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## Journal on Protected Mountain Areas Research and Management



Vol. 16 No. 2 – July 2024

eco.mont – Journal on Protected Mountain Areas Research and Management
is published by Austrian Academy of Sciences Press and *innsbruck* university press

Publishers
eco.mont – Journal on Protected Mountain Areas Research and Management is published by
• Austrian Academy of Sciences Press, Postgasse 7, 1011 Vienna (online version), ISSN 2073-106X
in cooperation with
• *innsbruck* university press (*i*up), Technikerstraße 21a, 6020 Innsbruck (print version), ISSN 2073-1558

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Subscriptions and Back Issues
• electronic: open access
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Design
Logo and basic layout of the journal developed by Sigrun Lange
Cover photograph: © *Andreas Baldinger. Kleinvenediger (3,468m) with the Untersulzbachkees, which feeds the Untersulzbach, and the Schwarze Hörndl (3,100m) on the right.*

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Published by:

ÖAW AUSTRIAN ACADEMY OF SCIENCES

IGF

universität innsbruck

Publisher:

AUSTRIAN ACADEMY OF SCIENCES PRESS

*innsbruck* university press
peer reviewed

Initiated by:

ISCAR

alparc

ISSN 2073-106X print version
ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont

eco.mont – Volume 16, Number 2, July 2024
ISSN 2073-106X print version – ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont
https://doi.org/10.1553/eco.mont-16-2s3


## Editorial

Dear readers!

Famous last words – the title of the final album recorded by the rock band Supertramp with the original line-up would be a fitting title for this editorial. After 15 years, initially as founding editor (together with my friend and colleague Axel Borsdorf), it is now time for me to retire from the editorial team of eco.mont and say goodbye to you.

I still remember very well the strenuous negotiations Axel and I had with the presidency of the Austrian Academy of Sciences at the time. It was not easy to convince people of our idea of founding an international journal on research in alpine protected areas, but after persistent discussions, we finally succeeded in obtaining funding from the Academy. Together with our congenial colleagues at the IGF, namely Valerie Braun and Brigitte Scott, who were later both accepted into the editorial team, we began to set up the journal with great enthusiasm. At this point, I would like to mention two colleagues who strongly supported eco.mont from the very beginning, namely my long-standing professional counterpart at the Swiss Academy of Sciences, Thomas Scheurer, and the then head of the ÖAW publishing house, Herwig Stöger.

The path from founding the journal from nothing to becoming a renowned publication was initially very rocky: as the journal was of course completely unknown in the scientific community, it was hard work to acquire contributions. At the time, we attended practically every relevant conference to approach scientists and protected area managers to persuade them to publish in eco.mont. Then as now, publications in journals that were highly rated were of fundamental importance for a successful university career, and it took a lot of persuasion and a great deal of charm to get colleagues to submit an article to eco.mont. It was only when the journal was included in the Science Citation Index Expanded (SCIE), which happened relatively quickly, and thus given an impact factor, that the work became somewhat easier and paved the way for the journal to become established.

In addition to my main job as coordinator of the international ÖAW research programmes, the associated intensive international networking and, last but not least, my scientific work as an Arctic researcher, the work as editor was a considerable commitment for me. However, the wonderful, amicable and professional co-operation with the entire team always made my work a pleasure.

The editorship was also a welcome opportunity for me to realize my desire to make scientific findings accessible to a wider scientific community. As editor, I have had the opportunity to be the first to read and publish a number of fascinating articles that have not only advanced the scientific discourse, but also provided practical solutions and new approaches to protected area management and the conservation of our valuable mountain ecosystems. It has been an honour to work with so many talented and dedicated scientists, researchers and practitioners and to bring their work to a wider audience.

If I had one wish for the future of eco.mont, it would perhaps be for protected area managers to feel much more of an urge to showcase their region's specificities, achievements, scientific results and best practice to a wider audience through articles in the journal. This would help other protected area managers to build on the knowledge and experience of others to inform their own work.

I would also like to take this opportunity to thank my fellow editors, the members of the Editorial Board, as well as all the authors, reviewers and you, dear readers. You have all made eco.mont what it is today: a recognized and valued platform for the exchange of knowledge and experience on the sustainable development and protection of mountain regions worldwide.

I would also like to emphasize that I see the future of eco.mont in very good hands. I am convinced that my successor will bring fresh ideas and new energy to the journal, and that the editorial team will maintain and further develop the high quality and scientific standards that characterize eco.mont.

Finally, I can assure you that my commitment to the protection and sustainable development of mountain regions will not end with my official retirement. I will continue to dedicate myself to these important issues, particularly through my work for the UNESCO World Network of Mountain Biosphere Reserves (WNMBR), and I look forward to following the continuing development of the journal and of the vital research that it publishes from a new perspective.

Thank you all for the wonderful time and the many inspiring encounters. Stay curious, committed and critical – our mountain regions need us.

Kind regards
Günter Köck

eco.mont – Volume 16, Number 2, July 2024
ISSN 2073-106X print version – ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont
https://doi.org/10.1553/eco.mont-16-2s4

# Perceptions of mountain ecosystem services in Golija-Studenica Biosphere Reserve, Serbia: latent transformation from sustainable towards regenerative tourism

*Milica Luković, Marija Kostić, Branislav Dudić, Velibor Spalević & Danijela Pantović*

*Keywords: mountain ecosystem services, local stakeholders, tourist perceptions, regenerative tourism, sustainability*

## Abstract

Regenerative tourism is a new approach that seeks to establish and foster a symbiotic relationship between humans and nature based on the use of nature's ecosystem services (ESs) for people's improved quality of life and general wellbeing while promoting human contributions to the natural environment for the benefit of all. This research focuses on ESs as indicators of latent tendencies in the transformation from sustainable to regenerative tourism. The research was conducted in two cycles over a period of 11 years. The Participatory Rural Appraisal method (PRA) was used to gather information and local stakeholders' views concerning Serbia's Golija-Studenica Biosphere Reserve. Ninety-nine tourists were also interviewed face-to-face regarding their interests and demands. The research method included a Relative Frequency Citation index (RFC), which identified the ESs that respondents considered most important. The local stakeholders were unanimous in accentuating the importance of providing ESs that bring economic value, while tourists focused more on regulating or supporting cultural services. Our research methodology may serve as a benchmark for studies in other mountain tourism destinations and communities that are investigating developments towards regenerative tourism.

