social, and policy dimensions into research to maximize impact.
- Potential joint publication (TBD based on contributions).

Session format:

Standard and short presentations and scientific debate.

Related to ESP Working Group:

BWG 7 – Tundras / BWG 8 – Polar regions & High mountains

II. SESSION PROGRAM

Room: A1
Date of session: Thursday 21, May 2026
Time of session: 11:00 – 12:30

Timetable speakers:

Time	First name	Surname	Organization	Title of presentation
11:00 – 11:05	Miguel Rositsa Benjamin	Villoslada Yaneva Burkhard	University of Eastern Finland Bulgarian Academy of Sciences Leibniz University Hannover	Session introduction
11:05 – 11:15	Alexander	Störmer	Leibniz University Hannover	Zooming in on palsa wetland dynamics: recent developments revealed by high-resolution multi-sensor remote sensing
11:15 – 11:25	Federico	García Castro	University of Eastern Finland	Assessing the spatiotemporal dynamics of defoliation caused by the novel outbreaks of the common heath moth (*Ematurga atomaria*) in the Arctic tundra
11:25 – 11:35	Shriya	Adhikari	Indian Council of Forest Research and Education	Ecosystem Services and Conservation Significance of Taxus spp. in High-Elevation Montane and Sub-Alpine Himalayan Forests
11:35 – 11:45	Mathilde	Rebiffé	University of Eastern Finland	Capturing fine-scale fire severity patterns in low-intensity boreal surface fires using multi--scale remote sensing
11:45 – 11:55	Anindita	Debnath	Wildlife Institute of India	Spatio-temporal changes in alpine ecosystems and their impact on carbon storage: Indian Himalayan Region
11:55 – 12:05	Hristina	Prodanova	National Institute of Geophysics, Geodesy and Geography - Bulgarian Academy of Sciences (NIGGG-BAS)	GIS-based modelling of landscape patterns in mountain areas using climate indices and regression analysis
12:05 – 12:15	Laura	Malinauskaite	University of Iceland	Cryosphere's ecosystem services, disservices, and related indicators
12:15 – 12:25	Miguel	Villoslada	University of Eastern Finland	Ecosystem Services in the Arctic: A pathway for better integration into policy making, management, and research.

III. LIST OF ABSTRACTS

The first author is the presenting author unless indicated otherwise

1. Zooming in on palsa wetland dynamics: recent developments revealed by high-resolution multi-sensor remote sensing

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Palsas are permafrost-induced peat mounds that provide important ecosystem services in subarctic landscapes, including carbon storage, hydrological regulation, and habitat provision. As sensitive indicators of climate change, their degradation directly affects the capacity of palsa wetland ecosystems to deliver these services. However, palsas are small-scale landforms with complex microtopography, making their monitoring challenging for conventional satellite-based approaches. In this study, we investigate the microtopographic evolution of two degrading palsa sites in northern Finnish Lapland between 2022 and 2024 using a high-resolution multi-sensor remote sensing framework. Annual surveys were conducted with unmanned aerial systems (UAS) equipped with RGB and LiDAR sensors and complemented by terrestrial laser scanning (TLS). Structure-from-motion photogrammetry, airborne LiDAR, and TLS point clouds were processed into digital terrain models (DTMs) and validated using high-precision RTK-GNSS reference measurements. Active layer thickness (ALT) was measured in situ and combined with terrain data to derive spatially explicit estimates of ice core geometry. Our results show that palsa degradation has accelerated compared to previous observations, with pronounced volume and area losses at the larger site and more gradual, laterally dominated retreat at the smaller site. These changes are strongly controlled by microtopography, snow redistribution, and moisture dynamics. From a methodological perspective, we demonstrate that merging complementary remote sensing datasets significantly improves DTM accuracy in complex, actively degrading terrain, while single high-quality methods can be sufficient in shallow, low-relief settings. By resolving fine-scale degradation processes, this approach provides critical information on the loss of permafrost-related ecosystem services, such as long-term carbon storage and surface hydrological stability. Our findings underscore the importance of high-resolution, multi-sensor monitoring for linking permafrost degradation to ecosystem service dynamics, which is essential for assessing ecosystem stability in Arctic wetland environments and their implications for local communities.

