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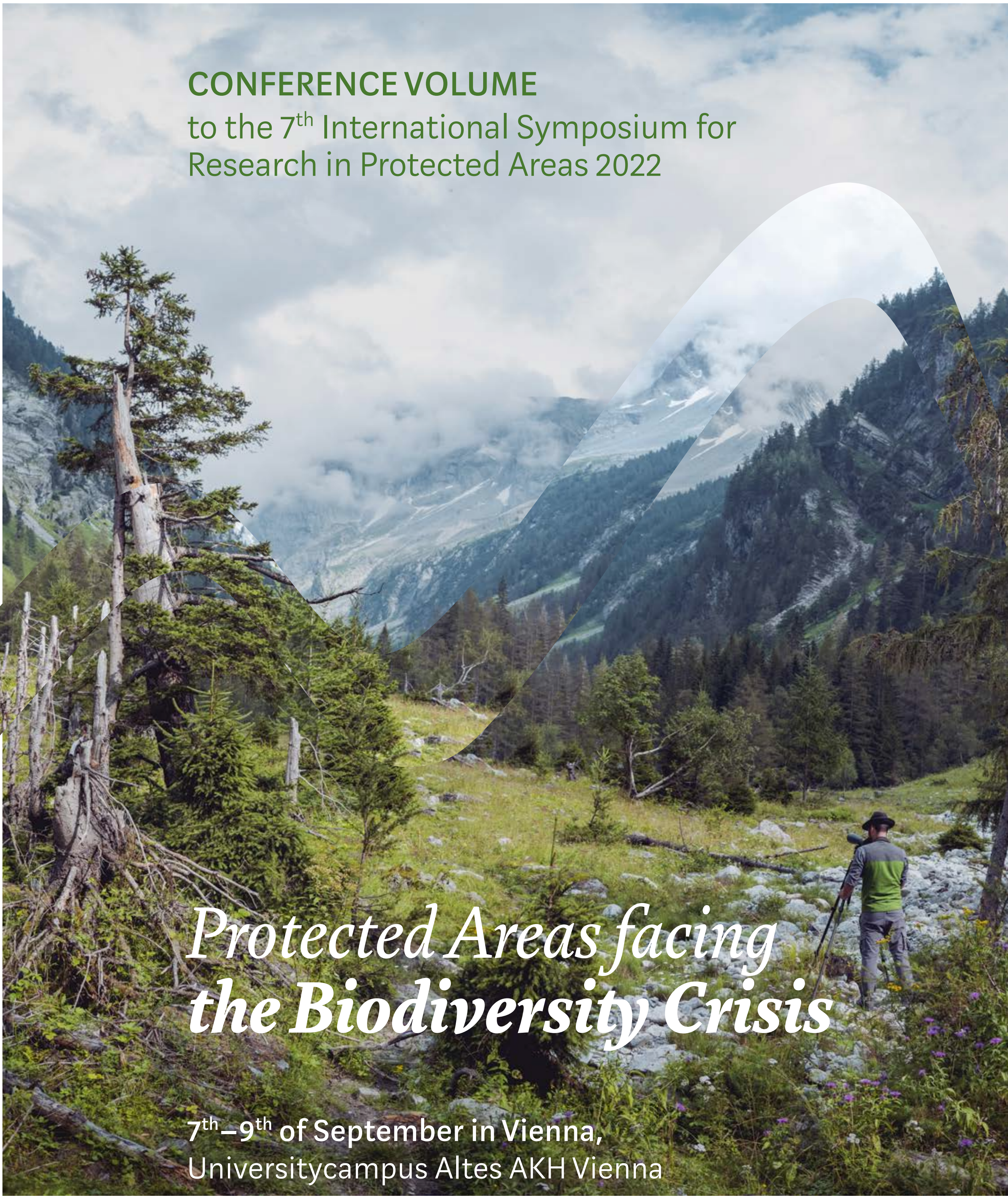
CONFERENCE VOLUME

to the 7th International Symposium for Research in Protected Areas 2022



Protected Areas facing ***the Biodiversity Crisis***

7th–9th of September in Vienna,
Universitycampus Altes AKH Vienna

Supported by the federal government and the European Union

Federal Ministry
Republic of Austria
Climate Action, Environment, Energy, Mobility, Innovation and Technology

LE 14-20
Entwicklung für den Ländlichen Raum

European Union
The European Agricultural Fund for Rural Development: Europe investing in rural areas.

Federal Minister
Leonore Gewessler, BA

Dear participants and dear readers,

In recent years, especially during times of a global pandemic, the importance of nature reserves as recreational areas for humans has significantly increased. However, the value of protected areas goes far beyond that. These treasures of nature are refuges for endangered species, play an important role in environmental education, and make a crucial contribution to the preservation of biodiversity through their research and management.

The scope of research in and about protected areas is correspondingly large. Research ranges from natural, environmental, and social sciences to new methods and technologies in nature conservation and the potential of participative approaches. We all need this broad, holistic view to face the biodiversity crisis as well as other global challenges.

I am delighted that the seventh research symposium has emphasized the decisive role of science in and about protected areas. The contributions to the proceedings are proof of the conference's success in promoting international exchange, fostering new innovative approaches, and strengthening scientific networking at an international level. By joining forces, we can preserve our unique natural heritage for future generations.

Let me thank all of you for your participation and your valuable contributions.

Leonore Gewessler, BA

Federal Minister for Climate Action, Environment, Energy, Mobility, Innovation and Technology

Dear participants!

It is with great pleasure that we present the proceedings of the 7th Symposium for Research in Protected Areas 7 to 9 September 2022, Vienna. The National Parks Austria Research Symposium is an international meeting where experts come together to discuss science and research in protected areas. It takes place around every four years. It has its roots in the Hohe Tauern National Park, where it was set up in 1996 to promote the exchange of research in the alpine region. At the 5th symposium in 2013, the umbrella organisation National Parks Austria took on the role of organiser and also opened up the research conference to the scientific concerns of non-Alpine protected areas. For the 7th symposium this year, the event was held in Vienna for the first time, and the University of Vienna was entrusted with running the symposium as scientific partner. After a considerable break, this conference was an incredible opportunity for scholars and professionals from Austria and neighbouring countries to re-join and share their knowledge and experience in the field of ecological and interdisciplinary research.

Although the announcement of this conference in autumn 2021 was well received, and the organizers saw great support from all sides, the process of preparing was somehow disrupted by the COVID pandemic, leading to a postponed date. Despite these challenges, the event could take place in September 2021 in the "Campus of the University of Vienna", one of most atmospheric conference venues in the heart of Vienna. Not surprisingly, it finally became a great success, with 400 active participants, more than 100 oral presentations and numerous interesting poster presentations.

The global biodiversity crisis has become increasingly prominent in recent years. As already stated in the national biodiversity strategy, protected areas make a special contribution when it comes to counteracting the loss of biodiversity. This year's research symposium named "Protected areas confronting the biodiversity crisis" focused on this issue. Organized in four parallel sessions the conference provided a sound mixture of basic and applied research. As intended by the organizers, a higher share of presentations focussed on topics relevant for National parks and Biosphere reserves in Eastern Austria, but not neglecting the network of alpine reserves. It could be demonstrated, that long term research, like consistent monitoring programmes are beginning to yield eminent insights into fundamental ecological processes, that can ideally be studied in well-protected landscapes. Protected areas such as national parks or wilderness areas are in a unique position in this respect. Almost undisturbed natural processes can only be observed in natural landscapes. Many surveys on biodiversity or changes in biocenoses are not even possible elsewhere, as the species are simply missing. On the other hand, it became evident, that changes outside the reserves are of increasing influence, highlighting the important role of protected areas as early-warning system for environmental policies. In this sense, the urgency of some management topics, like water-management in dry periods or visitor guidance during the pandemic was stressed by entire sessions.

We are confident that the knowledge and insights shared during the conference will have a lasting impact on the field, and will help to shape the future of protected areas. Based on the expertise of a growing community of both professional and citizen-scientists Austrian national parks and biosphere reserves will hopefully continue to serve as a platform for high-level research. But as illustrated in several contributions, it will be of equal importance to include site managers in design and conduct of transdisciplinary projects, not only to provide access to important scientific findings, but also to support them in overcoming the challenges laying ahead.

We would like to thank all of the participants for their hard work and dedication in making this conference a success. We would also like to thank the Federal Ministry for Climate Protection and the European Union (Rural Development Programme) for funding the research symposium.

We hope that you find the proceedings of this conference to be of great value, and that they will help to further the cause of Research in Protected Areas.

Sincerely,
Christian Übl & Thomas Wrbka

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The European Agricultural Fund for Rural Development: Europe investing in rural areas.

Event Schedule

Wednesday, 7th of September 2022

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Thomas Wrbka, University of Vienna

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Franz Essl, University of Vienna (AT)

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Reed Belt of Lake Neusiedl – Preservation and/or Management

Chair: Arno Cimadom, Neusiedler See – Seewinkel National Park (AT)

Water level dynamics and exchange processes between the open lake and the reed belt in Lake Neusiedl
Georg Wolfram, DWS Hydro-Ecology GmbH (AT)

Unexpected pathways of mercury in Lake Neusiedl: a mesocosm approach
Franz Jirsa, University of Vienna (AT)

Carbon fluxes and sediment analysis of the reed belt of Lake Neusiedl
Pamela Baur, University of Vienna (AT)

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Erwin Nemeth, BirdlLife Austria, (AT)

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Recent Advances in River & Floodplain Connectivity Research

Chair: Ronald Pöppl, University of Vienna (AT)
Co-Chair: Thomas Hein, University of Natural Resources and Life Sciences, Vienna (AT) & Elisabeth Bondar-Kunze, University of Natural Resources and Life Sciences, Vienna (AT)

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Marie-Christine Moser, University of Natural Resources and Life Sciences, Vienna (AT)

Long-term hydrological changes in the Lobau (Donau-Auen National Park, Viennese part) – effects on the regional species composition of molluscs
Michael Duda, Museum of Natural History Vienna (AT)

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Peter Bader, University of Natural Resources and Life Sciences, Vienna (AT)

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Connecting protected areas with Green Infrastructure: Assessing connectivity and functionality of ecological networks as a foundation for the development of stakeholder-driven and evidence-based strategies and action plans
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Lea Reusser, SCNAT – Swiss Academy of Sciences (CH)

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Chair: Christina Laßnig-Wlad, Austrian Federal Forests (AT)

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Gernot Waiss, Austrian Federal Forests (AT)

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Birgit Rotter, Austrian Federal Forests AG (AT)

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Zoran Trailovic, University of Natural Resources and Life Sciences, Vienna (AT)

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Tatjana Koukal, Austrian Research Centre for Forests (AT)

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Recent Advances in River & Floodplain Connectivity Research

Chair: Ronald Pöppl, University of Vienna (AT)
Co-Chair: Thomas Hein, University of Natural Resources and Life Sciences, Vienna (AT)
& Elisabeth Bondar-Kunze, University of Natural Resources and Life Sciences, Vienna (AT)

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Luise Schratt-Ehrendorfer, University of Vienna (AT)

A tale of two rivers: phytosociological revision of the grasslands in the Danube and March-Thaya floodplain
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Karolina Taczanowska, University of Natural Resources and Life Sciences, Vienna (AT)

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John Edward Perez, University of Vienna (AT)

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Chair: Harald Grabenhofer, Neusiedler See – Seewinkel National Park (AT)

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Rudolf Krachler, Neusiedler See – Seewinkel National Park (AT)

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Stefanie Suchy, Tyrolean Environmental Ombudsman (AT)

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Günther Wuchterl, Kuffner Observatory (AT)


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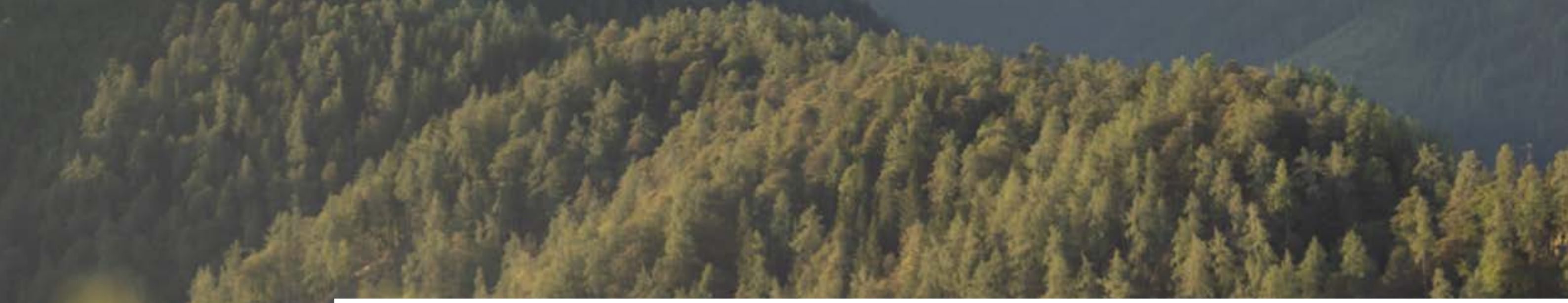

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Managing European ground squirrel, European hamster and some other selected small mammals in the national park area
Barbara Herzig, Naturschutzbund Austria (AT)

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Julia Kelemen-Finan, Engineering Office Kelemen-Finan (AT)

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Alice Laciny, Austrian Entomological Society (AT)

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Nastasja Harnack, Austrian Research Centre for Forests (AT)

Dynamics of regeneration in accordance to dead wood status in Goldeck Natural Forest Reserve in Carinthia, Austria
Dimitrios Manousidis, University of Natural Resources and Life Sciences, Vienna (AT)

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Herfried Steiner, Austrian Research Centre for Forests (AT)

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Christoph Plutzar, Kommunalkredit Public Consulting (AT)

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Andreas Hilpold, Eurac Research (IT)

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„BioTaxSyst" – summer schools of the Austrian Zoological-Botanical Society teaching taxonomy and systematics of selected animal and plant taxa
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Chair: Christian Rossi, Swiss National Park (CH)

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Tobias Köstl, E.C.O. Institute of Ecology (AT)

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From spectral to grassland biodiversity
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Chair: Michael Jungmeier, FH Kärnten University of Applied Sciences (AT)

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Michael Paster, University of Natural Resources and Life Sciences, Vienna (AT)

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Chair: Elisabeth Haring, Museum of Natural History Vienna (AT) & Klaus Peter Zulka, University of Vienna (AT)

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Long term conservation strategies for the endangered plant *Artemisia laciniata*
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Chair: Georg Gratzer, University of Natural Resources and Life Sciences, Vienna (AT)

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Mario Pesendorfer, University of Natural Resources and Life Sciences, Vienna (AT)

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Does fine scale spatiotemporal variation in seed rain translate into plant population structure?
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Iris Oberklammer, University of Natural Resources and Life Sciences, Vienna (AT)

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Katharina Lapin, Austrian Research Centre for Forests (AT)

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Gerhard Aubrecht

Keywords

summer schools on taxonomy and systematics, biodiversity, Austria, ZooBot Austria

Summary

Numbers of taxonomists and their expertise for naming and determination of animal and plant species are globally decreasing. Known as “taxonomic impediment”, this situation has already been raising concern since the 1990’s (De Carvalho et al. 2007).

To understand and protect biodiversity, specialists are needed who are able to determine and describe animal and plant species. Many of the 54.124 animal species (Geiser 2018) native in Austria cannot be determined by Austrian specialists. Especially invertebrate taxa need our closer attention on a global level (Troudet et al. 2017).

While expertise is still concentrated at natural history museums with their scientific collections, taxonomic research continuously lost importance at universities. From this understanding, the author tried organizing and joining together experts in taxonomy from museums and university teachers in order to provide scientific training possibilities in taxonomy. The goal was linking knowledge generated from scientific museum collections with experience in university courses. Thus, taxonomic training should be openly accessible for both, students and the interested public.

Administrative problems had prevented any implementation for some years. But in 2011 discussions with Univ. Prof. Friedrich Schiemer and Univ. Prof. Friedrich Steininger resulted in a meeting of Austrian experts from museums and universities at the Biology Center in Linz. As an outcome the first „BioTaxSyst“-course started in 2012 (Aubrecht 2013; Aubrecht et al. 2015).

Since 2012 the Zoological-Botanical Society in Austria has organized 13 courses together with museums and universities (see Table).

We believe that research in national parks is especially suitable for gaining knowledge of biodiversity because 80 percent of Austrian habitat types are represented in Austrian National Parks (Zulka 2022). At least in national parks, knowledge of biodiversity should not only cover the occurrence of some keystone species but also take into account species which need experts for determination.

Therefore, it will be crucial to offer an increasing number of courses, which concentrate on continuous teaching of taxonomy and systematics of animal and plant species (Schiemer et al. 2022).

Co-operation with Austrian National Parks and the Austrian National Park Academy would be very welcome.

Table: List of "BioTaxSyst" courses already held in Austria

2012: „Mollusken", Wien. H. Sattmann & M. Harzhauser, Univ. Vienna & NHMW

2013: „Bestimmungskurs Schlupfwespen und verwandte Familien", Linz. M. Schwarz, Biologiezentrum Linz & Univ. Bodenkultur Wien

2014: „Bestimmungskurs Eintagsfliegen", Wien. E. Bauernfeind, U. Humpesch & M. Schletterer, Univ. Vienna & NHMW

„Flechten Bestimmungskurs", Mallnitz. R. Türk, Univ. Salzburg & Nationalpark Hohe Tauern

2015: „Heuschrecken Bestimmungskurs", Wien. M. Sehnal & G. Wöss, Univ. Bodenkultur Wien

2016: „Schmetterlinge Bestimmungskurs", Innsbruck. B. Wiesmair, Tiroler Landesmuseum & Univ. Innsbruck

2017: „Helminths", Wien. A. Joachim & H. Sattmann, Univ. Vet. Med. Vienna & NHMW

2018: „Gräserkurs. Diversität – Bestimmung – Ökologie", Wien. C. Gilli, Univ. Vienna„Wildbienen. Bestimmen – Biologie – Ökologie – Naturschutz", Linz. G. Hölzler, Biologiezentrum Linz & Univ. Salzburg

2019: „Gräserkurs Teil II: Sauergräser. Diversität – Bestimmung – Ökologie", Wien. A. Berger, Univ. Vienna

„Heimische Zikaden", Graz. W. Holzinger & G. Kunz, Univ. Graz & Ökoteam

2021: „Bestimmungskurs Wasserkäfer Österreichs", Wien. M. Brojer, Univ. Vienna & NHMW

2022: „Taxonomie, Systematik und Ökologie freilebender Nematoden", Wien. W. Traunspurger, Univ. Wien.

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Analyzing the importance of spatial connectivity and environmental conditions of amphibian metacommunities in river-floodplain systems of the Danube using eDNA metabarcoding

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Summary

Riverine ecosystems are hotspots of life and highly threatened by anthropogenic alteration and climate change. The Austrian floodplain system of the Danube inhabits 74% of native fishes and 67% of native amphibian species (14 anurans and 7 caudates). Hence, it is important to understand the assembly of metacommunities in riverine landscapes to manage their conservation and restoration. We assess diversity and composition of an amphibian metacommunity to evaluate the relative importance of local environmental conditions and spatial connectivity on its assembly. Therefore, 26 water bodies were sampled twice in summer 2021 according to connectivity and floodplain typology. This was done in the riverine floodplain system "National Park Donau-Auen" between Vienna and Bratislava in Austria (Europe), one of the last free-flowing sections of the Danube River. This dataset, obtained by using the innovative tool of environmental DNA (eDNA) metabarcoding, is then applied for metacommunity analysis. To date, eDNA studies have been limited to exclusively lotic or lentic freshwater ecosystems. For the first time, in this research project (RIMECO) eDNA metabarcoding is used in highly dynamic riverine floodplains. By using this innovative method for community detection and explicitly including spatial connectivity, we expect to get a deeper insight in managing protected communities of fragmented riverine ecosystems. So far, our results show that out of the 7 detected amphibian species *Lissotriton vulgaris*, *Pelobates fuscus*, and *Bombina bombina* are correlated with high aquatic algal concentrations and that *Pelophylax* species prefer water bodies with woody debris. Overall, a preference of amphibian metacommunities towards mainly isolated water bodies.is derivable.

Keywords

environmental DNA (eDNA) metabarcoding, riverine floodplain systems, amphibians, metacommunity, spatial connectivity, environmental conditions, Danube River)

Introduction

River-floodplain systems are extraordinarily complex and highly diverse biospheres [1,2], which provide a vast number of essential ecosystem functions and services [2-7]. Due to cultivation processes like habitat alteration or flow and flood control, they are among the most endangered ecosystems [2,8-14,15]. This finds expression in loss of floodplain area, riparian biotopes, and alteration of hydro-morphological conditions, particularly in Europe [2,7,16,17, 18]. Thus, there is an urgent need to conserve, restore, and manage these vulnerable systems. To achieve this, we rely on comprehensive monitoring methods to understand their dynamics and functioning [7,19-24].

Studying metacommunities, in particular those of amphibians, contributes substantially to this issue, as these semiaquatic organisms are the most threatened animal group on Planet Earth according to the IUCN Red List of Threatened Species [25, 26]. Wilson (1992) [27] describes a metacommunity as a network of potentially interacting local communities, which are linked by dispersal [28,cf.29]. This is a key concept in community ecology [30] and mainly addresses patterns of species distribution, abundance, and interactions on the level of local to regional scales [cf.29,31]. It includes patch dynamics, species sorting (niche concept), mass effect (source-sink dynamics) and the neutral model [32] as the four fundamental theoretical frameworks [30].

On the local scale, environmental conditions determine habitat suitability (the fundamental niche) and therefore the occurrence of a species (realized niche) [33]. These characteristics can further be divided in (a) biotic parameters like interspecific (e.g. predator-prey interaction) as well as intraspecific competition [33-36], and (b) abiotic characteristics of the environment [33,37-40], which both define the fundamental niche (niche dimensions; [see 41, pp. 193ff.]). Of these factors hydroperiod [11,31,33,42,43], patch size (surface area; [11,43,44]), aquatic vegetation [44-49], canopy-cover [31], local population size or biomass [11,43], and predation [11,31,33,43,50,51] seem to be the most important to explain amphibian metacommunity structure and dynamics on a local scale [52].

Whereas, on a regional scale, spatial connectivity is the main determinant of habitat availability (hence the realized niche). In other words, whether dispersal (or accessibility via mobility [29]) is favored or limited. This is dependent on several factors such as urbanization (e.g. road density, land cover proportion and types as well as their distances to occupied habitats) [51], surrounding terrestrial matrix (e.g. density of vegetation or forest cover and their distance to waters) [51,53], climate (e.g. annual precipitation patterns) [33], linkage of waterbodies (distance and connectivity) [43], and total area of the wetlands [31]. As a surrogate parameter hydrological connectivity (= linkage to the main channel in days per year) can be used, which describes the gradient from lentic to lotic conditions and how often these conditions change in floodplain water bodies. Furthermore, spatial connectivity could be expressed as a connectivity index that accounts for terrestrial landscape or geographical distance weighted by landscape pattern. However, differences in species traits, such as life history, specialization to habitats, dispersal abilities (terrestrial or aquatic), and responses to disturbances (e.g. urbanization, floods, droughts, predation) are key factors to understand vertebrate metacommunity patterns [31,33,52].

Overall, heterogeneity is distinctive of dynamic river-floodplain systems and prerequisite to provide habitat availability and quality as well as biochemical processes [31,54-56]. All this support a high diversity and a vast number of different taxa groups, such as amphibians, birds, reptiles, mammals, and invertebrates [31,57,58]. More precisely, α-diversity represents the species richness on a local scale (at a patch), whereas β-diversity conforms the variation of α-diversity between patches [cf. 29], which interlinks biodiversity patterns at local and regional scales.

Traditional methods have been applied for several decades to investigate metacommunity patterns and their functionality. Such physical surveys are rather time consuming [59,60] and thus cost- intensive compared to the innovative tool of environmental DNA (eDNA) [61]. Hence, it is applied with increasing frequency since it enables quick and non-invasive investigation. eDNA consists of a complex mixture of fragmented DNA taken out of the environment (e.g. water, soil, air, feces, etc.) stemming from different organismic origins [62]. Taberlet *et al.* (2018) [63] give an illustration of eDNA usage since its emergence, as described below. It was first mentioned by Ogram *et al.* (1987) [64] and applied to ancient sediment, but it became more common for investigating microorganisms post-millennial. Ficetola *et al.* (2008) [65] performed the first application to aquatic organisms. However, in the last decade a strong increase in the usage of eDNA for ecological assessments on macro-organisms by utilization of water samples has occurred [62].

Several studies demonstrated that eDNA based survey can be a more comprehensive tool to detect aquatic organisms across various ecosystem types than traditional methods [14], specifically for rare and cryptic species [60] as well as for amphibians [61,66-71]. For example, Valentini *et al.* (2016) [71] showed that at least four serial traditional investigations in the field are necessary to obtain the same success of amphibian detection compared to one single sampling using eDNA metabarcoding. However, many influencing factors need to be considered when dealing with eDNA due to the fact that the sampled DNA is highly fragmented and present at very low concentrations [24,72-75]. Among others, these are DNA degradation rates, eDNA transport, and differences in concentration (e.g. during or after amphibian spawning).

Most preliminary eDNA studies in freshwater ecosystems were conducted in lotic or lentic waters [e.g. 14,67,68,70,72,74], whereas highly dynamic systems like riverine floodplains are represented inadequately or not at all [76]. Therefore, this study aims to assess the relative importance of (a) local environmental conditions, and (b) spatial connectivity for amphibian metacommunity assembly by using eDNA metabarcoding. To test this the free-flowing section of the Danube floodplain system between Vienna and Bratislava in Austria was used as the investigation area. This is one of the last remnants of fluvial ecosystems in the Upper Danube and in Central Europe [18] with 67% of the 21 native amphibian species in Austria (14 anurans & 7 caudates).

Methods

The investigation area is the "National Park Donau-Auen" in Lower Austria, a floodplain system in the free-flowing section of the Danube River between Vienna and Bratislava in Austria (Europe). There, 26 water bodies have been selected according to their type classes (eupotamon A & B or parapotamon A, parapotamon B, plesiopotamon, paleopotamon) and connectivity (low to high) [cf. 77-79]. These sites were sampled twice (with exception of three sites due to insufficient water content), first in August (26 sites), approximately two weeks after a flood event, and second in September (23 sites) 2021.

At each site 133 environmental conditions like 18 physio-chemistry (e.g. water depth, temperature, total phosphorous) as well as 68 biotic variables (e.g. aquatic vegetation cover, chlorophyll concentration, fish eDNA) were recorded and connectivity indices were calculated (e.g. river based harmonic centrality). Simultaneously, eDNA samples were taken. This included in-situ filtration of approximately 28 Liters in average (from 6.6 up to 94 Liters dependent turbidity) of water per sample using a peristaltic pump, cross-filtration capsules (with 0.45µm porosity), and single-use equipment like plastic tubes, gloves, and more. After filtering the requested volume of water (or till the cross-filtration capsule was clogged) 80ml of conservation buffer have been added for DNA-fixation. Afterwards, the samples were transmitted to the SPYGEN laboratory (specialized on eDNA analyses) in France for further processing. There they conducted DNA extraction, amplification, purification, sequencing, and a taxonomic assignment via reference databases (for amphibians: *SPYGEN*, *AUTRICHE*, and *EMBL 142*; for fishes: *SPYGEN* and *DANUBE 2019*). For a better taxa assignment, a local database of amphibian DNA sequences has been constructed beforehand by providing available tissue of certain amphibian species to the SPYGEN laboratory. From all this it follows that the results represent semi-quantitative data. The obtained datasets were then converted to proportional data, on demand Hellinger transformed and used for basic statistical and multivariate analyses (e.g. RDA, PCoA) to examine the relationship between environmental conditions and metacommunity assembly (structure).

Results

Overall, amphibian eDNA was detected at 17 of the 26 sites, stemming from two species of caudates (*Triturus dobrogicus* KIRITZESCU 1903; and *Lissotriton vulgaris* L. 1758) and five anuran taxa (*Bombina bombina* L. 1758; *Bufo bufo* L. 1758; *Pelobadets fuscus* LAURENTI 1768; *Pelophylax* kl. *esculentus* L. 1758 and/or *P. ridibundus* PALLAS 1771 hereinafter referred to as *Pelophylax* sp.; and *Rana temporaria* L. 1758) in total. In August amphibian eDNA was detected at 11 sites of the 26 sampled sites. At four of them amphibians were just recorded in August, however three of them were not sampled in September due to insufficient water content. In September 13 sites contained amphibian eDNA out of the 23 sampled sites. At six of them no amphibians were detected the previous month. At the site with the highest species richness four different amphibian species were recorded (dominated by *Pelophylax* sp., Pelobates *fuscus*, *Lissotriton vulgaris*, and *Triturus dobrogicus*, respectively). Three sites contained DNA from three amphibian species (two with *Pelophylax* sp., *Pelobates fuscus*, and *Lissotriton vulgaris*; and one with *Pelophylax* sp., *P. fuscus* and *Bombina bombina*). At five sites there was eDNA of two species detected and at eight sites only of one species. *B. bombina*, *T. dobrogicus*, and *Rana temporaria* were just detected ones. In general, there was a shift towards *Pelophylax* sp. from August to September except of one site, where *L. vulgaris* was replaced by *B. bombina*. Regardless of the month, *Pelophylax* sp. was the dominating genus in August and Sepember. Nevertheless, two sites were dominated by only one species (ones by *L. vulgaris* and ones by *Bufo bufo*) before it shifted towards *Pelophylax* sp., respectively. Another site only sampled in August showed a dominance of *L. vulgaris*, *P. fuscus*, and *Pelophylax* sp. respectively. All six sites with unique detections in September showed a proportion of 100%, five of them of *Pelophylax* sp. and the remaining one of *B. bufo*.

RDA analysis showed a relevance of woody debris for *Pelophylax* sp. (with high statistical significance, $p < 0.001$) and a relevance of aquatic algae (chlorophyll) concentration for *L. vulgaris*, *P. fuscus*, and *B. bombina* (with a statistical significance of $p < 0.05$). Three connectivity indices showed statistical significance as well. Two are river based (dPCflux, which is based on probability of connectivity and an area weighted flux through network connections from other nodes with a threshold distance of 10 000m; and harmonic centrality) and show a negative influence on aquatic algae (chlorophyll) concentration and therefore likewise on *L. vulgaris*, *P. fuscus*, and *B. bombina* (with a significance level of $p < 0.05$). The third one (MEM20 indicates the scale of community composition pattern depending on the distances between water bodies) implies a small-scaled pattern with similar composition of amphibian communities (with a significance of $p < 0.001$). The PCoA analysis indicates that this influence applies at mainly the three sampled paleopotamon water bodies. Furthermore, it shows a similarity of composition at plesiopotamon sites correlated with woody debris, that one specific site is strongly isolated (highlighted by the connectivity indices), and that this isolated site plus two additional ones are correlated with high concentrations of aquatic algae (chlorophyll).

Consequently, high connectivity has a negative influence on amphibian metacommunities which are dependent on mainly isolated sites. In particular, *L. vulgaris*, *P. fuscus*, and *B. bombina* prefer less connected stagnant water bodies with aquatic algae, whereas *Pelophylax* sp. prefers sites with woody debris. Nevertheless, the dynamic character of river-floodplain systems is essential for amphibian metacommunities to provide a variety of suitable habitat.

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Participative Research as a means to promote involvement of residents in Swiss Parks

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Summary

Participative Research, also known as “Citizen Science”, is an excellent tool to involve people in scientific processes. Not only can Participative Research generate important data and knowledge, it also raises the awareness of involved people for specific topics and research in general.

We argue that Regional Nature Parks and UNESCO world heritage sites provide an excellent setting for Participative Research projects and that all involved parties such as the park management, researchers, residents and visitors can benefit from well-organised Participative Research projects. For the Regional Nature Parks and UNESCO world heritage, it is an outstanding mean to strengthen ties and the collaborations with different actor groups, to actively integrate them into a project lead by the park management, and thereby strengthen the local populations’ and visitors’ acceptance of and identification with the respective park.

However, Regional Nature Parks and UNESCO world heritage sites face challenges when initiating Participative Research projects. The planning and technical implementation can be costly and complex. Adequate funding, experience in planning and conducting Participative Research projects and technical expertise are therefore crucial for the success of a planned project. This is where the presented study sets in.

All Swiss Regional Nature Parks and UNESCO world heritage sites were surveyed to assess the current situation and future requirements regarding Participative Research projects. We present the first results that show an overview of initiated and/or planned Participative Research projects in Swiss Parks, the lived experiences by the park management, opportunities and threats of conducting Participative Research projects in Regional Nature Parks and UNESCO world heritage sites, and recommendations for park management to successfully conduct further Participative Research projects.

The study is conducted by the Centre for Development and Environment (CDE) at the University of Bern and accompanied by a steering board including members of the Scientific Monitoring Group for Swiss Park Research, the Forum Landscape, Alps, Parks (Swiss Academy of Sciences), Science et Cité (Citizen Science competence center), the Swiss Parks Network, researchers at Swiss universities as well as park management representatives.

Keywords

Citizen Science, Participative Research, participation, park research, parks

Introduction

Switzerland has currently 20 parks (of which 2 candidates) and 3 UNESCO World Natural Heritage Sites (see Fig. 1). Regional Nature Parks (RNP), Nature Discovery Parks (NEP), National Parks (NP) and UNESCO World Heritage Sites (WES) represent a great unexploited potential to accompany and initiate existing and new participatory research projects (PFP). Especially RNPs have close contact to park visitors and inhabitants thanks to their educational and awareness raising activities and are therefore the ideal institutions for accompanying lay researchers.

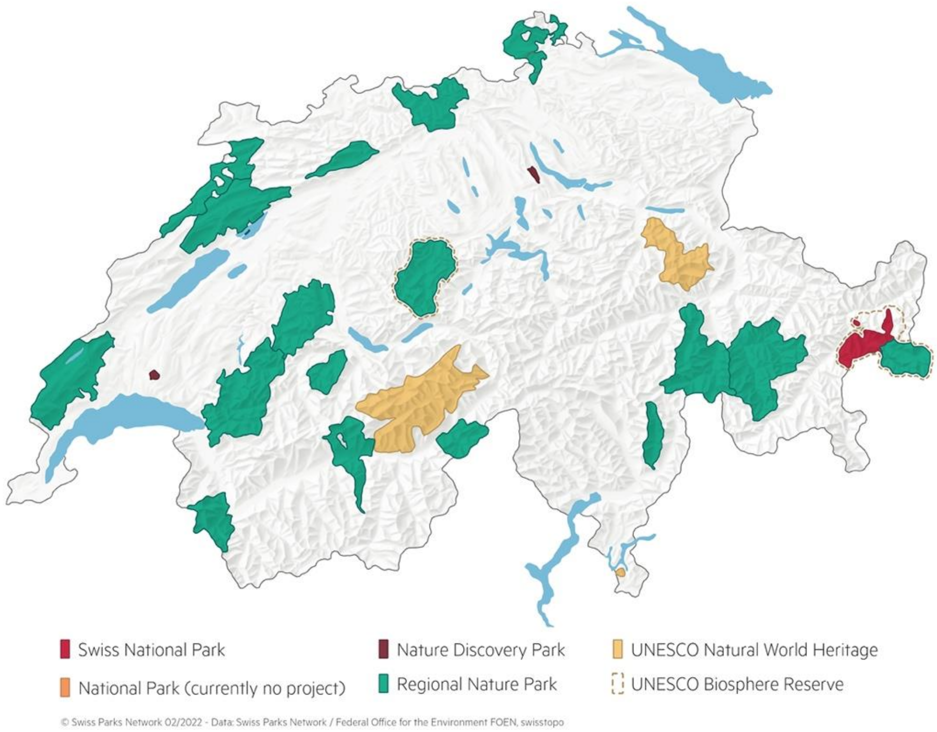

Figure 1: Map of the Swiss Parks and UNESCO Natural World Heritage sites (Swiss Parks Network, 2022).

The participatory research (PF) approach has many advantages. On the one hand, it is an effective tool for knowledge transfer and awareness raising in the areas under study (Hecker et al. 2018; Pandya and Dibner 2018). On the other hand, data collection and analysis by amateurs can open up new sources of data and knowledge for practice-oriented and academic institutions (e.g. cantonal or national environmental offices, universities, regional nature parks, ...) (McKinley et al. 2017; Ballard et al. 2018; European Commission 2020).

However, the cost of setting up a PFP (e.g., through mobile app development) and the lack of experience in implementing PFPs may be potential barriers that discourage parks and WES from implementing PFPs. The implementation of PF requires expertise and experience in conceptual planning, the know-how and finances for technical implementation, as well as financial and human resources for mobilizing and accompanying lay researchers. A survey of Swiss educational institutions also revealed that better expertise, more financial resources, and support in accompanying lay researchers would be desirable (Stämpfli 2019).

However, it is often research institutes or interest groups that initiate PFPs. These value parks and WES as local project partners and potential multipliers. Nevertheless, PFPs are ongoing in parks and WES that the management of the park / WES does not know about and has not been involved in. Here, raising awareness of the relevant research institutes or stakeholders is crucial to better exploit potential synergies.

The aim of the project is therefore to conduct a first site survey on PFP in the RNP, NEP, Swiss National Park and WES of Switzerland. The results provide an overview of past, current and planned PFPs in parks and WES, identify needs and challenges, highlight unused potentials of PFPs for parks and WES, and suggest support possibilities. The findings should allow the parks/WES to identify and implement new opportunities for PFP and to sensitize external initiators of PFP (i.e. research institutes or interest groups) to the needs of the parks/WES, thus creating new synergies.

Methods

In preparation, a questionnaire has been developed. The draft by the CDE has been sent to the steering board and discussed in a joint meeting. On this occasion, specific adjustments were agreed upon. The CDE then implemented the agreed changes and sent the online questionnaire to the parks management centres/WES.

The steering board includes members of the Scientific Monitoring Group for Swiss Park Research, the Forum Landscape, Alps, Parks (Swiss Academy of Sciences), Science et Cité (Citizen Science competence center), the Swiss Parks Network, researchers at Swiss universities as well as park management representatives.

Subsequently, the answers in the questionnaire were evaluated. The majority of the analyses are descriptive and quantitative. Free text answers (open questions) were analysed qualitatively with content analyses.

The results will be discussed in the steering board. The findings and recommendations for parks, WES, operators of PFPs and other stakeholders will serve as a basis for writing the project report.

Results

Discussions during the first steering board meeting have already shown two major challenges regarding PFPs in Swiss Parks. One is the definition of PFPs within park management. While most of the parks are probably active in this area, some of them do not classify their projects as PFPs. This effect is accompanied by the fact that, even though coordinating research in the respective park, the research responsible may not be aware of all the PFP projects going on in their own park. It is therefore crucial that the right people are addressed and that the definition of a PFP is clear to have as complete answers as possible. The questionnaire has been adapted respectively.

So far, the questionnaire has been filled in by 18 park management. 89 % of them (n=16) show an engagement in altogether almost 40 different PFPs, of which most can be attributed to nature and landscape topics. Most of the regional nature parks have their inhabitants as the primary target audience for PFP participants, while among other park types also visitors are contributing. The park management is often the project lead (58 %), but sometimes also acts as a co-lead partner (29 %) or multiplicator (10 %). PFPs are seen as important instruments to promote park projects and to give insights into the parks' activities as well as sensitise the population for specific topics, such as biodiversity. In addition, they are appreciated as a relatively easy and low-cost way to generate data. The effects regarding output data, participation, awareness-raising and knowledge generation are therefore rated (rather) successfully for more than 70 % of the projects respectively (see Fig. 2).

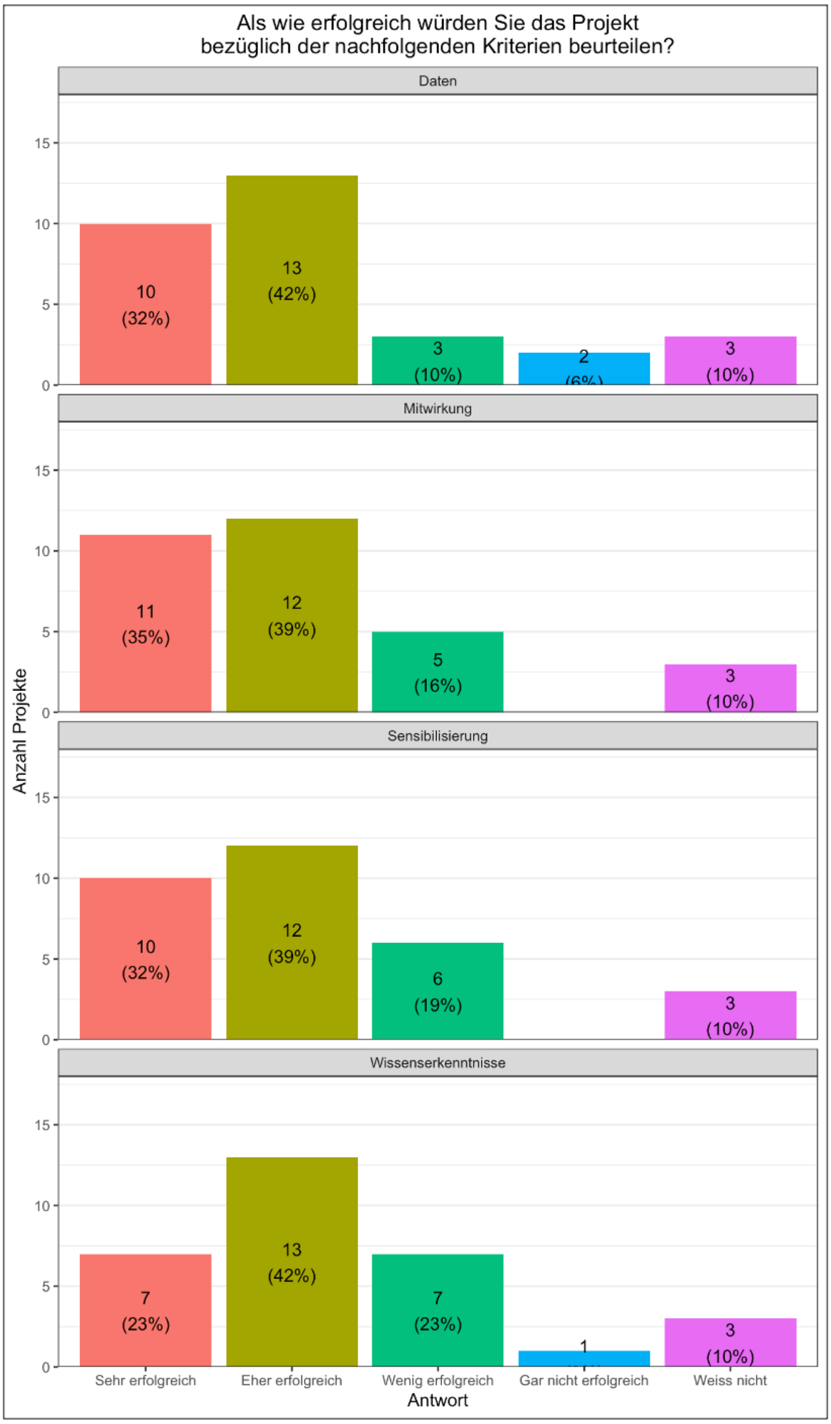

Figure 2: Judgement of the project success with regard to data generation, participation, awareness-raising and knowledge generation (from top to bottom, bars from left to right represent "very successful", "rather successful", "little successful", "not successful", "I do not know").

Almost 85 % of the park management see the potential for further PFP in their region. Some of them share in their experiences that communication (before the project start, while running it and also afterwards) plays a key role in motivating people to participate in PFPs. However, the network "Schweiz forscht", a communication platform for PFPs in Switzerland, is hardly known and used. One of the major challenges to implementing or conducting PFPs are the limited resources of staff within the park management.

We conclude that park management are already involved in many PFPs, most of them being successful with regard to data generation as well as sensitisation of the people involved. To gain a surplus, the projects require support from the park management and therefore enough resources of staff. Most of the Swiss parks are motivated to pursue further PFPs and interested in further exchange of knowledge. Future work of the Swiss Park Research, Swiss Parks Network and Science et Cité will therefore focus on this aspect.

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Dark sky areas in the Czech Republic

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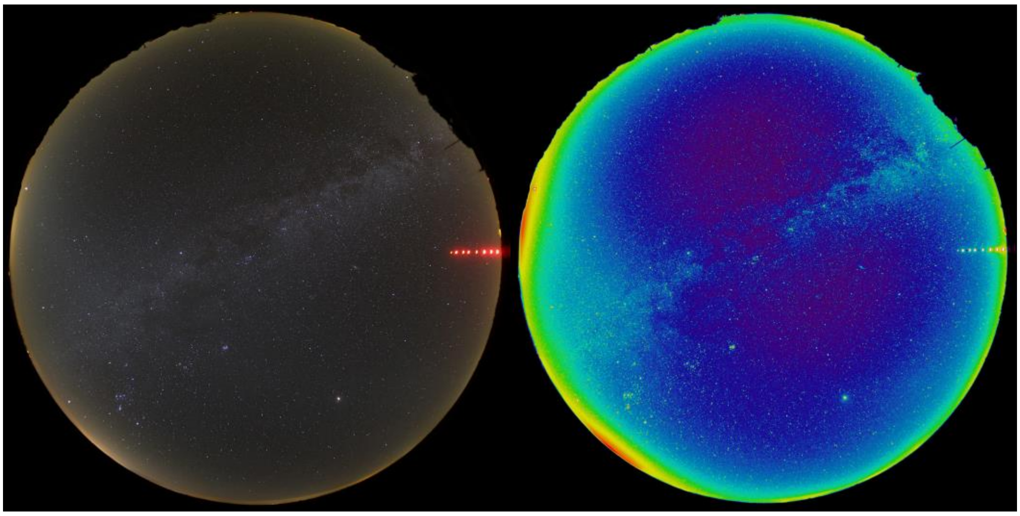
Abstract

Protection of the nighttime environment from the disturbance caused by the artificial lighting has been largely neglected for decades. Natural darkness has not been perceived as an essential resource worth protecting even in the National parks and has been completely missing in the respective management plans and local or country wide policies.

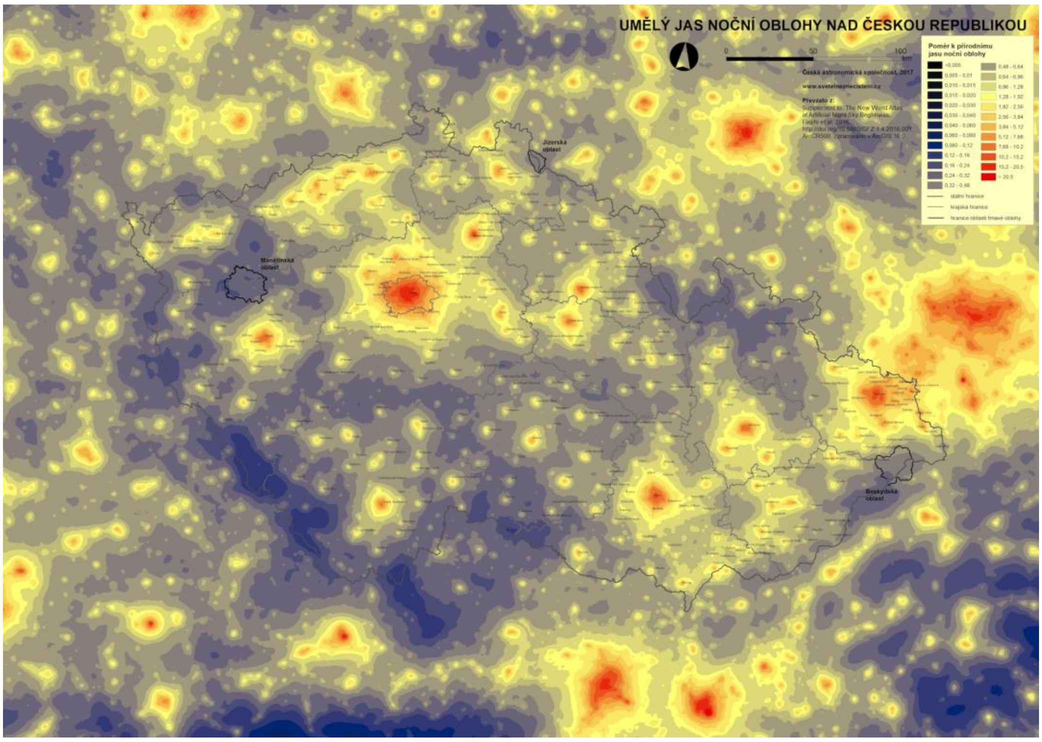


Astronomers were among the first who expressed concerns about disappearing darkness at night and consequences for observing conditions and accessibility of the starry night sky, but they faced misunderstanding and general lack of knowledge among nature conservationists, authorities and decision makers and general public.

While this has started to change in the recent years and we see more and more research being done in the field of ecological light pollution, there is still a lot of education needed in order to make everyone recognize the value and importance of undisturbed night environment not only for people but for all living beings.

Dark sky places proved to be one of the most effective ways how to raise awareness about the issue of light pollution among general public. "Protection of the dark" is attractive topic for mainstream media and visiting place that is not flooded by the artificial light at night light is a unique and eye opening experience for many people living in cities and sadly, for most of the children today. I present practical experience with establishing and running Dark sky areas in the Czech Republic, communication with the local citizens and municipalities, issues related to missing legal and technical support, the success stories and challenges we face.

Unfortunately and surprisingly, there is still significant lack of interest and support from the public authorities and management of the protected areas and most of the activities are done by volunteers who are not professionally involved in nature protection. Some places that would certainly deserve designation of a Dark sky park due to near natural nightime conditions are therefore still missing on the map.



Keywords

Dark sky park, Light pollution, Czech Republic, Nighttime environment

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Carbon fluxes and sediment properties of the reed belt of Lake Neusiedl

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Summary

Half of Lake Neusiedl consists of a wetland ecosystem dominated by reed, which is influenced by its underlying sediment, highly sensitive to changing climate and which we investigated here.

Over the last three years (2019-2021), the reed belt of Lake Neusiedl developed from a strong to a low carbon source: The annual emission of CH_4 decreased by 59 % and of CO_2 by 95 % from 2019 to 2021. Most likely explanations for this trend are: declining water level in the reed belt, increasing reed growth (in area and biomass) and reduced lateral exchange between lake and reed belt. The CH_4 fluxes of the reed belt had a seasonal variability with a clear diurnal cycle from June-September. Also, the CO_2 fluxes had a clear diurnal cycle but for the entire vegetation period of *Phragmites australis* (May to October).

The successive decline of water levels at Lake Neusiedl not only decreased the water content of sediment samples during 2021, but also influenced redox conditions below the sediment surface and chemical characteristics of pore water. In addition, we observed that vegetation enhances the oxygenation of sediments, probably due to oxygen transport through aerial shoots and reed rhizomes (Armstrong *et al.* 2006). Caused by lack of water recharge, total salt content in the water was rising, which could be shown by rising electrical conductivity values.

We conclude that long-term wetland research of the carbon cycle of the reed belt of Lake Neusiedl have to be continued to further understand the underlying processes and confirm the drivers.

Keywords

reed belt, sediment, carbon dioxide, methane, eddy covariance, Lake Neusiedl

Introduction

Wetlands dominated by common reed (*Phragmites australis*) are able to store carbon (C) due to photosynthetic assimilation of carbon dioxide (CO_2) and sequestration of organic matter produced in the wetland soil (Brix *et al.* 2001). That can lead to the accumulation of organic C in peaty layers while also releasing C by emission of sediment-produced methane (CH_4). Annually, about 15 % of the net C fixed by wetlands may be released to the atmosphere as CH_4 (Brix *et al.* 2001).

Wetland ecosystems with *P. australis* have a broad range of annual NEE (net ecosystem exchange) of CO_2: The annual NEE of temperate fens ranges from 68 g C m^{-2} a^{-1} (Günther *et al.* 2015) to -244 g C m^{-2} a^{-1} (van den Berg 2019). Serrano-Ortiz *et al.* (2020) showed in a 5-year observation that the interannual variability of NEE in a Mediterranean wetland with reed could range from -10 to -410 g C m^{-2} a^{-1}. In this wetland, Serrano-Ortiz *et al.* (2020) showed that the greater interannual variability of C fluxes mainly depended on the behavior of reed growth dynamics during the transition to the senescence period. They confirmed that with the enhanced vegetation index as a proxy of photosynthetic activity and used EVI data from MODIS.

The magnitude and the range of the annual net CH_4 flux for wetlands with reed is smaller compared to the NEE of CO_2: It ranged from 23 g C m^{-2} a^{-1} for a fen in Germany (van den Berg *et al.* 2016) to 9 g C m^{-2} a^{-1} in a Mediterranean wetland (Serrano-Ortiz *et al.* 2020). In comparison to CO_2, Serrano-Ortiz *et al.* (2020) found a more or less constant annual rate of CH_4 release .

Lake Neusiedl, the largest lake of Austria, is the westernmost steppe lake of Europe with an area of ca. 320 km² and no natural outflow. Due to its shallowness the lake is very sensitive to climate variations (Soja *et al.* 2013). The reed belt represents half of the lake area and is the second largest coherent reed population in Europe. *Phragmites australis* is the dominant species of the reed belt, which forms a seasonally varying mosaic of water, reed and sediments. Reductive and oxidative conditions in soil and sediments control the cycling of redox sensitive elements as iron (Fe).

At Lake Neusiedl, Soja *et al.* (2014) showed that around 2/3 of the CH_4 and CO_2 emissions originated in the reed belt and only 1/3 in the pelagic zone, however, the authors only measured manually in water areas (without plants) by floating chambers. Podgrajsek *et al.* (2014) showed that floating chambers in a lake do not capture the spatial variability of CH_4 fluxes in comparison with the EC (eddy covariance) method, which measures the flux over a large area. This indicates that more thorough investigations of the greenhouse gas exchanges (GHG) of the reed belt at Lake Neusiedl are needed, especially with a higher temporal and spatial resolution. The results of Rõõm *et al.* (2014) also confirmed that the GHG emissions from helophytes such as *Phragmites australis* should be better investigated and included in the lake's net GHG budget because of the potentially large role of these plants.

The season of C fixation and CH_4 release varies annually, seasonally and diurnally. In addition, little is known about the effects of climate change on reed dominated wetlands and the contribution of central European reed belts as a source of greenhouse gases (GHG) in a changing climate. The current ongoing drought periods affect especially the water balance but also the carbon fluxes of wetland ecosystems with reed. These changed climatic conditions modify physico-chemical characteristics of sediments, and thus the microbial activity including decomposition of organic matter. Therefore, we investigated the C storage and losses such as CH_4 emission and their drivers of the reed ecosystem of a shallow saline lake under climate change over the last three years. To examine underlying conditions in sediments, we evaluated mid-term redox conditions in spring and summer and measured microbial biomass in peaty horizons and underlying sediments.

Methods

We use the eddy covariance (EC) technique to continuously quantify the vertical turbulent GHG exchange of CO_2 or CH_4 between the reed belt and atmosphere. The EC observations have been conducted near Illmitz (Lat. 47.769140, Long. 16.758492) in the natural zone of National Park Neusiedler See - Seewinkel for more than 3 years (from summer 2018 to now). The annual rain varied in our study site from 450 mm in 2021 to 503.65 mm in 2020. The EC fluxes describe the integrated net fluxes primarily from the landscape upwind of the point of measurement. Comprehensive data quality checks are needed to verify the theoretical assumptions of EC technique and to separate high quality data via quality flags (Foken & Wichura 1996; Foken *et al.* 2005). The processing tools EddyPro (LI-COR, Inc. 2021) and REddyProc (Wutzler *et al.* 2018) are used. All other analysis, statistical tests and plotting are done with R (Version 4.1.2, R Core Team (2021)). For taking the reed development of the studied ecosystem into account, vegetation indices data from MODIS were used.

We have quantified the seasonal variations of CO_2 and CH_4 fluxes and examine the differences in diurnal patterns to answer the question if the reed belt acts as a C source or sink and how the C storage in sediments change over time. We also investigated the current ongoing drought periods (higher frequency, longer duration) on the C fluxes/balances of the reed belt and its influence on physico-chemical properties on sediments and peaty layers.

To investigate long term redox conditions, we installed polished iron rods in May and August 2021 in the sediment of the reed belt on three sites along a landward to lakeward transect for integrative measurements following Owens *et al.* (2008) and Williamson *et al.* (2017). Sites were separated in two microsites (open patches, and reed covered patches) and on each patch, 3 rods were installed. Rods were collected after three weeks in the field and visual colour changes were recorded immediately after removal. It needs to be noted that we observed water levels above the sediment only when inserting rods in May, while on dates of removal and installation in August, no water level above sediment layer was observed. For quantification, only sediment-covered parts of iron rods were used. In addition, sediment samples (triplicates of each microsite) were taken three times (May, August and November 2021), using a Russian corer in immediate proximity to iron rods. Samples were separated in organic top horizons (A) and sediment horizons (B) and further examined in the laboratory.

There we analysed sediments for microbial biomass carbon using an adapted chloroform fumigation-extraction method (Vance *et al.* 1987). Subsamples were freeze-dried, sieved (< 2 mm), finely ground and analysed for total organic carbon (TOC) and total inorganic carbon (TIC) by combustion (LECO RC612, ramp: 105-450°C (TOC), 450-1000°C (TIC)). To characterize the chemical conditions of sites, we measured pH, electrical conductivity, dissolved oxygen (DO) and reduction/oxidation potentials in the field. Therefore, porewater was sampled in a bucket, after sediment cores were extracted (except for sampling time 1 in May, where surface water was sampled).

Results

The reed belt had a diurnal cycle of the NEE-flux (net ecosystem exchange of CO_2) from May to October in all three years but the dimension increased from 2019 to 2021. A strong difference of the diurnal cycle can be found in May between 2019 and 2021. The seasonally variability of the NEE-flux from May to October was following the vegetation period of *Phragmites australis*. The CH_4-flux had only a daily variability in summer (June to August/September) but in contrast to the CO_2-flux, the CH_4-flux decreased strongly from 2019 to 2021.

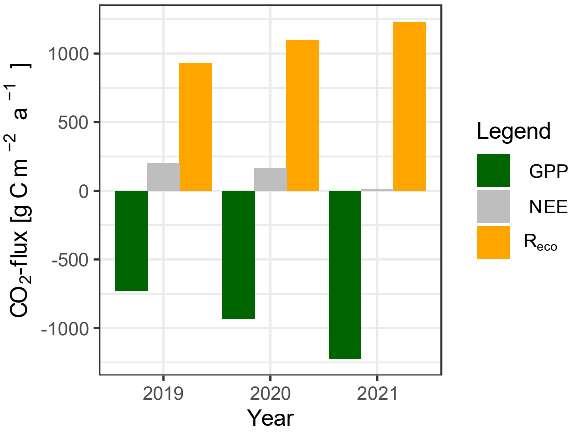

Figure 1: Annual CO_2 fluxes of the reed belt from 2019 to 2021 separated in net ecosystem exchange (NEE), gross primary production (GPP) and ecosystem respiration (R_{eco})

The annual CO_2 emissions decreased from 200.5 g C m^{-2} in 2019 to 9.2 g C m^{-2} in 2021. GPP (Gross primary production) and R_{eco} (ecosystem respiration) both increased from 2019 to 2021 (see Figure 1). The annual emissions of CH_4 decreased from 9.5 g C m^{-2} in 2019 to 3.9 g C m^{-2} in 2021 (see Figure 2). The reed belt tended from a strong carbon source to a low carbon source. One explanation is the decreasing water level in the lake between 2019 to 2021, which was followed by a drying out of the reed belt (≙ no water above the surface) in the late summer of 2020 and a longer period in 2021. The second explanation is the increasing reed growth (in area and biomass) which increased the photosynthetic rate. The vegetation indices like NDVI, EVI and LAI from the reed belt support this by an increasing tendency from 2019 to 2021. A third explanation could be that there was less lateral exchange via channels between the reed belt and lake in 2021 compared to 2019. Orthophotos of the reed belt from 2021 indicate that especially north of the dam road (in our study area) due to the change of colour of the water in the channels from white water' to 'brown water'.

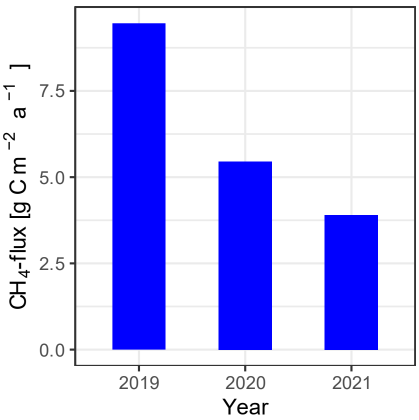

Figure 2: Annual CH_4 emission of the reed belt from 2019 to 2021

The reed belt had a seasonal variability of the evapotranspiration rate (ET) with a strong diurnal cycle from April to October in all three years (2019-2021). The annual ET rate varied from 597.8 mm in 2020 to 630.8 mm in 2021. In all three years (2019-2021), considering only vertical fluxes (ET and rain), the reed belt had a negative water balance.

Iron rods provided us with information about long-term (3 weeks) reductive/oxidative conditions in sediments. Generally, we observed that reductive conditions dominate during spring 2021. The mean thickness of reductive zones decreased from 42 cm in spring, to 35 cm in August, while means of oxidation zones increased from 2 cm to 13.5 cm. Zones with lower reductive features increased from 17.7 cm to 28 cm, together with transitional zones from 3.8 cm to 17.8 cm. Lower oxidative zones increased from 4 cm to 13.5 cm. In addition, our data suggests that reed covered microsites are strongly more affected by oxidative conditions in deeper horizons than open patches, especially in August.

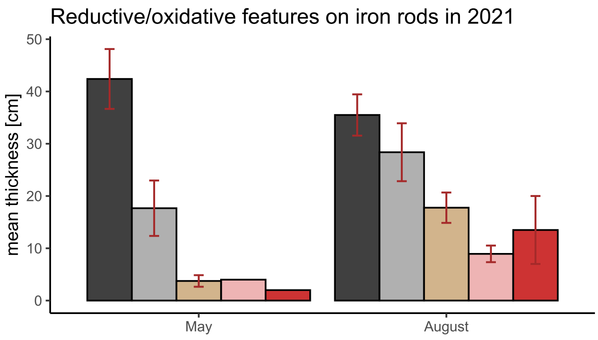

Figure 3: Bars represent mean thickness of reductive or oxidative features on iron rods for May and August. Bars are ordered from pure reductive features (black bar), mainly reductive (grey), transitional (brown), mainly oxidative (pink) to oxidative features (red)

Table 1. Field parameter characterizing sites along the landward to lakeward transect in Illmitz 2021.

Site	Month	pH	Conductivity [mS/cm]	Redox potential [mV]	Dissolved oxygen [%]
Lakeward	May*	7.7	3.4	28.8	32.7
	August	7.3	5.35	-403	0.5
	November	7.4	6.02	-382.6	0.8
Intermediate	May*	7.8	3.13	-242.9	8.4
	August	7.2	4.67	-405.4	0.2
	November	7.4	4.88	-399.5	1.6
Landward	May*	8.2	3.73	189.6	78.9
	August	7.3	6.5	-416.7	1.7
	November	8.7	7.58	-255.4	21.2

*surface water due to higher water tables

Mean microbial biomass carbon was lowest in spring (0.78 mg C g^{-1} dw in upper horizons, 0.92 mg C g^{-1} dw in bottom horizons), increased in summer (3.1 mg C g^{-1} dw (A), 1.01 mg C g^{-1} dw (B)) and highest in autumn (5.1 mg C g^{-1} dw (A), 1.07 mg C g^{-1} dw (B)). These findings indicate that microbial activity has a seasonal variability in upper horizons while being relatively constant in bottom sediments. Mean TOC contents of samples varied greatly between top and bottom horizons, sites along the transect and also between seasons. Mean contents of top horizons varied between 8.4 % in spring, 14.5 % in summer and 13.1 % in autumn. Contents of bottom horizons amounted to 9.1 % (spring), 5.2 % (summer) and 6.3 % (autumn). Mean water contents of top horizons decreased from 39 % (spring), 30 % (summer) to 28 % in autumn, and underlying bottom horizons decreased from 38 % (spring), 37 % (summer) to 34 % (autumn).
The successive decline of water levels at Lake Neusiedl not only decreased the water content of sediment samples during 2021, but is also influenced redox conditions below the sediment surface and chemical characteristics of porewater. Electric conductivity varied seasonally and between sites, while pH showed smaller variations (Table 1). Redox potentials and DO were highest in spring (surface water available), lowest in summer and increased slightly in autumn. Microbial biomass in peaty horizons were higher during warmer periods with lower water tables (summer and autumn), where we also observed increased oxic conditions and higher TOC contents than in spring. Also, results showed that sites are heterogeneous and do not respond equally on drying conditions.

Most likely due to the water level decrease and reed growth, the reed belt of lake Neusiedl has changed from a strong carbon source to a low carbon source over the past 3 years (2019-2021). The increase in oxidation zones in the sediment in 2021 due to the decline of water tables resulted probably in higher CH_4 oxidation and/or less CH_4 production and therefore influenced the carbon balance by less CH_4 emission.

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Using meadow bird monitoring data to evaluate grassland management in the Neusiedler See – Seewinkel National Park: possibilities and limitations

Georg Bieringer

Summary

Since its foundation, the Neusiedler See - Seewinkel National Park has placed a special emphasis on the management of meadows and pastures. An important indicator group for the success of these measures are meadow birds such as Lapwing, Black-tailed Godwit and Redshank, whose populations have been surveyed in the Seewinkel for 30 years. The lecture presents the development of wader populations in differently managed grassland and relates it to grassland management and other local, regional and global factors.

Keywords

grassland management, meadow birds, monitoring, remote sensing, water regime

Introduction

Since its establishment, the Neusiedler See - Seewinkel National Park has placed a special emphasis on the management of meadows and pastures. An important indicator group for the success of these measures are meadow birds such as Lapwing, Black-tailed Godwit and Redshank. After a more or less stable trend in the 1990s and 2000s, population numbers have recently declined (Dvorak et al. 2016). The presentation discusses the role of grassland management and other factors.

Methods

Meadow bird populations were assessed by counting warning adults twice during the breeding season at 18 study sites in 23 years between 1991 and 2020. However, no data were available for land use or for grassland management (grazing and mowing). The missing information had to be replaced by remote sensing data (aerial photographs and Landsat images). Hydrological parameters and weather parameters were included in the analysis, as well as European population trends of the species. The statistical analysis was carried out using GLMM.

Results

Simple univariate analyses of the effects of grassland management on meadow birds did not make sense (e.g. the number of Black-tailed Godwits was negatively correlated with grassland area). GLMM showed strong influences of variables related to water regime on population numbers of Lapwing and Redshank. For Black-tailed Godwit, local population numbers were strongly correlated with the (negative) European population trend. These factors – which are negatively correlated with indicators of grassland management results - outweighed the effects of grassland management on meadow birds, with the exception of a few selected study sites with exceptionally strong management impacts. Therefore, both the potential for analysing the effects of grassland management and the National Park's ability to improve habitat for grassland birds by optimising grazing or mowing are limited. To restore a favourable conservation status of meadow birds in the Neusiedler See - Seewinkel National Park, a comprehensive management of the (ground)water regime of the entire region is required. But even then, it may not be possible to secure the local breeding population of the Black-tailed Godwit in the long term due to strong drivers on the continental scale.

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Ist der Klimawandel das einzige Problem für den Nationalpark Neusiedler See - Seewinkel?

Alfred Paul Blaschke

Abstract

Für den Nationalpark Neusiedler See - Seewinkel und insbesondere für die darin vorkommenden Salzlebensräume ist ein geringer Flurabstand speziell im Frühjahr/Frühsommer von essentieller Bedeutung für deren Erhalt.

Im Seewinkel ist es in den letzten Jahrzehnten immer wieder in dieser Hinsicht zu kritischen Grundwasserständen gekommen, dieser konnte sich jedoch immer wieder nach mehreren nassen Jahren erholen. Die klimatischen Verhältnisse in den letzten Jahren haben jedoch noch nie zuvor gemessene extreme Grundwassertiefststände hervorgerufen, sodass eine Erholung ohne entsprechende wasserwirtschaftliche Maßnahmen fraglich erscheint.

Um die Planung von erfolgreichen Maßnahmen, die für einen Erhalt der Salzlebensräume unbedingt notwendig sind optimal unter Berücksichtigung der vielfältigen Interessen im Gebiet zu gestalten, ist eine klare Auseinandersetzung mit den Ursachen für diese extreme Situation notwendig. Eine natürliche Erholung der Grundwasserverhältnisse in der Region erscheint auch aufgrund der zu erwartenden klimatischen Veränderungen unwahrscheinlich.

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Effects of side-arm reconnection in a large river on hydro-morphological conditions and main trophic levels

Elisabeth Bondar-Kunze, Hubert Keckeis, David Ramler, Andrea Funk, Marcel Liedermann, Michael Tritthart, Thomas Hein, Helmut Habersack

Changes in riverine assemblages in response to anthropogenic changes are well known, many studies describe a general loss/decrease of characteristic riverine species and a concomitant increase/dominance of generalist species. Less information is available about the reverse process, namely the effects of process-oriented restoration measures in Large Rivers on changes in the assemblages (species occurrence, -diversity and abundance) or even trophic dynamics and food web structure.

This study examines short term changes (1- 3y) of the hydrodynamic conditions, sources of organic material, productivity as well as changes in the assemblages of macrozoobenthos (MZB) and fishes before and after the re-connection of a side-arm of the main stem in a free-flowing section of the River Danube in Austria. Within an interdisciplinary approach in the framework the Integrated River Engineering Project for the Danube East of Vienna (IREP) the changes of the abiotic, hydraulic and hydrodynamic conditions as well as production and the development of two major indicator groups (MZB and fishes) after the two-end reconnection of a side arm was monitored 6 years before and 1 and 3 years after the measures. We wanted to know to which extent (how, how fast) the measures are reflected in the assemblage structure and trophic composition of these two important groups of organisms.

The results are discussed with regard to the contribution of process oriented restoration measures (required spatial and temporal scales) to attenuate consequences of human induced river modifications.

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The acceptance and perception of the Stelvio National Park (Italy) by the local population and the tourists

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Introduction

Originally conceived to conserve ecosystems and wildlife, protected areas have to be confronted with an increasingly diverse set of social and economic challenges. This is particularly true for European conservation areas, where extensive zones without human impact can hardly be found anymore. Therefore, a sustainable development within protected areas can only then be guaranteed with the support by the local population. Thus, for an effective management of protected areas in inhabited and cultivated regions it is necessary to know which factors influence the acceptance of the protected area, where obvious conflicts of use do occur, and which instruments are available for politics and administration to increase the acceptance.

Together with the National Parks Gran Paradiso, Abruzzo and Circeo, the Stelvio National Park belongs to the four historical National Parks of Italy, which have been founded during the first part of the 20th century. In particular, the Stelvio National Park, has been established in 1935 without any consultation of the population and partly against strong objections. The park area borders on the Swiss National Park, the Nature Park Adamello-Brenta, and the Regional Park Adamello and is thus of great strategic importance regarding its location in the center of the Alps. The Stelvio National Park extends across two autonomous provinces (Bolzano and Trentino) and one region (Lombardy). Linguistic, cultural, demographic, economic as well as landscape-ecological differences made the cooperation between the three sections of the Park difficult.

Until the 1990s, there was very limited understanding of how local people perceive it and how they support its aims. It is fundamental to understand the different perceptions of the park to elaborate possibilities for participation, which should contribute to a better nature conservation management.

In 2001, a first representative survey of about 1000 residents of the Stelvio National Park has been carried out, which was integrated by a second part dedicated to tourists.

The survey was based on a questionary with 32 questions, related to the following topics:

- general situation of the respondent and his/her attitude to nature,
- potential of conflicts (hunting, game fences, modification of the park boundary ...),
- relevance of and satisfaction with the National Park Authority,
- awareness and added value in the choice of holiday location for tourists.

In 2020/2021 a second survey was conducted with an almost unchanged questionnaire compared to the first survey. 3300 persons (1100 residents, 1100 winter tourists and 1100 summer tourists) were queried (personal, face-to-face interviews) within the entire National Park.

The aim of this study was to analyze the acceptance by the local population and the tourists, to investigate the attitude of the local population against “their” Stelvio National Park, and to compare the results with those from almost 20 years ago.

The following hypotheses are tested:

(1) Acceptance depends on local populations' attitude towards nature

(2) Acceptance depends on the work of the National Park Administration

(3) Acceptance has increased during the last 20 years

All in all, the results show that a survey of the population carried out in the present way can contribute considerably to a better distribution of the priorities within the tasks of the National Park Authority.

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The monitoring global guideline framework for biodiversity monitoring

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Summary

To preserve and protect nature, the Post-2020 Global Biodiversity Framework calls for increasing the area of the Earth under effective conservation management (CBD, 2021). Monitoring the status of species and habitats allows assessment of management outcomes and is the cornerstone to improve adaptive management strategies. The applications for biodiversity monitoring extend to outreach, education, and general scientific discovery. We provide a framework through the Monitoring Global Guideline (MoniGloG) for monitoring the state of biodiversity in conservation areas around the globe.

The MoniGloG describes four phases of a monitoring programme. In the Preparatory Phase, legal obligations of regional or international scope must be considered. The next step is to assess the availability of previous data and determine the main threats facing the park. Balanced against the site conservation goals, a mission statement containing a monitoring priority list of biological and environmental features should be generated.

The programme should then be collaboratively assessed with stakeholders and park staff during the Conceptual Phase. We propose the use of a monitoring concept worksheet to help frame the following questions: why monitor, what requires monitoring, where and when will monitoring occur, who will participate in the programme, and how many human and financial resources are available to the programme. Questions can be addressed iteratively and revisited as necessary. The outcome is to identify realistic monitoring targets considering site logistics.

Selection of methods and tools occurs in the Implementation Phase. This step requires clear research objectives, basic knowledge of the selected indicators, and a robust statistical design. After determining methods, equipment should be obtained and customised for the programme. Technical staff must receive appropriate training, particularly with unfamiliar technologies. Test runs are recommended to optimise field procedures. Data should be collected in a simple, standardised way and should include descriptive metadata. Following the test runs, data should undergo a statistical analysis to verify the suitable procedures. All elements of test runs should be recorded in a preliminary field manual.

When the field manual is finalised, the ongoing monitoring cycles can begin. We provide field logistics and data management checklists that can be adapted to any monitoring programme. Data should be backed up and archived in their simplest form in a stable digital environment. For transparency, findings should be presented in different formats to stakeholders. Results of the monitoring programme will guide decisions in the Re-evaluation Phase whether the monitoring programme should continue, be adapted, or terminated and resources dedicated to another purpose.

Keywords

adaptive management; long-term monitoring; monitoring guideline; change detection; conservation; evidence-based decision-making

Introduction

The state of biodiversity continues its global downward trajectory, despite intergovernmental policies intended to preserve it (Cowie et al., 2022; IPBES, 2019). The 1992 Rio Convention is perhaps the most consequential of these policies, resulting in the ratification of the Convention on Biological Diversity (CBD) in 1993. This landmark agreement was intended to protect global biodiversity and to this day guides international biodiversity policy. Since ratification, multiple strategic plans have been implemented to halt biodiversity loss and promote ecosystem services. The 2010s-era Aichi Target 11 called for at least 17 per cent of terrestrial areas and 10 per cent of coastal and marine areas to be conserved (CBD, 2010). Target 3 of the CBD's current Post-2020 Global Biodiversity Framework has set forth a goal of placing at least 30 per cent of the world's terrestrial areas under effective conservation by the year 2030 (CBD, 2022), the so-called 30 × 30 objective.

Much work will be required to reach the 30 × 30 objective, not only through designating additional areas for nature conservation, but also by improving management effectiveness of present and future sites. Management effectiveness can only be determined through targeted monitoring programmes. Yet, globally unaligned monitoring protocols used in protected areas (PAs) and other effective area-based measures (OECMs) challenge our scientific ability to determine whether management actions are truly effective. We introduce the Monitoring Global Guideline (MoniGloG) to remedy the shortcomings of these globally unaligned monitoring protocols. MoniGloG provides a framework to conceptualise biodiversity monitoring systems (BMSys) prior to and during implementation, facilitating comparisons of data and techniques in a standardised way.

Methods

The proposal for MoniGloG was accepted in 2020 for eventual publication by the International Union for Conservation of Nature World Commission on Protected Areas (IUCN WCPA). MoniGloG is a designated Work Package of the Austrian FFG-funded project BioMONITec, which began in 2021. Since then, development of MoniGloG has been guided by a core writing team at the UNESCO Chair on Sustainable Management of Conservation Areas, Carinthia University of Applied Sciences (CUAS), and supplemented with contributions by external collaborators and a diverse international Working Group. Existing guidelines from IUCN and other scientific organisations were consulted, and professional experiences from contributors were used as the basis for the guideline.

Results

Setting up a new BMSys is a complex process. The higher the quality of conceptualisation that is invested prior to implementing a BMSys, the less effort is required during implementation. The value and ease of implementation of a well-considered programme will further exceed that of a poorly conceived programme. We propose a framework for establishing new BMSys consisting of four phases. The first phase is the Preparatory Phase. In this phase, the background site information is gathered to help target the BMSys appropriately. The Conceptual Phase follows, in which all logistical considerations are identified and debated internally. The third phase is the Implementation Phase. During this phase, the field work and data analysis procedures take place. The MoniGloG framework concludes with the Re-evaluation Phase. During this final phase, managers and administrators determine whether the BMSys adequately achieved its purpose, whether it should be renewed in the original form, or whether it requires a significant revision before being renewed.

The Preparatory Phase establishes the need for site-based biodiversity monitoring through producing a list of priority monitoring targets. PAs and OECMs have certain legal obligations and site goals. A background investigation of the site will help managers identify the requirements. The outcome of the Preparatory Phase is the development of a brief BMSys mission statement. The mission statement should summarise the primary conservation targets and how the BMSys will evaluate the activities, considering threats, reporting requirements, key species and habitats, and biodiversity obligations.

In the Conceptual Phase, the details of the BMSys are articulated. Logical, well-reasoned responses to the fundamental questions of the Conceptual Phase will provide managers with a realistic view of what can be accomplished given the circumstances surrounding the BMSys (Lindenmayer and Likens, 2009). These questions are:

- **Why monitor**:
  what is the purpose of the monitoring effort;
  what is the expected outcome;
  is there scientific, cultural, or other value associated with monitoring?
- **What indicators should be monitored**:
  is the object under observation a rare species or habitat;
  is population size important;
  is an abiotic proxy being monitored to represent the biological community?
- **Where will monitoring occur**:
  what is the area of interest;
  will monitoring be area-wide or plot-based;
  what is the minimum spatial resolution of the indicator?
- **When will monitoring occur**:
  at what point of the season should monitoring begin;
  how often will monitoring be repeated;
  how long will the programme go on;
  does monitoring occur due to a special circumstance, i.e. natural disaster?
- **Who will be involved in monitoring**:
  who are the partners and stakeholders;
  how large is the monitoring team;
  what skills are available in-house;
  will third party assistance be required?
- **How many resources are available for monitoring**:
  what is the available budget;
  what infrastructure is on-hand;
  do available human resources match the minimum required human resources;
  is involvement of staff secured for many monitoring cycles;
  are supplemental resources available?

We provide the reader with a blank monitoring concept worksheet to help shape the responses to the fundamental questions (Figure 4). Working through the worksheet allows managers and field personnel to consider factors in a step-by-step manner, minimising the complexity of each topic. Questions can be discussed in any order amongst managers, staff, and stakeholders. Questions can be revisited. The outcome is to identify a realistic and achievable scope of the BMSys based on available resources and site factors.

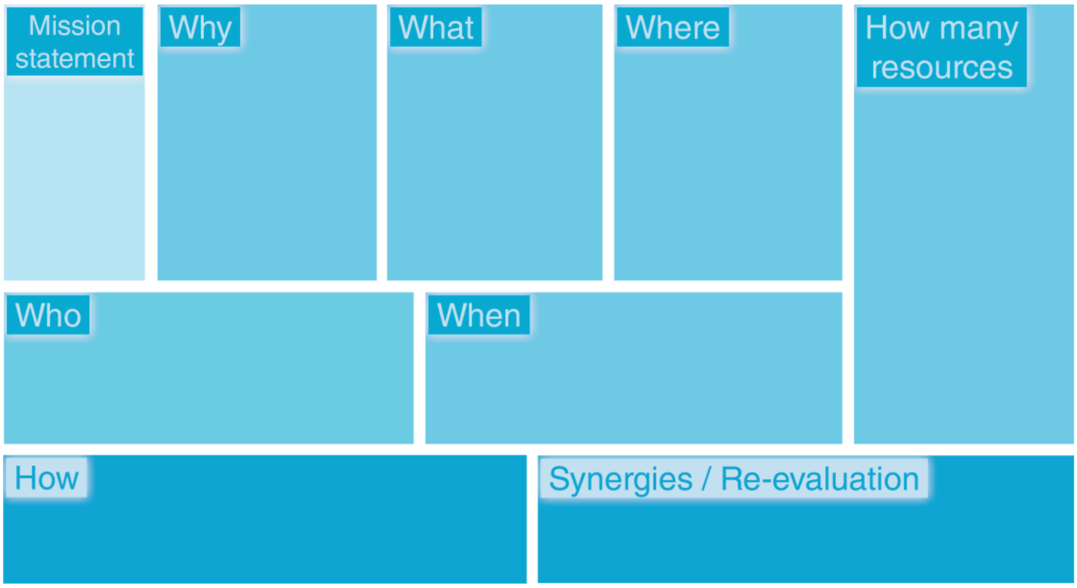

Figure 4 Overview of the Monitoring Concept Worksheet (MCW). The basis of the BMSys is determined through the mission statement developed during the Preparatory Phase (light blue coloration). The six questions "why", "what", "where", "when", "who", and "how many resources" (intermediate blue coloration) of the Conceptual Phase will identify "how" monitoring will be conducted in the Implementation Phase, as well as potential synergies with other management programmes (dark blue coloration).

During the Implementation Phase, the field procedures of the BMSys are put into practise. A decision on sampling design – supported by adequate statistical procedures – is a required first step and will be based on knowledge of the indicator that will be monitored. Once the field design is determined, materials are acquired. Many new monitoring devices are available today, and an overview of traditional and novel techniques is provided in MoniGloG. All components of field implementation should be documented in a preliminary field manual. This should include collecting metadata (Huettmann, 2009), how field data will be analysed and to whom the data will be presented. A series of test runs should then be conducted to ensure that the methodologies are suitable for the site and the selected indicators. Any deficiencies identified during the test runs can be corrected without affecting the quality of the actual data series. The preliminary field manual should be revised to reflect the best work flow from the test runs, resulting in a finalised field guide. Closely following the field guide should help maintain continuity of the BMSys despite personnel changes. In sum, the Implementation Phase outlines on the monitoring concept worksheet "How" the BMSys will be implemented.

The final Re-evaluation Phase of the BMSys is a critical element of management effectiveness. By the nature of scientific programmes, most projects are time-bound. Whilst most projects successfully reach their scheduled conclusion, projects occasionally fade away in an elusive manner. To determine effectiveness of a management programme, this must be avoided. This phase reserves resources to review the outcomes of the programme at its scheduled conclusion, identifying successes and deficiencies. The analysis will provide a basis for administrators and decision-makers to approve a continuation of the programme as-is, to recommend significant modifications, or to allocate limited resources in a different way. In the face of ever-evolving biodiversity obligations, and given the pace of today's technological breakthroughs, re-evaluation will provide room to incorporate the most recent developments into future programmes.

We conclude MoniGloG with a brief review of methods and technologies that are available to implement BMSys. High-throughput genetic techniques and advanced sensors are enabling a new era of 'big data' collection driven by artificial intelligence and machine learning (Dalton et al., 2021). Modern devices include acoustic sensors, camera traps, drone- and satellite-based sensors, and miniaturised telemetric devices. However, uneven availability of these tools, and in some cases non-standardised methodological approaches, may limit their value. As traditional monitoring techniques will continue to be an important component in BMSys, their implementation is discussed in comparison to high-tech methods.

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Connecting protected areas with Green Infrastructure: Assessing connectivity and functionality of ecological networks as a foundation for the development of stakeholder-driven and evidence-based strategies and action plans

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Abstract

Green Infrastructure (GI) defined as a strategically planned network of natural and semi-natural areas is a key strategy in the European biodiversity strategy and the landscape connectivity agenda. Road networks and infrastructure development currently disconnect about 15 % of the Natura 2000 sites from other nature areas, reducing their contribution to maintaining biodiversity and capacity for the provision of ecosystem services. Therefore, GI could mitigate habitat fragmentation and contribute to a trans-European nature network by connecting the European Union’s network of protected sites, Natura 2000 both within and with other protected areas.

To implement this approach in Central Europe’s (CE) landscape planning policies the Interreg project MaGICLandscapes (ML) tried to operationalise the GI concept in CE, to provide land-managers, policy makers, conservation practitioners and communities with tools and knowledge, at different spatial levels.

Based on the example of case study areas throughout Central Europe, comprising National Parks and other protected areas, the aim of this work is to present an easy-to-use approach, starting from producing a highly-detailed regional GI database. By compiling regional cadastral and agricultural information, highly detailed data on the water network as well as forests, this detailed representation of the GI network allows to enhance the regional applicability and acceptance of GI initiatives. Additionally, it provides a crucial foundation for assessing the quality of local GI to develop evidence-based strategies and action plans through stakeholder involvement to direct future actions and investment in GI.

In this work we demonstrate GI assessment methods that focus on functionality in terms of connectivity and provision of landscape services and furthermore communicate and facilitate the adoption of those assessment methods and the strategies derived from them by institutions through participatory approaches.

The additional analysis and mapping of landscape service supply offered by these GI elements, built on expert-based assessments to score each service through a capacity matrix, may therefore complement the information basis for the sustainable planning of GI in the case study areas by visualising focus areas, which provide or are in need of capacities of certain landscape services.

The results provided planning and environmentally oriented institutions with information and methods as well as action plans and strategies that recognise landscape ecological functions and landscape services and identify opportunities for enhanced multifunctionality.

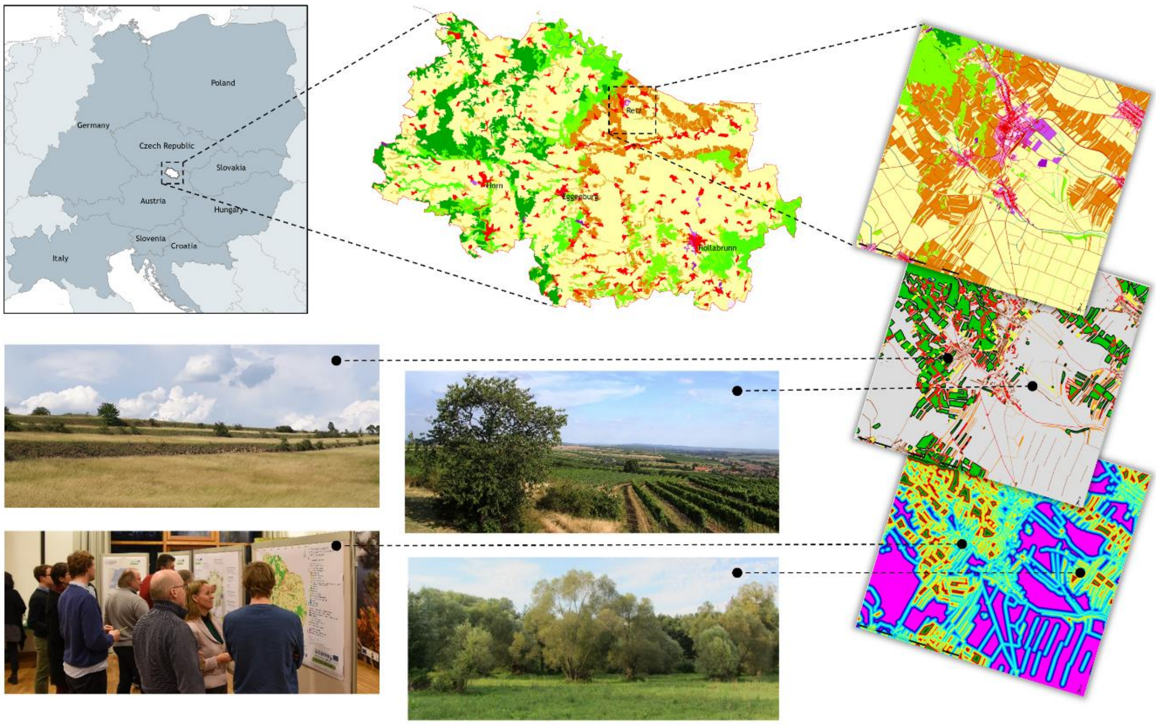

Figure 1: Schematic representation of the implemented approach for mapping and assessing green infrastructure at different spatial scales in Central European landscape types to provide a basis for planning and stakeholder engagement

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The role of Protected Natural Areas (PNAs) as a key component of local and regional socioeconomic development as well as for the biodiversity conservation

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Summary

Protected Natural Areas (PNAs) are a main component of many local and regional socioecological systems that provide a diversity of cultural, economic, environmental, and social benefits. The sustainable use of these spaces by the population has revealed the wide range of ecosystem services that offer in the areas of socioeconomic influence. The increase of scientific literature on protected areas, their current and potential functions, the awareness, and appreciation by the inhabitants, and of course the best way to plan and manage them, shows this growing importance. Interest in conserving and even enhancing biodiversity in PNAs is increasing, not only for the intrinsic value of biodiversity conservation itself, but also for their benefits to society. Our aim is to generate a debate to analyse the importance of the PNAs and their areas of influence for the conservation of biodiversity as well as the innovative approaches for their management. From a collective perspective, in the last years there has been an increase in the awareness of how these spaces benefit people by including new economic, environmental, and social factors. Interplays are ranging from supporting local and regional economies, attracting visitors, offering programs of educational environmental, and ensuring a progressive positive perception of the cultural and natural heritage.