Profile

Protected area

Golija-Studenica

Biosphere Reserve

Mountain range

Dinaric mountains

Country

Serbia

## Introduction

The term *ecosystem services* (ES) is most commonly used to denote *nature's benefits*. The Millennium Ecosystem Assessment (MEA 2005) provides the most widely applied framework for understanding ESs, which it divides into four categories: supporting services (water and nutrient cycling, formation of soil); provisioning services (food, clean water, raw materials such as wood and cotton, natural remedies); regulating services (crop pollination, climate regulation, waste decomposition, water and air purification, biological control of pests), and cultural services (recreational opportunities, therapeutic effects of the natural environment on human health). When natural ecosystems are degraded and land is repurposed, the species and functions that constitute the ecosystems are usually disrupted, which means that the range and level of ESs decline, incurring huge costs and losses for various stakeholders (Negev et al. 2019). The proper evaluation of the resources that nature provides results in greater interest and investment in, and improved preservation of, natural resources. The assessment of ESs is of long-term importance for both national and local economies (Chan et al. 2006; Egoh et al. 2007). ES mapping and assessment are the topics of numerous studies published in the past decade or so (Egoh et al. 2008; Häyhä et al. 2015; Wolff et al. 2015; Kulczyk et al. 2018; Vannier et al. 2019). Although the scientific literature exploring the relationship between tourism and ESs is scant, certain sources emphasise the importance of the tourism sector for understanding the relationship between nature and society (Pueyo-Ros 2018). The tourism sector, like many other economic areas, depends on ESs (Smith & Ram 2016). The local economy also requires different types of ES (e. g., provisioning services or regulating services) as a basis for destination choice (Mieczkowski 1985). According to Garrido et al. (2017), concerning studies conducted in European countries, local stakeholders perceive provisioning ESs as the most beneficial type.

UNESCO's MAB Programme implements a unique approach to protected area management and biosphere reserves (BR). The concept of the BR includes the protection of natural and cultural heritage, but also provides a model for the cohabitation of humans and nature, i.e. for combining ecological aspects with economic and social needs in *living laboratories* (Poikolainen et al. 2019; Jančič et al. 2021; Raviv et al. 2021). Mountain areas are exceptionally important centres of biological and cultural diversity and traditional knowledge. They include a mosaic of different ecosystems that provide key goods and services to the entire community. UNESCO's BRs provide excellent sites for case studies on the linkages between biodiversity, ESs and land use by different actor groups (Viirret et al. 2019).

The most important challenge in the management of natural resources is to bridge the differences in the perceptions of various interest groups (Bridgewater 2002; Stoll-Kleemann & Welp 2008; Coetzer et al. 2014). This is an opportunity for tourism to move towards regenerative tourism in protected areas. By fostering reciprocal relationships between humans

and nature, regenerative tourism contributes to creating regenerative communities, places and destinations. This supports the development of tourism destinations, host communities, accommodation facilities and capacities, while benefitting the tourism industry in general (Bellato et al. 2022a).

Regenerative tourism is a step forward regarding environmental protection. According to Bellato and Cheer (2021), it unifies science and community knowledge and practices in the tourism context, using a transformational approach to increase positive effects on local communities and ecosystems. Regenerative tourism seeks to transform conventional tourism by embracing *tourism as a living system* and celebrating a holistic approach to nature, wellbeing, health, indigenous practices, and the goods provided by nature and its ecosystems (Becken & Kaur 2021). Belatto et al. (2022b) indicate that establishing regenerative tourism requires different stakeholders to discuss how to reconfigure the tourism system. Economic dependency on tourism in protected areas is defined by a range of services that ecosystems can provide, and these services can be integrated in a regenerative approach to the complex relationship between inhabitants and nature (Vermeeren 2020). One of the most powerful tools for understanding this relationship is to understand ESs themselves (Pueyo-Ros 2018).

The relationship between ESs and regenerative tourism is mirrored in *place-based*, *whole-system* and *community-led* models, ecosystem-centered approaches, the concept of human and non-human wellbeing, the *getting back to tradition* paradigm, as well as in the appreciation of socio-cultural, ecological and economic values (Bellato et al. 2022a; King 2022). Yuan (2020) indicates that regenerative tourism finds inspiration in indigenous practices (e.g., traditional agriculture and food systems, or local ecological knowledge). The regenerative tourism approach tries to mimic nature, get closer to nature-based solutions, and allow for reviving traditional practices in ESs while enhancing economic wellbeing and resilience (Hussain & Haley 2022). The approach might best be recognized in the aftermath of natural disasters or pandemics when local communities wish to rebuild or revive traditional knowledge and skills based on natural solutions (Vermeeren, 2020). The UN Decade of Ecological Restoration (2021–2030) recognizes that communities have become more resilient to crises such as the Covid-19 pandemic thanks to nature-based solutions (Edrisi & Abhilash 2021).

There is a need for research projects that support global trends from *sustainable* to *regenerative* tourism (Solimar International 2022), as well as to investigate the core factors that enable tourism businesses to be more ecologically, socially and culturally regenerative while respecting community needs and improving ecosystem integrity. However, a comprehensive analysis of the literature on this topic, as well as of other available resources, has identified several gaps concerning regenerative tourism (Thurow 2023). Pioneering efforts to scientifically establish and explore the concept of regenerative tourism were made by several publications (e.g. Zaman et al. 2022; Bellato et al. 2022a, b; Bellato et al. 2023), especially in discussing the relationship between ESs and tourism (Pueyo-Ros 2018). Most of the literature focuses predominantly on the concept of regenerative tourism and its relationship with human wellbeing and touristic experience (Thurow 2023), but we are still lacking a homogeneous and systematic research methodology, research knowledge, and examples of its application. In particular, tourists' perception of regenerative tourism needs to be examined, since there is insufficient data on this topic.

While holistic tourism focuses on natural resources as the means for achieving the pillars of sustainability, regenerative tourism is an *alternative paradigm* focusing on a symbiotic human–biosphere relationship (Farsari 2021). Tourism experience, wellbeing and feeling for tradition have for a long time been important aspects of eco- and nature-based forms of tourism. In the new paradigm, however, ESs are emerging as the foundation of the economy. They direct stakeholders' perceptions towards regenerative tourism, fostering better and inclusive strategic and / or planning documents, improving the decision-making processes, and bringing a positive contribution to overall wellbeing (Vermeeren 2020). The novelty of this study is its focus on this new aspect. It therefore opens the doors for conducting further research in this area.