***Keywords*:** permafrost, climate change, UAS, LiDAR, TLS

2. Assessing the spatiotemporal dynamics of defoliation caused by the novel outbreaks of the common heath moth (Ematurga atomaria) in the Arctic tundra

***First author*:** Federico García Castro
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Geometrid moth outbreaks are a well-known phenomenon in northern Fennoscandia, where widespread defoliation can lead to changes in ecosystems composition, and potentially ecosystem functioning. The study of these events is becoming increasingly relevant, especially considering that the current trends of environmental change point towards warming environments, which can lead to favorable conditions for the occurrence of outbreaks in the region. This is the case of the common heath moth (Ematurga atomaria), which has recently been reported to occur in outbreaks at the Pallas-Yllästunturi National Park in Finland, something that has not been reported or observed in the past. Here we assess and characterize how these novel outbreaks have developed over the past years at Ounastunturi in the north part of the National Park. This is achieved by using an upscaling approach, where plot data and imagery from an uncrewed aerial vehicle (UAV) are used to generate a model of predicted defoliation levels in the area. Furthermore, the resulting UAV-based model is used to train a satellite-based model which enables

the assessment of outbreak-related defoliation over larger spatial extents, as well as studying the phenomenon across different years, thus greatly improving our understanding of how these novel outbreaks are developing. Additionally, this method serves as a great example of how the advantages of UAV and satellite remote sensing can be integrated into a single study, using the UAV imagery as an intermediate transition point from the fine spatial resolution of plot data and the coarser spatial resolution provided by satellite imagery; while simultaneously taking advantage of the wide temporal availability satellite-based data. Ultimately, this leads to timely, relevant, and reliable spatiotemporal assessments of ecosystem condition in the Arctic tundra.

Keywords: Geometrid, Defoliation, Tundra, Remote sensing, Upscaling

3. Ecosystem Services and Conservation Significance of Taxus spp. in High-Elevation Montane and Sub-Alpine Himalayan Forests

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Taxus species are slow-growing conifers that occur primarily in high-elevation montane and subalpine forest ecosystems of the Himalayas, generally between approximately 1,800 and 3,300 m a.s.l. Although known for their pharmaceutical significance as sources of taxanes, Taxus-associated forest patches also contribute to a broad suite of ecosystem services that remain insufficiently represented in assessments of cold and high-altitude regions. Drawing on field observations, biodiversity ground-proofing surveys, and synthesis of existing ecological, genetic, and phytochemical literature, this contribution situates Taxus within an ecosystem services framework encompassing regulating, supporting, provisioning, and cultural values near the upper forest treeline. Forest cover in these landscapes plays an important role in slope stabilisation and erosion control, with montane forests generally exhibiting substantially lower surface erosion compared to degraded sites. High-elevation temperate and sub-alpine conifer forests further function as long-term carbon reservoirs, with aboveground biomass carbon stocks commonly reported within the range of ~80–150 Mg C ha^{-1}. Taxus-associated trees also support diverse understory communities, including a range of medicinal and culturally valued plant species, highlighting their importance for biodiversity conservation. Despite these contributions, natural regeneration of Taxus is frequently reported as limited, with low seedling densities linked to overexploitation, habitat disturbance, and increasing climatic stress near the forest–alpine transition. Such constraints pose risks to the long-term continuity of ecosystem functions and services in fragile mountain systems. The study emphasizes the need to move beyond species-focused conservation toward ecosystem services-based approaches that integrate sustainable management, nature-based solutions, and community participation to enhance resilience in high-elevation social–ecological systems under global environmental change.