People who live near or care about NPAs, e.g., wildlife managers, conservation professionals, planners, and logically local population, have deliberated on what biodiversity means in this context. The majority approach to biodiversity has recognized the importance of conserving rare species and habitats, but also the importance of managing habitats in and around where rural people live and work. Thus, it is necessary to develop communication, environmental education, and awareness programs on the importance of protected areas in biodiversity conservation and sustainable socioeconomic development. These programs would aim to train local stakeholders to understand its role in managing protected areas, as well as to apply research advances to the implementation of new natural resource management practices.

As expected, results we highlight: i) disseminate information on the importance of PNAs; ii) establish and/or reinforce strategies and programs for environmental education and public awareness of the value of the PNAs based on their role in the biodiversity conservation and sustainable socioeconomic development. For that, as plants are the origin of the ecosystems, changes in plant species diversity influence processes such as biomass production and nutrient cycling. Conserving biodiversity is a complex task that includes scientific, social, and political challenges. International Union for Conservation of Nature (IUCN) Red List of Threatened Species is a key conservation tool for both policy makers and researchers.

Keywords

Ecosystem services, local stakeholders, sustainable growth, plant diversity

Introduction

Despite increasing conservation efforts, biodiversity has been constantly declining globally (World Bank, 2018). As human population in biodiversity hotspots continue to grow, the biodiversity crisis is expected to worsen and, consequently, the number of endangered species is projected to rise (IPBES, 2019). The conservation of the natural heritage by different means has as principal instrument the Protected Natural Areas (PNAs), based on a culture of conservation of natural ecosystems and on sustainable local development. PNAs are environmental policy tools differentiated by the preservation and protection of varied ecosystems, where the original environment has been little altered, producing a series of ecosystem services that are increasingly valued (Olmos-Martínez et al., 2022). PNAs are legally, and spatially defined areas set aside primarily for biodiversity conservation. They seek to conserve genes, species and habitats that provide a range of benefits in terms of ecosystem services to nearby human populations and society (Rodríguez-Rodríguez and López, 2020; Gatiso et al., 2022). They do so by enforcing a legal and management regime that restricts some human activities that may endanger the conservation of biodiversity (Rodríguez-Rodríguez et al., 2016). The potential for economic, social, and political wellbeing that a PNA offers be determined by the strategies applied for natural biodiversity management and conservation (CBD, 2010; IPBES 2019; Olmos-Martínez et al., 2022).

The Convention on Biological Diversity (CBD) set a goal of reaching 17% of terrestrial and freshwater ecosystems under protection by 2020 (CBD, 2010). This implied that approximately 3 million square kilometres more should be conserved effectively compared to Bhola et al. (2016), with important consequences for the users of land and fresh water. Based on these data, it is very important to distinguish which stakeholders are most affected by PNAs declaration and how, to maximise returns and mitigate losses, so human wellbeing, social support for PNAs, and nature conservation can be improved (Bhola et al., 2016; Rodríguez-Rodríguez and López, 2020). Rigorous PNAs regulations restricting most human activities are likely to be more effective at conserving biodiversity but also likely to have more impact on the local socioeconomic than more tolerant, multiple-use regulations (Gatiso et al., 2022).

Nonetheless, it is unclear whether the expansion of the PNAs promotes both conservation and local sustainable development simultaneously or promotes biodiversity conservation at the detriment of local sustainable development (Gatiso et al., 2022). It is also not clear whether development-oriented activities of PNAs have adverse effects on the PNAs ecosystems (Rada et al., 2019). Simultaneously achieving conservation and sustainable development goals requires coordination between both. The PNAs should have a strategy to coordinate the conservation plans with the development initiatives of the local communities that live in them and in the areas of socioeconomic influence (Watson et al., 2014). Impacts of the legal designation of protected natural areas (PNAs) may have uncommon implications for the diverse stakeholders, and at different spatial scales (Rodríguez-Rodríguez and López, 2020).

Therefore, in the present study we analyse the interplays between human communities and biodiversity conservation. Our aim is to generate a debate to examine the importance of the PNAs and their areas of influence socioeconomic in the conservation of biodiversity, as well as the innovative approaches for their management.

Methods

People depend on biodiversity in their daily lives (CBD, 2010). Biodiversity loss can have important human health impacts if ecosystem services are no suitable to provide community needs. Indirectly, changes in ecosystem services affect livelihoods, income, local migration and, on occasion, may even cause political conflicts (Gatiso, et al., 2022). Communities have a vital role to play in conserving biodiversity. However, community-based and like government-based conservation as a panacea, overlooks the need to manage the commons (Bhola et al., 2016). In this context, plants are the basis of ecosystem architecture and agriculture, and as such, changes in their diversity strongly influence processes such as biomass production, decomposition, and nutrient cycling. Plant diversity is therefore critical on other trophic levels. Conserving biodiversity is a complex task that includes scientific, social, and political challenges (CBD, 2010). Both species and geographic areas must be identified as targets for conservation while considering time, financial costs, and community acceptance. For that, the International Union for Conservation of Nature Red List of Threatened Species is a key tool for conservation (Picture 1) (Pelletier et al., 2018).

The Patriarch, a thousand-year-old cedar (Juniperus cedrus Webb & Berthel) that lives in the Teide National Park. National Parks Network Newsletter 62, 2019. Photo: Manuel Suárez.

Results

Biodiversity ensures human and social needs, including food and nutritional security, energy requirements, drug development and clean water. Elements that together favour adequate people health. It also supports the economic opportunities and leisure activities contributed to overall well-being (IPBES, 2019; Heberling et al., 2021; Olmos-Martínez et al., 2022).

The Red List of Threatened Species is a key conservation tool for both policy makers and researchers. This list represents the most comprehensive and consistent listing of conservation status for animal and plant species worldwide (Vié et al., 2009). However, despite the essential ecological role of plant species, plants are not as well represented on the Red List as animals and are often neglected in favour of charismatic vertebrates (Balding and Williams, 2016). Consequently, there is an urgent need for more efficient methods of identifying at-risk plant species (Pelletier et al., 2018).

To meet this need, Pelletier et al. (2018) developed a protocol that permits a rapid assessment of conservation status for understudied plant taxa. This procedure assesses risk for all plant species with geographic coordinates available on the Global Biodiversity Information Facility (GBIF). GBIF is an international organization funded by different countries and aimed to provide free and open online access to global biodiversity data supporting at the same time research, conservation, and sustainable development (Heberling et al., 2021). Coordinated by the Secretariat settled in Copenhagen, it is a network of national nodes that provides data-holding institutions around the world with common standards, best practices and open-source tools enabling them to share information about where and when species have been founded (GBIF Secretariat, 2022). Now, GBIF comprises 61 countries, 40 organizations and 1,796 data providers. Spain is one of the GBIF founder members since the Memorandum of Understanding was signed by the Ministry of Science and Technology and commissioned the Spanish High Council of Research (CSIC) to initiate and coordinate the activities of GBIF.

Spain currently shares through the GBIF network over 46.1 million records of biodiversity under a common standard, including quality control procedures and mechanisms for evaluation and data reuse (Otegui et al., 2013). The main mission of the Spanish node (GBIF.ES) is to support natural history collections, institutions, and relevant biodiversity projects in order to increase their participation by: i) providing them with technical support, information, training, standards, software, and recommendations; ii) supplying coherence between national initiatives and the GBIF information architecture in order to guarantee interoperability; iii) analysing how to maximize the data value by developing tools for data analysis, validation, and visualization; iv) collecting and distributing relevant information to the benefit of collections as well as to our knowledge of biodiversity and its management; v) coordinating the activities of the institutions and international initiatives.

With more than 46.1 million published records of biodiversity, Spain is still among the top ten countries mobilizing more data to GBIF network. From the statistics for Spain can be seen that our country is one of the most active countries in biodiversity data usage. The high level of usage of GBIF platform in our territory is an indicator of the importance of the biodiversity research in Spain and the relevance of its management.

Conclusions

Plants are involved in innumerable interspecific interactions, contribute to the diversification of organisms, can prevent natural disasters, and promote to ecosystem productivity in general. Given the Global Strategy for the Conservation of Plants of the Convention on Biological Diversity, a considerable number of species will be left unprotected, resulting in faster biodiversity loss than we are already suffering. On a global scale, the level of threat to plants is much higher than expected. Also, several geographic regions should receive more attention from conservation decision-makers than they currently do. Both the IUCN Red List and other deeply defined conservation assessments can have an important impact on policymaking and conservation actions at various scales.

In order to understand and manage biodiversity crisis, having large-enough sets of qualified data is necessary. Information facilitators such as the Global Biodiversity Information Facility are ensuring increasing availability of primary biodiversity records by linking data collections spread over several institutions that have agreed to publish their data in a common access scheme. The Spanish node of GBIF (GBIF.ES), hosts on behalf of a number of institutions, considered to be a highly representative sample of the total volume of available data for our country in order to know the quantity and quality of the information made accessible.

The available data may be of large importance for the development of biodiversity research, both locally and globally. However, some swaths of records lack of the data part such as georeferencing or taxonomical levels. Although the remaining information is suitable and fit for many uses, improving the fullness of the records would likely increase their usability span.

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Biodiversity assessment in the Spanish National Parks Network

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Abstract

Protected Natural Areas (NPAs) in general, and National Parks in particular, are considered basic “strongholds” for the conservation of biodiversity. At the same time, their function as (semi-) natural laboratories for biodiversity research as well as for evaluating methodological innovations in this field, make these natural spaces privileged places for this purpose. Although the original aims for the declaration of a protected area may differ, e.g., the protection of the landscape or the protection of fauna species and flora, the benefit of the declaration goes beyond this initial intention and, in general, all the wildlife and flora inhabiting a protected area enjoy higher protection than populations living outside the NPAs.

National Parks are the ones with highest level of protection and are defined as ‘natural areas with high ecological and cultural value, little transformed by exploitation or human activity which, due to the beauty of their landscapes, the representativeness of their ecosystems or the singularity of their flora, fauna, geology or geomorphological formations, possess outstanding ecological, aesthetic, cultural, educational and scientific values whose conservation deserves a preferential attention and are declared of general interest for the country. The National Park Network of Spain was established a century ago, and nowadays it is formed by 16 protected areas, being 10 of them in mainland Spain. The main objectives of the Spanish National Parks are closely linked to the concept of sustainability: i) to conserve natural and cultural assets in the long term; ii) to promote public use; iii) environmental awareness; iv) research and socioeconomic development; v) the maintenance and conservation of biodiversity. In recent years, progress has been made in the development of different methods for effective assessment and monitoring of biodiversity. Monitoring biodiversity is not as simple as supervising other environmental characteristics. The biodiversity of an area undergoes considerable fluctuations because of natural processes. These natural variations need to be identified and checked so that they can be considered. Moreover, it is often difficult to assess the impact of some activities on biodiversity in the short term. Therefore, monitoring must rely on indicators of likely success rather than absolute measurements of biodiversity. Indicators can be quantitative or qualitative variables which can be measured or described and which, when observed periodically, demonstrate trends in biodiversity characteristics over time.

The Network of National Parks occupies only a small percentage of the Spanish territory, but it has great natural resources both in terms of geodiversity and biodiversity. In fact, the most current information available shows nearly 80% of vascular plant species and 80% of vertebrate species in Spain are found within the Network. These spaces are a refuge and reservoir for endangered species as emblematic as the Iberian lynx, the bearded vulture, the imperial eagle or the capercaillie, as well as many other endangered species of flora and fauna. They are privileged spaces for research and monitoring of biodiversity, ecological processes, and global change.

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Perceived crowding, coping strategies and place attitude among visitors in the Bavarian Forest National Park

Stefanie Döringer

Summary

In recent years, a renewed interest in recreational activities in natural and protected areas emerged. This trend intensified during the COVID-19 pandemic resulting in visitation records in National Parks in Germany and Austria. A high volume of visitors and recreational crowding, however, are problematic for protected areas including not only ecological impacts but also social impacts. These processes are also evident in the Bavarian Forest National Park experiencing high visitor density, an increase of day visitors, and crowding. This study is concerned with the phenomenon of perceived crowding in the Bavarian Forest National Park focusing on visitors' coping strategies and attitude towards the park. This research is based on a sequential explanatory mixed-methods design. A survey was conducted (n=716) in the year 2021 to examine perceived crowding and behavioural coping strategies among visitors in the park. The results show significant differences among local visitors, day visitors, and tourists. Particularly local respondents report feeling crowded and making frequent use of coping strategies, such as temporal and spatial displacement. In order to interpret the survey results, in-depth interviews were conducted in 2022. The qualitative interviews aim to scrutinize how perceived crowding might influence attitudes of (local) visitors towards the Bavarian Forest National Park by considering recent dynamics in visitor numbers caused by the COVID-19 pandemic. The results provide a nuanced picture of perceived crowding and coping strategies among different visitor groups and point to the influence of media reports on crowding perception.

Keywords

Crowding, Coping, Visitor Management, Bavarian Forest National Park, Mixed-Methods Design

Introduction

Visitor numbers in protected areas in Europe significantly increased during the COVID-19 pandemic, as people were seeking for recreation and alternative leisure activities. High visitation numbers also raised situations of crowding and lead to conflicts between nature conservation and recreational use in national parks. This spatial and temporal concentration of visitors lead to major management challenges for the parks, e.g. littering, trail widening, or parking congestion that did not only put the park's administration under stress but particularly the crowds themselves (Ferguson et al., 2022). Perceiving crowding within a recreation setting can essentially diminish visitors' satisfaction and the quality of recreation.

The phenomenon of perceived crowding received huge attention in outdoor recreation research and practice in the last decades (Arnberger and Haider, 2007, Manning et al., 2009, Manning and Valliere, 2001, Pikkemaat et al., 2020, Dogru-Dastan, 2022). Perceived crowding is defined as "a negative evaluation of density and involves a value judgment that the density or number of encounters with other visitors is too many" (Vaske and Shelby, 2008: 112). The term "perceived crowding" is used to stress the subjective dimension of this phenomenon. Several factors have been examined shaping crowding perception, such as visitor characteristics, encounters or situational effects (Schamel and Job, 2014). Moreover, there is a huge knowledge about how visitors react to crowding by applying different coping strategies, such as temporal or spatial displacement or activity substitution (Manning and Valliere, 2001, Kyle et al., 2022). Recent studies also show that crowding experiences can not only lead to a spatial displacement but also result in absolute displacement (Fefer et al., 2021). Particularly the latter one might also result in a negative attitude towards the crowded place.

This study draws upon this literature focusing on crowding in the Bavarian Forest National Park (BFNP). The park experienced an increasing number of (day) visitors in recent decade and underwent spatially and temporally crowding during the COVID-19 pandemic in 2020 and 2021 (see figure 1). The BFNP is the first German national park, founded in 1970, and covers nearly 25.000 ha. Approximately 1.4 million people visit the park each year including local residents, day tourists, and overnight tourists (Döringer et al, 2022; Porst et al., 2020).

Figure 5: Crowding and illegal parking at a parking lot in the Bavarian Forest National Park in 2020 (credits: F. Porst)

The study aims to explore crowding perceptions and coping mechanism among visitors in the BFNP and seeks to detect underlying factors shaping their behaviour. In this context, the first major objective is to analyse how visitors experience and feel about crowding in the National Park bearing in mind the high visitor density during COVID-19 pandemic at certain spots. The second major objective is to understand which coping strategies are applied and why the visitors choose for certain strategies. A mixed-methods design was applied in order to gain a deeper understanding of crowding and coping in the National Park considering differences between local residents, day tourists and overnight tourists.

Methods

The study uses a sequential explanatory mixed-methods design. First, a survey was conducted to examine perceived crowding and behavioural coping strategies among visitors in the park in the year 2021. Data was collected from September to October 2021 on eight sampling days at six highly frequented locations in the National Park. The sampling days were stratified by the expected visitor frequency including weekdays that usually show a comparatively low number of visitor and weekends displaying higher numbers. A sample size of 716 questionnaires was achieved comprising overnight tourists (43,9%), day tourists (34,0%) and local residents (22,1%). Most of the respondents are hikers (93,0%) followed by bikers (5,3%) and joggers (1,8%). The visitors were asked, for instance, to indicate their overall and current crowding perceptions (measured by means of a 5-point Likert scale) and the frequency of behavioural coping to mitigate the risk of high visitor densities.

Second, qualitative interviews are conducted in order to interpret the survey findings and to gain a more nuanced picture of perceived crowding in the National Park. The interviews aim at scrutinizing the effects of crowding during COVID-19 pandemic on crowding perception and the differences between local residents, day tourists and overnight tourists. The on-site qualitative (group) interviews are based on a topical guide and have been taking place since May 2022 on three locations in the park. In the first period from May to June 2022, we conducted 33 interviews with recreationists. The interviews took 14:04 minutes approximately. All interviews were anonymised, recorded and transcribed. The second period will last from the end of August to October, as autumn shows the highest number of visitors in BFNP. The interviews are analysed by means of qualitative content analysis.

Results

Hereinafter, intermediary results of the survey and the qualitative interviewing are presented. The survey results indicate significant differences between perceived crowding on weekdays and Sundays. Only 2,3% of the respondents think that weekdays are very or extremely crowded, while the crowding experience was significantly higher on Sundays (37,4%). Significant differences can also be observed for the different visitor groups in the park. Crowding seems to be a minor problem for overnight tourists and day tourist, while local residents tend to feel more crowded. More than half of the local residents (60,6%) report that they feel very or extremely crowded on Sundays (see figure 2).

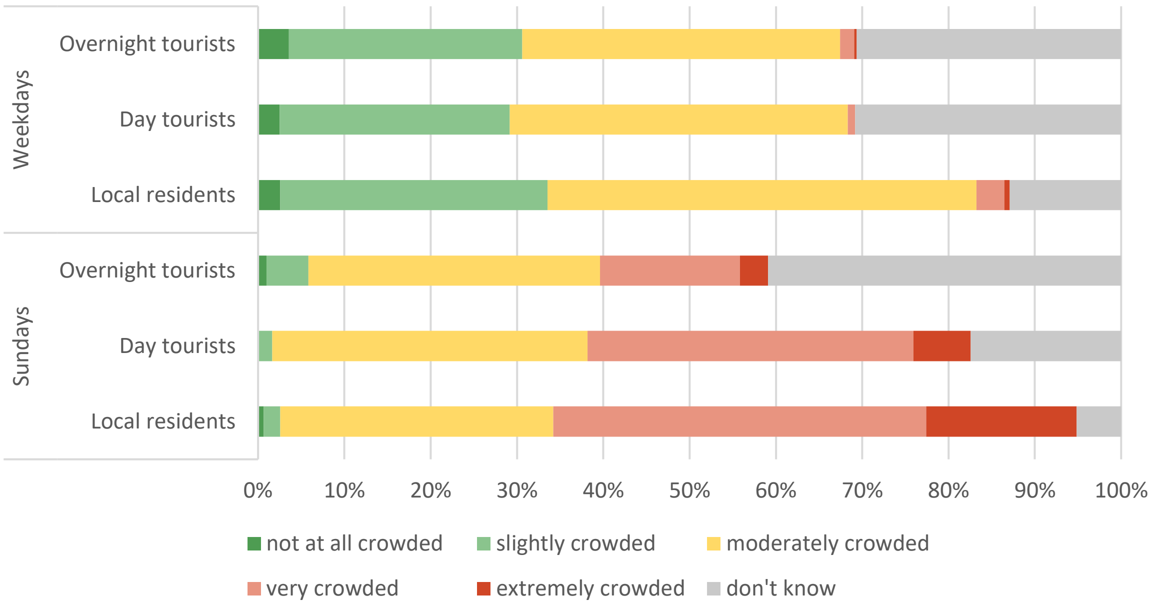

Figure 6: Perceived crowding at weekdays and Sundays. Comparison of overnight tourists, day tourists and local residents (n=716)

The respondents were also asked to indicate coping strategies in order to avoid crowding. Overall, results suggest only slight forms of coping. Visitors prefer temporal strategies of displacement by daytime or weekdays. Particularly for local residents these two strategies were an expedient way to deal with the problem. Spatial displacement, i.e. choosing less frequented trails or destinations, returned to be the third most common strategy among all respondents.

Based on these findings, the qualitative interviews set out to gain a nuanced understanding of factors and effects related to different crowding perceptions and coping strategies. First analysis shows that local residents seem to have a tacit knowledge of crowded spots in the National Park gained through personal experiences and social resources. Based on this knowledge, temporal and spatial coping strategies can be applied by this visitor group purposefully and efficiently. Additionally, several interviewees reported to shorten their stay at the summits in BFNP in order to avoid visitor crowds – a strategy that barely has been discussed in the crowding literature so far.

The interviews further indicate that the majority of interviewees notices increasing visitor numbers in the park in recent years. However, most of the respondents consider the immense crowding in the park as a temporal phenomenon limited to the period of COVID-19 pandemic. Moreover, the analysis indicates that local newspaper reports about crowding in the National Park published during the COVID-19 pandemic have been strongly affecting and are still shaping the crowding perception of local residents. This could also be a possible explanation for the high share of local residents reporting that they feel very or extremely crowded in the survey (see figure 2). However, the interviews also reveal that the tendency towards higher visitor densities and crowding during the last two years did not negatively affect the visitors' attitude and attachment towards the National Park.

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Long-term hydrological changes in the Lobau (Donau-Auen National Park, Viennese part) – effects on the regional species composition of molluscs

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Summary

The mollusc fauna of the Lobau, the Viennese part of the National Park Donau-Auen, underwent several changes since the Danube regulation 1870. After the regulation many bayous, which were originally floating waters, became stagnant water bodies. This reduced the habitat qualities of formerly frequent, typical danubian streaming water species like *Theodoxus danubialis* or *Anodonta cygnaea*. However, this first impact triggered on the other hand the development of a mollusc fauna consisting of peculiar still water and swamp dwelling species. But also even this habitat type was, after some time, afflicted by negative tendencies. River regulation and the construction of a hydroelectric power station reduced the transport of gravel downstream and therefore triggered the drawdown of the soilwater level. Additionally, climate change and extreme weather events led to extreme unfavourable hydrological conditions including complete desiccation exsiccation of bayous and wet reed beds. This caused disappearance not only of unioinid mussels and some freshwater snails, but also of typical wetland species like *Trochulus striolatus danubialis* and *Pseudotrichia rubiginosa* in the Viennese part of the National Park. On the other hand, several introduced molluscs become more and more common in this protected area. They also might be involved in the extinction of native species. A more intense dotation of freshwater, which is long overdue, could stabilize the hydrological situation and preserve at least a basic freshwater and wetland fauna including the FFH species *Anisus vorticulus*.

Keywords

Mollusca, National Park Donauauen, Lobau, Vienna

Introduction

The Viennese part of the National Park „Donauauen“ is currently heavily affected by draught. Reasons for that are, besides the Danube regulation of 1875, an ongoing decrease of water level caused by river engineering and climate change. Plans of floodplain restoration exist, but are hardly realised. Molluscs are heavily afflicted by these changes. An overview on the historical development and future perspectives of the mollusc fauna of this area is given in this study.

Methods

The data originate from the project „molluscs of the areas of rural development in Vienna“ 2020-2021 including the Viennese woods, Bisamberg area, several agricultural areas in the east of Vienna and the Danubian flooplains including Lobau area. As a first step a literature research was conducted. For the time before 1970 only comparative data from other areas were available (Fischer & Müller 1996, Pišút ´et al. 2021). All literature data after that time, were analyzed, located and entered into a database. Field work was conducted in the years 2020 and 2021. As the available data did not allow a quantitative comparison, the main focus was on qualitative sampling (hand catch, scooping, soil samples) to achieve maximum knowledge on present species diversity. Litter samples were dried and sieved with mesh widths of 4 and 0,5 mm. Species were determined morphologically, in single cases also DNA barcoding was used.

Results

In total, 61 sample sites investigated were investigated during 2020 and 2021. A comparison of recent and historical data showed 124 potential species, which live or had lived in the Viennese part of the Lobau. A comparison with historical data showed a decrease of 92 species from 2000-2019 to 82 from 2020-2021. A remarkable fact is, that this decrease was detected despite „new records“ of formerly overlooked species. The comparison with historical data shows three phases: Until the regulation of the Danube, species of floating water were dominating, like e.g. the snails *Theodoxus danubialis*, *Theodoxus transversalis* and *Viviparus acerosus* or the unioid mussels *Anodonta cygnaea* and *Unio crassus*. This can be deduced from data of Fischer & Müller (1996) and Pišút´et al. (2021), who analyzed subfossil material in and area close to the Lobau and, somewhat downstream, near Devín. Later, in the course of the river regulations, the second phase, the Lobau was dammed in the north and south. Only one meander stood in direct contact with the river. As a result, some of the species typical for floating water became rare or locally extinct. On the other hand, species of stagnant water and semiaquatic areas became more common dominated, among them many of high value of nature conservation. Additionally, new open grassland areas on top of coarse river gravel and on the southern dam became established. At the same time, also several problems began to afflict the Lobau area. On the western borders house developing destroyed some former river forests, in the 1940s a big harbor (Ölhafen Lobau) was built in the center of the area. More detailed research concerning molluscs of the Lobau started at this time (Reischütz 1973). Power plants upstream led to a continous decrease of water level in Danube and soil water. This led to the third phase, the desiccation of the wetlands within the Lobau starting in the 1990s. Also the increasing draughts caused by longer heatwaves and drier summers afflicted the water level. Additionally, an increase of invasive species could be detected. All these negative impacts led to regional extinction especially of aquatic and semiaquatic species. Examples for locally extinct aquatic species are the unioid mussles *Anodonta cygnaea*, *Unio pictorum* and *Unio tumidus*, all species with higher degrees of endangerment in the Austrian red list. Within the semiaquatic species in contrast, not only endangered species like the *Pseudotrichia rubiginosa* or *Trochulus striolatus danubialis* became extinct in large parts of the area, but also the formerly common species *Arianta arbustorum.*

In the Northwestern part of the Lobau (“Obere Lobau”) continuous dotation of water attenuated the situation at least a little bit. An extension of this measure to the southeastern parts would perhaps enable the semiaquatic species mentioned above to re-settle the Lobau area and stabilize the populations of several aquatic Gastropods, especially *Anisus vorticulus*, a species listed in the Annex II of the FFH-directive,

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The Zitzmannsdorf's Meadows – initial assessment of grassland management in an ongoing study

Sebastian Dunkl

Summary

Characterized by a diverse patchwork of numerous habitat types in spatial proximity, ranging from semi-natural dry grasslands to alkaline fens, the Zitzmannsdorf's Meadows (Northern Burgenland) represent the largest area of continuous lowland-meadows in Eastern Austria and are habitat for a vast number of species, many of them critically endangered or threatened by extinction. Due to its high environmental and biological diversity, this area is of significant importance for biodiversity conservation in Austria.

The major threat for conservation of nature in the region of Seewinkel are large-scale hydrological changes, caused by human activity, with all its consequential effects. Nevertheless, additional threats for conservation assets in the Zitzmannsdorf's Meadows were identified. Besides reduced water availability in general, suboptimal date and spatial extent of mowing in some subareas, insufficient consideration of habitat complexes and small habitats like wet swales and strong segregation between fallow land and hay meadows, resulting in reduced edge density, are key issues in this area.

Unbalanced conservation measures, e.g. focusing on bird conservation and selecting suboptimal mowing dates from a botanical point of view over several years, could not only threaten habitat quality and plant species in the long term, but also animal species adapted to certain plant communities or species indirectly.

It is recalled that designation of an area as Special Area of Conservation (SAC) leads to a legal obligation for implementation of conservation measures in context of favourable conservation status and prohibition of deterioration, according to Habitats Directive. However, the current management of the Zitzmannsdorf's Meadows seems to fulfil this obligation only partially. Immediate actions should be taken by policy-makers and an adaptation of the current management plan is highly recommended.

Therefore, inter alia, improving the match between mowing dates and habitat types, improving the temporal and spatial staggering of mowing, desistance from grassland management based primarily on land parcels, sufficient consideration of habitat complexes and small habitats, increasing the area of ecotones and blockage of all drainage ditches are recommended adaptations.

Keywords

Zitzmannsdorfer Wiesen, Grassland management, Conservation measures, Meadows, Vegetation, Syntaxonomy, Plant community, Biodiversity crisis

Introduction

Grasslands, one of the most diverse and species rich habitats in Europe, are highly endangered due to land conversion, agricultural intensification, eutrophication, and abandonment (TÖRÖK et al. 2018; HABEL et al. 2013), going hand in hand with biodiversity crisis. Lowering of the groundwater table, resulting in reduced soil water availability, is an additional threat for wet grasslands, caused by climate change and water extraction for agricultural purposes (JOYCE et al. 2016; DAWSON et al. 2003).

This is where conservation instruments come into play, e.g. designation as Natura 2000 site or National Park conservation zone and implementation of agri-environment schemes (ÖPUL program in Austria), facilitating the protection of valuable grassland habitats.

However, there is a need for an adaptation of Zitzmannsdorf's Meadows management plan because current conservation measures seem not to be sufficient for maintenance of protected assets, especially those of Annex I (Habitats Directive), which was the major impetus for this study, in the context of my master's thesis.

Second motive for doing this study was the fact that Zitzmannsdorf's Meadows have not been studied sufficiently from a botanical point of view since KÖLLNER (1983) has written his dissertation about the vegetation in the west of Seewinkel.

This study may serve as the basis for adapted conservation measures in the future.

The following questions shall be addressed:

1) Has syntaxonomic diversity of open land habitats changed since 1983?

2) Has conservation status of open land habitats changed since 2010?

Methods

The Zitzmannsdorf's Meadows, located northeast of Lake Neusiedl in Northern Burgenland (Eastern Austria), are part of Habitats Directive site 'Neusiedler See - Nordöstliches Leithagebirge' and designated as conservation zone of the Neusiedler See - Seewinkel National Park in large parts.

Containing about 540 ha of Annex I habitat types (Habitats Directive), the 744 ha large study area is dominated by lowland hay meadows (habitat type 6510) and Molinia meadows on calcareous, peaty or clayey-silt-laden soils (6410). Further habitat types present in this area are Pannonic salt steppes and salt marshes (1530), semi-natural dry grasslands and scrubland facies on calcareous substrates (6210), Pannonic sand steppes (6260), calcareous fens with *Cladium mariscus* and species of the Caricion davallianae (7210) and alkaline fens (7230).

In this ongoing study, 105 sample plots were selected via stratified random sampling within the mapped Habitats Directive site, using mapping data from 2009/10 (Fig. 1).

Vegetation surveys took place 2021 and 2022, using a modified version of the BRAUN-BLANQUET method (1921). Plot size was mainly 5 × 5 m. During field work, a plot-based assessment of the current conservation status of habitats with indicator values for Article 11 monitoring from ELLMAUER et al. (2005) and UMWELTBUNDESAMT (2020) was also done.

At this moment, syntaxonomical analysis is in progress, to get an overview of the current syntaxonomic composition. This will be followed by comparison of data from this study with data from KÖLLNER (1983) and a detailed evaluation of the current conservation measures.

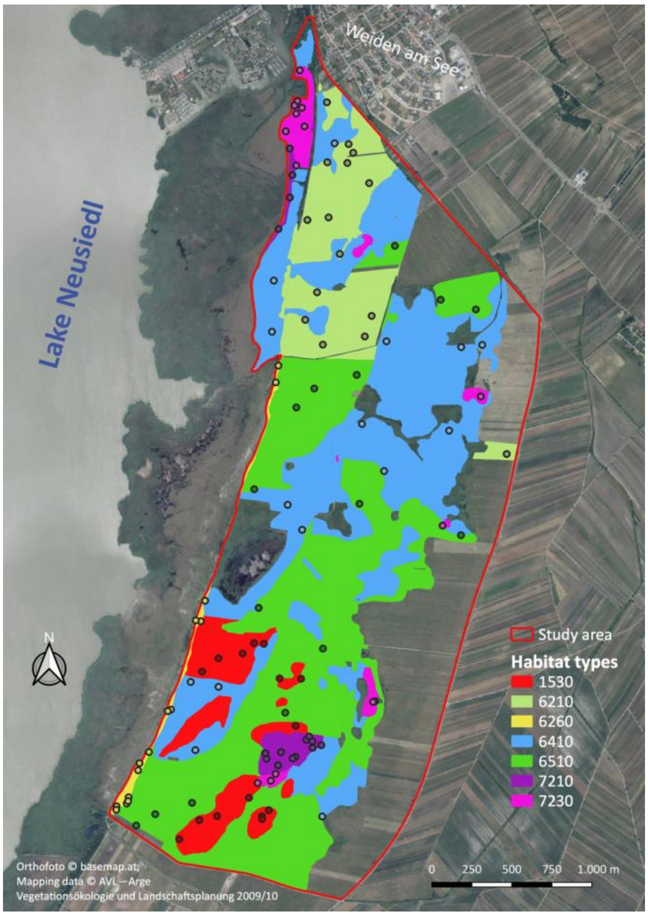

Fig. 1: *Location of 105 sample plots within the mapped Habitats Directive site, selected via stratified random sampling. Sources: Mapping data © 2009/10 AVL – Arge Vegetationsökologie und Landschaftsplanung, Orthofoto © basemap.at*

Initial assessment of grassland management

The following threats for conservation assets in Zitzmannsdorf's Meadows have been identified during field work:

1) suboptimal date and spatial extent of mowing in some subareas, especially in habitat types 6410 and 7230

2) strong segregation between fallow land and hay meadows, resulting in reduced edge density (Fig. 2)

3) insufficient consideration of habitat complexes and small habitats like wet swales in grassland management, especially in habitat types 6410 and 7230 (Fig. 2)

4) climate change, drainage (there are still active drainage ditches) and groundwater extraction

5) hardly any meadow, including alkaline fens, remaining unmown over the winter, except parts of 'Seevorgelände'

6) shrub encroachment in some subareas, especially in 'Seevorgelände' south of Weiden am See

7) on 'Seedamm', a narrow, sandy ridge along the eastern shore of Lake Neusiedl, broad stripes on both sides of the bike trail are mulched several times per year, impairing reproduction success of vascular plants, e.g. *Ophrys sphegodes* and *Iris pumila*

Fig. 2: *Strong segregation between fallow land and hay meadows in southern part of Zitzmannsdorf's Meadows. Fallow, overmature Phragmites-/secondary Cladium-stands (1–5). Wet swales (remnants of Molinia meadows and alkaline fens (*) mown together with drier meadows on June 23rd, 2022, similar in 2021. Photo © S. Dunkl, June 27th, 2022*

As an outcome, some subareas seem to suffer from species impoverishment and conservation status of many open land habitats seems to have deteriorated since 2010.

Furthermore, plant communities and species, dependent from higher groundwater levels, seem to be highly threatened in Zitzmannsdorf's Meadows. Therefore, further decline of area covered by those communities is imaginable in the future and conservation status of certain habitat types could deteriorate further, especially in habitat types 6410 and 7230.

The current conservation measures seem therefore not to be sufficient for maintenance of all protected assets of community interest.

A recent example to illustrate the issues: *Pedicularis palustris,* a species of alkaline fens, was last seen 2015 in a wet swale in Zitzmannsdorf's Meadows. This species is now classified as RE (regionally extinct) in Burgenland because former open habitat on peaty mineral soil is now mainly grass-covered, caused by water table drawdown (GILLI et al. 2022).

Conclusions (regarding current conservation measures)

The following adaptations to the current management plan are highly recommended:

1) improving the match between mowing dates and habitat types

2) improving the temporal and spatial staggering of mowing

3) desistance from grassland management primarily based on land parcels

4) sufficient consideration of habitat complexes and small habitats in grassland management

5) increasing the area of ecotones

6) leaving subareas unmown over the winter, in annually shifting positions (where grassland birds like Eurasian Curlew or Common Redshank won't get affected negatively)

7) reintroduction of mowing in 'Seevorgelände' Weiden am See and clearing of trees/shrubs, where ecologically worthwhile

8) extensification of bike trail management on 'Seedamm'

9) blockage of all drainage ditches

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The degradation of the soda pans in the national park Neusiedler See - Seewinkel and its implications for breeding and migrating waterbirds

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Abstract

The soda pans of the Seewinkel, in conjunction with the landward margins of Lake Neusiedl support one of the most diverse species communities of breeding and migrating waterbirds in inland Central Europe. Systematic surveys and counts of the breeding and migrating waterbirds (swans, geese, ducks, rails, waders, gulls and terns) are conducted in the area since the 1980ies. Quantitative changes over 40 years were therefore documented for many species. While the populations of some species increased in this period others were affected by decreases or strong fluctuations. Different factors are responsible for these contrasting patterns.

In this talk we evaluate the impact of the degradation of the soda pans during the last four decades and its implications for a selection of characteristic breeding and migrating species: Northern Shoveler Spatula clypeata, Eurasian Teal Anas crecca, Eurasian Wigeon Anas penelope, Pied Avocet Avosetta recurvirostra and Ruff Calidris pugnax.

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Definition and ecological assessment methods of alkaline soda lakes/pans in the Pannonian Biogeographic Region

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Abstract

In line with the themed session of assessing biodiversity foundations and methodological innovations, we would like to review of the definition and ecological assessment methods of soda lakes/pans in the Pannonian Biogeographic Region in this study. The Pannonic salt steppes and salt marshes habitat complex (1530) has a high priority in the Natura 2000 network by Annex I of the Habitats Directive (92/423/EEC). This wetland and grassland complex consists of various types of intermittent semi-aquatic and aquatic habitats (alkaline soda wetlands mostly related with solonchak soils), among which the most characteristic are the soda and soda-saline chemical type of shallow intermittent pans (e.g. as the several pans in the Seewinkel Austria). The geographical distribution of this unique wet ecosystems is limited worldwide and significantly concentrated to the Pannonian biogeographical region in Europe.

Although the spatial extent of the habitat complex (*1530) seems to be stable since the beginnings of 21st century based on the Natura 2000 network assessments, however, the intermittent alkaline soda affected wetlands are significantly threated and their habitat loss is still intensive, estimated to be 85% in the region during the last few decades because of local, regional and global environmental changes.

This is the reasons that is why more effective restoration and management strategy is needed for these special wetlands, which is fostered by this initiative study. The baseline of this review is the latest regional assessment (LIFE07NAT/H/000324) completed with the new scientific issues. The main results of the review: physical, chemical and biological factors are evaluated and their technical parameters are suggested for the monitoring practices with a reviewed definition for the alkaline soda lakes/pans in the region:

1. Regular fluctuating or intermittent water cover

2. The average salinity is at least 1 g/liter

3. The sodium and sum of carbonates (HCO3+CO3) exceed the 25 equivalent percent (e%), and the sodium is always in the first place in the order of cation dominance

4. Presence of alkaline soda character species and/or communities.

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Rewilding the floodplains of Morava river - first results after eight years of grazing with semi-wild horses

Gerhard Egger

Abstract

The Morava Dyje floodplains in the Northeast of Austria are one of the few lowlands in Central Europe with high nature development potential. The forests and grasslands are near-natural and the shape of the landscape is still influenced by frequent floods. The wetlands along Morava and Dyje are an outstanding refuge for endangered species such as white-tailed eagle, white stork deadwood beetles and rare plants. In the lower course of Morava river, right on the border between Austria and Slovakia, a remarkable nature reserve is situated. It belongs to WWF since 1970. The long-term goal of the site management is to re-establish near-natural conditions and dedicate the site to natural processes.

In spring 2015 a new ambitious project has been started in the floodplain reserve. A small herd of polish konik horses was introduced. Since then the horses are kept almost like wildlife with a minimum of interventions. The horses roam a reasonable part of the reserve (approx. 70 hectares). Enough for a small group of horses to live quite self-reliant.

Large herbivores are keystone species for productive temperate ecosystems. Due to the extinction of Tarpan and Auerochs centuries ago and changes in land-use in the cultural landscape in the past decades relevant herbivores are almost absent today. By reintroducing a robust breed of horses WWF expected natural processes to return to the reserve. In addition to the permanent presence of the horses a small herd of robust cattle is released to the site for grazing several weeks a year.

Since 2015 the project team has gathered valuable experiences with wildlife management. Many aspects of wildlife- and visitor management have been monitored. In a two years term the vegetation of the site is monitored. Furthermore habitats, abundance of target species such as birds, insects is investigated.

The monitoring of the project so far revealed many interesting results. Habitat structures and distribution of insects, birds and plants changed significantly. While the transformation of the vegetation structure became apparent immediately, plant-species composition is changing slower. Overall species richness increased slightly. Some rare plants like *Trifolium retusum* or *Veronica orchidea* became more abundant. With great anxiety we saw dispersal of unwelcome weeds and alien species. However with great relieve we also saw weeds disappearing again, yet sometimes for unclear reason. Overall the abundance of invasive species is stable, but significant increase of *Symphyotrichum lanceolatum* in open grassland has to be addressed.

Self-reliant animals unfold a variety of different behavioural patterns and the spatial preferences in terms of resting, feeding and grooming grounds shape the landscape. The most obvious effect is visible in former meadows. Neat forest edges are dissolved and less tasty shrubs enrich heavily grazed parts of the pasture. Monitoring shows that the abundance of pioneer species increased and trees slowly spread in former meadows.

Our monitoring does not indicate that any rapid change of the reserve is happening and extensive grazing seems not to contradict conservative conservation objectives. The frequency of characteristic species increased. It is obvious that a remarkable transition started, however the long-term outcome remains unpredictable.

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Gewässerperle PLUS – for the benefit of people and nature

Antonia Eisenhut, Walter Wagner

Summary

A report commissioned by the WWF proved: Most Swiss water bodies show major ecological deficits. Only around 20 % of Swiss water bodies still largely meet the objectives of the Water Protection Ordinance. The preservation of the last ecologically most valuable water bodies is of extraordinary importance to strengthen the resilience against the consequences of climate change and to preserve biodiversity. However, not even a quarter of these valuable stretches have a sufficiently good protection status. Swiss legislation has a relatively wide range of protection instruments, some of which are very effective, but there is no national inventory for valuable watercourses and the implementation of existing protection instruments is extremely time-consuming and often meets with political resistance. The "Gewässerperle PLUS" quality label makes it possible to close the gap in the protection system in a meaningful way. It not only honors valuable water bodies. It promotes and demands the commitment of the local stakeholders to take responsibility for their river. And it provides incentives to further improve the water bodies. In this way, we are creating a necessary, low-threshold supplement to the already existing set of protection instruments, which includes more legally binding instruments.

Organizations applying for the label must be rooted in the region and need to prepare and submit a candidature dossier covering two areas:

1. A river stretch for certification of at least 2 km in length is defined. Based on 13 exclusion criteria, proof must be provided that the stretch is of high ecological value. Revitalized stretches are eligible.

2. A participatory process is established and ensures that all local stakeholders with an interest in the watercourse participate in this process. A development plan is elaborated, which specifies how the maintenance and further development of the high ecological value river stretch is to be ensured during the five-year certification period. The development plan includes not only the certified stretch, but also the lower and upper reaches as well as the tributaries. The development plan must include measures to raise awareness and education, and it checks whether measures in the areas of upgrading, local recreation and neobiots are necessary and if so, defines them. Research work can also be addressed as part of the development plan.

Ideally, the implementation of measures during the certification period of 5 years will allow to expand the certified river stretch and the scope of the development plan for the following certification period.

The first two rivers have been certified in 2021. Initial evaluations show that the instrument is working and achieving its goals: conservation, protection and development of valuable river stretches. Even if such river stretches are only informally protected, the certification process strongly contributes to the support of nature protection measures in society and will improve the quality of the network of legally protected areas in the Alps.

Keywords:

freshwater, biodiversity, protection, Gewässerperle PLUS, local, certification, label, people, nature

Introduction

Rivers, streams and lakes characterize the landscape of Switzerland. Natural water bodies and their surroundings are habitats for a multitude of animal and plant species, provide clean drinking water and protect against flooding. However, only 3.6% of Switzerland's water bodies are in an ecologically valuable condition. Most of the watercourses are straightened and forced into dams, used for electricity production, or polluted by agriculture and therefore cannot fully fulfil their natural functions. More than 2/3 of the fish and crayfish species in Switzerland are endangered or even extinct. 70% of the extremely species-rich riparian areas that accompany watercourses have disappeared.

However, not even a quarter of the remaining valuable river stretches have a sufficiently good protection status. The last few natural water bodies - our so-called "water pearls" - must urgently be protected, so that the biodiversity in and around the water bodies does not decrease further and we can continue to benefit from the ecosystem services of the water bodies for drinking water supply, flood protection, recreational use, etc. However, achieving binding legal protection is costly, time-consuming, and hardly realistic in the current political situation. However, we must not lose any time, because the destruction of water bodies and the resulting extinction of species are taking their course.

The label "Gewässerperle PLUS" makes it possible to raise awareness. It has been developed in cooperation with WWF Switzerland.

It recognizes not only ecologically valuable streams and rivers, but also the commitment of the people behind them. It promotes and demands the commitment of the local population, which takes responsibility for its river. And it sets incentives to improve the water system further ecologically.

Methods

The quality label "Gewässerperle PLUS" is a low-threshold addition to the already existing set of legally binding protection instruments.

"Gewässerperle PLUS" offers the label holders, for example a municipality, broad added value. It strengthens and promotes various habitats and species, creates pride, shared identity, and joy. It secures local recreational areas and ensures their sustainable and careful use. It helps to protect against natural hazards and to guarantee clean drinking water, thus making a significant contribution to maintaining the quality of life. Resilience to climate impacts is strengthened. In addition, the association “Gewässerperlen” with its network can offer support in financing measures or in launching research projects. It offers a platform for exchange and joint communication with other label holders.

Most importantly, the label brings stakeholders together and creates enthusiasm and commitment for the protection and conservation of water bodies. "Gewässerperle PLUS" is meant to be fun: There is forward thinking and visions are developed and implemented together. People enjoy their “River Pearl” together, celebrate it, decide for themselves in its spirit and thus pave the way for further collaboration. A certified water body brings innovative added value to the region.

Organizations applying for the label must be rooted in the region and submit their candidature in two areas:

1. A river stretch for certification of at least 2 km in length is defined. Based on 13 exclusion criteria, proof must be provided that the stretch is of high ecological value. Revitalized stretches are also eligible.

2. A participatory process is established and ensures that all local stakeholders with an interest in the watercourse participate in this process. A development plan is elaborated, which specifies how the maintenance and further development of the high ecological value river stretch is to be ensured during the five-year certification period. The development plan includes not only the certified stretch, but also the lower and upper reaches as well as the tributaries. The development plan must include measures to raise awareness and education, and it checks whether measures in the areas of upgrading, local recreation and neobiots are necessary and if so, defines them. Research work can also be addressed as part of the development plan.

Ideally, the implementation of measures during the certification period of 5 years will allow to expand the certified river stretch and the scope of the development plan for the following certification period.

Fig. 1: Initial certification: Upper section is certified (green). The development plan (yellow) includes measures to remove obstacles/ obstructions in the lower reaches.

Fig. 2: Ideally, recertification occurs after 5 years: The former development plan (green) is implemented, obstacles/obstructions are removed, the lower reach is now also certifiable. The new development plan (yellow), aims at removing impairments in the estuarine waters.

Results

The first two rivers have been certified with the label “Gewässerperle PLUS” in 2021. Initial evaluations show that the instrument is working and is achieving its goals: conservation, protection and development of valuable river stretches. Even if such river stretches are only informally protected, the certification process strongly contributes to the support of nature protection measures in society and will improve the quality of the network of legally protected areas in the Alps.

In a festive ceremony in June 2021, the municipality of Bever was honoured with the first certificate for the upper reaches of the Beverin and its tributaries. This area is for example home to the otter, as the structure of the habitat is excellent and the supply of brown trout is rich. There is hardly a greater compliment for a stream, because the otter only colonizes intact and healthy waters.

The municipality of Bever immediately recognized the potential of the quality label for ecologically valuable waters and actively participated in its development. It has established a lively stakeholder process. Representatives of cantonal and communal authorities, tourism and its service providers, landowners and land managers, the private sector, associations, and societies, as well as the scientific community actively collaborate.

Fig. 3: Beverin in the Canton of Grison, Switzerland: In a festive ceremony on June 25, 2021, the municipality of Bever was honoured with the first certificate "Gewässerperle PLUS" for their river Beverin and its tributaries.

What all the stakeholders have in common is the attitude that they want to preserve the quality of the Beverin and the Val Bever. The local population and visitors are increasingly getting aware of the value of the water body and start to behave accordingly. The recognition of the value and potential of "their" water bodies is the prerequisite for people to take action to protect and restore rivers even outside of the certified stretch.

In October of the same year, the second pilot certification was awarded to the Ova Chamuera. This river in the Upper Engadin is in the vicinity of the Swiss National Park. To date, the catchment area with a total river length of 218 kilometers is still largely untouched by human interventions. A plan to build a hydropower station with a huge reservoir in the Chamuera valley was rejected by the municipality after long and intense discussions. The people of La Punt decided to rather preserve the natural mountain valley in its original beauty in the long term rather than to go for short term financial benefits. Today, the area is a dedicated "cantonal landscape conservation area" and home to bearded vultures, golden eagles, summer lady's slippers and many other orchids. The valley could even become part of an extended national park one day.

Fig. 4: Ova Chamuera in the Canton of Grison, Switzerland: In October 2021, the second certification was awarded to the Ova Chamuera. Together with its tributaries the ecosystem is now better protected.

Natural waters such as the Ova Chamuera play an important role: with their natural habitat diversity they support a huge biodiversity. They are nurseries for insects, fish, and many other species. In addition, they are also important recreational areas for locals and tourists.

Based on these two pilot certifications, the label criteria and the business model behind the label have been optimized. There is a huge interest of other Swiss municipalities for the certification. The label is also gaining traction in Germany. We will be able to certify the first river stretch in Bavaria soon. And the intention is to introduce the label also in other alpine countries such as Austria and Slovenia to contribute to the conservation of the last natural rivers in the alps.

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Ways to secure and use forest genetic resources in protected areas

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Summary

In north-eastern A2 ustria there is a shortage of suitable seed and planting material from deciduous tree species. Therefore, the aim of this study is to secure valuable forest genetic resources of the National Park Thayatal by establishing two stands with the sessile oak (*Quercus petraea* (Matt.) Liebl.)) in the regions particularly affected by drought, which can be used in the long term as seed orchards for seed production and will be available for both forest enterprises and nature conservation bodies. For this purpose, 404 mature trees from eight populations were characterized in the Thayatal, in the area of the National Park Thayatal, using different methods (wood core analysis, analysis of water use efficiency, genetic diversity analyses). Two classes of trees were of particular interest: those with high drought tolerance and those with high genetic diversity. Acorns of selected oak trees were then collected and grown. The young plants (the progeny of mature oak trees) will be finally planted in Lower Austria at two sites outside the national park. At one site, progeny with high genetic diversity will be planted, and at the other site progeny with high drought tolerance.

From a forestry management perspective, obtaining seed and planting material of suitable drought-tolerant sessile oaks is of great importance, as the supply of such material is largely lacking not only in north-eastern Austria. The seed stand of high drought tolerance will contribute to seed supply for dry sites. Forest reproductive material of this stand with autochthonous genetic material of a native tree species can be used for forest management adaptions to climate change.

From a nature conservation perspective, the genetic diversity of *Q. petraea* in the Thayatal National park is studied. As the recording and maintenance of biological diversity is a core task of the national park, this study is of great importance for the knowledge foundation of the national park. The Thayatal National Park will gain this way a more comprehensive understanding of its conservation assets, the origin and the status of the genetic diversity of its main tree species, the sessile oak.

Keywords

Sessile oak, biodiversity, genetic diversity, Thayatal National Park, drought tolerance, seed stands, sustainable forest management

Introduction

The conservation of biodiversity in forests is important to enable their adaptability to climate change and therefore plays an important role in both the Austrian Forest Strategy and the Austrian Biodiversity Strategy. A high genetic diversity of forest trees ensures their adaptability to rapidly changing environmental conditions and thus the ecological and economic functions of forests. Unfortunately, forestry practice still pays too little attention to the right choice of origin of forest reproductive material. This is also related to the fact that the necessary genetic resources in the form of seed and planting material (forest reproductive material) are not always available.

The Thayatal National Park is characterized by high site and species diversity on small spatial scales. The reason for this is the special geology and geomorphology as well as the location in the transition area from the Pannonian to the Central European flora and fauna region. Of particular importance in this national park is the sessile oak (*Quercus petraea* (Matt.) Liebl.)), which grows also on very dry and steep slopes. The sessile oak is the stand-forming tree species in the Thayatal National Park and one of the main structural elements. It is also not known whether the Thayatal sessile oaks are autochthonous or of anthropogenic origin, i.e. entirely or partially introduced to the area, as many oak forests in Central Europe.

Here, we investigate the autochthony, intraspecific diversity and genetic adaptation of sessile oak populations to drought events by addressing the following three questions:

(1) Do the Thayatal sessile oaks show a special adaptation to dry environmental conditions (drought tolerance)?

(2) Are the sessile oaks in the Thayatal National park of autochthonous origin?

(3) What is the intraspecific genetic diversity of the sessile oaks in the Thayatal National Park?

Methods

(1) Drought tolerance

In 2020, wood cores of 404 mature trees from medium to very dry sites were collected. The wood cores were taken for tree ring analysis and used to determine drought tolerance by comparing growth pattern in three periods of pronounced drought stress compared to long-term mean. The response of individual trees to three historical drought events (1992-1994, 1947, 1917) was evaluated using four measures of drought response according to LLoret *et al.* (2011), namely resistance, recovery, resilience, and relative resistance. For statistic analyses, only mother trees that experienced all of the three drought events were included in the selection. For all four measures of drought response, mature trees were ranked per drought event. Only those trees, which reacted to drought events in a predictable way and displayed uniform relative growth performance were assigned to be highly sensitive or having low sensitivity to drought events (thus be most probably drought tolerant). Water use efficiency was to serve as another trait for drought tolerance of the mature trees. For this purpose, isotope analysis of δ13C of latewood in wet (1987) and dry years (1994) is compared.

(2 &3) Autochthony and genetic diversity

DNA was extracted from 404 cambium of all mature trees and used for the genetic diversity and autochthony studies. For the former, the DNA was amplified with 10 nuclear SSR markers and universal M13 primers and sequenced (Kampfer *et al.* 1998, Steinkellner *et al.* 1997). Sequencing results were subsequently analyzed using software GeneMarker and allele frequencies were determined. The software STRUCTURE and COLONY were used to identify genetic population structure and relationship analysis of sessile oaks in the national park area. The genetic distances of the populations in the Thayatal National Park were derived from the software GenoDive and a cladogram was created using the software PAUP (Fig. 1). We used chloroplast SSR to determine autochthony of sessile oak stands. To assess population autochthony and genetic distances, 16 samples from the Thayatal National Park, 12 samples with known PCR-RFLP haplotype and 24 samples from previous case studies were amplified with 7 oak-specific primers and 3 universal primers (Deguilloux *et al.* 2003, Weising & Gardner 1999).

Results

(1) Drought tolerance

The highest scoring individuals in the trait combination were selected for seed stand establishment. A total of 85 top trees were selected based on the four defined growth performance traits of resistance, recovery ability, hardiness, and relative resistance. The isotope analysis is underway.

(2 & 3) Autochthony and genetic diversity

The preliminary DNA analyses indicate high genetic diversity in the studied mature trees. They also show that some mature trees differ significantly from the other oak samples in the Thayatal National Park. This could indicate that some sessile oaks descended from a limited number of mother trees. Moreover, relationship analysis shows a higher proportion of full siblings in this area. All other sessile oak populations studied did not show a comparable population structure.

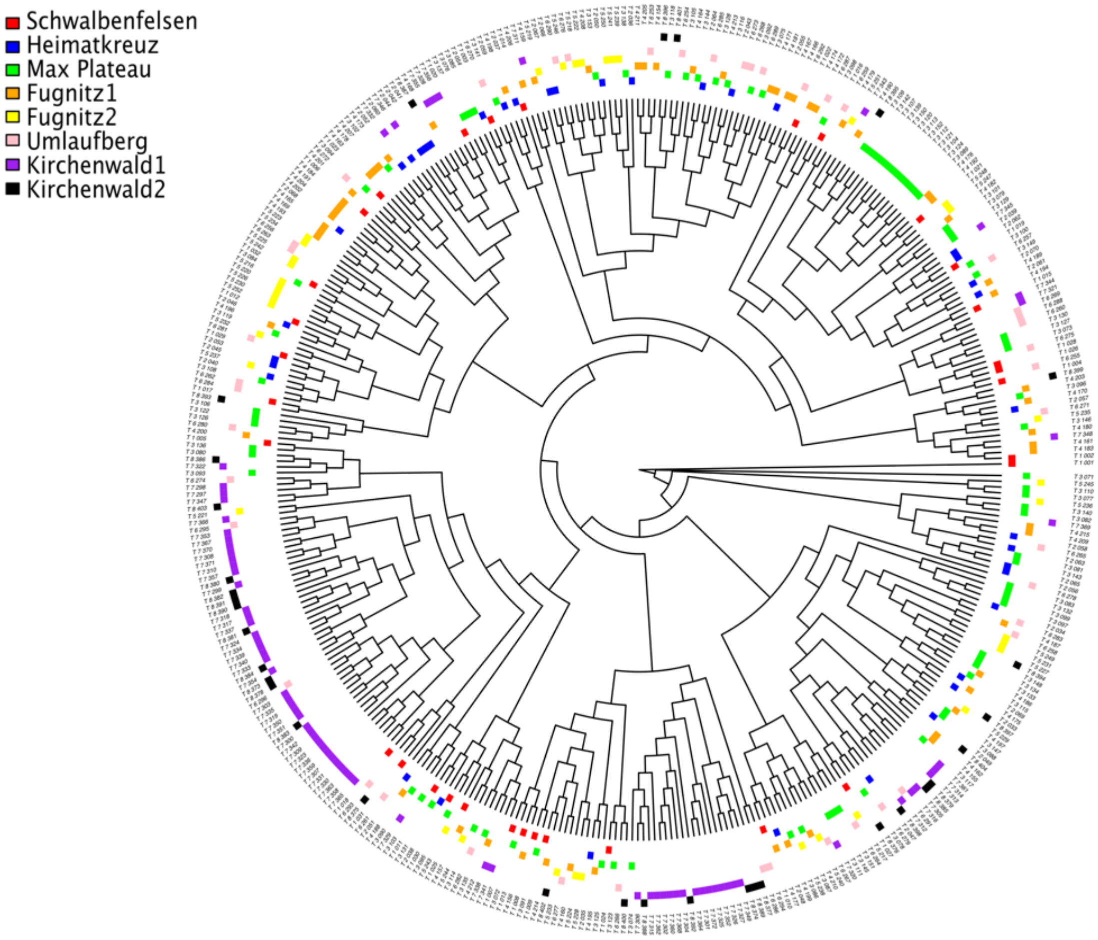

Fig. 1: The genetic distances between mature trees from eight sessile oak populations in the Thayatal National Park. The cladogram displays close relationships in the population `Kirchenwald´ (violet & black dots).

To search for probability of autochthony, sessile oak samples from the Thayatal National Park were grouped in cladogram with previous study samples. The samples resemble a haplotype known as 17a (Petit *et al.* 2002). This haplotype seems to be autochthonous for the National Park Thayatal. The Thayatal National park was post-glacial very probably recolonized by sessile oaks from Italian refugial area (Fig. 2).

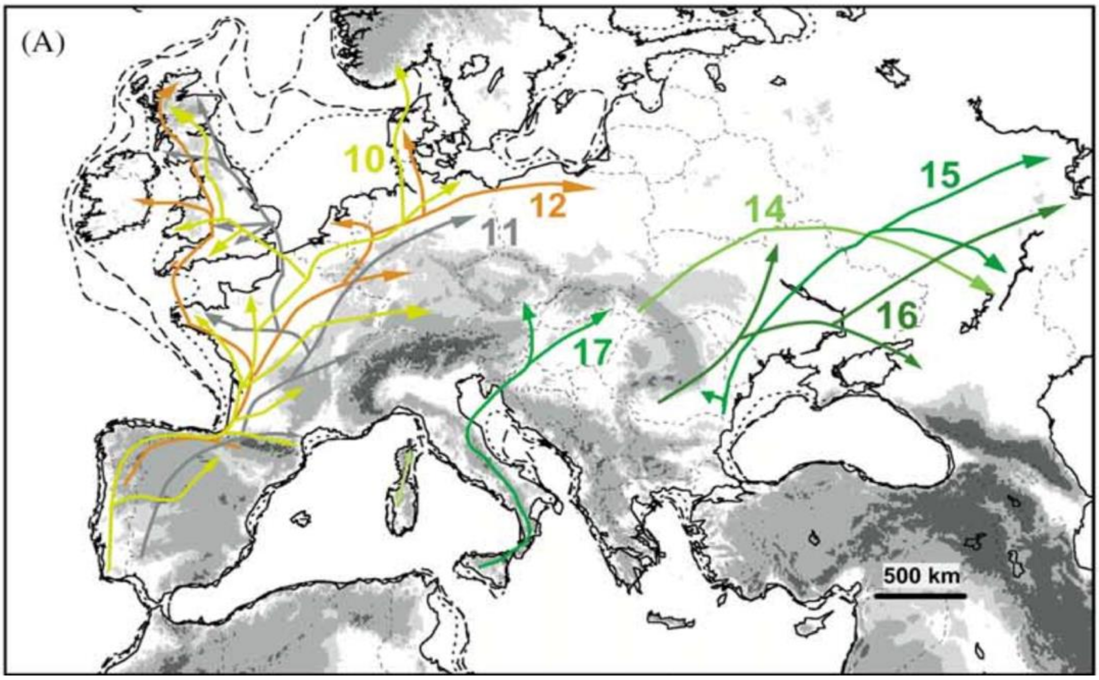

Fig. 2: Recolonization of the Thayatal National park by the haplotype 17a from Italian refugium (Petit et al. 2002).

In 2021, acorns of 306 selected individuals were collected in order to grow about 100 seedlings per selected and analyzed mature tree. These seedlings will be used in 2022/2023 to establish two seed stands. One seed stand will contain progeny of high genetic diversity, the other progeny of high drought tolerance.

We believe that this study, which aims not only to establish new seed stands for seed production for new climate smart forests and to characterize trees in the Thayatal National Park, but also to contribute to education in protected areas, for example by training national park rangers in a "train-the-trainer" approach, bridges the gap between forestry, nature conservation and social acceptance. Moreover, it promotes local public awareness for the major importance of genetic diversity to adapt to climate change and maintain forest biodiversity.

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Geophysical imaging of the salt content at the soda lakes from the Neusiedler See – Seewinkel National Park

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Summary

The soda lakes of the National Park Neusiedlersee - Seewinkel harbor rare and endangered waterfowl species and plants adapted to these extreme biotopes only found in this area within Austria. The high salt content at the surface is driven by capillary forces that permit the up-flow transport of salt from the subsurface through a shallow soil layer characterized by low hydraulic permeability. Such a shallow soil layer also hinders the percolation of surface water; whereas while salt transport to the surface is only possible if the low permeable layer remains wet during the summer periods when evaporation reduces the volume of the surface water. Hence, soda lakes are sensitive to climate change because long dry periods or changes in the groundwater levels may degrade the soda lakes, endangering the rich biosphere that depends on them. The design of adequate methods to restore and preserve the soda lakes requires a good understanding of the surface-groundwater interactions that control the salt dynamics. In particular, it is required to understand the spatial variations of the water content, geometry, and hydraulic properties of the shallow soil layer, which ultimately control the salt dynamics in the soda lakes. To date, subsurface investigations in the soda lakes are still based on the analysis of soil and water samples, thus, they rely on the interpolation of discrete data and may be biased by the characteristics of the samples. To overcome this limitation, we propose applying electrical and electromagnetic geophysical methods, which permit to map variations in subsurface electrical conductivity based on non-invasive measurements in an imaging framework. The electrical conductivity is mainly controlled by water content, porosity and salinity, three relevant parameters driving salt dynamics. The combination of different geophysical methods allows for an improved interpretation of the results and permits the estimation of relevant parameters for managing soda lakes. In particular, we apply frequency-domain electromagnetic methods to map variations in the salt content at the lake-scale, while using monitoring measurements with electrical resistivity tomography to resolve temporal changes in water content at different depths. We obtained deeper information, as required to understand the geometry of the aquifers, by combining dc-resistivity measurements and transient electromagnetic soundings. We also deploy a joint inversion strategy combining induced polarization and refraction seismic to directly solve for porosity and the hydraulic conductivity in the soil layer and the aquifer in an imaging framework. Interpretation of the geophysical images is evaluated through the analysis of soil sediments in the laboratory.

Keywords

soda lakes, Seewinkel, Geophysics, salinity, conductivity, remediation, soil moisture, porosity

Introduction

The soda lakes of the Seewinkel sustain flora and fauna which subsist in the extreme biotopes only found in area within Austria. From the total area of lakes available in the XIX century, only 18% are conserved to date, with only five lakes considered to be in good conditions (e.g., Krachler et al., 2000). The degradation of the lakes has been attributed mainly to the rising temperatures and reduced precipitation in summer due to climate change, while groundwater extraction and other anthropogenic activities are also playing an important role. Current efforts to maintain and restore the soda lakes require a precise knowledge on the temporal and spatial variations of salt content, as well as the variability in relevant hydrogeological parameters, such as soil moisture and porosity in the near surface. Such information is critical for the management of the soda lakes in frame of climate change.

To date, the management of the soda lakes is based on subsurface information gained through borehole data, which provides precise measurements on water level, salt content and soil moisture. However, such investigations provide limited spatial information, as the number of boreholes and samples is minimized to reduce costs and the impact of the investigations on the soda lakes. Additionally, analysis of soil samples are not suited for monitoring purposes (e.g., Flores Orozco et al., 2019). Hence, the development of non-invasive methods able to characterize the dynamics of the salt content in the soda lakes is critical.

Electrical and electromagnetic geophysical methods are sensitive to the electrical properties of the subsurface. Hence, they are optimal tools to delineate changes in the salt content, considering that an increase in the salinity is related to higher electrical conductivity. Geophysical methods are non-invasive as the sensors are dragged along the surface, just requiring none-to-minimal contact with the ground. Accordingly, the use of geophysical methods permits to characterize larger areas without drilling or excavations (i.e., without affecting the soda lakes), permitting extensive investigations with higher details than those based on direct methods.

Here we demonstrate that we can use measurements of the electrical conductivity (σ) as a proxy to map variations in the salt content across the soda lakes of the Seewinkel. We propose the combination of induced polarization (IP) imaging - an electrical method - as well as the electromagnetic at low induction number (EMI) and transient electromagnetic (TEM) methods.

Methods

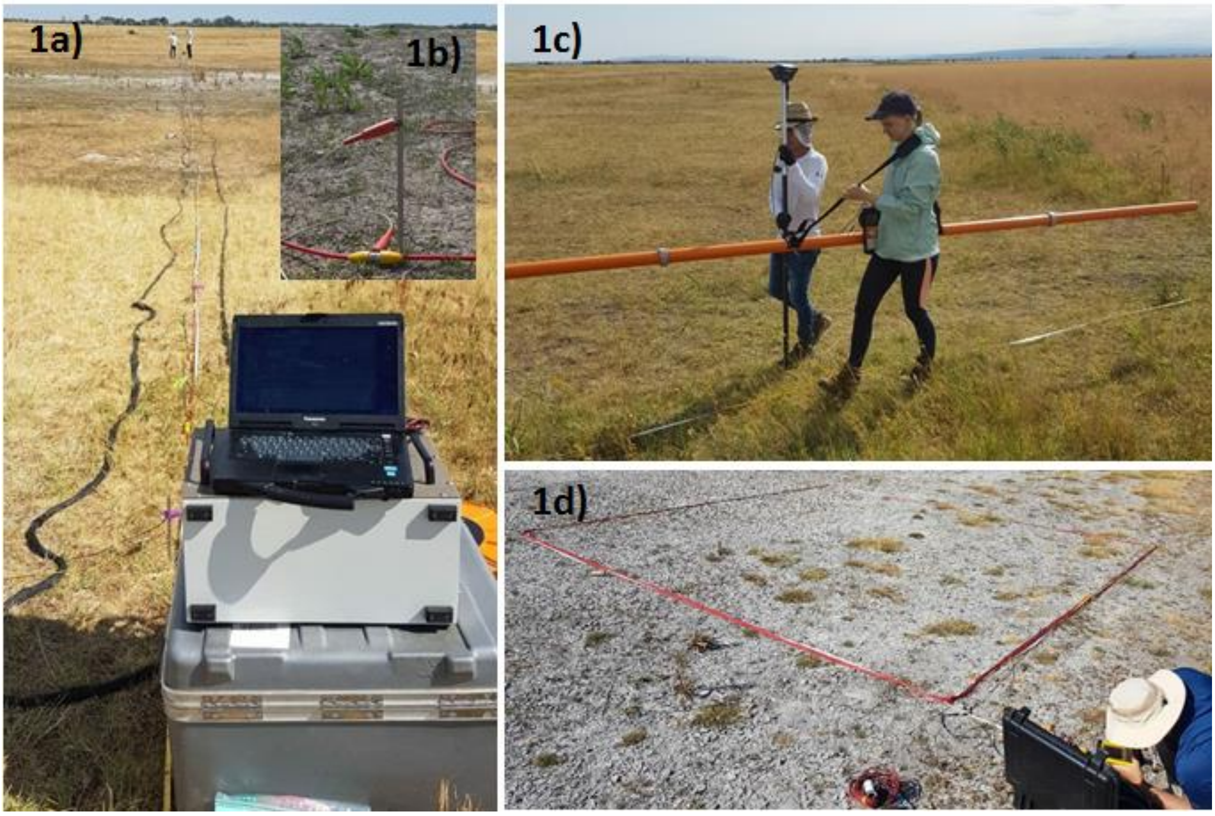

Figure 1: Geophysical methods deployed here: induced polarization, IP (Fig. 1a), requiring galvanic contact with the ground based on electrodes (Fig. 1b), as well as electromagnetic at low induction number, EMI (Fig. 1c) and transient electromagnetic, TEM (Fig. 1d).

The IP method is based on four electrode measurements, where two electrodes are used to inject current and other two permit to measure the resulting electrical impedance (Fig. 1a). Electrodes are commonly stainless steel rods (with a diameter of 1 - 2 cm) which are hammered 3-4 cm into the ground to have galvanic contact with the measuring device (Fig. 1b). Measurements using tens of electrodes (for a few thousands of 4-electrode readings) together with an inversion algorithm permit to solve for changes in the electrical conductivity and capacitive properties of the subsurface. Here we present 2D imaging results as cross-sections from measurements collected with 72 electrodes (spacing between them either 0.5 or 1 m) using a Syscal Switch72 pro unit (from IRIS instrument), and current injections vary in the range between 10 and 100 miliamperes. The collection of a data set lasted about 30 minutes, and electrodes were removed afterwards; thus, without affecting the soil, flora or fauna.

EMI measurements were collected with the CMD-Explorer and CMD-Mini Explorer (from GF Instruments) to map electrical conductivity of the soil at varying depths between ca. 0.25 and 6.7 m. These instruments provide information about the electrical conductivity in real time, and do not require contact with the ground (Fig. 1c), as they are based on induction of an EM field. Also known as “terrain conductivity meters”, the instruments provide measures of σ at the position of the device, which can be attached to one operator. Collection of the data is performed while walking (Fig. 1c), thus, permitting the elaboration of conductivity maps for different depths.

The TEM method provides information about the changes in depth of the electrical conductivity at a given point. As illustrated in Fig. 1d, the transmitter and receiver is a single wire laying on the floor forming a square (i.e., loop), where the circulation of a current and its sudden turn-off generates a primary EM field that propagates in the subsurface. Hence, variations in the secondary EM field over time provide information about changes in the electrical conductivity of the ground without need of galvanic contact. We use a single-loop configuration (the same cable is used as transmitter and receiver), yet conducted measurements with different loop-sizes (12.5 x 12.5, 25 x 25, 50 x 50, and 100 x100 m) to enhance the magnetic momentum and, thus, the depth of investigation. TEM measurements aimed at gaining information about the number of possible aquifers (and their thickness) in depths down to 75 m. Mapping TEM measurements were conducted with a 6 x 6 m loop to gain information about lateral changes in σ in depths between 1 and 10 m.

Results

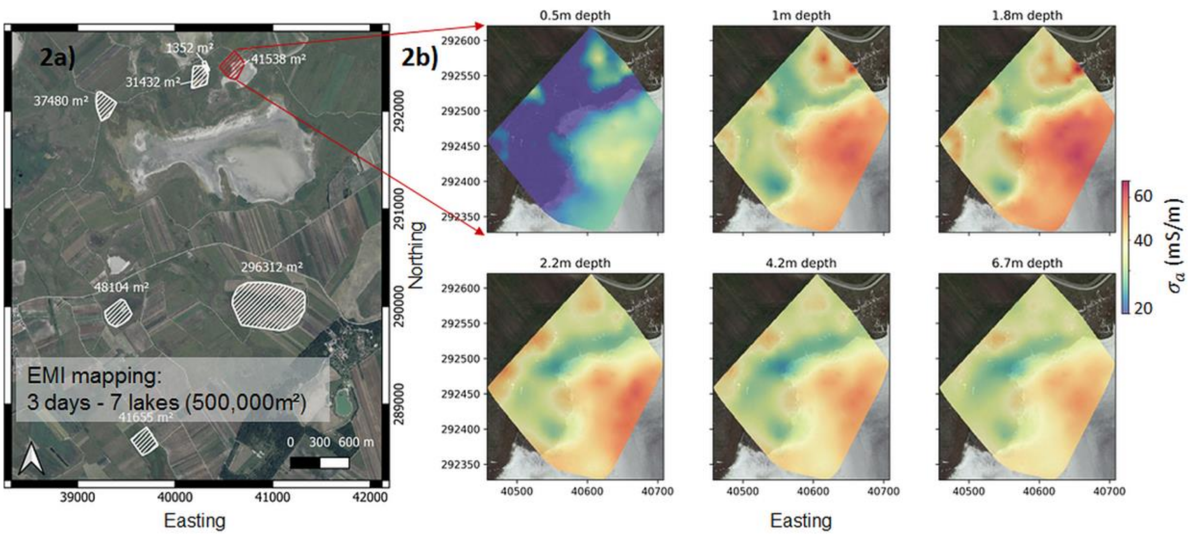

Figure 2: EMI measurements were conducted at different lakes covering a total area of 50 ha (Fig. 2a) to map variations in the apparent electrical conductivity (σ_a). Illustrative results are presented in Fig 2b for a selected lake (red polygon in Fig. 2a) in terms of the lateral changes in σ_a sensed at different depths. The σ_a represents the average conductivity from the surface to the nominal depth of investigation

EMI permits the mapping of large extensions with high spatial resolution in relatively short time. As presented in Fig. 2, we managed to cover an area of 50 ha in three days, corresponding to different soda lakes in the Seewinkel. We will discuss in detail the results obtained in the lake Katschitzl (Fig. 2b), yet similar conclusions can be drawn for the other lakes under investigation. Fig. 2b presents the lateral variations of the apparent conductivity (σ_a) in the same area at different depths. The apparent conductivity as the quantity represents an average value from the surface to the nominal depth of investigation. It can be observed that the lowest values ($\sigma_a < 30$ mS/m) are resolved in the shallower regions (0.5 m depth) to the North of the lake, where the vegetation is already visible on the surface; thus, indicating a degraded lake. In the active part of the Katschitzl lake, the conductivity is much higher (varying between 40 and 60 mS/m), yet clear lateral variations are observed, with some features revealing a main trend NW-SE. The limit between the high and low σ_a is in agreement with the geometry of the white sand in the orthophoto, corresponding to high salt concentrations observed at the surface (Fig. 2b). Such agreement can be consider as a first validation on the ability of the EMI results to delineate a lateral increase in the salt content as an increase in the σ_a values.

Lateral variations in σ_a are helpful to identify the geometry of the soda lakes. Moreover, EMI information reveals a significant decrease in the conductivity values at depths below 1.8 m. The decrease in the conductivity at depths is clearly related to the lower salt concentrations. However, σ_a values at depths below 1.8 m still are influenced by the high salinity in the near-surface. To solve for the actual conductivity at different depths, the inversion of the EMI data is required. After the inversion, it is possible to delineate the extension in depth of the conductivity anomalies. Such results can be found elsewhere (Hettegger, 2022) and will not be presented here, where EMI data is used for the mapping at large extensions.

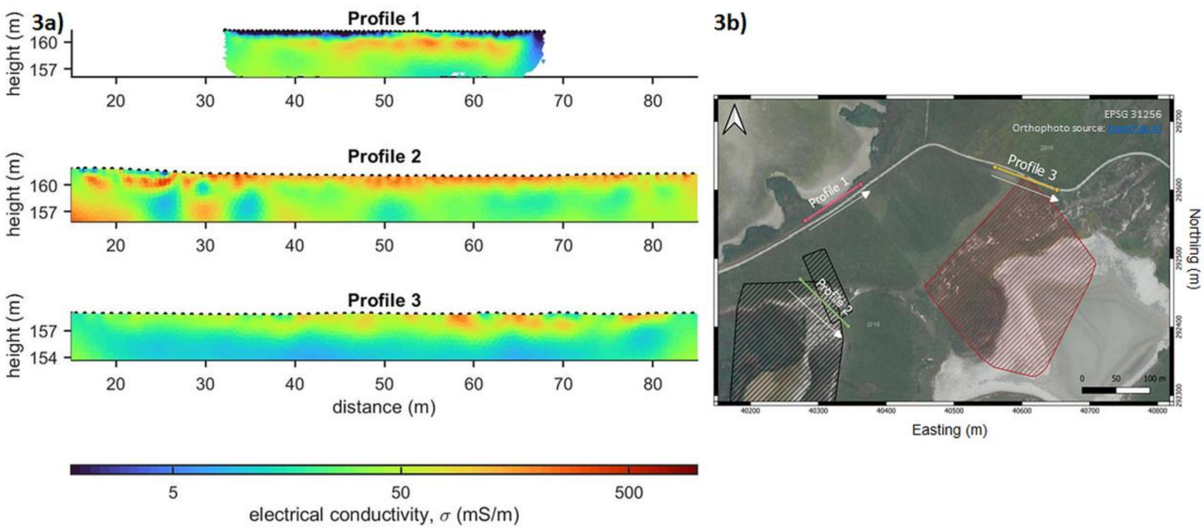

Figure 3: Conductivity (σ) results for data collected along Profiles 1, 2 and 3 (Fig. 3a). The position of the profiles in the soda lakes is presented on the orthophoto (Fig. 3b).

Fig. 3 shows the variations in σ resolved by means of the IP data collected at selected transects. Data were collected in Profile 1 with an electrode spacing of 0.5 m (resolution of 0.125 m), while in Profiles 2 and 3 the electrode spacing was 1 m (resolution 0.25 m). Fig. 2 reveals that the highest values ($\sigma > 60$ mS/m) are resolved in Profiles 1 and 2, corresponding to active lakes, whereas measurements in Profile 3 are related to much lower values ($\sigma < 50$ mS/m) in a degraded lake, in an area that is currently used as farming land. Plots in Fig. 3 also demonstrate that σ values retrieved with EMI and IP methods are comparable.

Imaging results for data collected in Profile 1 reveal three units: (i) a soil layer on the top (ca. 0.2 m thickness and $\sigma < 10$ mS/m), (ii) an intermediate layer corresponding to the salt-rich materials (ca. 0.5 m thickness and $\sigma > 50$ mS/m), and (iii) a bottom layer with moderate conductivity values (average 20 mS/m) corresponding to the aquifer. The high σ values in the second layer are clearly related to the accumulation of salts, which are transported upwards due to capillary forces. The salts act as free ions in the pore water that facilitate current conduction, thus, the increase in the electrical conductivity. However, as revealed in Fig. 2, the salt-rich layer is not continuous across the lake, with variations in the thickness and lateral extension. In particular, Fig. 2 reveals important lateral variations along profile

2, with much lower values in the first third of the profile, evidencing much lower salt content, likely a degraded part of the lake. Lateral changes are also observed along Profile 2, which also show the thicker layer between 45 and 55 m distance, corresponding to the most active part of the lake, where capillary forces result in a larger accumulation of salts.

Capillary forces at the top of the phreatic surface leads the upwards transport of salts, as well as clays. Consequently, an impermeable layer is formed close to the surface due to the clays clogging the pore space (Flores Orozco et al., 2019). The geometry of such impermeable layer is evidenced for the three electrical profiles in Fig.2 associated to the highest σ values. Such impermeable layer hinders the percolation of surface water and permits the formation of lakes following raining events. Likewise, lateral variations in such layer with low conductivity values, for instance in the first 10 m of Profile 1 (Fig 3.) are indications of degrading conditions in a soda lake, i.e., where salts are not being transported upwards anymore. Likewise, images of Profile 3 (Fig. 3) revealing only modest conductivity values, clearly indicate a degraded lake.

The presence of clays limits a direct quantification of salt content from σ values. This is because clay minerals act as a second path for current conduction, due to the accumulation of charges in the so-called electrical double layer (EDL) formed at the interface between clay surface and the pore water (see Flores Orozco et al., 2020). Hence, during current injection, the extra charges accumulated at the EDL form an alternative path for current flow, known as surface conductivity. It has been noticed that surface conductivity might dominate over electrolytic conduction, especially in soils with high clay content and organic matter (e.g., Flores Orozco et al., 2019; 2020; Katona et al., 2021). IP measurements provide information on both the conductive and capacitive properties of the subsurface. The former is controlled by both surface and electrolytic conduction; whereas the latter is only a function of the surface conductivity. Accordingly, images of the capacitive properties (only related to the polarization of the EDL) may help to improve the interpretation of the conductivity images.

In Fig. 4 we present the IP imaging results obtained for Profile 2, yet expressed in terms of the complex-valued electrical conductivity, where the real component (σ') is related to the conduction, while the imaginary component (σ'') to the polarization effect. Such plots reveal that the polarization effect ($\sigma'' <$ 0.5 mS/m) is negligible within an active soda such as Profile 2. The high salinity of the active soda lakes is reducing the mobility of the ions in the EDL; thus, hindering surface conduction mechanisms (e.g., Flores Orozco et al., 2019; Katona et al., 2021). Hence, an increase in σ'' may permit a quick identification of areas where the impermeable layer has been washed out, likely related to a degraded part of the soda lake.

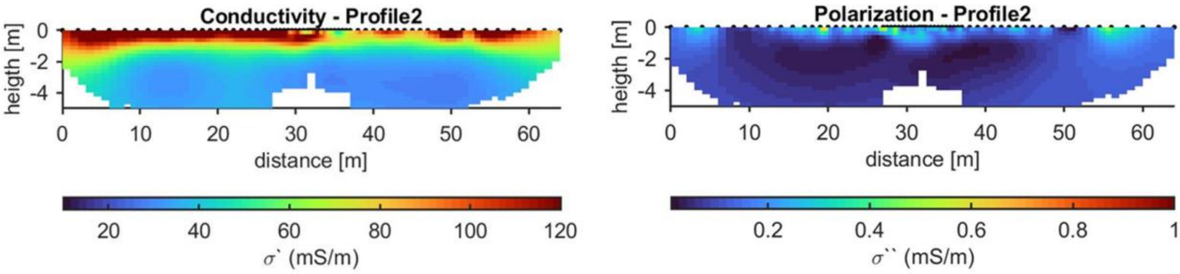

Figure 4: IP imaging results for data collected along Profiles 2 expressed in terms of the conductivity (σ') and polarization (σ''). Blanked areas refer to model parameters of poor sensitivity.

To gain information about the geometry of the aquifer underlying the salt-rich impermeable layer, we conducted TEM soundings in the area between Profiles 2 and 3. Data were processed using the steps described by Aigner et al. (2021), and a 2D section of the study area was elaborated by interpolating the 1D electrical conductivity models obtained. To differentiate these from previous results, we present in Fig. 5 the electrical model obtained by means of TEM soundings in terms of the electrical resistivity (ρ), the inverse of the electrical conductivity ($\rho = \frac{1}{\sigma}$). TEM results presented in Fig. 5 reveal the existence of two aquifers in the area of study: (1) a shallow aquifer between 2 m and 10 m depth, and (ii) a deeper aquifer between 20 m and 30 m depth.

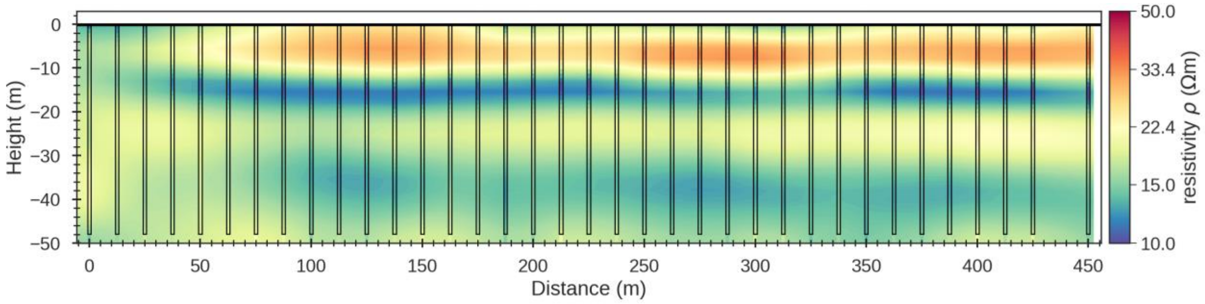

Figure 5: TEM imaging results presented in terms of the electrical resistivity (ρ), the inverse from the conductivity ($\rho = 1/\sigma$), to differentiate those from the EMI and IP. TEM soundings were collected in the area between Profiles 1 and 3.

Conclusions

We demonstrate that EMI permits to map extensive areas with high lateral resolution, as required to identify variations in salt content, as well as preferential flowpaths for surface water; whereas IP permits to gain detailed information at depth, in particular to characterize the geometry of the shallow impermeable layer and well as spatial variations in clay and salt content. TEM measurements permit fast investigations at depth required to delineate the geometry of the aquifer. Ongoing research corresponds to the repetition of geophysical measurements for a non-invasive monitoring of changes in soil moisture, clay and salt content. Additionally, we test the use of joint inversion schemes that simultaneously solve electrical resistivity and refraction seismic datasets to obtain the spatial variations of porosity and soil moisture.

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Habitat classification and Connectivity-Functionality analysis along the European Green Belt using high-resolution satellite imagery

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Abstract

"The European Green Belt (EGB) forms an ecological backbone across Europe that is essential for biodiversity as well as for the human well-being by providing numerous ecosystem services (ESS) and a significant contribution to the EU Green Infrastructure as a whole, but suffers from fragmentation of those valuable landscapes. In the course of the Interreg DTP project “DaRe to Connect” the aim to implement an EU Danube Strategy to (re)connect and strengthen the network of Natura 2000 sites and other protected areas (PA) along the EGB was pursued.

In order to find suitable corridors, high-resolution Sentinel-2 satellite imagery was used to categorize the land cover classes within the project regions as Broader Habitat Types (BHT). Therefore, a machine learning approach was chosen, where the Sentinel-2 data was analyzed by an algorithm for the pilot regions. Subsequently, each pixel of the PR was classified as the BHT based on the spectral signature, resulting in detailed raster images with a resolution of 10m. Also, data from the EUNIS habitat classification was used to get a picture for the whole EGB.

Two analyses were conducted based on those data: A connectivity analysis, where BHTs of interest were categorized by their geometry, connectivity and spatial distribution into 7 classes (cores, bridges, etc.). Secondly, the various ESS that are provided along the EGB were visualized by combining the developed ESS capacity matrix with the BHTs.

Finally, these analysis results have been combined, so potential corridors between and within the PA can be identified. Those areas have both a high functional value as well as an important role as a connecting landscape element. These maps serve as a tool for policy recommendations and prioritization of where to take action."

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Monitoring Alpine rivers – an effective instrument for biodiversity and environmental-change research and management

Leopold Füreder, Georg H. Niedrist

Abstract

Climate change poses considerable threats to global biodiversity and are recognized to particularly affect alpine landscapes including their freshwaters. This high climatic sensitivity and lack of significant human impact make alpine river basins, especially in protected areas, important environments for examining hydrological and ecological response to environmental change.

Several research activities were started to concentrate on the potential effects of changing climate and environmental conditions on terrestrial and aquatic ecosystem structure and function in the alpine zone. As a consequence of glacier shrinking together with the altered catchment hydrology and geomorphology not only new habitats for plant and animal species develop, but also result in a more dynamic and complex pattern of environmental conditions further downstream, in many cases exhibiting steep gradients within relatively small spatial scales. Organisms living in alpine environments are well adapted to harsh environmental conditions and contribute to a unique biodiversity, including endemic and threatened species. Occurrence, abundance and diversity of benthic invertebrates have been observed to follow environmental gradients, making them potential indicators for environmental conditions and change.

In the Hohe Tauern National Park, we have been carrying out interdisciplinary research in six glaciated river catchments. We aimed at defining climate–hydrology–ecology interactions and demonstrating the importance of alpine river systems as indicator environments for hydrological and ecological effects from climate change and variability. In a first step, we tested the hypotheses that glaciation in the catchment is a major factor for defining the hydromorphological conditions, and the degree of harshness influencing taxa richness and diversity of the aquatic fauna, including their biological and ecological abilities and traits. Based on our results and models, we defined a specific set of indicators and their relevant and adequate application. This long-term monitoring scheme is built on a comprehensive set of hydrophysical and chemical as well as biological data. We believe, that this is an adequate tool-box for long-term monitoring in alpine river ecosystems and can serve as an excellent basis for the future explanation of biodiversity change and environmental/climate alterations.