Regenerative tourism includes shifts in mindset and practice which ultimately change the socio-ecological context by strengthening the human–nature relationship (Mathisen et al. 2022; Dredge 2022). ESs have been chosen as indicators of latent changes in the process of transition to regenerative tourism, notably the increased demand for natural products in recent years (Luković et al. 2023). Regenerative tourism supports the symbiotic relationship between ecosystems and communities by embracing nature-based solutions. Furthermore, the common interest of both local communities living in protected areas and the tourists visiting them lies in the preservation of ESs through sustainable resource management.

The key factors of the mindset shift include community needs / perceptions, ecosystem integrity, biodiversity benefits and human wellbeing (King 2022). This paper aims to present the shift in mindset over eleven years of different stakeholders who use a broad range of ESs, and to identify a potential transition towards a regenerative paradigm. It does so by asking two research questions: 1. What kind of ESs were perceived in the past, and which have been considered recently? 2. Is there indeed a latent transformation towards regenerative tourism?

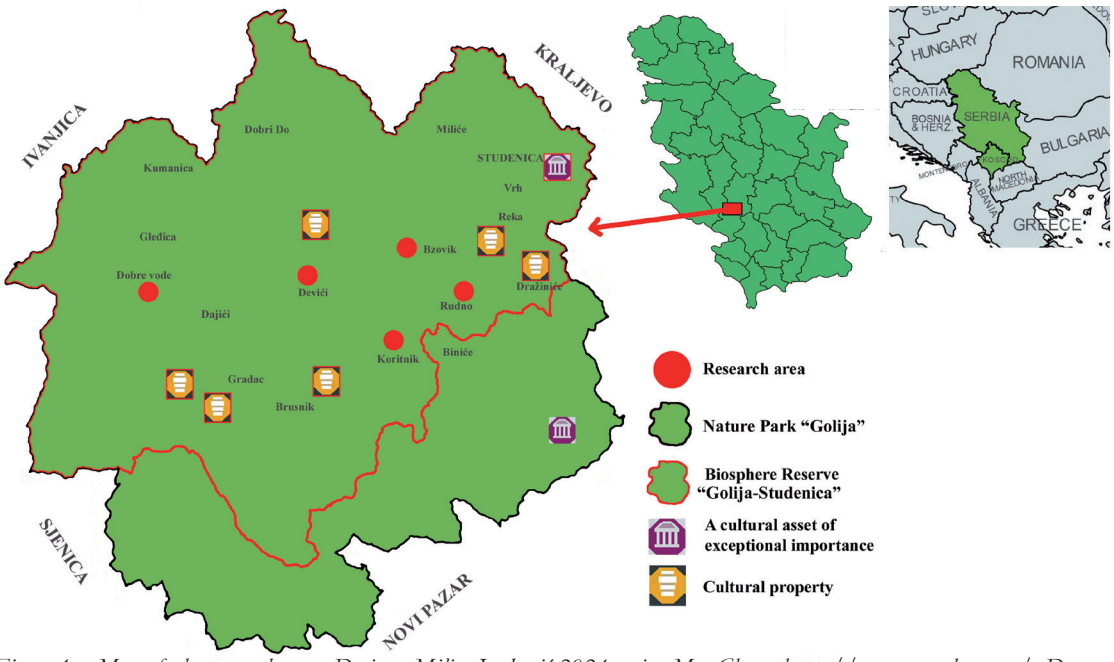



*Figure 1 – Map of the research area. Design: Milica Luković 2024, using MapChart, https://www.mapchart.net/. Datasource: Spatial plan of special purpose of Nature Park Golija, https://www.kraljevo.rs/prostorni-plan-podrucja-posebne-namene-parka-prirode-golija/; https://www.skijanje.rs/ski-centri/srbija/golija-ivanjica/prostorni-plan-parka-prirode-golija/.*

## Materials and methods

### Study area

The research was conducted in the Golija-Studenica BR (Serbia; designated in 2001). The research area is situated on the slopes of the Radočelo and Golija mountains in southwestern Serbia (N43.437642; E20.419426) and covers an area of 53,804 ha (Figure 1).

Today, there are about 6,000 inhabitants living in the area in 42 settlements, predominantly engaged in animal husbandry, and gathering herbs and mushrooms (Tomić & Stojsavljević 2013). A traditional lifestyle based on agriculture has evolved, creating a landscape of pastures, meadows and forests. The percentages of households whose main sources of income are related to agriculture (livestock, meat and milk production) or diverse non-agricultural activities (wood products, herbal sector) are presented in Table 1. Sustainable agriculture, crafted natural or wild products, and rural eco-tourism based on natural resources, which meet UNESCO's MAB principles of the cohabitation of man and nature, are considered the most significant (Vilimonović & Ralević 2008).

Studenica Monastery, built in the 12$^{th}$ century and a UNESCO World Heritage site (UNESCO 2017), is located at the north-eastern edge of the BR. Golija also has national protected status as a nature park. In recent decades, tourism in Golija has developed alongside the traditional economic activities and has been recognized as a factor in rural revitalization and the preservation of traditional architecture and customs (Sagić et al. 2019). However, the development of ski slopes and tourist resorts about ten years ago has resulted in soil erosion; water, soil, air, noise and light pollution; deforestation, loss and fragmentation of natural habitats, and reduction of biodiversity; negative changes in the balance of watercourses and groundwater, and at times in visitor overload (Rodríguez-Rodríguez & Bomhard 2011; Ćurčić et al. 2021).

This area has been developing for around two decades, and numerous recreational facilities can now be found here, such as hiking and biking trails, herbal routes, viewpoints, waterfalls and man-made structures, all supporting the development of ecotourism and enriching the area's tourism offer. Nevertheless, due to their geographical remoteness and above-average age, people in Serbia's mountainous areas, such as Golija, often suffer from insufficient information, resulting in their being less open to adopting new knowledge (Pantić 2019).

By understanding the unique potential of a place, stakeholders in tourism-related businesses can develop reciprocal relationships with communities and explore ways of harmonizing with nature while building the capacity of related social-ecological systems. Additionally, regenerative tourism facilitates net-positive effects on ecosystems by helping to provide the conditions necessary for their restoration and ongoing self-generation (Mang & Haggard 2016), while also improving the capacity for communities to flourish. In regenerative tourism, people, governments and businesses all work together to serve the broader systems affected by tourism (Howard et al. 2008; Pollock 2019).