Keywords: Taxus; sub-alpine forests; ecosystem services; Himalaya; high-elevation ecosystems

4. Capturing fine-scale fire severity patterns in low-intensity boreal surface fires using multi–-scale remote sensing

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Boreal forests provide essential ecosystem services, including carbon storage and climate regulation. Fire is a natural component of these key cold-region ecosystems, yet climate change is altering fire regimes, increasing the need for accurate spatial assessments of fire impacts on ecosystem functioning and resilience. In Finland, many fires are low-intensity surface fires that generate subtle, spatially heterogeneous burn patterns, particularly at the soil surface. However, widely used satellite-based fire severity indicators, like the differenced Normalized Burn Ratio (dNBR), implicitly assume homogeneous conditions within a pixel and may therefore fail to capture this fine-scale variability.
In this study, we investigate the extent to which conventional satellite-derived indices underestimate

within-pixel heterogeneity in boreal surface fires and explore a multi-scale UAV–satellite upscaling framework to address this limitation. We combine Sentinel-2 multispectral imagery with field-based observations at a prescribed burn site in eastern Finland to assess and classify fire severity using commonly applied indices. High-resolution UAV multispectral and LiDAR data are used to characterize fine-scale spectral and structural fire effects, including ground surface and canopy-level damage, and to quantify the variability present within individual satellite pixels assigned to standard severity classes. Preliminary results show that conventional satellite-derived indices classify most of the burned area within a narrow moderate severity range, while field observations reveal substantial spatial variability, particularly related to soil organic layer consumption. Early analyses indicate that this heterogeneity is largely unresolved at satellite resolution, highlighting limitations of conventional severity products for low-intensity surface fires. Ongoing work focuses on developing UAV-based models and testing approaches to upscale these fine-scale fire effects to satellite-compatible products.
By explicitly resolving within-pixel variability, we aim to improve fire severity mapping in boreal forests, supporting more accurate assessments of fire impacts on ecosystem resilience, soil processes, and ecosystem services, and informing forest management under a warming climate.

Keywords: Fire severity, Boreal forests, Prescribed fire, Remote sensing, Ecosystem resilience

5. Spatio-temporal changes in alpine ecosystems and their impact on carbon storage: Indian Himalayan Region

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Alpine and mountain ecosystems deliver essential ecosystem services, including freshwater regulation, carbon storage, biodiversity support, and cultural values, yet they are among the most climate-vulnerable systems globally. These high-elevation ecosystems harbour exceptional endemism and unique genetic resources, while supporting pastoral livelihoods, tourism, recreation, and culturally revered landscapes. The Himalaya hosts a vast and diverse alpine ecosystem network, playing a crucial role in climate change mitigation at both regional and global scales. However, high-elevation warming is accelerating glacier retreat, ecological shifts, reshaping hydrological regimes and species distributions. This study focuses on the Askot landscape in Pithoragarh district, Uttarakhand, India, spanning an elevation range of 600–6,500 meters and covering approximately 4,496 km². The alpine zone is characterized primarily by shrub-dominated communities, with small patches of Rhododendron spp. and high-altitude temperate scrubs and grasslands.
This study analyses alpine ecosystem dynamics and change in above-ground carbon storage. The year 1990 was used as the baseline for change analysis, and future land-cover dynamics were projected for 2050 using a Cellular Automata–Markov chain approach implemented in TerrSet (LiberaGIS). To assess the change in carbon stock, above-ground carbon value was compiled through meta-analysis and InVEST Carbon Storage & Sequestration model was used for further analysis.
The projected change between 1990 and 2050 indicated that the alpine region of the Askot landscape will reduce by -90.78 km2, raising serious concern for this fragile landscape. Above-ground carbon stocks are also projected to decline by about -8,781.12 megagrams of carbon (MgC), representing nearly a 10% reduction from baseline levels. Such declines in carbon storage imply the carbon potentially being released into the atmosphere and thereby exacerbating climate change impacts

Keywords: Above-ground carbon, InVEST, Climate change, TerrSet

6. GIS-based modelling of landscape patterns in mountain areas using climate indices and regression analysis

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The approach of defining landscape patterns based on climate indices is applied in a case study area in North-Central Bulgaria. The results proved the strong interrelation between the climate indices and the elevation, enabling the implementation of a regression model. The results of the regression are used to define threshold values for delineation of all potential contours based on climate indices. The GIS modelling enables the integration of the results from different indices for the delineation of landscape contours of five potential landscape types. Four of them are validated with higher precision, proving the approach's applicability. One of the main capacities of the proposed approach is the opportunity for reconstructing climax vegetation and furthermore, the climax ecosystems that form the matrix of the potential landscapes. This can significantly contribute to assessing ecosystems and their services for restoration measures and implementing nature-based solutions.