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Bringing the „Lebensraum Naturnacht“ to the Natural History Museum Vienna - Communicating the intact night habitats of Austrian world heritage sites to the general public with minimal conservation and protection conflicts

Christoph Goldmann, Günther Wuchterl

Abstract

A key element for the conservation of valuable night habitats is the interest of the general public accompanied by their support for sustainable protection. Unfortunately, a broad interest often leads to conflicts with conservation and protection goals.

Lebensraum Naturnacht managed to bring, for the first time ever, authentic scenarios of night sky landscapes of Austrian world heritage sites and other parks to the general public, to be used in education and outreach.

We give a short overview of the efforts made and methods developed to communicate the unique night time habitats to the general public, with the Vienna Natural History Museum as a virtual gateway to the wilderness and the intact night with its, often impressive night-skies and give implications for public outreach and low intensity night tourism in protection areas.

(An accompanying contribution gives an overview on the situation of the protection of the night-biodiversity in selected habitats and introduce the methods for quantitative ""night management"" in parks and emphasise the relation to guidelines by the IUCN and the international system of units and measurement to achieve long term intactness of sites at night).

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Does fine scale spatiotemporal variation in seed rain translate into plant population structure?

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Abstract

Seed production and dispersal are key processes in community dynamics; their spatial and temporal variation lay the template for future ecosystem structure and function. In the temporal domain, masting, the strong inter-annual intermittence of seed production of polycarpic plants, is assumed to drive seed fate and ultimately plant recruitment. However, the effects of temporal variation in seed crops on spatial patterns of seed rain and recruitment are poorly understood, in part because of limited data on fine-scale spatial variation of seed deposition.

To investigate how mast-seeding affects spatial variation in seed rain, we analysed a 15-year data set on seed rain and population dynamics in a montane old-growth forest (2 plots with 81 seed traps per ha), dominated by European beech (Fagus sylvatica L.) and, to a lesser degree, Norway spruce (Picea abies (L.) H. Karst) and European silver fir (Abies alba Mill.). Using geostatistical methods and point process modelling, we modeled (1) the relationship between annual seed crop and spatial heterogeneity of seed rain, (2) the temporal stability of seed rain hotspots, and (3) the spatial relation of seed rain and recruitment into the population.

The results illustrate the interaction between temporal and spatial variation in seed production and its consequences for population dynamics of mast-seeding trees. The signature of annual variation in seed rain fades with seedling mortality over time in all three focal species. For beech, the cumulative probability of seed arrival over the whole study period drives spatial seedling and sapling dispersion patterns – mediated by light competition with older trees; seedling density was most strongly reduced by sapling density, while saplings were most frequently found in areas of low adult density.

Such decoupling of spatial processes across life history stages, combined with spatial heterogeneity may play a larger role in driving stand-level spatial dynamics than previously assumed.

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Comparative assessment of natural regeneration across natural forest reserves in Austria

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Summary

Natural forest reserves are protected areas in Austria where no silvicultural treatments or any management is allowed. In 2021, 200 fixed radius sample plots of 300 square meters were resampled across 6 natural reserves to examine natural regeneration dynamics. All studied reserves are in a mountainous area with similar site conditions. A descriptive analysis of the main parameters of different natural regeneration categories with various height classes was carried out for Norway Spruce (*Picea abies* L). The analysis of the capacity of all natural reserves to regenerate naturally allowed determining the parameters that influence this process negatively or positively. A logistic regression model allowed to determinate the significant factors, that support a successful establishment of the seedlings. The ground vegetation, soil type and microrelief had a negative influence on the seedling occurrence, while mosses, slope, mesorelief, deadwood and basal area had a positive influence. The analysis revealed that deadwood in an advanced stage of decay has a significant positive influence on the natural regeneration. It was concluded that the dynamics of natural forest reserves are dependent on natural disasters and environmental conditions, but even without human intervention, these forest reserves have the capacity to restore and regenerate themselves over time.

Keywords

natural regeneration, natural forest reserves, Norway-spruce

Introduction

After signing the Resolution H2 of the Ministerial Conference on the Protection of Forests in Europe in Helsinki in 1993, the Austrian state committed to create a system of natural forest reserves to contribute to the maintenance of biodiversity on a European level. In 1995, the Austrian Natural Forest Reserves Programme was initiated, which allowed the long-term monitoring. In present, the Natural Forest Reserves Programme established over 195 natural forest reserves with an area of more than 8600 hectares, with most of the 125 forest communities included (BMLFUW, 2022). Research in natural forest reserves provides knowledge about dynamics and functioning of natural forests without any anthropogenic interventions besides hunting. For the current study, 6 Natural Forest Reserves from the subalpine regions dominated by Norway spruce (*Picea abies* L.) were selected and investigated. Especially the natural regeneration dynamics in the forest ecosystem at these high alleviation areas have been the main focus point of the monitoring efforts in the last decades. The findings of long-term monitoring of these forests can help to integrate and use natural processes in the management of forests. Knowing how human actions affect development of forest ecosystems supports our understanding of biological rationalisation and self-regulating capacity, especially the maintenance of the protection function in mountain forests is of key importance considering high costs for timber harvesting low integration of PES schemes in forest policy.

Study sites and method

The investigation was conducted in 6 Natural Forest Reserve (Figure 1) from Austria (*Goldeck, Hutterwald, Krimpenbachkessel, Kronawettgrube, Laaser Berg and Schiffwald*), areas dominated by Norway spruce. The reserves were located at altitudes between 840m to 2080m, with a mean precipitation between 1054 and 1532 mm.

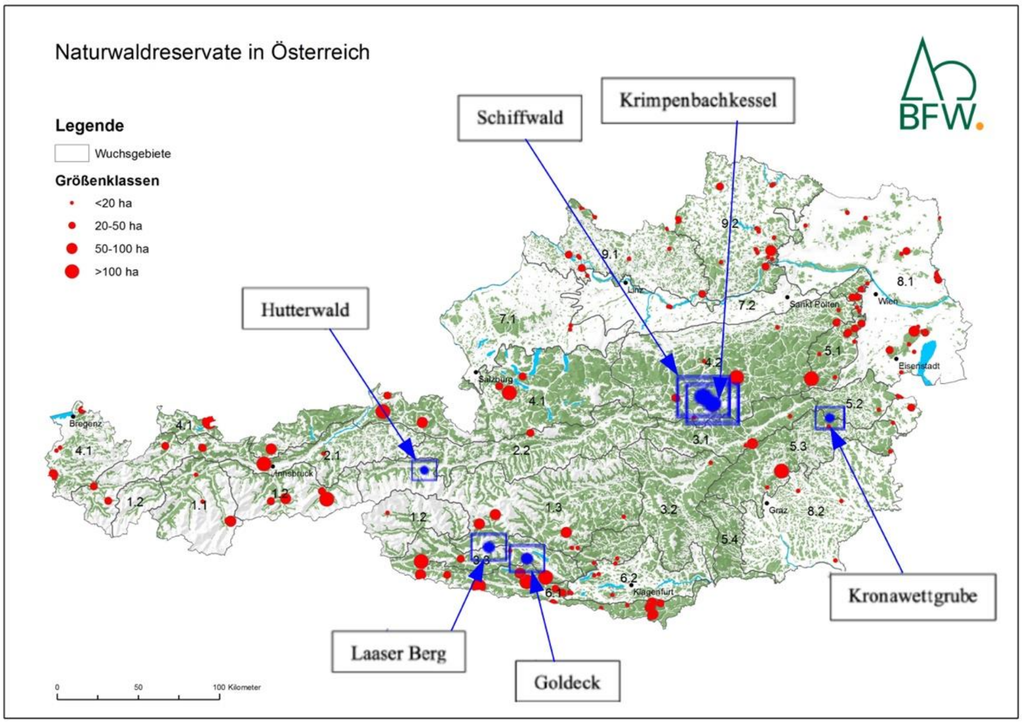

Figure 7. Distribution of natural reserves in Austria (Source: www.bfw.gv.at)

In order to collect the data, the sampling was carried out on 200 permanent plots by various teams across the six natural forest reserves, which were establish in the ELENA project (in German: *EmpfehLungEn für die NAturverjüngung von Gebirgswäldern)*. Due to difficulties in identifying all plots in the field, only 45 of the 56 sample areas in *Schiffwald* were found and investigated (Table 1).

Table 1. Natural Forest Reserves plots distribution and areas

NFR	Number of plots	Area (ha)
Goldeck	30	58.27
Hutterwald	29	29.4
Schiffwald	45	692.0
Laaser berg	26	63.0
Kronawettgrube	20	7.52
Krimpenbachkessel	50	151.2
Total	200	1001.39

The experimental design consisted of an inventory of existing sample areas from the ELENA project (Ruprecht et al. 2012). The sample areas were represented by fixed radius plots, with an area of 300 m^2 and a radius of 9.77m. Location survey and stand data were recorded within the sample areas. For the location survey, the following were recorded: elevation, slope, micro and macro relief, exposure, humus type and thickness, soil type and thickness. For the stand attributes, natural regeneration measurements, standing and lying deadwood and living trees were recorded. The natural regeneration was divided in 4 classes depending on the age and the height of the saplings.

Results

General description of natural regeneration

The densities identified from data processing revealed that a large variability is present both between reserves and categories of regeneration, from a maximum density of 47875±54140 (mean± standard deviation) to a density of 0±0 (mean± standard deviation). In the 15 to 30cm regeneration category, for *Goldeck* and *Hutterwald* NFR no saplings were recorded. The seedling category showed the biggest density, of an average of 9485±24380 (mean± standard deviation), 48% of plots being occupied by at least one seedling. In the 30-130cm category, 1505 individuals in total were measured.

Across all the reserves, browsing occurs in 38.9% of the cases, in 586 out of a total of 1505 saplings. The highest browsing percentage is found in Goldeck, with 84.2% of saplings affected, while the lowest percentage of browsing is found in Schiffwald, with 22.0%.

Table 2. Mean number per hectare and standard deviation

Reserve	Category of regeneration			
	Seedling	<15 cm	15-30cm	30-130cm
	N/ha	N/ha	N/ha	N/ha
Schiffwald	388 ±1503	306 ±737	28 ±186	232 ±273
Kronawettgrube	47875 ±54140	2781 ±5124	781 ±2658	168 ±256
Laaser Berg	962 ±3942	793 ±1219	24 ±123	131 ±177
Hutterwald	12931 ±18934	948 ±2214	0 ±0	229 ±520
Krimpenbachkessel	550 ±1975	1575 ±2601	238 ±534	487 ±770
Goldeck	16167 ±19127	1979 ±3340	0 ±0	63 ±161
Total	9485 ±24380	1297 ±3108	59 ±284	204 ±380

Analysis of the seedling establishment

A binary logistic regression model was used to examine the likelihood of a successful establishment of Norway Spruce seedlings in the natural regeneration without human intervention. The logistic regression predicts the likelihood of an observation to fall into one of two categories of a dichotomous dependent variable, which was represented by the occurrence of spruce seedling (Table 3). The independent variables were represented by both stand and site parameters. All the nominal values were dummy coded to distinguish between various groupings of interval scaled independent variables.

Table 3. Variables used in the binary logistic regression

Dependent variables	Values in the binary logistic
One or more spruce seedling/sapling occurred in the subplot	1
No spruce seedling/sapling occurred in the subplot	0
Independent variables	**Values in the binary logistic**
Slope gradient [%]	metric
Basal area of living trees (m^2)	metric
Deadwood area (>10cm)	metric
Coverage of vascular plants [%]	metric
Coverage of mosses [%]	metric
Mean height of dominant ground vegetation [cm]	metric
Microrelief	nominal
Mesorelief	nominal
Exposition	nominal
Soil type	nominal
Humus type	nominal
Humus thickness	nominal
Deadwood below 10 cm	nominal

After running the binary logistic regression, a model with a proportion of 87% accurately predicted cases resulted. Variables with a significant impact (Table 4) on seedling occurrence are the mean height of dominant ground vegetation, mosses, soil type, microrelief, deadwood area and deadwood below 10 cm. While mean height of dominant ground vegetation, soil type and microrelief have negative impact of the seedling establishment, the mosses, slope, deadwood area and deadwood below 10 cm have a positive impact.

Table 4. Binary logistic regression for predicting the spruce seedlings occurrence

	B	S.E.	Wald	df	Sig.	Exp(B)
M.H.D.G.V.	-,061	,025	5,722	1	,017	,941
Mosses	,040	,014	8,182	1	,004	1,041
Soil type	-,017	,003	25,782	1	<,001	,983
Slope	,025	,011	5,381	1	,070	1,025
Microrelief	-1,066	,209	25,981	1	<,001	,344
Mesorelief	,120	,176	,464	1	,496	1,127
Deadwood area	,114	,055	4,333	1	,037	1,121
Basal area	,147	,468	,098	1	,754	1,158
Deadwood <10cm	1,499	,535	7,851	1	,005	4,478
Constant	-1,212	2,319	,273	1	,601	,298

Discussion and conclusion

The low representation of saplings in the 15 to 30 cm category might be explained by a high rate of mortality of the seedlings due to inhibitor effects like insufficient light, root penetration and water availability (Sofletea, 2007). Microrelief variation causes different water availability and specific conditions where seedling can develop in proper conditions (Hunziker & Brang, 2005; Štícha et al., 2010). The moisture content of mosses (Brang, 1996) and moss species are the characteristics that determine the positive influence on seedling occurrence (Brang, 1996; Hunziker & Brang, 2005; Motta et al., 1994).

Deadwood habitat is important for water condition, nutrient recycling, soil formation, vegetation length, herbivory, snow cover, but also for light availability after falling of trees (Hunziker & Brang, 2005, Grassi et al., 2004; Lonsdale et al., 2008). Overall, the deadwood in advanced decomposition stages has a positive impact on the establishment of the seedlings in correlation with the other factor present (Ruprecht et al., 2012, Ruprecht et al., 2013; Zielonka & Niklasson, 2001).

Norway spruce can regenerate by itself in natural forest reserves (under certain conditions) without human interventions, but the required time for achieving sufficient number of seedlings is much longer than with silvicultural treatments. The subalpine coniferous forests in the Natural Forest Reserves evolve simultaneously with climate change and natural disasters (windthrows, snow breaks, bark beetles' outbreaks) and tend to achieve equilibrium with time.

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Long live the forest and all its dead – Succession phases and mortality indices in Austria's Natural Forest Reserves

Nastasja Harnack, Herfried Steiner, Khatanbaatar Dashbat, Georg Frank, Georg Kindermann

Summary

The natural amount of dead wood in a forest ecosystem is one of the major topics of discussion when it comes to questions concerning the naturalness of forests and sustainable forest management. Especially the time horizon of its dynamics and the corresponding forest succession phase in different forest communities are hard to target in Europe, where large-scale natural forest development is rare. For those specific questions the Natural Forests Reserves (NFR) in Austria can be used as important reference areas.

Latest research results deliver information on NFR in different sites and succession phases regarding their stand structure, vegetation types and their dynamics on deadwood enrichment and living wood increment over a long observation period. 80 repeated surveys over around 25 years in 22 different forest communities in Austria show a differentiated picture on the mortality rates in unmanaged forests. An index based on deadwood amounts and volume increment of living trees shows whether the stand is in a phase of accumulation or decomposition of wood biomass or in equilibrium. We assume that this increment-mortality-index (IMI) allows conclusions on the succession phase and thus on stand maturity.

A large proportion of the forest association groups investigated in the reserves are in an accumulation phase, where the increment is higher than the mortality rate. It seems like poor and dry sites with permanent associations (e.g. oak-forests) are more likely to be in a decomposition phase since increment is low. We can confirm that the IMI decreases with increasing stand age as one would expect. Furthermore, there is a recognizable trend for different management intensities at least in oak-hornbeam-forests: after former coppice use the recovery time is higher than in forests which have been more intensive managed (e.g. clear cuts). Still there is a need for a larger number of old NFR with longer time since abandonment to generate more data and reliable results on different forest communities.

Keywords

Deadwood, Natural Forest Reserves, Forest communities, Increment Mortality Index

Introduction

Within the scope of the Austrian Natural Forest Reserve program, areas have been set up in which forest management measures are avoided. Since then a natural forest development is ensured. Currently there are 192 reserves on a total area of approximately 8.631 hectares. The first areas were set up 25 years ago. Since then, the abandonment of forest management has been contractually secured and an undisturbed development of the naturalistic stands is possible. As part of establishment of these areas, stand and vegetation surveys were implemented, hence vegetation-ecological and yield-science information is available. What this means in concrete terms - also with regard to biodiversity-relevant aspects such as the presence of deadwood - has been investigated since 2013 by the Department of Biodiversity and Nature conservation at the Austrian Research Center for Forests (BFW). As part of the research projects "Biodiversitätsmonitoring für Bildungsgrundlagen in Naturwaldreservaten" (2013-2015) and "Biodiversitätsreferenzflächen Naturwaldreservate" (2015-2017), which has been funded by the Rural Development Program (LE), field surveys in almost 50 reserves were implemented, regarding stand structure, natural regeneration including browsing evaluation, vegetation and stand stability and also the amount of deadwood. With regard to climate change and carbon dioxid storage capacity, collected data provide information on the current stand development phases (decrease in stand volume, increase in stand volume, equilibrium). In the course of current surveys, the amount of deadwood is now quantified. However, there is a lack of information on enrichment rates, which are of high importance - according to current demands for higher biodiversity in forests. Assuming that the stand mortality corresponds to the deadwood accumulation, however, it is possible to determine the mortality rate through the results of the stand development. In this way attempts are made to make statements about the development phases on the level of forest association groups. The basis therefore is the vegetation mapping of the reserves.

Guided by the question „How do forest community, former management intensity and the time since abandonment affect the enrichment of a sustainable deadwood amount in Austrian forests?“, we will present data on deadwood stock in NFR in relation to latest observations of Austrian Forest Inventory (ÖWI) and selected close-to-nature-managed sites. Secondly, we will present a forest-type based distribution of deadwood stocks to draw conclusions on site parameters and finally present evidence-based findings on deadwood dynamics and mortality indices as possible reference values for future studies.

Methods

The data collection in Natural Forest Reserves took place at the level of mapped forest associations (plant sociological associations). In the evaluation, these are summarized in forest association groups. The forest types were classified according to the vegetation maps based on phytosociological classification following Willner and Grabherr (2007). We included only NFRs with at least 5 plots per forest type.

Steiner et al., 2019:
Angle count sampling (counting factor 4)

In a predominant part of the reserves, a grid of angle counting sampling points was established for purposes of assessing the compensation fee for the reserve owner (Frank & Koch 1996). This fact forms the basis for the use of the existing data of the last survey for a comparison with currently collected data in order to visualize dynamic processes in basal area, stand volume and number of stems.

300 m² fixed sample plot

Aim of the fixed sample plot is to make quantitative statements about the number of stems, diameter at breast height (DBH) distribution and tree species composition. The precision of these statements exceeds those of the angle count sampling in the lower diameter ranges. The information is to be collected on an area of 300 m² (r = 9.77 m horizontal) clearly defined on the terrain, which on the one hand ensures a repeatability of the survey and, on the other hand, allows further surveys concerning other issues on the same sample plots. By using the horizontal distance, data from the angle count sampling is compatible with this module.

Deadwood

The aim is to provide quantitative information on the volume, dimension, degree of decomposition, species composition and causes of death of deadwood, to elaborate the basics for the assessment of mortality rates and to provide information on the stand and deadwood dynamics. The module is based on the surveys of the Swiss National Forest Inventory (Roth et al. 2003) separately for standing and lying deadwood starting from a diameter of 10 cm. Standing elements are measured on a sample plot with an area of 300 m², lying by means of line intersection method using lines positioned in the main cardinal directions.

Results

Our database consists of 965 plots in 48 NFR and 1 primary forest and 13 forest communities. As expected, the lowest average deadwood volume is calculated for the larch and pine forests at 27.1 (± 7.0) m³ / ha. In the spruce forests it is already significantly higher with 69.1 (± 17.9) m³ / ha. There are minor differences in the broadleaved dominated forests, with 77.7 (± 15.2) m³ / ha in the oak and hop hornbeam forests and 85.5 (± 12.1) m³ / ha in beech and lime forests. The highest average amount of deadwood is found in lowland forests and black alder- ash forests with about 90.3 (± 22.2) m³ / ha. However, this data is just a snapshot of the deadwood amount in those forests to the time of the data collection and does not allow any conclusions to be drawn about the general state of the forests in terms of succession phase or stand maturity. This is why we developed the dynamic Increment-Mortality-Index (IMI). Increment and the ratio of mortality /increment can be used to draw conclusions on the stand dynamics of the forest associations. A value below 0 means that the mortality exceeds the increment - the stand is in a phase of decreasing volume. When the IMI is above 0 the stand accumulates biomass, because the increment exceeds the mortality. An index value of 0 represents an equilibrium state. Since the mortality corresponds to the deadwood accumulation, the ratio of increment and mortality can also be used to infer the deadwood enrichment of the period. Thus, in addition to the stand dynamics, the annual accumulation of deadwood can be estimated for differential forest association groups in the reserves.

$$Increment - Mortality - Index\ (IMI) = \frac{i_n - m_n}{i_n + m_n} \qquad (-1 < IMI < 1)$$

$$i_n = Increment\ over\ period\ (ingrowth\ volume + volume\ increment)$$

$$m_n = Mortality\ over\ period$$

A large proportion of the forest association groups investigated are in an accumulation phase, where the increment is higher than the mortality rate (Figure 1). It seems like poor and dry sites with permanent associations (e.g. oak-forests) are more likely to be in a decomposition phase since increment is low. High deadwood enrichment rates can of course also be a consequence to disturbances, such as wind throw or bark beetle gradations. The influence of those calamities on the IMI should become less significant with longer observation periods.

With the calculation of the IMI we can now determine "turning points" for different forest communities, which describes the time when a forest switches from an accumulation to a decomposition phase or the other way around or reaches an equilibrium state. This can help to understand the forest's stage of development. Of course this time is heavily influenced by stand age, time since abandonment and former management intensity. We can confirm that the IMI decreases with increasing stand age as one would expect (Figure 2). Furthermore, there is a recognizable trend for different management intensities at least in oak-hornbeam-forests: after former coppice use the recovery time is higher than in forests which have been more intensive managed (e.g. clear cuts) (Figure 3).

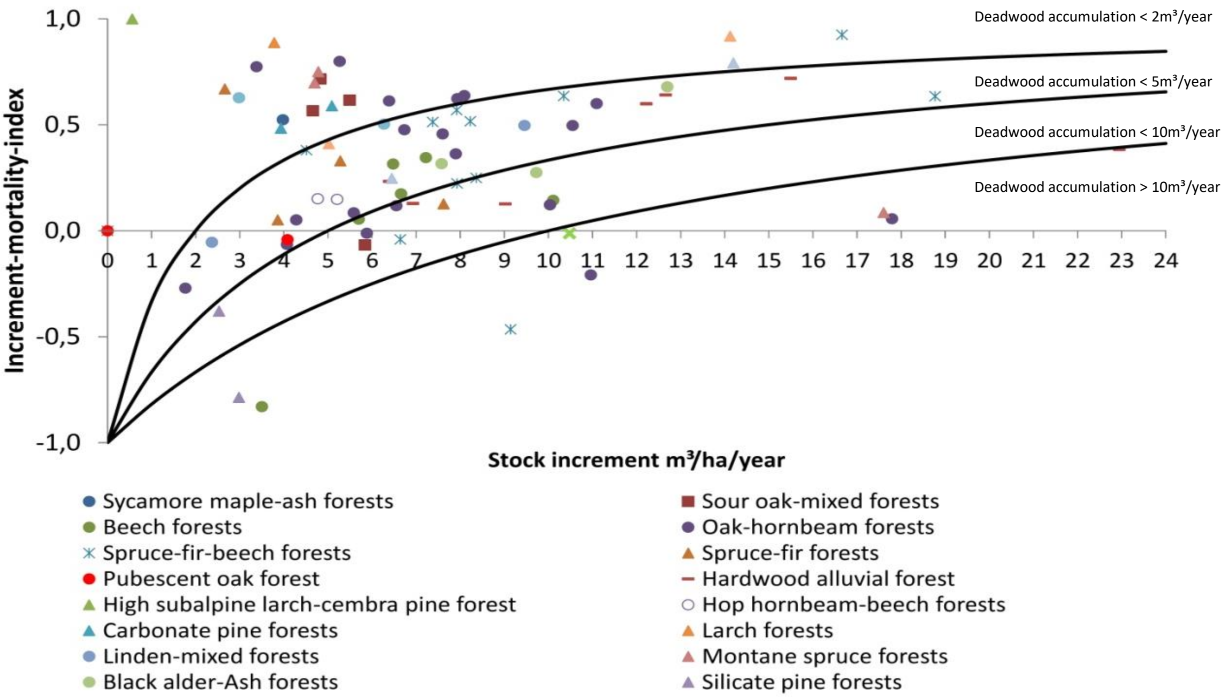

Figure 1: Increment-mortality-index in different forest types in 48 Natural Forest Reserves

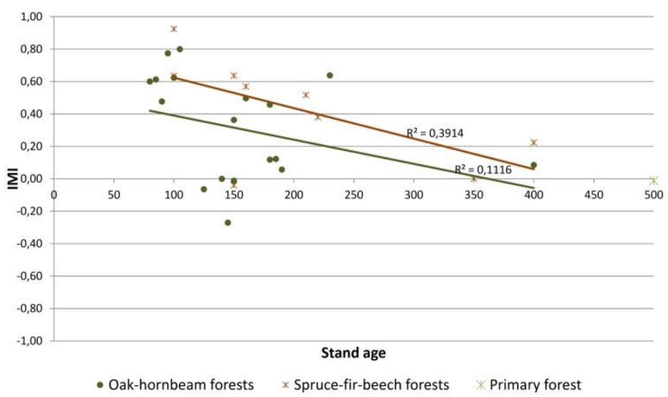

Figure 2: IMI over stand age for Oak-hornbeam and Spruce-fir-

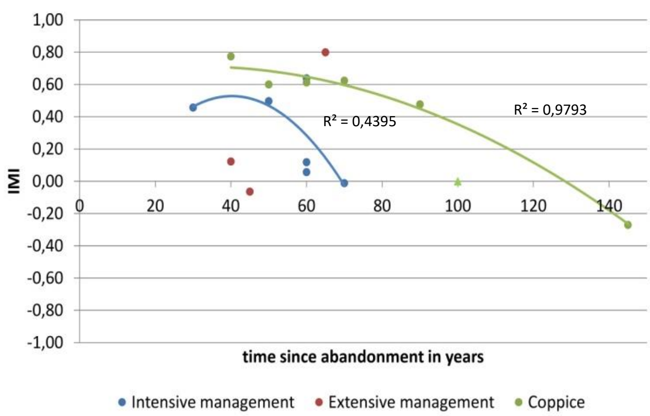

Figure 3: IMI over time since abandonment for Oak-hornbeam forests and different former management intensities

Due to insufficient data on all forest communities we only could analyze oak-hornbeam forests and spruce-fir-beech forests and even for those the data situation is not satisfying. For valid and more reliable results we definitely need more old NFR with longer time since abandonment. So we are striving to carry out repeated surveys continuously in more NFR and thus generating a broader data base. In the future, information on the amount of deadwood of all existing forest association groups in the Natural Forest Reserves should be available. Furthermore the validation of the index with respect to the real deadwood accumulation is only possible through repeated surveys on deadwood amounts in every NFR. Nevertheless, the great importance of a dynamic index on mortality and increment in future discussions about the conditions of our forests is already clear.

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New geological concept explaining the evolution of salt pans in the Seewinkel region (Northern Burgenland, Austria)

Hermann Häusler

Summary

For the very first time, investigational results on isolated groundwater bodies below salt pans of the Seewinkel are presented. These local aquifers in the unsaturated zone are referred to as perched aquifers. Drilling profiles as well as electrical resistivity tomography provide an insight into the distribution of fine-grained and coarse clastic sediments. The hydrogeologic assessment of these aquifers is based on the knowledge of the spatial distribution of permeable and less permeable aquifers as well as on the hydrological, hydrochemical and isotope hydrological properties of these groundwater bodies. This results in a qualitative hydrogeologic model of the groundwater conditions under the shallow saline pans and deeper saline lakes of the Seewinkel. The high salinity of the perched groundwater bodies originates from a salt-bearing horizon formed by evaporation of surface waters during a warmer climate of the Riss/Würm Interglacial. When this horizon was preserved during subsequent sedimentation saline soils such as Solonchak and Solonetz developed by capillary rise of saline groundwater. In remote sensing imageries of the Seewinkel meanders are missing. Therefore, both fine-grained deposits beneath the saline pans and coarse clastic deposits mined in neighboring gravel pits are interpreted as fluvial sediments of an anastomosing river system.

Keywords

Quaternary, Illmitz Formation, fluvial deposits, anastomosing river model, salt-bearing horizon, salt soils, perched aquifer, grainsize analysis, hydrochemistry, stable isotopes

Introduction

The 10-25 m thick Quaternary deposits east of Lake Neusiedl that were previously mapped as "Seewinkelschotter" (of Würm Glaciation), were defined as Illmitz Formation by Häusler et al. (2021). Based on vertebrate finds, gastropod finds and pollen spectra finds as well as optically stimulated luminescence (OSL)-, infrared stimulated luminescence (IRSL)- and ^{14}C-analyses, the Illmitz Formation contains deposits dating from the Riss- and Würm Glaciation continuing into the Holocene. In the climatically warmer period of the Riss/Würm Interglacial, gravelly silts were deposited which are referred to as salt-bearing horizon due to their high proportion of water-soluble salts (Franz & Husz, 1961). Due to long lasting evaporation processes of surface waters in the Riss/Würm Interglacial, high salt concentrations in gravelly silts developed. In the Seewinkel, in general, three groundwater levels (A1-A3) can be distinguished. The regional uppermost aquifer (A1) is bound to the Quaternary deposits of the Illmitz Formation. Corresponding to the geothermal gradient, thermal waters in Neogene deposits form the deepest groundwater storey (A3). In between, both confined and artesian confined groundwater in Pannonian aquifers is referred to as the middle groundwater storey (A2). The comparison of drilling profiles with geoelectric resistivity profiles under the salt pans shows that the rapid horizontal and vertical change in lithology corresponds to the changing values of resistivity tomography. Due to strongly varying permeability, the uppermost groundwater storey (A1) in the western and central Seewinkel does not form a coherent groundwater body but a mosaic-like system of groundwater bodies of small horizontal and vertical extent, which are connected and communicate with each other in a complicated way.

Methods

About 40 drillings in salt pans with a hand-held auger and 64 grain-size analyses of samples from 12 profiles down to a depth of maximum 3 meters revealed a rapid lateral and vertical variation of beds composed of clay, silt and sand intercalated with gravelly silt and gravelly sand (Weiss, 2015). These lithologic changes encountered in boreholes also are reflected in electrical resistivity patterns of electrical resistivity tomography. The locally changing lithologic conditions below salt pans caused perched groundwater bodies in the unsaturated zone with different hydrochemical and isotopic physical properties (Dober & Gritzmann, 2014; Mykhaylyuk, 2016). Remote sensing imagery was used for mapping of subsoil textures.

Results

The grain size distribution of the fluvial deposits of the Illmitz Formation caused the lateral and vertical distribution and geometry of local aquifers, aquitards and aquicludes (Fig. 1, left). Wherever thicker fine-grained deposits below the salt pans prevail, perched aquifers developed that commonly are not in contact with the regional upper aquifer A1. Therefore, values of electrical conductivity, pH, and stable isotopes of these isolated groundwater bodies differ considerably (Fig. 1, right). For example, the electrical conductivity of local groundwater bodies (A1x) under the salt pans varies between ~1.7 mS/cm and >66 mS/cm. The concentration of chloride varies between 7.0 mg/L and 2.000 mg/L, of sodium between 900 mg/L and 26.500 mg/L, of sulfate between 50 mg/L and ~5.800 mg/L and the concentration of hydrogen carbonate varies between ~800 mg/L und ~65.000 mg/L. Alkalinity varies between pH 7.2 and pH 9.8 and high levels of alkalinity were measured where loess rich in calcium carbonate was deposited. δ^{18}O-values differ between –1.94‰ and –10.66‰ and allow for an interpretation of evaporation processes below the salt pans. If the groundwater below the salt pans is marginally influenced by the groundwater of the first regional aquifer A1 flowing south-east from Frauenkirchen, then it achieves a relatively low electrical conductivity of 1.500 µS/cm at relatively low pH values of ~7.0.

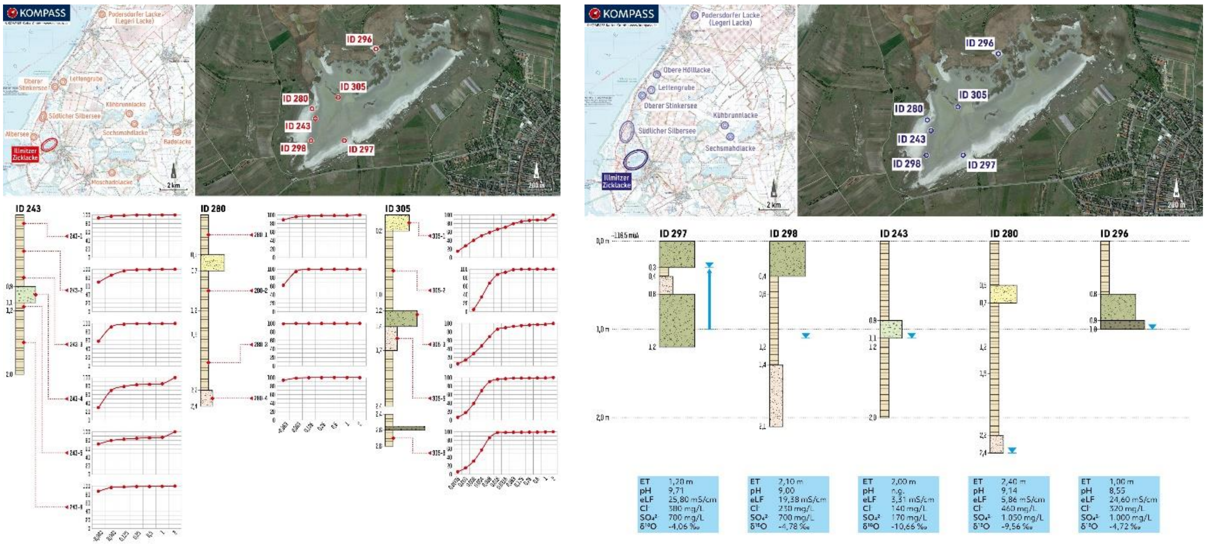

Fig. 1: Grain size analysis of drilled sediment material from three boreholes of Illmitzer Zicklacke (left) and hydro physical and hydrochemical characteristics of perched aquifers from five boreholes of the same salt pan (right).

Where there is no exchange of local groundwater A1x with the regional groundwater flow A1, and stagnant conditions prevail, the electric conductivity increases to over 60 mS/cm which corresponds to the salinity of seawater (Fig. 2). Highest values of electric conductivity of isolated groundwater bodies were measured in the western Seewinkel where the Seewinkel Formation predominantly consists of fine-grained deposits. The ion-concentration of the shallow surface water in salt pans reflects the hydrochemical composition of groundwater in the underlying perched aquifers, seasonally rising by capillary processes.

At the same time, groundwater, which is isotopically enriched compared to the standard, demonstrates subsoil evaporation processes, which are effective down to a depth of at least three meters. Due to the regionally determined isotope fractionation, based on the climatic effect, groundwater that is isotopically depleted, is interpreted as Ice Age water. The geohydraulic model of descending meteoric waters in Quaternary times contradicts the previous assumption of ascending marine formation waters. The perched aquifers of the Seewinkel show confined but no artesian confined conditions. For higher chloride concentrations of up to 6.000 mg/L in aquifers of A2 migration of saline deep groundwaters cannot be excluded.

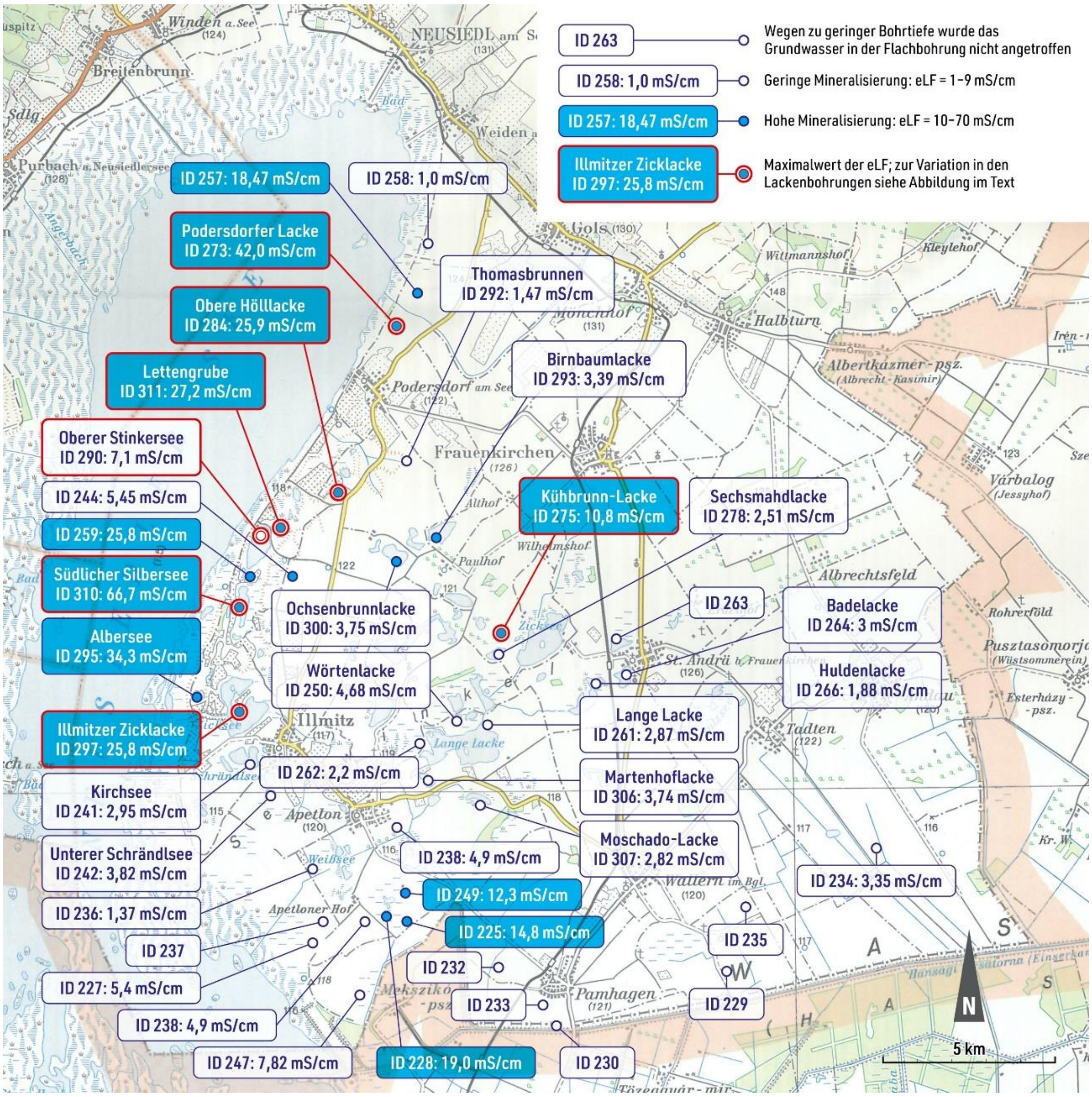

Fig. 2: Maximal values of electrical conductivity of perched aquifers below saline pans of the Seewinkel. Measurements during field capaign in 2014. Electrical conductivity of spring water of the Thomasbrunnen south of Podersdorf am See for comparison.

Mapping the subsurface textures of satellite images revealed that in the western and central Seewinkel meanders are missing. Meanders with typical point bar deposits first appear some 30 kilometers to the east in the Little Danube area near Monsonmagyaróvár in Hungary. In the Seewinkel, the abrupt lateral facies change between gravel areas (without thicker beds of clay and silt) and salt pans (without thicker layers of sand and gravel) suggests channel-fill deposits between vegetation-covered interchannel areas. Figure 3 shows that gravel pits and neighboring salt pans occur at short distances of several hundred meters to a few kilometers. Such a spatial distribution of fine-grained and coarse clastic deposits and the lack of meander textures is considered typical for a vein-like, branched facies model.

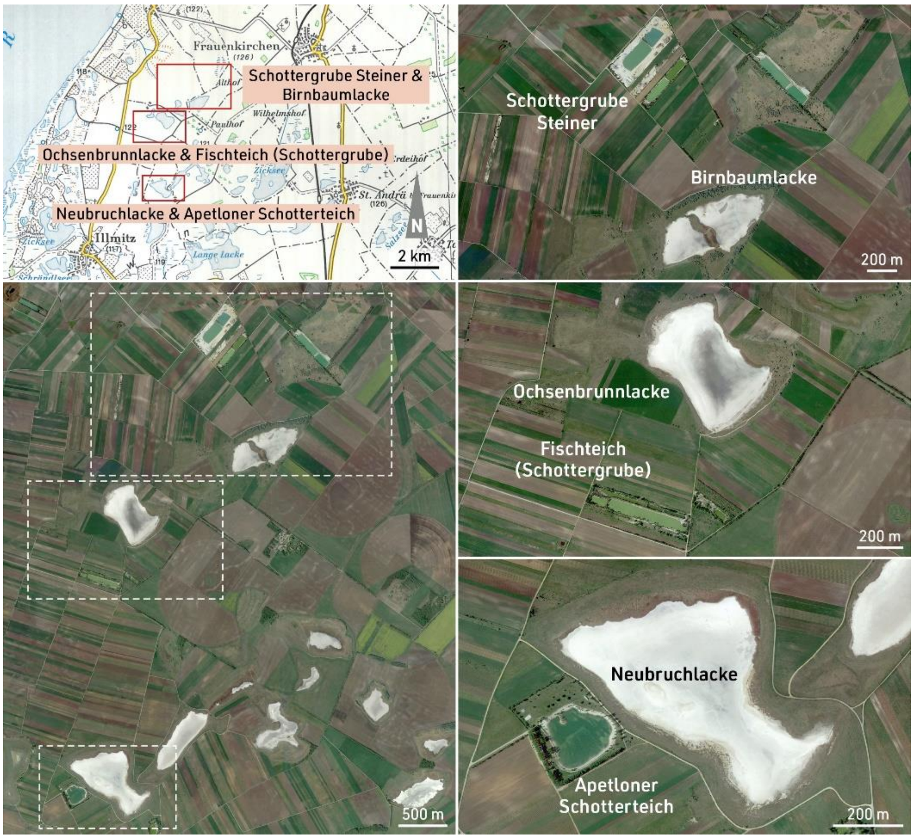

Fig. 3: Gravel was mined at many places in the central Seewinkel at distances of a few hundred meters from the salt pans. Abandoned gravel pits subsequently were used as fish ponds and bathing lakes.

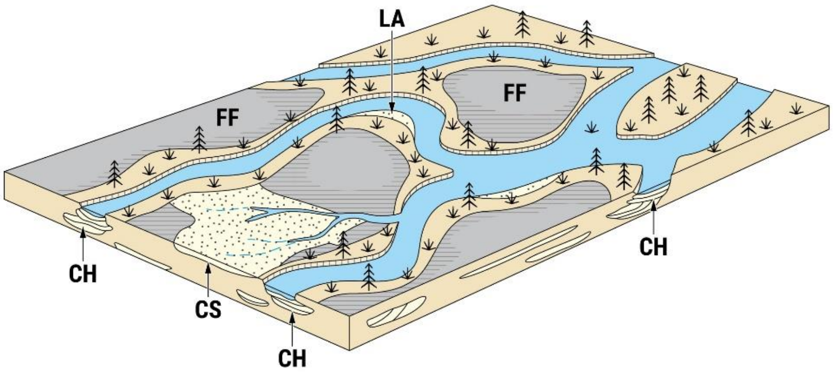

Fig. 4: Deposition model of the Quaternary Illmitz Formation (Häusler et al., 2021). Abbreviations: LA = lateral-accretion deposits, CH = channel deposits, FF = flood plain fines, CS = crevasse splay deposits.

In conclusion, the distribution of fine-grained strata-bound deposits in the Seewinkel does not result from collapsed intrapermafrost ice-cored hills, termed pingos or palsas, but from an anastomosing flow system that since Riss Glaciation occasionally was fed by rivers such as Paleo-Danube, Paleo-Rebce and Paleo-Ikva. Sandy gravels are interpreted as channel deposits and silt and clay were deposited on floodplains (Fig. 4). Plant remnants drilled in fine-grained sediments 1.5 to 1.7 meters below salt pans near St. Andrä am Zicksee and near Podersdorf am See were ^{14}C-dated (Häusler et al., 2021: Tab.1). The ages of such plant remnants range from ~32,000 Before Present (Badelacke) to ~29,000 BP (Ochsenbrunnlacke) up to ~10,000 BP (Lettengrube) and ~7,200 BP (Höll-Lacke). The subsoil of these salt pans is thus formed by clay and silty sediments that were deposited from Riss Glaciation to the Holocene. Hence it is very unlikely that the saline lakes and saline pans of the Seewinkel originally formed as thermokarst lakes during permafrost degradation after the end of the Last Glacial Maximum (after 19,000 BP) as proposed by Draganits et al. (2022).

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Managing European ground squirrel, European hamster and some other selected small mammals in the Nationalpark area

Barbara Herzig, Elke Schmelzer

Abstract

We discuss the development of populations of the European ground squirrel (Spermophilus citellus) in parts of the National Park Neusiedler See – Seewinkel starting with data from the 1970ies. It can be shown that only few colonies still exist today and individual densities are low. There are different causes of these facts and some of them have not been clarified yet.

We will recommend possible ways to enhance a positive development of this species in the park and its close surroundings. These measurements for instance include special mowing and/or grazing regimes or strict speed limits on roads, particulary from Apetlon to Frauenkirchen in the part bordering the Nationalpark-area. Most of the recommendations will also be in favour of the Common Hamster (Cricetus cricetus) and other rodents.

A possible management tool is also the cultivation of grain in some small parts of the area to support hibernation or the mound-building proclivities of the steppe mouse (Mus spicilegus). Regarding small mammals like rodents and shrews we suggest a monitoring by collecting owl pellets (mainly barn owl) and have the remains of the small mammals identified by a skilled person. It enables the discovering of new arrivals and in times of climatic changes the overall presence or absence of certain small mammal species.

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Biodiversity surveys in protected areas within the long-term project Biodiversity Monitoring South Tyrol

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Summary

In 2019, a permanent biodiversity monitoring program for South Tyrol has been set up on the initiative of the South Tyrolean provincial government. The monitoring not only serves basic research but is also intended to provide the scientific basis for political decisions, especially in connection with nature protection, spatial planning, and agriculture. The outcomes of the project will also be used to evaluate or improve species and habitat conservation measures in protected areas. Finally, communicating the results to the broad public is a crucial part of the Biodiversity Monitoring South Tyrol (BMS). Using standardized protocols, the BMS aims to survey taxonomic groups sensitive to climate and land-use changes across scales. The surveyed taxa cover vascular plants, bryophytes, birds, bats, and insect groups, like grasshoppers and butterflies as well as water insect larvae in aquatic sites. In addition, data on abiotic factors, soil, landscape structure and site management are also collected. The study sites are distributed evenly across the region. They include a representative selection of near-natural habitats and habitats that have been strongly influenced by humans. The sites are being surveyed over a period of 5 years (4 years for running water sites). In the subsequent years, the same sites will be surveyed again. About one fifth of the terrestrial and more than one third of the aquatic sampling sites are situated in protected areas. Another major focus of the initiative is the constant dialogue between the BMS experts, and the local authorities typically related to questions on the impact of agricultural and forest management practices on biodiversity and ecosystem services as well as current impacts of environmental changes such as extreme natural events or invasive alien species.

Keywords

South Tyrol, monitoring, flora, fauna, habitats, protected areas, terrestrial monitoring, aquatic ecosystems

Introduction

The need for long-term regional data on biodiversity and population trends has grown rapidly in recent decades. This is particularly true for protected areas, considered global refuges for biodiversity. In 2019, a permanent biodiversity monitoring system for South Tyrol has been set up on the initiative of the South Tyrolean provincial government and under the direction of Eurac Research and in collaboration with the Museum of Nature South Tyrol and the offices for nature and agriculture of the Autonomous Province Bozen/Bolzano. The monitoring not only serves basic research but is also intended to provide the scientific basis for political decisions, especially in relation to nature protection, spatial planning, and agriculture. Using standardized protocols, the Biodiversity Monitoring South Tyrol (BMS) aims to survey species groups sensitive to climatic and land-use changes across scales.

Methods

The study sites of the BMS are distributed evenly across the Italian province of South Tyrol (7400 km^2). They include a representative selection of near-natural habitats, such as high-mountain grasslands, alpine brooks and forests, as well as habitats that have been strongly influenced by humans, such as meadows, vineyards, and residential areas. In total, 320 sites will be investigated during 5 years as part of the project's terrestrial monitoring. For the aquatic part of the monitoring, a total of 120 individual sites of running water are being surveyed during a period of 4 years. In the subsequent years, the same sites will be surveyed again. About one fifth of the terrestrial and more than one third of the running water sites are situated in protected areas: mainly within the National Park Stelvio/Stilfser Joch and in the seven Nature Parks of South Tyrol (Figure 1). A minor number of sites is protected as "Biotope" or Natural Monument ("Naturdenkmal"). The surveyed taxa cover vascular plants, bryophytes and lichens, birds, bats, and insect groups, like grasshoppers and butterflies and soil-dwelling invertebrates as well as water insect larvae in aquatic habitats. The methodology for the vascular plant survey is based on the protocol of the European Dry Grassland Group (EDGG) combining a floristic assessment with an estimation of the coverage (Dengler et al. 2016), soil-living lichens and bryophytes are sampled on four subplots within the botanical plot, birds are surveyed in three repetitions following the Italian breeding bird monitoring (https://mito2000.it/), bats are surveyed via ultrasonic devices in three consecutive nights, butterflies are surveyed four times during the warm season following the Austrian Viel-Falter protocoll (https://viel-falter.at), grasshoppers are surveyed in early summer on the botanical plots following Hilpold et al. (2020) and the monitoring of running water is conducted following Scotti et al. (2022). In addition, data on abiotic factors, soil parameters, landscape structure, and land use management are also being collected. The methodology of the BMS is explained in detail in the project handbook (Hilpold et al. in press) and on the project website (https://biodiversity.eurac.edu/).

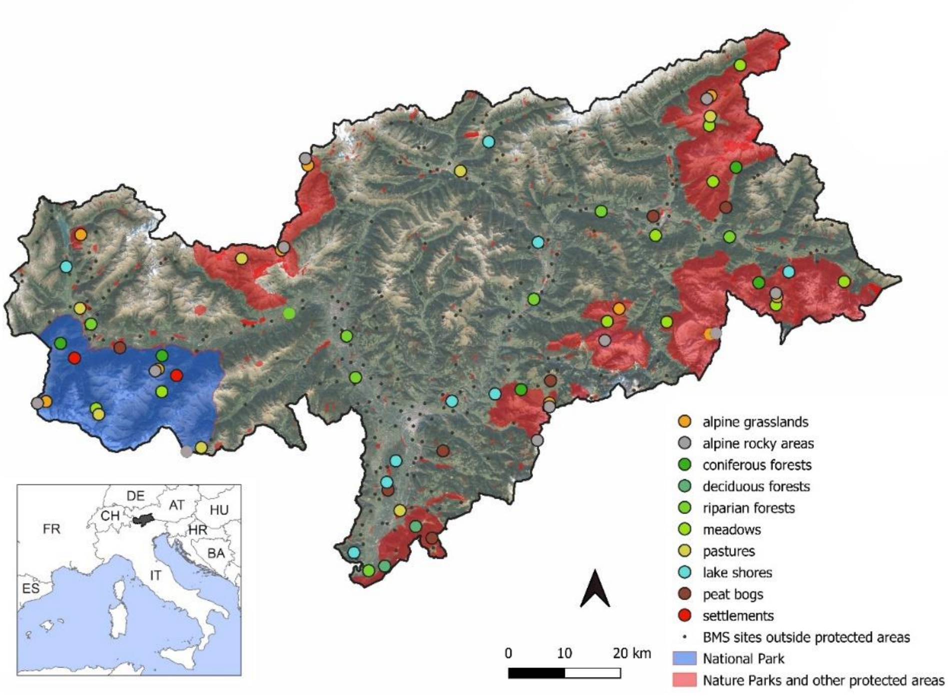

Figure 8: Map of the terrestrial monitoring sites within protected areas, i.e., within the Stelvio/Stilfser Joch National Park, the seven Nature Parks and within smaller protected areas ("Biotope", "Naturdenkmäler"). The entire monitoring is conducted on a total of 320 terrestrial and 120 running water sites.

Results

After three years of sampling, a high percentage of the known species for South Tyrol has been recorded for the project focus groups. Percentages range from 49 % for vascular plants to 84% for breeding birds (Figure 2). These numbers imply, that the sampling design is well suited to monitor the flora and fauna of South Tyrol.

As only one survey per site has been conducted so far, no temporal trends can yet be derived. However, comparative patterns can already be identified well with the data collected. For example, the relationship between landscape diversity and species diversity (for birds and bats) was already very well explored (Anderle et al. 2022a, Anderle et al. 2022b, Paniccia et al. in prep.). Additionally, the importance of the studied habitat types for the specific needs of single taxonomic groups could be shown (e.g., for butterflies; Guariento et al. 2022).

In the first four survey years, several new species records were made for South Tyrol. Particularly remarkable is the observation of a previously undetected bat species: *Nyctalus lasiopterus* (Schreber, 1780), the largest and one of the rarest bats of Europe. It has been recorded on five sites (Paniccia et al. 2022) and is the first proof of a continuous presence during the breeding season for the entire Eastern Alps. Several new insect species have been detected so far. The discovery of three new grasshopper species is particularly surprising, as the research status of the group was already very good before the start of the project. In 2021 two thermophilous species were found in Altrei/Anterivo: *Bicolorana bicolor* (Philippi, 1830) and *Euchorthippus declivus* (Brisout de Barneville, 1848) (Hilpold & Heimer 2021), while in 2022 *Pezotettix giornae* (Rossi, 1794), a Mediterranean species was found in the South of Bolzano/Bozen (Hilpold & Guariento 2022). Already in the first year of the project a new bryophyte species *Ephemerum recurvifolium* has been found in an intensive apple orchard (Spitale et al. 2020). Finally, all the bird species surveyed were already known for the province, a large number, however, are considered rare, as in the case for the barred warbler, *Sylvia nisoria* (Ceresa et al. 2020).

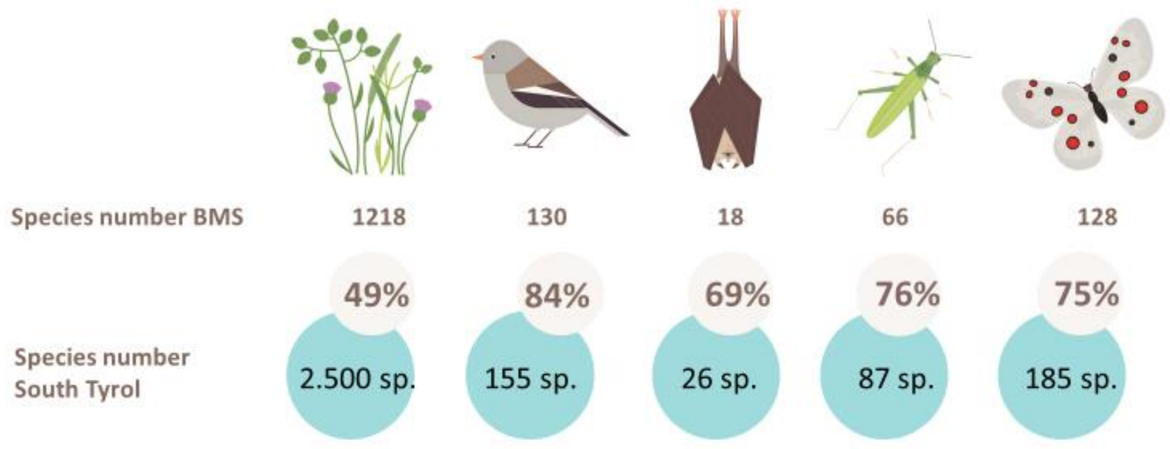

Figure 2: Share of species surveyed for five focus groups, i.e., for vascular plants, birds, bats, grasshoppers and butterflies.

Dissemination and stakeholder collaboration

The BMS not only aims at understanding patterns and trends of South Tyrolean flora and fauna, but it aims at fostering the entire field of biodiversity research and its conservation (Figure 3). Specific questions are tackled in special projects, partly following directly the stakeholders' needs or surveying special habitats not included in the standard monitoring. These typically relate to important questions on the impact of agricultural and forest management on biodiversity and ecosystem services as well as current impacts of environmental changes such as extreme events or invasive species. The outcomes of the projects will also be used to evaluate or improve species and habitat conservation measures in protected areas. Examples for such projects were the search for *Lopinga achine* (Scopoli, 1763), a butterfly species of the Habitats Directive that has not been found locally for more than 20 years. Further special projects included a biodiversity survey in herb fields together with the agricultural Laimburg Research Centre, a survey for the planning of a revitalization of the Adige River south of Bolzano or a biodiversity survey in the windfall areas hit by the storm Vaia in 2018 (Frieß et al. 2021). The BMS team collaborates also for the GLORIA surveys in the Italian Dolomites (Pauli et al. 2015) and with the COST Bottoms-Up project (www.bottoms-up.eu) on forest biodiversity.

In a further special project, orchard meadows were investigated in the framework of the Baumgart initiative, launched by Eurac Research with further seven partners from all over the province and including many activities to raise awareness for the habitat.

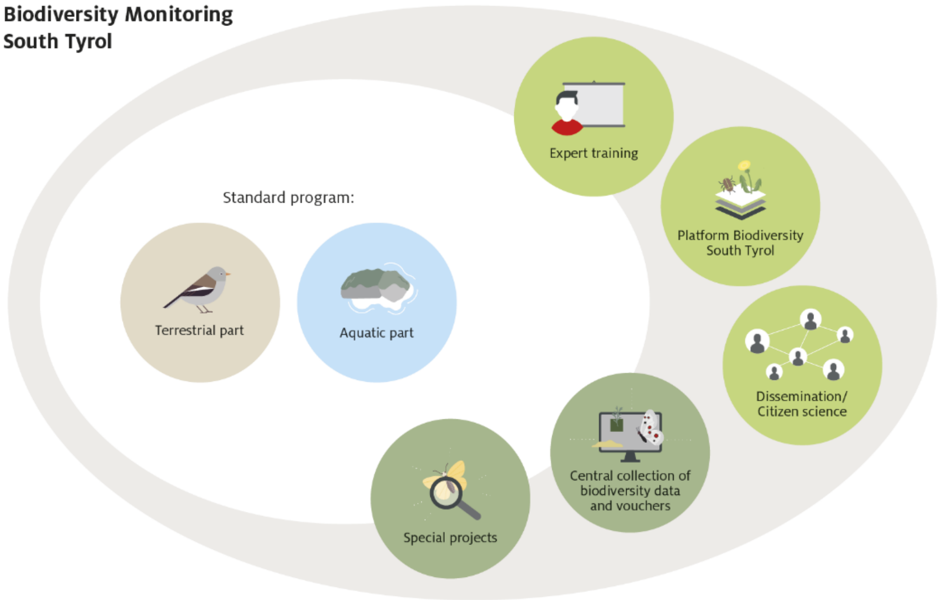

Figure 3: Work task scheme within the Biodiversity Monitoring South Tyrol. Besides the standard monitoring program various workpackages to improve biodiversity research and dissemination in South Tyrol are included. Within special projects research questions are tackled which cannot be solved within the standard program.

The outcomes of both, the standard monitoring and the special projects, are the base for a constant dialogue between the BMS experts and the local authorities and for communication with the public (e.g., Hilpold 2021) in different local and regional newspapers. As of 2021, the BMS maintains an Instagram profile, spreading information about various species found during the surveys. In addition, every year, the team members of the BMS hold several presentations for the local public: in 2022 a total of 15 public presentations and 15 workshops were held for schools (for pupils, as well as for teachers). In the four years of its existence, the BMS hosted a total of 28 interns, conveying taxonomic knowledge on animal and plant groups and a methodological base for their survey.

Finally, the BMS also uses Citizen Science approaches to directly involve the local population. In 2021 a citizen science project on grassland birds was initiated (ongoing until 2023) that involves hobby ornithologists. They are asked to survey grasslands in their surroundings for grassland birds, contributing to significantly enlarge the knowledge about the presences of these birds in South Tyrol. Finally, the BMS organizes once a year, together with the Museum of Nature South Tyrol, the City Nature Challenge South Tyrol, a citizen science activity that asks people to survey their surroundings via the iNaturalist app.

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Improving biodiversity literacy and biodiversity data: the "Insect-Camps" of the Austrian Entomological Society

Elisabeth Huber, Werner E. Holzinger und Herbert C. Wagner

Summary

“Austrian Insect Camps” are successful annual events of the Austrian Entomological Society (*Österreichische Entomologische Gesellschaft* = ÖEG), launched in 2014, to address two main aims: Getting students of biology closer to entomology and gathering biodiversity data from different landscapes in Austria. These camps are platforms that link invertebrate specialists and students through joint research of target areas. Standard methods are used to investigate the Arthropoda and Mollusca fauna, with students and experts actively working together in the field and in the lab (preparation and identification of material).

The event location is mostly chosen as a region that promises a high level of biodiversity, is still relatively unexplored and offers suitable accommodation and working facilities. There, the participants of the Camp – about 40 people, half of them specialists – try to detect as many species as possible within 3-5 days.

For students of biology, the Insect Camps offer good opportunities to familiarize with methods of invertebrate field research and identification tools, and they obtain first-hand experience in writing scientific publications.

Four of the eight previous ÖEG-Insect-Camps were hosted by Austrian national parks: Gesäuse in 2015, Neusiedlersee in 2016, Donau-Auen in 2018 and Thayatal in 2021. (WAGNER et al. 2015, 2018 & HUBER et al. 2021) At each of these occasions, the participants could detect well over 1000 species, including new records for federal states, and could significantly improve the knowledge on the faunae of the National Parks. These results of the camps are usually published as illustrated and commented checklists in the scientific journal of the ÖEG, Entomologica Austriaca.

Raising awareness and improving knowledge are important tools in the fight against biodiversity loss. The ÖEG-insect camp is a proper opportunity to address both.

Keywords

biodiversity, entomology, invertebrates, faunistic, insects, arthropods, education

Introduction

Global change impacts ecosystems and biodiversity – in protected areas as well as beyond their borders. To counter or mitigate effects of global change, good biodiversity data are necessary: these enable researchers to identify trends in populations, range shifts, or detect local extinction processes. Such information is vital for decision-making towards the protection and conservation of nature, and thereby human societies. Unfortunately, also biodiversity literacy declines and biodiversity knowledge in the greater public continues to deteriorate — mirroring the taxonomic impediment observed in biological sciences. And the future prospects are bad, as dissemination of “traditional” taxonomic knowledge and field work abilities aren’t important contents of biological curriculae at Austrian Universities any more.

Facing these problems, the Austrian Entomological Society (*Österreichische Entomologische Gesellschaft* = ÖEG) decided to establish a new type of event in 2014: The “Insect Camps”, as modification of an idea from Slovenian colleagues, where similar camps run very successfully for about two decades.

Figure 9: Sampling sites of the National Park Gesäuse (left) and Neusiedlersee (right). Photos: W. Gunczy & G. Kunz.

Figure 10: Sampling sites of the National Parks Donau Auen (left) and Thayatal (right). Photos:G. Kunz & R. Borovsky

Concept

Raising awareness and improving knowledge especially in young people are very important weapons in the fight against biodiversity loss and the first aim of the ÖEG Insect Camps. Thus, the target group for the "Insect Camps" are students, interested in Insects, Spiders, Molluscs etc. The students spend 3 to 5 days together with taxonomic experts, usually members of the ÖEG, do field and laboratory work and increase their skills in insect preparation and identification.

The first camp was held in 2014, and since then eight camps were organised in different parts of Austria. The event location is mostly chosen as a region that promises a high level of biodiversity, is still relatively unexplored and offers suitable accommodation and working facilities. There, the participants of the Camp – about 40 people, half of them specialists – try to detect as many species as possible within those days.

The second aim of the camp is to collect as many biodiversity data as possible during the time in the field and provide checklists for the study area. Because of the large number of specialists and students, usually a big amount of data from different taxonomic groups can be achieved in course of one of these camps. In course of any of the camps, between 16 and 57 sites of the very different habitat types were sampled. The results are usually published as richly illustrated and commented checklists in the scientific journal of the ÖEG, Entomologica Austriaca.

Figure 11: Participants of the camps in the NP Gesäuse (1), Neusiedler See (2), Donau Auen (3), Thayatal (4).

Methods

For the field samples, most of the “usual” methods are applied, such as pitfall traps, litter reducer, light trap, sweep net, water insect net, insect suction sampler (modified suction sampler, "G-Vac"), malaise trap, hand picking and photography (Fig. 7, Fig. 8). Most of the collected material is usually prepared and identified (e.g. mounted on cards) during the camp. Parts of the material were also used for DNA barcoding (in course of the "ABOL - Austrian Barcode of Life" project).

The material is stored in private collections and in the collections of the Natural History Museum Vienna, the Universalmuseum Joanneum, the Tyrolean State Museum and the Ökoteam.

Figure 12: light trapping, identification and preparation, sorting of a soil sample. Photos: P. Schattanek.

Figure 13: Use of sweep net, Malaise trap and the insect suction sampler. Photos: E. Huber, E. Papenberg & G. Kunz

Sampling Results

In course of the eight camps, between 400 and 1429 species could be detected (tab.1). Four species records were new to Austria, and several species were new for different federal states (9 for Vienna, 16 for Lower Austria and 27 for Burgenland). (WAGNER et al. 2015, 2017, 2018, 2019 & HUBER et al. 2021, 2022)

table 2: total species numbers of all insect camps.

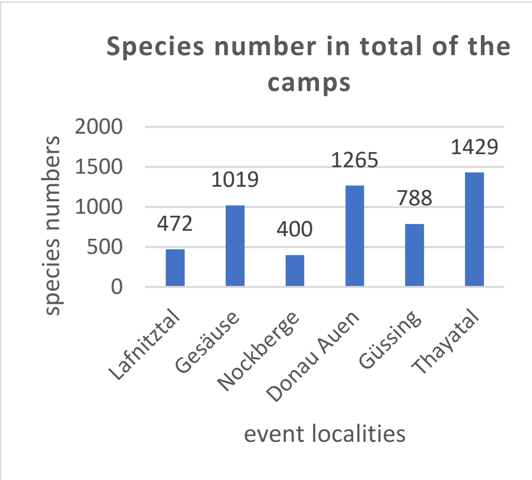

table 3: distribution of the involved persons during the camp days.

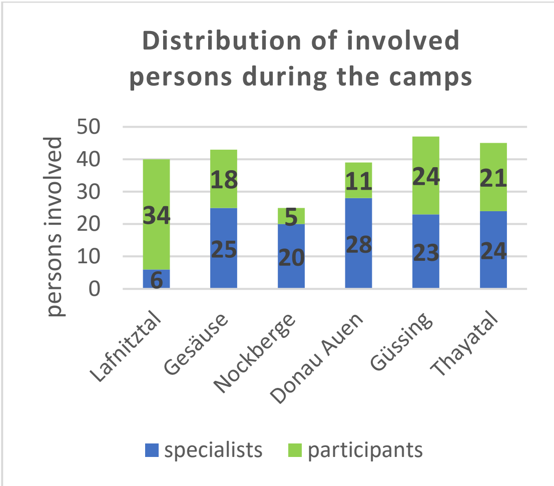

table 4:dispersion of verified orders of the three National Parks.

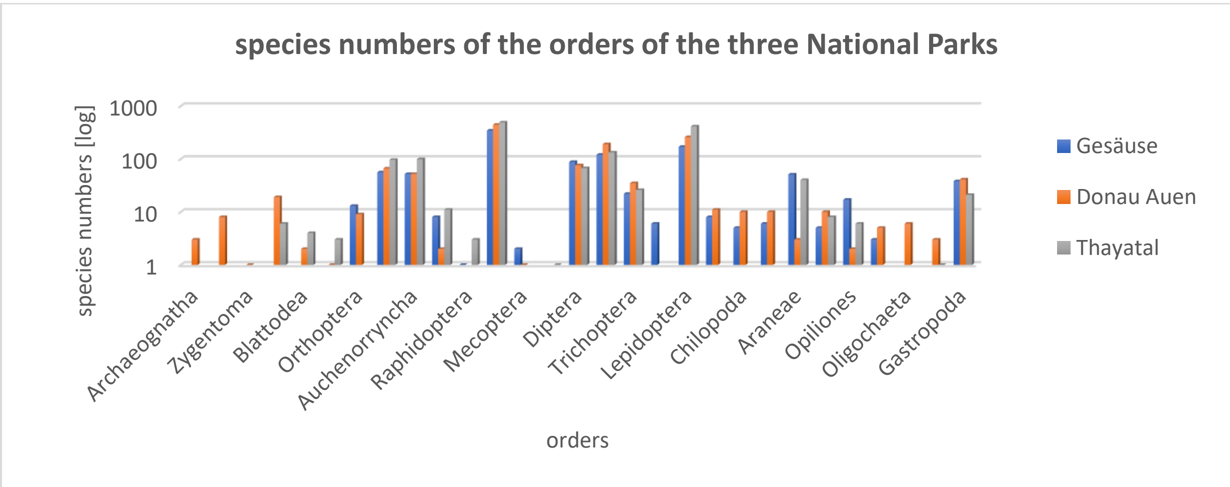

Figure 14: excamples of highlights of the camps: Gewöhnliche Ovalspinne (Enoplognatha ovata); Große Lindenprachtkäfer (Lamprodila rutilans); Südliche Dickkopfzikade (Anaceratagallia laevis).

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Are wet grasslands drying-out in the NP Donau-Auen?

Karl Hülber, Norbert Sauberer

Abstract

National parks (NP) belong to the most strongly protected areas in general. However, global change effects do not necessarily stop at their borders and might fundamentally affect the functioning, development and composition of protected ecosystems and their species. The NP Donau-Auen, partly located within the capital of Austria, comprises a variety of grasslands of high conservation value ranging from wet sedge-bed marsh vegetation to dry meadows on gravel and sand banks.

In 2011 a monitoring scheme of 65 permanent plots covering the whole moisture gradient within the NP´s grasslands was established. Re-observations of vascular plants only eight years later revealed a significant shift towards species adapted to more dry conditions. This shift in species composition was particularly strong for wet and moist grassland types. Such asymmetric shifts identify local factors like the lowered groundwater table rather than changes in global climate as the most likely cause of the observed changes. This is particularly worrying as the wet grassland types and their associated species are at high risk of being lost from the NP within the near future.

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What you see is what you get: How historic concepts of primeval forests in Central Europe shaped present conservation landscapes

Iris Oberklammer, Georg Gratzer

Abstract

Primary forests and old-growth forests are currently receiving increased attention. While the role of such forests in terms of species conservation is increasingly acknowledged in view of the current biodiversity crisis their potential for carbon storage and thus mitigation of the climate crisis is discussed controversially.

The new EU Biodiversity Strategy 2030 calls for strict protection of 10% of EU land cover including all remaining primary and old-growth forests. This, sparks new interest in where such forests are located and how they can be characterized or identified. However, current primary forests are the results of (positive and negative) selection processes of the past: only forests that were considered worthy of protection or unworthy of utilization (or both) are remaining in natural or semi-natural states today. These selection processes have been shaped by cultural construction of ideas and concepts. One of these cultural constructions is the concept of primeval forests.

We traced back the evolvement of the German word “Urwald” (primary or primeval forest) from the early 19th century until the 1930s to discuss how primeval forest concepts affect remaining unused forests in the present. For this, we studied descriptions and definitions of “Urwald” in encyclopaedias and forestry journals from the 18th century onwards. The term Urwald first appears at the beginning of the 19th century. The first lexical description of the term was found in Meyer (1840-1852). There, primeval forest is described in the context of tropical forests, thus originating from the colonial view of exotic wilderness. Early mentions of “Urwald” in forestry journals also refer to forests outside Europe and mourn the loss of their existence in Europe. During the second half of the 19th century, descriptions of Central European Urwald appear more frequently in the records. Common attributes of these forests are a high deadwood presence and giant stand-dominating trees, as well as the relative (or perceived) absence of past human intervention. Natural disturbances are frequently perceived as agents destroying these forests that subsequently lost their conservation status.

We illustrate the cultural construction of primary forests with two examples from forests in the Alps and the Carpathians that were partly converted to managed forest based on the loss of such constituting characteristics. Based on our findings, we argue that awareness of the historic evolvement of concepts and ideas referring to nature can help reflect and improve decisions regarding the future of European forests.

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The relevance of urban and suburban protected areas during the pandemic - the Viennese people's perception

Alexandra Jiricka-Pürrer, Karolina Taczanowska, Donna Tansil, Jacqueline Wilfer, Isabella Burker

Abstract

The SARS-Cov-2-Pandemic catalysed multiple societal changes, including citizens' perception, needs and expectations posed towards urban green spaces. This presentation discusses the implications for large-green spaces and in particular protected areas deriving from a quantitative survey (representative online panel) among the Viennes population and border districts' residents in Lower Austria (n=1012).

The study shows not only partly changed recreation patterns and varied use of urban and suburban large green spaces and conservation areas but also the altered perception of their relevance. An increased importance of time spent in nature overall and possibility to visit large green areas was reported by Viennese citizens. Also, higher recognition of green spaces located close to home was observed. Particulary younger age groups ranked the perceived relevance of large green areas, a lot of them being protected areas in the Viennese metropolitan area, higher than other than older respondents. Among the most frequented green areas during the pandemic several protected areas ranked high.

Additionally, the study surveyed the perceived relevance for both emotional and physical health and wellbeing. Results show a strong impact on the capacity to cope with stress in these times of crisis. A reduction of symptoms such as depression or anxiety due to contact with nature was evident. Differences among age groups and gender could be observed.

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Unexpected pathways of mercury in Lake Neusiedl: a mesocosm approach

Franz Jirsa, Jakob Windisch, Christof Plessl, Christiane Christian, Thomas Zechmeister

Abstract

Mercury (Hg) as one of the most frequently, globally occurring pollutants is of major public health concern. Aquatic environments are of special interest in this regard, as they classify as the key compartment for methyl-Hg synthetization and consequent bioaccumulation.

This mesocosm study looked at the differences of Hg bioaccumulation in the macrophyte Ceratophyllum demersum and the sequestration of Hg into sediments in two contrasting waterbodies: Lake Neusiedl (LN) an alkaline, saline, eutrophic, biological highly productive lake and Panozzalacke (PL) an "average", oligotrophic European freshwater lake. Four mesocosms from each waterbody, containing water, sediments and macrophytes were spiked three times per week with Hg2+, resulting in calculated 70 ng L-1 dissolved mercury in the water phase after each addition. Before and after the experiment, which took eight weeks, the total Hg concentration in plants and sediments was determined after acid digestion using cold vapour atomic absorption spectroscopy (CV-AAS).

Results showed that significantly higher amounts of Hg accumulated in macrophytes from LN compared to PL. Compared to initial concentrations, the mean level of Hg in plants increased by the factor of 100 in LN and 50 in PL, respectively. However, sedimentation rates of Hg were significantly lower in LN compared to PL.

We conclude that the specific physico-chemical and biological conditions in LN lead to a fast conversion of incoming mercury, accelerating bioaccumulation and potentially leading to unexpected mercury biomagnification in this lake and other comparable waterbodies around the globe.

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Counting the Countless: Machine Learning for Long-Term Monitoring of Alpine Plant Diversity in the National Park Hohe Tauern

Roland Kaiser, Christoph Praschl, Gerald Adam Zwettler

Summary

Within an interdisciplinary monitoring and research program for long-term observation of alpine ecosystems in the Hohe Tauern National Park, a digital true colour image archive in the form of strictly standardised (geo-static, colourfast), high-resolution nadir photos (view vertical to the ground) is being built up. The technique's strengths are its high precision, the adjustable scale of analysis, reproducibility, and the absence of classical sources of error in fieldwork, such as varying degrees of attention and botanical expertise. In order to extract biological information from the very detailed image source (1 px. ≈ 0.1 mm), computer vision and machine learning algorithms were tested for their applicability. Image annotations for 13 typical species were created as polygon boundaries and were then used to train multiple deep learning models using a U-Net architecture. The developed software prototype accomplished the recognition of several plant species (including specific plant organs such as fruits) and provided semantic segmentations with spatial reference. The evaluation of the results shows that the software prototype enables the monitoring of small-stature plants in alpine regions. This property offers new possibilities for the analysis of vegetation stands. It allows, for example, the tracking of an individual (or ramet) over time and space or the analysis of patterns in previously unknown levels of detail (centimetre scale) with ease of effort. However, overlapping plant canopies constrain the method in dense communities.

Keywords

Alpine belt, computer vision, machine learning, monitoring, LTER, snow bed, biodiversity, plants

Introduction

The Hohe Tauern National Park (Austria) has founded an interdisciplinary monitoring and research program for long-term observation of alpine ecosystems (after this, referred to as 'Long Term Monitoring'). This initiative provides—among other findings—an ongoing digital image archive in the form of strictly standardised (geo-static, colourfast), high-resolution nadir photos (view vertical to the ground, 1 px. ≈ 0.1 mm) with overwhelmingly high information content . These data, comparable to earth ortho-photos, represent the basis for the project at hand. It focuses on developing a software prototype to automatically recognise plants from image data using computer vision and machine learning. The goals are threefold. First, the recognition of a plant species and its individuals, despite overlap with other plants or vegetation structures, is aimed. Secondly, a specimen's variation in nature and, thus, divergent appearance is addressed. Thirdly, detecting identical plants within a time series should be possible. In addition, the software prototype should allow the models to be updated when new data are available. The data and software are to be made available as open source.

Methods

As part of the 'Long Term Monitoring', 14 transects with a length of up to 8 m and a width of 1 m will be repeatedly surveyed with digital imaging equipment at three different sites. This way, an area of 87 m² is covered, which will never be the subject of invasive sampling by other research. Starting in 2017, the images were taken in two consecutive years, with a break of two years before the next regular campaign took place (2017–2018 and then again 2021–2022); additionally, it exists sparse data from the year 2019, which is unused (still).

A particular transect's precise extent is marked out in the field before the photo shooting can happen. For this task, a rope ladder-like sampling grid 8 m long and subdivided into 32 grid cells of dimension 50 cm 50 cm was invented; each grid cell sets the frame for a particular nadir photo (cp. panel a in fig.

1). The sampling grid, accurate to ±0.5 cm, is made of 17 pieces of 6 mm thick and exactly 1 m long carbon tubes and three strings of 1.5 mm thick Dyneema cord with extremely low elongation values. Of course, the grid is photographed and is thus part of every picture (fig. 1).

After the grid had been fixed to the ground, images of each 50 cm grid cell were taken with a camera and tripod rig covered with a shading curtain. The construction consists of five essential parts: an extra-large tripod, a tripod ball head mounted up-side-down, a full-frame camera with 50 mm lens, two friction arms attached with clamps to the tripod legs and equipped with camera rails to host two photo flashes, and finally, the two flash units with a diffuser. Two people can transport all the equipment with a total weight of approx. 15 kg. In 2017 and 2018 a Nikon D750 (24.3 MP) with Nikon AF-S Nikkor 50 mm 1:1.8 G and two Nikon SB 910 as illumination was used. The equipment was upgraded for the 2021–2022 campaign with a Nikon Z 7II (45 MP) with Nikon Nikkor Z 50 mm f/1.8 S and two Yonguno Speedlite YN560-III.

After developing the digital negatives, the images were rectified and fitted into a millimetre coordinate system using four tie-points obtained from the sampling grid. All image tiles that make up a transect, hereafter termed scene, can be displayed in GIS software like an ortho-photo mosaic. At the time of writing, the resulting geo-referenced 'Image Data Archive'(referred to as IDA) consists of 1,372 image tiles (50 cm 50 cm, 9 MP, 1 px. 0,1 mm) from four years (2017–2018, and 2021–2022); the year 2022 was not evaluated in this study. Using image slicing, a scene can be split up into sub-grid cells of any size. A sub-grid cell size of 10 cm 10 cm (25 per 50 cm grid cell) proved to be a good choice for visual inspection and analysis.

In an initial study in 2017, the then-available total body of 8.200 sub-grid cells was randomly subsampled and examined for the recognisable image classes. The obtained random subset of size 416 (approx. 5 %) was stored for the future and became the foundation for further analysis, including this work. By means of a repeated subsample, a test set of 49 sub-grid cells was selected from the IDA to create annotation labels as polygon contours in order to provide training data. This subset forms a 'Reference Data Base'(referred to as RDB) hosted on a web-based service. The RDB was further enriched with more annotations for a particular example transect studied in more detail (East-Tyrol, Innergschlöß, transect 4, N 47.11111°, E 12.42644°, 2,350 m.a.s.l.).

Multiple deep learning models were trained using a U-Net segmentation using the above training data. Training of deep networks requires many thousand annotated training samples. In this work, we adopted a training strategy that relies on strong data augmentation to use the available annotated samples more efficiently. The RDB was therefore extended using data augmentation techniques and supplied the training data. Image cutouts of 2 cm 2 cm (128 128 px.) were used to train models and obtain spatial predictions from them in the form of semantic segmentation.

Results

Annotations are the indispensable basis for training deep learning models. They are both the basis and the result of the chosen algorithms. In total, 12.187 annotations for 13 species are available in the 'Reference Data Base'. Up to now, six species account for almost 95 % of it; they are Scorzoneroides helvetica (3,338), Soldanella pusilla (3.114), Salix herbacea (2,683), Polytrichum sexangulare (1,526), Gnaphalium supinum (751), and Euphrasia minima (243). Analysis of this limited data set revealed significant pattern that were in line with previous analysis.

The software prototype accomplished the recognition of several plant species. It also depicted varying appearances of the same species (e. g., fresh vs senescent leaves or yellow vs white flowering variants). Furthermore, tracking an individual (or ramet) between image pairs over time is doable. The development goal of the software prototype, to enable classification and segmentation of typical plant species in the images, was achieved. The algorithms embedded in the software prototype can be updated by the user with new data.

Plant species (or plant organs) that points can approximate are evaluable as statistical point patterns (fig. 1). For example, a first analysis shows a striking change in the density of capsules in Polytrichum sexangulare, which, we assume, is positively related to the ecological fitness of the species. Humans can likely not achieve the spatial point pattern reported by the developed models in fieldwork.

An additional benefit was using the original annotation polygons to assess vegetation changes (fig. 2). The analysis of this data is worth it. Statistical inference helps to validate the training data for its properties. Ultimately, model predictions from complete transect analysis, not restricted to a random sample, will allow a more detailed comparison compared to a standard sampling design.

The evaluation of the above results shows that the software prototype enables the monitoring of small-stature plants in alpine regions. Except for the lack of support for visually ambiguous plant species, the algorithms captured biodiversity well. However, overlapping plant canopies constrain the method in dense communities. Although the models are also still preliminary, the software prototype is encouraging us to be able to accommodate the unmanageable feature richness of the 'Image Data Archive' by highlighting and isolating patterns. Future studies can rely on spatially explicit population statistics collected by machines rather than humans, which means counting the uncountable is now feasible, and new questions can be asked.

In summary, thanks to recent developments in computer vision and machine learning as well as advances in computer chip technology, the manual recording of species in study plots by humans can be automated and performed on the desktop. However, there are still some challenges to overcome. We can address these by providing more training data and additional species and by extending the model architecture to handle multiple species simultaneously.

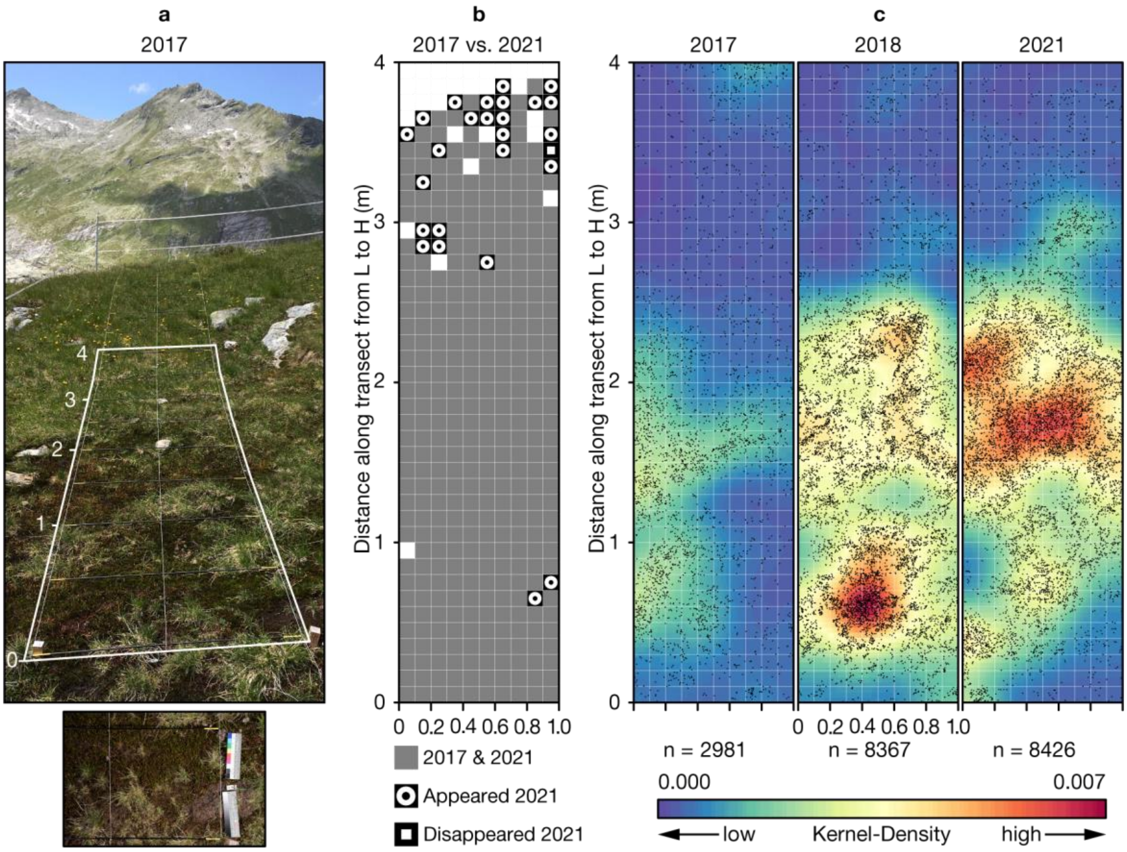

Fig. 1. a) View of transect 4 at the Innergschlöß site in 2017 with the white-bordered extent of the maps in b and c and an unedited original photo as an example; b) Distribution data for 2017 and 2021 of the moss species Polytrichum sexangulare with differences at the 10 cm 10 cm sub-grid level highlighted by different symbols ; c) Model results for the capsules of Polytrichum sexangulare in comparison of the years 2017, 2018, and 2021. Different scales and parameters unveil different processes. The comparison of b and c shows that a pattern emerges that cannot be observed with e. g. a fine-scale grid analysis of species occupancy.

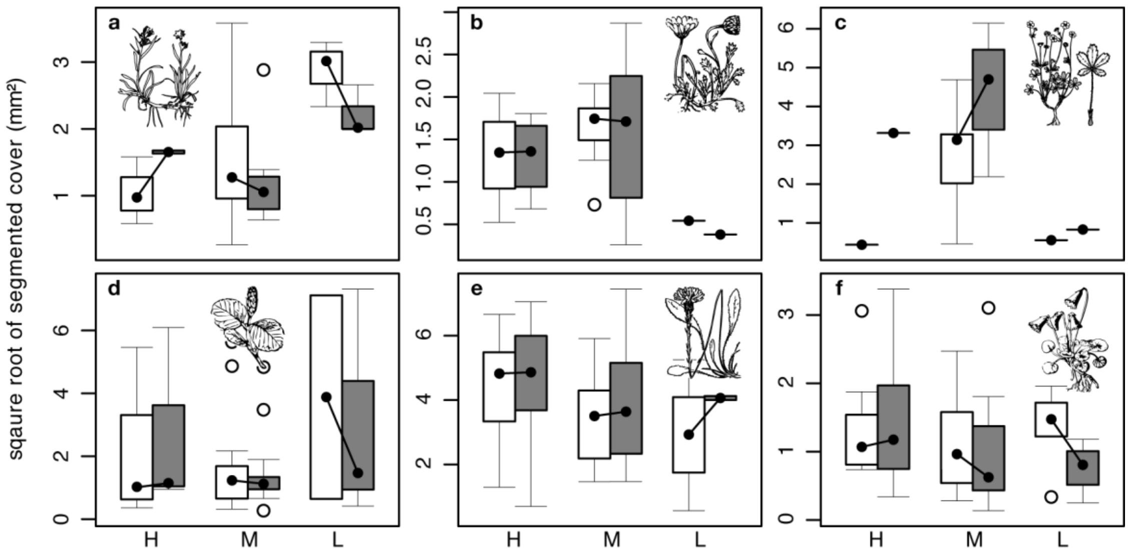

Fig. 2: Pairwise comparison of the annotations for the years 2017 and 2021 based on the initial subsample (N=49 per year). The comparison is grouped for three ecological zones representing a snowpack gradient [3]. All transects in the study were assembled post-hoc into three sections: bottom (least productive, L), mid- dle (M), and top (most productive, H). Especially in the L zone, decreases in numerous typical species for this habitat section are recorded. a) Gnaphalium supinum; b) Leucanthemopsis alpina; c) Potentilla aurea; d) Salix herbacea; e) Scorzoneroides helvetica; f) Soldanella pusilla.