### Data collection and analysis

Collection of data from stakeholders was organized in 2010 and 2021, and from tourists in 2012 and

*Table 1 – Households' main sources of income (2008) (Source: Vilimonović & Ralević, 2008; PLA/PRA Study within the project "Net for support to rural development").*

| Income sources | Income sources related to | |
|---|---|---|
| | agriculture | other activities |
| Sale of milk and dairy products | 85% | / |
| Sale of livestock | 80% | / |
| Sale of potatoes | 40% | / |
| Sale of wood products and wood for fuel | / | 30% |
| Rural – eco-tourism | / | 15% |
| Salary/pension | / | 12% |
| Sale of mushrooms, non-timber forest products/medicinal herbs | / | 10% |

2021, garnering information about the perception of ESs, and Local Action Groups were established, in line with the LEADER approach. Participatory Rural Appraisal (PRA) was applied for data collection in rural areas, a method based on the experiences of people living and/or working in rural areas in managing their natural resources (e.g. Ćurčić et al. 2021). Following PRA methodology criteria, respondents/participants and experts examined selected topics in face-to-face discussions, in order to gather information about local skills and knowledge, traditions and natural resource management, and to map important resources etc. The process was carried out during several sessions (e.g. to design ID cards for villages, map resources, and determine the socio-economic situation of various communities) in the context of a training programme for local stakeholders. The stakeholder group included local landowners, nature park managers, representatives of households engaged in rural tourism, farmers and teachers. Some of the stakeholders participated in research in both 2010 and 2021. Stakeholders were selected according to the recommendation of local authorities and representatives of local NGOs. Tourists were selected randomly in situ. In 2012, 42 tourists were interviewed using semi-structured questionnaire-based interviews (similar to those of, e.g., Garrido et al. 2017; Ahmad et al. 2009; Jain 2010). The data collection was repeated in 2021 on a sample of 57 tourists.

Our research used a relatively small number of respondents because the model requires fewer respondents than standard attitude questionnaires. In addition, the research area is relatively small, includes a small number of households involved in tourism, and has limited tourism capacities. Socio-demographic data are given in Figure 2. Particpants were asked about their views on ESs, but without reference to specific ES categories. Thus if they mentioned an interest in the local speciality known as *green bread* (containing nettles and herbs), for example, we categorized them in the cultural ES category. The research was based on concepts confirmed by previous similar studies (Garrido et al. 2017).

Specific resources or phrases used by respondents to describe ESs were allocated to one of the four basic categories: 1. Supporting, 2. Provisioning, 3. Regulating, and 4. Cultural. The standard classification systems proposed by Millennium Ecosystem Assessment (2005), Daily et al. (2009), TEEB (2010), and de Groot (2010) were used, modified by the authors to fit the objectives of this study. Each category included a list of ESs (Table 2). The interviews were analysed quantitatively using the Relative Frequency of Citation index (RFC),

$$RFC=FC/N$$

where FC represents the frequency of citations of a particular ES, and N is the total number of respondents.

To confirm the measurement of the diversity of perceptions, the entropy method was used as an indicator of system disorder, where a higher value means a larger number of differences. This method is used in numerous scientific fields, such as ecology, engineering, medicine, economics and finance (e.g. Chuansheng et al. 2012; Ermatita et al. 2012; Li et al. 2004; Guo 2001). The entropy statistic H(x) was also applied, to determine uniformity of distribution. This provides the basis for creating a measure of inequality I(x), or in this case, the differences between the perceptions of tourists and those of stakeholders, where x is the observed parameter (here, perceptions about the ESs). The calculation of equality or inequality can be represented by the equation (Czyz & Hauke 2015):

$$I(x)=H(x)_{max}-H(x)=\log_2 n-\sum_{i=1}^{n} p(x_i)\log_2\frac{1}{p(x_i)}$$

$$=\sum_{i=1}^{n} p(x_i)\log_2[n\,p(x_i)]$$

$$za\ 0\le I(x)\le \log_2 n$$

where I(x) = 0 indicates the absence of inequality (or uniform distribution), while I(x) = $\log_2 n$ indicates the maximum non-uniformity of the selected parameters x. In our case, $px_i$ represents individual perceptions about the ecosystem. Entropy measures were calculated separately for the perceptions of tourists and of stakeholders.

## Results

The sample of people from the local community comprised 61.9% men and 38.1% women in 2010, and 71.4% men and 28.6% women in 2021 (Figure 2). Recent studies indicate the existence of gender-specific roles in different rural-related activities and greater decision-making power of men in aspects of community management (Kalauni et al. 2020). Rafael and Almeida (2017) also indicate that women, who represented about 70% of the tourists interviewed, are more sensitive to ecological and bio-cultural heritage issues. The highest percentage (≈85%) of respondents were in the 31–50 and 50+ age groups. Of the Tourists,

*Table 2 – The ecosystem services most frequently mentioned by respondents (FC: frequency of citation; RFC: relative frequency of citation; n: number of respondents; %: respondents × number of sub-categories = 100%).*