Keywords: Landscape type, Climax vegetation, Selyaninov hydro-thermal coefficient, de Martonne aridity index, Thornthwaite moisture index

7. Cryosphere's ecosystem services, disservices, and related indicators

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The cryosphere, which refers to the parts of the Earth's surface where water is in solid form, is a major contributor to human wellbeing through the provision of vital ecosystem services. These include, e.g., groundwater recharge, water storage and purification, climate regulation, and diverse cultural and spiritual benefits. A systematized classification of ecosystem services can be used to define, measure, and value the ways in which the cryosphere contributes to society and to communicate these benefits in a clear, transparent and scientifically sound way, yet, it has been missing to date. This study builds on previous literature exploring the cryosphere's positive and negative impacts on human wellbeing in the context of rapid climate change. It further organises this knowledge on a global scale with a view to enhancing scientific exploration and policy guidance, along with facilitating comparability between different studies. Our research applies the Search-Appraisal-Synthesis-Analysis (SALSA) literature review method and the Common International Classification of Ecosystem Services (CICES) to source and systemise the existing information on ecosystem services and disservices provided by the cryosphere, and possible indicators for monitoring their changes are identified. A total of 30 ecosystem services and 10 disservices were identified, together with indicators that could be used to monitor their trends in biophysical, economic, and sociocultural terms. Our research finds that the cryosphere continues to provide vital ecosystem services despite accelerated retreat of glaciers and other cryospheric components, but also an increasing amount of ecosystem disservices because of global climate change. Monitoring trends in the cryosphere's contributions to human wellbeing has the potential to inform adaptive governance in fast-changing cryospheric environments.

Keywords: Cryosphere; Ecosystem services; Ecosystem disservices; Nature's contributions to people; Ecosystem services indicators

8. Ecosystem Services in the Arctic: A pathway for better integration into policy making, management, and research

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Arctic ecosystems are undergoing unprecedented environmental and societal change driven by accelerated climate warming and expanding human activities. These transformations alter key ecological processes, reshape biodiversity, and directly affect the well-being, food security, and cultural heritage of Arctic Indigenous peoples and local communities. Despite the urgency of these changes, the ecosystem services (ES) concept—widely used in biodiversity conservation, land-use planning, and policy-making

elsewhere—remains underdeveloped in the Arctic. Only a small fraction of global ES assessments address Arctic systems, reflecting conceptual misconceptions and structural barriers to uptake.

We argue that an adapted ES framework can provide an essential bridge between science, policy, and Indigenous and local priorities in the North. We identify three reasons for the limited use of ES in the region: misunderstandings of ES as primarily monetary valuation; fragmented, multi-level Arctic governance that constrains policy integration; and existing ES frameworks that inadequately represent Arctic socio-ecological realities. Climate-driven ecological transitions, strong seasonal dynamics, and culturally embedded relationships with the land require Arctic-specific approaches to ES assessment.

Building on the MAES framework, we propose an Arctic-tailored approach that embeds Indigenous and Traditional Knowledge throughout the assessment process, adapts ES classifications to reflect Arctic-specific values and ecosystem functions, and incorporates seasonality and rapid ecological change. We highlight opportunities to improve governance uptake, including the role of Arctic Council bodies such as CAFF and AMAP in supporting co-developed ES initiatives, stronger collaboration with Indigenous rights-holders, and greater visibility of Arctic ES in science–policy platforms such as IPBES and in international accounting frameworks like the SEEA-EA. Integrating an ES lens into Arctic biodiversity research and decision-making is timely and necessary, and a co-developed, context-aware ES framework can support more inclusive science–policy–decision-making dialogues and contribute to more sustainable actions in a rapidly changing Arctic.

***Keywords*:** Arctic ecosystems; Ecosystem services; Indigenous and Traditional Knowledge; Climate change; Arctic governance