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Restoration of semi-natural grassland: how does it work in practice?

Julia Kelemen-Finan and Thomas Holzer

Summary

The aim of this paper is to present the operation, efficiency and effects of machinery and procedures which have been applied to restore and maintain the biodiversity of Natura 2000 grassland sites across Lower Austria. The sequence of techniques and machinery used for the initial scrub and grass clearance, as well as the follow-up rotary mowing scheme and the uses for biomass are described. Techniques and machinery which are discussed include practices which are partly established agricultural technology in the grassland regions of Western Austria, but uncommon or even unknown in the lowlands of Eastern Austria which are dominated by arable crops. We also discuss how successful procedures rely on the clear definition of roles and tasks, and how the cooperation between stakeholders (including professional contractors, local farmers and volunteers) can work.

Keywords

Biodiversity, scrub clearance, hay making, agricultural technology, volunteers

Introduction

Species-rich semi-natural grasslands, such as semi-dry or wet meadows, are amongst the most threatened habitat types across Europe. The EU habitats directive requires maintenance or restoration of the conservation status of habitats at designated Natura 2000 sites. However, once the abandonment of traditional management has resulted in a certain level of scrub and grass coverage, the efforts to restore and maintain a site become increasingly challenging. This problem is particularly acute in Eastern Austria, where large arable fields dominate the agricultural landscape, and farmers use large and heavy machinery. Smaller and less productive, hilly, dry, rocky or wet grassland sites are not part of the traditional farming practice anymore. Consequently, farmers now lack smaller and lighter equipment, as well as the skills necessary for low-intensity management of sensitive grassland sites. On the other hand, the maintenance of sites of high conservation value is often carried out by non-farmers, with manual equipment (hedge clippers, hoes, saws, etc.) and the occasional brush cutter and rake. On larger sites this practice is slow and inefficient. Grazing would be another option, but is often very hard to organise.

We present an innovative approach which has been developed over the last few years to use modern agricultural technology effectively and efficiently for the restoration and maintenance of the biodiversity of grassland sites across Lower Austria. The sites include semi-dry meadows on hilly terrain, as well as wet meadows, in several Natura 2000 areas.

This presentation focusses on a case study restoring semi-dry grassland (mostly habitat types 6210 and 6510) on the “Waschberg”. This hill (top: 48.421966, 16.272487) is located east of the village of Leitzersdorf at the southern end of the Natura 2000 site “Weinviertler Klippenzone” in Lower Austria. It is a typical example of the many remaining small, “flowery hills”, where traditional land use stopped decades ago, but which are still biodiversity hotspots in the otherwise intensively managed agricultural landscape. At the Waschberg, restoration measures commenced in 2019, by clearing some initial parcels of scrub on a large slope (20 hectares in total) belonging to the local council. The long-term aim is to restore the intricate pattern of open meadows with some landscape elements (shrubs, single trees, un-cut areas, etc.), also considering the protection of various target species (for details see Kelemen-Finan 2020 and Kelemen-Finan 2022). A particular challenge for management is the uneven surface, resulting from several historic limestone quarries on the site.

Methods

1.) Procedure for the initial removal of scrub and old grass swards

The removal of trees and scrub strictly follows the management plan, which is based on extensive surveys and ongoing evaluation by experts on various taxonomic groups (vegetation, orthoptera, lepidoptera, wild bees, molluscs, birds). Scrub clearance is undertaken in the winter months (November – start of March) to reduce the effect on wildlife. The measures consist of work undertaken by professional landscapers (contracted by the community), which are assisted by staff and volunteers from the local community, farmers as well as students. The work is clearly defined for each stakeholder group: community staff clear access routes and cut larger trees (mainly pines) with chainsaws (photo 1). Professional landscapers cut scrub (with chainsaw and brush cutter) and then cut the old grass sward on the potential meadows with a flail mower/mulcher (photos 2&3). The old grassy material is placed into swathes with the belt rake. Volunteers help to load the scub onto the trailer (ph.4) and to collect the biomass in bags (ph.5). Everyone helps to transport the biomass off the fields and into the containers at the collection site. Local farmers load the biomass into the containers with their tractors and front loaders (to reduce the volume in the containers; ph.6). The containers with the biomass (wood, scrub, old grass) are subsequently picked up by a contracted company and transferred to the community biomass collection.

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2.) Procedure for the maintenance of the hay meadows

The initial clearance (see above) is done in such a way that the subsequent mowing can be performed without damaging the equipment, i.e. no stump of a tree or bush is left sticking out. To ensure this, the first task in spring is a control of level ground (and possible stump-cutting). Like the initial clearance, the mowing scheme also strictly follows the management plan. The mowing regime tries to replicate the timing of the traditional mowing: meadows are cut once a year (or less often), between the end of May and September, to create a mosaic of patches with different stages of vegetation development.

Depending on the inclination and evenness of the ground, as well as ecological factors, mowing is performed with a front mount disc mower (without conditioner; photo 7), finger bar mower (photo 8) and brush cutter (photo 9). On the Waschberg, the finger bar mower is the least used equipment and needs to be left behind when there is a lack of space for transport on the trailer (photo 10). Additionally, manual tools such as hoes are used to remove deep-rooting and fast-growing plants such as *Clematis vitalba*.

The hay is used by local farmers, to feed their sheep and cattle. To facilitate this, the professionals place the cut grass in swathes on flat ground with a belt rake (photo 11) and wooden rakes. There, the farmers can pick up the hay with their self-loading wagons (photo 12). Alternatively, the cut grass is dried, then placed in swathes and pressed into small bales, using a baler for easy-to-handle small (20 kg) bales (photo 13). The summer work is mostly performed by the professionals. Volunteers help mostly with raking hay on uneven or steep ground, where the belt rake cannot be used (photo 14).

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Results

The aim of this paper is to describe the machines and the management process, which has been given in the Methods section. Conclusions are presented below. Results about effects of the management on biodiversity are presented elsewhere. However, we would like to give some examples for the positive effects on the Waschberg: (1) The initial conservation status of the main habitat types, grassland types 6210 and 6510, has improved from B and C resp. (EEA 2022), to A for the year 2022. (2) The populations of several FFH-plant species, such as *Pulsatilla grandis* (photo 16), as well as many other target species (e.g. *Orchis ustulata neotinea*, photo17), have increased considerably. (3) A large population of the oligolectic long-horned bee *Tetraloniella fulvescens* has been discovered in 2022, using the large restored flowering areas (photo 18; pers.comm. Bärbel Pachinger).

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Conclusions and recommendations:

1.) The presented techniques, using light-weight modern agricultural technology for the restoration and maintenance of dry and wet species-rich semi-natural grasslands, which cannot be managed with the common large tractors, are reliable, effective and efficient for sites in Eastern Austria.

2.) Mobility, i.e. the transport of the larger machinery between sites, is a serious restriction, because it may be very time consuming. Therefore use of this equipment is only sensible and efficient (1) when enough fields can be managed within an area (to work for a least a full day in an area) and (2) when the funding is available.

3.) Professionals, farmers and volunteers can complement and support each other best when roles and tasks are clearly defined, and each group contributes their specific skills and equipment.

4.) Inclusion of local volunteers and farmers greatly increases the acceptance of the management in the area. On the Waschberg, the local community is proud of the in-creased attention the site has experienced: they won the Lower Austria Nature con-servation prize and their activities were shown in a nation wide TV program in 2022.

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MIT UNTERSTÜTZUNG DES LANDES NIEDERÖSTERREICH UND DER EUROPÄISCHEN UNION

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Fostering the cultural and natural assets of alpine pastures and mountain meadows

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Summary

Due to the traditional cultivation by farmers and their unique flora and fauna, alpine pastures and mountain meadows can be considered as highly valuable but at first glance contradictory cultural and natural assets for the region and people who live there and visit it. The aim of this analysis is to gain a better understanding of the societal preferences of managing alpine pastures and mountain meadows and identify utilization strategies and framework conditions in order to develop an optimum of both, the cultural and natural asset and also consider recreational aspects. Therefore, we combine different methods of participatory research as well as economic modelling in order to calculate preferences as well as marginal willingness to pay (MWTP). Within the participatory process we identified six crucial attributes of alpine pastures and mountain meadows, which were analysed in a discrete choice experiment (DCE). 360 respondents from Eisenwurzen and surrounding areas with complete and valid responses participated in the DCE. Their responses were used to calculate the preferences and MWTP. The first preliminary results indicate overall positive preferences for all non-monetary attributes, in particular regarding an increase in the diversity of plant and insect species. According to this result, the highest MWTP is shown for a high diversity of plant and insect species. Based on final model results and further interactions with stakeholders, we aim to outline alternative land management paths for alpine pastures and mountain meadows and support policy in the development of appropriate strategies and avoid future conflicts between agriculture, nature conversation and tourism in the Eisenwurzen region and beyond.

Keywords

Eisenwurzen region, Alpine pastures and mountain meadows, discrete choice experiment, marginal willingness to pay

Introduction

Austria's landscape has been shaped by agriculture for centuries. Agriculture is thus instrumental in shaping the living space in rural regions and the resulting cultural landscape. In alpine regions cultural landscape extends up to high altitudes in the form of alpine pastures and mountain meadows. Due to the traditional cultivation of these alpine areas by farmers, alpine pastures and mountain meadows can be considered as a highly valuable cultural asset for the region and people who live there (Pötsch, 2010). Additionally, they form a habitat for a unique flora and fauna and can therefore considered as natural asset (Hilpold et al. 2018). With the aim of preserving these habitats, some alpine pastures and mountain meadows in Austria have been included in the zones of Natura 2000 areas, nature reserves and national parks.

However, the clash of different interests with regard to conservation and future development of cultural and natural assets can lead to conflicts of use. In particular such conflicts occur between agriculture and nature conversation. Since both alpine agriculture and nature conservation are of great societal relevance and these alpine areas are a point of attraction for recreation, societal expectations play a crucial role in the future development of cultural and natural assets.

The aim of this analysis is to gain a better understanding of societal preferences for managing alpine pastures and mountain meadows within the Eisenwurzen region and its surrounding areas. The results will be used to shape utilization strategies and framework conditions of such areas in order to achieve an optimum of both - at first glance contradictory – cultural and natural assets and also consider recreational aspects.

Methods

We apply a participatory approach combining participatory research and economic modelling. With regard to the first, we elicit local expert knowledge by means of stakeholder interviews and conduct a literature review to identify the crucial features (attributes) of the design of alpine pastures and mountain meadows. Furthermore, we organized two workshops with local experts a) in order to identify the most crucial attributes in terms of their natural and cultural assets and b) to learn and discuss about potential utilization strategies and framework conditions of such areas. Whereas the first workshop was used for preparation of the economic modelling described above, the second was organized after the modelling. Within the workshops we apply different methods of participatory research which can help to facilitate processes in which all stakeholder groups are on an equal footing. These includes the method "Personas", which aims to motivate stakeholders to look at the problem from different perspectives. For this case we developed hypothetical persons with different interests and characteristics. Stakeholders were then asked to rank the attributes in their own interest, but also in the name off the two hypothetical persons. This procedure helps to erase the personal view of the stakeholder and therefore the bias of an inequality of interests in the stakeholder group.

With regard to the second, different configurations of these attributes are combined to land use scenarios and assessed by the local population through a discrete choice experiment (DCE). DCEs are increasingly applied to analyse preferences of individuals with respect to non-market goods and services connected to agriculture. The key advantage of such a stated preference approach is that it can be used to valuate non-market outputs, for which no market values exist. DCEs are based on the rationale that people do not derive utility from goods and services directly, but from their attributes. In a DCE, choice data is generated through the construction of a hypothetical market by using a survey, where respondents are presented with several choice sets, each consisting of at least two alternatives, which are marked by a set of attributes with varying outcomes (i.e. levels). By choosing their preferred alternative in each choice set, they make trade-offs between the levels of the attributes of the respective alternatives in each choice set, from which their preferences for the good/service of interest can be derived. We analyse the choice data of the DCE with different econometric models. In a first step, we employ a Multinomial Logit Model (Train, 2009) and estimate the parameters reflecting preference weights for the attribute levels

$$P_{jn} = \frac{e^{\beta' x_{jn}}}{\sum_k^K e^{\beta' x_{nk}}},$$

where the choice probability **P** of an individual **n** for an alternative **j** has a logit structure, with **e** denoting the exponential, **x** the attributes of the DCE, $\boldsymbol{\beta}$ are the parameters to be estimated, reflecting preference weights for the attribute levels, and the subscript **k** refers to all alternatives other than **j**. The model is estimated with maximum likelihood estimation and a Gumbell Type-B distribution is assumed for the stochastic error term further included in the model.

In a second step we further estimate Latent Class Choice Models (LCCM) to better reflect heterogeneity in preferences, between different segments (also referred to as latent classes) of respondents in the sample (Train, 2009), using several of their socio-demographic variables. In addition, preference structures as well as willingness-to-pay for individuals can also be determined for such models

(Colombo et al., 2009). For each latent class separate choice probabilities are estimated and the model also considers several choices made by a person, which is reflected in an additional subscript **t** for a series of choices

$$P_{jn|c} = \prod_t^T P_{nt|c} = \prod_t^T \left[\frac{exp(\beta_c' x_{jnt})}{\sum_k^K exp(\beta_c' x_{knt})}\right], c = 1, \ldots, C.$$

The allocation of respondents to latent classes is carried out with a class allocation model, which also has a logit structure and can incorporate characteristics **z** of respondents to influence the modelling of preference heterogeneity and estimate for each person the probability **π** to be in each of the latent classes

$$\pi_{cn} = \frac{exp(\lambda_c' z_n)}{\sum_c^C exp(\lambda_c' z_n)}, c = 1, \ldots, C.$$

Further, welfare estimates can be calculated based on the results. Specifically, marginal willingness to pay (MWTP) can be calculated as the ratio of the estimated coefficient of a non-price attribute and the estimated coefficient of the price attribute for the respective class multiplied by minus one. By further weighting MWTP-estimates according to the estimated respondent-specific class allocation probabilities it is possible to calculate respondent-specific MWTPs

$$\widehat{MWTP}_{jn} = \sum_c^C \hat{\pi}_{cn} \left(-\frac{\hat{\beta}_{c,NON-PRICE}}{\hat{\beta}_{c,PRICE}}\right). \quad \text{(X)}$$

Case study region

The Eisenwurzen region, which is located in the border region of Upper Austria, Lower Austria and Styria, serves as a case study region for the present analysis. Being part of the international network of Long-Term Socio-Ecological Research (LTSER), the region offers a regionally and internationally networked field of research. Small scale agriculture has been of great importance in this region for a long time and contributes to the preservation of the cultural landscape to a very large extent. So far, the touristic activities within the region are relatively low, but the region has a high potential for sustainable tourism. Two national parks, low population density and an attractive and diverse alpine landscape all have the potential to be appreciated by people from nearby urban centres who look for outdoor activities, both in summer and winter.

Results

Through the participatory approach we developed 6 attributes for the DCE, which are shown in Table 1. In the survey, respondents were presented with 6 different choice sets, each consisting of 3 alternatives. One of these three alternatives was always identical, referring to a reference scenario, which described the possible status of alpine pastures and mountain meadows in the case study region in around 10 years in a business-as-usual scenario. The other two alternatives were varied based on a d-optimal experimental design (Street et al. 2005).

Table 5: Attributes and levels used in the DCE.

Attribute	Levels (number of level)[a]
Mountain hut function	*Resting place (1)*; food and drinks (2); accommodation (3)
Scenery	*Forest dominated (1)*; grassland and forest balanced (2); grassland dominated (3)
Share of regional food	*Low (1)*; medium (2); high (3)
Diversity of plants and insect species	*Low (1)*; medium (2); high (3)
Knowledge transfer	*None (1)*; information signs (2); guided tours and courses (3)
Price (€/household and year in additional taxes)	*0*, 60, 120, 180, 240

[a]reference level in *italic*. n = 360 respondents

360 respondents from Eisenwurzen and surrounding areas with complete and valid responses were included in the econometric analysis. The model was specified, so that all the parameter estimates describe the difference in utility with respect to the business-as-usual scenario. The first preliminary results indicate overall positive preferences for all non-monetary attributes, in particular regarding an increase in the diversity of plant and insect species, and a negative preference for the price attribute, reflecting disutility for an increase in taxes for scenarios other than the reference scenario.

On average across all respondents, the highest MWTP is shown for a high diversity of plant and insect species, followed by information boards, nature trails, apps for knowledge transfer and awareness creation (see Table 2). This is followed by a medium diversity of plant and insect species, more interactive forms of knowledge transfer and awareness creation (guided tours, courses, collaboration on the alpine pasture), a high share of regional food, stay options with food and accommodation as well as with food only, a medium share of regional food and finally the landscape. If we look at the marginal willingness to pay by group, the differences in preferences described earlier now become even more visible.

Table 2: Results of the marginal willingness to pay calculation

Attribut: level	Average (100%)	Class 1 (9%)	Class 2 (38%)	Class 3 (53%)
Mountain hut function: food and drinks (2)	70	-5	**120***	**55***
Mountain hut function: accommodation (3)	78	-1	**203***	2
Scenery: grassland and forest balanced (2)	44	5	**102***	10
Scenery: grassland dominated (3)	40	-1	**90***	13
Share of regional food: medium (2)	65	-15	**129***	**42***
Share of regional food: high (3)	83	-9	**176***	**38***
Diversity of plants and insect species: medium (2)	92	21	**179***	**45***
Diversity of plants and insect species: high (3)	164	**34***	**368***	**40***
Knowledge transfer: information signs (2)	115	20	**247***	**38***
Knowledge transfer: guided tours and courses (3)	84	0	**208***	10

Source: own representation. Values marked with * are statistically significant at the 5% level. No statistical significance is shown for the average values across all respondents, as the values describe a mixture of the 3 groups

Conclusions and Outlook

The first results indicate a high value of biodiversity as well as of attributes concerning recreation, knowledge and regional food within society. These results are now discussed with regional and national stakeholders in order to outline how alternative land management paths for alpine pastures and mountain meadows in the Eisenwurzen region could look like. The recommendations to be derived from this process should increase both, the (agri)cultural value as well as the natural value of such alpine areas, support policy in the development of appropriate strategies and avoid future conflicts between agriculture, nature conversation and tourism in the Eisenwurzen region and beyond.

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Channel-forming discharges and their change rates as indicators of disequilibrium or equilibrium in fluvial morphology, and applications to the Danube in the National Park Donau-Auen

Gerhard Klasz, Severin Hohensinner, Christian Baumgartner, Dieter Gutknecht

Summary

In fluvial morphology, as in ecology, the concept of dynamic equilibrium (steady state) is quite fundamental. Rivers and their sediment budgets are usually supposed to be in that state or at least in a quasi-equilibrium. However, this is not always the case. In particular caused by human impacts, fluvial systems can tip over into a state of strong geomorphic disequilibrium. The Danube River east of Vienna, which is the ‘lifeline’ of the Donau-Auen National Park, is an example for that. This river reach has been strongly affected by river training and also by bedload deficit due to hydropower plants and other barrages in the upstream reaches of the river and its tributaries, thus the river bed is incising, with incision rates of about 1.5 cm/yr. In addition, the natural levee formation has been increased, as the side erosion, which is the opposing tendency to floodplain sedimentation, has been disabled by bank protection. As a result of these processes the river channel and its floodplain are vertically diverging, including strong ecological consequences because of reduced hydrological connectivity and reduced erosive processes in the floodplain ecosystems. In that context an important question arises: Which hydromorphological indicator is suitable to quantify the degree of disequilibrium in the sense of a surrogate parameter? In this contribution we present and discuss the application of the bankfull discharge Q_b and its change rates, and the relation between Q_b and the effective discharge Q_e.

Keywords

fluvial morphology; incision; in-channel aggradation; hydrological connectivity

Introduction

This contribution addresses three topics. Firstly, the attempt to quantify the influence of permanently varying discharges on the morphology of rivers by a single parameter, the so-called “channel-forming discharge” Q_{cf}, whereat two main concepts are applied: (a.) the bankfull discharge Q_b and (b.) the effective discharge Q_e, compare [1] and [2]. Secondly, the question if these parameters are sensitive to geomorphic disequilibrium. And finally, the application of these concepts to the Danube River east of Vienna, which is part of the National Park Donau-Auen (founded in 1996) and which has been strongly affected by human impacts, mainly by river engineering (in the second half of the nineteenth century) and then, in a second stage, by bedload deficit due to the construction of hydropower plants in the upstream (and in its tributaries) [3; 4; 5].

The bankfull discharge is the maximum discharge that the channel can convey without overflowing onto the floodplain [6]. Thus, Q_b is not defined by any hydrological statistics, but directly by the morphology of the channel-floodplain-system. There are strong correlations between Q_b and the bankfull geometry, the channel slope and other geomorphic features, which is summarized under the term “Downstream Hydraulic Geometry” [7, 8].

The effective discharge is based on a concept of Wolman and Miller, regarding the term of geomorphic work [9]. Increasing discharges are related to increasing sediment transport rates, that is to increasing geomorphic work. Otherwise, increasing discharges are increasingly infrequent, thus the product $\phi(Q) = g(Q) \cdot f(Q)$ of magnitude (the sediment transport rate) g(Q) and discharge frequency f(Q) must be considered. With other words, we must weight the sediment transport rates by the frequency of the discharges. On that basis, Q_e is that discharge, where the product function (the relative effectiveness) $\phi(Q)$ reaches a maximum [1]. There are two relevant transport modes [8]: (a.) bedload, which is supposed to be the dominant mechanism for channel-forming processes (especially in gravel-bed rivers), and (b.) suspended load, which is important for the floodplain formation and therefore for the floodplain-channel interaction. In our study reach, data on both transport modes are available, thus we have determined the effective discharge both for bedload (denoted by Q_{e1}), and for suspended load (Q_{e2}), and all input data are obtained by field measurements.

If both Q_b and Q_e are suitable surrogates of the channel-forming discharge, then both parameters should be equal or close to equal. And indeed, several studies empirically suggest that bankfull and effective discharges can be assumed to be equivalent $Q_e \approx Q_b$, at least in dynamically stable alluvial rivers [10–12], compare also [13]. However, most of these findings are from gravel- and cobble-bed rivers in the Rocky Mountain Region, that is, in a specific geomorphic region with a very special flow regime (snowmelt-dominated). In rivers with a flashy hydrology Q_b and Q_e seem to diverge more [2]. On the other side, the hypothesis $Q_e \approx Q_b$ is also supported by four very large rivers (Parana, Brahmaputra, Araguaia, Lower Mississippi River) [14]. A closer view on the data suggests, that the ratio Q_e/Q_b mostly is somewhat below unity. Latrubesse [14] mentions that the Q_e could be related to the “bar-full” stage, representing the elevation at the top of the channel bars, which is less that the bankfull stage.

Disequilibrium may be another reason for a divergence between Q_b and Q_e. Goodwin [1] pointed out, that $Q_e < Q_b$ can be assumed for incising channels, accompanied by the formation of new and deeper floodplain, and the former (“abandoned”) floodplain is becoming a terrace. Vice versa, $Q_e > Q_b$ should be related to aggrading channels, compare also [2]. Taking this into account, the ratio Q_e/Q_b (or the relative change rates of Q_b) may be applied as an indicator of the deviation from a dynamic equilibrium (steady state).

This article is an intermediate result of a broader research study, which will submitted soon to a peer reviewed journal [15].

Methods

Morphological changes have been quantified by changes of characteristic water levels (KWD) for different reference years [16-22]. For two gauging stations (Hainburg, river-km 1883.92; Fischamend, km 1908.5) annual mean water levels and annual low water levels are plotted against time (Figure 1); these data are provided by [23, 24] and by http://ehyd.gv.at. The fluctuations in this plot mirror the variations between years with low and high flows, but the moving averages correspond to the mean elevations of the river bed and their changes.

The current bankfull stage and the related Q_b were determined directly from field data, applying the floodplain/channel-geometry from [25] and characteristic water levels from KWD2010 [22]. Previous bankfull discharges are based on previous KWDs (KWD1956; KWD1970; KWD1976; KWD1985; KWD1996) [17–21]. The bankfull discharge of “1901” was obtained from a study of the K.K. Hydrographisches Zentral-Bureau [26], in which a bankfull situation (on 17. April 1901) has been documented and further analyzed.

The effective discharges have been determined by an analytical approach, which is described more detailed in [1]. The frequency distribution f(Q) of the mean daily discharges (at Hainburg; period: 1977/2018) is approximated by a log normal function, and the sediment transport curves for bedload $g_1(Q)$ (applying measurements, [27]) and suspended load $g_2(Q)$ (mean daily transport rates, measured at Hainburg-Strassenbrücke; period: 2008/2017; unpublished data by http://ehyd.gv.at) are fitted by power functions (of discharge Q):

$$g_1 = \alpha_1 Q^{\beta_1} \wedge g_2 = \alpha_2 Q^{\beta_2}$$

This approach, applied to the constraint (for a maximum) $d\phi/dQ = 0$ (at $Q=Q_e$) leads to

$$Q_e = exp[\mu_y + \sigma_y^2(\beta - 1)]$$

where μ_y and σ_y are the mean and the standard deviation, respectively, of the discharge's natural logarithm y=ln(Q), characterizing the hydrological regime, and β is the exponent of the sediment transport rating curve [1, 9], whereas $\beta=\beta_1$ (for bedload rates) leads to Q_{e1}, and $\beta=\beta_2$ (suspended load rates) to Q_{e2} [15]. This equation can also be applied for theoretical considerations.

Results / Discussion

Starting from the 1930s, the mean water levels (obtained by characteristic water levels: KWD) at all gauging stations were declining. Averaged over the last more than seven decades (1935/2010) and the reach (km 1920 to 1880) we determined an incision rate of ~12 mm/yr. However, in the upper and middle parts of the reach and the period after 1985 the rates were higher, ~20 mm/yr [15]. Starting with the first observed water stages (at the gauging station Hainburg, data since 1846), and comparing the moving averages of the annual mean water and the annual lower water levels, the picture is more nuanced, see Figure 1: (a) prior to the channelization, the water levels seemed to be stable; (b) between ~1870 and 1890, that is during and shortly after the great channelization programme upstream (at Vienna) and during the channelization works in the study reach, the water levels were strongly increasing (aggradation by ~1.0 m); (c) over the next decades (~1890/1940) there was a temporary equilibrium, followed by (d) a phase of degradation, with averaged incision rates of ~15 mm/yr, but sometimes the rates were higher (especially in the 1980s: ~40 mm/yr). The findings for the gauging station Fischamend (closer to Vienna) are similar, however, the transitions between the phases were somewhat earlier there [15].

The degradation in the last decades is mainly driven by bedload retention due to hydropower plants in the upstream section. A smaller share (~20%) might already has been caused by the increase of bedload transport capacity, which was related to the channelization [3, 28]. However, river engineering (in a reach) does not necessarily lead to incision. The temporary aggradation (in the late nineteenth century) might be related to the increase of bedload transport capacity in the upstream section (at Vienna), caused by the channelization in the 1870s, whereas the transport capacity in our study reach was increased but at a later stage (~20 years later) [3].

The current bankfull discharge (in 2010) was obtained to be ~4860 m^3/s (at Hainburg). In previous decades (related to KWDs) the values were lower, see Figure 2 and [15], and for the time shortly after the regulation (April 1901) a Q_b of ~3830 m^3/s has been reported [26].

Combining these findings, we can conclude: (1.) Q_b for a given river reach is not necessarily a constant (or: quasi-steady) parameter, it can be varying, and such variations can be understood as symptoms of disequilibrium; (2.) in our reach and in the last decades (since 1976) we obtained rate changes $\Delta Q_b/\Delta t$ of ~26 $(m^3/s)/yr$, that is, relative change rates of ~0.65% per year [15]; (3.) on the other side, in the first half of the twentieth century (and until the late 1960s) the Q_b was almost constant. This development is reverse to the changes of water levels (Figure 1), in-channel aggradation leads to a reduction of the bankfull area and thus a reduction of Q_b, and channel degradation to an increase of Q_b. Thus, it can also be expected, that the bankfull discharge of the pre-channelized Danube probably was close to the current level, and indeed, Hohensinner and Trautwein [29] have estimated a Q_b of ~4800 m^3/s for the situation in 1817 and the upper part of the study reach (at Vienna/Lobau).

If degradation cannot be stopped by an effective bedload management, compare [5], then the increase of Q_b will be ongoing. The overbank sedimentation will intensify that additionally. In a natural river, floodplain sedimentation usually is balanced in the very long term by channel migration (side erosion) [4, 25]. However, in our study reach this has been hindered by bank protection (riprap), leading to undamped floodplain sedimentation and natural levee formation [25]. Extrapolating the recent trend, Q_b will increase until 2050 to ~5950 m^3/s, which would reduce the frequency of floodplain inundation from a recurrence interval of currently ~1.3 yr to about 2.2 years in 2050 (these values are derived on the basis of annual maximum floods: AMF- statistics), compare [15]. The associated reduction of hydrological connectivity is a major problem for the National Park Donau-Auen. In the present situation, the elevations of low and mean water levels approximately correspond to the values before the great Danube regulation in the late nineteenth century (Figure 1), but with an inverse trend (declining now), and in a completely different landscape: the floodplain is aggrading, without side erosion as an opposing tendency, and especially pronounced in the vicinity of the channel (natural levee formation) [25], and the side arms also have been silting up. As a result of regulation structures and bank protection, erosion in the floodplain and along the side arms cannot occur, and these habitats cannot be adjusted to the declining water levels. Thus, the increase of bankfull discharge is related to an increasingly dry and infrequently flooded landscape, which finally will be endangered to lose its character as a riparian habitat.

The current effective discharges have been determined Q_{e1}=2100 m^3/s (bedload transport), and Q_{e2}=2480 m^3/s (for suspended load transport) [15]. The value for bedload transport Q_{e1} has already been found in [27]. In Figure 3, Q_{e1} is plotted versus Q_b and compared with data from literature [2, 10, 11, 12, 14]. Both Q_{e1} and Q_{e2} are in the same order of magnitude as Q_b, however the effective discharges are lower, the ratios are Q_{e1}/Q_b~0.43 and Q_{e2}/Q_b~0.51. On the one side, $Q_e<Q_b$ can be understood as a symptom of incision [1, 2], which is confirmed in our study reach. On the other side, and to the best of our knowledge there is no theoretical reason for an identity $Q_e=Q_b$ in a strict sense [15]. We assume, that the ratio Q_e/Q_b in steady-state usually ranges between about 0.5 and 1.0, however in case of disequilibrium this ratio is decreasing (incision) or increasing (aggradation).

Conclusions

Bankfull and effective discharges are regarded as surrogate parameters for the channel-forming discharges. In the context of river restoration projects and ecological-oriented river management, these parameters should receive more attention. In the past, in many rivers, Q_b has been increased, which was often desired in view of flood protection. However, from an ecological perspective, the frequency of floodplain inundation as a critical boundary condition, must be considered, and in most cases this frequency should not be reduced. The increase of Q_b may be attributed in case of smaller channels directly to regulation works (e.g., channels with trapezoid cross-sections with increased flow areas), and in larger rivers (and also in our study reach) more implicitly and over longer time periods to disruptions of the sediment budget and an associated channel incision. In the latter context, and also in case of aggrading channels, the (relative) change rates of Q_b and also altered ratios between Q_e and Q_b may be used as measures of disequilibrium.

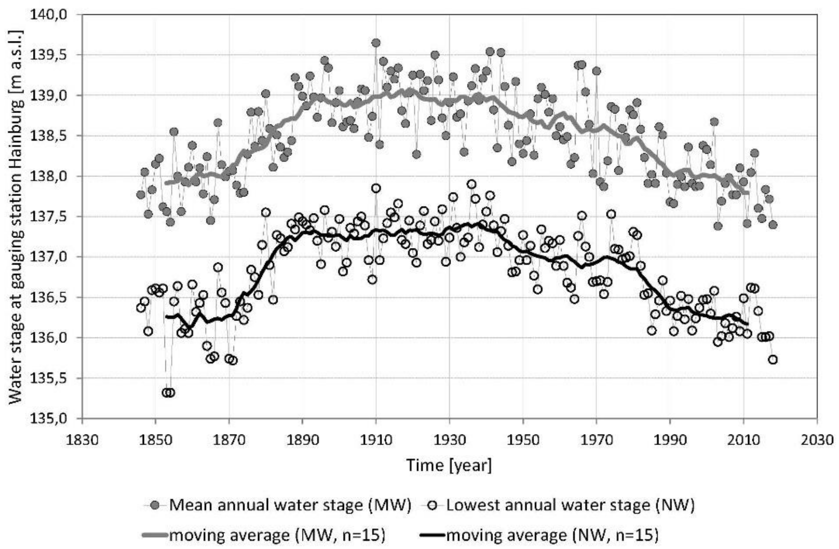

Figure 1: Annual mean water level and annual lowest water level and moving averages (n=15 yr) for gauging station Hainburg (river-km 1883.92; period: 1846-2018); modified from [4] and [15]

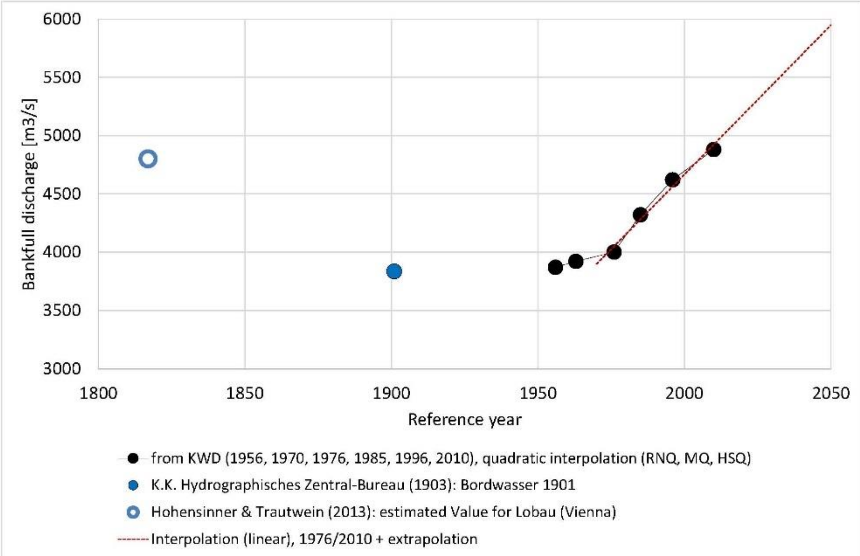

Figure 2: Bankfull discharges of the Danube east of Vienna, determined for the gauging station Hainburg, for different reference years (1817, 1901, 1956, 1970, 1976, 1985, 1995 and 2010); applying [26] and [29], and modified from [15]

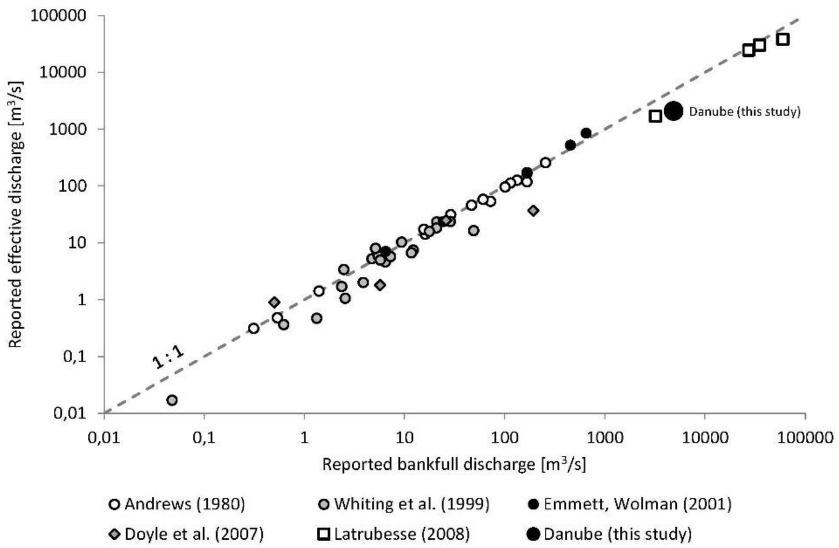

Figure 3: Effective discharge versus bankfull discharge for our study reach (Danube east of Vienna) and for comparison for other river reaches, data from literature [2, 10-12, 14], and modified from [15]

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Parasitism against invasions: native parasitic plants as a tool in nature conservation

Katerina Knotkova, Jakub Tesitel

Summary

Invasions of alien species are identified as one of the five most important causes of species diversity loss on Earth (IPBES, 2019). Also, expansions of competitively strong native species are one of the crucial causes of degradation and overall loss of valuable natural communities (Chytrý et al., 2019).

Both invasion and expansion have occurred due to human activity; unlike other human activities, such as pesticide use or land development, the uncontrolled spread of these problematic species can hardly be prohibited by law. They spread regardless of the boundaries of protected areas, making them all the more difficult to combat. Conventional approaches such as mechanical or chemical removal of undesired species are not always suitable for protected areas, as they can damage the overall diversity of communities, e.g. plant management often hurts insect diversity.

Therefore, more environmentally friendly approaches are constantly being sought, such as using biological control commonly used in agriculture that uses parasites or predators, including animals, fungi or bacteria. But plants can also offer the necessary properties, e.g. hemiparasitic plants take nutrients and water from their hosts, limiting their growth and reproduction. Thus, they may act as biocontrol agents suppressing pest species.

A good example is the usage of the hemiparasitic plant *Rhinanthus alectorolophus* to suppress the expansive grass *Calamagrostis epigejos* (Těšitel et al., 2017). This approach has already been well established in ecological restoration in the Czech Republic. However, the potential of hemiparasitic plants for suppression of invasive/expansive plants may be much greater than this single model example.

To explore this potential, we aim to find other promising interactions between hemiparasites and invasive/expansive plants to expand the application of these species on different hosts with different ecological requirements. To avoid the introduction of other alien species, we decided to work only with native hemiparasites.

In a multi-level approach using pot experiments and in situ field experiments, we aim to document the functional connectivity through haustoria to different invasive/expansive host species and further investigate the ability of hemiparasites to limit the growth and fitness of their hosts directly in invaded communities and assess their ability to restore these communities to a more species-diverse state.

So far, we have identified two very promising combinations. Root hemiparasite *Melampyrum arvense* suppresses invasive hosts *Symphyotrichum lanceolatum* and *Solidago gigantea*. Our field experiments show that invasive hosts' growth is significantly reduced in the first year after sowing the hemiparasite.

Keywords

Biological control, hemiparasite, hemiparasitic plants, *Melampyrum arvense*, invasive species, invasion, expansion, *Symphyotrichum lanceolatum, Solidago gigantea*

Introduction

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Both invasion and expansion have occurred due to human activity; unlike other human activities, such as pesticide use or land development, the uncontrolled spread of these problematic species can hardly be prohibited by law. They spread regardless of the boundaries of protected areas, making them all the more difficult to combat. Conventional approaches such as mechanical or chemical removal of undesired species are not always suitable for protected areas, as they can damage the overall diversity of communities, e.g. plant management often hurts insect diversity.

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To explore this potential, we aim to find other promising interactions between hemiparasites and invasive/expansive plants to expand the application of these species on different hosts with different ecological requirements.

Methods

In situ experiments take place in *South Moravia*, Czech Republic, including *National Park Podyjí* (*Nationalpark Thayatal*). From previous pilot experiments, invasive *Solidago gigantea* and *Symphyotrichum lanceolatum* were selected as host plants and hemiparasitic *Melampyrum arvense* was selected as biocontrol. Before-after-control-impact (BACI) design was chosen. Experimental plots (1,5x1,5 m each) mown control, unmown control and mown plot with host and hemiparasite were arranged in blocks. In total, 22 and 18 blocs on 4 and 3 sites were established for *Sol. gigantea* and *Sym. lanceolatum* respectively. A phytocenological survey of the plots is carried out in mid-June, recording species composition and cover according to the Braun-Blanquet scale, host height and percentage cover of host and hemiparasite.

The experiment started in 2020 and is expected to continue into 2023.

Results

Preliminary results show that a combination of mowing and usage of hemiparasitic *Melampyrum arvense* shows the best results in suppressing both *Solidago gigantea* and *Symphyotrichum lanceolatum*. Although mowing alone can significantly reduce the height and coverage of the host in the first year, the effect does not increase in the second year and is significantly smaller compared to the treatment with hemiparasites.

As for *Solidago gigantea*, a decrease in coverage of 60 % on average was recorded in the first year. In the second year, the decline in coverage was more than 90% compared to the baseline. The Heigh of the host was also affected, but more importantly, the host plant didn't flower.

In the case of the invasive *Symphyotrichum lanceolatum*, there was also a significant decrease in cover due to mowing and parasitisation. The effect, however, is not as pronounced as in the case of *Solidago gigantea*, and there is more variability in individual sites. Nevertheless, the cover of the invasive plant declined by an average of 75% over the two seasons. Also, in this case, the parasitised plants do not flower.

While the suppressive effect of the semi-parasite is obvious, its impact on other plant species and biodiversity on the site is not yet clear, nor are the dynamics of species returning to newly created gaps, which will certainly vary depending on seed availability and seed bank.

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Long term conservation strategies for the endangered plant Artemisia laciniata

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Abstract

The aim of the current project is to establish a sustainable wild population of Artemisia laciniata (Asteraceae) in the National Park Lake Neusiedl (Austria). At the beginning of the project in 2015, only 11 A. laciniataplants were known. The population in the slightly saline meadows is the only extant population in Europe. The species is mainly distributed in south Siberia and Central Asia.

Early on, the mowing regime was identified as one of the key factors to the survival of the few individuals. Regular mowing of the meadows is done in summer, when birds have finished nesting which is not compatible with A. laciniata, which sets seed at the end of October. A simple mowing regime was sought after. Since the population grows in a remote place, mowing experiments were carried out in garden beds at the University in Vienna.The results showed that cutting back the plants to 80 mm (height of the mowing bar) in mid-June resulted in 25 % fewer plants with inflorescences and 75 % fewer inflorescences compared to the control group. The later the mowing took place, the fewer plants produced inflorescences and the lower the number of inflorescences was.

In 2018, 13 new individuals were found near the known population. The vigorous plants were fairly productive and seeds became available for the reinforcement of the wild population. Ten new sites were established in the meadows. Young plantlets raised in the Botanical Garden of the University of Vienna were planted out in autumn. Survival in the field one year after planting was 88.8 %. Flowering could be observed already in the second year. Additionally, achenes were sown on old flat molehills or onto freshly dug sites in two different seasons. Winter sowing resulted in a germination rate of 23.5 %, while early spring sowing was not successful. Seedling survival was 6.5 % over the first summer. Freshly dug sites were found more suitable than molehills, probably because of less exposure to weather conditions.

The in-situ population from 11 individuals has now grown to 245 due to our planting activities. While now protocols are in place and the measures look promising, it is important to continue monitoring to evaluate the long-term success of the plantings.

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Conference Volume | **7th Symposium for Research in Protected Areas** 7 to 9 September 2022, Vienna | Pages 140-140

The Data pool initiative for the Bohemian Forest Ecosystem – Concept, Activities, and Impact of an International Forest Remote Sensing Cooperation

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Abstract

Remote sensing data acquired by satellites, planes, and unmanned aerial vehicles is a key asset for the research and monitoring of forest ecosystems. At the same time, a better understanding of these ecosystems is vital in the wake of global warming, especially with respect to topics like biodiversity, climate mitigation, and disaster prevention. The Bohemian Forest, comprising the adjacent Bavarian Forest (Germany) and Šumava (Czech Republic) National Parks covers the largest protected forest area in Central Europe and provides forest infrastructures, as well as excellent opportunities for ecological remote sensing for both science and practice.

To bundle the remote sensing activities in both national parks and provide new insights for forest management, the Data Pool Initiative for the Bohemian Forest Ecosystem (Latifi et al. 2021) was founded in 2015. Currently, it comprises 15 international research institutions, from the national park administrations to universities to space agencies. This talk highlights some examples of the remote sensing research carried out in the Bohemian Forest. This includes topics like the 3D-assessment of forest structure and leaf traits, the characterization of forest phenology as well as the mapping and assessment of bark beetle disturbance.

Besides, the concept and success of the data pool initiative will be highlighted: since the founding of the initiative in 2015, the scale of remote sensing activities in both national parks has considerably increased. At the same time, the yearly output of scientific publications distinctively increased and a high number of studies received high international attention. Furthermore, international cooperation was intensified and important impacts for research beyond the two national parks were set. Finally, not only the research itself profited from the cooperation, but important advances could be made with regards to the application of research results in practical management, including forest inventory or habitat mapping. In summary, the Data Pool Initiative for the Bohemian Forest Ecosystem has been a success that may serve as a model for the advancement of remote sensing activities in other national parks.

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From rapidly rising treeline to monitoring alpine biota in the Hohe Tauern National Park

Christian Körner

Summary

Across the globe, mountain biota are subdivided into a montane and an alpine (including a nival) belt, separated by the high elevation treeline. Starting with the theory of treeline formation and the causes of treeline sensitivity to climate change, I will illustrate the case of an exceptional expansion of stone pine, *Pinus cembra*, way above the famous 'Oberhauser Zirbenwald' in the Defreggen Valley of East-Tyrol in most recent years. The highest locations where stone pine reaches 2 m height are currently close to 2500 m above sea level, a high elevation record for the Austrian Alps. Easily measurable, the vigour of these pioneers is also exceptional by growing up to 25 cm in stem height per year, hence these individuals are less than 30 years old. The upslope advance of treeline will reduce alpine terrain. However, in high enough mountains such as the Hohe Tauern, these changes of high elevation land cover will not necessarily reduce alpine species richness, because of the microhabitat diversity above treeline. In order to understand these micro-scale processes in the alpine belt a long-term monitoring project had been launched in 2016 under the auspices of the Hohe Tauern National Park (HTNP). I will close by briefly summarizing the concept of this project as an introduction to the three following presentations on research in the HTNP. The last two presentations of this session will further underpin the general need and power for standardized long-term monitoring in natural high elevation ecosystem.

Keywords

Alpine ecology, Climatic warming, High elevation, Long-Term monitoring, Mountains, Pinus cembra, Treeline,

Introduction

The high elevation climatic treeline represents the upper edge of the fundamental niche of the life form tree (Körner 2012, 2020, 2021a). Only few tree species have the capability to grow at the climatic tree limit, and all other species have species-specific elevational limits below treeline. Globally, the climatic treeline follows a common isotherm of seasonal mean temperature of ca. 6 °C. Trees may be absent from treeline for a number of non-mountain specific reasons such as logging, pastoralism, fire, shortage of water or lack of soil, causing the realized distribution of trees often differing from where trees could, biologically, grow. This difference between fundamental niche edges (the potential treeline position) and the realized tree distribution fueled a century old confusion and debate, which can be resolved by applying the isotherm concept, as first coined by von Humboldt (Körner and Spehn 2019).

Given the fact that temperature is the only overarching, and mountain specific, determinant of upper tree limits across the globe, the current climatic warming will (an in part does already) facilitate a global upslope migration of trees and forests. Yet, it will take time for treeline to come into a new equilibrium with temperature, and perhaps reach similar elevations, or go beyond of where it had been during the warmest period of the Holocene (Körner 2012). The reason why treeline, in contrast to alpine vegetation, will track climatic warming by upslope migration, is the tight coupling of tree crown temperature with air temperature. This also explains why a treeline is formed and why the alpine belt is treeless, by definition. The smaller stature alpine flora above treeline makes a living by escaping cold air temperature through reduced heat convection and canopy warming, thus 'engineering' its microenvironment by short stature and dense ground cover that traps solar heat. This also causes a strong dependency of the alpine vegetation in micro-topography and associated patterns of snow distribution. In this presentation I will evidence ongoing upslope tree migration in the Hohe Tauern National Park and introduce a long-term monitoring programme in the core of alpine belt, both aiming at elucidating impacts of environmental change in the Alps.

Methods

The report on trends in treeline dynamics rests on site observations, photo-documentation and morphometric measurements along elevation gradients in the treeline ecotone in the Defreggen Valley of East-Tyrol, adjacent to the 'Oberhauser Zirbenwald', a rather impressive, almost monospecific stand of *Pinus cembra* (stone pine). For the methods employed in the alpine long-term monitoring project, I refer to a most recent synthesis paper (Körner et al. 2022). In essence that program applies the permanent plot concept and standardized protocols to assess plant responses, soil mesofauna and soil microbes along terrestrial snow melt gradients, as well as biota in adjacent lakes and streams in micro-catchments (see the separate presentations from that project).

Results

The obvious upper limit of the 'Oberhauser Zirbenwald' is a result of geomorphology and land use history, and despite its relatively high position at roughly 2250 m, does not represent the climatic treeline. Due to the U-shaped glacial morphology of the valley, the closed forest can reach up to the valley's shoulder without avalanche impact, hence, the exceptionally undisturbed forest edge right at the shoulder. The less steep terrain above, not only collects all the avalanches, it also was under centuries of pastoralism, with earliest records from the nearby Jagdhausalm dating back to the year 1212 (Kammerlander 1985).

A closer inspection of the ridges above that grassland plateau, reveals a substantial number of trees, most likely older than 150 years, at elevations up to 2360 m (Fig. 1). These old and tall individuals are confined to rocky outcrops away from avalanche tracks. Most of these individuals had obviously been there during the late 'little ice age' period, hence do represent the potential tree limit before the onset of the 20th century's and ongoing warming trend.

Currently, there is massif infilling with younger recruits due to both, reduced grazing pressure and, most likely, climatic warming. Recruits also reach far beyond the 'old' growth limit and reach highest positions close to 2500 m, with individuals of >2m in height. These uppermost trees grow half as fast as trees at around 2300 m, but annual leading shoot increments of up to 20 cm are not uncommon (Fig. 2). With a mean annual height growth of 12.5 cm (Fig. 3), the 'shooting' stems of these trees are not older than 30 years, with signs of a longer presence as krummholz, that is, small stature shrubby morphologies, until the warmer climate permitted vertical advance.

These trees presumably represent the highest growing trees in the National Park, and of Austria, with similarly high tree occurrences in the most western part of the Eastern Alps, the lower Engadin area near Scuol (2526 m of elevation on Mot Falain) in the vicinity of the famous Tamangur forest (Rikli 1909) that resembles all features of the Oberhauser Zirbenwald, including the geomorphology and pastoralism history.

Since this presentation also introduces and leads over to the next higher elevation step of monitoring in the Hohe Tauern National Park, in the alpine belt, this is not the place to anticipate results of the follow-up presentations lead by R. Kaiser, L Füreder and S Wickham. A first summary of 5 years of monitoring results can be found in Körner et al. (2022). These data are still dominated by strong year to year variation, and thus do not yet reveal any trustworthy trends, but they provide a well substantiated reference data set for the Tyrolian,

Fig. 1 One of the many c. 6-10 m tall and >150 year old trees at 2350-2360 m elevation, representing the pre-global warming treeline position in the upper Defreggen Valley.

Carinthian and Salzburg parts of the National Park, plus terrestrial sites in S-Tyrol (Match Valley) and the Furkapass in the central Alps of Switzerland.

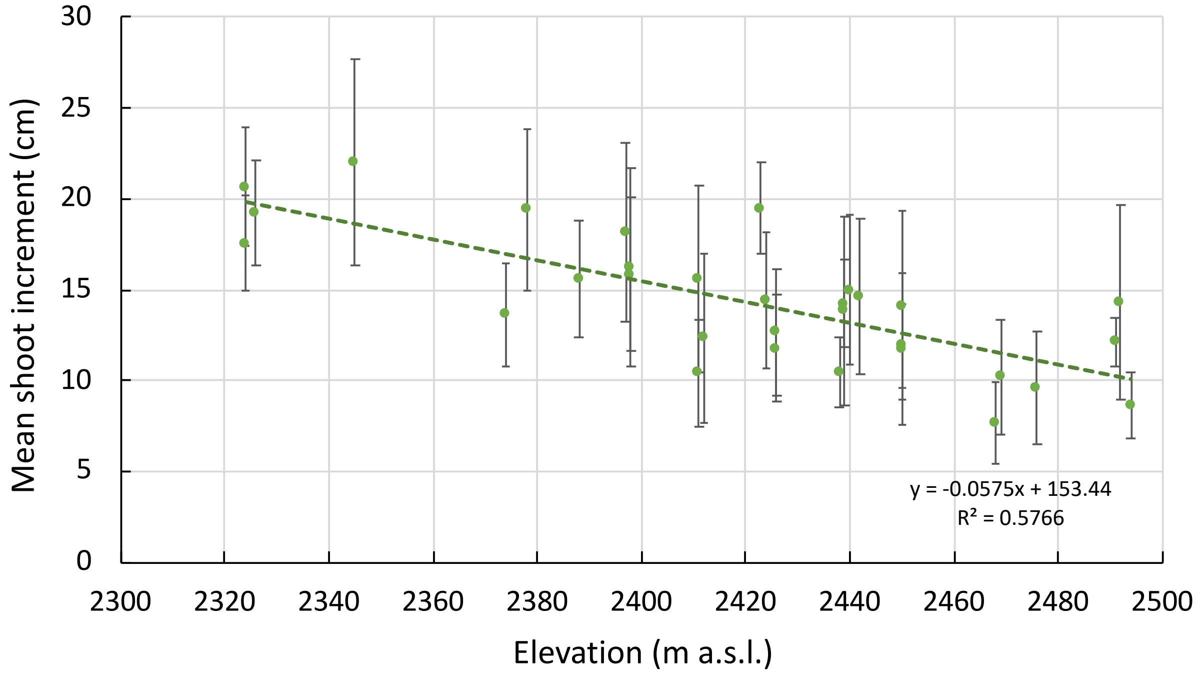

Fig. 2 Annual shoot length increment across elevations in Pinus cembra. Each point represents the mean (and s.d.) for the last 10 years (2013-2022).

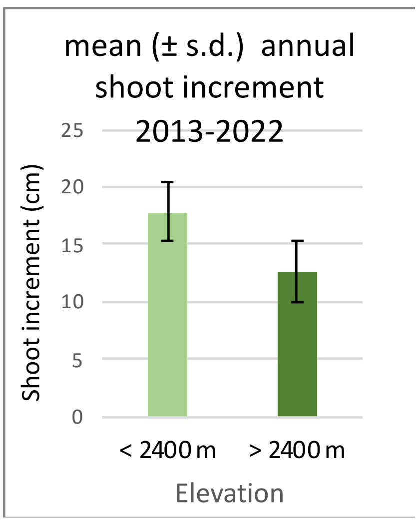

Fig. 3 The sofar highest elevation tree known for Austria and the Hohe Tauern National Park at 2494 m elevation in the Defreggen Valley of East Tyrol (210 cm tall). Trees of this size are abundant above 2460 m in that region. Above 2400 m, they grow by c.12.5 cm a^{-1} in height, compared to 17.5 cm a^{-1} in trees between 2300 and 2400 m a.s.l.

Discussion

The observations and data presented, evidence recent and rapid advance of treeline in the continental climate of the eastern Austrian Alps. The data for the uppermost Defreggen Valley match observations (not shown) from the Trojer valley in the same region, where *Larix decidua* reaches almost as high as *Pinus cembra*. In other words, both these taxa reached record elevations during the last 2-3 decades. Given the c. 2 K warming since the mid 19th century in the Alps (Körner 2021b), the observed elevation records at 150 m above the 'old' treeline in that region (around 2350 m a.s.l.), a thermal-equilibrium treeline elevation would currently be at a 300 m higher elevation (that is 2650 m). Thus, it does not come at a surprise that the trees at the observed current upper limit grow so fast, with annual length increments exeeding 20 cm not uncommon. Temperatures currently recorded by data loggers installed at these sites will soon reveal the actual position of the treeline isotherm in that region.

This part of the Eastern Alps had long been known for its dry, warm summers (continentality, Gams 1932) and high treelines (Kerner 1864; Rikli 1909; Klebelsberg 1961). According to Kammerlander's (1985) analysis, 1.3 m size individuals at c. 2200 m grew less then 5 cm a^{-1} year in height before 1985, mostly around 3-4 cm (averaged for the entire tree size), and he described everything above 2290 m as krummholz (hence, he must have missed the tall old trees at 2350 m above the pasture plateau).

Given the vigorous tree growth 150 m above the 'old' tree limit, a rapid establishment of a new, though fragmented, forest can be anticipated near 2500 m elevation, to the extent, avalanche dynamics, soil availability and winter storms permit in this steep, exposed terrain. Early signs of accelerated tree growth near treeline had already been evidenced by Paulsen and Körner (2000). All former pasture land between 2250-2400 m could carry >8 m stone pine forests already under current climatic conditions. A similar worldwide tracking of isotherm position by treeline, would consume ten times as much alpine land area compared to the new land released by global glacier melting (Körner and Hiltbrunner 2021).

Acknowledgements

This work is supported by the Austrian Hohe Tauern National Park. I thank M. Kurzthaler for suggesting to explore the forests in the Defreggen Valley, for help in the field and with GIS applications. I am grateful to Susanna Riedl for help with data analysis and artwork.

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Documentation of natural processes in the Gesäuse National Park

Tobias Köstl, Vanessa Berger, Hanns Kirchmeir,

Corinna Hecke, Michael Jungmeier

Abstract

From a scientific point of view, wilderness can be described as the sum of unaffected natural processes. Natural processes are therefore subsystems of wilderness. Like species, habitats and ecosystems, natural processes are distributed differently, have specific characteristics, and are endangered by different human interventions. An inventory and a well-founded knowledge basis of the characteristic natural processes of an area are therefore essential cornerstones of wilderness protection. Ecosystem and natural process research are designated as research priorities and as central components of the science accompanying the national park (Maringer & Kreiner 2012). The present series of projects presents a basic survey based on vegetation studies and a nature conservation concept for the documentation of natural processes and is also intended to serve as a template for further inventorying of natural processes in protected areas.

In a pilot study in 2014, a methodology for recording and documenting natural processes was developed using the system factor "avalanche". The pilot study was also published in the reports of the Natural Science Association for Styria (Jungmeier et al., 2016). As a result, the system factor "water" and its influence on the surrounding vegetation were examined (area of interest: Johnsbach, Enns and debris flow Kühgraben) in 2015 and 2016. Using standardized vegetation maps along transects, which are intended to cover a cross-section of the disturbance-affected habitats, an attempt was made to map the intensity and frequency of the disturbance events and the progressing succession in response. The vegetation studies were carried out based on high-resolution aerial photos that were created using UAS (UAS, i.e., Unmanned Aircraft System, commonly "drone"). With the help of high-resolution aerial photographs, vegetation patterns could be delineated in particularly detail and further processed in a GIS.

The documentation of spatial-temporal patterns and the connection between biodiversity and process dynamics was chosen as the methodological approach. The methodological approach focused on the analysis and characterization of habitats based on ecological indicator value analyses. The data was then processed and visualized graphically as dynamograms and structural diagrams of the processes. The UAS recordings helped to depict the process dynamics on a larger scale and still in detail. Additionally, TLS (Terrestrial Laser Scanning) and ALS (Airborne Laser Scanning) technologies were used to create a digital twin for the documentation of these processes.

Keywords

biodiversity, natural processes, process dynamics, vegetation monitoring, remote sensing

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How Remote Sensing can support the Monitoring of Forest Biodiversity Parameters in Natura 2000 Sites

Tatjana Koukal, Alexandra Freudenschuß, Janine Oettel, Franziska Krauße

Abstract

Biodiversity has become a key issue in ecosystem conservation including forest environments. The aim of this study is the remote-sensing-based identification of forest patches with old trees, a significant amount of deadwood and a tree species composition that corresponds to the site conditions. Such patches are considered to be rich in species diversity across various taxonomic groups of plants and animals. In this project we call patches that meet these criteria and have a minimum size of 1 ha ‘biodiversity hotspots’. The approach developed within the project is applied to all Natura 2000 sites in Austria, thus including almost the whole area declared as national parks. The project is funded by the EU within the Austrian Rural Development Programme for the 2014 to 2020 period (LE 14-20) and will run till end of 2022.

The methodology is based on remote sensing data from different sensors. Three-dimensional spectral information derived from aerial photos are used to assess forest canopy structure as well as to detect dead standing trees. Sentinel-2 satellite imagery is used to derive information on the tree species composition. Field data collected on sites that are part of the Austrian Natural Forest Reserve Programme serve as reference data. In total, twelve natural forest reserves representing different forest types were selected that show hotspot-like conditions at least in some parts of the area. On these sites, a set of parameters related to forest structure, deadwood and tree species was collected at sample plots. Based on these parameters, each plot was labeled if it is a hotspot or not. This information is used to create a rule set applicable to parameters derived by remote sensing, such as tree height, stand density and other canopy characteristics. In addition, ancillary information such as elevation above sea level and the forest ecoregions of Austria are taken into account. Finally, the rule set is applied to the forest area within the Natura 2000 sites. The identified hotspots are checked randomly in the field and based on data sets provided by the ÖBf AG.

As a result, the size of the total area that meets the hotspot criteria is specified for each Natura 2000 site. The study contributes to a better knowledge about ecologically valuable forest resources in Austria and can methodically support efforts aiming at forest biodiversity monitoring by means of remote sensing.

Keywords

remote sensing, forest biodiversity, old natural forest, deadwood, Natura 2000

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Saline Habitats: unique, harsh, endangered

Rudolf Krachler

Abstract

Chemical basics of salt pans

While raised bogs benefit from abundant precipitation, saline soil systems require little precipitation but a highly permeable pore water system with the groundwater table close to the soil surface.

Permanent leaching keeps salinity and nutrient level of raised bogs poor while saline habitats by evaporation accumulate nutrients besides electrolytes.

Sodium concentrations in Seewinkel porewaters are exceptionally high and exceed by far sodium concentrations in other quaternary pore water systems (Krachler et al., 2018).

One more key factor for the formation of alkaline soda soils and pans is the relation between calcium and the hydrogencarbonate/carbonate system, as calcium precipitates together with carbonate yielding calcite, an important component of the turbidity and the sediment aquitard in soda lakes.

Hence, the most important requirement to generate sodic waters is an excess of the hydrogencarbonate/carbonate system with respect to calcium within the surface near porewater body as is given in all the Seewinkel porewaters.

The lower the concentration of calcium in the exfiltrating groundwater and the longer the water balance of the pan is left undisturbed, the higher accumulates the alkalinity of the water column.

Calcium, magnesium, and silicate are not stable in the water column and sooner or later are found together with parts of the carbonate system in the turbidity and in the sediment, as already has been mentioned.

In June, once the water column due to evaporation has retired into the pore system of the overlying sediment layer, the remaining solution is oversaturated with respect to silicate and hence smectites and other clay minerals as dispersed particles will precipitate. Even at pH as low as 4 clay minerals tend to exhibit negative electric surface charges. This so-called structural zeta-potential makes clay minerals an extraordinary stable component of the turbidity. They are dispersed under almost all conditions.

Sodium, potassium, chloride, and sulphate are soluble under all conditions and accumulate in the water column.

On the other hand, carbonates such as calcite and all types of protodolomite require a pH close to 9 and higher to achieve a negative surface charge. The higher the pH the more hydroxide ions adhere to the calcite surface and thus raise the surface charge of calcite particles, yielding a turbidity stable even under a shield of ice (Stojanovic et al., 2009).

In Seewinkel, the long-term average precipitation is about 600 mm, whereas the long-term average evaporation is as high as 900 mm (Mahringer, 1970).

As evaporation exceeds precipitation by 300 mm it‘s quite clear that without any additional input of water every pan has to dry out during hot season.

As a consequence of the lack of any surface inflow, Seewinkel perennial pans depend on an additional contribution of groundwater to the water balance in a long-term average of approximately 300 mm. This is exactly what we see in 1986 in the hydrography of Lange Lacke.

1986 - a perfect year for a perennial salt pan

From January through June, in addition to precipitation, at least 300 mm of groundwater exfiltrated into the basin of Lange Lacke, thus completely compensating for the water losses through evaporation.

During the months of January and February, in 1986 the groundwater level exceeded the water column of the Lange Lacke by 0.75 m. These are best conditions for the exfiltration of groundwater.

What we may learn from Lange Lacke in year 1986:

1. Exfiltration of groundwater into the Lange Lacke basin requires a groundwater table of at least 0.4 m above water table of Lange Lacke. This of course is a value specific solely to Lange Lacke.
2. 0.3 m of groundwater input into water balance of Lange Lacke together with precipitation compensates for the evaporation and keeps the water column to some degree constant throughout the year.

In spring 1989, the excess of the groundwater table of 0.4 m above Lange Lacke water table was too small to carry on groundwater exfiltration considerably.

And as we all know, as a result, Lange Lacke completely dried out in 1990.

Components of the salt balance of Seewinkel salt pans

The only salt supply is the exfiltration of groundwater providing salts to the sediment body and to the water column during groundwater maximum in springtime.

In contrast, the losses of salts are manifold:

- Loss of salts by infiltration of saline pan water at very high water levels during spring time.
- Loss of salts by outflow of saline pan water through ditches.
- Loss of salts by wind driven export (deflation) of salt dust during the dry season.

Groundwater dynamics required for the ecological stability of Seewinkel salt pans

The tolerated minimum and optimal maximum of groundwater orientate themselves on the surface of the salt sediment aquitard.

Two significant groundwater stages have to be mentioned:

During dry season, groundwater table has to reach the surface of the sediment body in order to keep it water-logged and thus prevent the salts to be leached.

Besides, a water-logged sediment body is the prerequisite for the efflorescence of salts.

In spring, every few years at least, the maximum groundwater level should exceed the top of the sediment body to ensure some groundwater inflow and to compensate for unavoidable salt losses.

The pH value of Seewinkel alkaline saline waters is effectively kept constant between 9.0 and 9.5 by the homogeneous hydrogencarbonate/carbonate buffer system. Within the water column, microbial oxidative decomposition of organic matter releases CO_2 and thus shifts the buffer equilibrium in favour of hydrogencarbonate while the CO_2-consuming production processes increase the carbonate concentration with the mandatory consequence of calcite and protodolomite precipitation.

However, in the absence of dissolved calcium, photosynthesis accumulates carbonate with respect to hydrogencarbonate, thus pushing pH up even to 12, frequently observed in late May, when plenty of sunlight and rising temperatures promote growth of algae. With the beginning of June, degradation processes regain more importance and thus, within a few days lower the pH back to values below 10.0 again.

The way sediment generates alkalinity

During the dry season, the water-logged pore system of the saline sediment body is depleted of oxygen, so sulphate is relied upon as an oxidant for the organics while sulphate itself is reduced to sulfide $S^{2\ominus}$ (Krachler et al., 2009).

Sulfide acts as a strong base and thus with water and CO_2 yields hydrogencarbonate and sulfides from iron or manganese. Iron and manganese sulfides provide the characteristic black color to the reducing sediment. This mechanism only works under the condition of a water-logged and thus oxygene depleted reducing sediment pore system.

There is no indication to suggest a shift in the proportion of a single chemical constituent in the water column while the total salinity rises by evaporation or decreases by dilution.

Since photosynthesis removes carbonate from the water column as calcite and thus decreases the proportion of alkalinity on the total of anions, therefore, a constant or even increasing proportion of alkalinity in the total amount of anions in the water column is clear evidence for the generation of hydrogencarbonate/carbonate in the sediment by microbial sulphate reduction.

Focusing on the development during the last seven decades, the significance of the sedimentary sulphate reduction to the proportion of alkalinity on the total salinity may easily be shown at numerous Seewinkel saline waters:

- The never by ditches drained pans like Kühbrunnlacke, Ochsenbrunnlacke, Birnbaumlacke, and Sechsmahdlacke have preserved or even encreased their high relative alkalinity arisen by sulphate reduction within the sediment body. Thus, within decades and even centuries, these pans have developed their own and completely individual salt composition and have retained it until present.
- On the other hand, starting in the early fifties, the vast majority of Seewinkel pans like Darscho, Lange Lacke, Wörthenlacken, and St. Andräer Zicksee rigorously have been drained by ditches. The repeated export of the water column has removed the distinct salt mix of the pans. Since then, exfiltrating groundwater replaces the original water column and hence, the salt mix we find nowadays is very close to groundwater chemistry characterized by lower proportions of alkalinity. Even under the optimal conditions of an undisturbed water balance, it will take again decades for the artificially drained salt pans to redevelop an individual and distinct salt composition independent of groundwater.

Reestablishing lost salt pans

Under some special cicumstances degraded salt pans may be reestablished (Krachler et al., 2012).

As a conditio sine qua non, the groundwater dynamics have to be raised to an extent, that the sediment, even in the dry and hot season, still is left water-logged. During early springtime, the table of the groundwater should be high enough to allow exfiltration to a certain amount into the salt pan.

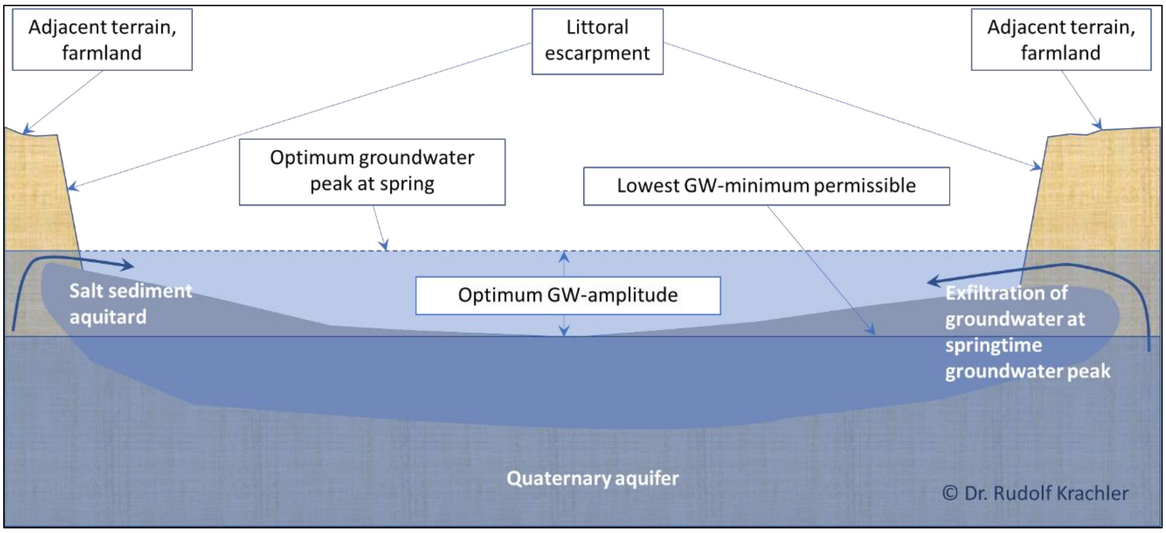

Fig. 1: General cross section of salt pans in central Seewinkel

There is no danger of flooding adjacent farmland. Fig. 1 shows that raising the groundwater tabel to ensure the water and salt dynamics of the pans has no impact on the adjacent farmland, as even during springtime, at the groundwater maximum, there is left a buffer zone of at least 0.5 to 1.0 m on average in between.

But raising the groundwater table is not easy, because economical and political constraints are getting stronger.
The original villages were built on elevations that rose a few metres above the surrounding landscape and therefore have been save against higher groundwater peaks. Since the middle of the 20th century, the communities have been growing rapidly and spreading into the lower-lying adjacent countryside. Examples are the estates "National Park Siedlung" and "Krotzen" in Apetlon and the estates "Pfarrwiese", "Kirchsee" and "Schrändlsee" in Illmitz.
Therefore, the groundwater level in the surrounding countryside of the villages has to be kept low under all circumstances.

Hence, only a selection of the more remote salt pans like Birnbaumlacke, Ochsenbrunnlacke, Kleine Neubruchlacke, Große Halbjochlacke, Fuchslochlacke, Stundlacke, Auerlacke, Kühbrunnlacke, Sechsmahdlacke, Lange Lacke, Wörthenlacken, Illmitzer Haidlacke, Hölllacken, Stinkerseen, Silberseen, Albersee, Herrnsee, Tegeluferlacke, Arbesthaulacke are candidates to be restored.

After this, the fact has to be faced that degraded salt pans have lost their surface salts to a high extent. So first, after raising groundwater table, very rapidly, plant communities including reed and bullrush will establish an inland marsh and thus, prevent effectively accumulation of surface salts. Hence, besides the raising of the groundwater table, care has to be taken on an effective method to prevent establishing of a freshwater marsh. Grazing by cattle or pigs has prooved effective and economical (Kirschner et al., 2007).

Of course, adding salts, soda, sodium chloride and sodium sulphate will be helpful and accelerate the restoration of a saline habitat. But this is very expensive and never makes sense without previously restoring the prerequisite groundwater dynamics.

About climate change in Seewinkel

Of course, climate change is one more player in the pot of factors of the Seewinkel groundwater crisis.

As a fact, in Seewinkel, climate warming started around 1990 and, up to present, ranges by 2°C.

Even if we assume constant precipitation activity, as the available data suggest, without any doubt, climate warming does increase the need for irrigation of crops, resulting in additional consumption of groundwater.

Climate warming thus is one more argument, not immediately to drain precipitation whenever it falls but to keep the water in the region and to manage it economically.

The traditional and dense network of ditches in Seewinkel without any control is no longer timely. It takes too short as it does not take into account future periods of scarce precipitation, nor future need for irrigation.

Keywords

Saline habitats, Neusiedlersee Seewinkel National Park, climate warming, restoration, salinity, alkalinity, turbidity, groundwater, salt balance

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Barcoding of rare fungal species within the framework of ABOL in the National Park Kalkalpen

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Summary

Within the framework of the Austrian barcoding initiative ABOL (sub-project "Establishment of university DNA barcoding pipelines for ABOL" of the „Higher Education Structural Funds“) barcodes of critical and rare species of special habitats, such as meagre pastures in the Kalkalpen were found and about 25 genetically recorded, e.g. *Clavulinopsis helvola, Cuphophyllus flavipes, Dermoloma cuneifolium* var. *punctipes, Entoloma bloxamii, Hygrocybe ingrata*. Equally important are moist meadows with seepage springs, where Bovista paludosa was found. For the preservation of a large fungal diversity, unmanaged primary or near natural forests are also extremely important, where so-called proximity-to-nature indicators occur, such as *Cystostereum murrayi*. Several species could not be assigned to any existing barcodes until now indicating cryptic genetic diversity that could be sustainably preserved in the national parks.

Keywords

macromycetes, mapping, Sanger sequencing, nature protection

Introduction

Macromycetes are fungi with fruiting bodies visible without enlarger. This simply is a practical term and comprises polyphyletic groups. In terms of biodiversity, there are more than 8000 macromycete species in Austria. They are extremely important for ecosystem services, such as ectomycorrhizae in woods. Others live in close association with bryophytes in grasslands, or degrade wood and litter, i.e. the primary plant biomass. Fruiting bodies are a microcosm and harbour many species of collembola, staphylinida, Mycetophilidae, Platypezidae and others. Marginally, they proved food for deer, rodents and slugs.

Within the framework of the Austrian barcoding initiative ABOL, it was also possible to generate barcodes of fungi. Besides barcoding of common species, the sub-project "Establishment of university DNA barcoding pipelines for ABOL" of the „Higher Education Structural Funds“ was also dedicated to critical and rare species of special habitats. The meagre pastures in the Kalkalpen NP are of particular importance as a refuge for such species.

Methods

Fresh fruiting bodies of macromycetes were collected in the field. Photographs were taken from all specimens and notes on macroscopical character conditions made wherever necessary. DNA extraction of the dried herbarium material and amplification of the ITS followed Klofac & Greilhuber (2020). The newly generated sequences are already or will be deposited in GenBank (www.ncbi.nlm.nih.gov) (Tab. 1). Identification check was done by blasting with GenBank or BOLD (www.boldsystems.org) and critical evaluation of the resulting species hypothesis.

Results

Altogether 542 fungal species are known up to now in the national park Kalkalpen (state of knowledge as at July 2022) form forest and grassland habitats. In the course of the project, many indicator species for meagre pastures, moist meadows with springs and small water bodies, and near-natural forests were found.

Fig. 1. Entoloma bloxamii, a critically endangered species from meagre pastures in the National Park Kalkalpen.

Table 1. Species list of the barcoded specimens, Red List (Dämon & Krisai-Greilhuber 2017) assignment and record numbers known in Austria so far

Taxon	Red List	Reord no.
Bovista paludosa Lév.	EN	24
Cantharellopsis albida (Fr.) Kuyper	VU	42
Clavulinopsis corniculata (Schaeff.) Corner	VU	47
Clavulinopsis fusiformis (Sowerby) Corner	EN	70
Clavulinopsis helvola (Pers.) Corner	VU	36
Clavulinopsis sp.		
Cuphophyllus flavipes (Britzelm.) Bon	EN	27
Cuphophyllus virgineus var. fuscescens	L	68
Cystostereum murrayi (Berk. & M. A. Curtis) Pouzar	EN	71
Dermoloma cuneifolium var. punctipes Arnolds	VU	8
Entoloma bloxamii (Berk. & Broome) Sacc.	CR	27
Geastrum minimum Schwein.	VU	75
Geoglossum sp.		
Hygrocybe acutoconica f. subglobispora (P. D. Orton) Boertm.	L	12
Hygrocybe chlorophana (Fr.) Wünsche	L	269
Hygrocybe citrinovirens (J. E. Lange) Jul. Schäff.	NT	167
Hygrocybe ingrata J. P. Jensen & F. H. Møller	CR	29
Mycena galericulata (Scop.) Gray	L	>2000
Neoboletus praestigiator (R. Schulz) Svetash., Gelardi, Simonini & Vizzini	L	>1800
Neohygrocybe nitrata (Pers.) Kovalenko	CR	23
Neohygrocybe ovina (Bull.) Herink	EN	66
Porpoloma pes-caprae (Fr.) Singer	VU	80
Porpolomopsis calyptriformis (Berk.) Bresinsky	EN	80
Pseudotricholoma metapodium (Fr.) Sánchez-García & Matheny	EN	27
Trichoglossum Boud.		
Tricholomopsis rutilans (Schaeff.) Singer agg.	L	>1700

Species number will raise with further ongoing research and about 25 specimens were genetically confirmed (Table 1), e.g. for meagre pastures these are e.g. *Clavulinopsis helvola*, *Cuphophyllus flavipes*, *Dermoloma cuneifolium* var. *punctipes*, *Entoloma bloxamii* (Fig. 1), *Hygrocybe ingrata*. Equally important are moist meadows with seepage springs, where very rare fen species such as *Bovista paludosa* can be found. For the preservation of a large fungal diversity, forests that have been put out of use are also extremely important, where so-called proximity-to-nature indicators occur, such as *Cystostereum murrayi*. One species each of the genera *Clavulinopsis*, *Geoglossum*, and *Trichoglossum* could not be assigned to any existing barcodes until now. These records will be subjected to further taxonomic investigations and indicate an existing cryptic genetic diversity that could be sustainably p reserved in the national parks.

Problems for survival of rare grassland fungi within the National Park Kalkalpen are fertilizer input from the environment, change in management, e.g. unfavourable mowing plans and trampling by tourist in dry grasslands. Outside of national parks besides fertilization fungi are endangered mainly by habitat destruction.

Problems for the survival of rare natural-forest species are changes induced by climate change and a high deer density. Outside of the National Park again habitat destruction and change in management (e.g. planting of non-native tree species,) threaten fungal well-being.

We thank Kesiban Özdemir for technical assistance with sequencing as part of ABOL, the Austrian Barcode of Life project, sub-project HRSFM, University of Vienna, supported by the Federal Ministry of Education, Science and Research.

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Macromycete diversity of mapping areas in the Nationalpark Danube riverine forest in the Lobau in 2017 - changes compared to 1981-1990

Irmgard Krisai-Greilhuber, Gerwig Winklbauer

Summary

In 2017 the funga of hardwood alluvial forests and dry grasslands within the Lobau, a national nature reserve close to Vienna, was surveyed with the aim to contribute to the knowledge of fungal biodiversity in Austria and of its temporal variability. Various aspects of fungal ecology were compared with results of a long-term study between 1981 and 1990 as well as a recent study which took place in autumn 2015. Number of species as well as proportion of ecotypes varied among plots and months during this study. Findings indicate a change of the relative proportion of ecotypes as well as shift of fruiting time. 51 species not recorded yet in the Lobau, one of them previously not recorded in Austria, were found.

Keywords

macromycetes, mapping, Sanger sequencing, national park, nature protection.

Introduction

Our goal was to study fungal biodiversity and how it was influenced by climate change via investigating the presence of fruiting bodies on permanent plots in the Lobau and comparing the new results (present investigation and Stulik 2016) to monitoring data from the 1980ths (Krisai-Greilhuber 1992). The plots were all located within the UNESCO biosphere reserve Lobau, a riparian zone of the Danube, close to Vienna. The vegetation ranged from alluvial forests to dry grasslands.

Dry grasslands poor in nutrients are considered valuable localities for fungi and many species can be considered as “grasslands specialists”. These species mostly are red-listed because of the decrease in number of dry grasslands in Europe.

Methods

Monitoring was conducted in seven plots within the Lobau representing different vegetation types. Grassland (Heißländen) and soft and hardwood riverine forest plots. Macromycetes were collected in the field, photographed and notes on fugitive characters were made. The frequency of fruit bodies was estimated following Krisai-Greilhuber (1992). Molecular genetic methods to confirm the identification of rare species were accomplished according to Klofac & Greilhuber (2020) including blast analysis. Statistical analysis was done with R (version 3.4.2) and SPSS Statistics 20 (see Winklbauer 2017).

Results

From March to November 2017 247 fungal species could be reported from the seven permanent plots with different vegetation types within in the Lobau. Each month the species curve raised (Fig. 1). Nearly a fourth (23.69 %) of all species was already recorded in the first month. April and May contributed over 10 % of the total number of species each, while between June and August the number of new discoveries decreased each month. The highest increase of the total number of species took place during September and October, because it is the main mushroom season.

The number of species varied between the plots and months. Most species (116) were found one time on one plot (Fig. 2). Only one species i.e. *Schizophyllum commune* could be seen each month and at every plot. Most species were considered dispersed, no highly frequent species were encountered during this study (Winklbauer 2017). The seasonal fluctuation of the number of species also varied with a low abundance of fruiting bodies during summer and high numbers in autumn.

Over 80 % of the species found were Basidiomycota, 16.47 % were Ascomycota and only 2.4 % were Myxomycota. The most abundant order was Agaricales, with over 58 % of the total species found.

Thirtyfour species i.e. 13.76 % of the total number of taxa found in this study were redlisted (Dämon & Greilhuber 2017).

Concerning ecotypes (Fig. 3), a high number of saprotrophic species of the forest plots was caused by the greater amount of lignicolous fungi due to a higher amount of woody debris. In each plot except one lignicolous species were the most common ecotype followed by terricolous species. Dry grasslands are dominated by saprotrophs, parasites of vascular plants and mosses, but also arbuscular mycorrhizae. The abundance of ectomycorrhizal fungi outside forests is generally low. In the forest plots lignicolous species were dominant, whereas in the grasslands terricolous were in the majority or the number of terricolous and lignicolous species was almost equal. Although the total number of species found was higher in the forest plots, the amount of ectomycorrhizal fungi seems smaller compared to the other plots.

Generally alluvial forests, with a high abundance of lignicolous fungi, had more species than the grassland plots. The relative amount of mycorrhizal fungal species was higher in the grasslands than in the forests. Compared to the former studies conducted at the very same plots the amount of ectomycorrhizal species has declined in forest plots, whereas it remained mostly stable in the grassland plots.

In the present study 247 fungal species were found, in the long-time study 518 species and in 2015 78 species on three of the forest plots between August and November. Only 32 species were present in all three studies, 101 were found in the long time study and in 2017 again (Fig. 4); 99 taxa were found for the first time on the investigated plots, but most of these species were present at other localities within the Lobau; 17 species were encountered in 2015 and 2017 but not in the long time study. 18 species were found in 2015 but neither in the long time study nor during this investigation. 13 species were found in 2015 and the long time study but not again in 2017. 373 species were found in the long time study only but neither in 2015 nor 2017. And even in such a mycologically well investigated area as the Lobau 51 species have not been recorded there previously. *Paxillus ammoniavirescens* is one of these species, because it was described as new species in 1999 only. *Ramaria pseudogracilis* was not found (or simply not recorded) in Austria before because it is quite similar to *R. stricta* and has maybe been mixed up with the latter. *Crepidotus crocophyllus* is a is a thermophilous species that is spreading more and more due to global warming. *Hymenoscyphus fraxineus*, the causative agent of ash shoot dieback, is a recently introduced neomycete.

By comparing the fruiting season of the species from the long time study (Krisai-Greilhuber 1992) and from 2015 (Stulik 2016) and 2017 (Winklbauer 2017), we see that the number of species which fruit in March and November has increased the number of species producing fruit bodies in June has decreased (Fig. 5) and the season starts earlier in the year and lasts a bit longer.

We thank Dr. Christian Baumgartner for permits for the Nationalpark Donauauen and all other people who helped during this research work.