| Main categories and sub-categories of ecosystem services | Stakeholders | | | | Tourists | | | |
|---|---|---|---|---|---|---|---|---|
| | FC | RFC2010 | FC | RFC2021 | FC | RFC2010 | FC | RFC2021 |
| | (n=21) | | (n=21) | | (n=42) | | (n=57) | |
| **Supporting ES** | | | | | | | | |
| Biogeochemical cycles | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.02 |
| Photosynthesis | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Biodiversity | 3 | 0.14 | 7 | 0.33 | 5 | 0.12 | 12 | 0.21 |
| Species | 6 | 0.29 | 7 | 0.33 | 6 | 0.14 | 18 | 0.32 |
| Food chains | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Structure | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Function | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| % | 6 | | 9 | | 4 | | 8 | |
| **Provisioning ES** | | | | | | | | |
| Crops | 16 | 0.76 | 15 | 0.71 | 10 | 0.24 | 24 | 0.42 |
| Fodder | 18 | 0.86 | 16 | 0.76 | 1 | 0.02 | 0 | 0.00 |
| Wild edible plants | 13 | 0.62 | 15 | 0.71 | 22 | 0.52 | 41 | 0.71 |
| Wild mushrooms | 14 | 0.67 | 15 | 0.71 | 24 | 0.57 | 40 | 0.70 |
| Wild game | 11 | 0.52 | 12 | 0.57 | 16 | 0.38 | 12 | 0.21 |
| Meat | 13 | 0.62 | 13 | 0.62 | 30 | 0.71 | 18 | 0.32 |
| Milk and dairy products | 15 | 0.71 | 16 | 0.76 | 33 | 0.79 | 35 | 0.61 |
| Wild berries | 12 | 0.57 | 15 | 0.71 | 25 | 0.60 | 38 | 0.66 |
| Wild fruits | 9 | 0.42 | 13 | 0.62 | 14 | 0.33 | 30 | 0.52 |
| Medicinal plants | 10 | 0.48 | 14 | 0.67 | 20 | 0.48 | 45 | 0.79 |
| Timber | 9 | 0.43 | 10 | 0.48 | 3 | 0.07 | 7 | 0.12 |
| Wood for fuel | 9 | 0.43 | 9 | 0.43 | 2 | 0.05 | 0 | 0.00 |
| Plants from which bees collect nectar | 8 | 0.38 | 10 | 0.48 | 0 | 0.00 | 0 | 0.00 |
| Meadows | 13 | 0.62 | 13 | 0.62 | 0 | 0.00 | 0 | 0.00 |
| Hay | 15 | 0.71 | 14 | 0.67 | 0 | 0.00 | 0 | 0.00 |
| % | 58 | | 63 | | 32 | | 34 | |
| **Regulating ES** | | | | | | | | |
| Air quality | 12 | 0.57 | 14 | 0.67 | 31 | 0.74 | 38 | 0.67 |
| Pollination | 14 | 0.67 | 18 | 0.86 | 15 | 0.36 | 21 | 0.37 |
| Soil erosion control | 5 | 0.24 | 7 | 0.33 | 0 | 0.00 | 0 | 0.00 |
| Climate regulation | 4 | 0.19 | 10 | 0.48 | 6 | 0.14 | 9 | 0.16 |
| % | 42 | | 58 | | 31 | | 30 | |
| **Cultural ES** | | | | | | | | |
| Social relations | 11 | 0.52 | 12 | 0.57 | 19 | 0.45 | 21 | 0.37 |
| Natural landscape beauty | 13 | 0.62 | 12 | 0.57 | 23 | 0.55 | 24 | 0.42 |
| Natural heritage | 14 | 0.67 | 15 | 0.71 | 24 | 0.57 | 27 | 0.47 |
| Historical remains | 16 | 0.76 | 13 | 0.62 | 25 | 0.60 | 24 | 0.42 |
| Sense of place | 10 | 0.48 | 12 | 0.57 | 20 | 0.48 | 18 | 0.32 |
| Aesthetics | 9 | 0.43 | 13 | 0.62 | 18 | 0.43 | 22 | 0.39 |
| Recreation and eco-tourism | 12 | 0.57 | 17 | 0.81 | 27 | 0.64 | 34 | 0.60 |
| Education and knowledge | 7 | 0.33 | 12 | 0.57 | 16 | 0.38 | 30 | 0.53 |
| Health | 13 | 0.62 | 17 | 0.81 | 22 | 0.52 | 42 | 0.74 |
| Man-made landscape | 11 | 0.52 | 16 | 0.76 | 20 | 0.48 | 34 | 0.60 |
| Spiritual and religious values | 17 | 0.81 | 13 | 0.62 | 23 | 0.55 | 26 | 0.46 |
| Traditional skills, food, recipes | 9 | 0.43 | 15 | 0.71 | 17 | 0.40 | 45 | 0.81 |
| % | 56 | | 66 | | 50 | | 51 | |
| Entropy measure H(x) | 1.375 | | 1.395 | | 0.165 | | 0.181 | |

63.2% were university-educated, whereas among the Stakeholders, the largest group of respondents had left education after completing secondary school (61.9%).

In order to answer our research questions, the perceptions of local stakeholders and tourists regarding ESs were evaluated according to the frequency of mentioning. Provisioning and cultural ESs were specified by both respondent groups as the most important. For the stakeholders, ESs were considered important as a source of economic contribution or of wellbeing, while the tourists identified them as sources of recreation, experience and education, and as having health benefits (among other things). Comparison between the perceptions of ESs in 2010 and 2021 shows small-scale changes, among both groups of respondents, in individual types of ESs. The general perception of

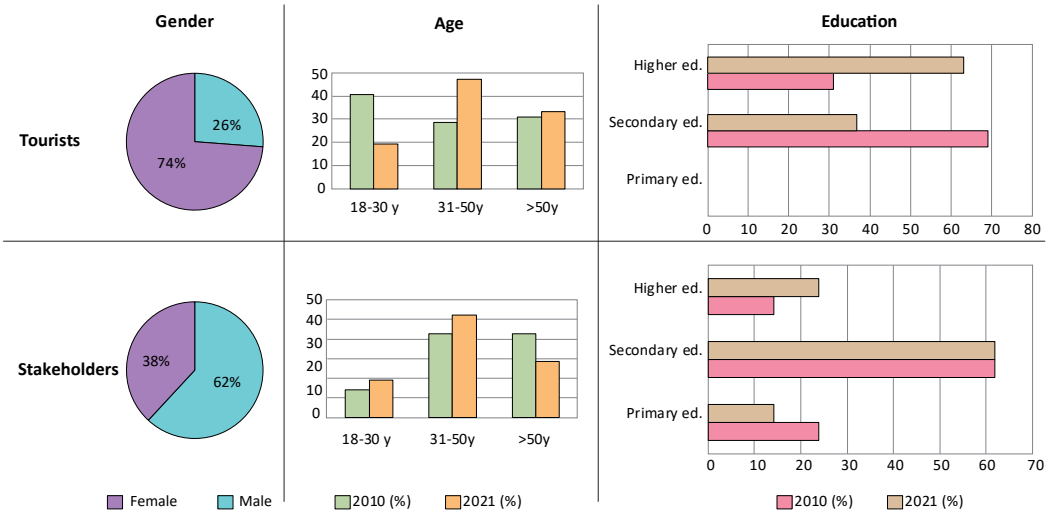



*Figure 2 – Sociodemographic data.*

supporting and regulating ESs is still poor because the respondents are not fully aware of their significance. These types of ES are not therefore a matter of direct interest to participants, except when clean water, clean air or pollination are mentioned.

The entropy measure calculation shows that there are no statistically significant differences between the two groups, at the level of $p < 0.05$. Small differences between 2010 to 2021 are expressed as 1.375 to 1.395 for stakeholders, and 0.165 to 0.181 for tourists (Table 2). Considering the RFC index for single ES sub-categories (e.g., traditional skills, food, recipes or wild edible plants), there is a latent tendency towards regenerative tourism, which values indigenous knowledge and nature-based solutions.

## Perceptions of local stakeholders related to ESs

The perceptions of ESs in the past and in recent times were analysed during PRA sessions. Situational analysis tools gave insight into the way locals see their situation, including relevant issues, and potentials or opportunities. The local stakeholders saw opportunities for income by developing agricultural potentials such as livestock and crops such as buckwheat and rye (Table 2, fodder −0.86; crop production −0.76; milk production −0.71; meat production –0.62; selling wild mushrooms −0.67). Due to a lack of local employment options and hence low incomes, the local population tended to grow their own food and valued ESs. They also recognized the development of rural tourism as an opportunity. The period 2010–2021 saw a significant increase in the number of beds provided for tourists by households (Tomić & Stojisavljević 2013; Sagić et al. 2019). The latent changes after eleven years also show increased interest in wild edible plants (0.71) and medicinal herbs (0.67), both in terms of trade and as a return to tradition. Regarding cultural ESs, tourism in 2010 was based on the promotion of natural and cultural-historical values, which was also the case in 2021 (spiritual and religious values −0.81; historical remains −0.76; natural heritage −0.67). In addition to the area's cultural potential, the typical mountain climate, natural products and healthy food gave the area significant tourist potential, which is reflected in the local stakeholders' perceptions, particularly in terms of getting back to *healthy roots* (0.81), education and knowledge (0.57), and ecotourism (0.81). This change was probably a spontaneous one that occurred during and after the Covid-19 pandemic.

## Perceptions of tourists related to ESs

The second round of interviews was with tourists, and related to their perceptions of, and interest in, the benefits from nature which they expected at the tourist destination. Over the period 2010 / 2012–2021, the study area changed in terms of tourism capacities. The earlier motivation of tourists to visit the BR related mainly to cultural services (in particular historical remains), natural beauty and recreational activities. However, the impact of global trends and the notion of *getting back to wellbeing* have shifted tourists' attention to health (0.74), and to traditional skills, food and recipes (0.81) as motives for visiting a particular destination. Tourists' perceptions of provisioning ESs also changed, especially concerning the category of wild natural products (in 2021: edible plants −0.71; mushrooms −0.70; medicinal plants −0.79).

## Comparative analysis of latent changes occurring over a ten-year period concerning the perception of ESs

The comparative analysis reveals changes that occur over time (2010 / 2012 to 2021) in the perception of the main ES categories (supporting ES, provisioning ES, regulating ES, and cultural ES). The results show a slow change in the perceptions of a limited number of ESs, and a latent movement towards regenerative thinking. Perceptions of regulating ESs increased significantly, by 16%, which implies raised awareness of the importance of natural goods and services. For

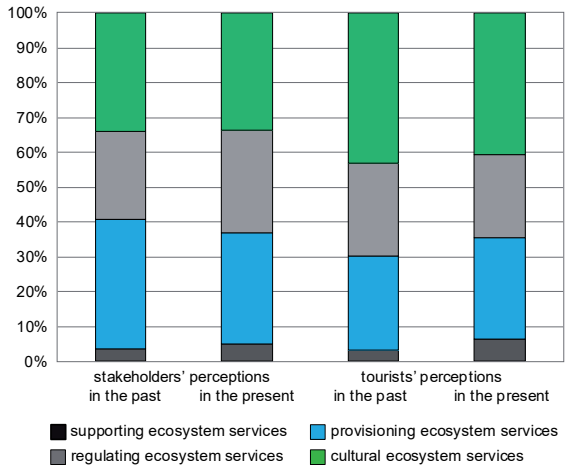



*Figure 3 – Proportions of the most frequently mentioned ecosystem service categories in 2010/2012 and 2021.*

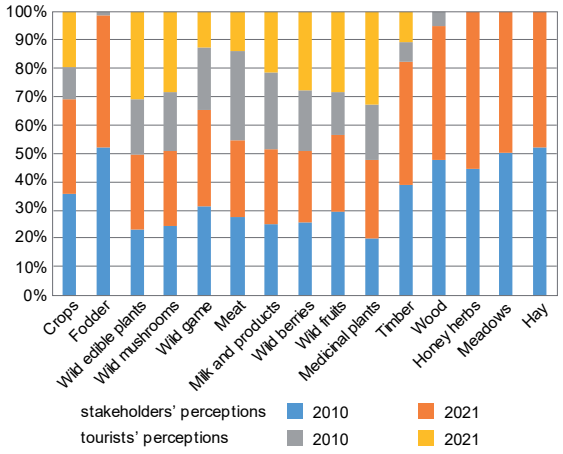



*Figure 4 – Proportions and comparison of specific sub-categories in the provisioning ecosystem services category (2010–2021).*

provisioning services, there was a small decrease between the two periods, probably due to the diversification of non-agricultural activities and improvements in the tourism sector, which resulted in a 3% increase in interest in cultural ESs. The most important trend was a very large increase in demand for natural products (see e.g. Galanakis 2020; Timoshyna et al. 2020). Supporting ESs also record a small increase compared to the previous period, probably because of increased awareness of global environmental issues and increased interest in ecology following the outbreak of the Covid-19 pandemic (Figure 3).

Local communities consider provisioning ESs as having a key role, because they bring direct economic value through traditional landscape management (in the production of meat, milk, fodder and other crops, for example). If we analyse the particular sub-categories within the provisioning ES category (Figure 4), it is evident that for local stakeholders, those ESs that generate economic benefits maintain their importance through the years. However, there are small changes, notably a slight increase in interest in wild natural products. Tourists' perceptions show decreased interest in meat and meat-based food and wild game, and a small increase in the demand for natural plant-based products.

Traditionally, cultural services are identified with natural beauty and cultural heritage. Both groups of respondents specified historical remains and natural beauty (a sub-category of cultural ESs) as important components of the local economy and as an attraction / motivation for tourists. The results of a comparative analysis related to sub-categories in the cultural ES category show increases of interest in traditional skills, knowledge and recipes, and recently in ecotourism. Local stakeholders recognise and respond to the demands of tourists, following trends that complement the local economy. There is an evident increase in the perception of traditional skills, food and recipes, and improved health and wellbeing. Education and knowledge are about 0.20–0.30 higher compared to the past (Figure 5).