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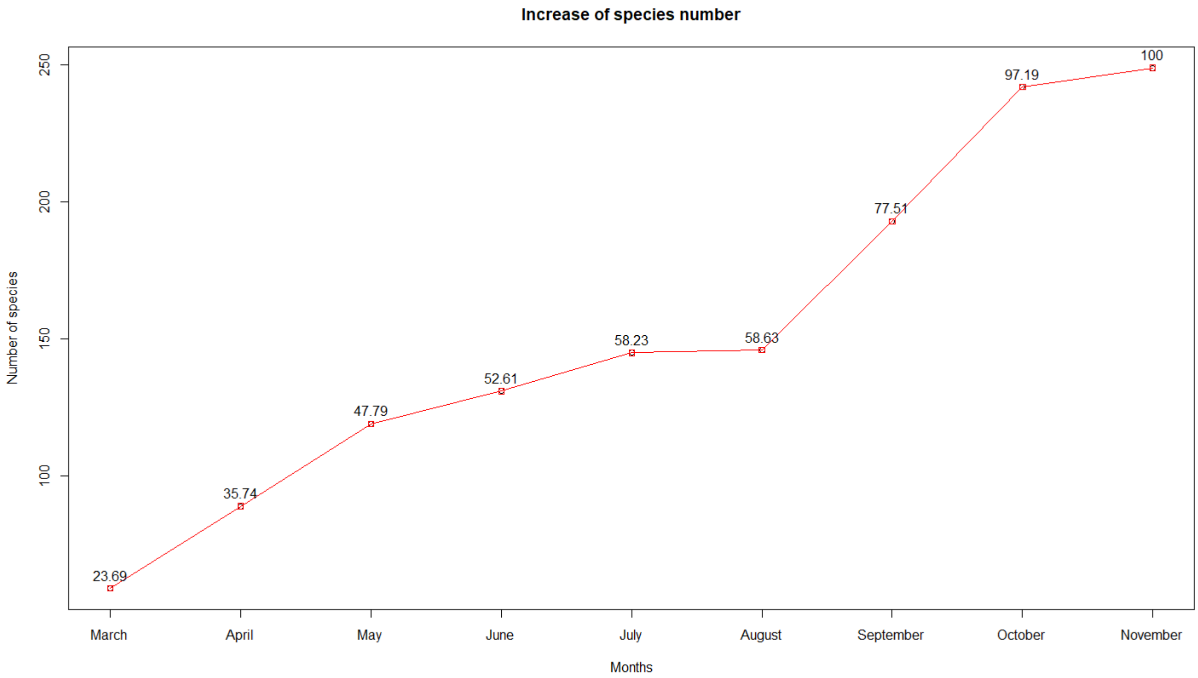

Fig. 1: Increase of total number of found fungal species and subspecies respectively found during this study (Winklbauer 2017)

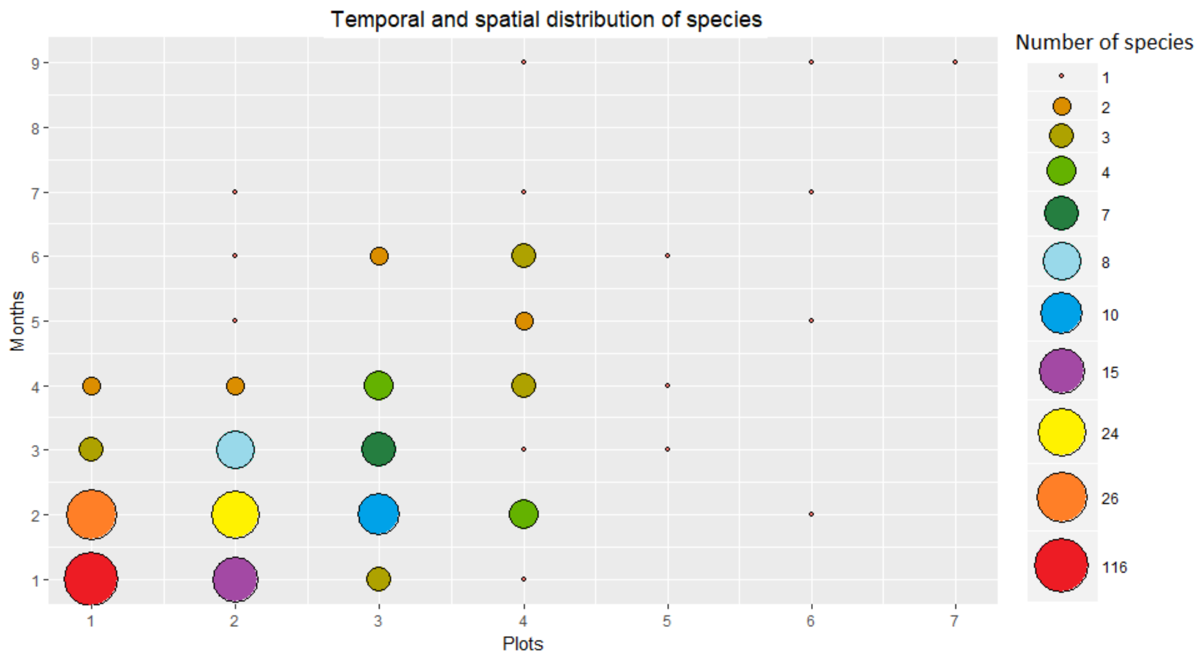

Fig. 2: Scatterplot of the number species which appeared at nplots (x-axis) in nmonths (y-axis) (Winklbauer 2017)

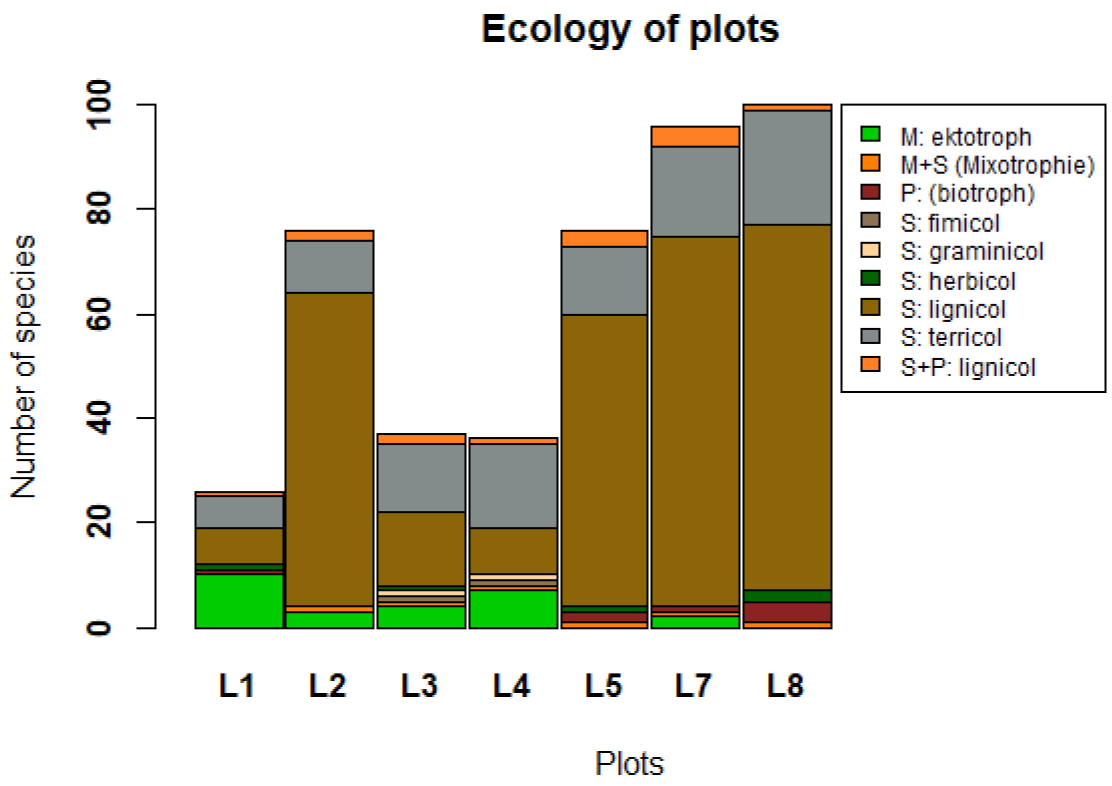

Fig. 3: Numbers of species found at each plot with respect to the ecotype the species belongs to (Winklbauer 2017)

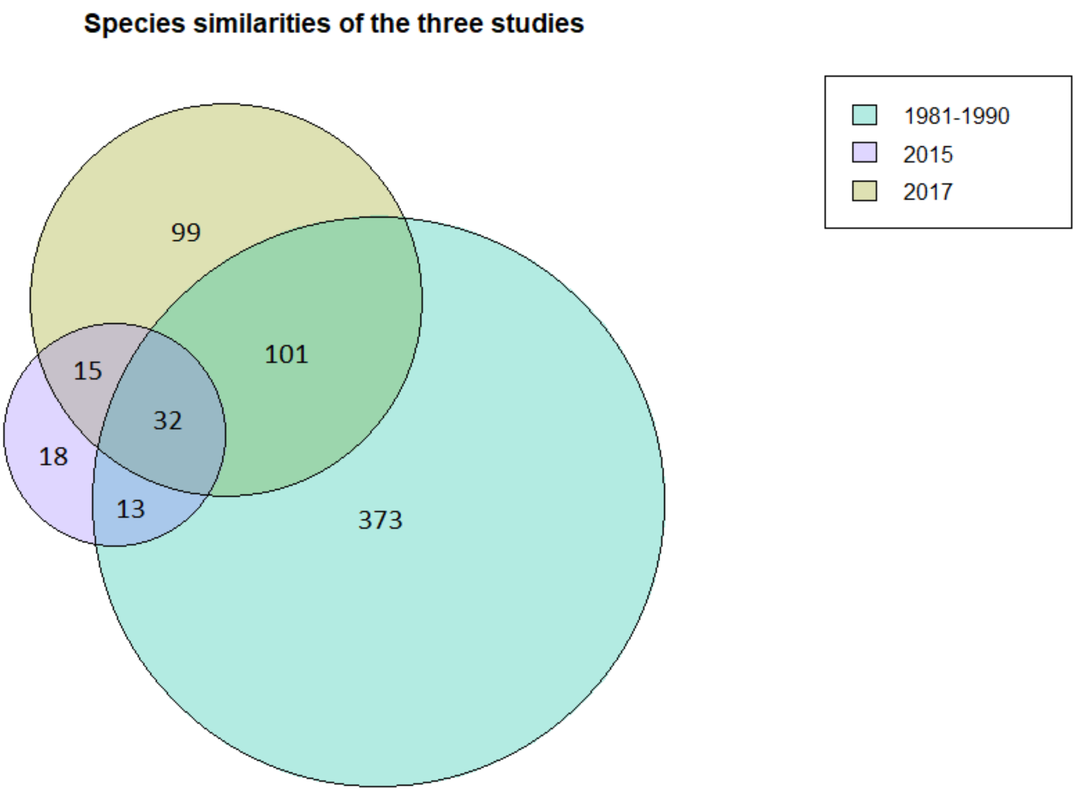

Fig. 4: Venn diagram of species similarities of the three studies i.e. 1981-1990, 2015 and 2017. (Winklbauer 2017)

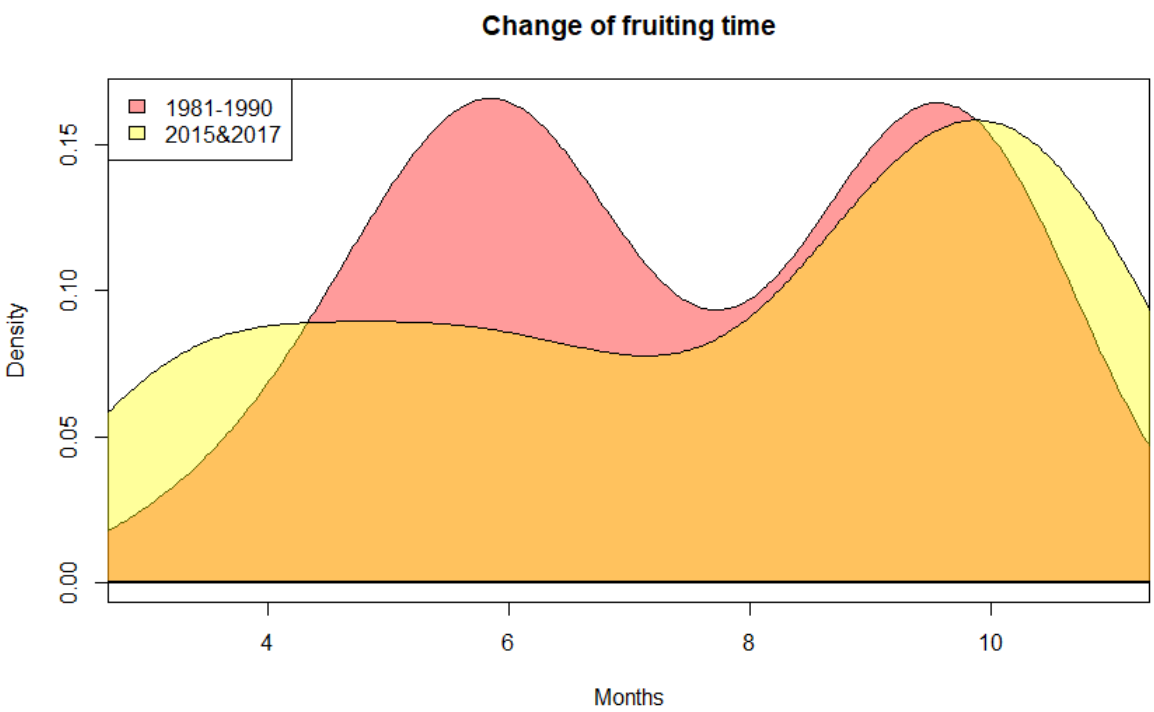

Fig. 5: Density plot based on the frequency of months in which fruit bodies were produced by species found in the long-time study and again in 2015 and 2017 (Winklbauer 2017)

The hymenopteran fauna of soda pans in the “Neusiedlersee-Seewinkel” national park

Alice Laciny, Herbert Zettel, Sabine Schoder, Katharina Zenz, Heinz Wiesbauer, Franz Seyfert, Esther Ockermüller

Abstract

In 2020 and 2021, members of the Austrian Entomologists’ Association (AÖE) conducted a qualitative assessment of Hymenoptera occurring in the saline environments of the “Neusiedlersee-Seewinkel” national park in Burgenland, Austria. Although the insect fauna of the Seewinkel region has been thoroughly investigated in the past, little is known about the biodiversity of the hymenopteran groups that inhabit these salty habitats, their ecological specializations and possible need for protection measures. Therefore, numerous field-trips were conducted within the project to compile current faunistic data. Priority was set on wild bees, but data on other Aculeata families such as Formicidae, Sphecidae, Crabronidae, Pompilidae, and Chrysididae were also gathered to address this gap in scientific knowledge.

The talk will present the highlights of the project, including new records and rediscovered species. To only name a few notable examples, we found large populations of the andrenine bee Camptopoeum friesei and its cuckoo bee Parammobatodes schmidti at several localities. Another highlight was the record of Euchroeus purpuratus, a species whose populations are currently in decline throughout Europe. In contrast, the plasterer bee Colletes pannonicus, only known from the Seewinkel and more common at this locality just a few years ago, was recorded only in a single specimen. The most exiting finding was the ant Cardiocondyla dalmatica, a representative of a genus hitherto unrecorded from Austria. The precarious situation of these fragile ecosystems and their insect inhabitants in the face of climate change and receding groundwater levels will be discussed.

In conclusion, future prospects for this ongoing project will be presented.

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Risks management for biodiversity conservation in riparian forests of the UNESCO Mura-Drava-Danube Biosphere Reserve

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Summary

Worldwide, protected areas … protected areas aim to safeguard ecosystem resilience and biodiversity and thus may also contribute to the mitigation and adaptation to climate change. However, climate change poses one of the greatest threats for protected areas, together with the occurrence of invasive species and the impacts of intensiv tourism. Riparian forest ecosystems are among the most protected areas in Europe. We investigated the diversity of tree species, tree regeneration, the role of introduced tree species, deadwood occurrence and volumes, and genetic resources in hardwood and softwood floodplain forest types in the transnational biosphere reserve Mura-Drava-Danube (TBR). We quantified the effects of tree species, climate, site, and silvicultural characteristics on leaf damage caused by insect pests and pathogens and the abundance of alien herbaceous plants, as well as their overall impact on forest regeneration to gain a deeper understanding of the interactions of risks and forest management under climate change. The data collection was performed on angle count plots along randomly located 47 transects with their axes oriented orthogonal to the river. The transects were, 20 m wide and at least 300 m long. Riparian forests in TBR provide habitats for several protected and threatened plant and animal species. Deadwood was observed more often in natural (78% of angle count plots) and uneven (74%) than in even (64%) and coppice (49%) stands. Biotic threats were affected in numerous ways by silvicultural practices, climatic and site characteristics. Our results show that a higher percentage of insect-induced leaf damage in coppice than in even-aged forests, while the other management types were not significant compared to even-aged forests. Stands with closed canopy revealed higher fungus- and insect-induced leaf damage. We identified numerous management options that can help safeguard biodiversity in riparian forests from adapting management systems, tree species composition, providing structural heterogeneity – e.g., by including deadwood and unmanaged patches into forests – and others. In conclusion, forest management measures can help support and promote stress resistance, resilience, and dynamic response to maintain and improve riparian forests ecosystem functioning.

Keywords

Flood plain, riparian area, hardwood floodplain, lying deadwood, UNESCO Biosphere reserve, wetlands

Introduction

Riparian forests provide multiple ecosystem services and host large shares of terrestrial biodiversity in Europe (González et al. 2017; Turunen et al. 2021). Riparian forest ecosystems are among the most protected areas in Europe. They are of particular importance for accumulating carbon stocks, rapid carbon sequestration in the short-term and for providing ecosystem services, although they cover only 0.5% to 1% of the global land surface. Understanding the challenges of climate change on riparian forest ecosystems helps to adapt to these new climate conditions and increase the resilience of riparian forest in future. However, the biodiversity of riparian forests is at risk. The main threats to riparian forests are habitat degradation, climate change, river regulation and invasive species. Over the past decades, there has been a huge decline of riparian forests, leaving many in unfavourable or even bad state (EEA 2016). River regulation, climate change, invasive alien species, emerging pests, habitat destruction, and disconnection from the respective watercourse are the major threats contributing to this decline (EEA 2016; FAO 2020). There is therefore an urgent need to understand the interplay of the various threats, their causes and forest management to preserve riparian forests and improve their ecosystem status.

Biotic impacts are strongly linked to abiotic impacts and cause shifts of biotic threats to forest ecosystems (Biedermann et al. 2019; Kausrud et al. 2012). Europe's forest damages are most frequently caused by biotic impacts (Rivers et al. 2019). Climate change causes the increase of biotic threats, which are extremely challenging due to their unpredictability. Biotic challenges include recently observed changes in growth rates, phenology, composition, shift of species distribution and an increase of pests and diseases infesting forests. Furthermore, an increase in winter temperatures impacts the survivability of some pest species and the period they can pose a threat to the trees (Sallmannshofer et at. 2021). Silvicultural practices can influence forests to make them more resistant to climatic change and biotic threats. Sustainable silvicultural practices that can increase resistance to insect and pathogen outbreaks have been tested in different forest ecosystems, and it has been shown for example, that increasing tree species richness can decrease the defoliation rate by insects (Jactel et al. 2017). Moreover, a reduction of single species stands, and keeping up with planned cutting regimes were found to increase resistance to bark beetle outbreaks (de Groot et al. 2019). Other ways of counteracting biotic threats are to increase structural diversity in terms of age classes or vertical structure. Resistance to alien plant species can be increased by avoiding large gaps from forest management and planting tree species with a dense canopy cover, as most invasive alien species are shade-intolerant (Eschtruth and Battles 2009). Combining all these silvicultural practices would give a sustainable forest management which increases the resistance to biotic threats.

In this study we quantified biotic threats in different management types and across a climatic gradient, thus testing the potential increase in temperature due to climate change, in order to quantify the effects of tree, site, and silvicultural characteristics on the defoliation caused by insect pests and pathogens and on the abundance of alien herbaceous plants as well as on their overall impact on forest regeneration.

Methods

The transnational Biosphere Reserve Mura-Drava-Danube (TBR) covers an area of nearly 850,000 ha in the countries of Austria, Slovenia, Hungary, Croatia and Serbia. The entire core zone of this important ecological corridor - a belt of riparian forests along the three rivers - has been designated as part of the Natura 2000 framework and contains protected areas of various categories. New parts of the Biosphere Reserve were recently nominated and now it is the largest protected river area in Europe and the only UNESCO Biosphere Reserve spanning across five countries. A share of 27% of the Biosphere Reserve is covered by forest. This portion increases to 61% within the core zone. The rivers are embedded in eutric Fluvisols (33%), surrounded by Luvisols (14%) and Cambisols (5%). Phaeozems (35%) are the dominant soil type.

The sampling sites per country were determined by their estimated river coast lines within in the TBR. GIS orthophoto and river analysis in QGIS (v. 2.18.16) from Bing satellite images were used for locating the sampling sites as transects systematically with their axes orthogonal to the respective river, a width of 20 m and a minimum length of 300 m located in a forest complex. If the criteria were not met, transects were shifted up- or downwards the river to the closest position meeting the defined criteria. Additionally, extended transects were planned in every country in order to allow sampling in forests more distant to the rivers. Therefore, the largest forest complexes close to the TBR borders were selected and transects were extended by 300 to 600 m, each. Along these transects sampling plots were located every 75 m. In total, 36 transects and 11 extended transects resulting in 322 plots were sampled. At each sampling plot the forest structure (tree height, regeneration, DBH, canopy closure) and the forest management intensity was assessed. Lying deadwood was recorded using the line intersect method developed by Warren and Olsen (1964) and improved by Van Wagner (1968). In the angle counts, we quantified fungus-induced defoliation and insect-induced defoliation on tree level. For both fungus-induced defoliation and insect-induced defoliation, the share of affected leaves and mean share of infection area per leaf were estimated from the ground using binoculars. However, where necessary, one branch per tree was cut off and leaves were examined for the presence of necrotic lesions, fruit bodies, leaf mines and other symptoms and signs of leaf diseases and insect pests using hand lenses. Alien plant occurrence was identified along the transects. The abundance of invasive plant species was determined using an adapted Braun-Blanquet approach (Londo, 1976; Moore, 1962). Browsing on saplings was measured only last year's browsing damage of individual plants was counted. Climate data for each transect were obtained from the HISTALP database (Auer et al. 2007). The database contains homogenized precipitation and temperature data from 192 respectively 131 weather stations in the broader Alpine and Dinarides region. We calculated long-term (1985-2014) mean temperature (MTVP) and total precipitation (TPVP) during the vegetation season (April-September).

We used a general linear model (GLM) with a Gaussian distribution to analyze the data. The models were tested for spatial autocorrelation with a Moran's I test. When the models turned out to be spatially autocorrelated, spatial filtering was applied, and Moran's eigenvector was included in the model. Browsing was analyzed with an ordinal regression. Model selection was performed for every biotic threat by first preparing a complete model. Then the Akaike Information Criterion was calculated and ordered from the smallest to the largest AIC. Data management, statistical analysis, and visualization were performed in the program R (R Core Team 2018) using the packages "ggplot2" (Wickham 2016), "spdep," "spatialreg" (Bivand and Piras 2015), MASS (Venables and Ripley 2002) and "adespatial" (Dray et al. 2018).

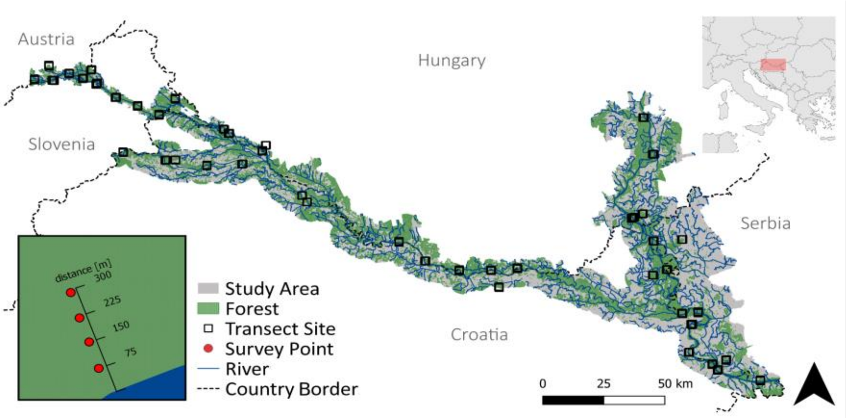

Figure 1: *The Mura-Drava-Danube Transboundary Biosphere Reserve is located in Europe along the rivers Danube, Mura and Drava in Austria, Slovenia, Croatia, Hungary, and Serbia.*

Results

The obtained field data provided the opportunity to simultaneously investigate different threats as well as their interactions and corresponding management options in riparian forests (de Groot et al. 2022). Biotic threats were affected in numerous ways by silvicultural practices, climatic, and site characteristics. When tree species richness was higher, there was less damage from fungus-induced defoliation. This was not the case with insect-induced defoliation and the presence of alien herbaceous plants, which were unaffected by tree species richness. Further the results show that alien herbaceous plant species are more abundant in areas with open canopy, whereas fungus-induced defoliation is facilitated with closed canopy. Insect-induced defoliation fluctuates over a gradient of canopy openness. These differences between groups most likely lie in the niches they occupy. Alien herbaceous plant species are often light demanding species and therefore will flourish in disturbed habitats with large gaps (Eschtruth and Battles 2009). In contrast, fungal pathogens generally require moisture to spread and infect plants and thus they prefer closed canopy where the microclimate is moist compared to forests with open canopies (Huber and Gillespie 1992, de Groot et al. 2022).

The analysis of the field data revealed that forests with different management system show varying degrees of deadwood, with highest deadwood volumes in nature-like forests and lowest volumes in high-growing coppices/plantations. However, binomial models for deadwood occurrence revealed that other site variables such as river-distance and climate parameters where of larger importance within the study area of TBR. More generally, the results from this study show the significant impact of climatic variables on the various biotic threats. The mean temperature in the vegetation season was negatively associated with both insect defoliation and alien herbaceous plant species. Additionally, precipitation during the vegetation season was negatively associated with insect defoliation. Furthermore, an increase in winter temperatures impacts the survivability of some pest species and period in time that species can have an effect on trees. Consequently, the magnitude of biotic threats may lead to a transformation of major vegetation types in Europe.

In conclusion, the major challenges of climate change include an increase in high temperature extremes, drought events and heavy precipitation events as well as biotic threats, such as the spread of pests and diseases in forests. Forest management measures can help to support and assist forests' stress resistance, resilience, and dynamic response in order to preserve ecosystem functions (Sallmannshofer, Schüler, Westergren et al. 2021).

Future studies should further investigate riparian forest dynamics including information on river regime in order to allow for model improvements and predictions under climatic change. For detailed conclusions on the importance of the different floodplain types for biodiversity, indicator species should be considered in monitoring efforts. This will further support the development of recommendations for silvicultural management and allow for more precise information on the different floodplain types.

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Collating biodiversity data for 20 years: Is the knowledge we have the knowledge we need?

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Summary

In species conservation and research, there is a bias that strongly correlates with the popularity of the respective species group. As one way to overcome this bias Mammola et al. (2020) argue that first of all "we should promote species inventories and data compilation" and close the main knowledge gaps. The Biodiversity Database of the Hohe Tauern national park was initiated in 2002 with exactly that aim: To create a biological inventory of the region as comprehensive as possible by mobilizing existing data (from museum collections, research projects and literature). The database should become the bookkeeping of biodiversity for the national park and provide baseline information for management decisions.

As of today, the biodiversity database of the Hohe Tauern national park comprises about half a million records on more than 12,000 taxa. Adjusting this number of taxa for known synonyms and evaluated at species level, the currently documented number of species in the national park can be stated to be about 11,000 species.

The level of knowledge documented in the biodiversity database varies greatly depending on the organism group and geographic scale. For many groups – mainly invertebrates – however it is obvious that species lists are incomplete. If the number of species for these poorly documented organism groups is extrapolated, it must be assumed that nearly twice as many species have to be expected. Although the number of commissioned surveys on biodiversity inside the national park is higher than outside, the present evaluation makes it clear, that at the moment biodiversity research, would be inconceivable without the largely voluntary initiative of countless experts. In our analysis, we explore the discrepancy between the knowledge we have and the knowledge we need to ensure unbiased conservation actions.

Keywords

Biodiversity, documentation, databases, long-term data-repository, species numbers, national park , Hohe Tauern

Introduction

In 2020 Mammola et al. found that there is a huge bias in the allocation of financial resources of the European conservation scheme LIFE. Their analyses showed that "conservation effort is primarily explained by species' popularity rather than extinction risk." As one way to overcome this bias they argue that first of all "we should promote species inventories and data compilation" and close the main knowledge gaps. The Biodiversity Database of the Hohe Tauern national park was initiated in 2002 with exactly that aim: To create a biological inventory of the region as comprehensive as possible by mobilizing existing data (from museum collections, research projects and literature). The database should become the bookkeeping of biodiversity for the national park and provide baseline information for management decisions.

Methods

As of today, the biodiversity database of the Hohe Tauern national park comprises about half a million records on more than 12,000 taxa. The annual increase in data since the beginning of the project was about 28,000 records (see figure 1). About 40 percent of the data are from before 1950, but the majority are from the last two decades (see figure 2). If the number of taxa mentioned here is adjusted for known synonyms and evaluated at the species level, the currently documented number of species can be stated to be about 11,000 species (for the organism groups thus covered, see table 1). For many groups of invertebrates, however, not even the species lists are completely recorded. It must therefore be assumed that many species that could be expected in the Hohe Tauern on the basis of their biology have not yet been concretely documented in the database. If the number of species for these poorly documented organism groups is extrapolated on the basis of Austria-wide data, it can be assumed that at least 20,000 plant, fungal and animal species occur in the Hohe Tauern (for comparison, there are over 76,500 species in Austria).

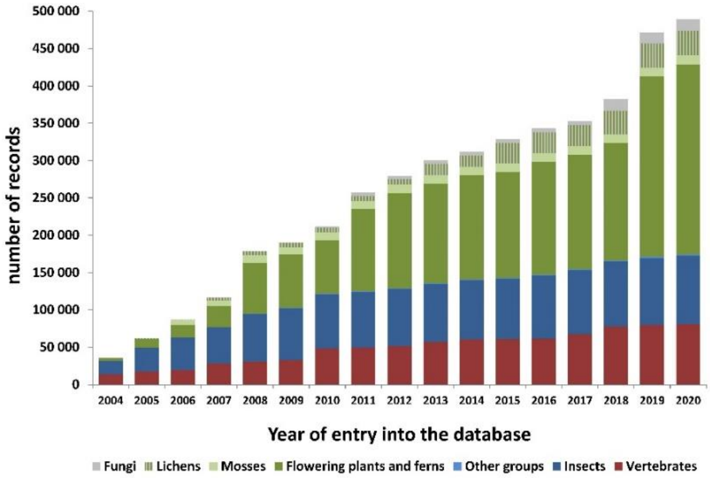

Figure 1. The annual increase in data in the biodiversity database of the Hohe Tauern National Park since 2004 has averaged 28,000 records.

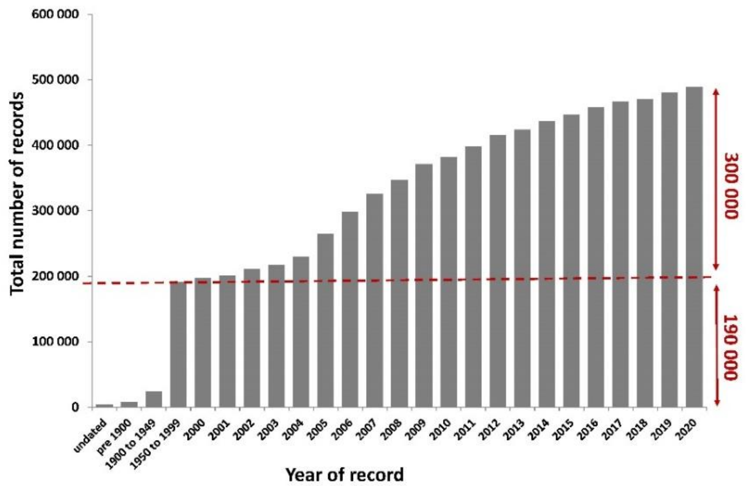

Figure 2. Total number of records in relation to the year in which they were collected. The columns represent the total data of a year, i.e. new data including data from previous years.

Table 1. Overview of species numbers of individual organism groups worldwide as well as in Austria compared to the species numbers documented for the Hohe Tauern in the biodiversity database. Data sources: DÄMON & KRISAI-GREILHUBER 2016 (a), TÜRK & HAFELLNER 2017 (b), GRIMS & KÖCKINGER 1999 (c), FISCHER et al. 2008 (d), GEISER 2018 (e). For information on the Hohe Tauern see the respective chapters on the organism groups. Numbers in brackets indicate species numbers that are certainly significantly too low due to the lack of database documentation.

Organism-group	World	Austria	Hohe Tauern	National park
Fungi	400.000	15.000 [a]	2.236	1.308
Lichens	25.000	2.500 [b]	1.083	989
Algae	72.500	5.000	(148)	(133)
Mooses	16.000	1.000 [c]	782	681
Flowering plants and ferns	380.000	> 4.000 [d]	1.834	1.286
Protozoa	> 8.100	> 1500 [e]	(45)	(45)
Mollucs	>50.000	537 [e]	93	39
Crustaceans	> 47.000	530 [e]	(6)	(5)
Arachnids	> 102.000	4.200 [e]	(209)	(191)
Centipide	> 16.000	330 [e]	(4)	(3)
Other invertebrata (excl. inscts)	> 70.000	> 6.300 [e]	(45)	(43)
Ephemeroptera	3.000	119 [e]	(15)	(14)
Plecoptera	3.500	135 [e]	(24)	(24)
Odonata	4.875	78 [e]	46	20
Orthoptera	25.500	139[e]	53	30
Coleoptera	350.000	8.000 [e]	(1.952)	(959)
Hymenoptera	156.000	11.200 [e]	(184)	(138)
Trichoptera	13.000	315 [e]	(58)	(50)
Lepidoptera	180.000	4.090 [e]	1.612	1.213
Hemiptera	200.000	920 [e]	(154)	(123)
Diptera	160.000	11.500 [e]	(167)	(147)
Other insects	-	3.500 [e]	(1)	(1)
Fish	28.000	86 [e]	(8)	(3)
Amphibia	7.000	24 [e]	10	4
Reptilia	11.136	16 [e]	9	5
Birds - breeding / guests	18.000	217 / 430 [e]	145 / 249	118 / 140
Mammals	5.000	105 [e]	71	58

Results

The level of knowledge documented in the biodiversity database varies greatly depending on the organism group and scale. It is obvious that vertebrates and plants are disproportionately well recorded compared to their species-specific share of Austrian biodiversity (see figure 3). Insects are clearly underrepresented, the "other invertebrates" are almost not mapped at all! While plants and vertebrates are comparatively well recorded with a data density of more than 100 records per species on average, knowledge about many insect groups is so limited that regional distribution maps are hardly meaningful. Despite these documentation gaps, the biodiversity database of the Hohe Tauern National Park is an important step towards making biodiversity-relevant data available. About half a million records are available for decision makers in natural area management. At the same time, the Hohe Tauern National Park is the first and so far only Austrian national park to provide its own data node for the GBIF network (www.gbif.org) and for the Austrian Biodiversity Atlas (biodiversityatlas.at), thus making biodiversity-relevant data accessible to the global scientific community.

Although the proportion of publicly commissioned data within the National Park is higher than, for example, the Salzburg-wide average, the floristic and faunistic documentation, i.e. biodiversity research, would be inconceivable without the voluntary commitment of countless experts. The knowledge about biodiversity, not only in the Hohe Tauern region but also in Salzburg and Austria, is based on the decades-long commitment of many Citizen Scientists. The further deepening of the cooperation with these (voluntary) data providers should also be a central point in all future efforts to improve the documentation of biodiversity.

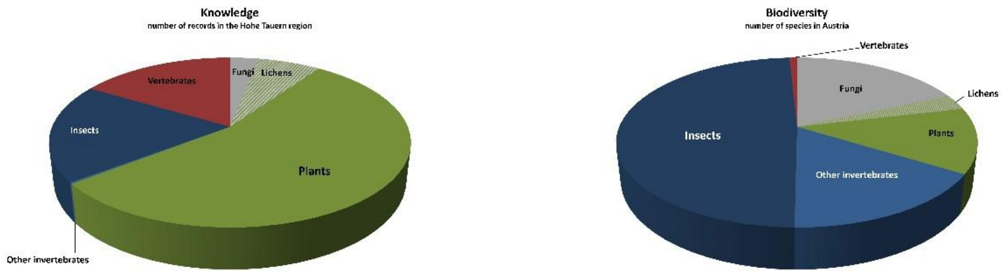

Figure 3. Comparison between the numbers of species known for Austria as a measure of biodiversity (left) and the number of documented records in the biodiversity database of the National Park as a measure of the state of knowledge on the individual groups (right).

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Improvement of tourist accessibility and enhancement of the local economies of protected natural areas using behavioral science and design for territories techniques

Pasquale La Malva, Luca Cetara, Samara Ferreira Crispim

Abstract

In recent years, the society has paid more attention to protected natural areas, trying to enhance their governance and usability to generate socio-economic benefits on a local scale (Liu et al., 2012; Stolton et al., 2015). Current attempts are mainly aimed at the digitalization of natural and cultural services using smart technologies and platforms both for tourism development and for the data collection and monitoring (Tenkanen et al., 2017; Luković & Kostić, 2018). However, these new approaches can be difficult to apply especially in particular territorial contexts such as protected areas. To ensure effective and continuous promotion over time, a re-adaptation of governance to such innovative approaches and the development of customized strategies could be essential.

We describe a case study within a protected area focused on the development of a methodology that allows to enhance local economies through an improvement of tourist accessibility using techniques from behavioral sciences and design for territories to improve the tourist experience simultaneously spurring local development. The methodology makes use of a low frequency Bluetooth technology, which consists in the installation of devices in different points of interest in the area to provide a digitization service using an online platform and a smartphone app that acts both as output of information aimed at promotion and local development, and as input for the collection and monitoring of data for refining the behavioral techniques applied.

In summary, the method includes: a socio-economic analysis of the territory; the selection of cultural and natural sites and the installation of technological devices; the identification of priorities for territorial development with local administrations and stakeholders; the definition of a local development strategy through the use of nudging techniques aimed at facilitating the achievement of the selected priorities; the application of concrete solutions to promote the territory and its economic activities through the use of methods deriving from design for territories.

Finally, the methodology can update and refine the applied strategy through the analysis of the data and the control of the results, providing the approach with constant effectiveness and temporal continuity.

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Dynamics of regeneration in accordance to dead wood status in Goldeck Natural Forest Reserve in Carinthia, Austria

Dimitrios Manousidis, Harald Vacik, Georg Frank, Ajdin Starcevic

Abstract

The Natural Forest Reserves programme aims to establish a representative network of natural forest reserves to maintain and monitor the biodiversity of the main forest types in Austria. In this context, the natural regeneration of the tree species in the natural forest reserve Goldeck was investigated in correlation to the conditions of the existing deadwood in Carinthia, Austria.

The data collection took place under the research project ELENA, which is studying the natural regeneration in unmanaged forests in Austria. In the studied area of the natural reserve Goldeck, there were 30 permanent circular sample plots established for a long-term monitoring, in which the quality, quantity and age of the lying and standing deadwood was estimated and categorized. The decomposition rate, the classification of the deadwood type, the size and the identified species were documented. Regarding the natural regeneration, the number and condition of all individuals were measured up to a tree height of 130cm. The species and their age were identified and for individuals with a height between 15-130 cm, the collar diameter and annual growth was measured.

The aim of the current study is to analyze the correlation between the quantity and decomposition rate of dead wood with the occurrence of natural regeneration on dead wood and its characteristics. Additionally, a comparison between the data collected on the same plots during the investigation in 2008 and the ones taken in 2021 will be done to investigate the regeneration dynamics.

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National parks and pollination: Synergies and trade-offs with other forest ecosystem services and adjacent agricultural activity

Andreas Mayer, Sarah Matej, Tim Anders, Claudine Egger, Veronika Gaube, Stefan Kirchweger, Sara Minoli, Merijn Moens

Abstract

Interactions between pollinators, plant diversity, and crop yields in the context of climate and land use changes are not well understood in scientific research, and quantitative assessments of feedbacks are missing. In a current EU-wide project, we aim to unravel these complex interactions through assembling a set of complementary models of climate, forests, pollinators and crops, run at the regional level on a 3x3 km2 grid. The LTSER region Eisenwurzen is used as a case study, since it provides a unique perspective on these interactions through the presence of the National parks Gesäuse and Kalkalpen. So far, research on pollinators has focussed on their provisioning of ecosystem services, but less emphasis has been put on the role played by National parks and other land uses in supporting pollinators presence under climate change conditions. Pollinators find multitudinous suitable habitats in National parks with little or no forest management and extensive flower-rich grasslands, and might also have positive impacts on adjacent agricultural lands. Moreover, National parks provide a baseline with little or no human intervention from land use which can be compared with adjacent regions with agricultural activities and forestry.

We use a large number of scenarios to separate the effects of climate, land use, and forest management on the distribution of pollinators, and their repercussions on yields of pollinator-dependent crops. These include: two climatic scenarios (RCP 2.6 and RCP 8.4); two scenarios of forest management outside National parks (intensive with clear-cut and extensive with continuous cover management, differentiated by rotation period, amount of thinning, and target diameter and simulated with the LPJ-GUESS vegetation model); and two scenarios of agricultural land use (globalized or regional agricultural production). The historical forest structure and management of both National parks are represented by the historical land use (based on inventory data) in LPJ-GUESS. For the future scenarios, we use both climatic and one adapted extensive forest management with subsequent succession (including natural disturbances) within the National parks, and an agricultural land use management plan which aims at maintaining extensive (mountain) grasslands. Furthermore, the scenario for the National park is co-developed based on available management plans and consultation with the local stakeholders.

Results will allow to compare pollination-related indicators with other forest ecosystem services (e.g., carbon storage) provided by forests in National parks under future climate conditions. Furthermore, the comparison of marginal agricultural activity within the National parks and more intensively used areas outside will allow to identify agricultural areas with an estimated higher pollinator diversity, e.g., in areas bordering National parks. Results can indicate benefits on agricultural fields in close proximity to the National parks.

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Protected Areas – potentials and measures for green and blue infrastructure, agriculture and local recreation

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Summary

The Middle Styrian Enns Valley is one of the most important wetland habitats with a variety of highly endangered plant and animal species. Particularly noteworthy is the corncrake (*Crex crex*), listed in Annex I of the EU Birds Directive and known as a leading species for this region. The large number of protected plant and animal species with their corresponding habitats were the basis for the designation of these valley floors, shaped by the Enns River, as Natura 2000 sites „Ennsaltarme bei Niederstuttern" (Mayer, Plank, 2017). The agricultural use of the areas has increased due to the river straightening of the Enns since the middle of the 19th century. These areas are characterized by major flooding, as was the case most recently in 2013. The expansion of linear (rail, road, renewal of overhead power lines) infrastructures and land consumption for settlements, commercial and industrial enterprises are characteristic for the current development. The pressure of use on grassland areas, justified by private and public interest, does not stop at the borders of Natura 2000 sites and corresponding buffer zones are also becoming smaller. Today, regulation measures along the Enns River as well as the preservation and restoration of wetland habitats are being renaturalized through appropriate measures. Programmes and initiatives for adapted ecological land use are being implemented.

The diverse use of land and its effects in and at the edge of Natura 2000 sites are shown by means of examples and analysed with the new challenges to land use management for multifunctional areas.

Keywords

Land use development, green and blue infrastructure, integral land use concepts and site adapted measures, multifunctional areas

Introduction

Due to the current situation and discussion about food security and expansion of the use of green areas for arable farming, the proposal of the EU Commission for a new regulation on nature restoration (European Commission, 2022) is being discussed very controversially.

In summary, the "green infrastructure" consists of green and open areas with different functions. These include, for example Natura 2000 sites and surrounding areas with similar character, stepping stone biotopes, green corridors, landscape elements, riparian strips or parks and landscapes for local recreation. In this paper, we define blue infrastructure for flood retention areas, which are normally used as agrarian land. According to the definition in §6(1) of the Austrian Forestry Act 1975 as amended, the functions for green and blue infrastructure can be divided e.g. into use (agriculture), protection (against flooding, against erosion, loss, destruction), welfare (purification of water and air) and recreation, whereby several functions are usually affected at the same time. When a particular land use can fulfil several functions at the same time, we speak of synergies or multifunctionality (Schönhart, M. 2020).

To ensure the conservation of protected species and habitats, specific coordinated management measures are necessary, which must be in harmony with the habitat requirements of the respective protected species and habitat types. In practice, however, this means walking a tightrope between Natura 2000 objectives and the interests of land users, the needs for a healthy living and recreational space, safety demands from natural hazards and regional resource availability in connection with climate change and other unpredictable potential hazards.

Due to the late involvement of the land managers, the designation of the Natura 2000 sites in the Middle Styrian Enns Valley was very conflictual. However, the fact that land use, landscape- and nature conservation and protection against floods are not an obstacle has already been demonstrated in different projects and initiatives.

Methods

GAP analysis as a basis for targeted management

In the project BeNatur (Better Management of Natura 2000 sites, INTERREG SEE), the areas of legal and institutional framework conditions for the implementation process of Natura 2000 sites, management and organisational structures as well as ecological assessment (monitoring of protected areas) were assessed. In a "GAP analysis" corresponding recommendations were elaborated on a country-specific basis (Kirchmeir, H., Köstl, T., Getzner, M., Zak, D. 2014). In the region of the “Middle Styrian Ennsvalley”, the recommendations were very well accepted and implemented with all relevant stakeholders.

CAMARO-D Best practice Manual (BPM) for spatial planning in catchment areas and along rivers

From the point of view of flood protection, flood risk management is oriented towards giving more space to watercourses or also creating natural retention areas. The increasing importance of land use for flood risk management is in line with CAMARO-D objectives. The project discussed on a transnational level how the principle of Green Infrastructure as protection and enhancement of nature and natural processes, as benefits for society (EU Commission. 2013), should be implemented in spatial planning and territorial development. Flood events do not stop at administrative boundaries (e.g. municipality boundaries), so regional approaches in spatial planning make sense. In particular, the targeted handling of upstream-downstream relationships requires the coordination of land use claims at the level of catchments or river sections. This BPM presents two planning options for this purpose: regional planning as a regulatory planning instrument and voluntary cooperation of planning actors (administrative authorities, experts at federal and federal state level) at catchment level.

Measures:

- Establish a legal framework for the conservation of flood runoff and flood retention areas in regional planning or in regional water management programmes.
- Creation of financial and organisational incentives for voluntary cooperation between actors for flood risk management in catchments and river sections.
- Compensation measures, i.e. a financial transfer between municipalities for flood risk management and municipalities that benefit from these measures.
- Inclusion of regional planning and voluntary cooperation in flood risk management plans (Seher, W. 2019).

GUIDER – Guidance for sustainable land use planning

River basins and wetlands provide a variety of services as described. The CAMARO project developed a guidebook of policies and procedures for sustainable land use planning in an integrated approach. The GUIDER is an experience-based action catalog and best practices /toolbox for water and land use planners (Siegel, H., et.al. 2019, p.29, 30).

Contractual Nature Conservation Programme

As example, the Natura 2000 Contractual Nature Conservation Programme only concerns the Styrian European protected areas and, if necessary, direct border areas, for nature conservation reasons. In the case of measures or abandonment of management, for the favourable conservation status, the managers are supported flexibly. (Amt der Steiermärkischen Landesregierung, 2022).

Awareness-raising activities

Awareness-raising activities and training are important to motivate for the implementation of measures. It is evident from the projects that cross-age participation has the greatest success and working groups/advisory boards with different stakeholder groups support land managers and institutions for voluntary activities (municipalities, schools, NGOs, public bodies such as the “Steiermärkische Berg- und Naturwacht” with its operating locations).

Project implementation through the multiple use of land

Selected projects explain how the multiple use of protected areas and their marginal land in and at the edge of Natura 2000 areas in the Middle Styrian Enns Valley works. The international exchange of experiences and best practice examples enables a discussion process on the instruments for sustainable land use planning.

Results

The field tested approaches are summarised as followed:

The **Life Project "Middle Enns Valley - Wörschach Moor** (1999-2004) in cooperation with Enns Valley land managers, the Bird Watching Association "Die Vogelwarte", the Styrian Nature Conservation Association, experts from the HBLFA Raumberg-Gumpenstein and decision-makers (Bohner, Buchgraber, 2005). The area around the Wörschacher Moor with the “Rosswiesen” is one of the most important wetland habitats of the Enns Valley and has therefore been designated as NATURA 2000 site „Wörschacher Moor und ennsnahe Bereiche“ (LGBI. Nr.3/2007). Leasing contracts with management conditions (cutting times in the core and marginal zones) were assigned with the farmers.

Other Nature protection initiatives on surrounding land, such as the re-cultivation of abandoned wet meadows for agricultural use, flood retention and biodiversity conservation, promotes green-blue infrastructure for habitat connectivity and green oases for local recreation in the **ReKult Iris Projekt** (Mayer, R., Starz, W., Plank, C. 2018). These single-cut meadows are mown around the beginning of September, depending on the weather. The hay is used as feed for ARECs organic farm Moarhof. With a current price of 300 €/ton of straw and a quantity of approx. 8,000 kg of dry matter/ha, this is a valuable own utilisation. The area is an open-air laboratory for school classes and is located directly on the international Enns cycle path. In cooperation with the Styrian Nature Conservation Association (the adjacent areas belong to the Federal State of Styria), an old hay house has been adapted into a small visitor centre which can be used as research laboratory for young people. Students from our college built an observation tower. Every year, at the End of May, there is a 2 days „*Iris sibirica green event*“ with school classes and the interested population to promote these wet meadows for multiple use. The relevant institutions work together and organise various information stations. International excursions and field research on soil, water and plants is implemented.

Fig. 1-4: Trautenfelser Blühwiesen; Moarhof @ HBLFA Raumberg-Gumpenstein,

CAMARO-D Cooperating towards Advanced MAnagement ROutines for land use impacts on the water regime in the Danube river basin (INTERREG) was carried out between 2017 and 2019. The Agricultural Research and Education Center Raumberg-Gumpenstein (AREC) implemented, in the Middle Styrian Enns valley, in and at the edge of Natura 2000 sites, i.e. the following interventions: wetland management, management of invasive plant species, spatial planning and flood risk management, site-specific re-cultivation, drinking water protection at alpine meadows and awareness raising activities for protection measures against floods, nature conservation and agriculture in wetlands and along riparian stripes.

Fig. 5: Flooding 2013, Provincial road L735 Crossing Öblarner Straße L734, © Mayer, M.

Fig. 6: Wetland meadows between Enns river and Grimming Mountain, left ESG 07/AT2240000 "Ennsaltarme bei Niederstuttern. @ Mayerl, M. 2022

Blooming River banks

The aims of the project was to strengthen the self-purification capacity of rivers, minimize gaps in the plant population, promote native biodiversity, maintain or expand plant corridors as habitats, prevent establishment of invasive plan species, prevent erosion damage and counteract warming of the water bodies. The target groups of the project were municipalities, landowners, corporate entities as well as the general population.

Although every system or method has its weaknesses, there are good solutions that can be shared. Consistent implementation and control are just as necessary as regular adaptation to new challenges and the provision of sufficient resources and transferability. These field-tested approaches need to be integrated into a land use development plan that considers ecosystem services and impacts and makes the watershed, which extends beyond municipal boundaries, resilient to unpredictable and calculable risks. This will require not only adjusting the funding landscape accordingly but need to elevate land use planning and conservation tools to a higher level of decision-making. The implementation of regulations needs adequate funding and appropriate structures for concrete instructions. Instruments of land use planning and nature conservation at a higher level of decision-making is a possibility for integrated solutions.

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The Vjosa – biodiversity of an outstanding European river

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Abstract

The floodplain morphology of the Vjosa is characterised by an exceptionally high near-natural status, thus representing an extremely rare reference site for large-sized rivers in Europe. Overall, the Vjosa is 270 km long, with a total catchment area of 6710 km2 and a total stream network length of approx.1100 km of permanently flowing river. The high values of its habitats listed in the EU Habitat Directive underscore its value at an international scale. These protected habitats support a highly endangered fauna and flora containing over 1100 documented species (mollusks, arthropods, amphibians, fish, birds, mammals, reptiles, and vascular plants), including high numbers and vital populations of many protected and endangered species that are listed in national and international laws and conventions, highlighting the significance of this natural environment on an international scale. The fauna and flora of the Vjosa comprise typical and sensitive elements of highly dynamic large rivers, all of which have lost large areas of their former distributions in Europe.

The investigations carried out to date were time-limited, revealing only snapshots of the existing biodiversity. Nevertheless, the present study represents a sound baseline survey, listing the documented fauna and flora, and includes their status according to national and international guidelines and Directives.

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Spiders and carabid beetle assemblages of inland salt pans in Neusiedler See – Seewinkel National Park: a comparison between 1993 and 2019

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Abstract

The Seewinkel region east of Neusiedler See is the westernmost alkaline inland salt pan region in Eurasia and one of the most important biodiversity hotspots in Austria. In 1993, we investigated the relationship between environmental conditions and surface-active spider and carabid beetle assemblages. We studied 60 study sites of 20 salt pan littorals with 180 pitfall traps and measured conductivity, pH value, soil water content, vegetation cover and vegetation height. Since 1993, the region has undergone substantial changes; agricultural intensification and water abstraction in cultivated areas adjacent to the park have continued and intensified. Climate change has led to an increased average temperature by 2 °C. To investigate the effects of these changes on the surface-active arthropod fauna, we repeated the 1993 study in 2019 at the same sites, during the same sampling periods, with an identical sampling effort, and recorded the same environmental variables with identical methods. In 2019, the average salinity in the saline soils has dramatically decreased to only a fifth of the conductivity values measured in 1993. Consequently, both spider and ground beetle fauna showed a strong turnover. The number of the target species among the spiders declined significantly about 61% in the alkaline saline habitats. Several typical salt pan carabid beetles that were caught in large numbers in 1993 could only be found in single specimens or no longer at all in 2019. Rapid groundwater level stabilization and the restoration of original hydrological conditions appear to be urgently required to preserve the remaining salt pans and their species assemblages.

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The effects of connectivity and morphology on the pelagic and benthic algal composition and function

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Summary

In recent years, connectivity has become a concept widely used in floodplain ecology. However, mostly lateral, and longitudinal connectivity indices have been considered in the past. Less emphasis has been placed on network connectivity. To study the effect of network connectivity on floodplains algae present an ideal model organism, as they respond quickly to environmental changes caused by variation in connectivity. In our study we expect pelagic algae to be more severely influenced by changes in the water column and thus more affected by variations in connectivity. We hypothesise for benthic algae to be more affected by the local conditions in the water body (e.g. sediment conditions, macrophytes cover) than by the differences in connectivity. However, we assume that the community composition and function of pelagic as well as benthic algae will be more similar between closely connected water bodies, than in water bodies showing a low degree of lateral or network connectivity between each other. To verify these hypotheses, samples have been taken twice during spring and summer 2022, in both seasons, during a high and low water period (above and below MQ). Water, sediment and algal samples from 10 water bodies located in the Danube national park, the Lobau and the Donauinsel were taken. Water and sediment samples were analysed for C, N and P and we have determined the function of algae by measuring photosynthesis via PAM fluorometry. We have analysed the diversity of algae by determining algae pigments via HPLC. In this presentation we want to present first results of this ongoing study.

Keywords

benthic algae, pelagic algae, network connectivity, brown food webs, green food webs

Introduction

Floodplains are one of the most diverse and productive ecosystems on this planet (Tockner & Stanford, 2002). For example, the variability of hydrological and morphological water bodies in floodplains is verry high, as for instance oxbows, lakes, lagoons, streams and backwaters can occur (Mihaljević et al., 2015). The floodplains and their diversity are however severely threatened, this can result in a great loss of biodiversity and ecosystem services in the floodplains (Tockner & Stanford, 2002). To further investigate alterations in freshwater ecosystems, suitable bioindicators are needed. Benthic and pelagic algae generally show a short live cycle and respond quickly to environmental changes, which makes them ideal organisms to study variations in connectivity and the resulting changes in river parameters of floodplain systems (WFD; European Commission, 2000; Schagerl et al., 2009; Pfeiffer et al., 2015).

While longitudinal and lateral connectivity are already widely studied in river ecology, little is known about network connectivity (Vannote, 1980; Ward, 1989). Network connectivity is a concept originally developed for landscape conservation planning (Saura & Pascual-Hortal, 2007) and will be used in this study as connectivity concept. This connectivity coincides with hydrological variability, which consequently leads to variations in the chemical and physical conditions in a floodplain system. In turn, these environmental changes affect the algae living in this habitat (Mihaljević et al., 2015). We therefore expect Variations in connectivity and thus variations in the environment to have an influence on the community composition of benthic and pelagic algae. Due to this community dispersal, pelagic and benthic algae in a floodplain can be seen as metacommunities (Leibold et al. 2004; Holyoak et al. 2005; Altermatt 2012; Altermatt, 2013). We therefore hypothesise, that benthic and pelagic algae in floodplains will be more similar in their community composition and function the closer the sites are connected to each other and, or to the main channel along the connectivity gradient. We furthermore suspect connectivity to have an influence, not only on algae, but also on the promotion of green (autotroph-based) and brown (detritus-based) food webs within the aquatic system (Evans-White & Halvorson, 2017). We hypothesise for green food webs to be dominant in well connected systems, while brown food webs will occur in more isolated waterbodies.

However, connectivity is not the sole parameter being considered to have an influence on algae and food webs, which is why morphological parameters are also taken into consideration. Especially benthic algae are suspected to be more influenced by the morphology of floodplain waters, such as the sediment, which they are closely connected to, than by connectivity. We hypothesize however that pelagic algae will be more influenced by changes in the water column, in which they live in, and therefore by connectivity.

Methods

Field sampling took place twice during spring and twice during summer of 2022, two times below and to times around mean flow (MQ). Ten sites were chosen for the study within the Danube National Park, the Lobau and the Danube Island, varying in their connectivity from connected to isolated. The connectivity indices were calculated static (for the whole network) and dynamic (depending on the hydrological connectivity with the Danube) for the study sites. The connectivity indices, used were the: harmonic centrality (Rochat, 2009), betweenness centrality (Barrat et al., 2004) and the probability of the connectivity index (Saura & Pascual-Hortal, 2007). The sampling sites are furthermore either gravel or psammopelal dominated, stones samples were scraped in the laboratory, while psammopelal samples were taken with plexiglass petri dishes (Fig.1.). Additionally, the study sites were characterized by their depth, flow velocity, turbidity, canopy and macrophyte coverages, as well as light.

Figure 15: *Benthic algae collected from psammopelal*

Furthermore, physico- chemical properties were evaluated for the water and sediment of each sampling site. Conductivity and pH of the water were measured with the pH probe HQ Series Multi (Hach Lange) in the field, while the dissolved organic carbon (DOC), dissolved organic nitrogen (DON), ammonium (NH4), nitrate (NO3) and soluble reactive phosphorous (SRP) were analysed for three water samples in the laboratory. Ten samples were taken for the physico-chemical evaluation of the sediment. The evaluation included the determination of SRP, NO3, NH4, C, N and P.

Ten phytobenthos and three phytoplankton samples were taken from each site to analyse structural variables, such as the percentage of organic matter, the ash free dry mass (AFDM), Chlorophyll a (Chl-a), pigments; C, N, P, as well as C:N, C:P, and N:P ratios. Apart from structural variables, functional variables were evaluated for ten phytobenthos samples per site and five phytoplankton samples per site. The functional variables: electron transport rate (ETRmax), the yield and photosynthesis indices were determined with the Diving PAM II (Walz) for phytobenthos, in the field and the Phyto PAM (Walz), for phytoplankton, in the laboratory.

Outlook

The results of this master thesis will evaluate and give new insights how and to what extent two autotrophic communities– pelagic and benthic algae, are controlled by morphology and connectivity (represented as connectivity indices). Additionally, the planed examination of basal food resources will allow to get an overview of brown (more heterotroph) and green (more autotrophic) food webs and their CNP ratios in different connected floodplain areas. These two aspects – effect of morphology or network connectivity on primary producers and basal food resources, will contribute important information for future management measures.

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Reed die-back and conservation of small reed birds at Lake Neusiedl

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Abstract

The reed belt around Lake Neusiedl is one of the largest connected reed areas in Europe, and thus has international importance for the conservation of species depending on this habitat. In the last decades, a decline of reed harvesting has led to the formation of very old reed areas. We investigated how age and structure of degraded reed affect breeding bird species.

We related extensive bird counts of eight species at 111 points to habitat measurements and reed age. Species differed in their preferred age class; for example, Great Reed Warblers Acrocephalus arundinaceus are found mainly in up to 4-year-old reed stands, while Little Crakes Zapornia parva prefer to settle in more than 14-year-old vegetation. We expected some species to be more common in older age classes, but our results demonstrate that large parts of the reed stands become too degraded even for these “old reed” specialists.

Several bird species showed an inverse u-shaped relationship to habitat characteristics associated with reed die-back, e.g. accumulation of broken reed stems, occurrence of matted reed, low vegetation height or open water areas. At present, harvested areas are small and burning of reed is prohibited, and in the future, we expect more reed die-back with declining bird numbers. Missing ice cover in wintertime because of climate warming prevents sustainable cutting of these very old reed stands.

Thus, we recommend the cautious introduction of fire management a cautious introduction of fire management as a measure to secure this unique bird habitat. Global warming also gives rise to a new anthropogenic threat for this ecosystem: an artificial water supply from the neighbouring river Danube to compensate possible future water loss. The main reason is the political will to guarantee high water levels for recreational boating and water sports. Besides a problematic change in water chemistry this hydrological intervention could lead to stagnating water levels with a negative impact on reed growth and to a further acceleration of reed die-back. Therefore, as an adaptation to global warming, we recommend not an artificial water supply but the greatest possible retention of water in the area.

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Vegetation mapping on selected areas of the Hohe Tauern National Park

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Summary

In the years 2020 and 2021, as part of the project "Vegetation mapping on selected areas of the Hohe Tauern National Park", commissioned by the Secretariat of the Hohe Tauern National Park Council, comprehensive vegetation mapping was carried out in three sub-areas of the Hohe Tauern National Park, namely in the Seebachtal (Carinthia), in the wilderness area of Sulzbachtäler (Salzburg) and in Innergschlöss (Tyrol). Under the leadership of REVITAL Integrative Naturraumplanung GmbH, six experienced mappers who had proven themselves at mapping areas at high altitudes, were responsible for collecting data. The results obtained, serve as the basis for the large-scale, interdisciplinary project "Monitoring and research program for long-term ecosystem observation in the Hohe Tauern National Park".

A total of 3,258 biotopes were mapped over a total area of around 158 km² over 180 days using a recording method based on the official biotope mapping of Salzburg. 2,612 biotopes (103.3 km²) were recorded by an on-site survey, which corresponds to over 80 % of the biotopes or over 65 % of the total area. Due to the given impassability, the remaining areas had to be surveyed by means of mapping from the other side of the valley, mapping with binoculars or an evaluation of aerial photographs. Biotopes covering around 146 km² were rated “very high” – the highest nature conservation value that can be awarded – which corresponds to around 92 % of the total area.

A total of 143 different biotope types were mapped, with geomorphologically shaped biotope types such as rocks and screes, but also glaciers, accounting for almost 58 % of the total area. This is followed by high-mountain grassland, including upholstered fields and grass fragments, and snowy soils with 21 %, as well as forests including mountain pine and green alder bushes with 10.5 % of the total area. Other habitats such as water bodies, moors, swamps and springs, grassland and fallow grassland, tall herb meadows, tall grass meadows and felled meadows, woody open land, and bushes as well as dwarf shrub heaths each only account for less than 5 % of the total area, but overall, they make a significant contribution to the habitat diversity in the mapped areas.

Furthermore, 25 FFH habitat types and 11 subtypes of FFH habitat types were recorded, so that more than one third of the FFH habitat types known in Austria are present in the mapping area. 145.3 km² were assigned to an FFH habitat type, which corresponds to almost 91.7 % of the total area. 78.8 % of the recorded habitat areas were classified as conservation grade A (“very good”), 3.2 % with B (“good”) and 18.0 % with C (“moderate to poor”). Realistic management measures (“improvement measures”) are proposed at the conceptual level, especially for areas with conservation grade C, where possible and reasonable.

Using so-called reference recordings, 34,804 data sets of a total of 786 plant species (including subspecies) were collected, which will be included in the database of biodiversity, managed at the

museum Haus der Natur in Salzburg. In addition, 126 occurrences of 22 particularly valuable, i.e., rare or endangered plant species (flagship species) were mapped. Special plants including Myricaria germanica in the Seebachtal, Sparganium angustifolium in the Obersulzbachtal and Salix glaucosericea in the Innergschlöss can be found as flagship species.

All terrain data was entered into a database after extensive checks and test routines, which were handed over to the client together with the final report at the end of the project

Keywords

Vegetation mapping, Hohe Tauern National Park,

Introduction

In the years 2020 and 2021, comprehensive vegetation mapping was carried out in three defined sub-areas of the Hohe Tauern National Park (total 158 km²), namely in the Seebachtal (Carinthia), in the wilderness area of Sulzbachtäler (Salzburg) and in the Innergschlöss (Tyrol). A total of six mappers were used.

Methods

The recording method used represents an adaptation of the method of the official Salzburg biotope mapping. The main mapping contents were: biotope delimitation, biotope types and FFH habitat types (including conservation status), protection status, relief / subsoil / biotope structures, suitability for monitoring, impairments/threats, nature conservation assessment, reference recordings (selective species lists, vegetation units and biotope descriptions), flagship species, photo documentation.

Results

The results obtained serve primarily as a basis for the large-scale, interdisciplinary project "Monitoring and research program for long-term ecosystem observation in the Hohe Tauern National Park". All terrain data was entered into a database after extensive checks and test routines, which were handed over to the client together with the final report at the end of the project.

- 180 field days spent
- 3,259 recorded biotope areas, of which 2,613 biotope areas were mapped by an on-site survey
- 143 recorded biotope types
- 25 recorded FFH habitat types and 36 recorded FFH habitat types including subtypes
- 92 % of the total mapped area was recorded with the highest nature conservation value
- 1,025 reference recordings (plant species lists)
- Collection of 34,804 data sets for a total of 786 plant species
- Recording of 126 occurrences of 22 particularly valuable plant species (flagship species)

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Decay of deadwood – current knowledge on carbon stocks in Austrian forests

Mathias Neumann, Sebastian Echeverria, Hubert Hasenauer

Summary

Decay of deadwood is important for ecosystem functioning, but is understudied in Austrian forests. In a pilot study we collected missing information on deadwood decay, density and carbon and nitrogen content for eastern Austria. Decay class can be assessed in the field and is critical for estimating carbon stocks in deadwood. Methodological considerations, biogeochemical modelling and further field observations are needed for improving our understanding of deadwood dynamics and contribution of deadwood to the carbon cycle.

Keywords

Decomposition, necromass, detritus, soil, water storage, nature protection, European beech, Sessile oak, Norway spruce, Silver fir, Scots pine

Introduction

Deadwood is a prominent part of forest ecosystems. It is important for multiple forest functions, including habitat, water storage, nutrient cycling and carbon storage. Deadwood volume is now routinely measured in many large-scale inventory programs, including the national forest inventory or inventory of nationalparks or nature reserves. We explore here the available knowledge and opportunties for modelling to better understand the decay of deadwood, focussing on carbon (C) and nitrogen (N) content and release. We base our findings on selected case studies on deadwood stocks and dynamics located in eastern Austria.

Methods

We focussed on oak-hornbeam forests, beech forests and mixed spruce-fir-beech forests. Deadwood volume can be quantified, among others, using fixed area plots, sampling by diameter (Bitterlich samples) and transects. Decay classes can be assessed in the field and provide a potent proxy for deadwood density, pore volume, and C:N ratios. We used a modified five-stage decay class system, similar to the system used by the Austrian National Forest Inventory. We collected in pilot studies wood samples across size classes, species and deadwood types. We used both increment cores and wood discs / wedges for collecting wood samples. C and N content was analysed for subsamples using elemental analyzers.

Results

Using C:N as proxy for decomposability suggest that decomposition is non-linear and that advanced decay stages have faster decomposition. Standing deadwood is less decayed compared to lying deadwood and dead stumps and in consequence has different C and N content. Per cubic meter standing deadwood has higher carbon stocks than deadwood on the forest floor due to differences in density linked to decay classes. Our results further highlight that smaller sized deadwood (2-10 cm diameter, often called ‘fine woody debris’) can store substantial amounts of C and N, but are only measured by some forest inventories. Additional field work and modelling can link decay stages with time since death and allow estimating mass and volume loss by decomposing organisms. Non-destructive methods like resistance or conductivity measurements could deliver accurate data on density and internal decay also for strongly decomposed deadwood, that can not be sampled using cores or wedges, as well as for protected forests, where removing samples is not permitted.

For understanding the dynamics between standing and lying deadwood, we will need models that are able to predict the disintegration of trees, considering loss of less stable stem parts, like bark or sapwood. Continuos monitoring systems, including webcams or citizen science approaches may broaden our available knowledge and involve interested societies and stakeholder. We will need more complex models to understand the main pathways for deadwood decay, the effects of climate on decomposition and the role of management in deadwood accumulation and dynamics. Complementing available data with new methods and models will allow us to quantify the capacity of managed and unmanaged forests for deadwood, the carbon sequestration in deadwood and its persistance in the future.

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High-altitude micro-catchments as indicators of global changes: physical, chemical, and biological signals

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Abstract

Aquatic ecosystems and biodiversity are threatened worldwide by global changes (e.g., climate, nitrogen pollution, emerging contaminants) with accelerated changes being observed in mountain regions. While past and ongoing research in Alpine rivers ecology have focused on the effects of retreating glaciers on the ecology of these systems, observations and evaluations of changes and expected ecological shifts in small non-glacial headwaters are not available. Given that non-glacial and low-order headwaters represent the most common elements of Central European stream network, understanding situations and developments in these river types is urgently needed.

This study presents observations of water temperature, water chemistry, periphyton and invertebrate communities in multiple sites along three low-discharge and non-glacial alpine headwater streams. We found that these small streams are warming at high rates within small distances and that the colonization reflects the abiotic conditions and limitations (e.g., increasing biofilm stock from upstream to downstream sections). The results from pigment analyses along the summer seasons indicate that the typical dominance of cyanobacteria in these habitats can be disrupted by short dry conditions, indicated by emerging green algae in the periphyton. Further, we identified Chironomidae as the dominant invertebrate group in all sites (>80% of all invertebrates), confirming their role as initial colonizers in such types of rivers.

Apart from this ecological perspective, we identified appropriate chemical indicators for global changes and excluded others based on the natural variability of different compartments in these natural ecosystems (e.g., nitrate = stable vs. total nitrogen = highly dynamic). Based on the presence of invertebrate species and the known climate-change-vulnerability of European invertebrate species, we identified suitable biotic indicators for small alpine headwaters.

Embedded in the long-term monitoring project of the Hohe Tauern National Park, these long-term observations of micro-catchments will allow quantifying and anticipating ecosystem changes of non-glacial headwaters in mountain regions.

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Channel evolution process in a diamictic glacier foreland: Case study Pasterze/ National park "Hohe Tauern"

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Summary

High mountain areas are heavily affected by global warming and glacier retreat. In response to changing hydrology, the altered hydraulics of proglacial rivers will significantly impact future glacifluvial processes and channel development. Furthermore, the increasing availability of metastable and poorly sorted sediment has major implications for future proglacial river morphology. Based on runoff forecasts by 2050, channel evolution processes at the forefield of Austria's biggest glacier Pasterze in the national park *Hohe Tauern* were investigated. Using a high-resolution digital elevation model (DEM), sampled channel bathymetry, and bedload transport formulas, the predictions show clear stabilization tendencies of the proglacial channel with increasing distance to the glacier terminus. Already detectable big non-fluvial deposits started to form an erosion-resistant pavement layer preventing further channel bed incision. This finding leads to the revision of the conceptual model of proglacial sediment cascades, as fluvial subsystem processes are subordinated in proglacial channel evolution.

Keywords

proglacial morphodynamics, channel evolution, pavement layer formation; sediment cascade model

Introduction

Glacier retreat and permafrost decline cause major changes in high mountain areas (Harris et al., 2019; Fischer et al., 2018). Deglaciation has accelerated in recent years (Sommer et al., 2020), which continuously increased formerly glaciated areas, characterized by high geomorphological activity (e.g., Avian et al., 2018). This area between the LIA moraine and the actual glacier terminus is termed proglacial (Heckmann & Morche, 2019). Thus, proglacial areas are steadily increasing, where poorly sorted sediment ranging from silt up to boulder (diamictic till) from an outwash plain. This behavior in combination with the typical diurnal and seasonal meltwater fluctuations characterizes proglacial areas as highly dynamic fluvial systems (Baewert & Morche, 2014). While braided channels emerge in direct glacier proximity, parameters like channel slope, sediment composition and potential confinement or channel bed incision turn them into single-thread channels with increasing distance to the glacier terminus (Gurnell et al., 1999). All this glacifluvial sediment reworking is considered in a generalized way as the last transport process of a proglacial sediment cascade model. However, if the transport capacity of the proglacial channel will increase due to changing runoff conditions triggered by global warming or non-fluvial sediment will support proglacial channel stabilization, was investigated in this study.

The objective of this investigation was proglacial channel evolution triggered by global warming. For this purpose, the proglacial part of the river Möll at the forefield of Austria's biggest glacier Pasterze was investigated. Located in Carinthia in the national park Hohe Tauern, this study area is characterized by poorly sorted sediment forming a diamictic outwash plain, which covers big quantities of dead ice. As this outwash plain is decoupled from the surrounding active hillslopes, the glacifluvial transport system is transport-limited (Geilhausen et al., 2012). Confined by debris-covered dead-ice landforms, the investigated proglacial channel is composed of four distinct sections: (i) a flat headwater section near the glacier terminus, (ii) a transition section into (iii) the canyon and (iv) the flat outlet into the delta area of the lake 'Pasterzensee' (Fig. 1). As typical for glacial discharge regimes, the runoff shows high summer and low winter runoff and strong seasonal and diurnal fluctuations.

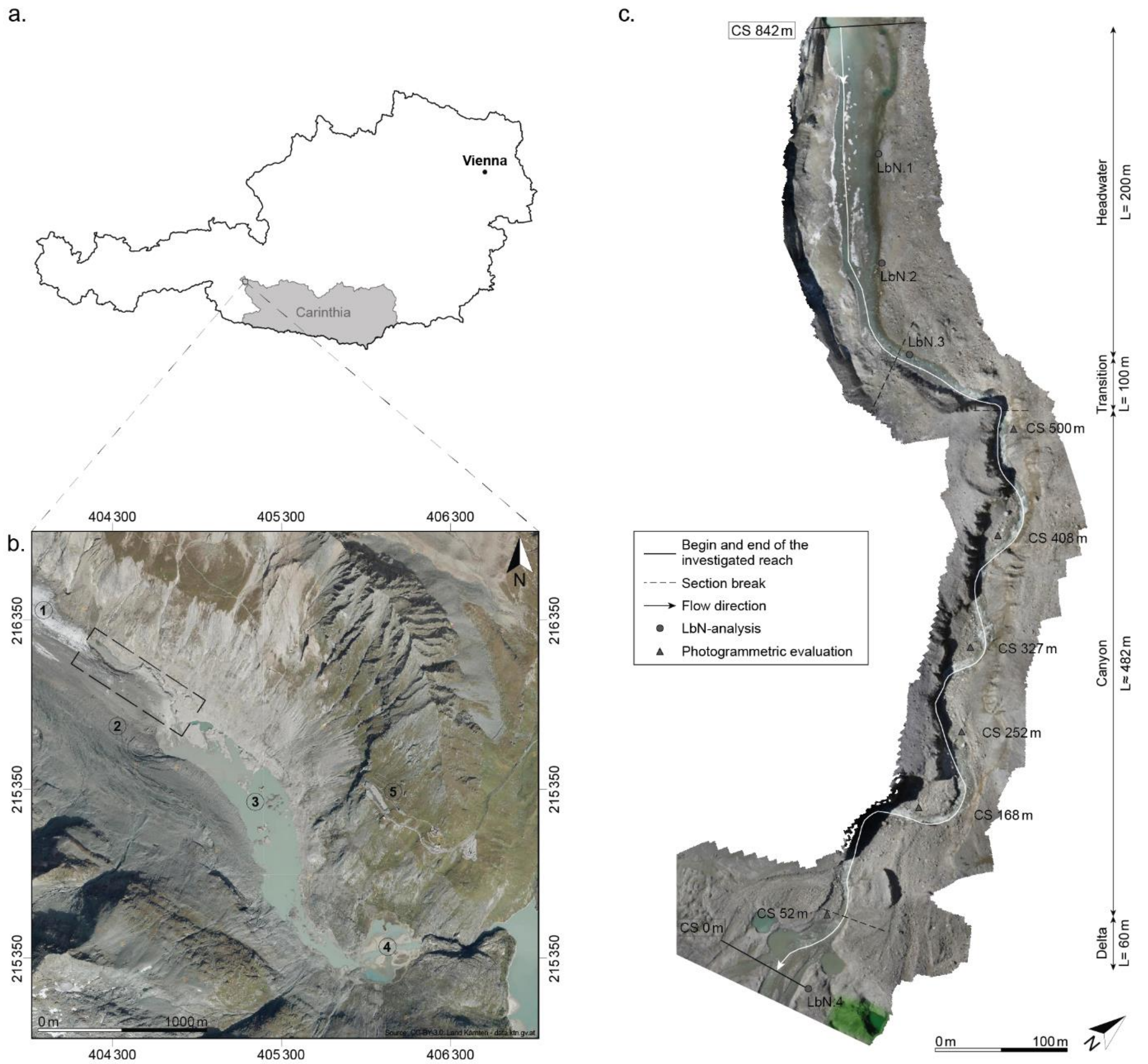

Figure 16: *Location of the study site:* ***(a.)*** *Carinthia, Austria,* ***(b.)*** *proximal forefield of the Pasterze Glacier, where the dashed rectangle indicates the proglacial river Möll: (1) glacier tongue (clean part), (2) glacier tongue (debris-covered), (3) Pasterzensee, (4) Sandersee, (5) Kaiser-Franz-Josefs-Höhe;* ***(c.)*** *study reach, based on the UAV survey and supplemented by the measuring sites for sediment analysis.*

Methods

The basis for this investigation was a high-resolution digital elevation model (DEM) carried out by an unmanned aerial vehicle (UAV, type: hexacopter KR615) during low flow conditions in autumn 2018. To achieve the best resolution possible for geometry acquisition and photogrammetric sediment analysis in the inaccessible canyon, the mapping was done at two flight altitudes (55 m and 20 m above the channel bed). To improve the geodetic accuracy of the latter DEM and orthomosaic, ground control points (GCPs) were placed near the investigated channel. For creating the DEM, the software PhotoScan by Agisoft was used to create a 3D point cloud following the principle of Structure-from-Motion (SfM). The GCPs (mapped with an RTK device) were used for georeferencing and accuracy assessment of the DEM. Finally, the DEM was calculated (478 231 187 points; 3940 points m^{-2}) and an orthomosaic arranged (1.59 cm px^{-1}). The accuracy assessment by the GCPs led to a root-mean-square-error (RMSE) of 0.056 m (X_{RMSE}= 0.025 m; Y_{RMSE}= 0.044 m; Z_{RMSE}= 0.024 m).

The channel bathymetry was sampled according to the commonly used method for gravel-bed mountain streams according to Fehr (1987). In the accessible sections (headwater and delta area), the line-by-number method was applied. In the inaccessible canyon, the sediment analysis was done photogrammetrically according to Fehr (1987) on the high-resolution images taken during the UAV mapping.

For modeling the hydraulic parameters (e.g., bed shear stress, energy gradient) with the predicted discharge by 2050, a hydrodynamic numerical 1D model was set up. The modeling results were then compared to the calculation results according to bedload transport formulas for mountain streams. Without big roughness elements in the headwater, transition section and delta area, Eq. (1) by Rickenmann (1990, 1991) was used. To consider the big roughness elements in the canyon, Eq. (2) by Rickenmann & Badoux (2008) with the reduced energy gradient *(I_{red})* was applied.

$$q_c = 0.065 * \left(\frac{\rho_s}{\rho_w} - 1\right)^{1.67} * g^{0.5} * I_R^{-1.12} * d_{50}^{1.5} \qquad (1)$$

The specific discharge *(q_c)* is a function of the characteristic grain diameter *(d_{50})*, the energy gradient *(I_R)* and the ratio between sediment *(ρ_s)* and fluid density *(ρ_w)*.

$$I_{red} = I_R * \left[\frac{n_r}{n_{tot}}\right]^a \qquad (2)$$

The reduced energy gradient *(I_{red})* is calculated by the ratio of the grain roughness *(n_r)* and total roughness *(n_{tot})*, *a*= 1.5 is a constant.

Results

The sediment analysis shows a downstream coarsening of the grain size distribution ($d_{50.m:LbN.1}$= 29.9 mm < $d_{50.m:LbN.2}$= 49.6 mm < $d_{50.m:LbN.3}$= 79.6 mm) with almost the same distribution in the delta area ($d_{50.m:.LbN.4}$= 40.3 mm) as in the headwater (Fig. 2). The analysis of the photogrammetric UAV-based sediment measurements for six characteristic points in the canyon (triangles in Fig. 1) indicate a much coarser sediment composition as in the headwater ($d_{50.m:CS500}$= 202.5 mm; $d_{50.m:CS408}$= 219.1 mm; $d_{50.m:CS327}$= 241.2 mm; $d_{50.m:CS252}$= 201.3 mm; $d_{50.m:CS168}$= 211 mm; $d_{50.m:CS52}$= 116.3 mm). Large particles were measured in every characteristic point (up to $d_{90.m}$ = 850 mm), while the largest grain size was detected in the steepest part of the entire proglacial channel at the beginning of the canyon (CS 512 m; *b*= 3700 mm).

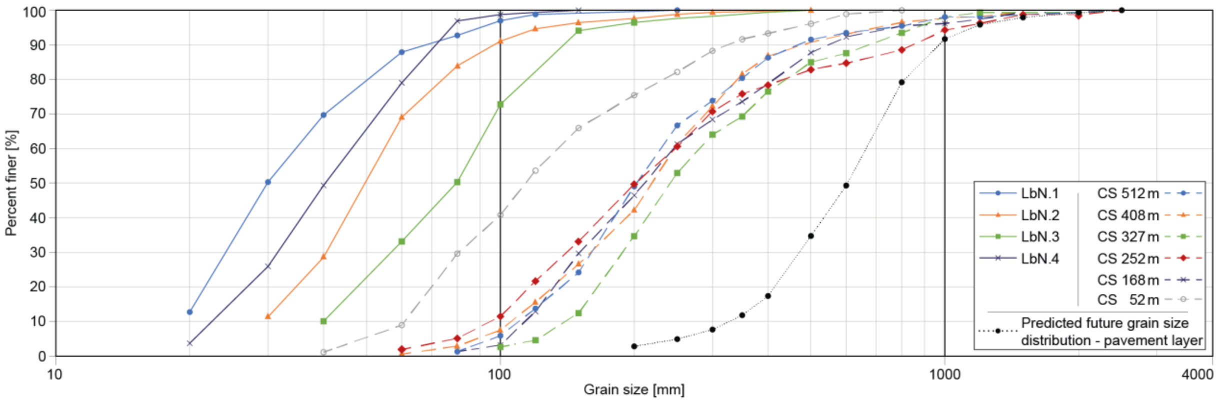

Figure 17: *Partial grain size distribution curves:* ***(a.)*** *four line-by-number (LbN) analyses (continuous lines) and photogrammetric evaluations (dashed lines) for six characteristic points in the inaccessible canyon.* ***(b.)*** *the dotted black curve refers to the potential future grain size distribution of the pavement layer.*

The comparison of the calculated characteristic grain sizes ($d_{50.c}$, $d_{50.r}$) and the grain size measurements ($d_{50.m}$) shows two contrary results in the longitudinal course of the proglacial channel. Basically, the seasonal course of the modelled transport capacity runs parallel to the typical glacial discharge regime: smaller transportable grain sizes in the cold months and the largest transportable grain sizes in the ablation season. According to decreasing glacier ice volume due to global warming in the future, the highest mean monthly discharge by 2050 is predicted for June 2030. Therefore, Fig. 3 shows the calculation results according to the predicted runoff conditions in 2018 *($Q_{m.max.2018}$)* and the highest predicted discharge in 2030 *($Q_{m.max.2030}$)* compared to the grain size measurements. While in the headwater and transition section the theoretical transport capacity of the highest predicted discharge will exceed the measured grain size distribution (up to $d_{50.c}$= 59.4 mm > $d_{50.m}$= 49.6 mm; Fig. 3a), the opposite was observed for the canyon. In all investigated six characteristic points in the canyon (triangles, Fig. 1), the calculated characteristic grain sizes with the reduced energy gradient *(I_{red})* are smaller than the measured grain size composition on the high-resolution images (up to $d_{50.r}$= 220 mm < $d_{50.m}$= 241.2 mm; Fig. 3b). The comparison of the calculation and measurement results shows for all characteristic points in the canyon that the measured characteristic grain sizes *($d_{50.m}$)* theoretically exceed the calculated transportable characteristic grain sizes *($d_{50.r}$)* by the order of 1.1-1.6 at the maximum predicted discharge *($Q_{m.max.2030}$)* in June 2030 (Fig. 3).

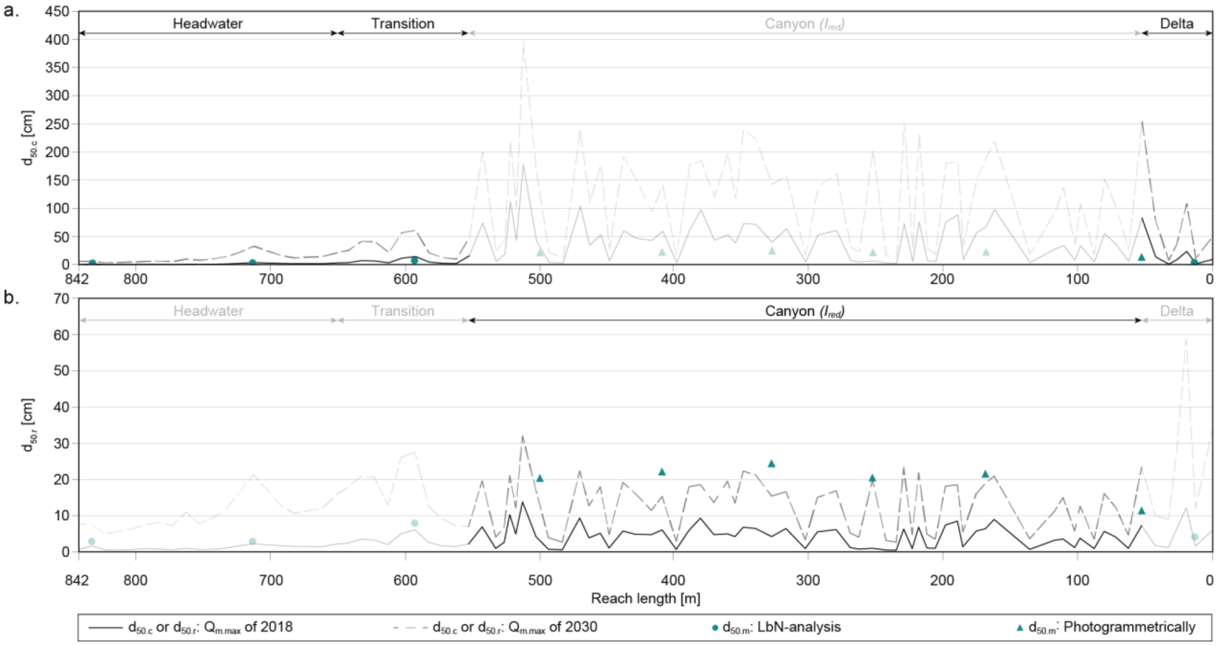

Figure 18: *Longitudinal course of the calculated characteristic grain sizes (flow competence) according to **(a.)** Rickenmann (1990, 1991) ($d_{50.c}$) and **(b.)** Badoux & Rickenmann (2008) with the reduced energy gradient ($d_{50.r}$). The transparently displayed parts of the graphs are beyond the scope of the respective approach and invalid for the respective sections. Each graph is supplemented by the measured characteristic grain sizes ($d_{50.m}$) on-site (circle) and those, evaluated photogrammetrically in post-processing (triangle). The results refer to the maximum predicted mean monthly runoff until 2050 ($Q_{m.max.2030}$) compared to 2018 ($Q_{m.max.2018}$).*

This predicted limited transport capacity after the ablation season in 2030 will develop a new in-stream storage type within the fluvial system of the sediment cascade model, defined by the erosion-resistant pavement layer composed of non-fluvial sediment (grey highlighted in Fig. 4). This extension by the new in-stream storage type (non-fluvial deposit) is accompanied by the refinement of the fluvial system of subsystem IV of the sediment cascade approach (dotted frames in Fig. 4). Sediment reworking by glacifluvial erosion leads to the exposure of non-fluvial sediment, which contributes remarkably to proglacial channel stabilization. That this development is already underway is visible in measurements of single non-fluvial boulders (*b*≥ 1000 mm) in all characteristic points in the canyon section. The establishment of an erosion-resistant pavement layer is considered as one of the last development stages in proglacial channel evolution and leads to a differentiation regarding the stabilization degree in the longitudinal course of proglacial channels. While braided channel sections in direct glacier proximity show transport-limited conditions, already incised river sections with greater distance to the glacier terminus are (partly) supply limited ('developed channel'). Although the changing runoff characteristics will limit bedload transport and the final development stage of an established pavement layer will prevent further channel bed incision, high magnitude/low frequency or heavy precipitation events will still allow lateral sediment supply.

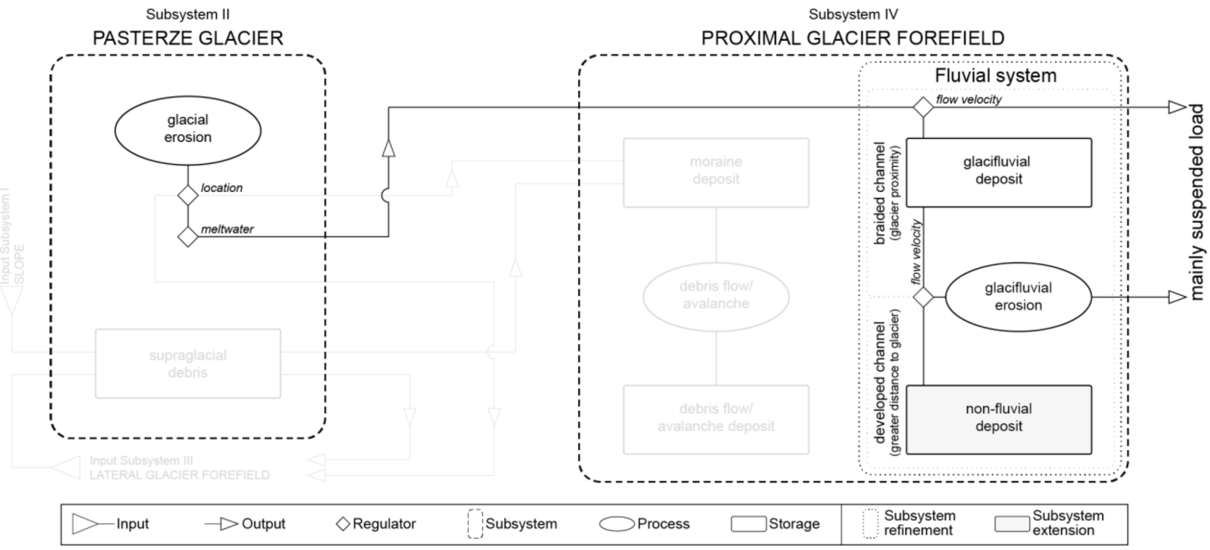

Figure 19: *Refinement (dotted frames) and extension (grey highlighted in-stream sediment storage type) of the fluvial system within subsystem IV of the conceptual model of a sediment cascade for proglacial catchments. Due to the decoupled subsystems in the catchment (Geilhausen et al., 2012), the grey lines and connections only complete the cascade model but are irrelevant to the objectives of this study. Modified after Geilhausen et al. (2012).*

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Alpine plant diversity monitoring in protected areas: The GLORIA observation network after 20 years of operation

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Summary

High mountain ecosystems might be less vulnerable to progressive anthropogenic impacts of global economies, because of their rugged topography, which impedes exploitation, but facilitates the availability of cold refugial habitats. Eutrophication on the regional and climate change on the global level, however, also reach pristine mountain regions, where the treeless alpine zone often only covers small areas, which commonly hosts many small-ranged and cold-adapted species. Over the past 20 years, the international GLORIA network (https://gloria.ac.at), therefore, has developed a standardised monitoring protocol for alpine plants and has implemented a global site-based network. Here we show the relevance of protected areas for the operation of its permanent plot monitoring, we focus on GLORIA's role as nexus of interdisciplinarity and show three different monitoring results of high relevance in a conservation context. GLORIA's core protocol, the Multi-Summit approach, has been incorporated into the US National Park inventory and monitoring programme. Outside of the USA, sites are more commonly run by research institution, but are often situated within protected areas. GLORIA's activities go well beyond vascular plant monitoring. Stimulation effects led to the emergence of interdisciplinary studies, including zoology, soil ecology and socio-economy, as demonstrated by the example of the tropical Andes. European data showed that increases in species numbers have accelerated in coincidence with warming rates. When looking at species' abundances, however, progressing declines of cold-adapted species have been observed. Finally, we show that small-ranged species have declined concurrently with gains of large-ranged nitrophilous ones in lowland grassland, forests as well as in the alpine zone of Europe.