## Discussion

### Ecosystem services: looking to the future

Recent research has shown that regenerative tourism promotes innovations by implementing new tourism practices within local communities (Bellato et al. 2022a). These new practices are based on sustainable ecological processes that contribute to human and non-human wellbeing. This paper also offers very practical guidance for tourism stakeholders who are working towards regenerative futures of tourist destinations. Perceptions of stakeholders and tourists show that changes occur spontaneously or under the influence of more global trends and problems (COVID-19, global ecological issues, questions of wellbeing and healthy lifestyle) and not as a result of state or local policy, planning and strategies. The pandemic has brought new challenges to society and ultimately restarted travel habits (Lukovic et al. 2023). New tourist demands focus on local traditional practices or ESs (e.g. wild edible plants) as part of the culinary experience (Lukovic et al. 2023). Some global discussions (e.g., Tourism Industry 4.0 2019) recognize regenerative aspects of tourism, putting local inhabitants and their quality of life at the centre, with all other stakeholders around them, hence drawing attention to and fostering indigenous traditions and bio-cultural heritage. However, this approach has not yet been incorporated into national documents.

The Tourism Development Strategy of the Republic of Serbia 2016–2025 highlighted the importance of the sustainable development of tourism, in terms of ecology and nature protection, and in terms of conserving local communities' traditional practices and cultural heritage. However, regenerative tourism itself was not considered in this strategy. In addition, the Biodiversity Strategy (Radović & Kozomara

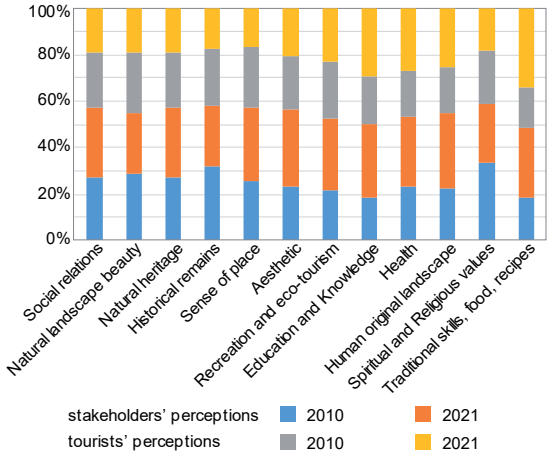



*Figure 5 – Proportions and comparison of specific sub-categories in the cutural ecosystem services category (2010–2021).*

2011) recognized tourism and recreation as risk factors for habitats. Recent development documents on agriculture (FAO 2023) highlight the importance of protecting biocultural heritage and of *getting back* to traditional roots, while the national Strategy for Agriculture and Rural Development of the Republic of Serbia for 2014–2024 (2014) recognized tourism as an opportunity for local economic diversification. Again, however, a regenerative approach was not considered. The results of this research could, and should, facilitate the inclusion of regenerative tourism in future strategic documents.

Because of the range of pressures on natural resources, sustainable management is a global challenge for various interest groups (Stosch et al. 2018). Understanding the perceptions of different stakeholder groups in relation to ESs and how they are valued can help maximize and balance the benefits for different users (Cumming et al. 2014). In our study, provisioning ESs were given the most importance, followed by cultural and regulating ESs. This finding is in line with patterns found in other studies (Dang et al. 2021). According to Schirpke et al. (2020), a tendency to a healthy diet correlates with an importance given to provisioning ESs. Such a tendency implies that the tourist-driven demand for animal-based products (milk and dairy products, meats, eggs) will be reduced, so that arable crops will be diverted from the livestock sector to direct human consumption. It is interesting to note that education finds its place in future perspectives, both as a cultural ES itself, and in the need to educate people about the roles of ecosystems,and about natural and ecological principles (Gould et al. 2018).

Our study site, the Golija-Studenica BR, is one of the most biodiverse mountainous areas in Serbia. The region saw rapid tourism growth several years ago, causing tension between natural resource conservation and economic stability. Recent studies conducted in this region (e.g. Luković et al. 2021; Milićević et al. 2021) highlight potential natural resources, such as wild edible plants, as part of the touristic offer and among tourists' motives and sources of satisfaction with the destination. The results of our study show the direction in which tourism should be developed in this area, which is in accordance with previous studies that stress nature conservation, authenticity, tradition and natural products. Organic livestock production involving the conservation of traditional pastures and meadows was recognized more than a decade ago as a development option for Golija-Studenica BR (Arsić et al. 2010). Our results show a similar interest on the part of local stakeholders. The main drivers of changes (biodiversity, socio-cultural and economic development, and management) in Golija-Studenica BR indicate that responsible tourism may contribute to repopulation, economic diversification and nature protection (Pantić et al. 2021).

## From sustainable to regenerative tourism

Although Pantić et al. (2021) state the need for planning documents to be updated in line with recent developments, regenerative tourism is still not usually considered. Regenerative tourism, however, could play an important role in the ESs framework and be a powerful tool for understanding the relationship between nature and society (Pueyo-Ros 2018).

Over the past few years, the focus of sustainable tourism changed from balancing social, economic and environmental aspects to regenerating ways of thinking, and of rebuilding and renewing the local community through the use of the natural and cultural heritage (Roblek et al. 2021). Regenerative tourism, however, goes a step further. Rather than focusing on the potential negative effects of tourism, this new type of tourism aims to transform and improve socio-ecological systems where tourist activities occur (Hes & Coenen 2018). The interest in regenerative tourism flourished during the Covid-19 pandemic, satisfying the primary needs of communities and new tourist demands, while contributing to the quality of life of local people (Hutchins & Storm 2019).

The difficulties of establishing regenerative tourism are for both sides, local stakeholders and tourists alike. All must be aware of the need to share responsibility. The challenges that they face are related to achieving memorable, authentic and transformative experiences, the development of creative solutions for locals' and tourists' needs, local innovation through reviving tradition, culture and natural resources, and empowering local people to get back to their roots (Fountain 2021; Major & Clarke 2021). The results of this study show that latent changes in perceptions of crucial ESs (e.g., Provisioning ES – a move towards what is wild and natural; Cultural ES – greater focus on tradition and education) drive the transformation from conventional through sustainable to regenerative tourism.