Keywords

alpine plants, climate change, eutrophication, biotic homogenisation, long-term monitoring, protected areas, species range shifts

Introduction

Protected areas should rapidly gain in importance in the face of the unabated expansion of unsustainable practices of global economies, including forestry- and agro-industries, and the associated degradation and shrinkage of near-natural ecosystems (Ripple et al. 2022). Mountain regions might be on the safer side, compared to lowland regions, because a rugged topography provides some protection from detrimental land-use and exploitation and may provide cold-climate refugia (Scherrer & Körner 2012; Graae et al. 2018). Some anthropogenic impacts, however, come without roads and cable cars, such as pollution on a regional, and climate change on a global level, irrespective of remoteness. Further, mountain regions commonly host highly scattered and fragmented ecosystems, where the upper zones are the smallest in spatial extent, populated by often small-ranged, cold-adapted species, which are most vulnerable to climate change impacts. Thus, the risk of biodiversity losses as well as the need to know about magnitudes and velocities of anthropogenic habitat transformation is exceptionally high in alpine regions.

This paper provides an update of the activities of the Global Observation Research Initiative in Alpine Environments (GLORIA), an Austrian initiative emerging at the turn of the century, dealing with long-term monitoring of alpine biodiversity (of vegetation and vascular plants in particular) in the context of climate change (https://gloria.ac.at; Pauli et al. 2015). The initiative rapidly turned into a site-based network and international monitoring programme which predominantly operates in protected areas, including many national parks. Since the last presentation at an Austrian National Parks Symposium, in Mittersill in 2013 (Pauli et al. 2013), the network has expanded to ~130 regions and reached the level of repeated resurveys on all populated continents.

Methods

First, we provide an overview of GLORIA monitoring activities in mountain protected areas, followed by examples where protected area authorities play a core role in conducting field surveys for biodiversity monitoring.

Second, we focus on GLORIA's role as a nexus of interdisciplinary approaches, ranging from monitoring of different organism groups, soil ecology to socio-ecological studies, with examples from different continents, and on synergies through collaboration with other research initiatives.

Third, we show some examples of changes in plant diversity revealed through monitoring, which are of high relevance in a nature conservation context. In this part we concentrate on Europe, because of the availability of the longest biodiversity time series from permanent plots both regarding GLORIA sites as well as other monitoring networks.

Results

Biodiversity monitoring in protected areas

Co-operations between research institutions and protected area managements hold a strong potential for continued long-term biodiversity monitoring in the context of climate warming. The protection status of habitats allows for a long-term perspective of monitoring without disturbance from direct land-use activities. In turn, monitoring time series inform about magnitudes and velocities of vegetation changes driven by large-scale anthropogenic impacts and, thus, enable for designing targeted conservation measures (Pauli et al. 2013). Protected area managements often only have low budgets for monitoring and research activities. GLORIA's Multi-Summit approach, being designed as low-budget monitoring, thus, can be an attractive opportunity for protected areas to join a globally comparable observation effort. For example, in the United States, the majority of GLORIA sites is situated within national parks. Organized by federal institutions (USGS - United States Geological Survey) and regional co-operations such as the Rocky Mountain Inventory and Monitoring Network, GLORIA's Multi Summit approach is incorporated in the National Park Service monitoring protocols (National Park Service 2021). Outside of the Rocky Mountains, GLORIA monitoring is operated by a research network (GLORIA Great Basin, 2022) in close cooperation with national park authorities. Unlike in Europe, the long-term maintenance of GLORIA sites is predominantly ensured by the protected area authorities rather than by research institutions, which often have rapid turnover rates of researchers. There are, however, also some notable examples in Europe, such as the Swiss National Park (Wipf & Scheurer 2016) and the National Park Gesäuse, where monitoring activities including GLORIA are directly organized by the national parks. In Asia, notably in the Himalaya region, national parks are relevant as locations of GLORIA sites, which, however, are coordinated by regional or foreign research institutions, such as the Missouri Botanical Garden.

Nexus of interdisciplinarity

GLORIA's core approach encompasses the monitoring of vascular plant diversity and vegetation, as the minimum requirement of the establishment of a GLORIA region. The GLORIA field manual (Pauli et al. 2015), however, contains a number of additional, optional approaches, ranging from monitoring of invertebrate and vertebrate animal groups to soil variability and socio-economic and cultural aspects in GLORIA regions. A noteworthy example showing GLORIA's role as a nexus of interdisciplinarity is the development in the tropical Andes (Red GLORIA Andes 2022). Here, activities besides the core approach include a focus on distribution patterns of Andean alpine plants (Cuesta et al. 2020), experimental studies using open top chambers for passive warming as well as nutrient additions (Ecuador and Peru), and furthermore plant phenological and pollination monitoring is pursued at GLORIA sites in Venezuela. Moreover, herpetological monitoring has been conducted in view of the rapid expansion of the chytrid disease of amphibians (Seimon et al. 2017) and socio-economic studies (including workshops with the campesino population in GLORIA regions of Bolivia and Peru) have been performed with a focus on variability of land-use impacts. Outside of South America, arthropod monitoring on GLORIA summits was initiated at different locations such as in California as well as in the Russian Ural mountains. Studies on soil ecosystems have been done at Pyrenean GLORIA sites (Jimenez et al. 2019), on soil microbial diversity on Swiss GLORIA summits (Adamczyk et al. 2019) an on soil microbial and soil meso fauna diversity at the GLORIA master site Schrankogel in the Tyrolean Alps (Winkler et al. 2018; Praeg et al. 2019). Finally, a large European Research Council (ERC) project, MicroClim, has commenced in 2021. The project assesses the thermal micro-niches of alpine plant species in the context of projected biodiversity losses through ongoing climate change. It combines so far separate research strand of experimental approaches, predictive modelling and monitoring, where the latter component is based on the GLORIA-Europe network and the GLORIA master site Schrankogel.

Observed plant diversity changes

Here we present three recent monitoring studies, based on GLORIA data, combined with data sets from other European networks. Their results are of high relevance in a nature conservation concern, although they show different, partly contrasting features of anthropogenic biodiversity change.

The first one deals with changes in vascular plant species numbers in summit areas, by bringing together the new and old data from all historical alpine summit study sites across Europe and GLORIA data from the same regions (M. Steinbauer et al. 2018). Covering a timespan of over a century, data not only showed that summits usually experienced a net-increase in species numbers, but that this increase has accelerated during the recent decades. The rate of increase was remarkably synchronized with the degree of anthropogenic warming. This suggests that the amplified temperature rise as significantly boosted an upward migration of plant species, which leads, at least transitionally, to a local increase in species numbers. Over the longer term, however, the same process is expected to lead to competitive displacement of cold-adapted short-stature species, which are restricted to the zone above the alpine treeline.

The second study shows that species declines are already observable with monitoring data from high elevation sites from the recent past. Repeated permanent plot surveys of the abundance of species in high-alpine to subnival plant assemblages at the GLORIA master site Schrankogel in the central Alps over a 20-years period provided a differentiated picture of species-specific directional changes. While some species have been gaining in abundance and, thus, fitting to the results of the above pan-European study, virtually all specialist species which populate the highest and coldest elevations showed a continued decline in abundance – i.e. the area they cover has been shrinking from 1994 to 2004 and further to 2014 (K. Steinbauer et al. 2020). The overall change in the vegetation composition indicates an increasing thermophilisation of alpine communities (i.e. a higher ratio of warm-demanding to cold-adapted species), but also a shift towards a community adapted to drier soil conditions (Lamprecht et al. 2018). Although the alpine zones of the European Alps are exposed to a moderate to humid climate, warming leads to higher evapotranspiration rates and, thus, can lead to increasingly drier conditions, even without a decrease in precipitation. Drought effects may cause critical impacts to a vegetation which is not adapted to a dry summer season (Rosbakh et al. 2017).

The third study compared alpine summits (GLORIA sites) with understory vegetation of protected forest ecosystems and species-rich lowland grassland in terms of species gains and losses with respect to the overall distribution of species (Staude et al. 2022). The three ecosystem types, distributed over the wider central part of Europe, showed different patterns of change, with net losses in species numbers in lowland grassland and forests, but net gains on alpine summits. Surprisingly, however, all three ecosystem types coincided in that smaller-ranged species showed displacements by larger-ranged ones. At the same time, communities shifted to more nutrient-demanding species, with species from nutrient-rich habitats having larger distribution ranges. Worryingly, these processes did occur in protected sites, located away from industrial agriculture and tree plantations. Obviously, increased and accumulating nutrient input from agricultural sources and combustion processes had effects across most of the central part of Europe, irrespective of the protection status. In alpine ecosystems, combined effects of higher temperatures and a warming-related better availability of nitrogen is probably the driver leading to similar effects as in lower-elevation ecosystems. Both eutrophication as well as climate change have shown to operate as highly potent drivers of biotic homogenisation, forcing ecosystems to become more equal to each other.

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Identifying hot spots and hot moments of fine sediment connectivity on agricultural hillslopes of the Fugnitz catchment (Thayatal National Park region) using sediment transport modeling and network analysis

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Summary

Impacts of intense agricultural land use in the Fugnitz catchment are reflected in high rates of soil erosion and fine-grained sediment and nutrient inputs from hillslopes to channels. The material is further propagated through the Fugnitz channel network until reaching the Thayatal National Park. To manage this problem effectively, it is necessary to identify sediment sources, sinks, and the pattern of linkages in pathways where sediment is transported - within hillslopes, between hillslopes and channels, and along the channel network. The concept of connectivity is an emerging approach that can help address off-site impacts of soil erosion by describing and quantifying the efficiency of sediment transfer between these different zones of the sediment cascade. Multiple studies have assessed soil erosion and sediment connectivity in the Fugnitz catchment using field surveys and soil erosion modelling, while recent literature in connectivity studies adopted network-based approaches which have been considered a major advance in the concept. This study aims to assess the use of a combined sediment transport modeling and network approach in identifying hot spots and hot moments of fine sediment connectivity within selected agricultural hillslopes that are laterally connected to the Fugnitz channel network. Sediment transport modeling was done using the process-based MAHLERAN model (Wainwright et al., 2008). Simulated results were then translated into an adjacency matrix and its corresponding network graph – composed of nodes and links representing individual geomorphic units and the fluxes between them as connected through runoff and sediment pathways. Structural properties of this network were finally quantified using network-analysis tools in MATLAB. Results show distinct patterns and pathways where sediment transfer is relatively more efficient and thus can be useful to designate connectivity hotspots where interventions may be targeted to mitigate on- and off-site impacts of soil erosion.

Keywords

sediment connectivity, Nationalpark Thayatal, network analysis, soil erosion modeling

Introduction

Soil erosion is a problem of increasing global significance due to its threat to food production through intensive agriculture – a key driver that further drives erosional processes (Borelli et al., 2020; Parsons, 2019). On-site problems related to soil erosion in agricultural areas include soil loss and soil degradation, consequently affecting agricultural productivity. However, water-mediated soil export of these eroded material also lead to off-site impacts through fine-sediment input into the river network, eventually leading to economic damages, e.g. as muddy floods in towns, and environmental damages, e.g. freshwater pollution and eutrophication, damage to riverine habitats, or the loss of water storage capacity in reservoirs (Boardman et al., 2019; Poeppl et al., 2019). Thus, it is important for effective catchment management to identify the material transfer from sediment source areas, their pathways, and their potential sinks, along with the pattern of how these zones are linked (Poeppl et al., 2019; Poeppl et al., 2020; Najafi et al., 2021). „Connectivity thinking“ plays an important role to address this need.

While there is a long history of related concepts in geomorphology, connectivity research began to develop increased interest at the start of the 21st century, with new concepts emerging to understand geomorphic system complexity and related process feedbacks (Poeppl et al., 2017; Turnbull et al., 2018). In many disciplines, connectivity is used as a framework for representing connections and flows between different parts of a system (Pearson et al., 2019) which has been a „transformative concept“ in understanding complex dynamic systems (Turnbull et al., 2018). In geomorphology, Bracken et al. (2015) defines sediment connectivity as „[…] the integrated transfer of sediment across all possible sources to all potential sinks over the continuum of detachment, transport and deposition […]“. Through a sediment connectivity framework, possible responses of the system to disturbances and the degree that these responses are propagated throughout the system – and the trajectories of system change – are considered, and thus useful for river and catchment management (Keesstra et al., 2018; Poeppl et al., 2020).

Sediment connectivity has both structural and functional components. Structural connectivity (SC) is the spatial organisation of system elements and their characteristics, e.g. assemblage of landforms, while functional connectivity (FC) refers to the interactions and relationships between structural components, e.g. fluxes of matter or processes linking adjacent areas.

Key challenges remain in the study of connectivity in geomorphic systems, including how systems organise processes at different spatial and temporal scales that lead to emergent behavior or structures (Turnbull et al., 2018). Here, multi-method approaches can be used to derive relationships between SC and FC. However, while measurement of SC is well-established by measuring the morphology of the landscape, direct measurement of FC is still limited, if not available. Only snapshots of information are often available to infer connectivity and modeling approaches are used as a surrogate for direct measurements of FC (Turnbull et al., 2018).

A major development in connectivity analysis in geomorphic systems has been the adoption of network analysis which has been extensively used in the analysis of connectivity in different complex systems for varying disciplines (Pearson et al., 2018). Turnbull et al. (2018) argues that disciplines that more advanced in using network-based approaches appear to be less limited by the key challenges common in connectivity analyses. Recent applications in geomorphology include work in agricultural and alpine catchments (Heckmann and Schwanghart, 2013; Fressard and Cossart, 2019), river deltas (Tejedor et al., 2015; Passalacqua, 2017), and open coasts (Pearson et al., 2020).

The Fugnitz River is a mixed-load perennial stream that drains a medium-sized catchment approximately 140 km^2 directly within the boundaries of the Thayatal National Park. The catchment is dominated by agricultural areas from the upper and middle reaches of the river, mainly for cultivation of crops under conventional management. The impacts of this setting is reflected in the high rates of soil erosion and associated fine-grained sediment input into the channel network (Poeppl et al., 2012; Poeppl et al., 2019; Luetzenburg et al., 2020). Consequently, these leads to degradation of aquatic habitats due to fine-sediment accumulation. Previous studies regarding sediment connectivity in the Fugnitz catchment included field mapping (Poeppl et al., 2012; Poeppl et al., 2019, Poeppl et al., 2020), statistical analyses (Poeppl et al., 2012), process-based modelling (Poeppl et al., 2019; Poeppl et al., 2020; Luetzenburg et al., 2020)

This study aims to assess the use of a combined sediment transport modeling and network approach in identifying hot spots of fine sediment connectivity within an agricultural hillslope that is laterally connected to the Fugnitz channel network.

Methods

2.1 Field methods

Field surveys and soil sampling were done on May 2022 in a 0.08 km^2 hillslope to derive inputs for model parameters. Field surveys include aerial image acquisition using a consumer-grade unmanned aerial vehicle (UAV) referenced to a real-time kinematic global navigation satellite system (RTK-GNSS) survey of ground control points (GCP) taken with the same set of flights.

To further differentiate soil properties and surface cover spatially, the study area was divided into three zones based on their position in the hillslope profile – (1) the top slope, covering the summit until the shoulder, (2) the backslope, and (3) the footslope and the toeslope. Boundaries between zones were delineated based on breaks in slope and change in slope gradient. Infiltration rates were measured once for each zone using a double-ring infiltrometer. For each zone, six undisturbed soil samples were also taken using 100 cm^3 metal rings for bulk density and subsequent soil moisture measurements. On the other hand, three grab samples were taken for each zone for grain size analysis.

2.2 Field data and sample processing

UAV-acquired images were georeferenced to GCPs and were then used to generate a digital elevation model and a corresponding orthoimage using Structure-from-Motion photogrammetry in Pix4DMapper (Pix4D SA, Switzerland). Vegetation and pavement cover was derived from orthoimages and verified with field observations. Ring samples were weighed for initial bulk density and subsequently oven-dried until constant weight. The bulk density for dried samples were used to derive porosity based on a particle density value of 2.65 g/cm^3 (Haan et al., 1994). Particle size distribution was acquired using wet sieving analysis for coarse particles and a pipette extraction method prescribed by Austrian Standards for fine particles (ÖNORM L 1061-2, 2002).

2.3 Process-based modelling

A process-based model for runoff and erosion (MAHLERAN; Wainwright, 2008) was used to simulate a 44-mm rainfall event at the study area that lasted 2 hours with intermittent intense spells. Simulations were tested for a scenario where saturated soil moisture has been reached, thus with conditions conducive for runoff generation. Inputs used for model parameters came from primary data acquired in previous steps and from literature values based on soil texture. Due to the large spatial extent of the study area, the resolution of the DEM used was resampled to 1m to address computational limitations, especially in the subsequent network analysis. Sensitivity analyses was performed to assess changes in discharge and sediment transport magnitudes with varying parameter values.

2.4 Network analysis

The structure of a flow network with the same routing patterns as MAHLERAN outputs (i.e. discharge and sediment transport) was constructed in MATLAB. Each pixel in the DEM was translated into a node while an edge was created between adjacent cells (nodes) by finding a neighbouring pixel in one of the four cardinal directions with the steepest descent. Functional attributes, i.e., total water and total sediment transported per cell, from MAHLERAN outputs were added as node attributes to create discharge and sediment transport networks. Using the constructed networks, betweenness centrality was quantified for each node to identify its influence to the overall network.

Results

The highest total event discharge and the highest total sediment transported according to process-based modelling results can be found at the outlet which shows that all connected areas eventually move their material, i.e., water and sediment, towards and through the lowest point of the connected pathways. Figure 1 shows the spatially-referenced network representation of the simulated discharge and sediment transport, re-oriented with the outlet at the bottom, along with the magnitude of total event discharge and total sediment transport.

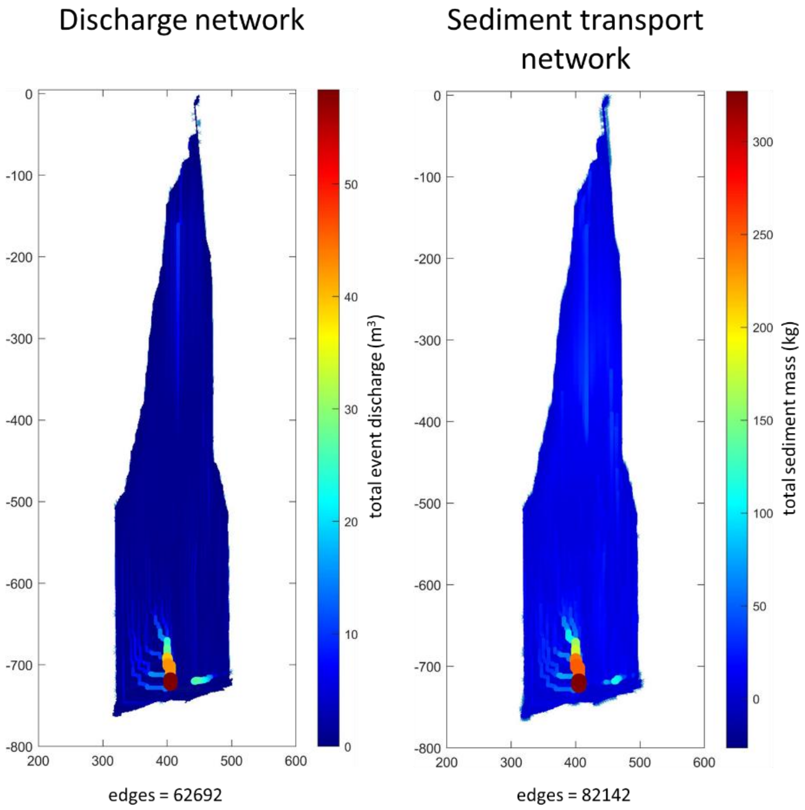

Figure 1. Discharge and sediment transport outputs from the MAHLERAN simulation represented as a network.

Betweenness centrality (BC) in each network was subsequently assessed. In river networks – typically exhibiting a tree-like network structure – this connectivity metric can be interpreted as environmental fluxes being "controlled" by specific nodes (Sarker et al., 2019). Similarly, hillslope networks are tree networks and BC has been used in this study to identify hotspots where water and sediment may be more efficiently transmitted to the rest of the area and ultimately, to the outlet. The application of betweenness centrality in the study area reveals the node (or set of nodes) with the highest BC score which is proximal to the outlet relative to the whole hillslope for both functional networks of discharge and sediment transport, and follows the pattern of the structural network as well (Figure 2). It is important to note that the points identified with the highest BC score does not necessarily coincide with points with the highest magnitude of fluxes but instead along one of its main pathways, and thus could have an implication in the success of management measures that are heavily impacted by the magnitude of fluxes (e.g. buffer strips and sediment fences; Poeppl et al., 2020) These high betweenness locations can be characterised as locations where flow pathways converge as well as where more source areas upstream are connected to the outlet by the transfer of material through these locations.

While the structural and functional networks may differ slightly in terms of the number of edges due to disconnections from areas with very low fluxes – brought about by environmental conditions and their topographic configuration, the location of the hotspot does not change due to the BC being a topologybased measure and possibly with the most connected areas being part of the main pathways that generate enough fluxes to remain connected during a 40-mm rainfall event.

Other connectivity metrics are available in graph theory once structural and functional networks are created and thus the approach potentially allows for a deeper understanding of connectivity in agricultural hillslopes. Betweenness centrality is a topological measure that could identify locations where interventions may be targeted to limit the most efficient transfer of material from the hillslope to the river network.

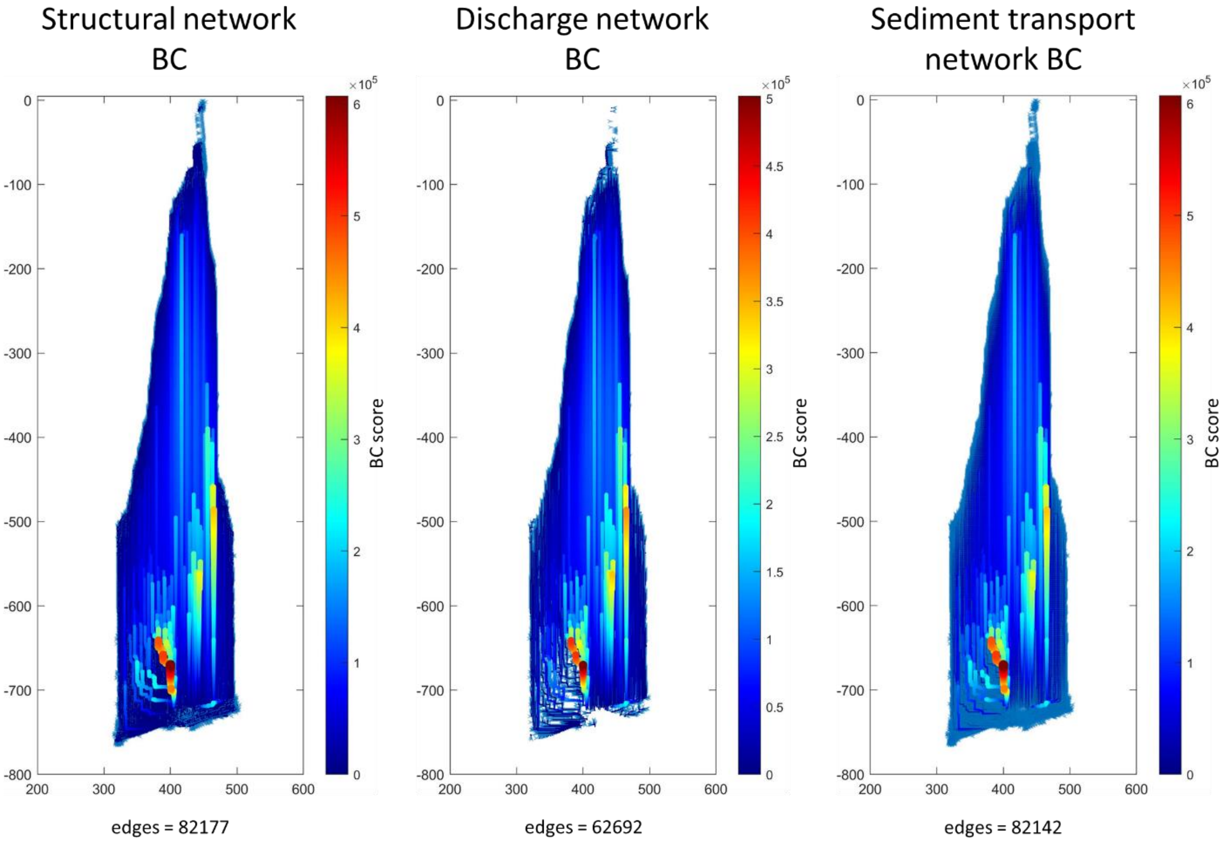

Figure 2. *Between centrality scores for the structural network and the functional networks for discharge and sediment transport.*

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Why protected areas are essential to advance our understanding of mast-seeding

Mario Pesendorfer, Iris Oberklammer, Georg Gratzer

Abstract

Synchronized annual variation in seed production, termed mast-seeding, is an important driver of forest ecosystem dynamics and management. As a bottom-up driver of recruitment dynamics and trophic chains, masting not only affects the efficacy of forestry operations, but also influences the success of habitat restoration, species conservation, and predator control efforts, and even predicts the incidence of zoonotic diseases transmitted to humans by ticks.

To understand the ecological and evolutionary drivers and consequences of masting, however, it is essential to study annual variation in seed production and seed fate under natural conditions. Long-term studies in protected areas, such as national parks and wilderness, therefore provide important opportunities to observe ecological dynamics. Furthermore, they provide a baseline for comparisons with human-modified habitats.

We provide a short overview on how understanding of masting can support conservation and land management decisions and use examples from two montane protected areas of central Europe, Rothwald (Austria) and Babia Góra (Poland/ Slovakia) that provided important insights into the drivers and consequences of masting.

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SARS-Cov-2-Pandemic chance or burden for urban and suburban protected areas and their management?

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Abstract

International studies have shown enormous changes for nature reserves worldwide as a consequence of the SARS-CoV-2-pandemic. In particular urban and suburban protected areas faced intensified impacts by increased numbers of visitors and diverse visitation patterns.

With a focus on the metropolitan area of Vienna this study examined the influence on diverse types of urban and sub-urban protected areas. Interviews with experts of protected area management, NGO´s and environmental administration departments in Vienna and Lower Austria gave insights into the impacts the corona crisis caused for protected areas, the response in visitor management and preservation strategies as well as educational options caused by more frequent visits in protected areas. The study also investigated whether the experts perceived a change in the perception of nature protection and its goals due to an intensified contact with nature during the lockdown periods.

Results show that sensitive habitats and threatened species often had to face severe effects of intensified visitor flows (frequency, duration of stay and distribution) as well as of behavioral changes of the visitors. Modified visitor management, new communication strategies and adapted strategies to deal with problematic issues like litter, overuse of areas or vandalism were also part of the discussion. Finally, the study evaluated whether interest in awareness-building or political attention for conservation related topics could be observed by the authorities. Only the minority of visitors developed an increased appreciation of ecosystem services according to the opinion of the experts interviewed. Most people used the natural environment more for their own satisfaction and as alternative to closed facilities like cultural venues, sport centers or gastronomy in the opintion of the interviewees.

The presentation discusses future prospects including chances and risks for urban and sub-urban protected areas as a follow-up of the pandemic base on the findings of this survey and in light of similar global studies.

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Opportunity for Austrian Biodiversity: the new Biodiversity Fund

Christoph Plutzar, Andrea Stockinger, Johannes Laber

Keywords

biodiversity, funding, European Union's Recovery and Resilience Facility, Austrian Recovery and Resilience Facility, biodiversity fun

Introduction

Biodiversity loss is seen as the most significant global environmental threat alongside climate change. The causes of threat to biodiversity worldwide include, in order of importance: land use change, resource extraction, climate change, pollution and alien species.

With the Biodiversity Fund, the Austrian Federal Government has created a funding channel to contribute to the implementation of the Austrian Biodiversity Strategy and the achievement of Austria's biodiversity targets. The Biodiversity Fund aims to conserve, enhance and restore biodiversity in Austria by supporting measures to implement the national biodiversity strategy in addition to the scope of the Common Agricultural Policy and the Austrian Forest Fund. The Biodiversity Fund will contribute significantly to the implementation of the Biodiversity Strategy Austria 2030+, which will also make important contributions to the implementation of the EU Biodiversity Strategy 2030+ and other initiatives of the European Green Deal (e.g. Farm-to-Fork Strategy, etc.). Furthermore, important contributions are made to achieving the goals of the national bioeconomy strategy, the forest strategy and moreover the achievement of the global Sustainable Development Goals (SDGs).

Part of the funds provided come from the European Union's Recovery and Resilience Facility (RRF), which distributes a total of 672.5 billion Euros, 312.5 billion of which are non-repayable grants. The Austrian Recovery and Resilience Plan (ÖARP 2020-2026) comprises measures with a total volume of 4.5 billion euros, with the focus on ecological and digital transformation. The Biodiversity Fund, as part of the ecological transformation, has 80 million euros at its disposal, 50 million of which comes from the RRF. The RRF runs until 2026. The fund will be implemented legally authorized by Kommunalkredit Public Consulting (KPC) on behalf of the Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) and will be handled in the form of thematic calls for proposals. These calls are to take place at least once a year.

The priorities and objectives of the Biodiversity Fund are:

Implementation of projects to restore priority, impaired ecosystems, particularly focusing on peatlands, wetlands, and special sites (dry grasslands, sand dunes, etc.).

Implementation of projects to protect endangered species and their habitats as a contribution to improving the status of 30% of endangered habitat types and 30% of endangered species by 2030+ ("endangered" includes the categories of Red List Species: Critically Endangered, Endangered, Vulnerable, and Near Threatened (Advance Warning Level) and Red List Endangered Habitat Types: Threatened with Complete Destruction, Critically Endangered, Endangered).

Objects of the funding and eligible costs include:

Costs of measures

a. for the conservation of biodiversity
b. for the improvement and restoration of damaged ecosystems and for habitat networking
c. for the establishment of infrastructural facilities for the communication of knowledge to the general public and for the guidance of visitors

Costs for the acquisition, leasing or compensation for restrictions on the use of areas that are important for the protection or improvement of biodiversity in Austria.

Costs of preliminary work, measures for the establishment of biodiversity monitoring and public relations work in connection with the initiation, planning and implementation of measures.

Costs of projects to improve the knowledge and principles of biodiversity and ecosystem services, as well as the causes of their endangerment and their reduction.

The following steps are planned for the processing of the fund:

1. Announcement of the call on the landing page (www.biodiversitätsfonds.at)
2. Submission by funding applicant
3. Examination of the formal criteria and evaluation of the projects by KPC
4. This evaluation results in a ranking of the projects worthy of funding
5. Consultation in the Biodiversity-Fund-Commission
6. Approval of projects by the Federal Minister
7. Conclusion and acceptance of the funding contract

Who can submit a project and how much is funded?

Both natural persons and legal entities and partnerships in Austria are eligible to apply and receive funding.

Only direct project costs are eligible for funding, i.e. costs that are necessary for the implementation of the measures presented in the project application.

Funding can amount to up to 100 % of the eligible costs. For competition participants (companies according to the general block exemption regulation), the funding amounts to between 40 - 60 % depending on the size of the company.

The minimum grant amount is 15,000 euros. The upper limit of an individual grant depends on the endowment of the funding calls

Contact point landing page

A landing page will be installed at www.biodiversitätsfonds.at that will provide all relevant information, such as:

- Funding Guidelines
- Evaluation criteria
- Guideline for own contributions
- FAQs

Furthermore, the link to the submission platform of the KPC can be found there.

The finalization of the landing page is planned mid/end September 2022.

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Wilderness Character Mapping – a suitable tool for national park stewardship?

Christoph Plutzar, Bernhard Kohler, Josef Schrank

Summary

In this study, we present a Wilderness Character Mapping (WC) conducted in 2020 for the Hohe Tauern National Park Salzburg. The WCM was developed in the USA as a framework to provide wilderness areas with a uniform tool for spatially explicit recording and monitoring of the wilderness character of the area. The results show that large areas of the study area still have high wilderness character. These should be preserved, while areas that have low wilderness character should be enhanced. The WCM can support national park management in a variety of ways, such as locating and assessing potential threats or developing a monitoring plan.

Keywords

wilderness character mapping, National Park Hohe Tauern Salzburg, wilderness, wilderness quality

Introduction

According to the IUCN-guidelines for protected area management, national parks are “large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area” (EUROPARC Deutschland, 2010). The result of process protection implemented over large areas is a state of the landscape that can be described by the term "wilderness". Wilderness, however, is a predominantly cultural construct, and notoriously difficult to translate into management concepts and decisions for protected areas. In order to come to terms with these difficulties, the four federal US-agencies entrusted with wilderness and national park management have launched a joint initiative in 2005 (Landres et al., 2008). The “Keeping It Wild”-intiative aimed at the development of a framework for a nationwide uniform stewardship of wilderness areas. In the process, methods were developed to map the elusive wilderness character of protected areas, providing the basis for long-term, uniform monitoring of wilderness qualities. Through this so-called Wilderness Character Mapping (WCM), and the monitoring based on it, protected area administrations are provided with an important tool for their management decisions, the ultimate goal being the maintenance and improvement of the wilderness quality of the areas under their care.

WCM is an expert-led process and accompanying spatially explicit analysis that links and synthesizes various GIS datasets reflecting different aspects of the wilderness character of the study area. These are the following five aspects: “Untrammeled”, “Natural”, “Undeveloped”, “Solitude or Primitive and Unconfined Recreation” and “Other features of Value”. These qualities and the resulting survey methods are guided by the content of the Wilderness Act of 1964 (U.S. Congress, 1964). The Wilderness Act contains the world's first clearly articulated definition of wilderness and uses predominantly qualitative statements to define what is important in the protection and management of wilderness areas. Because this was the first codified wilderness legislation with a highly sophisticated content, it has spread far beyond the borders of the United States and has influenced the theory and practice of wilderness protection worldwide, the qualities derived are applicable not only in the narrow context of national implementation in the U.S., but of international relevance.

The five wilderness qualities tie into the following key concepts of the Wilderness Act (Quotations from the text of the law (U.S. Congress, 1964)):

- **Untrammeled**: „…Wilderness is an area where the earth and its community of life are untrammeled by man…“ …“generally appears to have been affected primarily by the forces of nature“ and „retains its primeval character and influence“
- **Natural**: „…Wilderness is protected so as to preserve its natural conditions“
- **Undeveloped**: „…Wilderness is an area of undeveloped federal land…. without permanent improvements or human habitation…where man himself is a visitor who does not remain…“
- **Solitude or Primitive and Unconfined Recreation**: „… Wilderness has outstanding opportunities for solitude or a primitive and unconfined type of recreation…“
- **Other Features of Value**: „…Wilderness may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value…“

Methods

Numerous U.S. wilderness areas have already conducted corresponding mapping projects in accordance with the requirements of Keeping it Wild 2 (Landres et al., 2015), e.g. (Carver, Tricker, and Landres, 2013; Burrows et al., 2016; Tricker et al., 2017). In the present study, a corresponding WCM was carried out for the Hohe Tauern National Park Salzburg in 202, in cooperation between the National Park Administration, the University of Natural Resources and Life Sciences, and WWF Austria, probably carried out for the first time for a European protected area. Therefore, it was not possible to draw on empirical data on how this approach, which was developed specifically for U.S. conditions, can best be implemented in a European or Central European context. With this in mind, as well as for reasons of comparability, the general approach chosen was therefore to follow as closely as possible the guidelines defined in the Technical Guidelines of the National Wilderness Preservation System (Tricker and Landres, 2017).

Figure 1 schematically illustrates the calculation process. For four wilderness qualities (the quality “Other Features of Value” was not considered in this study), a total of 19 measures (Tab. 1), that could be represented by data, were identified during a two-day workshop and in the further modeling process. These measures were subsequently assigned weights to reflect their relevance to wilderness quality, and the corresponding wilderness quality was derived by overlaying them using Ordered Weighted Averaging (e.g. see Malczewski and Liu, 2014).

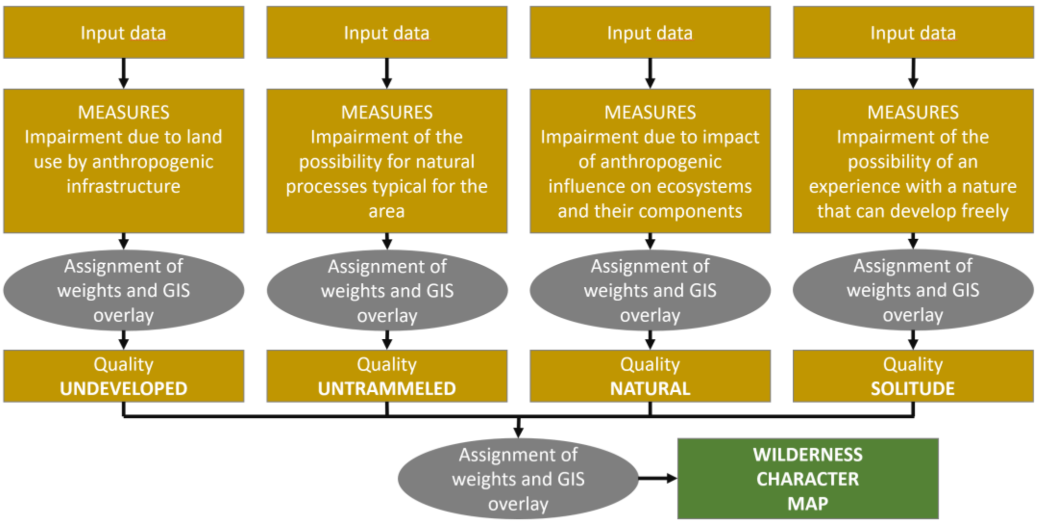

Figure 1: Schematic representation of the calculation of the Wilderness Character Map (modified from Tricker and Landres, 2017).

Table 1: List of measures and assigned weight used for the mapping process.

Measure	Weight
Quality Undeveloped:	
Impairment due to the presence of anthropogenic objects and infrastructures	9
Quality Untrammeled:	
Potential impairment due to legally/contractually permissible or naturally possible land use	9
Impairment of the morphology of watercourses	7
Potential Impairment due to the proposed use of parcels	5
Occurrence of management-dependent FFH habitat types with conservation obligation	4
Possible disturbance of chamois and red deer in the winter half-year (resting zones)	1
Quality Natural:	
Impairment due to grazing	9
Impairment of the naturalness of land cover or habitats.	9
Impairment of the ecological status of watercourses	7
Impairment of the conservation status of near-natural bogs	7
Deviation of tree species composition from that of potential natural forest vegetation	5
Air quality impairment due to nitrogen dioxide (NO2)	2
Air quality impairment due to particulate matter (PM25)	2
Air quality impairment due to ozone (O3)	1
Quality Solitude or primitive and unconfined recreation:	
Impairment of the wilderness-typical nature experience due to visibility of civilization facilities.	9
Impairment of the wilderness-typical nature experience due to facilitation of accessibility	7
Impairment of the wilderness-typical nature experience due to the likelihood of encounters with other visitors	7
Impairment of the wilderness-typical nature experience due to cell phone accessibility (network coverage)	4
Impairment of the wilderness-typical nature experience due to light pollution (night luminosity)	1

Finally, by overlaying the wilderness quality maps, the wilderness character map was calculated, where all four qualities were assigned the same weight, i.e. all four were given the same importance.

Results

The results (Fig.2) show that large portions of the park have a high or very high wilderness character, more than 60% of the area can be assigned to the best wilderness classes (Fig. 3). These are mainly found in high altitude areas, while valley locations - especially when used for agriculture or tourism - tend to show low wilderness character values.

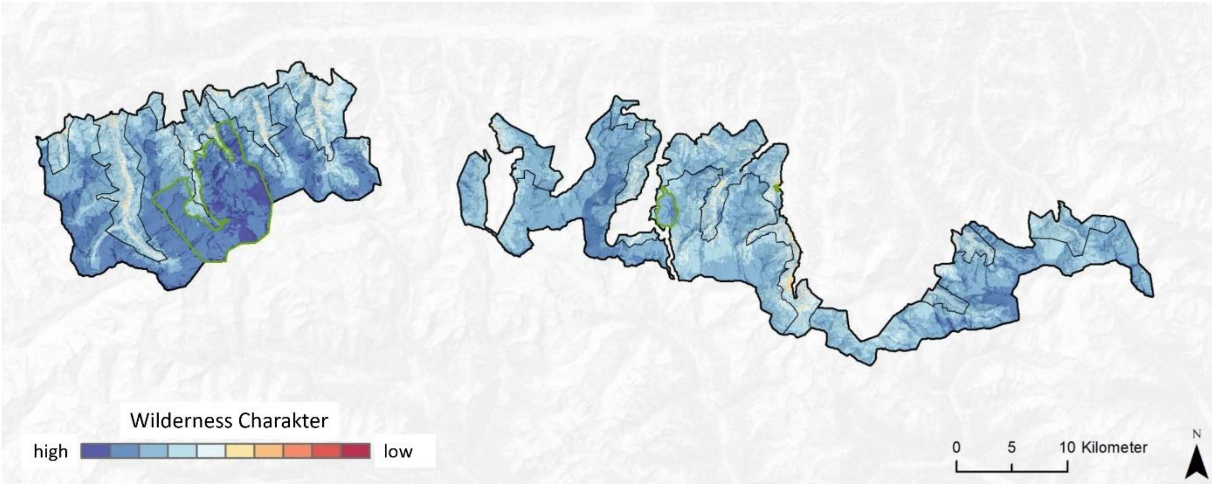

Figure 2: The wilderness character map of the Hohe Tauern National Park Salzburg. The value space of the wilderness character values (0 to 255), which results according to the calculation method, is shown in ten color classes according to an "equal-interval" representation.

The high rating of the Sulzbach valleys wilderness area is striking, a subsequent confirmation of the selection of this area.

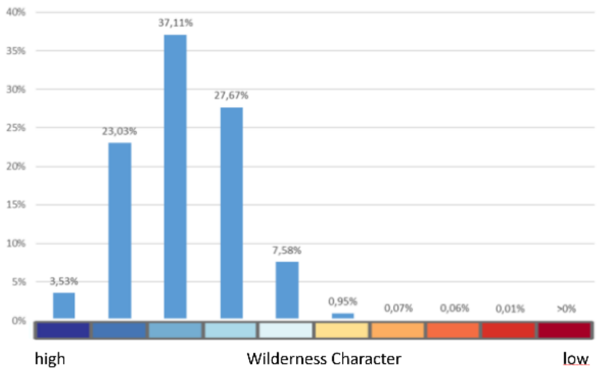

Figure 3: Area distribution of wilderness character values in the Hohe Tauern National Park Salzburg.

The initial mandate that can be derived from the wilderness character mapping is to preserve all areas that already have a high wilderness character rating, and to positively enhance areas with lower ratings in the long term develop.

In the long run wilderness character mapping can support the National Park's protected area management in a variety of ways. For example, it can be used to locate and assess potential threats, as well as provide a wilderness-based information base when making management decisions. The calculation process can be re-implemented with changes (e.g., a proposed infrastructure project) in the data baseline to visualize potential impacts to the wilderness character of the area. Once the database used is updated, the entire wilderness character mapping process can be repeated with these new baselines, thus establishing monitoring to highlight positive and negative changes in wilderness character. Last but not least, the entire development process of the wilderness character mapping promotes the discussion of requirements for wilderness protection and can reveal data and knowledge gaps in this regard, thus contributing to the identification of necessary research priorities.

The following limitations should be considered when implementing WCM: (i) the maps should not be used to "sacrifice" parts of the area that the map indicates have low wilderness quality ("non-degradation principle"); (ii) because the WCM maps of different protected areas are based on different indicators and weightings, and also because the wilderness continuum within the areas usually looks different, the maps should not be compared with each other; (iii) not make claims that the map would fully capture the wilderness character, maps are based on input data suitable for GIS display; often they are only approximations of more complex, elusive wilderness qualities.

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The dark side of light

Christian Raffetseder MSc

Abstract

The dark side of light is the artificial brightening of the night sky caused by humans (light pollution), which has far-reaching effects on nocturnal creatures and on humans. The loss of an intact natural night poses challenges to animals and plants as well as human health, which is affected by an artificial light overload. Beginning during twilight a change of the environment takes place. The daily life goes to sleep and creatures and phenomena of the night appear.

Guided tours during the twilight and night hours have something mysterious because a different world of sensory perception and unfamiliar night landscapes. In this context, nature education addressing diverse topics such as biodiversity, astronomy, health, light pollution is used to guide visitors into unknown habitats. Linked with age-appropriate methods participants experience new insights into the life of nocturnal birds and mammals, insects, sounds and smells of the night. These tours could help to raise awareness for the problems of light pollution in context of protected areas.

Keywords

light pollution, nature education, educational methods, astronomy, biodiversity of the night

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Assessing short-term mobility-dependent responses of benthic macroinvertebrates to restoration of connectivity at the Donau-Auen National Park

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Summary

Pioneer river restoration aimed to increase hydrological connectivity between endangered floodplain ecosystems and the main Danube river channel. However, spatially explicit assessments of the effects that restoration-induced changes on connectivity have on biodiversity have been scarcely applied in freshwater systems such as floodplains. In this study, we used a network theoretical approach to explain short-term Benthic Macroinvertebrates (BM) mobility-dependent responses to restoration. We described changes in habitat connectivity in terms of structural connectivity (SC) and functional connectivity (FC), based on network theory. We calculated network connectivity metrics to compare system- and local-scale (network- and node-level) connectivity conditions for before and shortly after restoration. Afterwards, we related the results of the assessments of connectivity with the taxa compositional variation of the non-flying and flying mobility traits. Overall, there was an increase in the network-level connectivity and local-level connectivity in the short-term. The node-level metrics node degree, in-degree, out-degree, node strength, integrated betweenness centrality and probability of connectivity index (BC-PC), PageRank centrality and local efficiency were ranked as the most influential connectivity variables with both mobility traits for before and after restoration. The non-flying mobility group was the most sensitive to changes in habitat connectivity, with a short-term increase in alpha diversity and decrease of beta diversity. In this connectivity assessments, our results reflect an increase in the capacity of the habitat to sustain aquatic dispersal processes, which may indicate positive outcomes of restoration in the short-term.

Keywords

network theory, habitat connectivity, mobility traits, SC and FC networks

Introduction

Pioneer river restoration programmes have been implemented to improve the ecological functions of endangered floodplain ecosystems, by increasing their hydrological connectivity with the main river channels (Hein et al., 2016; Reckendorfer et al., 2006; Schiemer et al., 1999). Network theoretical representations of ecosystems provide a variety of tools and novel methods developed by different disciplines to assess general changes in connectivity as well as spatially explicit patterns. However, despite the growing number of studies applying network science in Ecology, its applications to assess the outcomes of restoration are still scarce in freshwater ecosystems, especially in floodplains (Volk et al., 2018). In this work we apply network theoretical tools, developed by different disciplines, to assess short-term changes induced by restoration in the habitat connectivity of Benthic Macroinvertebrates (BM).

Methods

Study area

The area of study is located in the Donau-Auen National Park. Specifically, we focus on the pilot restoration measures (side-arm reconnection) carried out in the floodplain section of Haslau-Regelsbrunn.

Benthic Macroinvertebrate community

This work relays on a large dataset on empirical information about the BM communities, sampled before restoration (1996) and shortly after (1999). Changes in habitat connectivity can be perceived differently by organisms with contrasting dispersal modes and abilities (Ishiyama et al., 2014; Tonkin et al., 2018). For this reason, we divided BM taxa in two different mobility traits: non-flying and flying.

Local habitat conditions

We included a set of 24 abiotic parameters available for the studied area. These parameters account for the local habitat conditions and characterize the hydrology and hydraulics of habitat patches.

Connectivity analyses

Following the landscape ecological concept of connectivity, we define it as the landscape permeability for movement (Bishop-Taylor et al., 2015; Taylor et al., 1993). Subsequently, we subdivided this concept as structural connectivity (SC) (water-driven connections between habitat patches) and functional connectivity (FC) (connections between habitat patches via dispersal processes) (Bishop-Taylor et al., 2015; Erős & Lowe, 2019; Turnbull et al., 2018). SC and FC networks were built to represent the habitat connectivity conditions before the implementation of restoration measures (1996) and short-term after (1999). In SC networks, habitat patches or nodes are located on surface water habitats (Bishop-Taylor et al., 2015) and links are the surface water connections between nodes. For FC networks, nodes are in the same locations as in SC networks, although links account for likelihoods dispersal events (Bodin & Saura, 2010; Saura & Pascual-Hortal, 2007).

A total of **3 network-level** (*assortativity coefficient, global efficiency, probability of connectivity index*) and **9 node-level** connectivity metrics (*node degree, in-degree, out-degree, node strength, dPC (node-level fraction of the network-level index probability of connectivity*), *betweenness centrality, integrated betweenness centrality and probability of connectivity index* (*BC-PC*), *PageRank centrality and local efficiency*) were calculated for both SC and FC networks to capture short-term connectivity changes for the whole area and localized patterns.

Statistical analyses

The explanatory role of connectivity parameters (**connectivity factors**) vs. local habitat factors that characterize the hydrology and hydraulics of habitat patches (**environmental factors**) was assessed using Partial Least Squares Regression (PLS). We selected the most influential connectivity variables based on their Variable Importance in the Projection (VIP) scores and standardized regression coefficient (SRC). Afterwards, a Redundancy Analysis (RDA) was computed to depict the strength of correlation between the highly ranked connectivity variables (based on the PLS' VIP scores and SRC) and taxa composition of flying and non-flying traits.

Results

Overall, there was an increase for the network-level metrics *Global efficiency* (increase in the efficiency of the network to facilitate transport) and *Probability of Connectivity* (habitat availability/reachability index). As for the network-level metrics, increases in node importance were mainly located in sites in sites under the influence or in neighbouring areas of the sites reconnected during the restoration measures.

Node strength (SC Network), *local efficiency* (SC network) and *out degree* (SC network) were within the node-level metrics with the strongest correlations with the taxa composition of the non-flying mobility group. *Node strength* (strength of the connections of a node based on the minimum amount of days when there is a surface water connection between a couple of nodes and the main Danube channel) was the metric that better captured both spatial and hydrological aspects of connectivity and had higher VIP scores and SRC with the compositional dissimilarity of flying and non-flying taxa (beta diversity), after restoration. Overall, the non-flying mobility group was the most sensitive to changes in habitat connectivity induced by restoration (alpha diversity increased and beta diversity decreased after restoration). For this group the explanatory power of connectivity increased shortly after restoration.

As for the flying organisms, changes in alpha and beta diversity were not so evident as for the non-flying group. However, there was a strong relation, before and after restoration, between taxa composition and the node importance values of the highly ranked node-level metrics *node degree* and *in-degree* (SC Network), *BC_PC* (SC/FC Network) *PageRank* (SC Network) and *local efficiency* (FC Network).

In particular, the node-level variables that were highly ranked for both mobility groups show an increase in the capacity of the habitat to sustain aquatic dispersal processes. This together with increases in local diversity (alpha diversity) and decrease in beta diversity of the non-flying taxa might reflect positive outcomes of restoration on habitat connectivity in the short-term.

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Impacts of ungulates in national park forests – woody plant biodiversity and management issues

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Summary

In the Austrian national parks Kalkalpen, Thayatal, and Donau-Auen since 1999 systematic vegetation surveys have been carried out on browsing control plots in order to record the long-term effects of wild ungulates on the development of forest regeneration. The monitoring method used is the Ungulate Impact Control System (UICOS) that works with comparison plots, i.e. unfenced areas vs. ungulate exclosures (fenced areas).

There were clear differences in the development of tree and shrub species influenced by ungulates compared with the forest development under ungulate exclusion. It is up for debate whether the goals and benchmarks for the national parks will be achieved or not with the lasting effects of ungulates. Most of the negative as well as positive effects caused by ungulates, measured against forest benchmarks, resulted from the influence on the height increment of the tree species. Related to biodiversity, the impact of ungulates had different effects on the tree and shrub species, depending on the biodiversity index used.

Keywords

Forest, ungulates, biodiversity, national park, management, Austria

Introduction

In the Austrian national parks Kalkalpen (sl. 390 - 1,960m), Thayatal (sl. 260 - 530m), and Donau-Auen (sl. 140 - 180m) since 1999 systematic vegetation surveys have been carried out on browsing control plots in order to record the long-term effects of wild ungulates on the development of forest regeneration (REIMOSER et al. 2018, 2021, 2022), here focused on the biodiversity of tree and shrub species. Occurring ungulate species in all three parks are red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*), additionally wild boar (*Sus scrofa*) in the national parks Donau-Auen and Thayatal, and chamois (*Rupicapra rupicapra*) in Kalkalpen National Park.

Browsing on forest vegetation by mammals (ungulates, hares, mice, etc.) is basically a natural impact factor on forest development. But for the large-scale living ungulates, national parks are usually only a part of their habitat. Therefore, their impact in a national park often depends heavily on the ungulate and habitat management in the vicinity outside of the park. This can lead to unnatural influences in the national park if interventions on wildlife animals are completely prohibited inside the park. An ungulate management concept to coordinate ungulate management outside and inside the parks is used.

Methods

The pairs of comparison plots (Figure 1) are established on areas where forest regeneration is in an initial phase. The survey and evaluation methods are standardized (ungulate impact control system - UICOS/WIKOSYS, REIMOSER et al. 1999, 2011, 2014, REIMOSER 2002). The ungulate impact on tree seedlings can only be clearly identified or made visible with this method. Such comparison procedures offer the possibility of directly and reliably assessing the effects of the ungulate impacts on forest regeneration (NOPP et al. 2020).

One plot of each comparison pair is accessible to ungulates (unfenced area = control plot), the second plot is inaccessible to ungulates (fenced area = treatment plot). Which of the two previously demarcated areas is fenced is chosen randomly (decision by lot). Suitable comparison sites are forest areas (1) that are able to regenerate (sufficient light in the lower layer), (2) where forest regeneration is at the beginning (trees predominantly less than approx. 0.5 m in height), and (3) are distributed as evenly as possible over the study area. A pair of comparison plots consists of two 6x6 m areas (each with a 5x5 meter survey area, Figure 1) at a distance of 5 to 20 meters between the two plots (on comparable sites).

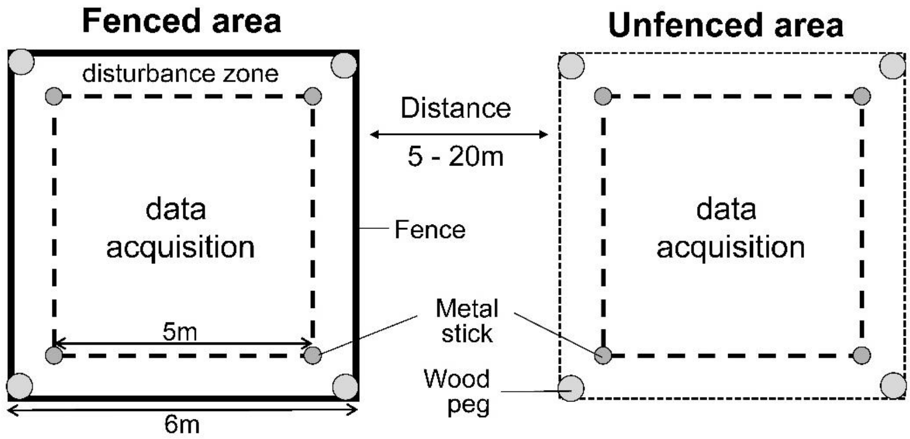

Figure 1: Scheme of the comparison-area method using pairs of unfenced control plots vs. ungulate exclosures (fenced plots).

Within a few weeks after the fences have been erected, the first survey of the vegetation is carried out with regard to site characteristics, present tree and shrub species, their number and height, browsing characteristics etc. The follow-up surveys are usually carried out at 3-year intervals. In each survey, the respective difference in the measured variables between the unfenced (control) plots (U) and the fenced plots (F) is determined. When determining the effects of ungulates for the observation period, the following two differences are formed for each pair of comparison areas: The difference in the values (per indicator) between U and F for each recording year and the difference between these two difference values between the end (B) and the beginning (A) of the respective observation period.

$\Delta A = U_A - F_A$, $\Delta B = U_B - F_B$, $\Delta\Delta = \Delta B - \Delta A$ (e.g., A=1999, B=2020)

The effects of the ungulates on the vegetation determined by the fence-control comparison can be positive, negative or insignificant with regard to the achievement of a predefined desired anthropogenic benchmark. So, basically, largely differing effects can result. Since, in addition to undesired, also desired effects on forest development can be detected on a comparable scale, a neutral, mutually open approach is created, which enables a balance of positive and negative ungulate influence in terms of human targets. Positive functions of ungulates in forest ecosystems can be, for example, the spread of seeds and the penetration of plant seeds into the soil, the browsing of competing vegetation from desired tree species, the change in germination conditions through the production of excrement and nutrient redistribution. The value-neutral ecological effects of ungulates within forest ecosystems, and the valuation (positive or negative) of ungulate impacts on human targets should be clearly separated (REIMOSER et al. 2022).

Due to the special framework conditions for national parks (IUCN Category II), conventional approaches assessing damages of ungulates to forest vegetation, such as those used in managed forests, cannot be used appropriately. Alternative ways of assessing the influence of herbivores on vegetation, which are compliant with the national park's predefined targets and guidelines, are required, which make it possible to objectively determine the necessity and extent of regulation of ungulate populations in national parks, in the case of anthropogenically disturbed plant-herbivore interactions (REIMOSER et al. 2022).

The legal framework and management plan for e.g. the Donau-Auen National Park comprise the following basic targets (REIMOSER et al. 2022): Wild autochthonous ungulate species have the same protective status in the park as autochthonous plant species and forest communities. One of the goals of national park management is to promote and maintain natural forest vegetation in the park. The following criteria define the acceptable impact load from ungulates on the national park´s vegetation: (1) No ungulate-related changes in the development and regeneration of the forest communities in their typical structure and species combination (i.e. sustainable seed production through sufficient seed trees) on at least approx. 50% of the forest area in the national park (benchmark); the remaining area may be redesigned by the ungulates, which can result in a higher biodiversity on the entire park. (2) No permanent reduction in the local species diversity of autochthone woody plants by ungulates in the national park. (3) A natural regeneration of the forest should be possible in the course of each forest generation. The evaluation is carried out according to a standardized procedure that is also used in other regions and national parks (REIMOSER et al. 1999, 2014).

The biodiversity of tree and shrub species was represented using the four biodiversity indices Richness, Shannon index, Evenness, and Gini-Simpson index (MÜHLENBERG 1993, SUPRIATNA 2018) and calculating the mean values from the comparison plots as well as from the total area adding up all comparison plots as one area.

(1) Richness: number of species

(2) Shannon index: Takes into account both the number of species and their abundance (number of individuals per species), maximum value depends on the population size (e.g. for Donau-Auen National Park approx. 2 for mean values of comparison plots and 3 for the entire survey area)

(3) Evenness: Quotient of the Shannon index and the maximum Shannon index value, is a measure of the distribution of individuals in a population (between 0 and 1)

(4) Gini-Simpson index: expresses the probability that two individuals selected at random from all individuals in a recording belong to a different species (between 0 and 1)

Results

There were clear differences in the development of tree and shrub species influenced by ungulates compared with the forest development under ungulate exclusion. It is up for debate whether the goals and benchmarks for the national park have been achieved or not with the lasting effects of ungulates. Most of the negative as well as positive effects caused by ungulates, measured against forest benchmarks, resulted from the influence on the height increment of the tree species (REIMOSER et al. 2018, 2021, 2022).

Related to biodiversity, the impact of ungulates had different effects on the tree and shrub species, depending on the national park, the duration of ungulate impacts (years), and the biodiversity index used (Tables 1-3). The development of the woody species inside and outside the fence was compared (difference U-Z at the time of the last survey), and this final difference was adjusted by the initial difference that was already present when the comparison areas were set up (calculation of the double difference, cf. methods).

Donau-Auen National Park (DA): In the 1st series of comparison areas (DA1, since 1999) the impact of ungulates on the biodiversity of tree and shrub species is shown after 9 and after 21 years of exposure to ungulates, in the 2nd series (DA2, since 2011) after 9 years of exposure (Tables 1-3). For the entire comparison period of the 1st series (21 years), the ungulate impact ($\overline{x}$) on the four biodiversity indices can be classified as indifferent for tree species (positive and negative values) and slightly negative for shrub species (Tables 1, 2). For woody species as a whole (trees and shrubs together) there was also a slightly negative impact (Richness -0.05, Shannon -0.24, Evenness -0.12, Gini-Simpson -0.11; Table 3).

For the 9-year study period of the 2nd series (2011-2020), overall (all indices) there was up to now no clear impact of ungulates on the biodiversity of tree species. Both negative and positive effects were found. In the case of the shrub species, the ungulate impact had a negative effect on all indices (Tables 1, 2). If tree and shrub species are combined, the result was a positive ungulate impact on Richness and a negative impact on all other indicators.

If the indices are not calculated as a mean value from the individual comparison plot indices, but all comparison plots are taken as a total area and added up (total), then in the 1st series the biodiversity indices for tree species and trees plus shrubs together resulted more often in positive effects due to the ungulate impact (Tables 1, 3).

Thayatal National Park (TH): The impact of ungulates on biodiversity of tree species is somewhat stronger than in the Donau-Auen National Park (Table 1). Positive ungulate effects arose particularly in the 1st series in Richness. There were no positive effects in the 2nd series (TH2; Table 1). The indicators for the volume index show stronger negative effects than the same indicators for number of trees.

Kalkalpen National Park (KA): Compared to the other two national parks, ungulates have the relatively strongest negative impact on the biodiversity of tree species, while the shrub species in the Kalkalpen N-Park, 2nd series, show the relatively strongest positive impact (Tables 1, 2).

Table 1: Trees. Impact of ungulates on the biodiversity of tree species based on various biodiversity indices, separated for tree number and volume index. Volume index = tree number × height. $\bar{x}$ = mean values from the single pairs of comparison plots. Total = comparison plots summed up as one area. DA = Donau Auen, TH = Thayatal, KA = Kalkalpen, each for 1st and 2nd comparison series, duration of the exposure to ungulates in years. Noticeable positive effects green, negative effects blue.

				Volume-Index						Number of trees					
		Richness		Shannon		Evenness		G-Simpson		Shannon		Evenness		G-Simpson	
NP	years	$\bar{x}$	total	$\bar{x}$	total	$\bar{x}$	total	$\bar{x}$	total	$\bar{x}$	total	$\bar{x}$	total	$\bar{x}$	total
DA1	9	+0.10	-4	0	+0.05	+0.02	+0.06	+0.01	+0.02	-0.05	-0.09	-0.01	+0.01	-0.03	-0.01
	21	-0.06	+3	-0.14	+0.30	-0.16	+0.05	-0.08	+0.12	-0.09	-0.01	-0.03	-0.04	-0.04	+0.02
DA2	9	+0.39	+1	+0.07	-0.30	+0.01	-0.10	+0.04	-0.01	+0.12	+0.02	-0.02	0.00	+0.05	+0.02
TH1	9	+0.65	+3	+0.07	-0.16	-0.05	-0.09	+0.01	-0.02	+0.15	+0.06	-0.04	-0.03	+0.08	0
	15	+0.58	+1	-0.19	-0.13	-0.22	-0.06	-0.12	-0.01	+0.04	+0.02	-0.06	-0.03	0	-0.02
TH2	9	-0.72	+1	-0.25	-0.25	-0.04	-0.11	-0.13	-0.11	-0.23	-0.06	0	-0.05	-0.11	-0.03
KA1	6	-0.23	-2	-0.01	-0.55	+0.02	-0.18	0	-0.28	-0.06	-0.05	0	+0.01	-0,02	-0.01
	9	-0,29	-2	+0.01	-0.39	+0.03	-0.14	0	-0.21	-0.07	+0.02	-0.01	+0.06	-0.04	0
KA2	6	-0.13	-4	-0.02	-0.36	0	-0.08	-0.01	-0.12	+0.01	-0.05	+0.02	+0.07	+0.01	0
	9	-0.17	-4	-0.06	-0.46	-0.05	-0.12	-0.04	-0.02	+0.02	-0.15	-0.01	+0.03	+0.03	-0.02

Table 2: Shrubs. Impact of ungulates on the biodiversity of shrub species based on various biodiversity indices. Volume index = area coverage × height. $\bar{x}$ = mean values from the single pairs of comparison plots. Total = comparison plots summed up as one area. (Additional infos see Table 1).

		Richness		Shannon		Eveness		Gini-Simpson	
NP	years	$\bar{x}$	total	$\bar{x}$	total	$\bar{x}$	total	$\bar{x}$	total
DA 1	9	-0.10	-2	+0.04	-0.35	+0.03	-0.10	+0.02	-0.15
	21	+0.01	-3	-0.10	-0.19	-0.12	-0.03	-0.06	-0.07
DA 2	9	-0.04	+1	-0.18	-0.17	-0.13	-0.07	-0.09	-0.08
TH 1	9	-0.50	-1	-0.11	-0.61	+0.02	-0.22	-0.03	-0.14
	15	-0.26	-1	-0.01	-0.94	+0.29	-0.36	+0.02	-0.32
TH 2	9	-0.09	0	-0.19	-0.15	-0.06	-0.06	-0.11	-0.07
KA 1	6	0	+4	+0.01	-0.28	-0.09	-0.13	0	-0.12
	9	-0.09	+2	+0.04	-0.15	+0.20	-0.10	+0,03	-0.11
KA 2	6	+0.19	+1	+0.03	+0.31	+0.08	+0.12	+0.02	+0.16
	9	-0.05	0	0	+0.15	+0.06	+0.07	+0.01	+0.13

Table 3: Trees + shrubs. Impact of ungulates on the biodiversity of tree and shrub species based on various biodiversity indices. Volume index = area coverage × height. x̄ = mean values from the single pairs of comparison plots. Total = comparison plots summed up as one area. (Further infos Table 1).

		Richness		Shannon		Eveness		Gini-Simpson	
NP	**years**	**x̄**	**total**	**x̄**	**total**	**x̄**	**total**	**x̄**	**total**
DA 1	9	-0.10	-6	-0.09	+0.05	-0.04	+0.04	-0.06	+0.02
	21	-0.05	0	-0.24	+0.30	-0.12	+0.08	-0.11	+0.12
DA 2	9	+0.35	+2	-0.18	-0.30	-0.10	-0.09	-0.08	-0.01
TH 1	9	+0.15	+2	+0.08	-0.17	+0.04	-0.06	+0.06	-0.02
	15	+0.32	0	-0.09	-0.14	-0.05	-0.04	-0.03	-0.01
TH 2	9	-0.82	+1	-0.16	-0.32	+0.02	-0.11	-0.07	-0.13
KA 1	6	-0.25	+2	-0.11	-0.55	-0.04	-0.16	-0.06	-0.28
	9	-0.38	0	-0.12	-0.40	-0.04	-0.12	-0.08	-0.21
KA 2	6	+0.06	-3	+0.05	-0.34	+0.03	-0.10	+0.04	-0.12
	9	-0.22	-4	-0.07	-0.44	-0.03	-0.11	-0.02	-0.05

Across all national parks, the volume-index indicators for tree species (including tree heights) show stronger ungulate impacts than the same indicators for tree numbers (Table 1). Calculating the mean values from the comparison plot pairs (x̄) results in less effects than adding up all comparison plots to one area (total). If all woody species, trees and shrubs (including dwarf shrubs and Rubus spp.), are seen together, noticeable positive effects of ungulates on the biodiversity of woody plant species are also rare (Table 3).

In addition to these considerations on tolerance limits of herbivore-plant interactions within national parks that include forest cover, the avoidance of economically unacceptable game damage in the vicinity of the park can be of decisive importance (cf. chapter methods). Such game damages outside protected areas, caused by ungulates partly living in the protected area (e.g. during the hunting season in the vicinity of the park) and partly living outside the park (e.g. when hunting season is closed there), can be decisive for the necessity and extent of a regulation of ungulate populations through ungulate shooting in the protected area too. For all three national parks, the management of ungulates was coordinated with the national park environment as part of a Wildlife Ecological Spatial Planning (WESP; REIMOSER 1999).

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From spectral to grassland biodiversity

Christian Rossi

Abstract

Technological developments in passive remote sensing approaches, which measure the sunlight reflected by an object at a specific wavelength, allow for an efficient and relatively inexpensive collection of baseline data related to biodiversity. In particular, the use of spectral diversity, the variability in remotely sensed spectral reflectance from plant communities, has seen increasing use in the estimation of plant taxonomic, phylogenetic and functional diversity. Here, we provide different case studies in which spectral diversity approaches are used to quantify the biodiversity of grasslands in a strict nature reserve in the Swiss Alps and a tallgrass prairie reserve in Oklahoma. From community to landscape diversity, we highlight possibilities, gaps and integration of different platforms. Furthermore, trade-offs between space, time and spectral dimensions of remotely sensed datasets to map grassland biodiversity are discussed.

Keywords

Biodiversity, Remote Sensing, Spectral diversity

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"Of dormice and men" – Building habitat conservation guidelines for land managers with help from citizen science

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Summary

Our long-term monitoring program to identify factors that drive population dynamics of the hazel dormouse has shown that occupancy of nest boxes is subject to strong annual fluctuations. Based on experiences gained during this program, a three-year project was launched to detect the even rarer forest dormouse. The results of the first year show not only a surprising accumulation of forest dormice near or in anthropogenic areas, such as settlements and pastures, but also a concentration of sightings in Carinthia and adjacent areas.

Keywords

dormouse, hazel dormouse, forest dormouse, monitoring, Citizen Science

Introduction

The hazel dormouse (*Muscardinus avellanarius*) and the forest dormouse (*Dryomys nitedula*), both protected under the European Habitats Directive (FFH) in Annex IV, are native to a variety of Austrian forest habitats. Due to their nocturnal and cryptic activity they belong to the publicly lesser-known representatives of our native mammals. Although largely arboreal and particularly associated with woodland, even foresters are often unfamiliar with dormice. Therefore, suitable habitats for these species can be unknowingly lost in the course of forest management or traditional land use practices. As dormice live at low population densities even in ideal habitats, they are highly vulnerable to the risk of local extinction due to habitat deterioration or fragmentation. With rarely more than only one litter per year, populations do not recover quickly from losses, which makes it also important to establish corridors between habitats to prevent isolation of populations. However, current data on dormouse distribution and on their preferred habitat structures is scarce, especially for the forest dormouse. Accordingly, there are no official recommendations for forest managers to preserve and promote valuable resources for these protected species.

Based on our experience gained through a long-term monitoring program involving Citizen Scientists on the population dynamics of the hazel dormouse, we launched an extensive project to detect the even rarer forest dormouse in 2020. Data collected through these projects will be used to create a guide for forest managers aimed at protecting and enhancing dormouse habitat. Here we present our first results and conclusions.

Methods

Project hazel dormouse

To increase public awareness for the hazel dormouse and to identify factors that drive population dynamics, a long-term monitoring program involving Citizen Scientists was established in 2008 ("Blick ins Dickicht"; www.blickinsdickicht.at). We installed 243 artificial roosts (nest boxes and nest tubes) at 30 sites in the Wienerwald Biosphere Reserve (Fig. 1), most of which have been managed by Citizen Scientists since then. The artificial roosts are checked regularly at two-month intervals during the growing season. The contents of each box are documented in a data sheet; dormouse finds (live finds and nest finds) were assigned a value of 1, empty or otherwise occupied boxes were assigned a value of 0.

For further analysis, the number of boxes occupied by dormice at least once per year was determined for each site. The sum of all occupied boxes in the project area, as well as the sum of unoccupied boxes and the sum of boxes from which no data were collected in the respective years (n.a.) were then determined. To illustrate annual variation in nest box occupancy within a site, three representative sites that have been continuously monitored since 2008 were selected. All selected sites contained six nest boxes, which allowed us to plot annual box occupancy per site as a percentage in a histogram.

Project forest dormouse

Based on the experience gained during the long-term monitoring program in the project previously described we launched in 2020 the project "Waldflächen für den Baumschläfer" (www.baumschlaefer.at) to detect the forest dormouse. For this purpose, a total of 600 nest boxes were installed in forest areas that appeared suitable at a total of 20 sites in six federal states. Therefore, a comprehensive literature search was conducted on the currently known distribution range of the dormouse in Europe and in Austria, also considering reports of individual finds. Based on these data, the federal states of Upper Austria, Lower Austria, Salzburg, Styria, Burgenland and Carinthia were selected for further investigation (Fig. 2). Within the selected federal states, the areas for the installation of the boxes were selected according to the following criteria:

- Forest areas managed by ÖBf (Österreichische Bundesforste) that are not subject to large-scale forestry use at least until the end of December 2022 and are very low in disturbance

- Mixed forest stands (mixed deciduous forest or mixed deciduous-coniferous forest)

- If possible, in the vicinity of a standing or flowing watercourse

- Presence of a dense and preferably species-rich shrub layer or young growth

The nest boxes were installed during the wintertime in 2020-2021. The monitoring started in May 2021 and thereafter the boxes were checked three times per year (spring, summer, autumn). The control of the nest boxes is carried out by experts of the ÖBf, as well as by experts of the private institute for wildlife biology "apodemus".

At the same time, the project was publicized through various online and print media as well as radio and television reports. The population was asked to report their sightings. A project homepage was set up, which offers further information on the project as well as instructions for field methods to increase the likelihood of sightings. These include instructions for creating a track tunnel, a forest dormouse nest box, and instructions for reporting cat victims. Furthermore, it is possible to report findings directly via the homepage as well as on the platform "naturbeobachtung.at" provided by the NGO "Österreichischer Naturschutzbund". All received evidence are checked by the project staff and Citizen Scientists are given feedback about their reports.

Results

Project hazel dormouse

We could show that nest box occupancy throughout the project area is subject to high annual fluctuations (Fig. 3). These fluctuations were detected at a large scale with all data pooled for the biosphere reserve as well as within each selected regional study site. Fluctuations occurred also at study sites with little change in habitat quality over the years, such as old grown forest stands with diverse vegetation edges. Variations in nest box occupancy did not show a homogenous pattern for different study sites within the same year: e.g., where 50% of nest boxes were occupied at study site "Groissau" in 2013, in the same year no dormice could be detected at the nearby study site "Grillparzerstrecke". This suggests a variety of both small scale as well as large scale influences might govern nest box use. Our results implicate the need to design monitoring programs over timespans of at least two consecutive seasons to increase the likelihood of detecting dormice.

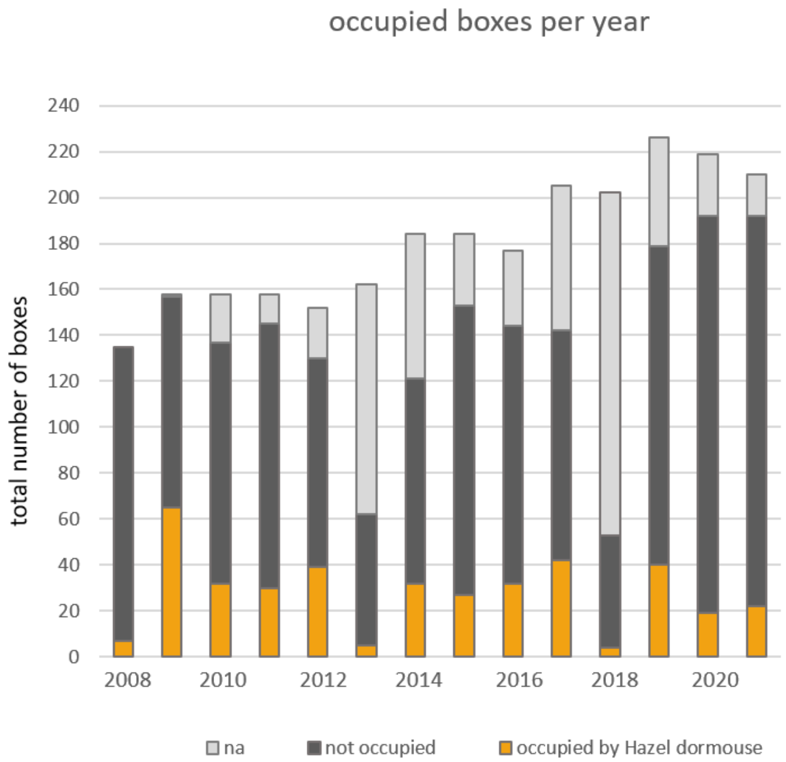

Fig. 3: Number of nest boxes occupied by dormice in the biosphere reserve Wienerwald. Orange beams show number of boxes occupied by hazel dormouse, dark gray beams show unoccupied nesting boxes or nesting boxes occupied by other animal species, light gray beam show boxes from which data is missing.

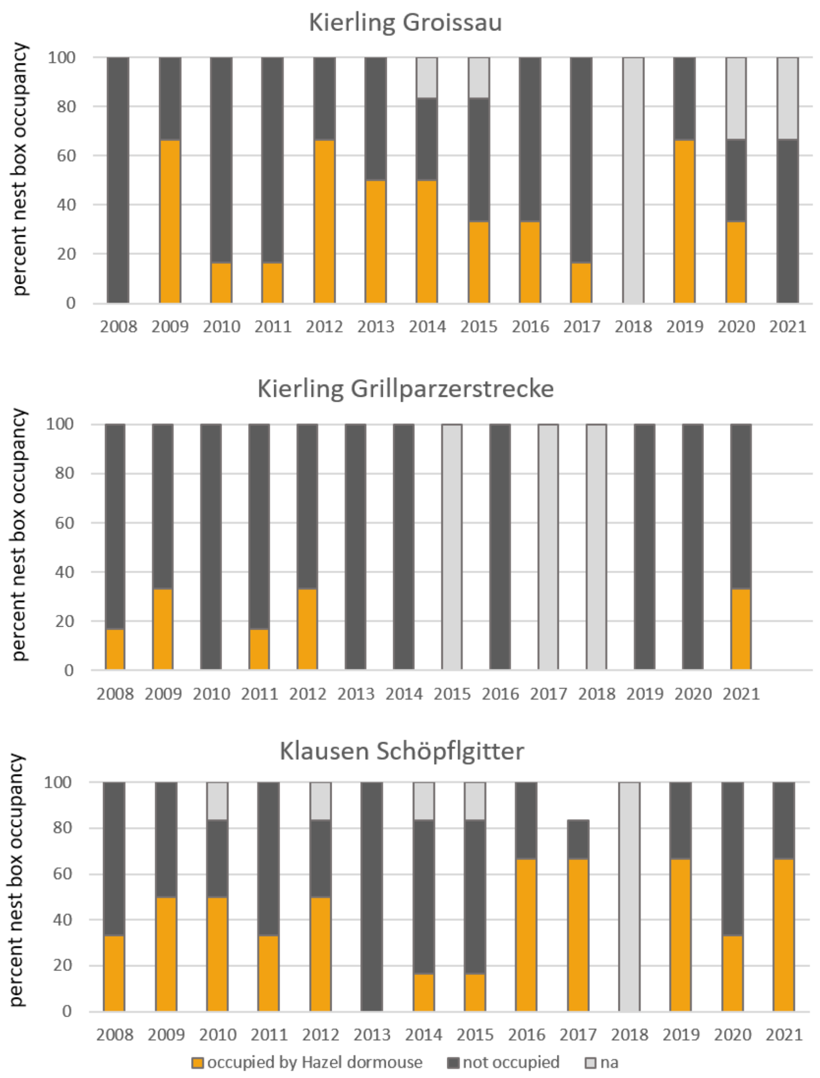

Fig. 4: Percent nest box occupancy per site and year. Orange beams show percent of boxes occupied by hazel dormouse, dark gray beams show unoccupied nesting boxes or nesting boxes occupied by other animal species, light gray beam show percent of boxes from which data is missing.

Project Forest dormouse

In the first two study years until the end of 2021, only one out of 600 nest boxes in forest areas was occupied by a forest dormouse. Within only the year 2021 however 28 citizen science submissions of records on the web platforms baumschlaefer.at and naturschutzbund.at could be verified via photo documentation as forest dormice. The records where cross referenced with CORINE land cover data. About a third (26%) of forest dormouse detections where from anthropologically shaped areas such as urban areas or agricultural areas. Most confirmed sightings were reported from Carinthia (53%), followed by Styria (25%) and Salzburg (21%). Records from Tyrol where all identified as garden dormice. Our first results suggest forest dormouse distribution in Austria is concentrated in mid country alpine areas.

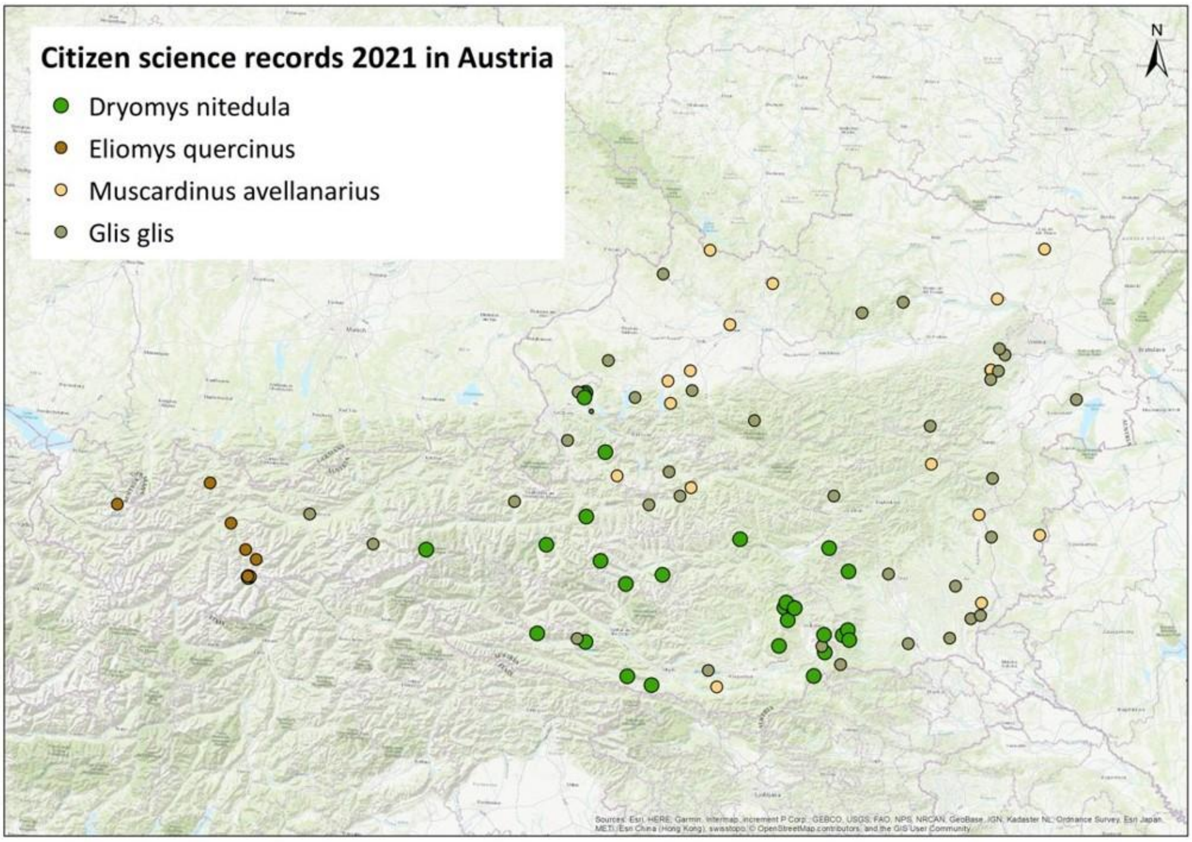

Fig. 5: Citizen Science records since 2021 in Austria. Till 29.12.2021, out of 116 reports, 28 could be confirmed as forest dormouse (Dryomys nitedula), 8 as garden dormouse (Eliomys quercinus), 16 as hazel dormouse (Muscardinus avellanarius) and 43 as edible dormouse (Glis glis). (Adapted map; QGIS.org, 3.12.0-Bucureşti. QGIS Geographic Information System. QGIS Association. http://www.qgis.org)

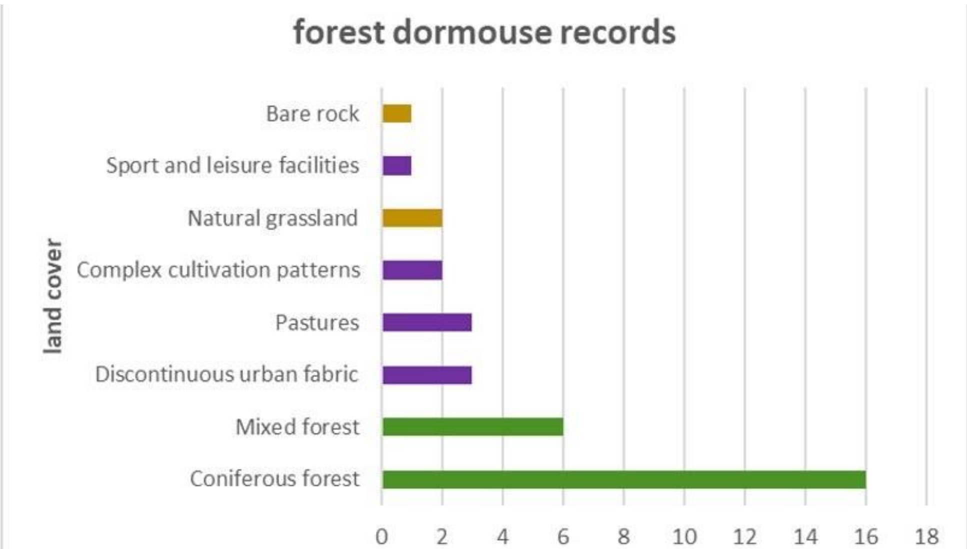

Fig. 6: Evidence of forest dormouse associated with land use obtained from CORINE. As expected, about 65% of the detections were in forests. However, about 1/4 of the detections (26%) were from anthropogenically dominated areas such as discontinuous urban fabric, pastures or sport and leisure facilities.

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Development and implementation of eDNA monitoring methods for fish in the alpine region and comparison to traditional ecological status assessment method

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Summary

Aquatic ecosystems are threatened worldwide due to human impacts. Water bodies in the alpine region seem to be particularly affected by climate change, therefore it is of major importance to keep track of the condition of these waters. The application of metabarcoding studies opens up completely new possibilities for the monitoring of aquatic systems. In this study, traditional ecological status assessment methods are compared with an eDNA metabarcoding approach in order to identify possible differences in species detections. To allow a direct comparison, the eDNA samples are taken from the same sites that were used for the traditional fish monitoring (gillnet- and electrofishing-sites). Our approach not only allows us the creation of taxonomic inventories, it also allows us to draw conclusions about the spatial distribution and persistence of eDNA in alpine lakes. Furthermore, different sampling strategies and filter systems are tested to develop a best practice protocol for sampling and further sample analysis. A total of 108 water samples, collected in four different water bodies, were collected, filtered, extracted and sequenced. In most cases, our approach has not only allowed us to detect all fish species that were also detected during the last traditional surveys, but we have also been able to detect species that could not be detected using traditional methods. However, only data from Lake Mondsee is presented here.

Keywords

DNA metabarcoding, fish monitoring, eDNA, biodiversity

Introduction

Fish are reliable indicators for anthropogenic degradation in lakes (Gassner et al. 2005) and rivers (Haase et al. 2013). In Austria, the ecological status assessment based on fish as biological quality element is regulated by the Austrian Lake Fish Index (Gassner et al. 2015) for lakes, and the Fish Index Austria (Haunschmid et al. 2006) for rivers. The status of waterbodies is assessed based on parameters such as species composition, biomass and age structure. For these assessments standardized methods are used: electrofishing, benthic and pelagic gillnet fishing and hydroacoustic surveys (CEN 2003, 2014, 2015). However, these established methods are known to have inherent limitations. Traditional methods rely on taxonomic identification, although it may be very difficult to distinguish between species, especially in early life stages (Hänfling et al. 2016). It is also known that these methods are highly selective and invasive, caught fish are permanently removed from the system and due to their behavior, the probability of catching certain fish species is very low. Furthermore, these methods are very labor and time intensive and therefore also expensive (Kubečka et al. 2009, Reese et al. 2014). Conservation management depends on detailed ecological data, but especially for lake ecosystems the standardized methods struggle to generate the data needed (Hänfling et al. 2016). Because of these disadvantages, a cost efficient, sensitive, non – invasive method for monitoring purposes needs to be implemented.

A molecular based (eDNA) monitoring approach may overcome the limitations of traditional methods, regarding selectivity as well as detection of rare and elusive species, which makes this approach a valid tool to complement traditional monitoring (Lawson Handley 2015). Environmental DNA is DNA that is released by organisms into the environment in the form of extracellular DNA, gametes, excreted cells via faeces and urine, tissue cells like skin, scale- or mucus- particles or decaying matter. Most of the early applications of eDNA in aquatic systems focused on the detection of certain organisms, using species specific primers. Usually, mitochondrial DNA is targeted for the analysis since the copy number is higher compared to nuclear DNA and therefore increases the probability of detection (Hubert et al. 2008). These eDNA approaches have shown their high accuracy in detecting targeted species across different taxonomic groups (Ficetola et al. 2008, Thomsen et al. 2012b, Tréguier et al. 2014, Thalinger et al. 2019). Due to progress in eDNA studies in recent years, another approach, the eDNA metabarcoding was successfully implemented in aquatic systems. This approach uses broad-range primers for taxonomic groups e.g. bony fish in combination with HTS (High throughput sequencing) and allows faster, more precise biodiversity assessment than traditional methods (Hänfling et al. 2016, Valentini et al. 2016).

In order to test the ability of 12S markers to detect the whole fish community within an alpine lake und furthermore investigate, if habitat preferences of fish are reflected by eDNA distribution, a sampling plan was developed based on the WFD requirements for fish ecological status assessment. The same sampling sites (gillnet locations and electrofishing stretches) were used, that were used for the last traditional monitoring carried out in 2010, which allows us to compare the both approaches regarding the creation of comprehensive taxonomic inventories.

Methods

Two different eDNA capture methods, using glass fibre filter discs (GFC, poresize 1.2 µm) and enclosed filtration cartridges (VigiDNA, poresize 0.45 µm) were applied, analysed and compared to traditional fish status assessment regarding species detection. For the GFC approach, 5L water samples were collected at the exact same locations and depths (electrofishing- and gillnet-sites) that were used during the last WFD fish status assessment at Lake Mondsee. For the VigiDNA approach, 30L water samples were collected along lakeshore transects (6 km each) and along a depth gradient. DNA from GFC filters was extracted using the PowerWater Kit (Qiagen), following the manufacturers protocol, the extraction of DNA from the VigiDNA filter-cartriges was done following the protocol from Pont et al. (2018). Afterwards, the samples were sequenced (MiSeq) using the MiFish primer pair (forward: 5`-3` GTCGGTAAAACTCGTGCCAGC, reverse: 5`-3` CATAGTGGGGTATCTAATCCCAGTTTG, Miya et al. 2015). Sequencing data analysis and taxonomic classification based on amplicon sequence variants (ASVs) was done using the qiime2 pipeline.

Results

GFC samples from the lake detected 22 different fish species, whereas the traditional approach detected 19 and the VigiDNA approach only 14. With the GFC samples from the lake, 3 species (*Onchorynchus mykiss*, *Cyprinus carpio* and *Scardinius erytrophthalmus*) were detected, that were not caught during the last WFD assessment. In addition, GFC samples that were taken in the tributaries obtained DNA from 25 different species, including 5 riverine species like *Cottus gobio*, *Barbus barbus* and *Salvelinus fontinalis* that do not occur in Lake Mondsee. Using the GFC approach resulted in a higher number of species detected per sample, the difference is particularly significant when you look at the number of species detected per litre of filtered water (Figure 1). Furthermore, it was observed that eDNA distribution in a lake represents habitat preferences of different fish species (Figure 2). Pelagic living fish like *Salvelinus alpinus* and *Coregonus lavaretus* showed highest DNA concentrations at sampling sites located in the Hypolimnion, whereas near shore dwelling fish like *Tinca tinca*, *Squalius cephalus*, *Perca fluviatilis* or *Abramis brama* showed highest DNA concentrations at sampling sites in the Epilimnion. Fish like *Rutilus meidingeri* and *Alburnus mento*, which shift preferred habitats during their life cycle, showed strong signals in both areas. The number of species detected was highest in the near shore areas (depth 0.5m) and decreased with increasing sampling depth (up to 60m) (Figure 3).

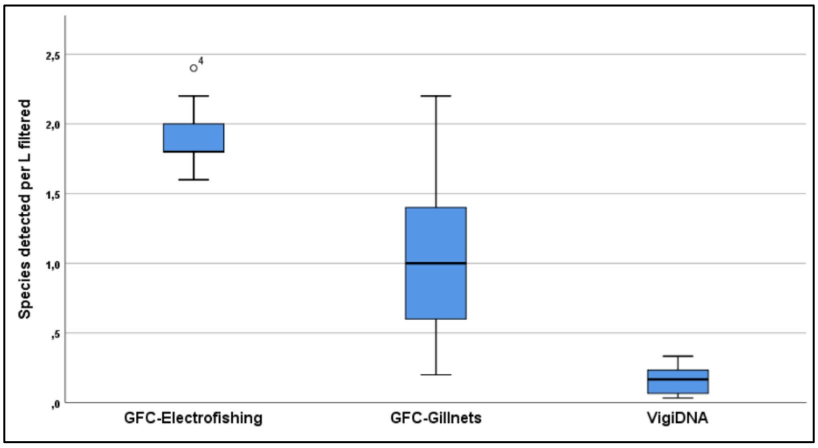

Figure 20 Boxplot showing the amount of species that were detected per liter water filtered. For the GFC filters (Electrofishing and Gillnet sites) 5 liters were filtered, for the VigiDNA filters 30 liters.

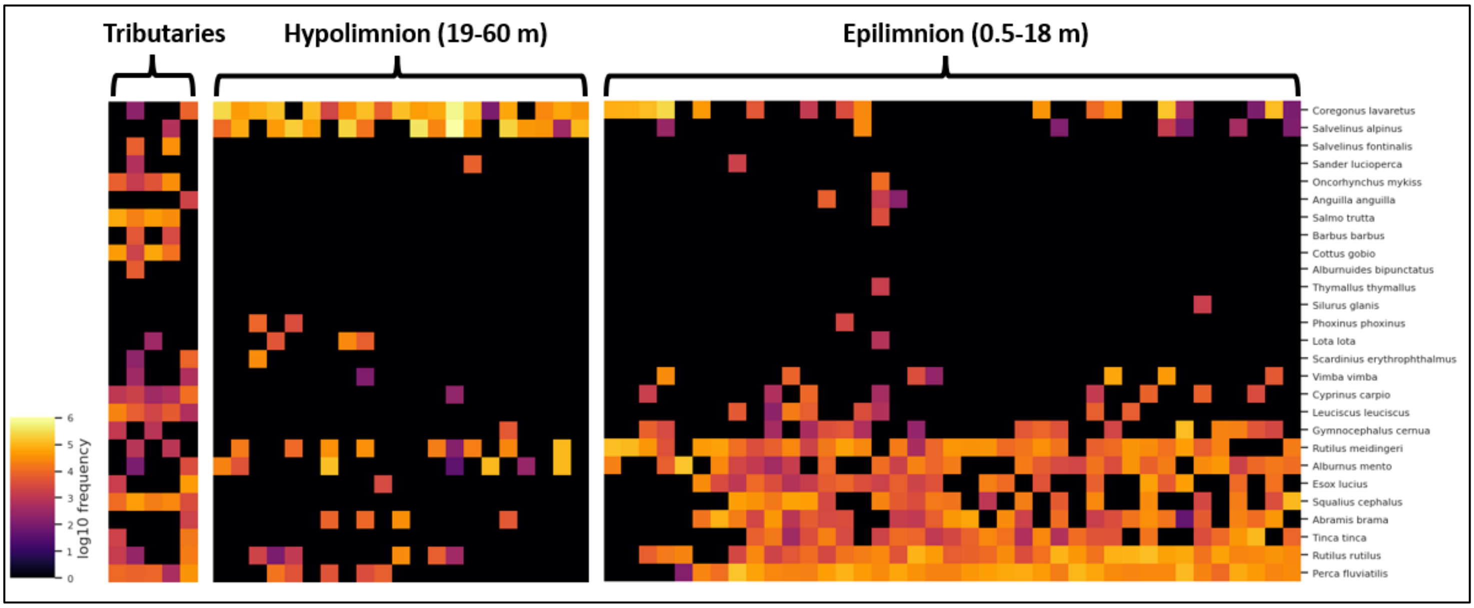

Figure 21 Heatmap showing that the distribution of eDNA at Lake Mondsee reflects known habitat preferences of fish. Each columne represents a sampling point located in the Hypolimnion, Epilimnion, or in the mouth of tributaries. The brighter the colors, the more DNA of a certain species was found at this location. Only GFC filters were used for this analysis.

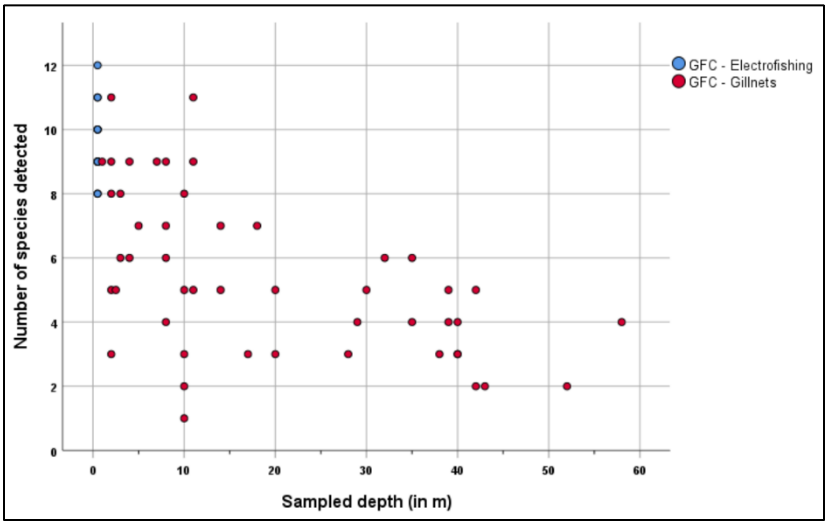

Figure 22 Scatter plot, showing the decline of species detected the deeper the samples were collected. All 14 samples that were collected at the electrofishing stretches (blue dots) at a depth of 0.5m detected between 8 and 12 different species).

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Differential spatial responses of rodents to masting on forest sites with differing disturbance history

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Abstract

Mast seeding, the synchronized interannual variation in seed production of trees, is a well-known bottom-up driver for population densities of granivorous forest rodents. Such demographic effects also affect habitat preferences of the animals: After large seed production events, reduced habitat selectivity can lead to spillover from forest patches into adjacent alpine meadows or clear-cuts, as has been reported for human-impacted forests. In unmanaged, primeval forests, however, gaps created by natural disturbances are typical elements, yet it is unclear whether the same spillover dynamics occur under natural conditions.

To determine whether annual variation in seed production drives spillover effects in naturally formed gaps, we used 14 years of small mammal trapping data combined with seed trap data to estimate population densities of Apodemus spp. mice and bank voles (Myodes glareolus) on 5 forest sites with differing disturbance history. The study sites, located in a forest dominated by European beech (Fagus sylvatica), Norway spruce (Picea abies), and silver fir (Abies alba), consisted of two primeval forest sites with small canopy gaps, two sites with larger gaps (after an avalanche event and a windthrow event), and a managed forest stand with closed canopy as a control.

Hierarchical Bayesian N-mixture models revealed a strong influence of seed rain on small rodent abundance, which were site-specific for M. glareolus but not for Apodemus spp. Following years of moderate or low seed crop, M. glareolus avoided open habitat patches but colonized those habitats in large numbers after full mast events, suggesting that spillover events also occur in unmanaged forests, but not in all small rodents. The species- and site-specific characteristics of local density responding to food availability have potentially long-lasting effects on forest gap regeneration dynamics and should be addressed in future studies.

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Conference Volume | 7th Symposium for Research in Protected Areas | Pages 247-247
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Pulling the plug - Restoration of Lake Sulzkarsee (Styria, Austria), an alpine lake degraded by fish introduction

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Abstract

Sulzkarsee is the only high-altitude lake in the National Park Gesäuse (Styria, Austria) and is severely degraded by fish (minnows, Phoxinus phoxinus) introduced half a century ago. Originally, it was home to large populations of three different amphibian species: Alpine newt (Ichthyosaura alpestris), Common frog (Rana temporaria), and Common toad (Bufo bufo). The latter still breeds with several thousand individuals, but the minnows prey heavily on the eggs and larvae of the other two species.

Amphibian abundance was assessed with counts and mark-recapture experiments. After intensive fishing and relocation of minnows, we drained the lake in 2018 in order to eradicate the remaining fish. However, a few hundred individuals survived in the sediment and the population increased rapidly again despite intensive fishing. Lower trophic levels (phyto- and zooplankton) reacted to the top-down control of zooplanktivorous fish. Effective purse seines were developed for effective reduction of the fish population. A 6 m long sediment core was taken in order to investigate vegetation development during the past 12.000 years. Additionally, we investigate ancient DNA to reconstruct plant communities and the colonization history of the lake by amphibians. Archaeological investigations confirmed the presence of humans near the lake as far back as 9.000 - 6.500 BC.

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Interacting effects of climate change and grazing exclusion on subalpine–alpine–subnival plant communities: Results of a long-term survey in the Nature Park Ötztal/Tyrolean Alps

Nikolaus Schallhart, Rüdiger Kaufmann, Roland Mayer and Brigitta Erschbamer

Abstract

Climate change is one of the main reasons for alterations in plant communities, species numbers are increasing in high elevations. However, grazing might interfere with climate change effects. To disentangle both effects remains a major challenge of alpine ecology. Here, we present a study that investigated climate change and grazing exclusion on species diversity along an elevation gradient in the Austrian Central Alps. We aimed to answer the following questions:

1. How do species diversity and frequency of subalpine–alpine–subnival plant communities change in grazed sites with time?

2. Do competitive plant species increase in the communities?

3. How does grazing exclusion affect species diversity, functional groups, and strategy types?

4. Are environmental changes (temperature, sunshine duration, precipitation) responsible for diversity changes or does grazing override climate effects?

The study was conducted at the LTER site Obergurgl (Nature Park Ötztal, Tyrol, Austria) along an elevation gradient from 1,958 to 2,778 m a.s.l., including seven different plant communities. A total of 11 grazing exclusions were established. At each community, the frequency of the species was counted in 1 m² plots yearly or at least every 3–4 years during a total period of 18 years. Environmental data were obtained from the TAWES weather station of the ZAMG in Obergurgl. Changes of community parameters and species composition were analysed by partial redundancy analyses and mixed-effect models. Species diversity increased with time at all grazed sites. In contrast, it was suppressed under grazing exclusion. Grazing exclusion effects became pronounced after 5 years. The most consistent result was the increase of bryophytes throughout. At the subalpine grassland, tall-growing species expanded in the exclosures; at the upper alpine *Carex curvula* grassland, snow bed species decreased with grazing exclusion. Among the environmental factors, sunshine duration of the previous year's autumn quarter was found to be the essential variable for the changes. We conclude that diversity increases in grazed communities of the Austrian Central Alps can be attributed to climate change. An indication of slightly reduced and altered weather effects under grazing exclusion was found.

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Effects of climate warming on Austrian wild bee communities and functional traits

Victor Scharnhorst, Bärbel Pachinger, Johann Neumayer, Katharina Thierolf, Esther Ockermüller, Benedikt Becsi, Herbert Formayer

Abstract

Wild bees provide important ecosystem services by pollinating crops and wild plants. However, their populations are declining and many species are endangered, with habitat loss and climate warming among the most important factors.

The aim of our ongoing study is therefore to document the effects of climate warming on the composition of wild bee communities and the associated functional characteristics of species in Austria. In order to be able to attribute the observed changes and diversity patterns to climate warming, a comparison with historical records before warming is essential.

The wild bee collection of Prof. Dr. Bruno Pittioni (1906-1952), which is kept in the Natural History Museum in London, contains several thousand specimens collected between 1920 and 1951, mainly in Austria. Thanks to the generally accurate recording of species and localities, this collection, together with other collections from museums and the literature, provides an adequate database before significant global warming occurred.

In this study, we compare these historical records with field sampling results that match the locations of the historical records. Preliminary results already show the presence of more thermophilic species in the area of the Neusiedlersee National Park, which correlate to increased mean annual temperatures and are currently being studied in more detail.

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Bullshit – Dung beetle and their impact

Tobias Schernhammer, Manuel Denner

Summary

Global insect decline is one of the key issues in the biodiversity crisis and one of the greatest challenges of the 21st century. While the public discourse is mainly limited to the pollination performance of some insect groups, a drastic decline of one of the most central organism groups is going on unnoticed, namely that of the decomposers. For example, serious declines in the group of dung beetles (coprophagous scarabaeids) have been documented throughout Europe since the 1950s (Sánchez-Bayo & Wyckhuys 2019). As a result, all those species that can process the dung of grazing animals are missing, especially in agriculture. The main causes, apart from changes in landscape and agriculture, are the prophylactic use of anthelmintics (deworming agents) and their immense negative impact on non-target organisms (Schoof & Luick 2019). Numerous studies show that this decline causes lasting damage to biodiversity and, consequently to the economic sector. Some of the many negative impacts of this decline include increased parasite pressure on rangelands (Sands & Wall 2017), increased methane emissions from undecomposed manure (Penttilä et al. 2013), delayed remineralisation of manure (Nichols et al. 2008), massive declines in insect biomass and subsequently insect herbivores (Buse 2019, Young 2015), etc.

Keywords

dung beetle, insect decline, nature conservation

Introduction – Results

Dung, especially that from large herbivores such as cattle, is a resource widely underestimated in conservation. Laurence (1954) describes that, especially from cattle dung, one fifth of the body weight of one animal can be produced as insect biomass in the course of one year. Furthermore, a manure pile provides specific habitat for over 500 species of evertebrates through all stages of decomposition.

One of the most important beetle groups in Central Europe are coprophagous Scarabaeids. So far, about 130 species have been recorded in Austria, 105 of which are found in the Pannonian lowlands of Austria. Three families are included: Geotrupidae (five species), Scarabaeidae (28 species) and Aphodiidae (72 species), whereby not all representatives of the Aphodiidae are coprophagous species in a strict sense.

Of the 105 species of eastern Austria, current records are available only for 69 species (Fig.1). The last records of all other species are already 20 years or longer ago. This is a decline of 35% and thus - as far as known - higher than of any other insect group in the study area. This dramatic decline is not limited to intensively cultivated land, but can also be observed in large protected areas. In a survey in 2021 in the National Park Neusiedler See - Seewinkel, from formerly 70 identified species were only found 47 species. The two main reasons for this decline are considered to be the prophylactic application of deworming agents in cattle herds and the large-scale decline in grazing areas.

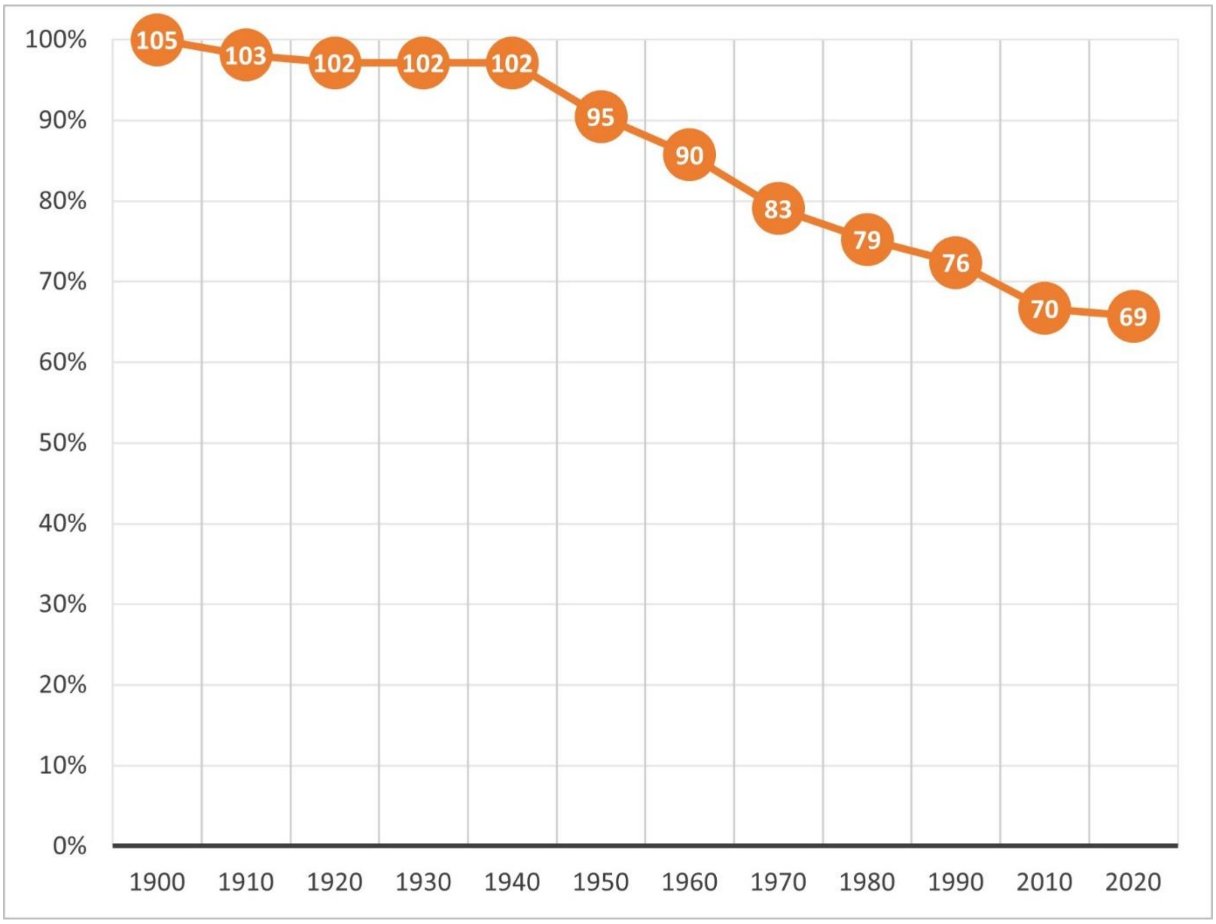

Fig.1: Decrease of Dungbeetle-Species (coprophageous scarabaeids) in Austria over the last 12 decades

As already mentioned in the study from the National Park Neusiedler See - Seewinkel, dewormers such as ivermectin are one of the main causes for the decline. These have a non-specific effect on many evertebrates and lead to delayed larval development, sublethal side effects or death of larvae or imagines (Koopmann & Kühne 2017). Another major reason for species decline is the loss of grassland habitats. While the area share in the 19th century was still 13.5% on average, this share has declined to only 1.3% today (Vinca 2021), with the decline of pastureland being even more dramatic. In addition, the quality of pasture ecosystems has also declined significantly. Whereas in the past pastures and meadows were intertwined in a small-scale, often very heterogeneous system or even found on one and the same area, nowadays there is a strict separation between mowing meadows and pastures. This has drastic effects on the availability of dung in the landscape, but also strong impacts on breeding bird populations, as mowing dates have shifted forward - and thus into the breeding season.

Within the coprophagous Scarabaeids, three guilds can be delineated: the rollers, the tunnellers, and the dwellers. Where the Rollers spend dung in the landscape, the Dwellers live within the dung piles, and the Tunnlers bury dung in the soil just below the piles. Other niches include seasonal occurrence (e.g., typical spring or winter species), size, preference for certain mammal species (e.g., european ground squirrels (*Spermophilus citellus*) or european hamster (*Cricetus cricetus*)), preference for certain habitats (forest species, steppe species, etc.), or elevation.

By their activity of excrement burying alone, they provide a number of different ecosystem services:

- Reduction of parasite pressure on grazing areas.

- Dispersal of seeds

- Support and improvement of nutrient cycling

- Reduction of methane production within dung

Over the seasons, the highest biodiversity in Austria is found in the months of May, June and September. The numbers of individuals are similar, with the peak in autumn being reached in October. However, there are large differences between the grazing systems: Permanent pastures, which are grazed year-round, have significantly more individuals, particularly in spring, than temporary pastures.

Extensive pastures are not only important for dung beetles, but also for a variety of other organism groups such as birds. Typical groups among these are wading birds such as black-tailed godwit or insectivorous species such as whinchat. Shortly grazed areas serve as nesting and feeding sites, higher vegetation structures as important perching sites.

In conclusion: Dung beetles occupy a key position in pasture ecosystems, but are dependent on an adequate supply of dung - both qualitatively and quantitatively. In this respect, large herbivores have an important role to play in both process conservation and species protection. The inclusion of meadows and mixed pasture systems, especially with forest grazing or even extensive year-round grazing within large protected areas, is one way to mitigate the biodiversity crisis in this aspect.

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A research concept for the Vjosa river system in Albania in view of the creation of a National Park.

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Introduction

The Vjosa river-system in southern Albania received considerable international attention during the last years because of its near-natural flow regime, largely undisturbed hydro-morphic dynamics and the threat of its destruction by hydropower dams. The river has been identified as a benchmark for European environmental policy and as a unique natural laboratory for river science that could guide restoration efforts in alpine rivers across Europe. The idea to create a Vjosa National Park was proposed by scientists and NGO`s, and was finally agreed by the Albanian government.

The main stem of the Vjosa at its middle section (foto Subic)

A cooperation between Albanian and Austrian scientists was initiated in 2015 in order to provide science based evidence for the value of the catchment with regard to its biodiversity and the ecological services. This cooperation included the organization of a conference at the University of Tirana organized within the "Save the Blue heart of Europe – Balkan Rivers campaign", an international Vjosa science week, followed by joint field surveys on the Vjosa 2017 and 2018. They resulted in a comprehensive publication of results (Schiemer et al. 2018 a, b), an international symposium in Tirana in 2019 and the opening of a small field laboratory directly on the Vjosa in 2020. Together with the continuous activities of NGOs- especially "Riverwatch" and "Eco-Albania", these research activities (e.g. Schiemer et al. 2020, Meulenbroek et al. 2020, Hauer et al, 2021) were successful in raising the public awareness both within Albania and internationally, and contributed to stop the hydropower plans on the main stem of the river. Further, these activities led to the present planning of a National Park supported by the Albanian Government.

In spring 2022 we succeeded to launch a research project extending from 2022 to 2026 financed by the Appear Programme of the OeAD. The project **"Environmental assessment of the Vjosa riverscape as the basis for an integrated water management and sustainable catchment development"** seeks to strengthen the research cooperation of Albanian and Austrian scientists in the field of water governance. It aims for a comprehensive understanding of then biodiversity and functional processes of the whole river system including its main tributaries as a basis for management. The project combines the research interests of 3 Albanian and 3 Austrian universities: it involves research teams on geomorphology, hydrochemistry, water quality assessment. vegetation ecology, groundwater ecology, macrobenthos, fish, terrestrial invertebrates and vertebrates.

Methods

The project focuses on four cross-cutting research topics, aiming for an interdisciplinary and translational character:

Work package 1: **"Monitoring and understanding the fundamental physical regime governing the Vjosa riverscape"** identifies the main physical processes. It is oriented towards a catchment-wide understanding of short-term and historical hydro-geomorphological processes as the framework for the characteristic biodiversity patterns and ecological functions.

Work package 2: **"Maintaining the Vjosa riverscape´s ability to support biodiversity"** is accordingly aiming for a detailed understanding of the high and specific biodiversity of the Vjosa and its major tributaries.

Work package 3: **"Ecosystem dimensions behind clean water provisioning, a key fluvial ecosystem service"** is concentrating on limnological processes and water quality aspects.

Work package 4: **„Science and Society interactions for sustainable developmen**t" has a transdisciplinary and translational focus, bringing the research findings in the focus of governmental institutions, decision makers and the public.

A main challenge at the start of the project was the selection a workable number of river reaches: 10 reaches of 1-3 km length were selected, representing the broad range of geomorphological characteristics and landscape ecological settings. The environmental and ecological features of these reaches will be studied by the different research teams at a range of scales - from reach scale (e.g. by e-DNA analysis) to microhabitat scale. The challenge will be to integrate and upscale the individual research efforts towards a broader understanding of the ecology of the whole catchment. This will be achieved by a formulation of joint research hypothesis and a continued interaction between the research teams.

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Urgent requirements for the conservation and support of Austrian biodiversity: A position paper of conservation experts.

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The Zoological-Botanical Society has started a discussion on biodiversity conservation among conservation experts in Austria. The initiative was inspired by an internal discussion on the question of process vs. species conservation, prompted by an article on the significance of Austrian National Parks for the conservation of the country's biodiversity (Zulka et al. 2022). The comments received were summarized in a statement published in ACTAZooBotAustria (Schiemer et al. 2022). The main points considered are outlined here. They are intended as urgent recommendation for decision-makers as well as a prompt to the technical discussions that conservation experts need to engage in.

The following aspects have been addressed:

1. Biodiversity conservation has to be comprehensive and nation-wide
2. Conservation concepts require further development and improvements
3. The focus should be laid on landscape and ecosystem processes
4. A well-directed priority research is required
5. The science-policy interface and the dialogue between conservation experts and stakeholders has to be intensified
6. The legal framework, its application and enforcement has to be strengthened.

Ad 1)

Biodiversity protection must be secured nation-wide and not restricted to conservations zones, in order to mitigate the manifold global (e.g. climate change) and local pressures and maintain and restore characteristic ecosystem processes.

On the other hand, the network of protection zones with its different categories has to be extended – in line with the EU criteria – **based on a comprehensive national strategy**.

Ad 2)

The various categories of conservation zones (national parks, EU-2000 areas, biosphere reserves, landscape protection zones, nature parks etc.) require different attention:

Many conservation areas exist only on paper, without **clearly defined goals, local management plans and measures of implementation.**

Conservation goals and management plans should be clearly and positively formulated and communicated with users and stakeholders.

Local management plans require a solid data base, secured by comprehensive and **science based monitoring programs**. Implemented measures - both successes and failures should be continuously evaluated in order to improve management procedures **(„adaptive management“** *)*.

The **allocation of puffer zone**s between conservation zones and used areas (“Nutzungsgebiete”) is urgently required in order to strengthen the protective effect. This is particularly important for protection zones embedded in “industrialized” agriculture and forestry areas and for small scaled protection areas like bogs or linear riverine landscapes.

A further important step in biodiversity conservation will be the stipulation of a catalogue of **examples of „good practice“** of low impact and high sustainability for all societal activities (e.g. agriculture, forestry etc.).

Ad 3)

Conservation approaches on processes, biotopes or species are complementary but should be seen in a hierarchical order:

An important strategic issue, which requires further discussion among experts, concerns the **focus on process-conservation** as a general approach for protection and restoration.

Besides the value of individual species as protected properties (“Schutzgüter”), the focus on species or species groups as indicators is significant for evaluating and calibrating the status and short term success of measures. However, the **taxonomic indication system should be broadened**: The focus on a few selected indicator groups has led to a tremendous loss of taxonomic knowledge and insight in ecosystem functioning e.g. pollination, nutrient cycling etc.

Ad 4)

Efficient conservation requires continued and well directed research:

For process conservation the understanding the **cause-effect chains at the landscape level** and the effects of the various pressures on biodiversity is mandatory.

With a better understanding of the **autecological requirements** and biocoenotic integration of characteristic species conservation management will improve.

A further urgent request is the promotion of **taxonomic and systematic studies** of groups of organisms for which during the last years the national expertise has been widely lost.

There is increasing demand to **improve the cooperation between universities, museums, and conservation practitioners** in order to strengthen the knowledge base for biodiversity conservation and management. Research requirements should be jointly formulated and training programs further developed. This requires a **well-directed and well-funded national promotion program**. The „Biodiversity Fund“ at the BMK could play a meaningful role when its goals and priorities are clearly defined, enlarged and a long-term budget secured.

Ad 5)

Because of the enormous conflict between the interest of conservationists and users -agriculture, forestry, tourism, traffic - a transdisciplinary science-policy approach is required. The challenge is to make users aware of consequences of their actions, increase the sensitivity of the public with regard to the continuous biodiversity loss and put pressure on decisions makers. The interaction between conservation experts, stakeholders, civil servants and political decision makers must be intensified. Biodiversity conservation issues should be taken into account at all levels of decision making and sufficient funds should be provisioned to make conservations issues attractive for users.

A main request is the appointment of long-term panels of conservation experts, stakeholders and decision makers with a clear mandate of involving experts in the preparation of political decisions related to biodiversity issues.

Ad 6)

The need for action is high both with regard to the further development of regulations as well as to their practical application. In order to develop an effective nationwide biodiversity conservation, the legal framework has to be consolidated by establishing the **conservation competence as a national law.** At the level of local decision making the competence in conservation matters should be restricted.

The existing regulations and legal approval processes and their execution are frequently unsatisfactory, insufficiently applied and not rigorously enforced (malpractice is often considered as trivial offence). There is **high demand for action by public authorities**.

In sum, the many actions and positive developments during recent years are by far not sufficient to compensate for the continuous biodiversity loss. It is important to recognize that the biodiversity crises, climate change and the societal development are strongly interrelated and therefore **integrative actions** are required. A continued and strengthened **science-policy dialogue is imperative**.

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Flora and vegetation of the alluvial area in Vienna and Lower Austria before and after the Danube regulation

Luise Schratt-Ehrendorfer, Doris Lindbaum-Rotter

Abstract

Around the mid 19th century and before the regulation of the Danube river, the botanist Siegfried Reissek studied its alluvial flora in Vienna and adjacent Lower Austria. He left a hand-written manuscript in the archives of the Museum of Natural History in Vienna. This manuscript is the only extensive botanical information source from the period before the regulation of the Danube.

Because of its complete species list and the detailed descriptions of the vegetational succession processes it is a suitable reference to compare flora and vegetation before and after the regulation of the Danube River. Furthermore, Reissek's notes on the ecology and vegetation of the Danube area can serve as an important basis for the protection of endangered species in the Danube National Park.

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Pollarding: a management tool in the conservation of veteran trees and their associated biodiversity

Pavel Sebek

Summary

Veteran trees and trees with hollows are key features that sustain biodiversity in wooded landscapes. However, they have become rare and localised, and most associated biota is in decline and/or endangered. Therefore, to safeguard the presence of the hollow and veteran trees in sufficient numbers is a challenge for conservation. Populations of numerous endangered species associated with tree hollows and deadwood are often found in habitats that were formed by formerly common traditional silvicultural practices. Pollarding, i.e. the periodical removal of upper tree branches, is an age-old practice that leads to the rapid formation of tree hollows, bare wood and other microhabitats usually associated with old trees. Pollard trees also tend to live longer than unpollarded ones, thus increasing the density and continuity of these precious and rare microhabitats. Since it was common in most of Europe, numerous old trees bear the signs of ancient pollarding. Such trees are key habitats for populations of many threatened veteran tree specialists such as *Rosalia alpina* or *Osmoderma eremita*. Pollarding is, therefore, a suitable tool for the conservation and restoration of saproxylic habitats. However, it is overlooked and rarely practiced in modern conservation management. Sadly, the ancient pollards disappear without replacement due to the abandonement of the practice in farmlands and prevailing “minimal intervention” approaches in forest reserves. Resumption of pollarding is necessary in order to increase spatial and temporal landscape connectivity for saproxylic organisms, and to prevent major loss of biodiversity across the continent.

Keywords

veteran trees, biodiversity loss, habitat restoration, landscape ecology, threatened species

Introduction

Veteran trees, i.e. large old trees providing deadwood and its microhabitats, such as hollows, large dead branches, or fungal fruiting bodies, are considered keystone ecological structures sustaining woodland biodiversity (Bouget et al. 2014, Müller et al. 2014, Lindenmayer et al. 2014, Read 2000). Veteran trees are, however, experiencing a rapid decline across the landscapes which contributes to the current trends in biodiversity loss (Lindenmayer et al. 2012).

Modern forestry practices have led to alteration of stand structural attributes of woodlands, characterised by a reduction of early-successional phases on one hand and a disappearance of late-successional phases on the other hand. In production forests, trees are usually felled after 80-120 years, thus before reaching maturity and developing specific microhabitats. However, the veteran trees disappear even from the protected areas which apply minimum intervention approach. This is because although protected from cutting, old trees are unable to compete with youger trees for light under high canopy closure prevailing in such forests and thus eventually die out. Besides, in open landscapes, due to agricultural intensification, many formerly scattered old trees or traditional hedgerows have been removed to make more space for productive crops and meadows. Nowadays, veteran trees can mostly be found in places resembling open woodlands, such as game reserves, chateau parks, orchards, or in tree alleys along the roads and watercourses (Miklín et al. 2018), thus in the places which escaped modern forestry and agricultural practices but remained outside larger protected areas.

In order to alleviate the biodiversity loss, safeguarding the veteran trees and maintaining populations of endangered organisms associated with them should be one of the primary goals for the conservation practice. Pollarding – a traditional pruning technique – is a suitable tool in the management of old trees as well as a technique of tree veteranisation, i.e. the measure of accelerating microhabitats formation on trees.

Method overview

Pollarding is a pruning technique based on the periodical removal of upper branches of trees which promotes the growth of a dense head of foliage and branches. Pollard trees were an indispensable part of many European silvopastoral and agricultural landscapes. The trees were usually cut at a height of 2-4 metres above ground which allowed to combine fodder and/or fire-wood production in the tree layer with grazing, hay or crop production on the ground (Petit and Watkins 2003). The branches used to be cut in the periods from 1 to 15 years based on the required woody product or based on the species of a tree.

Pollarding has several positive effects on biodiversity associated with old trees. It induces formation of deadwood microhabitats such as tree hollows and bare deadwood (Sebek et al. 2013, Siitonen and Ranius 2015). Young pollard trees, especially, form hollows much more often than unmanaged trees and moreover the hollows tend to be large as they form in the trunk, not in the branches. Stands of pollard trees thus offer high density of otherwise rare deadwood microhabitats to a wide spectrum of saproxylic (deadwood dependent) organisms. Thanks to their lower height, pollard trees are less susceptible to breaking and falling due to weight imbalance, as long as pruning is carried out periodically. Pollards thus tend to live longer than unmanaged trees (Read 2000, Lonsdale 2013), and a single pollard may provide continuum of various microhabitats for hundreds of years.

Perspective

Stands of pollard trees are key habitats for several threatened species of European concern. In the Forest of Sare, southwestern France, stands of ca. 15.000 huge, previously pollarded oaks host the greatest European population of the endangered hermit beetle (*Osmoderma eremita*), a specialist of tree cavities and an umbrella species for the conservation of hollow-associated fauna (Van Meer and Barnouin 2022). In southern Moravia, Czech Republic, the core of the beetle's distribution lies in a system of pollard willows in intensively farmed lowlands (Cizek et al. 2021). The lowland marshes of Marais Poitevin, western France, interlaced with hedges of pollard ashes form a crucial habitat for the Rosalia longicorn (*Rosalia alpina*), a beetle requiring dry fresh deadwood but otherwise mostly associated with montane beech forests. Pollard trees surrounding farmsteads also provide refuge for the last remaining populations of the little owl (*Athene noctua*) in Central Europe, a higly threatened owl whose populations have significantly decreased in the last century. And many other rare species of insects, invertebrates, and lichens benefit from the practice of pollarding.

However, the actual threat for the conservation of veteran tree-associated organisms is the temporal gap in the availability of veteran trees. The existing old trees have often been subject to some form of pollarding in the past whereas younger trees have never been pollarded. The natural formation of hollows and other microhabitats in trees, however, takes a long time, so the young trees that should substitute for the veterans in near future often do not provide any microhabitats. Moreover, the abandonment of the pollarding practice has led to a deterioration of the health state of many veteran trees. Without a regular care, the formerly pollarded trees often collapse under the weight of overgrowing branches and the microhabitats they offer are lost. To bridge the gap between the veterans and the young trees, active measures are needed. A proper care should include reintroduction of pollarding on young trees combined with careful repollarding of the extant veterans in order to keep them alive as long as possible.

Figure 1. Pollard willows just after the pruning with still uncut trees in the background. As a result of periodical cutting the trees form a swollen top part of the trunk. (photo: D. Hauck)

Figure 2. Exposed heartwood with insect galleries and fruiting bodies of saproxylic fungi - common microhabitats even on young pollard trees. (photo: L. Cizek)

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Bedload monitoring in the Gesäuse National Park

Dorian Shire-Peterlechner, Rolf Rindler, Sabrina Schwarz, Andrea Kreisler, Helmut Habersack

Summary

Species diversity of aquatic life forms are significantly determined by the availability of different habitats and their composition. In this context, the bed substrate (bedload) plays an important role in regard to the ecological functionality. As aquatic habitat for macrozoobenthos or also as spawning habitat for gravel spawning salmonids such as the brown trout. In both cases, the availability of sediments deposited in various grain sizes is a prerequisite for the formation of adequate habitats. Since 2014 the bedload monitoring station located in the Gesäuse national park at the Johnsbach stream derives precious long-term nature-based data, fundamental to various riverine applications and basic research. This paper focuses on relevant issues for aquatic lifeforms, namely: sediment composition, dynamics and quantity.

Keywords

Integrated Bedload Monitoring, Sediment Variability, Long-Term Monitoring

Introduction

Bedload measurements in gravel bed streams is fundamental for an enhanced understanding of bedload transport characteristics and set the fundament for riverine applications ranging from engineering tasks to morphodynamic models (Tritthart et al. 2011). The Institute of Hydraulic Engineering and River Research (IWA) at the University of Natural Resources and Life Sciences continuously measures the bedload transport at a total of seven gravel bed rivers in Austria. These sites range from alpine streams, such as the Johnsbach stream, to lowland rivers, such as the Danube, with catchment sizes ranging from 55-104,177 km² (Liedermann et al. 2020). In this regard the Johnsbach stream in the Gesäuse national park with a catchment area of 65 km² is the second smallest catchment with a bedload monitoring station operated by the IWA. The bedload monitoring station was established in 2014 in cooperation with the Austrian Torrent and Avalanche Control (WLV) in the course of the FWF funded project Sedyn-X (Interdisciplinary Investigation of Sediment Flows). Since 2016 the monitoring is funded by the WLV. At the Johnsbach stream, the integrative bedload monitoring station consists of direct (basket sampler and bedload trap) and indirect (geophone system) measurement methods (Habersack et al. 2017). The geophone system continuously records bedload activity and is calibrated with the basket sampler and bedload trap. The bedload quantity and availability are massively influenced at the Johnsbach stream by the input of side catchments until just before the measuring station (Rascher et al. 2017). The range of bedload flux becomes visible in long time series. Annual bedload yields range from D>10mm 1,900 t (2018) to 13,500 t (2016). Grain size distributions thereby range from d_{50} 15-72 mm (D>8mm basket sampler, period 2016-2020).

Methods

Integrative bedload monitoring

At the Johnsbach stream the bedload monitoring facility is designed as an integrative bedload measuring station, measuring transport parameters listed in table 1, combining **direct** and **indirect** measurement methods.

Table 6: parameters of bedload transport with the measuring capabilities of the indirect (green column) und direct (red columns) measuring devices used at the Johnsbach stream (- not suitable, + partially suitable, ++ suitable, +++ highly suitable (modified Habersack et al. 2017)

Transport parameters	Geopone plates	Basket sampler	Bedload trap
Specific bedload discharge [kg $m^{-1}s^{-1}$]	-	+++	+++
Bedload discharge [kg s^{-1}]	-	++	-
Bedload yield [kg] or [t]	-	+	-
Grainsize distribution	-	+++	+++
Initiation of motion [m^3s^{-1},m]	+++	++	++
Temporal variability	+++	++	++
Spatial variability	+++	++	+

Specific bedload discharge q_b is defined as the bedload transport within a meter of river width per timestep. The bedload discharge is calculated by integrating the specific bedload discharge over the entire river width. Summarizing the bedload discharge over time the bedload yield is calculated. The direct bedload measurement samples are sieved in order to obtain the sediment grain size distribution. The initiation of motion quantifies the necessary discharge at which bedload particles start to move. Measuring temporal and spatial variability is essential, since bedload discharge varies strongly by time and throughout the cross section. None of the measuring devices can measure all parameters of bedload transport (see table1), therefore, the measuring devices are combined to complement each other (Habersack et al. 2017).

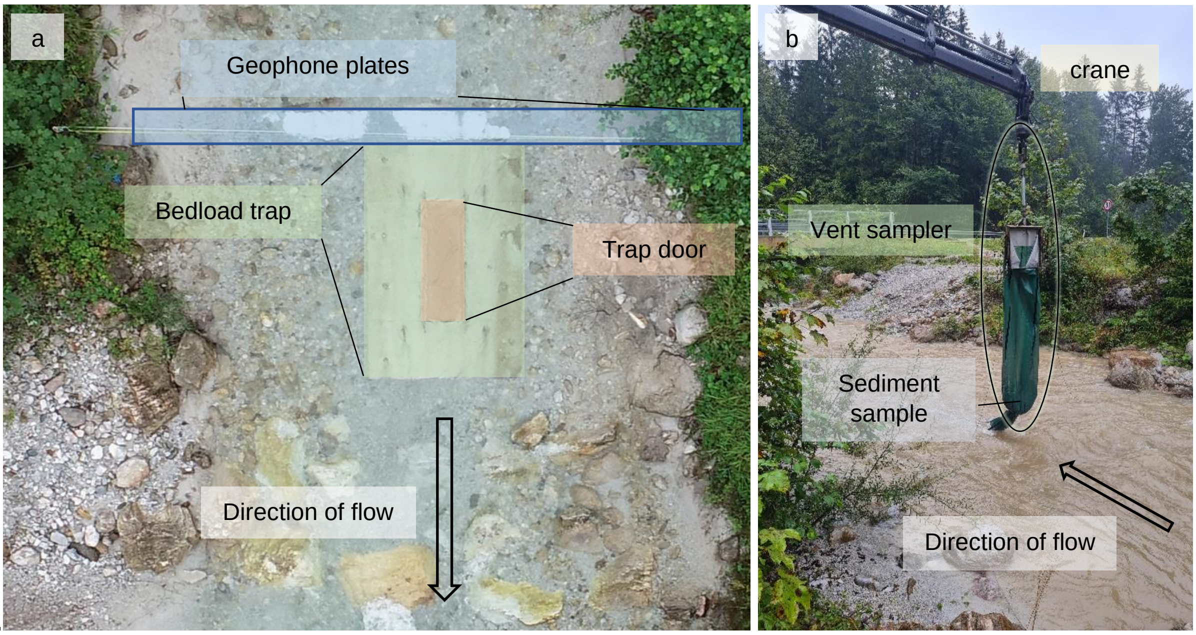

Figure 23: Integrative bedload monitoring at the Johnsbach stream: a) geophone pates and bedload trap (top few), b) vent sampler attached to crane with sediment sample.

Indirect bedload measuring: Geophone plates

Geophones are sensors originating from seismic technology capable of detecting vibrations (Habersack et al. 2017). In order to detect bedload transport, the geophone sensors, are mounted on the underside of steel plates. These steel plates are mounted on polymer mats protected by a steel frame covering the entire stream cross-section (see figure 1 a). As bedload particles are transported over the steel plates the impact generates vibrations, which are recorded after exceeding a certain amplitude. The sum of impulses per minute/second, maximum amplitude per minute/second and the integral of geophone signals are recorded continuously throughout the year. Particles D<10mm won't generate an impact exceeding the minimum amplitude for recording (Rickenmann and McArdell 2007). Therefore, particles D<10mm can't be measured with the geophone plates. Geophone plates make continuous recording of bedload transport activity both in time and space (laterally) (Rickenmann et al. 2014). Transferring the sum of impulses to bedload discharge is performed by calibrating the geophone impulses with direct bedload measurements.

Direct bedload measurement: Bedload trap

As one of the direct bedload measurement systems at the Johnsbach stream, the bedload trap or slot sampler is used during bedload transport events regardless of the magnitude. The bedload trap is located at the level of the stream bed, directly downstream of the geophone device. This bedload trap contains a sample box placed on load cells. The entire construction is covered with a lid, with a removable longitudinal trap door (see figure 1 a). The trap door is initially closed and opened for the measurement hydraulically. The load cells measure the increase of mass during the measurement (Kreisler et al. 2017). Bedload is first detected by the geophone plate and then collected in the sample box, and can therefore be used for geophone calibration. The bedload sample is later sieved to analyze the grain size distribution.

Direct bedload measurement: Basket sampler (Vent Sampler)

As a second direct measurement device at the Johnsbach stream during low to medium transport events, the Vent sampler comes to use. It was designed after the sampler introduced by Bunte et al. (2004). The inlet frame has the dimensions of 0.5 × 0.5 m. The net can be exchanged since it is mounted to a separate frame which attaches to the inlet frame (see figure 1 b) Depending on quantity and size distribution of bedload discharge, different nets with mesh sizes ranging from 1 mm to 8 mm come to use. With a crane (crane truck) the sampler is positioned downstream from a geophone plate in the riverbed for a defined period of time (Habersack et al. 2017). As with the slot sampler, the bedload particles are detected as impulses on the geophone plate before entering the basket sampler. The sample is weighed and sieved to analyze the grain size distribution of particles larger than the net size. After taking several samples during a transport event, the dynamics of grain size compositions can be analyzed.

Results

As an example of temporal and special variability of the bedload transport process the following 3D graph during the event of 08.07.2022 is displayed in figure 2. Bedload discharge occurs concentrated in the middle of the cross section, variating between geophone 5-9.

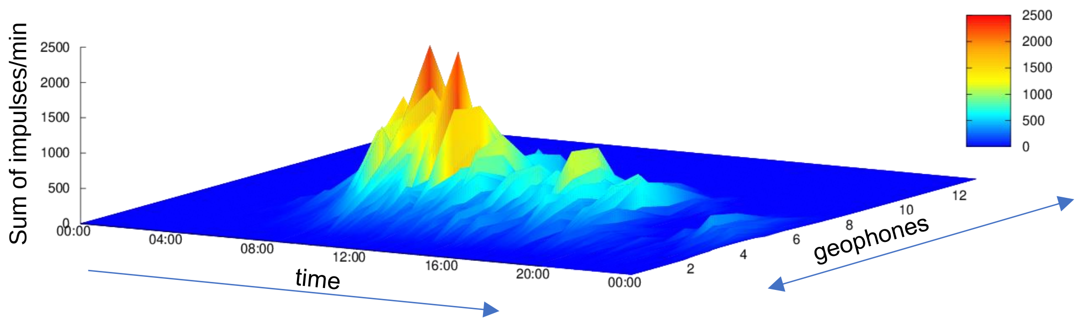

Figure 24: 24 hours geophone impulse graph of 08.07.2022 showing the temporal and special distribution, red indicates a high number of impulses per minute, blue indicates low impulses per minute.

During a single flood event the grain size distribution and specific bedload discharge can vary strongly over time as shown for example during the event of 26.04.2019 in figure 3. This measurement was performed at the same location in the river cross section with a specific bedload discharge ranging from 0-2.1 kg $m^{-1}s^{-1}$ and a highly dynamic sediment composition +/- 90% of size classes.

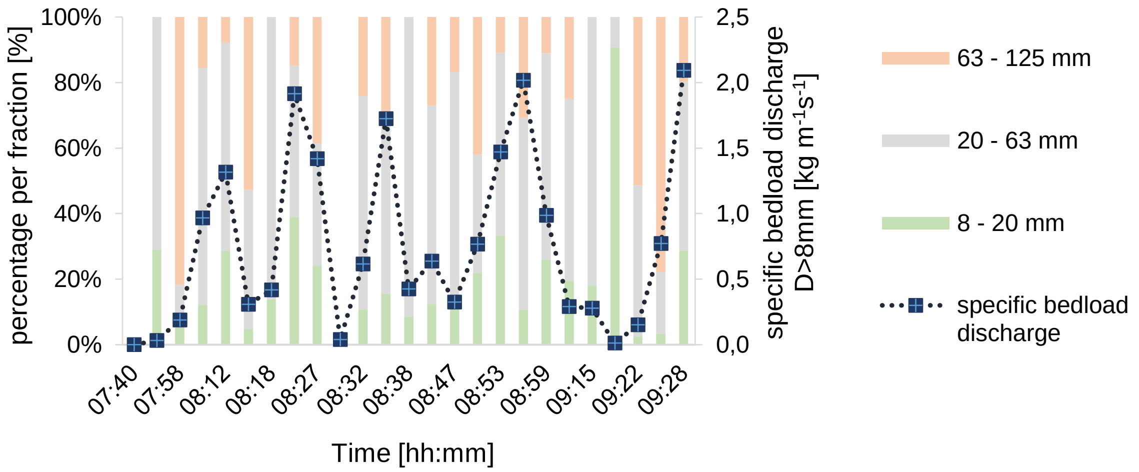

Figure 25: Grain size distribution during the event of 26.04.2019 derived from basket sampler D>8mm. the left vertical axis refers to the percentage per fraction displayed as a bar chart, the specific discharge is displayed as squares linked by a line and refers to the right vertical axis.

Comparing basket sampler measurements of the years 2016-2020 regarding the grain size distribution, the diversity of the transported sediments is illustrated in figure 4. With a d_{50} ranging from 15mm-72mm the sediment samples are highly diverse. Figure 4 displays grain size distributions of particles D>8mm since the largest mesh size used was 8mm. Each line in figure 4 consists of multiple measurements at a single event which were averaged for display.

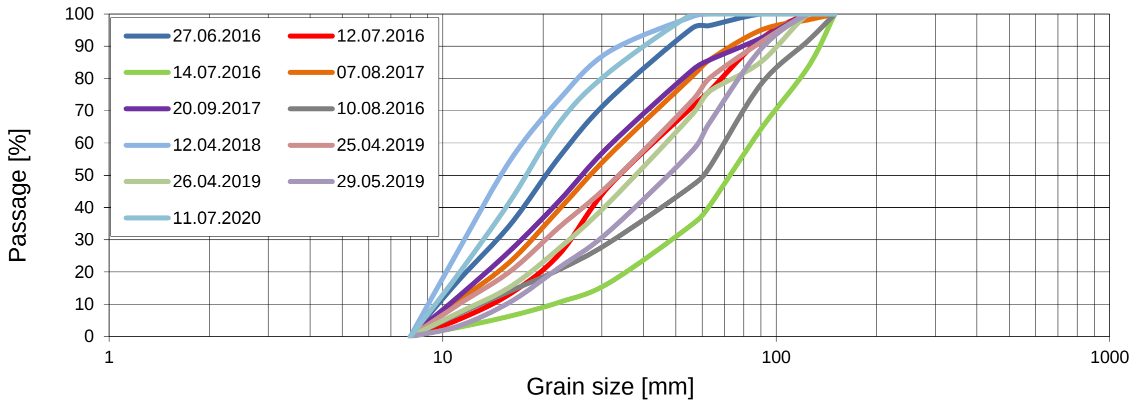

Figure 26 Grain size distribution >8mm derived by the basket sampler of the years 2016-2020, each measurement campaign consists of multiple single samples which were averaged for display.

Applying an integrative bedload monitoring setup, combining direct and indirect monitoring methods enable the continuous recording of bedload transport in a high temporal and spatial resolution. With an annual bedload mass ranging from 1,900-13,500 tons per year (particles D>10mm, 2014-2021) the Johnsbach river is a highly dynamic river regarding to the bedload flux. Grain size distributions ranging from d_{50} 15-72 mm display the heterogeneity of samples obtained with the Vent sampler. With the examples above, the sediment flux ranging from a single event scale to annual bedload masses, the capabilities and the available long-term data of the Johnsbach bedload monitoring station is highlighted.

In future, the Johnsbach will be particularly interesting since the main human impact (gravel mining) ended as the national park Gesäuse was founded, as addressed in Rascher et al. (2018). Therefore, the increase of bedload yield and a change in sediment composition is expected.

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Assignment of the IUCN protected area category for the Vjosa River and its tributaries, Albania

Andrej Sovinc

1.Background

The Art. 5 of the Law on Protected areas in Albania (81/2017) says: "*In categorising the protected areas and in determining the status of each of them, the responsible institutions in the Republic of Albania refer to the criteria of the International Union for Conservation of Nature (IUCN)*".

IUCN Guidelines for Applying Protected Areas Management Categories (Dudley, 2008 & 2013) are widely accepted as the international standards for protected areas. IUCN protected area management categories provide the basis for legislation, within the framework of international standards to help governments and others regulate activities, for example by prescribing certain activities in some protected area categories in accordance with the management objectives of the protected area. Signatory parties to the Convention of Biological Diversity (CBD) committed themselves to establish protected area systems, which are based on the IUCN protected area management categories and standards. This explains the role of the IUCN protected area management categories in planning, establishing and management of protected areas in the light of obligations of countries towards international standards for nature conservation.

2.Process of Assignment of the IUCN Protected Area Category

The process of assignment of the IUCN protected area category includes:

-verification if the given area meets the IUCN definition of the protected area[1];

-choosing and then agreeing the most suitable IUCN protected area category for given area (based on primary management objectives for the area, description and key characteristics of the area) and situation to meet the national legal requirements and international (IUCN) standards and norms and

-recording the protected area and category in the UNEP WCMC World Database on Protected Areas (WDPA).

Assignment of the IUCN protected area category does not imply that the area is effectively managed but it does imply how the area should be managed in relation to the IUCN Protected Area category it is assigned to.

Table 1 presents the IUCN protected area categories and principles that are applied to every protected area.

[1] "A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008 & 2013).

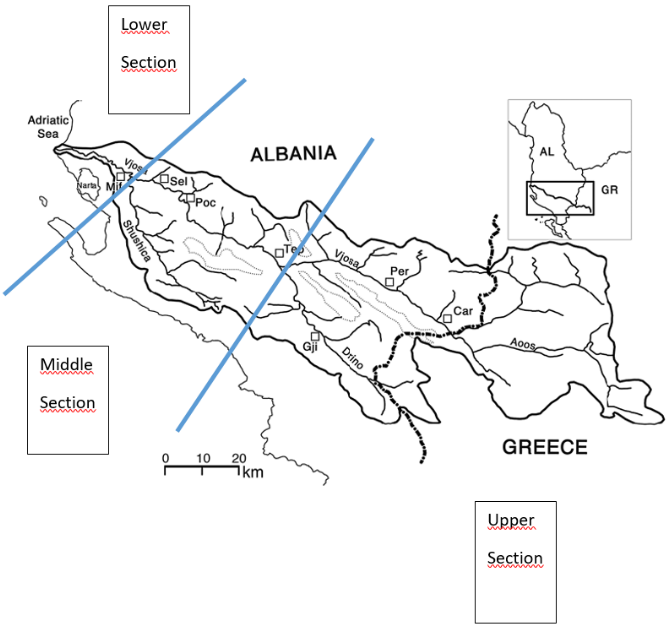
Table 1: short description of the IUCN PA categories and principles (Dudley, 2008 & 2013)

IUCN protected area category	IUCN protected area principles
Category Ia (strict nature reserve) set aside to protect biodiversity and also possibly geological/ geomorphological features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. "No-go" areas and not or just sparsely inhabited. Often **small**. ***Category Ib (wilderness area)*** are usually large unmodified or slightly modified areas, retaining their natural character and influence, without permanent or significant human habitation, protected and managed to preserve their natural condition. Fulfils the criteria for "wilderness" and covers one or more **ecosystems**. Usually large. ***Category II (national park)*** protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities. Usually large. ***Category III (natural monument or feature)*** protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature, such as an ancient grove. Usually **small**. ***Category IV (habitat/species management area)*** protect particular species or habitats, where management reflects this priority. Many will need regular active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category. Protect individual species/habitats or only fragments of ecosystem. Often **small**. ***Category V (protected land-/seascape)*** protect areas where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated values. These areas are cultural landscapes that have been altered by humans over longer period of time and rely on continuing intervention to maintain their qualities, including biodiversity. These areas and not natural ecosystems. Usually **large**. ***Category VI (protected areas with sustainable use of natural resources)*** protects ecosystems and habitats, and associated cultural values and traditional natural resource management systems. Generally large areas, with most of the area in a natural condition, where a proportion is under sustainable natural resource management with low-level non-industrial use of natural resources compatible with nature conservation. Biodiversity conservation is linked with sustainable use of natural resources and not left to natural processes.	Principles (relevant for every Protected Area) • Protected areas must prevent, or eliminate where necessary, any exploitation or management practice that will be harmful to the objectives of designation • Protected areas should usually aim to maintain or, ideally, increase the degree of naturalness of the ecosystem being protected • The choice of category should be based on the primary objective(s) stated for each protected area and should be applied to at least three-quarters of the Protected area – the 75% rule • The system is not intended to be hierarchical • All categories make a contribution to conservation but objectives must be chosen with respect to the particular situation; not all categories are equally useful in every situation • Any category can exist under any governance type and *vice versa* • A diversity of management approaches is desirable and should be encouraged, as it reflects the many ways in which communities around the world have expressed the universal value of the protected area concept • The category should be changed if assessment shows that the stated, long-term management objectives do not match those of the category assigned • However, the category is not a reflection of management effectiveness • The definition and categories of protected areas should not be used as an excuse for dispossessing people of their land

3. Description of the Vjosa River and its tributaries

The Aoos-Vjosa river extends over 272 km from its sources in Greece through the south of Albania to the Adriatic Sea. The first 80 km are situated in Greece. The total catchment size is 6.704 km^2 of which 4.365 km^2 are on Albanian territory. The descriptive part is given in the following sources: Drescher et al., 2018; Schiemer et al., 2018; Shumka et al., 2018

The Vjosa River has its source at the Pindus mountains in Epirus of Greece. Deep gorges are characteristic for the river's flow in the National park Vikos-Aoos in Greece.



Map 1: Vjosa River valley by sections.

The alluvial floodplains near the confluence of the Sarandoporo and Aoos rivers are particularly undisturbed with well-maintained floodplain forests. The channel pattern changes over its course in Albania. In the upper section the Vjosa River follows a sequence of steep canyons between Permet, Kelcyra and Dragot, entrenched in steep gorges intersected by areas with large alluvial fans and islands. Downstream of the Dragot area, the river valley widens except for the gorges of Kalivaci and Pocemi. At the city of Tepelena – before and after the confluence with the river Drino – large gravel and sand bars formed by the braiding river dominate the fluvial landscape. After Selenica the watershed slope of the river decreases, the valley becomes wide, and the river starts meandering.

The middle part of the Vjosa valley is surrounded by average mountain ranges with an elevation between 300 m a.s.l. in the north and almost 2000 m in the south. The Gribe mountain range separates the valleys of the Vjosa river in the north and northeast with the large basin of Kute and the Shushica valley in the southwest.

The floodplains of the Vjosa River in the south of Albania count as one of the most magnificent riparian ecosystems of the Balkan peninsula, standing out due to their natural hydromorphodynamic fluvial processes. A broad main stream with anabranches, open gravel bars and islands, and pioneer vegetation, as well as bushes of willows, poplars and tamarisks give Vjosa's floodplain an extraordinary distinction. Combined with large grasslands and small-area softwood forests, they build the vegetation mosaic along the river.

In the lower course, between the cities Fieri and Vlora, the Vjosa transits the lowlands of Myzeqe. The river is expanded in this section and forms widely outbound meanders. The river delta is located north of Narta Lagoon. The Vjosa River discharges into the Adriatic Sea north of the Narta lagoon.

The Vjosa river can be classified as a gravel-dominated, laterally active, anabranching river with high sediment yields in which bed load suppy is higher than the actual channel transport capacity, which is reflected in extensive, up to 2.000 metres wide gravel areas, crossed by several lateral and parallel rover flows, oxbowes and side-channels. Another criterion of the laterally active anabranching gravel beds are specific forms of avulsion at high flow rates, which is reflected in the rapid abandonment of a river channel during mostly extreme flood events and the formation of a new river channel in former floodplains (Meulenbroek et al., 2018).

Such river systems are frequently found in cold climate regions with snowmelt and glacier runoff areas. The Vjosa, however, demonstrates these features in a Mediterranean climate. A characteristic feature of braided and anabranching rivers is that bed load supply is higher than actual channel transport capacity. The only river which resembles the above characteristics and at least similar size of the Vjosa river in the central part of Europe is the Tagliamento river in Eastern Italy, however it is of much smaller size and lenght.

Photo: Vjosa River valley @A.Sovinc

4.Selection of the most suitable protected area category for the Vjosa river valley

Once an area has been identified as a protected area according to the IUCN definition, the next stage in classification is to determine which category matches most closely the overall management objectives of the protected area. The IUCN protected area categories system reflects management objectives.

4.1.Distinguishing features of the Vjosa River basin

Key distinction that separates the Vjosa River from so many other rivers and streams in Albania and Europe is that this river still remains wide, undisturbed riverine ecosystem. The key driver in running waters is the flow regime (the magnitude, frequency, timing, duration and rate of change of water flows). With the exception of the Langarica river and Carshove river tributaries, the entire flow of the Vjosa river, on the Albanian territory, is undisturbed; the complexity of unmodified ecological and hydrological processes within the wide profile of the Vjosa river and existing natural biodiversity of the river determine Vjosa river as a unique, functional natural ecosystem.

Inland rivers receive disturbances that are propagated across catchments and transmitted through water (e.g. pollution, hadro-power plants (HPP), small HPPs, regulation of flow and embankments, divertion of waters, river traffic, urbanisation...) that severly affect functioning of the natural processes in the riverine ecosystem. This is especially visible in streams and smaller rivers. The Vjosa river is unique not only as there is no major changes in the flow regime, but also because several of the external disturbances are minimised through the extensive size and width of the riverine floodplains. Vjosa river ecosystem is not modified by the human induced activities; it is probably the last undisturbed river of this size in the entire Europe. The river is long and large enough to contain all or most of the ecosystem processes, characteristic for the natural river flows, together with rich, native biodiversity. This confirms that the Vjosa river itself still functions as a dynamic natural ecosystem.

The upper reach of the Vjosa River is characterised by a steeper watershed slope. The middle part of the river, between Selenice and Tepelena, is a typical river-floodplain area. For the last 40 km before entering the Adriatic Sea, the slope of the river is low. Here the river changes from a braided to a meandering course, which occurs over a narrow stretch of about 15 km in length, and concludes in the Vjosa delta which comprises over 15 km river course and almost 30 km coastline including the Narta lagoon in the south (20,000 ha). Despite the fact that elevated upper floodplain areas are cultivated, grazed and provide space for human settlements, the core river bed remains in the natural conditions, which is made possible due to the extremely wide river corridor. Interconnected system of river and riverine habitats enables maintenance of the species' populations, communities and natural ecological processes, together with the flow of water, wind, materials and biota. The term 'connectivity' is used to describe how the spatial arrangements and the quality of elements affect the movement of organisms among different habitats; and the Vjosa river retains original high connectivity values for biodiversity.

- The Vjosa River area contains representative example of major natural river, and biological and environmental features or scenery, where native plant and animal species, habitats and geodiversity sites are of special spiritual, scientific, educational, recreational or tourist significance.
- The area is of sufficient size and ecological quality so as to maintain ecological functions and processes that will allow the native species and communities to persist for the long term with minimal management intervention.
- The composition, structure and function of biodiversity is to a great degree in a “natural” state or have the potential to be restored to such a state (riverine floodplain forests to be restored), with relatively low risk of successful invasions by non-native species.
- The Vjosa River is one of the last undisturbed river of this type in the wider European context.

5.Choosing the category

5.1.Size of the area

In terms of relative scale some protected area categories are more likely to be either large or small, because of their particular management objectives. The “small” categories are not an appropriate proposal for the Vjosa River area; in addition, those categories that refers to the natural monuments (rather than ecosystems) or habitats or species only could not be regarded as appropriate for the area of Vjosa; these include category Ia (strict natural reserve), category III (natural monuments), category IV (managed reserves).

5.2.Proposed primary management objective for the Vjosa River valley

Primary objective is to protect natural biodiversity along with its underlying ecological structure and supporting environmental processes of the wild Vjosa river and its tributaries, and to promote recreational and educational activities that are compatible with the concept of the “green tourism” and are beneficial for the development of the local communities of the Vjosa river catchment area.

The core zone of protection, where the primary management objective is protection of the natural biodiversity with accompanying ecological process, based on the undisturbed flow regime of the Vjosa River, is the narrow river bed, situated within the lowest floodplain plateau. This zone, which – according to the IUCN standards – needs to extend over at least 75% of the proposed protected area and where the primary management objective has to be applied, is a natural ecosystem, representing one of the last free-flowing wild rivers in Europe.

IUCN protected area category V aims to protect areas where the interaction of people and nature over time has produced modified »landscape«, which was shaped or modified strongly by humans and where human interactions with nature maintain such areas also as by today, and the areas are well settled by people. This might be true for the areas around the core Vjosa river lower floodplains, but the specifics of this proposal for protection is to focus on the extensive and unchanged natural wild river. There was no interaction between humans and river which would modify the natural flows of the Vjosa river; the main proof for such a standpoint is the fact that there are no HPP on the river along the entire river section in Albania. IUCN category V includes an option of continuous human interaction, the emphasis is on more intensive uses (like agriculture) while Categories Ib and II seek to minimise adverse human activities.

The term »landscape« in the IUCN protected area language refers more to those areas which were shaped or modified strongly by humans and where human interactions with nature maintain such areas also as by today, and the areas are well settled by people.

Despite the fact that the category VI sites are more “natural” than protected landscapes (Category V), where the landscapes have been transformed, the emphasis in IUCN protected area category VI is on sustainable use of environmental products and services. The protection of those areas is secured through promotion of sustainable use of natural resources; sustainable use of the natural resources is a means to achieve nature conservation. The core area of the proposed Vjosa River area is the river itself and there has never been any natural resource management in place; this is the essence of the wider European conservation value of the Vjosa river.

Of the remaining IUCN protected area categories, only categories Ib (wilderness area) and II (national park) provides protection for the natural or unmodified areas, which still retain a complete or almost complete complement of species native to the area, within a naturally functioning ecosystem.

Vjosa is a wild river but it not a wilderness area, category Ib.

Taking into account the narrow linear shape of the comprehensive riverine ecosystem, the Vjosa River protected area should be based along the longitudinal profile, embracing the lower floodplain area, where mainly gravel and sand bars with the network of side channels and streams are present. This zone should form the core zone of the future protected area. Although resembling the model of the Donau Auen National Park in Austria, embracing mainly only the river corridor can be considered as similar, it has to be underlined that the Vjosa River still retained the full “wild” character and unmodified flow and character. Uniqueness of one of the last vast European braided rivers with undisturbed flow regimes highlights the international importance of the Vjosa River ecosystem.

It can be concluded that the IUCN Protected area category II, the National park, is the most suitable designation to protect the ecological character of the Vjosa river, comprising diverse natural biodiversity and encompassing natural processes.

Traditional protected areas are often envisioned as polygons rather than linear features and are rarely designed around protection and management of the longitudinal connectivity of stream channels. The Vjosa river National park should be the first example of the Wild River national park in Europe – the river itself is the last representative of the undisturbed rivers of such type.

6.Conclusions

●Vjosa is not just one of many similar rivers in Albania. It possesses rich biodiversity, but its outstanding value is largely untouched water regime along the entire flow, which underlines the importance of the Vjosa River as the last unmodified braided river ecosystem at the European level.

●The Vjosa river and its tributaries comprise a functioning natural ecosystem, extensive enough to absorb the external disturbances arising from adjacent modified areas along the river corridor without important influence on the natural hydrological processes.

●International protected area standards, transposed into the Albanian Law, recommend establishment of the IUCN protected area category II – National park for the areas where native biodiversity is preserved and the area is in the vast majority shaped by unmodified ecological processes.

●Taking into account the narrow linear shape of the Vjosa river ecosystem, the protection model should follow the development concept for the »river national parks«, where only the narrow lower braided river bed with the lowest floodplain belt form the core zone of the National park; modified areas at the higher floodplain levels, where human presence is evident, encompass the second and third protection zone or are excluded from the National park territory. In those zones activities such as agriculture, housing and other forms of uses of natural resources, including re-forestation of degraded lands, are allowed to the extent that they do not harm other objectives of management and should be continued.

●Vjosa River represents a natural ecosystem and not a man-made cultural landscape. Aim of protection of the Protected Landscape areas, following the international protected area standards and legislation in Albania, is not the preservation of the intact ecological process with accompanying biodiversity but rather the protection of modified natural systems which are only developed at the higher floodplain belts along the Vjosa river. In addition, the legislation for Protected Landscapes in Albania, allows 'construction', which would not provide long-term and effective protection against modification of the hydrological regime of the Vjosa river and its tributaries.

●Only the National park designation provides effective protection of the core, lower river-bed zone of the unmodified Vjosa river and its tributaries, in which intensive occupation or exploitation of the natural ecosystem by the humans is prohibited, as well as introduction of fundamental changes to the biodiversity, structure and functions of ecosystems and alternation of the natural state of water and wetland systems. Human activities that are not prohibited outside the core zone which take into consideration the needs of local residents, include fishing, grazing and firewood. In addition, recreational activities and seasonal tourism activities, that do not require the permanent occupation of the land, are allowed which is extremely important for reaching the vision for the Vjosa river area: recognised destination for recreation and development of “green” and cultural tourism.

●In addition, the national park label provides a strong marketing tool for development of the various forms of recreation and »green” and cultural tourism which is considered as an additional development potential for the entire Vjosa River catchment; other international designations might also be considered since the conservation and scenic values of the Vjosa river and its tributaries exceed the national borders.

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Forest dynamics of the natural forest reserve Schiffwald

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Abstract

Natural forest dynamics can be generally described by changes of different forest attributes. Insights into how these changes occur, that influence the structure, growth and regeneration dynamics of forest ecosystems, can be utilized as a foundation for developing close-to-nature forest management practices. Natural forest reserves provide a valuable and rare chance to study forest dynamics since they are not subjected to human management.

The Austrian natural forest reserves programme aims at systematically establishing a representative network of such reserves to study and monitor those natural dynamics. In this context 56 permanent plots were resampled in 2021 in the natural forest reserve (NFR) Schiffwald to assess the ongoing dynamics of the forests in the last 13 years. The NFR Schiffwald is situated a couple kilometres south (47°36'N, 15°00'E) from the municipality of Wildalpen in the Austrian province of Styria. It is located on the northern slopes of the Hochschwab mountains, and with its 692 ha of area, it is one of the biggest natural forest reserves in Austria. Vertically, the NFR is situated between 960 and 1500 m.a.s.l.. The NFR Schiffwald covers the middle montane, upper montane and subalpine vegetation zones in the forest ecoregion eastern north Alps (4.2). Around 11% of the NFR is covered with mixed spruce-fir-beech forests and pure Norway Spruce forests are the most prevalent forest type, accounting for 35 percent of the total area. Whereas dwarf pines cover 45 percent of the NFR, with the remainder of the area made up of windthrow zones, screes, and meadows. After the formal stop of any human interventions in the year 1995, the first investigation in the NFR Schiffwald has been done.

The reinvestigation of the permanent sample plots allows for an assessment of the changes regarding basic forest attributes such as growing stock, species composition, height and diameter distribution, tree mortality, and natural regeneration over time. In addition to the evaluation of the current state of the forest, a comparative assessment will be conducted with the data collected in 2008 and 1995. The stand dynamics will be analysed among different tree species and forest communities.

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Vegetation dynamics in the natural forest reserve Geißberg – Results of a 20 year vegetation – monitoring

Herfried Steiner

Summary

The main aim of the Austrian Natural Forest Reserve Programme is not only to protect selected forests from silvicultural harvest and management but to enable natural processes in different forest ecosystems. In the natural forest reserve (NFR) Geißberg, we document this development with a vegetation-monitoring.

The NFR is situated in the Vienna woods and is dominated by thermophilous beech forests. Several different tree species are admixed. Some of them, in particular Austrian black pine are remnants of the former silvicultural management. In 1995 27 clusters of monitoring plots, each 8 x 1m², were installed and permanently marked. These plot-clusters are embedded in 500m² plots for the documentation of the tree layer. Every five years all occurring vascular plants were recorded and their cover estimated on the 216 (27x8) 1m^2-plots . Until now the survey was repeated five times revealing distinct changes in the herbal layer.

In the course of twenty years a significant and continuous decrease in vegetation cover from 39.7% in 1995 to 9.9% in 2018 could be detected. Simultaneously, the number of vascular plant species per m² halved in the same time span from 9 (median) to 4.5 species. An analysis with Ellenberg indicator-values shows that the highest losses of species occur in the group of species which has high demands regarding light . Several of these species are adapted to nutrient-poor conditions as well. Considering their phytosociological affiliation, we can observe a shift of the plant community from light flooded stands to more dense conditions with higher shares of beech.

Keywords

Natural Forest Reserve, vegetation monitoring, Vienna Woods, vegetation dynamics.

Introduction

The Austrian Natural Forest Reserve (NFR) Programme aims at establishing a representative network of NFR in respect to forest communities and ecoregions (Frank & Müller 2003). As the Austrian forests are utilized since centuries, also areas are included which were managed until recently and are thus not yet very close to nature. These areas make it possible to observe changes from production forests toward more natural structures and conditions. One of these areas is the NFR Geißberg, which allows observing the resilience of a forest ecosystem by repeated vegetation surveys.

Methods

The NFR Geißberg, 30 ha in size, was dedicated to natural development by the forest owner ÖBF-AG in 1995. The dominating forest type is a thermophilous beech forest (Cyclamini-Fagetum). Other occurring forest types are different variants of oak-hornbeam-forest (Galio sylvatici-Carpinetum). Due to the historical resin utilization, Austrian black pine still holds high shares in the tree layer of several forest types.

To observe alterations in this forest, a monitoring system was established in 1998 (Steiner & Karrer 2001). It comprises 27 plots each 500m² in size to document the stand structure. Embedded are 8 subplots with 1m² in size (Figure 1) for observing species composition and cover of the herbal layer. While the stand structure was measured twice with a time lag of 22 years, the observation interval of the 1m²-plots is 5 years. Until now data from five surveys is available.

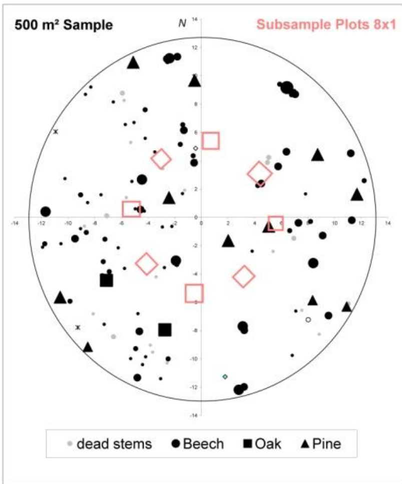

Fig. 1: Plan of one nested sample plot. The symbols indicate coordinates of trees with different stem-diameter within the 500m²-plot. Embedded is a cluster of 8 x 1m² plots (red) for the monitoring of the ground vegetation.

Results

Since there were no severe disturbances in the tree layer, we can notice an increase of the stem basal area from 34 to 45m²/ha. Several tree species contributed to this growth, however the highest increase (relative and absolute) could be observed for beech. In contrast, the shrub layer and the herb layer show a significant decrease. A moss-layer is only marginally developed.

The cover of vascular plants in the herbal layer decreased continuously from from 39.7% in 1995 to 9.9% in 2018 (Figure 2).

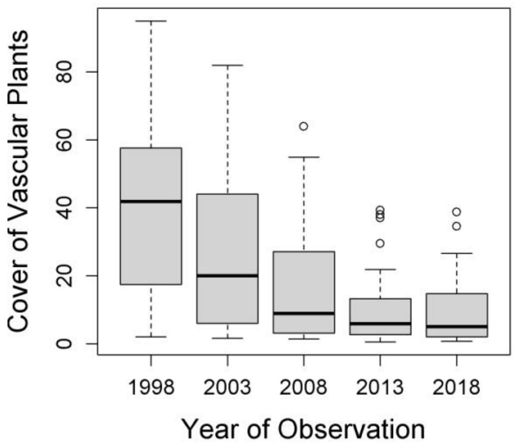

Fig 2: Boxplot of the ground-vegetation cover in the observation years.

Simultaneously the number of vascular plant species decreased. At the start in 1998 on average 9 (median) species occurred in one 1m²-plot. In the following surveys only 8, 5 and eventually 4.5 in 2013 as well as 2018 species (median) could be recorded. Figure 3 shows the distribution of the plots in relation to different species numbers. It becomes obvious that there was a shift to plots with low species numbers.

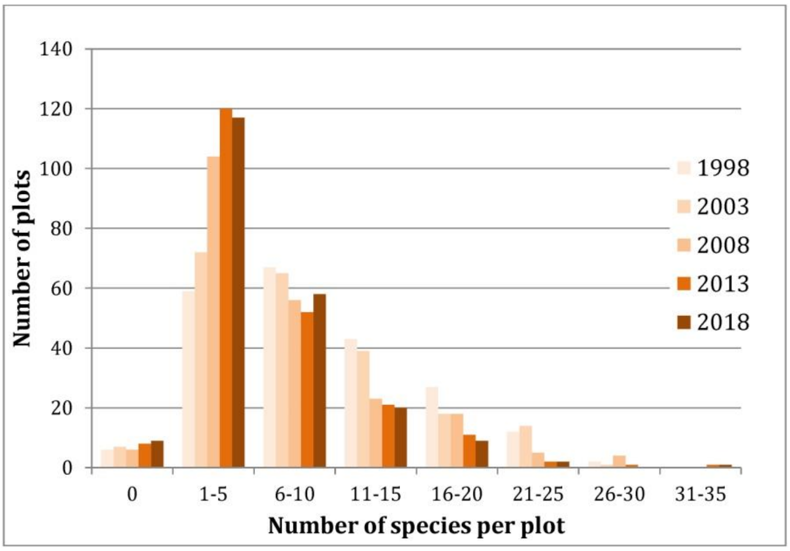

Fig. 3: Number of 1m²-plots in diversity-classes and observation years.

Most of the species recorded at the beginning of the investigation, declined during the last 20 years. Members of several phytosociological classes are affected. This is in particular true for species which are common in the surrounding stands of Austrian black pine, like Dwarf sedge (*Carex humilis*) or Blue moor-grass (*Sesleria caerulea*). Figure 4 shows the number of occurrences on the subplots of *S. caerulea* throughout the investigation.

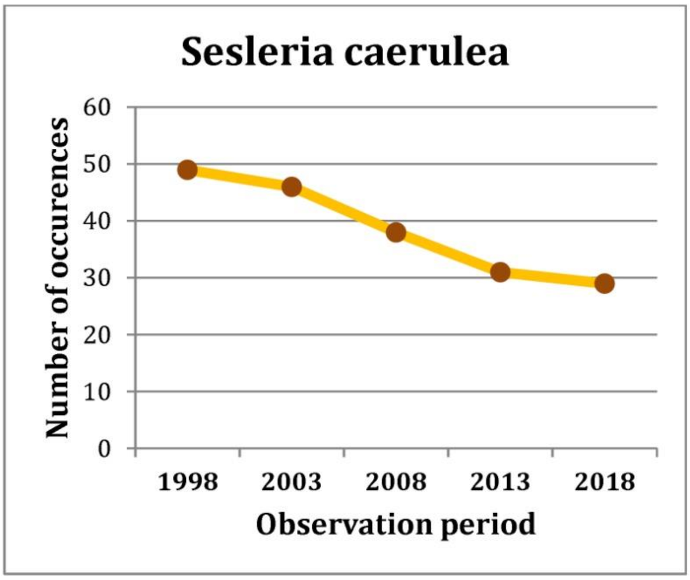

Fig.4: Blue moor-grass (S. caerulea) and its number of plots where it occurred in the observation period.

In contrast, only a few species could hold or even increase their occurrence. These are Coralroot (*Cardamine bulbifera*) (Figure 5), beech (*Fagus sylvatica*) in the herb layer and ivy (*Hedera helix*).

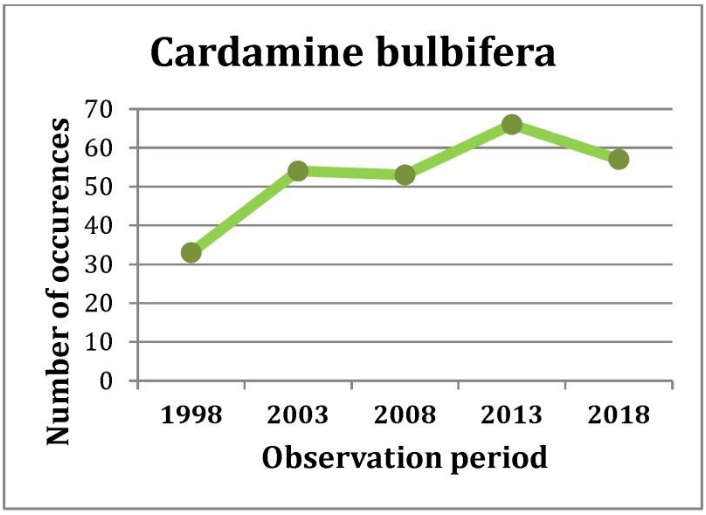

Fig.5: Coralroot (Cardamine bulbifera) and its number of plots where it occurred in the observation period.

Using Ellenberg indicator values the reasons of the main changes can be clarified. Contemplating light as indicator value (Figure 6), it is evident that the severest losses of species are occurring in the group of indicator values of 5, 6 and 7. Thus, especially light demanding species decreased.

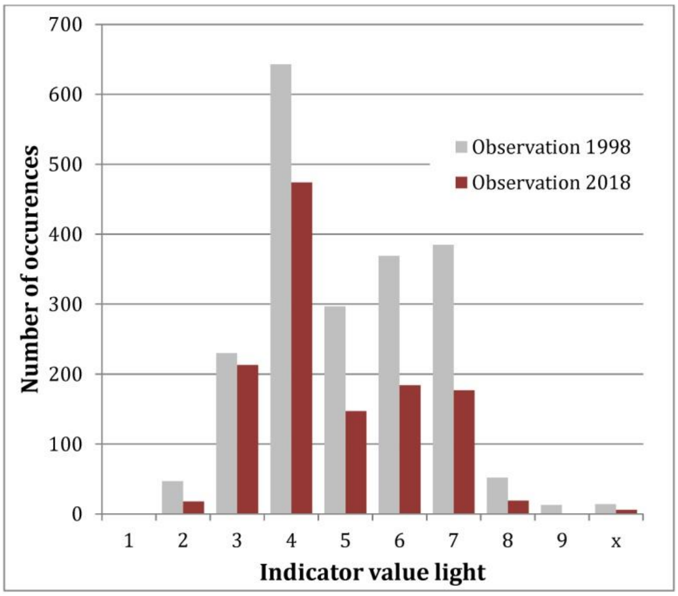

Fig.6: The occurrences of species transformed to the light number of Ellenberg indicator values. 1 indicates species of deep shady conditions, 9 very light demanding species. 'x' means "not sensitive" on this site factor.

While the indicator values of soil reaction, moisture, temperature and continentality show no distinct pattern, for the nitrogen-value a tendency is visible too (Figure 7). We can observe a pronounced loss in species with nitrogen-values at value 2 and 3 which means low demands on soil fertility.

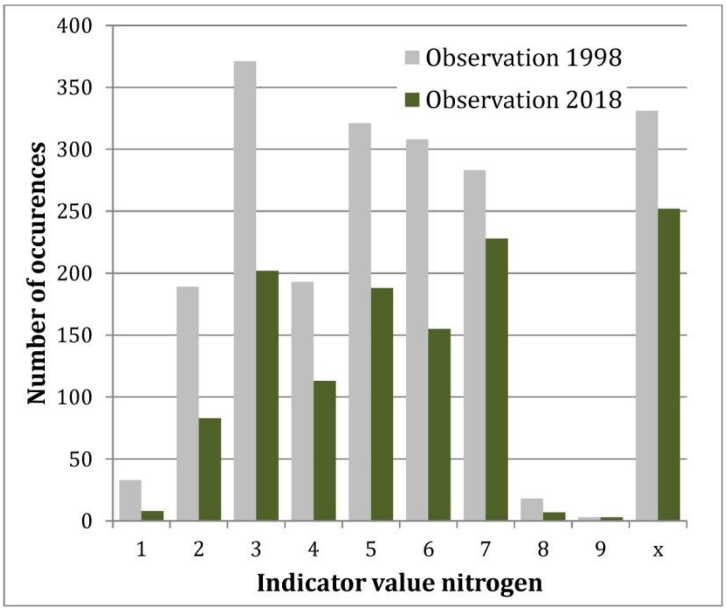

Fig.7: The occurrences of species transformed to the nitrogen numbers of Ellenberg indicator values. 1 indicates species of nutrient poor conditions, 9 high nitrogen demanding species. 'x' means "not sensitive" on this site factor.

The observation that the number of vascular plant species decreases without silvicultural intervention was also made by other authors (Heinrichs & al 2014, Mölder & al. 2014). Concerning the reasons we conclude that the current dynamics are mainly a consequence of changes in the forest stands due to the cessation of the silvicultural management. This manifests in an increase of beech in the tree layer. This shade tolerant species creates a dense canopy which leads to more shady conditions on the ground. The lack of thinning amplifies the density of the canopy. Additionally, high volumes of litter have a further unfavorable effect on small in particular evergreen plants. A considerable number of half rotten pine-stumps, as well as old recordings from the forest enterprise indicate that decades ago the share of Austrian black pine was considerable higher than today. This tree species provided good preconditions for light demanding species in the former production forest. In addition its slow decomposing litter favored unpretentious species. As the loss of many other species cannot be explained other factors like changes in climate and the particular life history of the species might need to be considered.

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The Dark Side of Artificial Illumination in Nocturnal Ecosystems

Stefanie Suchy

Summary

Value of the night: The night is the activity period of many animals. About two-thirds of the world's animal species are nocturnal.[1] Nocturnal animals depend on darkness and natural light from the moon and stars for orientation, movement, breeding, hunting or foraging, and also avoiding predators and food competitors. Light-dependent rhythms, such as the day/night cycle, seasonal changes in daytime lengths, and the lunar phases inform the circadian rhythms of many organisms. Over the history of the Earth, their vital functions and processes adapted to them. Finaly the natural night is responsible for recovery and regeneration – not just for humans, also for animals and plants.

Light pollution & biodiversity: There is increasing evidence for negative impacts of artificial light at night on all levels of biodiversity in terrestrial, aquatic and aerial biomes.[2]

Light pollution & insects: Artificial light drives nocturnal insects out of their habitats, an attraction distance of several 100 meters is possible.[3] The strongest attracting effects have short wavelength visible light and UV radiation.[4] Populations of nocturnal or light attracted moths are declining much faster than diurnal populations.[5] Artificial light at night reduces nocturnal pollinators, this results in a decreased number of fruits per plant.[6]

Light pollution & birds: Bird species such as robins, blackbirds, great tits and blue tits start their territorial singing earlier in the season. This results in earlier breeding, foraging and development,[7] which in turn can affect the birds' fitness and life expectancy. Artificial light at night can lead to disorientation and considerable energy losses of migrating birds. Worst case birds collide with structures and are killed.[8]

Light pollution & mammals: Illuminated areas are avoided by many mammals, for example by urban hedgehogs.[9] While some pipistrelles hunt insects attracted by the light, horseshoe bats and mouse-eared bats are disturbed by light pollution.[10] Artificial light at night was found to reduce commuting behavior of the lesser horseshoe bat, even as low as 3,6 lux (below the cool white LED lamp).[11] Illumination of buildings can cause bats to abandon their roost.[12] Lynx reduce their travelling distances during and immediately after new moon. This is in response to a more even distribution of their prey, which were found to become more spread out under darker skies. Areas which experience skyglow comparable to moonlight (0,3 lux max. full moon brightness) are sub-optimal for Lynx and other predatory mammals. Efforts to reduce skyglow should be focused upon the core areas of these mammal species, with the aim of reducing skyglow to below the sky brightness measured with a first quarter moon in the best astronomical sites (0,09 mcd/m^2).[13]

What level of brightness damages health? Illuminance levels of 0,01-0,03 lx in non-human mammals and fish and up to 6 lx in sensitive humans are sufficient to suppress melatonin production. Depending on wavelengths, even lower levels of illuminance can influence organisms.[14] Melatonin is produced in all vertebrates. The hormone controls a variety of bodily functions and has antioxidant properties.

Which colour temperatures and spectral ranges are harmful? Organisms react differently to various spectral ranges. There is greater evidence of detrimental effects from short-wave visible light (up to 490 nm) and from neutral to cool white colour temperatures (more than 3000 K).[15]

Keywords

light pollution, skyglow, artificial light at night, flora, fauna, biodiversity, illumination, darkness, dark sky, starlight, moon, brightness, colour temperature, wavelength, spectral range, melatonin, mammals, hedgehog, bat, lynx, insects, moths, pollinators, migrating birds, nocturnal animals, activity period, circadian rhythm, health

Introduction

With the steady increase of artificial illumination at night real darkness long became a valuable resource. In the context of the worldwide biodiversity loss light pollution is seen as an additional threat to already weak ecosystems, as a natural regime of darkness and starlight is important for fauna and flora.

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Applicability of eDNA metabarcoding for biodiversity assessment in the sensitive ecosystems of nature protection areas

Vid Švara, Vanessa Berger, Daniel T. Dalton, Klaus Steinbauer, Michael Jungmeier

Abstract

In the face of global change, novel monitoring methods are immensely important in biodiversity assessment and preservation of protected areas. In particular, the detection of environmental DNA (eDNA) is gaining traction in biodiversity assessments as well as in conservation practices due to standardized, cost-effective, and user-friendly implementation. The eDNA-based biodiversity detection methods have especially large potential to be regularly implemented in biodiversity assessments and conservation actions of protected areas because species detection is based on DNA from environmental samples like water, sediment, soil, air or organic material and has a broad application scope with fast, non-invasive, and comprehensive species identification. Here, we present a case of biodiversity assessment based on eDNA metabarcoding approaches conducted in the frame of our project BioMONITec. We tested practical aspects of the eDNA metabarcoding method in the protected wetland habitats consisting of streams, wet meadows, and a bog, with the aim of developing protocols that can be easily and efficiently used by nature protection area managers for biodiversity assessment. In particular, we tested the efficiency of different sampling approaches (syringe/pump water sampling), compared performance of three eDNA extraction methods, compared sample processing methods in the field and in the laboratory, and time-, cost-, and outcome-efficiency of tested approaches. We determined biodiversity indices of assessed habitats and compared them to samples acquired by traditional sampling methods and indices acquired by metabarcoding of these bulk samples. The results reveal the potential of eDNA metabarcoding to supplement traditional monitoring approaches and contribute to more precise and effective decision-making in protection areas monitoring. The methodological and scientific outcomes of the project will be included into the monitoring global guideline (MoniGloG) and communicated to the managers of protection areas and stakeholders who will apply these methods to their monitoring practices in biosphere reserves and national parks.

Keywords

eDNA, metabarcoding, protected areas, monitoring

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DNA based methods in the field of tension between local and global challenges

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Keywords

ABOL, DNA barcoding, eDNA, biomonitoring

Abstract

By building up a number of interdependent and interacting man-made systems, humanity has transformed the face of our planet. The unsustainable nature of these man-made systems (be it economy, land use, consumption and production etc.) creates ecological impacts which compromise the capacity of natural systems (ecological, climate) to sustain life for future generations (Millennium Ecosystem Assessment 2005, IPBES 2019). The major task of conservation biology is to mitigate the effects of man-made disturbances on earths ecosystems. For most of human history, most disturbances remained more or less local, only the industrial revolution has caused the rise of global disruptions. The drivers of biodiversity loss are quite well known, and at the global scales we already quite for a while know which measures would be necessary to bend the curve (Leclére et al. 2020). Since these measures are in conflict with demands of our man-made systems, however, we refrain from taking measures which would be necessary. For measures taken, thus it is necessary to monitor whether their effects are sufficient to achieve the goals of conservation biology.

Thus, nowadays the approaches of conservation biology have to cover the needs of both local and global challenges. Local and global challenges pose different demands on monitoring approaches. Local disturbances demand for approaches optimized on local demands, with non-invasiveness as one of the most important properties. Usually, monitoring is applied for a short time. Global disturbances ask for long-term approaches with strong demands for comparability and standardization. In both cases DNA-based monitoring can offer great possibilities.

Monitoring of threatened species should never pose an additional pressure to the populations, thus asking for non-invasive approaches. Refined sequencing methods allow for detecting even small traces of DNA in the environment (Bruce et al. 2021, Pawlowski et al. 2020).

Proposals for a European monitoring system often take the analogy of weather stations, since to achieve comparability, it is necessary to agree upon standardized measurements (Arribas et al. 2022). A consequence of the increased monitoring effort is the need to use scalable approaches, well exemplified by LIFEPLAN a global project, aiming for investigating the effects of climate change and land use on biodiversity. Each location consists of two sites, one highly affected by urbanisation, the other as natural as possible. Three types of semi-automated traps are analysed by a metabarcoding approach – a Malaise trap, a cyclone for spore analyses and a soil core. In addition, an audio and a camara trap are used to monitor biodiversity. Reasonably in Europe there is a cooperation with LTER-sites, so additional Long-term data can be used for further analyses.

A number of umbrella organizations and projects try to guarantee comparability and data interoperability, including iBOL (https://ibol.org/) and BIOSCAN Europe (https://www.bioscaneurope.org/).

This will help to, optimize our approaches for all possible aims of conservation biology, to be ready for upscaling monitoring efforts and to find a more sustainable way of handling biodiversity data. Ideally this should happen, by establishing a National Center for Biodiversity Documentation.

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National Parks in Social Media - Content Analysis of German-speaking Twitter Community

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Keywords

social media, sentiment analysis, Twitter, protected areas, national park

Abstract

Social media has become increasingly popular tool to promote and strenghten the role of protected areas in society (Heikinheimo et al., 2018). Especially areas targeting high nature protection regimes, such as national parks, need to carefully balance visitors needs and site capacities (Eagles et al., 2002). A proactive role of protected areas in shaping social media content is needed in order to response to a rapid development of information and communications technology (ICT) along with progressing digitalization in society. Data mining from social media platforms may support exploring visitors' behaviour, including human-nature relationships, environmental awareness or visiting protected areas (Heikinheimo et al., 2018). A respective body of research refers to digital content related to the national parks published in English language. International studies underline the necessity to analyse social media content also in other languages. Thus, our main aim was investigating Twitter content on national parks published between 2006 and 2020 in German (n = 144,126 tweets).

The tweets were sent mainly from German-speaking countries (e.g. Germany, Austria, Switzerland, Liechtenstein, and the Italian province South Tyrol). A considerable number were also sent from the the UK, France, USA, India, Australia and other countries. The most frequently mentioned national parks among German-speaking Twitter users (top 3) were: Nationalpark Bayerischer Wald (5860), Nationalpark Hohe Tauern (4219) and Yosemite National Park (3968). Within last decade also Nationalpark Schwarzwald was more frequently mentioned in Twitter (3331). The tweets most frequently contained words such as forest (Wald), holiday (Urlaub) and nature (Natur). The messages were related not only to nature protection, but also to natural disasters. Also a significant number of tweets were related to the COVID-19 pandemic and national parks in recent two years. A large share of the national-park-related Twitter content contained or were linked to multimedia resources (photographs and videos). The discussion expressed in the tweets was largely related to scenic natural landscapes. Nature protection issues were addressed less frequently. There was a relatively low interaction within Twitter messages related to national parks: 85% of all the studied tweets were never retweeted, 92% never received a reply and 74% were never assigned likes.

Thus, we conclude that there is still a potential to improve social media communications among administration and visitors of national parks, local inhabitants, stakeholders and a broad general public in order to promote the role of protected areas in society.

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An approach to monitoring forest biodiversity in the Donau-Auen National Park based on the natural area inventory

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Abstract

After the first natural area inventory during the winter month of 1998/1999 in the Donau-Auen National Park, two further follow-up inventories were carried out (2008/09 and 2018/19). The alluvial forest surveys are based on a grid-based (400*100m) permanent inventory concept, which was also gradually adapted to new requirements (e.g. survey of shrub species, ground vegetation, deadwood structures). In the course of the comparative baseline evaluations, the question arose what contribution the data basis can make to the estimation and monitoring of relevant biodiversity characteristics.

Therefore, the objectives of a project were I) a potential analysis of the alluvial forest inventory(s) for an objective quantification of species and structural diversity, II) the improvement of the knowledge about the spatio-temporal development of forest structures (species and structural diversity) and the development of a forest diversity index as an approach for forest biodiversity monitoring.

The results show that forest inventories, as implemented in the Donau-Auen National Park as a monitoring method, are very well suited to quantify changes in various forest diversity characteristics and data could be condensed/summarized in a forest structure index. The proposed additive concept is based on already existing approaches and was extended by added biodiversity indicators. The developed forest structure index is composed of 13 biodiversity relevant indicators. Each individual indicator assesses certain attributes, which can be measured directly in the forest or derived within the framework of a permanent sampling concept. This emphasizes a high objectivity of the index. The forest structure index can also be used to summarize comparisons between site types, forest types or owners. The values of the Forest Structure Index have increased during the last 20 years and differ significantly for the different forest types hardwood and softwood floodplain forests, Heißländen and slope forests.

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Fungi – the dark matter of biodiversity research?

Alexander Urban

Abstract

Fungi are highly diverse; they are involved in key ecological processes and in a multitude of interactions with all kinds of biota, including humans. Despite the vital and indispensable roles of fungi in ecosystems, and despite a high number of endangered fungal species, the assessment and monitoring of fungal biodiversity in Austrian National Parks and other protected areas is still in its infancy, compared to other groups of organisms, partly due to the non-inclusion of fungi in the list of FFH species.

The current biodiversity crisis coincides with the unprecedented availability of useful novel tools for field mycology: digital photography and real-time data sharing via smartphones, GPS assisted data recording, exchange with top-experts via internet and the sharing of monographic literature via internet made serious field mycology more accessible, opening up a window of opportunity for a new generation of experts. On the other hand, increasingly sophisticated species delimitations driven by systematic progress frequently demand the use of microscopy, also for the identification of common species, sometimes even DNA sequencing.

DNA barcoding has become an essential tool, not at least to test species hypotheses typically based on morphological or ecological observations – some exemplary results will be presented, highlighting the fact, that the inventory of fungal biodiversity is still far from complete, even in Central Europe, one of the world´s best-studied regions.

Fungal metabarcoding is a powerful strategy to apply next generation sequencing techniques to environmental samples (e.g. soil, dead wood, water, air samples). In addition to delivering massive quantities of data, this approach promises to be less dependent on the erratic patterns of fungal fruiting, which often torment classic mycological field work.

Given the dire prospects of climate change (resulting in drought-induced forest tree dieback events already), an ambitious monitoring of fungal diversity focusing on protected areas is needed, taking advantage of methodological progress, to better document the current state of fungal biodiversity, and to assess on-going change. A long-term programme would facilitate to build and maintain the required capacity and expertise. Experiences and results from projects and excursions in which I was involved will be presented – from the Biosphere Reserve Wienerwald (Urban et al. 2014), the National Park Podyjí – Thayatal (Urban 2021) to the WWF reserve Marchegg and the Compensation Area Tauglboden.

We need awareness, commitment and strategies for the protection of endangered biota including fungi. It is essential to consider data on fungal biodiversity in the delimitation and management of protected areas.

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Citizen science project "ArtenReich Streuobstwiese"

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Summary

Today, orchard meadows are among the most species-rich habitats in Central Europe, but also among the most endangered. In this project volunteers are encouraged to explore the speciose fauna of the orchard meadows in the Wienerwald Biosphere Reserve at least three times a year. These data are to be used to collect information on the condition of this valuable ecosystem in this region and to raise awareness of the importance of valuable cultural landscapes. So far, around 25 amateur researchers have recorded 53 of 64 habitat-typical target species on 16 meadow orchards, including common species such as great tit, hornet, or red admiral, but also rarer ones like hoopoe or little owl.

Keywords

orchard meadows, citizen science, volunteers, Wienerwald Biosphere Reserve, Austrian Federal Forests, biodiversity, old varieties, endangered species, ArtenReich Streuobstwiese, speciose fauna of orchard meadows, extensively managed ecosystem

Introduction

For several centuries, orchard meadows have provided livestock with hay and humans with fresh fruit. Thanks to extensive management in the past, they are now listed among the most species-rich habitats in Central Europe and are indispensable landscape elements of our cultural landscape.

Today, however, these valuable ecosystems are considered endangered, as many areas have been lost in recent decades due to abandonment, change of designated land use, or conversion to intensively managed orchards.

The Austrian Federal Forests, in cooperation with the Wienerwald Biosphere Reserve Management and with the support of the Province of Lower Austria, have been engaged in the maintenance and protection of orchard meadows for many years. Thus, since 2010, more than 1000 new fruit trees of old varieties have already been planted on more than 40 meadows. Today, the most abundant tree species are apple and pear, but also cherry, plum, walnut, medlar and service trees can be found. The lush abundance of flowers, fruits, and seeds provides a diverse food supply for numerous rare and sometimes endangered wild bees and butterflies (e.g., the scarce swallowtail), as well as small vertebrates such as the European goldfinch or hedgehogs. In addition, tree cavities in old fruit trees are valuable roosting sites for dormice, bats, and birds such as the Eurasian hoopoe and the Eurasian wryneck.

In the Citizen Science project "ArtenReich Streuobstwiese" (Species-rich Orchard Meadows), which was launched in 2020, amateur researchers are encouraged to explore the animal biodiversity of the orchard meadows in the Vienna Woods. One of the primary goals of the project is to document the diversity of orchard meadows in the Biosphere Reserve region. Based on the data collected, conclusions are to be drawn about the condition of this valuable ecosystem and, if necessary, measures to improve the habitat are to be developed. Another aim is to raise awareness of the importance of valuable cultural landscapes through public relations work accompanying the project and thus to promote a respectful and considerate approach to nature.

Methods

The volunteers investigate the speciose fauna of the orchard meadows in the Wienerwald Biosphere Reserve on at least three days a year at different seasons. By using standardized recording sheets, the citizen scientists collect data on animal species typical of this habitat, as well as various parameters on the structure and condition of the orchards. The collected data is subsequently transmitted to the project management to judge the condition of this valuable ecosystem and, if necessary, develop measures to improve the habitat.

The quality of the survey results is to be ensured by means of profiles of the target species, identification aids and a guideline for field work. A description of the survey areas is made once a year on a separate form in order to be able to draw conclusions about the occurrence or non-occurrence of the individual species based on the appearance and condition of the areas and the local conditions.

In the guideline, the researchers learn not only about the methodology, but also about correct behaviour while in the orchard, including when and how to enter it.

An annual meeting of the participants serves to discuss the results of the previous season, to exchange experiences and to get to know each other.

Results and discussion

In the first two years, the approximately 25 participants collected data from 16 orchards in the region. Of the 64 target species, 53 (83 %) have been recorded so far. Great tit, great spotted woodpecker, hornet, red admiral, blackbird and blue tit were among the most frequently observed species, but rarer species such as hoopoe and little owl have also been discovered. The Citizen Scientists' commitment does not end with the target species, however, so that more than 200 additional species have already been recorded.

As can be seen in Fig. 1, the number of fruit trees on the different project plots as well as their age structure varies considerably. After the first two years of the survey, however, no correlation with species diversity can be seen (see Fig. 2).

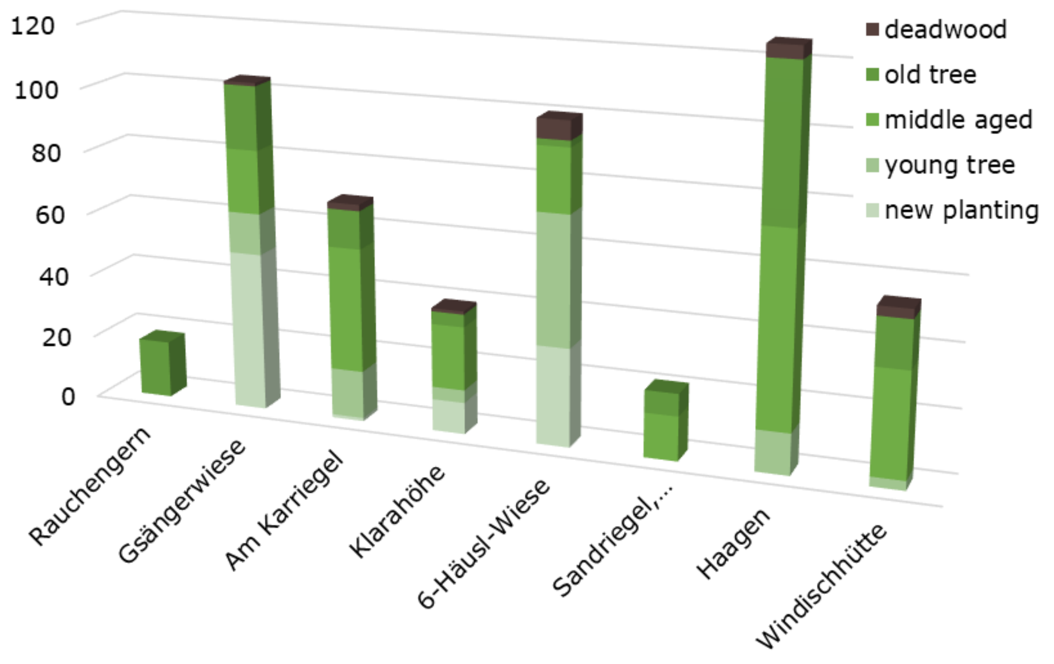

Fig. 1: Age distribution of the fruit trees in the orchard meadows of the project (examples)

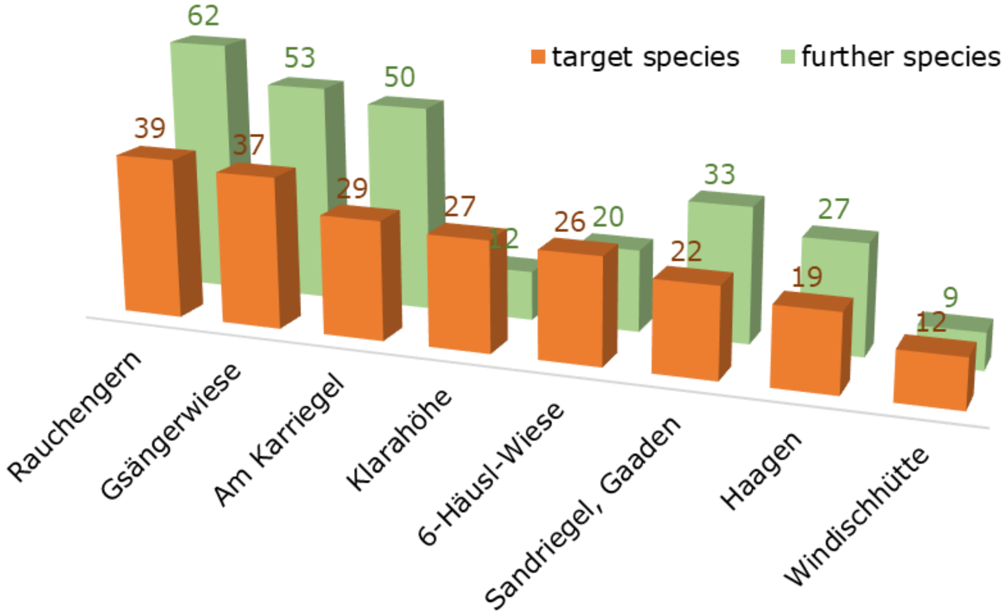

Fig. 2: Species per orchard meadow (examples)

The reasons for this are probably to be found in the different levels of prior knowledge of the participants on the one hand, and on the other hand and particularly in the frequency of the surveys as well as the respective time spent on the plot. A serious comparison of the different orchard meadows will therefore probably only be possible after several survey years.

However, as already described in the introduction, the focus of this project is more on the assessment of the condition of the habitat type orchard meadow in the Wienerwald biosphere reserve and on raising awareness for the conservation of valuable, traditional cultivated areas, rather than claiming the quality of a doctoral thesis.

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Biodiversity assessment via environmental DNA in national parks: possible applications and limitations

Corinna Wallinger[1,2], Daniela Sint[1,2], Michael Traugott[1,2]

Summary

Being hotspots of species richness, national parks are under particular pressure to preserve and, if possible, even improve biodiversity. In order to ensure sufficient protection of the occurring species, it is important to comprehensively investigate the development of biodiversity, to document the occurrence of protected species and to identify possible threats such as the invasion of neobiota or pathogens as early as possible. However, the assessment of species is challenged by the need to record a great diversity of organisms whose occurrences can rapidly change across time and space. Ideally, many samples would be examined across large areas at multiple time points to obtain accurate monitoring data, which reflect the status of biodiversity across a wide range of habitats. Conventional methods are quite cumbersome when it comes to sampling and analysing large sample numbers and areas that are often difficult to access. Retrieving biodiversity information by environmental DNA (eDNA) holds the promise that a wide range of taxa can be recorded with comparable little sampling effort. Scalable approaches provide the opportunity to examine considerably more organisms at significantly improved temporal and spatial resolution. In addition to the analysis of water samples, meanwhile also established methods for surveying diversity in terrestrial habitats, soil, and air are available. Building on our experience in research and application of DNA based methods, we will showcase approaches that are ready to be applied in routine biomonitoring and which type of data is generated with this technique. Based on a survey of the needs of the Austrian national parks, we show which specific needs can be addressed by DNA approaches. Moreover, we will highlight the challenges DNA-based biomonitoring currently faces and provide an outlook on the next steps this approach has to tackle in both research and practical application.

Keywords

eDNA analysis; biomonitoring; metabarcoding;

Introduction

One of the greatest challenges of our time is the global loss of biodiversity. According to the latest report of the IBPES up to one million species are currently threatened with extinction (IPBES 2019). Similarly, the World Wide Fund for Nature's Living Planet Index, a measure of the health of the planet, shows a clear negative trend (WWF 2018). The cause as well as the potential solutions for this biodiversity crisis – along with the climate crisis - are to be sought in human action.

National parks have been created in different countries to preserve habitats and the many species that live in them. In order to effectively protect biodiversity, sound knowledge about the species abundances and their interactions with the environment is of crucial ecological importance. Classical methods for species surveys often reach their limits here, as they are usually time- and labour-intensive and therefore often associated with high costs. Furthermore, especially for insects, fungi and microorganisms, the use of specialists is often indispensable in order to correctly identify the individual species. Currently, there is a distinct lack of taxonomists and even for them, species identification is time-consuming. DNA based methods offer an innovative possibility here, which can provide information about the presence (or absence) of species and their interactions with their environment faster and providing verifiable data. Complementing classical approaches these methods are promising tools also for the management of national parks that will be increasingly applied in the future.

DNA as source of information

DNA determines the structure and function of any living organism. DNA traces can not only be found in any kind of tissue, but also in feathers, fur, saliva, pellets or faeces samples. The latter can also be used to draw conclusions on trophic interactions, since prey DNA can be identified in such samples in addition to the one of the consumers. This makes it possible to investigate the food choices of animals and potential changes under certain environmental conditions, which in turn can be relevant for the management of species (Traugott *et al.* 2013). DNA traces can also be present independently from the organism, being referred to as environmental DNA, or "eDNA" (Deiner et al. 2017). Organisms release cells into the environment via mucus, tissue remnants, faeces, spores or seeds. These eDNA can be detected in aquatic but also terrestrial habitats and sampling is rather simple. Using eDNA, species can be detected in a habitat with unprecedented reliability and sensitivity and without the need of being collected. Since the first description of the molecular detection of aquatic organisms via eDNA (Ficetola et al. 2008), the diversity of possible applications has been increasingly grown.

Different DNA-analysis methods for various applications

There are various methods for molecular identification available, whereby the choice of the appropriate one depends on the respective sample type as well as the question. The best-known method is *DNA barcoding* (Hebert & Gregory 2005), where a part of the DNA, which is suitable for the differentiation of species is copied in a PCR, sequenced and then compared with a reference library to identify an organism. Even the smallest amounts of DNA are sufficient for species identification. Species can be detected independent of developmental stages and from tissue remains. In the last centuries, DNA barcoding has established as an important approach for the rapid and reliable genetic identification of animals, plants and fungi. The correct identification of the organisms from which the DNA sequences are stored in the reference databases is crucial. Here, barcoding initiatives such as the ABOL, GBOL and SwissBOL in Austria, Germany, and Switzerland ensure that genetic data are generated according to taxonomically verifiable criteria.

To search for individual species from an environmental sample, which usually contains a mixture of DNA from different organisms, species-specific *diagnostic PCR* is employed. This approach can also be used to search for several species in parallel, which makes it even more efficient. Diagnostic PCR is comparatively inexpensive, fast and allows efficient examination of larger sample numbers. This technique is particularly suitable for detecting rare and endangered, but also invasive species or pathogens, such as chytrid fungus or crayfish plague (Jerde et al. 2011; Sigsgaard et al. 2015).

For the assessment of the organismal spectrum of a habitat, all DNA sequences contained in an eDNA or mixed sample can be used to identify the species (Valentini et al. 2016). Similar to DNA barcoding, DNA fragments of the different taxa are read individually and compared with sequence databases. Since several DNA barcodes are sequenced simultaneously, this approach is called *metabarcoding*. Using this method, many samples can be examined across large areas at multiple time points to obtain accurate monitoring data, which reflect the status of biodiversity across a wide range of habitats.

Not only on their own, but also as an extension or in combination with conventional methods DNA-based approaches can be applied in nature conservation. For example, when it comes to evaluating classical mixed samples of organisms, such as the catches from kick net sampling, pitfall-, Malais- or pollen traps, which are used to survey the species spectrum of the macrozoobenthos, terrestrial arthropods, flying insects or flowering plants. The identification of species in these mixed samples (or bulk samples) is usually labour- and time-intensive. However, if a DNA extract is obtained from the fixation liquid or the ground specimens and analysed via metabarcoding, the captured animals in these classic sample types can be identified with high resolution in a comparable short time. Even composite samples with substrate can be ground and used as a basis for molecular analysis (Pereira-da-Conceicoa et al. 2019). For stream organisms from Finnish rivers, for example, significantly more animals relevant for assessment could be identified using the DNA-based method compared to the classical methods

(Elbrecht et al. 2017). Likewise, new indicator species that react more strongly to stress factors could also be detected (Macher et al. 2016).

Taken together, DNA based methods offer new possibilities for the early warning for the occurrence of invasive species or diseases as well as large-scale, standardised and regular biodiversity monitoring and on an unprecedented scale. The potential of these technologies is still far from being exhausted, which is why extremely diverse applications can be expected in the future.

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The development of light pollution and the establishment of dark sky protection areas in Austria

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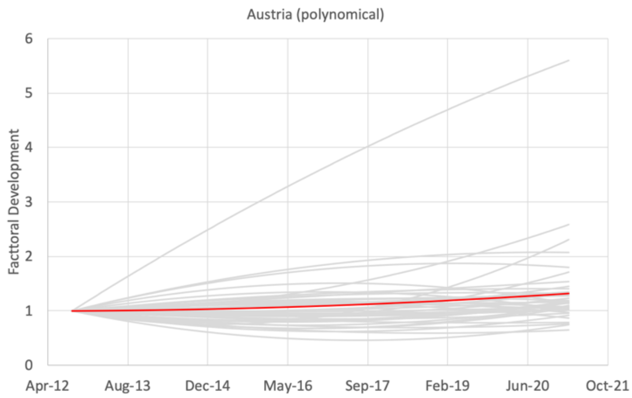
Abstract

A very important parameter for quantifying the development of light pollution in specific areas or even countries is the light growth rate, indicating an overall increase or decrease of the amount of light received by detectors. Ground-based observations, provided by light monitoring networks (e.g., Sky Quality Meters) have shown to enable small scale analyses of long-term trends with minor areas solely to be characterized in greater detail. In order to make statements about national policies regarding artificial light at night, whole country territories must be contemplated. Past studies have shown that satellite imagery (e.g., VIIRS) appear to be the best option to do so. Over a national scale, this potentially includes areas with high discrepancies in their radiance values, i.e., urban areas being very bright and rural areas very dark. Furthermore, for light emitting areas, also the spectral sensitivity of satellites can lead to distorting effects on long-term trends as cities continuously undergo lighting changes. With those impacts in mind, this work concentrates on the question, if only areas with no or extremely low amount of emitted light can serve as indicators for the light pollution development in a whole country, as such are usually not producing light themselves but suffer from peripheral influences. As a first step, in order to check this, we analyzed light-trends of all 48 nature parks in Austria over the past decade and check their trend towards an increase or decrease in radiance values. Results show that in those nature protected spaced the amount of light increased by an average of ~30% over the last ten years with some areas showing an increase up to ~550% and only few a decrease.



In order to be able to maintain the darkness of the night as well as the fascination of the starry night sky and its natural landscape, there is globally the possibility of establishing night landscape protection areas. The International Dark Sky Association (IDA) offers several categories of certification for this purpose, including the category of a "Dark Sky Park". It awards these titles to areas that take certain steps to protect the night sky, use outdoor lighting in an environmentally friendly and sustainable way, and raise awareness for the issue of light pollution. Especially, the goal of these "Dark Sky Places" is the use of lighting situations in harmony with wildlife. In addition to increasing the quality of life for people and nature, there are also new tourist opportunities. There are already almost 150 of such certified protected areas worldwide, almost 35 of them in Europe. In cooperation between the University of Vienna, the Upper Austrian Provincial Government, the Nature Park Attersee-Traunsee and additional local project partners, the "Sternenpark Attersee-Traunsee" has officially received its certification as an International Dark Sky Park after three years of work in April 2021. It is an area of over hundred square kilometers of area, which extends over the local communities of Weyregg, Schörfling, Aurach, Altmünster and Steinbach, with latter including the entire community area in the star park. After a scientific analysis of the quality of the night sky and existing lighting situations, the area between the two Upper Austrian lakes was considered to be ideal for certification as a night landscape protection area. The main criterion, an outstanding darkness of the night sky, which is characterized by the fact that, for example, the Milky Way can be easily seen with the naked eye, was easily fulfilled. The criteria for outdoor lighting, such as the complete shielding of light sources to avoid stray light, the emission of purely environmentally friendly, warm white light colors as well as shutdowns or dimming at night, were largely adjusted as part of the project in the star park area. Within ten years, the participating municipalities even committed to adapt 100% of the existing outdoor lighting to the criteria. Another feature of the Star Park is the legal anchoring of these criteria on the basis of municipal council resolutions, which contain clear statements about the use of artificial light at night and specify clear threshold values and thus significantly exceed current national guidelines.

In the talk I want to give an overview on current research activities and results regarding the development of light pollution in Austria and give insights on the establishment of the Sternenpark Attersee-Traunsee. Also, potentials for dark sky protection areas in Austria will be discussed.

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Diversity patterns in the plankton communities of high alpine lakes: the expected and unexpected

Stephen Wickham, Jana Petermann, Ulrike-G. Berninger

Abstract

Due to the combination of extreme environmental conditions in their habitats and rapid climate change, zooplankton communities in high alpine lakes are expected to undergo considerable change in the coming years. However, before change can be measured, a baseline needs to be established. In order to do this, 18 high alpine (2000 – 2600 m asl.) lakes in three valleys in the National Park Hohe Tauern have been sampled annually since 2017. Despite having an average ice-free period of only 32 – 143 d, the studied lakes have maximum temperatures ≤ 22°C, indicating not only extreme, but rapidly changing conditions. Moreover, while the lakes are generally nutrient-poor, substantial deep chlorophyll maxima have been found, with considerable year-to-year variance in their intensity.

As is common in high alpine lakes, the zooplankton species richness within individual lakes is low, between 1 – 11 species. However, the beta diversity (differences in species composition between lakes) is remarkably high, with only three spp. found in at least one third of the lakes, and some lakes having little or no overlap in their species composition, even with lakes within 1 km. The distinct differences between lakes in close proximity to one another, or that are easily accessible to hikers potentially carrying resting eggs, suggests that isolation and extreme habitats can at best only be partial explanations for the currently observed diversity patterns. It remains to be investigated in future studies how these diversity patterns change as environmental conditions become less extreme and the lakes become more accessible.

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A tale of two rivers: phytosociological revision of the grasslands in the Danube and March-Thaya floodplain

Wolfgang Willner, Gerhard Kadlec, Markus Staudinger, Norbert Sauberer, Katarína Hegedüšová Vantarová, Iveta Škodová, Thomas Zuna-Kratky & Luise Schratt-Ehrendorfer

Summary

We present the first comprehensive overview of the grassland diversity in the Danube and March-Thaya floodplain of Austria, including also the Slovak side of the March/Morava river.

Keywords

Austria, grasslands, phytosociology

Introduction

The floodplain of the rivers Danube, March and Thaya is one of the most important grassland areas of eastern Austria, harbouring a great diversity of wet and dry meadows, reed swamps and sedge-bed vegetation that form a mosaic with alluvial forests and water bodies. However, a phytosociological overview of the whole area has been lacking so far. In a new study (Willner et al. 2022), we present a phytosociological revision of the grasslands in the Danube and March-Thaya floodplain of Austria, including also the Slovak side of the March (Morava in Slovak and Czech).

Methods

We compiled all available plot records (relevés) from the study area belonging to the phytosociological classes *Phragmito-Magnocaricetea*, *Molinio-Arrhenatheretea* and *Festuco-Brometea*. Our data set comprised 2119 relevés, of which 355 were from Slovakia. We conducted a TWINSPAN classification using six levels of division. After a provisional syntaxonomic interpretation of the clusters, relevés were manually rearranged into classes, orders, alliances and associations using the total cover of the diagnostic species in each relevé as assignment criterion.

Results and Discussion

In comparison to previous works (Balátová-Tuláčková & Hübl 1974, Mucina et al. 1993), our revision includes the following main changes: (1) we accept the *Ranunculetum repentis* as a floristically well-defined association within the *Potentillion anserinae*; (2) we merge the four *Cnidion* associations of the March-Thaya floodplain (*Lathyro palustris-Gratioletum, Gratiolo-Caricetum suzae, Cnidio-Violetum pumilae, Serratulo-Plantaginetum altissimae*) into two (*Gratiolo-Caricetum suzae* and *Cnidio-Violetum pumilae*); (3) the *Ophioglosso-Caricetum tomentosae* is revealed as a geographical vicariant of the *Cnidio-Violetum pumilae*, replacing the latter along the Danube; (4) the "*Silaetum pratensis*" and "*Serratulo-Festucetum commutatae*", previously included in the *Molinion*, are transferred to the *Cnidio-Violetum pumilae* and *Colchico-Festucetum rupicolae* (*Cirsio-Brachypodion*), respectively; (5) *Ranunculo bulbosi-Arrhenatheretum, Pastinaco-Arrhenatheretum, Festuco rupicolae-Brometum* (= *Onobrychido-Brometum* sensu Mucina et al. 1993) and *Polygalo-Brachypodietum* are confirmed as widespread grassland types in the Danube floodplain.

Given the regional scope of our study, the alliance assignment of some communities is preliminary and can only be clarified by a broad-scale comparison. However, we are confident that the basic units presented here are floristically and ecologically well-defined and will hold in future revisions using data sets from larger geographical areas. We expect that our revision will become a valuable tool for mapping and monitoring of grassland communities in the Danube and March-Thaya floodplain.

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Symposium Nationalparks Austria – *Short Abstract*

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Introduction

Lake Neusiedl and its environs represent one of the most important natural and cultural landscapes in Central Europe. In the Interreg project REBEN the exchange processes between the reed belt and the open lake were investigated. The project was commissioned by the Province of Burgenland and the Directorate for Water Management in Northern Transdanubia (EDUVIZIG). The project was 85% financed by EU funds. The National Park Neusiedler See – Seewinkel and the National Park Directorate Fertő-Hanság were involved as strategic partners.

Methods

Over two years hydrological, chemical and biological surveys were carried out on both sides of the state border. To record water level changes and fluctuations of physico-chemical conditions in the reed belt in high temporal resolution, pressure and water quality online probes were used in selected areas. The results were incorporated into model calculations of water exchange, which in turn formed the basis for estimates of suspended sediment and nutrient transport from the open lake to the reed belt and vice versa. This touches on key issues related to water quality, as well as siltation of the reed belt.

Results

The technical reports and a bilateral synthesis are available online. Based on the findings of the project, proposals for a transboundary management were made, which should serve to secure the water quality and the good ecological status of Lake Neusiedl.

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The Benefits of extensive grazing for preserving steppe vegetation – results from 25 years of monitoring permanent plots

Thomas Wrbka, Victoria Werner

Abstract

In order to protect the valuable steppe landscape of the "Seewinkler Puszta" and its characteristic mosaic of salt marsh and sand-steppe vegetation the grazing was reintroduced in the area of Neusiedlersee-Seewinkel in 1987. A monitoring system based on changes in plant species composition was implemented. The presented study shows the results of long-time vegetation monitoring from 1995-2021 using uni- and multivariate analyses. Dominant and - in terms of nature conservation - problematic species, such as *Elymus repens* and *Calamagrostis epigejos* declined in the sample plots. Biodiversity indices showed significant effects only in areas of arid grasslands and abandoned vineyards. We could not detect negative effects of grazing on salt vegetation but in fact a slight increase of specific salt species (halophytes).

Keywords

Lake Neusiedl, halophile vegetation, grazing management, long-term monitoring, restoration, pasture landscape.

Introduction

The Nationalpark Neusiedlersee-Seewinkel in the far east of Austria holds around 30 shallow salt lakes with unique halophytic plant communities (Albert et al 2020) embedded in larger patches of dry grassland, most of them representing the habitat type "pannonic sand steppes". The entire area was heavily grazed in the past for over hundreds of years, shaping the so-called "Puszta" landscape. Large herds of cattle, horses and pigs where brought daily to the large communal pastures around the salt lakes, a traditional pasturing-system called "shifting grazing" (Dick et al, 1994). After grazing ceased in the mid-20lh century a herd of Aberdeen-Angus cattle was re-established in 1987 to restore this typical pasturing landscape with its specialised biodiversity (Korner et al. 2000).

In 1989 a monitoring project was set up to evaluate the grazing effects on the vegetation of halophytic plant communities and dry grasslands. Since then, the mid-term results were reported in a series of publication. With some breaks, the monitoring activities have continued and reported until today (Werner 2022 unpublished) and will proceed in the near future. Main research questions focussed on impact of grazing on potentially sensitive halophytic vegetation and lesser competitive plant species (e.g. orchids). In addition, the potential of free-range grazing for landscape scale restoration of "puszta grassland" was explored with special emphasis on re-establishing sand steppes on abandoned vineyards, Thirdly, it was investigated, which level of grazing intensity could effectively be used for halting the undesirable expansion of brackish reed belts around the salt pans.

Methods

Vegetation data were collected by estimating the cover of plant species in 1x1m sub-plots of permanent plots with a percentage scale. Data were stored in a database and analysed by various statistical methods, including ordination techniques.

To capture the grazing effects on all relevant vegetation types with a sufficient replication, a system of permanent plots (sized 2x2m and 5x5m) in and outside of grazing enclosures, arranged in transects, was established. These transects represent the zonation along salt lakes, following main ecological gradients (salinity, wetness). This initial sampling design was continuously completed by adding sites in all relevant grazing projects, including the large enclosures with Hungarian Grey-cattle, white donkeys, Przewalski-horses and riding horses. *Table 1* provides an overview of all investigated sites (Euller et al, 2014):

Table 1

Weidegebiet	Weideform	Nutztierarten	Weideintensität (nach Korner et al. 2008 und Steingruber 2013)	Anlage der Monitoring-flächen
Weiße Esel-Weide Sandeck	Koppel	Weiße Esel	intensiv	2001
Warmblut-Koppel, (Seevorgelände Illmitz)	Koppel	Reit- und Kutschen-pferde (Warmblut)	Mittel bis intensiv	1999
Przewalski-Pferde-Koppel, (Seevorgelände Illmitz-Hölle)	Koppel	Wildpferde (Przewalski)	extensiv	2001
Pferdekoppel Podersdorf, (Seevorgelände Podersdorf)	Koppel	Reit- und Kutschen-pferde (Warmblut)	Intensiv	1990
Hutweide Zicksee-Albersee-Seedamm	Hutweide (von Hirten betreut)	Rinder (vorw. Aberdeen-Angus)	Mittel	1990 (Zicksee), 2001 (Seedamm)
Hutweide Illmitz-Kirchsee	Hutweide (von Hirten betreut)	Rinder (Aberdeen-Angus/Fleckvieh)	Mittel	1990
Graurinder-Weide, (Seevorgelände Apetlon)	Koppel	Rinder (Ungar. Steppenrind, Wasserbüffel)	Mittel bis intensiv Max. 1,3 GV/ha (60% der Fläche sind Brackröhrichte & können nur in trockenen Jahren beweidet werden)	2001
Hutweide Apetlon	Hutweide (von Hirten betreut)	Rinder (vorw. Fleckvieh)	Mittel ca. 0,46 GV/ha	2001

Results

In general, our results show, that the implemented system of different grazing regimes in the whole management zone of the national park is an essential contribution to not only maintaining but partly also restoring the most valuable grassland and salt marsh habitat types. At the same time no evidence was found for a deterioration of potentially sensitive halophytic vegetation and red listed plant species, like orchids.

In detail, there was considerable variation in the effects of grazing to the wide array of ecologically contrasting vegetation types. As expected, results of this long-term study showed that the salty swamps and the periodically wet pastures are merged in reed-belts without an adequate management. This could be demonstrated by comparing the succession of ungrazed fenced transects with corresponding permanent plots outside such enclosures (Korner et al 2000, Euler et al, 2014).

On the other hand, a negative effect of grazing on salt vegetation could not be detected. In contrast, a slight increase of specific salt-tolerant vascular plant species (halophytes) was recorded. As an example, lake margins formerly overgrown with brackish reed could largely be transformed into typical salt marsh vegetation (Fig.1).

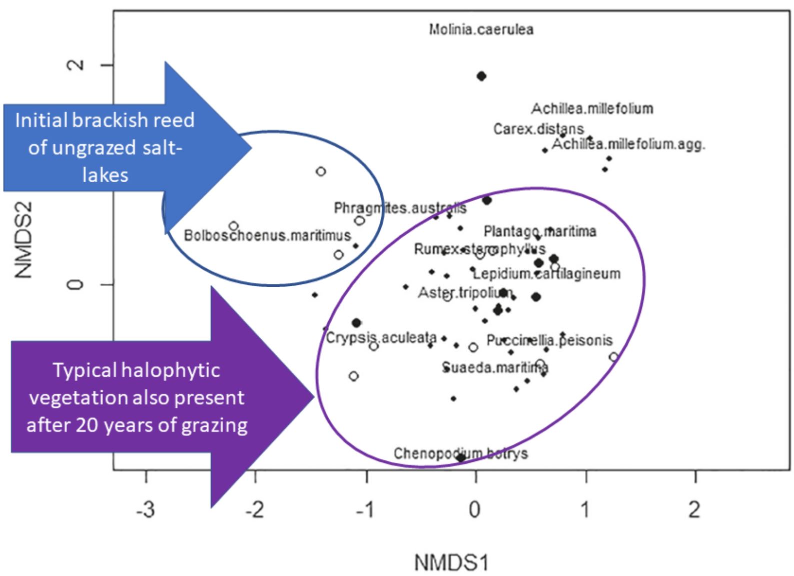

Fig.1: Development of the permanent plots of group 1 (salty swamps and vegetation on "Solontschak") in relation to species composition and species cover. White circles show recordings of the first three years of monitoring, large black circles show recordings of the last three years of monitoring. Small black circles label the intervening years. The main occurrences of characteristic species are also shown (modified from Euler et al. 2014)

Regarding the dry grassland sites, no significant change in species composition and species diversity could be detected on grazed sand steppes. Nevertheless, population sizes of less competitive, mostly threatened plant species, like orchids increased. When comparing enclosures with corresponding grazed plots, plant species diversity showed increasing differences during ongoing observation, with lower Simpson indices in the fenced transects. This indicates the validity of the "intermediate disturbance hypothesis" even in managed grasslands. At the beginning of our observation period, plots in neglected pastures showed high abundance of competitive grasses like *Elymus repens* and *Calamagrostis epigejos*. Grazing proved to be an effective control of these problematic species, and could be reduced significantly (Fig.2).

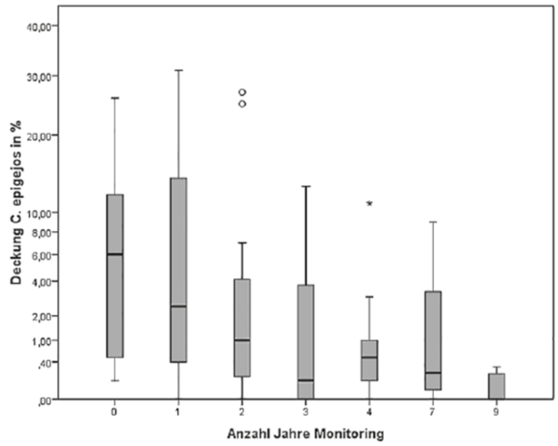

Fig.2: Development of Calamagrostis epigejos during the investigation period.

At the landscape scale, it became obvious, that the remaining fragments of formerly well-connected large tracts of grassland should be reconnected to avoid local extinction phenomena. To achieve this, several abandoned vineyards were included in the grazing management and the monitoring scheme. Analyses of vegetation data from respective permanent plots yielded promising results. It could be sown, that typical ruderal vegetation of fallow land was replaced by character species of sand steppes within few years, showing a rather quick restoration success (Fig.3).

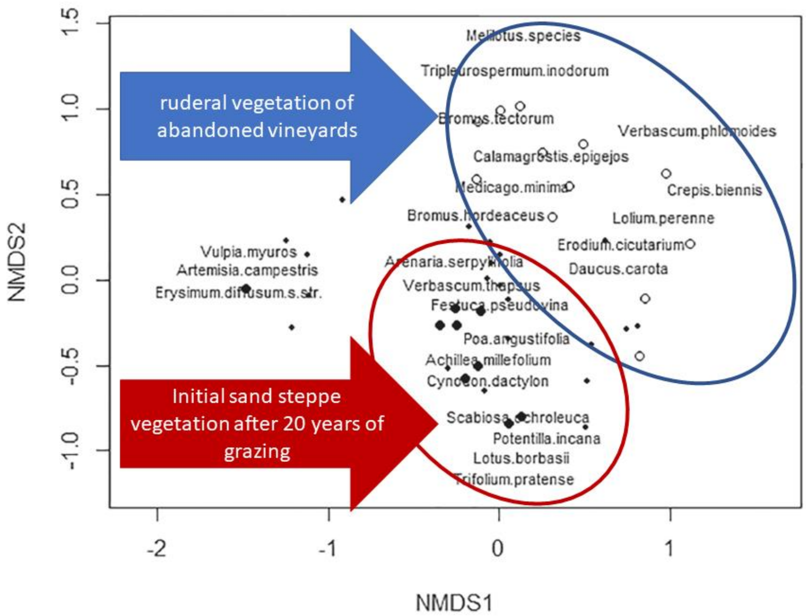

Fig.3: Development of the permanent plots of group 6 (vegetation of fallow land in former vineyards) in relation to species composition and species cover. White circles show recordings of the first three years of monitoring, large black circles show recordings of the last three years of monitoring. Small black circles label the intervening years. The main occurrences of characteristic species are also shown (modified from Euler et al.2014)

To summarize, it can be stated, that free-range grazing contributed substantially to high conservation value of the investigated sites, by promoting highly specialized elements of the regional flora. Recent analyses of plot-based monitoring data indicate, that the “climate change signal” becomes more visible, emphasizing the need for a more detailed investigation of hydrological effects on the biodiversity of grassland ecosystems in the region.

As a conclusion, we recommend to further develop scientifically founded grazing schemes responding to the local particularities of the vegetation, the habitat characteristics and to the habitat requirements of typical grassland fauna. A control of success by a constant monitoring scheme is important for the adjustment of grazing intensity in the different plant communities, both spatially and temporally. In addition, grazing has to be part of a locally adapted suite of grassland management (including hay-making, mulching etc) to achieve and maintain the desired conservation value (Fiedler et al 2017).

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Bryophytes in National Parks in the East of Austria

Harald G. Zechmeister, Michaela Kropik

Summary

We investigated the bryophyte flora of the Thayatal, the Donau-Auen, and the Neusiedlersee-Seewinkel National Parks during the last decades. The Thayatal National Park accommodated the richest bryophyte flora (328 taxa), followed by the Donau-Auen (247 taxa) and the Neusiedlersee National Park (168 taxa). A series of species, which were regarded as extinct could be re-found in each National Park. Dry grasslands were of major importance for bryophyte occurrence in each National Park. All of these National Parks have a high responsibility for the survival of many bryophyte species.

Keywords

Bryophytes, extinct species, responsibility

Introduction

Bryophytes are the second largest group of plants. They were among the first organisms which conquered terrestrial habitats (> 400 Mio. yrs.). Bryophytes developed in three polyphyletic lineages. They are grouped into the phyla hornworts, liverworts, and mosses.

Bryophytes occur in all ecosystems besides marine habitats. They play a major role in ecosystem services. They store enormous quantities of water which is a major source for other organisms. As pioneers, they enable other plants to grow. They are micro-cosmos of their own, habiting many other small organisms.

Methods

During the last years, we investigated the Thayatal, Donau-Auen, and Neusiedlersee-Seewinkel National Park regarding their bryophyte flora. Investigation intensity was best at the Thayatal National Park.

Results

In the Thayatal National Park 328 bryophyte taxa (268 mosses, 60 liverworts) were found. One species was new to Austria (*Riccia gougettiana*), and four species were estimated to be extinct in Austria before our investigations (*Cephaloziella stellulifera, Pyramidula tetragona, Oxymitra incrassata, Riccia papillosa*). The most important habitats were dry grasslands (169 species, 52 % of all species in the National Park, 71% of species listed in the Red List). The results of the investigation were published by Zechmeister and Kropik (2021a, b).

In the National Park Donau-Auen we found 247 taxa (212 mosses, 35 liverworts). Seven species were estimated to be extinct in Austria before our investigation (*Bryum knowltonii, Dialytrichia mucronata, Ephemerum cohaerens, E. recurvifolium, Fontinalis hypnoides, Riccia canaliculata, R. frostii*). The most important habitats for bryophytes were the Dynamic banks of the old and tributary arms of the Danube, sandy-loam banks on the Danube, and xeric habitats (Heißländen). The results of the investigations were recently published by Zechmeister and Kropik (2022).

In the National Park Neusiedlersee, 168 taxa (164 mosses, 4 liverworts) were found. One species was estimated to be extinct in Austria before our investigations (*Bryum warneum*). The most important habitats for bryophytes are Continental salt meadows, fen meadows, and the xeric habitats around the salt lakes. The investigation status is poor and should be improved by further studies. There is one older publication on bryophytes in the area (Zechmeister 2005).

The most severe problems for bryophytes in all of these National Parks are the high density of wild boar (trampling, wallowing), tourists which leave their paths (e.g. in dry grasslands), and management difficulties and failures, as different groups of organisms often have different demands. In the Thayatal National Park, monitoring of rare species for improving management measures is already performed, for the other two National Parks monitoring measures are recommended.

The Austrian National Parks have a high responsibility for the survival of many (rare) bryophyte species.

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Water as important Geoheritage in UNESCO Global Geoparks

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Summary

In times of climate change, reports of extreme droughts, heat records and environmental disasters are increasing. These events present us new challenges in a wide range of areas. Water, especially clean drinking water, is already not adequately available in many parts of the world, and this situation will continue to worsen. Therefore, it is of great importance to protect water resources in all their forms. UNESCO Global Geoparks (UGGps), as protected areas, can play an important role in the protection of water resources and their sustainable use.

UGGps aim to manage landscapes of outstanding geological importance (Mission UGGpN, 2022). Water is essential in the formation of geological features and contributes to the diversity of different ecosystems (Ruban, 2019). Therefore, UGGps can support the protection of water and the implementation of water management strategies. In the INTERREG VA SI-AT project KaraWAT, the EGTC[1] Karavanke UGGp and its corresponding research institutions developed a transboundary sustainable water management in a participatory process. The project activities aim to inform relevant stakeholders, inhabitants and visitors of the Geopark about the importance of water resources and the sustainable use. For the global perspective, one outreach activity aims to investigate the role of water in the Global Geopark Network (UGGpN). In a mixed-methods approach a questionnaire was conducted and an international online workshop was held. A World Café format was used to discuss facing challenges concerning water resources caused by climatic change, education and awareness raising activities, importance of water features for regional economy and their valorization, as well as the influence of geoparks concerning policy and decision making.

All participants emphasized the great importance of international collaboration within the Global and European Geopark Network and with other protected areas, sharing experiences and raising awareness on the protection and sustainable use of water resources. Participants saw the online workshop as a starting point for future collaboration within new working groups that will deal with water conservation and awareness raising. In this short paper we propose activities that UGGps can perform to support the protection and sustainable use of water resources, risk management and touristic valorization. We discuss risks that UGGps are facing concerning water quality and quantity issues.

Keywords

UNESCO Global Geoparks, Sustainable Water Use, Water protection, Coping with Climate Change, Cooperation

Introduction

Around 70 percent of the Earth is covered by water. The majority of it is salt water (97.4 percent). Subtracting glacier ice and permafrost (2.6 percent) about 0.3 percent is fresh water (Grundlehner, 2015). Only 0.007 percent of this fresh water is suitable as drinking water that does not need any water treatment (The National Geographic, 2010). According to an estimate of the Organization for Economic Cooperation and Development (OECD), global water consumption will double in the period from 2000 to 2050 (Grundlehner, 2015). Factors influencing the frequency of water shortages are rapid economic and population growth, and associated issues of waste water management and industrial water use (The National Geographic, 2010). Purely physical water shortages (driven by dry spells, wastage, etc.) are often amplified by poor water infrastructure (Petit, 2009). Deficiencies can occur due to inadequate

[1] EGTC: European Grouping of Territorial Cooperation

storage, distribution and access to clean drinking water (Petit, 2009). If water shortages and the unequal distribution of clean drinking water continue, research predicts a conflict-ridden future. Existing and future global disputes will be influenced by the availability of water. Therefore, it is important to secure and protect our water resources in all their forms (Houdret et al., 2012; Petit, 2009).

Water is a major factor in the formation of geological features and is therefore closely related to the development of distinctive landscapes, managed and promoted within the UNESCO Global Geopark Network (UGGpN) and the European Global Geopark Network (EUGGpN) (Mission UGGpN, 2022). UNESCO Global Geoparks (UGGps) aim to manage landscapes of outstanding geological importance "with a holistic concept of protection, education and sustainable development" (Mission UGGpN, 2022). Worldwide, 177 geoparks in 46 countries (status August 2022) are currently recognized by UNESCO. The mission of the UGGpN is to "promote the links between geological heritage and all other aspects of the area's natural and cultural heritage, clearly demonstrating that geodiversity is the foundation of all ecosystems and the basis of human interaction with the landscape (Mission UGGpN, 2022)". A bottom-up approach is taken, meaning that local communities are involved in the development and management processes (Mission UGGpN, 2022).

The topic of protection and sustainable use of water resources is critical for geo-conservation in UGGps and has recently appeared in the literature. Ruban (2019) highlights that water is essential in the formation of geological features and contributes to the diversity of different ecosystems. He illustrates that water resources are already included in official descriptions and therefore valued as an important landscape element for tourism. But the valorization of water resources has advantages and disadvantages. It attracts a lot of tourists and thus supports regional economies on the one hand. On the other hand, overuse of water resources and mismanagement of tourism flows may harm the environment. He argues that a deeper scientific and educational development of water resources is needed to identify opportunities for regional enhancement and solutions to potential risks (Ruban, 2019).

UGGps need to find a good balance between the integrity of nature and the visibility of the geological heritage. Particularly high visitor numbers and careless treatment of nature within UGGp areas may cause many problems for water resources. The Huangshan UGGp (China) investigated the negative impact of large-scale tourism use on the water retention and carbon sequestration capacity of soils (Gou et al., 2020). In the Karavanke UGGp, karstic water aquifers that stretch over the border of Austria and Slovenia are particularly sensitive to external influences. This transboundary groundwater body is used as the drinking water supply of Austrian and Slovenian border communities and is therefore under careful observation. Poltnig (2005) has shown that there is a risk of negative qualitative impact due to intensive tourist use. He proposes a joint catalog of measures, in which, among other things, the effects of tourist use should be compared with the economic benefits (Poltnig et al., 2005).

Depending on the form of organization, UGGps have different rights of participation and involvement concerning water management decisions. Schmalzl et al. (2022) investigated the advantages and disadvantages of different forms of cooperation for the management of transboundary water resources. Different laws and regulations, data standards, and language barriers may hinder successful cooperation across borders. Generally, UGGps can act as a lobby and demand changes from legislators. However, it should be pointed out that geoparks cannot take over governmental influence, they can only inform and advise them. Regional patchworks of laws and regulations can complicate the work. In response to the proposal of Ruban (2019) to look deeper into the opportunities of water protection in the areas of UGGps this paper aims to evaluate the common water-related threats facing UGGps, how water resources are valorized in UGGps, and how they can be protected in the future using sustainable approaches. For this purpose, we have addressed the following questions:

- What common threats do UGGps experience in relation to their water resources?
- What activities can UGGps perform to support the protection and sustainable use of water resources?

Methods

The overall research design is based on a mixed-method approach. A questionnaire and an international online workshop were carried out. These activities took place within the INTERREG VA SI-AT project KaraWAT, which deals with the protection and sustainable use of transboundary groundwater and surface water resources within the Karavanke UGGp.

Sixty-three UGGps were contacted through the online questionnaire. The sampling was based on Ruban's (2019) list of geoparks containing water objects in their official descriptions. Included UGGps are those that already include groundwater, springs and/or rivers and have experiences managing water resources. The results of the questionnaire highlight the topics of climate change, education, regional economy and valorization, policy and decision-making as well as future cooperation. They were used as the main topics of discussion at the international online workshop.

Thirty participants took part at the workshop. The invitation to the workshop was sent to the entire UGGpN. The participants consisted of twenty geoparks worldwide, members of the UNESCO Commission and the UNESCO Secretary. A World Café format was used to discuss the topics.

The results of the questionnaire and the workshop were coded and integrated into a SWOT analysis. The SWOT analysis gives and overview of the strength, weaknesses, opportunities and threats that UGGps face in terms of the protection and sustainable use of water resources, risk management as well as touristic valorization. For this paper we summarized the results of this analyses and worked on a list of recommendations and activities for the new working group of the UGGpN is proposed.

Results

To answer the question on common threats that water resources in UGGps face, it was confirmed that climate change is the most dominant issue. UGGps are struggling with decreased precipitation, stronger storms and extreme precipitation events culminate in flooding and erosion. Most local policies are not yet appropriately adapted to the requirements of climate changes. This can be seen in the ongoing improper land use and land management planning that leads to enormous land consumption. The problematic regions fueling this development are urban areas and urban sprawl, as well as intensively farmed areas. Increasing water consumption, even in drought periods (Summer 2022) and pollution increase the pressure on water resources. Next to the private sector (swimming pools for example), energy production and industry were named as two huge water consumers.

To support the protection and sustainable use of water resources, UGGps can perform many activities. Considering the risks and weaknesses regarding the opportunities of geoparks, it can be summarized that especially the areas of tourism, research and cooperation within the UGGpN hold great potential for current and future developments of water management.

UGGps are aware of the importance of a sustainable tourism approach that eliminates the problems of mass tourism. This includes geotourism as a new sector with a focus on geological heritage, the regulation of visitor streams and educational and awareness-raising activities for inhabitants and tourists. Through proper information boards and workshops in the geoparks, local stakeholders and tourists can become informed about water issues that already concern them or might affect them in the future. This may contain information on the origin of the water, on pollution as well as other threats. It may also include proposals on what each individual can do to save and protect water resources. For example, the Karavanke UGGp is currently installing an augmented reality model in its new info center that explains the karstic water flow on the Peca /Petzen mountain. The model enables users to understand the dynamics and the risks of the transboundary karstic water aquifers and gives suggestions for environmentally friendly behavior.

Apart from these sustainable touristic approaches, UGGps can identify common risks and hazards concerning water resources within their area in the frame of research projects. They can explore innovative technical solutions for water management and recommendations for adapting current laws and regulations to protect water resources for the future. UGGps have great potentials in advising local administrators on the protection of water. However, in many cases UGGps cannot take over decision-making tasks. They can only identify risks and pressures to inform and advise political stakeholders which measures should be taken. Project-based cooperation or other forms of cooperation within the UGGpN (associations, joint ventures, NGOs, working groups, EGTCs[2], etc.) may increase the liability and stake of UGGps in decision making processes. Regional differences concerning laws and regulations may still complicate the work.

The art of cooperation can be regarded as one of the greatest opportunities for UGGps. The UGGpN offers a large network of 177 UGGps worldwide that exchange information regularly. This network brings a huge benefit concerning the management and valorization of water resources. It was confirmed in the questionnaire and the workshop that the UGGpN supports cooperation concerning activities for the protection of water resources. They promote exchange within the network and suggest the formation of a new working group to work jointly on activities for the protection and sustainable use of water resources.

Working on a common water management strategy and the formation of the new working group one of the most important outcomes of the workshop. The formation of the new working group within the UGGpN will enable park managers to share experiences and develop guidelines and common strategies for the sustainable management and valorization of water resources within UGGps. Based on the data collected the recommended topics for this water-related working group can be summarized as follows:

- Determining common strategies for the sustainable management and valorization of water resources;
- Implementing a common sustainable tourism approach;
- Educating and creating awareness-raising activities for all stakeholders (inhabitants, tourists, guides, teachers, business owners, politicians);
- Developing a deeper participatory approach on the development of these areas;
- Informing and advising local politicians on ways to adapt laws and regulations to climate change;
- Involving more research and technical solutions to better cope with climate change;
- Expanding water protection zones.

[2] EGTC: European Grouping of Territorial Cooperation

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Following the digital tracks: Visitor monitoring using outdoor platform data

Julia Zink, Max Mangold

Summary

The growing popularity of digital media is evident in the fields of recreational activities and outdoor sports. Visitors of protected areas use digital media, for example, to plan activities, for orientation and navigation in the field, and to share experiences with friends and relatives via online platforms. Such platforms can also be used as a source of data for visitor monitoring, which can help understanding visitors' spatial behavior. We used data from different outdoor platforms such as Komoot and Bikemap to explore visitor activity in the Bavarian Forest National Park. The results allow identifying visitor hotspots and non-compliant behavior like movements besides the marked trail network. Many activities take place in the core area of the national park, which is the habitat of rare species like the capercaillie, which are sensitive to human disturbances. We demonstrate that digital media can give meaningful insights into visitor behavior and can be a valuable supplement for traditional methods of visitor monitoring.

Keywords

Digital visitor management, visitor monitoring, outdoor apps, social media, user generated content, protected area management

Introduction

As protected areas in general and national parks in specific are spaces in which nature experience plays a central role, they are popular destinations for tourists (Mayer & Woltering 2017). By definition, national parks are "managed mainly for ecosystem protection and recreation" (Dudley, 2013). This two-fold purpose makes visitor management one of the crucial tasks of national park management (Dupke 2019, Eagles et al. 2002, Job et al. 2016b, Leung et al. 2018). Visitor management comprises different tools that range from monitoring and visitor information to hard measures such as entrance fees or penalties for illegal behavior (Arnberger 2013, Clivaz 2013, Eagles et al. 2002, Job et al. 2016b). By using these tools, visitor management aims to minimize the negative impacts of outdoor recreation in protected areas while at the same time maximizing its positive aspects of it (Arnberger 2013, Leung et al. 2018).

In recent years, digitalization has found its way into most areas of society. The majority of Germans use the internet, the navigation service GPS is available almost everywhere on the globe and Smartphones have been adopted by most societal groups (Beisch & Schäfer 2020, Gram-Hansen 2009). Digitalization also affected outdoor recreation and lead to a wide range of services that target this area of activities. There are mobile applications for outdoor navigation, geocaching, and even outdoor platforms that have similar functionality as social media. These exist parallel to a vast number of blogs, forums, and groups on social media platforms dedicated to different areas of outdoor recreation (Hennig 2013, Ong & Ito 2019).

For visitor management in protected areas this development poses challenges but may also create new opportunities. The main challenge is linked to the "share" function that is inherent to most social media platforms. Visitors use it to share routes and special locations with other users. This might decrease the effect of traditional visitor management and might lead to a higher visitor load in sensitive areas. To ensure that the shared content is following the rules and regulations that apply within a protected area digital visitor management can be implemented.

Digital platforms can also be integrated in a digital visitor monitoring to observe trends in outdoor activities and in visitor behavior in general. For this national park administrations can acquire and analyze data from digital platforms. It is however important to note that digital visitor monitoring can only monitor the fraction of visitors that use digital outdoor services.

This article presents first experiences with digital visitor monitoring from the Bavarian Forest National Park using data from Komoot and Bikemap, two popular and widely used outdoor platforms.

Methods

The study area covers the Bavarian Forest National Park, which is located in Lower Bavaria at the German-Czech border. It has an area of 24 945 ha, which is mainly covered by forests. The main activities by visitors are hiking and cycling. The designated trail network within the national park has a total length of over 500 km of which about 350 km are hiking trails and 200 km of cycling trails. The national park records about 1.4 million visits annually (Nationalparkverwaltung Bayerischer Wald 2010, 2020).

For this study, we used data from the outdoor platforms Komoot (www.komoot.de) and Bikemap (www.bikemap.net). Komoot is a navigation app and platform that lets users plan and share outdoor activities. It has more than 27 million registered users (Hille 2022). Highlights are a central feature of the Komoot platform. They are created by users and mark points of interest for different activity types like hiking, cycling, mountaineering, and others. Users can also recommend highlights. For this study, we collected all highlights within the Bavarian Forest National Park in a table including the activity type, the name of the highlight, coordinates, and the number of recommendations/visitors. Data collection was carried out manually by browsing the Komoot map at half-yearly intervals. The first data collection was in May 2020, the latest in May 2022.

Bikemap is, according to their information, the world’s largest cycle route collection with about 7 million users worldwide (Bikemap 2022). The platform focuses only on cycling activities. We received all routes that have been online until the end of 2021 directly from the operators of the platform. The routes were provided as gpx files, supplemented by a CSV file with additional information like the routes name, length, and creation date. Both, Bikemap routes as well as Komoot highlights, are user-generated content.

Spatial analyses were performed in ArcGIS Pro and additional descriptive statistics were conducted in Microsoft Excel. Beforehand, Bikemap routes needed data cleaning to exclude routes with GPS errors. For that, routes with segments longer than 1 km were removed from the dataset. Komoot highlights were imported based on their coordinates and Bikemap routes were converted into feature classes. We created a heatmap, based on a fishnet grid with a size of 1 ha, to illustrate hotspots and the spatial distribution of routes. Illegal activities and activities in the core zone of the national park were detected and quantified using location-based selections.

Results

Komoot-Highlights

In total, 729 highlights were collected within the study area. 75% of all highlights are classified as hiking activities (hiking, running, and mountaineering) and 25% as biking activities (bike touring, mountain biking, road cycling). By May 2022, all highlights highlights had 42 786 recorded visits by users which equals an average frequency of 58.7 visitors per highlight. Hiking highlights are on average more popular (65.2 visitors per highlight) than biking highlights (38.6 visitors per highlight). It should be noted that the number of visits of the highlights does not match the actual visitation but rather represents the popularity of the highlights.

Regarding the spatial distribution, there are strong concentrations of highlights in certain areas, mainly in the surroundings of popular mountain peaks, peak bogs, mountain pastures, pristine forest areas, lakes, and streams. It is noticeable that five of the ten most popular highlights, according to their frequentation, are located around the summit of Lusen. In addition, the peaks of Rachel and Falkenstein are part of the "Top 10", as well as Schwellhäusl and Rachelsee (Figure 27). All of those highlights belong to hiking activities. The most popular biking highlights are Trinkwassertalsperre Frauenau, Großer Falkenstein and Racheldiensthütte.

There are 321 highlights (44% of all highlights) located in the core area of the national park. The core area provides habitats for disturbance-sensitive species such as the capercaillie and areas sensitive to trampling (like raised bogs) which should be protected from high visitor load.

There is a strong increase in the number of highlights from 299 highlights in May 2020 to 729 highlights in May 2022, with a large increase in the percentage of cycling highlights.

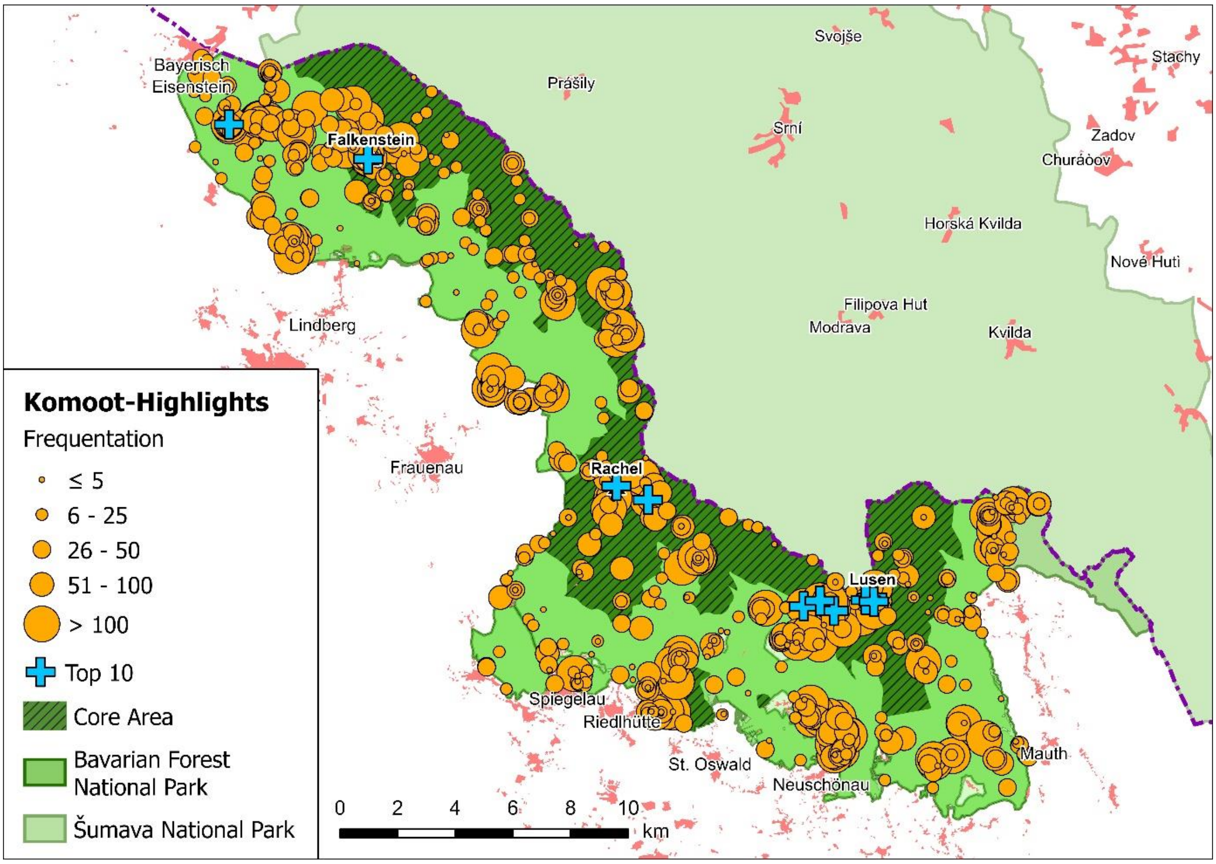

Figure 27: Komoot-Highlights in the Bavarian Forest National Park

Bikemap routes

In total, 1017 routes completely or partly pass the Bavarian Forest National Park. The mean route length is 330 km, and the median length is 66 km. The Heatmap illustrates the spatial distribution of the routes as well as activity hotspots. The most frequently used paths are mainly designated cycle paths in the lower elevations of the national park. Only a few highly frequented paths are in the higher elevations and the core area of the national park (Figure 28).

From all 1017 routes that have been analyzed, 644 routes (63%) completely follow designated cycle paths and official roads, so they are compliant with national park rules. However, 373 routes (37%) are classified as illegal as they leave the designated cycle trail network. Non-compliant routes take place in the whole area of the national park, but the most frequented illegal paths are mainly in the northern part of the study area.

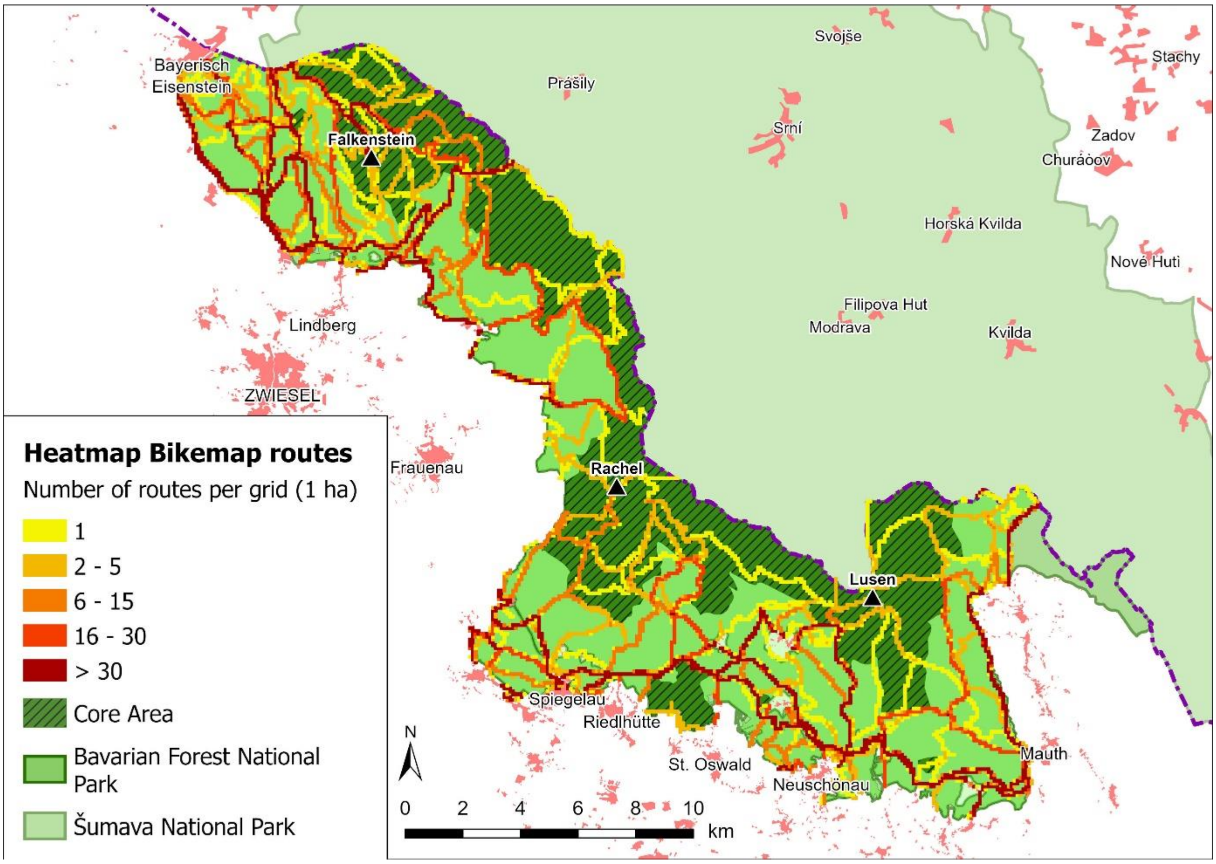

Figure 28: Heatmap of Bikemap routes in the Bavarian Forest National Park

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Assessing the potential of Natura2000 sites to achieve the 10%-strict protection goal of the EU Biodiversity Strategy to 2030

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Abstract

In response to the ongoing loss of biodiversity, the new EU Biodiversity Strategy calls for more ambitious conservation targets by 2030. The European Commission aims to expand the protected area network to at least 30% of the EU’s terrestrial and marine surface, of which one third should be strictly protected. While the Commission emphasises the need to adopt process-oriented management goals in these strictly protected areas, knowledge about the spatial location and distribution of suitable candidate sites remains scarce.

This paper specifically examines the proposition that the incorporation of process-oriented goals in Natura2000 management, which traditionally focuses on species and habitat conservation, could be a promising way to achieve 10% strictly protected areas in Europe. To assess the suitability of Natura2000 sites as areas for strict, process-oriented protection, this study first computes an adapted wilderness quality index for the Alpine Space area and investigates the significance of such Natura2000 sites in protecting the wildest areas (top 10%) of each ecoregion in the study area.

The results show that 50.4% of ecoregions’ wildest areas are currently under some form of protection, two thirds of which fall under the Natura2000 network. However, depending on the ecoregion, the share of Natura2000 sites can range between 22 and 98%. Also, we find significant variations in the absolute number and level of wilderness quality of Natura2000 sites falling within the wildest areas. Broadly, Natura2000 sites fall into two categories, depending on the ecoregions considered: In the first category, the contribution of Natura2000 can be attributed to a low number of sites. Since they are also characterised by already high levels of wilderness quality, we conjecture that a process-oriented conservation approach would likely cause little frictions with species and habitat conservation. Given the low number of sites, putting them under a different conservation protection scheme might be a more suitable strategy than changing established Natura2000 regulations. In the second category of ecoregions, a relatively large number of Natura2000 sites falls within the wildest areas. However, the level of wilderness quality is relatively low in those sites in comparison with the entire study area.

Adopting a process-oriented conservation approach in such ecoregions would likely lead to significant landscape changes, with potentially important implications for species and habitat conservation. We therefore show which species and habitats are currently being protected by Natura2000 in the wildest areas to guide future research concerning the conditions under which process-oriented and species/habitat conservation goals might be aligned.

In conclusion, we suggest that there is significant potential for the adoption of process-oriented conservation management of today’s Natura2000 sites in some ecoregions. Overall, however, it may prove more effective to switch to a different protection scheme rather than change existing Natura2000 regulations.

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Austrian National Parks: Biodiversity Coverage and Major Gaps

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Summary

In a project commissioned by National Parks Austria, species occurrence data provided by the six Austrian national parks were compiled, assigned to current taxonomic concepts and matched with current national checklists to analyse their coverage of Austrian vertebrates, vascular plants, Red List species, endemic species and habitats listed in Annex I of the European Union Habitats Directive.

The coverage of all national parks combined ranged from 69% for Austrian vascular plants (excluding apomictic taxa, aliens and extinct species) to 94% for breeding birds. About 80% of Austrian habitat types listed in The Annex I of the European Union Habitats Directive are represented within the boundaries of the Austrian national parks. With a coverage of 68% of Austrian breeding birds, Neusiedler See – Seewinkel National Park is a hotspot of bird diversity, whereas 74% of the Austrian fish fauna use the Donau-Auen National Park in one or another way. By contrast, the alpine national parks Gesäuse, Kalkalpen and Hohe Tauern are hotspots for Austrian endemic and subendemic species. Vascular plant species richness is higher in those alpine national parks and they protect more than twice the number of Austrian Annex I habitat types compared to the eastern national parks.

As cluster analysis showed, National Park Gesäuse and National Park Kalkalpen were very similar both in their vertebrate fauna and in their vascular plant flora. National Park Hohe Tauern was related to this this cluster, with higher similarity in vertebrates than in vascular plants. National Parks Neusiedler See – Seewinkel and Donau-Auen are aggregated into a separate branch and showed lower mutual similarity than the alpine parks. Thayatal occupied an interesting intermediary position, showing similarities to the alpine branch for vertebrates and to the eastern branch for vascular plants.

As these analyses showed, the high coverage on a restricted area is the result of complementarity between pannonian lowland national parks that protect species of open wetland, dry grassland, saltpans and floodplains on the one hand and alpine national parks harbouring species of woodland and mountain habitats on the other hand.

Even if the coverage of Austrian National Parks appears to be high, notable and highly conservation-dependent threatened species live beyond their borders. For instance, Rhine valley, Karwendel, Southern Alps, unglaciated mountains at the eastern border of the Alps and Morava floodplains are landscapes that harbour species and habitats of high conservation importance, but they lack presently large high-profile areas of strict protection.

In summary, the present analyses highlight the role of national parks within the Austrian protected area network.

Keywords

Systematic Conservation Planning, biodiversity, protected area network,

Introduction

Austria's national parks are situated in highly attractive landscapes, but they are rather small. All parks combined comprise only 2.8% of Austria's area, with Hohe Tauern National Park alone covering 2.2% and the smallest national park Thayatal only measuring 13 km^2 (0.02%). Could a high habitat diversity, the presence of rare habitat types alongside common habitat types and a high level of protection outweigh these size restrictions and allow for a high species richness within the national park archipelago?

Until recently, a straightforward answer was not available – while considerable research efforts have been invested into the compilation of inventories of the Austrian national parks, no overarching comparative analysis had been performed. In a joint effort by Umweltbundesamt – Environment Agency Austria and Department of Botany and Biodiversity Research at the University of Vienna, species lists of the national parks have been assembled and compared to national checklists developed and maintained at the respective institutions. The study was designed to (1) provide an overview on the biodiversity coverage of the national parks, to (2) identify species that are covered by one or more national parks and also those that are not covered and to (3) gauge and illustrate the strategic role of Austria's national parks in biodiversity conservation. While a formal gap analysis was beyond the scope of the present study, regions emerged that harbour species with high conservation value but without any high-profile protected areas. A full account of the project including the data compilations is provided in Zulka et al. (2021), additional over-arching analyses have been performed in Zulka et al. (2022). Here, we provide a short summary of the results.

Methods

National park species lists were already available in pre-compiled form or were generated from national park inventory database data. Data records were checked and assigned to current species delineation concepts and current nomenclature. National reference checklists were based on earlier compilations and complemented and corrected with recent additions and taxonomical changes.

Faunal and floral similarity between the national parks was calculated using Jaccard's coefficient of community. Then, proximity matrices were subjected to hierarchical cluster analysis (unweighted arithmetic average clustering, UPGMA, Legendre & Legendre 1998, p.319) using the software SPSS Windows 10.0.

For all national parks, a list of Annex I habitat types was compiled. The analysis was based on maps using a 3' × 5' grid (grid cell size 5.55 × 6.25 km). The analysis was restricted to data between 2013 and 2018, which led to omission of some habitat types being present in the national parks but were not recorded at that time.

Results

Biodiversity coverage of Austria's national parks was high, in particular for vertebrate species, but also for habitat types listed in the Annex I of the European Union Habitats Directive and to a lesser degree, for vascular plants (Table 1).

Table 1: Percentage of Austrian species/habitat types represented within the six Austrian national parks.

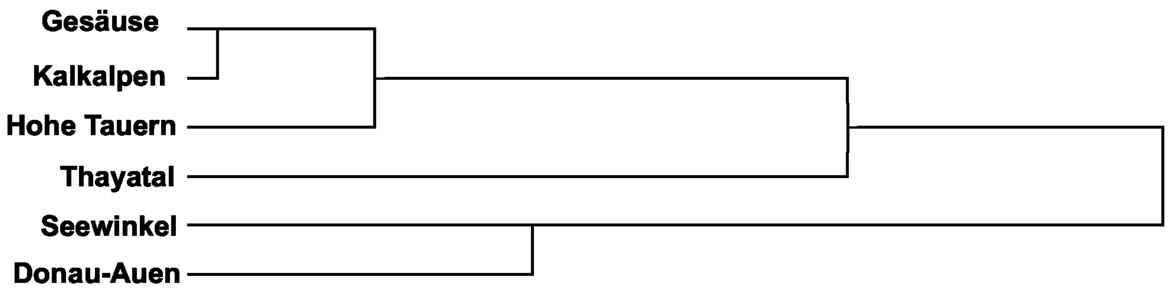
Organism Groups	Neusiedler See – Seewinkel	Donau-Auen	Thayatal	Gesäuse	Kalkalpen	Hohe Tauern	All national parks combined
Vertebrates	59%	52%	39%	39%	29%	43%	89%
Vascular plants	30%	31%	29%	35%	36%	35%	69%
Annex I Habitat Types	13%	24%	21%	41%	45%	42%	80%

The eastern national parks are particularly rich in vertebrate species. Neusiedler See – Seewinkel national Park is a hotspot on Austrian bird diversity, covering alone more than two thirds of all Austrian breeding bird species and a slightly lower percentage of reptile species. By contrast, within Donau-Auen National Park, 67% of Austria's amphibians and almost 80% of Austria's fish fauna have been recorded (Table 2).

Table 2: Vertebrate taxa covered by Austrian national parks and centre of their occurrence.

Class	Coverage (all national parks combined)	Hotspot
Mammals	87%	no particular hotspot
Breeding Birds	94%	Neusiedler See – Seewinkel (68%)
Reptiles	79%	Neusiedler See – Seewinkel (64%)
Amphibians	86%	Donau-Auen (67%)
Fishes	86%	Donau-Auen (79%)

The high coverage across the taxa may be explained with complementarity. Even if some single national parks already show a high representation of Austria's fauna and flora, it is the combination of complementary altitude, landscape, geology, and habitat types that may explain the high coverage on a small area. As Fig. 1 shows, assemblages are dissimilar between eastern lowland national parks but also between parks mainly on limestone (Gesäuse, Kalkalpen) and mainly on silicate (Hohe Tauern). Thayatal occupies an intermediary position; it combines floral and faunal elements from western Central European and eastern Pannonian ecoregions.



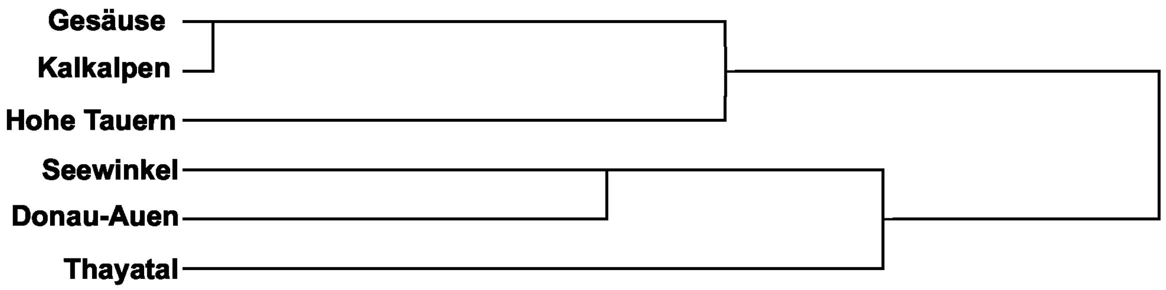


Fig. 1: Faunal (vertebrates, above) and floral (vascular plants, below) similarity between Austrian national parks.

Despite the overall high rate of representation, about one third of Austria's vascular plant flora is not protected in any national park. In vertebrates, coverage is even higher but also incomplete, leaving several high-profile conservation-dependent species unprotected. For example, the range of Bavarian Pine Vole *Microtus bavaricus*, an endemic Austrian mammal species, is quite distant from any national park, as are the ranges of several species with a western distribution in the Rhine valley. Karnic Alps, Karawanks, mountains at the eastern edge of the Alps with Gleinalpe, Stubalpe and Koralpe and the Morava floodplains are regions harbouring many endemic, subendemic, threatened or otherwise notable species, but they are not covered by national park protection.

Even if the Austrian national parks are not the result of any systematic data-driven planning strategy, they are effective in covering a large part of Austria's biodiversity. National parks are not a panacea alleviating all kinds of pressures impinging on conservation targets; climate change and nitrogen immissions do not stop at national park gates. Not all species occurring in national parks have viable populations there; many inhabit only the periphery, are less abundant than outside or have been encountered only as visitors (in particular mammals and fishes). Nevertheless, national parks are important building blocks of any biodiversity strategy and they represent the core of any protected area network.

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