## Conclusion

The shift towards regenerative tourism, wellbeing and equity was accelerated by the Covid-19 crisis. But serious challenges remain for the future. This paper has outlined spontaneous and latent changes from *sustainable* to *regenerative*, based on perceptions of ESs provided by tourists and local stakeholders from 2010 to 2021. The research confirms, on a small scale, a rethinking that was born ten years ago based on the principles of UNESCO's MAB programme – a movement towards combining community with tradition, culture, and ecosystem goods and services for wellbeing. As well as a great paucity of research in the area of regenerative tourism, there are still no strategic documents in the Republic of Serbia that incorporate it, even though European documents recognize the approach in different fields (e.g., agriculture, tourism, cultural heritage). Furthermore, the research results suggest the importance for everyone (tourists and local communities alike) of being conscious of ESs and the uses to which they are being put, and especially of traditional, ethno-ecological, knowledge and skills rooted in indigenous practices. Nature-based tourism implemented in a regenerative manner can produce a win-win conservation effect, for local communities and ecosystems.

Stakeholders in regenerative tourism collaborate by sharing roles, responsibilities, knowledge, tasks and resources. Through adopting a new paradigm, regenerative tourism seeks to transform tourism, seeing it as a network of living systems that facilitate encounters, create connections, and develop mutually beneficial relationships, through travel and experiences. Regeneration occurs mentally, physically, emotionally, spiritually, culturally, socially, environmentally and economically – a transformational process that helps tourism stakeholders in working towards regenerative futures.

Future regenerative tourism research should explore connections with existing concepts in tourism, such as tourism area life-cycle, carrying capacity, stakeholder inclusion and co-creation. The limitations of this study are related to the lack of previous theoretical and empirical knowledge about regenerative tourism and of consolidated methodological approaches that would allow results to be compared. The methodology and data-gathering process, as in many other empirical studies, have certain weaknesses, especially concerning the representativeness of the sample.

Applying and testing the proposed research model could be the basis of future research across locations, not just mountainous regions, and for planning, strategy and development documents.

## Acknowledgement

This research is supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia with the decision on the transfer of funds to finance the scientific research work of teaching staff at faculties in 2024, No. 451-03-65/2024-03 of 26 January 2024.

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eco.mont – Volume 16, Number 2, July 2024
ISSN 2073-106X print version – ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont
https://doi.org/10.1553/eco.mont-16-2s16

# Developing a data-driven approach to *climate-proof* a regional spatial planning instrument: the Bavarian *Alpenplan*

*Constantin Meyer & Hubert Job*

*Keywords: climate change adaptation, spatial planning, natural hazards, open space, nature-based solutions, green infrastructure*

## Abstract

This article develops a data-driven methodological analysis for the enhancement of a regional spatial planning instrument, the Alpenplan in the German federal state of Bavaria, regarding adaptation to climate change and the prevention of natural hazards. The approach considers six criteria related to climate risk: water retention potential of soils, extreme flood risk, forests for protection of soil and against avalanches, avalanche risk, landslide susceptibility, and climatic compensation areas. We computed a GIS-based overlay analysis for the Bavarian Alps to determine multifunctional areas of exceptional importance for future-proofing against climate change. It is recommended that their protection level should be upgraded to Alpenplan Zone C. As a Nature-based Solution for climate change adaptation, the recommendations are discussed in the context of spatial planning in the Alps more widely and in other mountain areas.

## Introduction

Climate change is progressing dynamically in the European Alps and will result in far-reaching changes under all possible development scenarios (Kotlarski et al. 2023). In addition to essential climate protection measures, forward-looking adaptation to climate change must be implemented, as incorporated in international agreements such as the Alpine Convention's Climate Target System (PSAC 2019) and Climate Action Plan 2.0 (PSAC). Among other things, these documents address the role of spatial planning in climate-resilient territorial development. We argue that it is not necessarily, or only, a matter of creating new planning instruments: long-established ones also need to be upgraded.

In the German federal state of Bavaria, a unique spatial planning instrument has been in place for more than 50 years, the Bavarian *Alpenplan*, which relates in numerous ways to challenges for Alpine territorial development in the face of climate change. The question arises of the contribution that the *Alpenplan*, as a regional spatial planning instrument, can make to the roadmap for climate-neutral and climate-resilient European Alps to be achieved by 2050 (PSAC 2019). The current Bavarian Climate Report 2021 (StMUV 2021) confirms that, particularly in the Alpine region, snowmelt, prolonged precipitation, and an increasing risk of heavy rainfall will raise the likelihood of climate-related hazards, such as landslides and debris flows. The report emphasizes that the best adaptation option for planning settlements and infrastructure is to avoid vulnerable areas.

The *Alpenplan* and its impact have been addressed quite extensively in the German scientific literature (Karl 1968, 1969; Hensel 1987; Goppel 2003, 2012; Speer 2008; Job et al. 2013, 2014, 2022a, 2022b; Roth 2014; Mayer et al. 2016/17; Hasslacher et al. 2018; Lintzmeyer 2018), but it is remarkable that to date there is only one peer-reviewed journal article in English on the subject (Barker 1982). Against the backdrop of rapid climate change in the European Alps (Pröbstl-Haider & Pütz 2016), which has become very visible with recent intense flooding (e.g. in Slovenia in summer 2023), and diminishing open spaces (Job et al. 2022), here we make an English-language plea for an adapted *Alpenplan*. The safeguarding of open space is a topic of concern in the entire region of the Alps which must be taken seriously and depends on increased cross-border spatial planning cooperation and harmonization (Hasslacher et al. 2018; ARL 2022) – also in other high mountain areas worldwide (cf. Lama & Job 2014).

The aim of this paper is to help bring about an amendment of the *Alpenplan*, since ongoing climate change requires this long-established planning instrument to be *climate-proofed* (Calliari et al. 2019; Juschten et al. 2021). We propose an expansion of *Alpenplan* Zone C (the quiet zone – see Infobox) because of the increased risks of natural hazards caused by intensifying climate change in the European Alps (Schindelegger, 2019). For climate change adaptation purposes, the existing *Alpenplan* would be updated with spatial data, and we argue for the consideration of six climate-risk related criteria for pro-active natural hazard protection: water retention potential of soils, extreme flood risk, soil and avalanche protection forests, avalanche risk, landslide susceptibility, and climatic compensation areas. GIS-computed thematic maps were drawn based on hydro-geographical landscape units of the Bavarian Alps and these six criteria.

## Study area and subject

The Bavarian Alps are located in the very south of Germany and border on the three Austrian federal states of Vorarlberg, Tyrol and Salzburg. The Bavarian Alps are a dynamic region that is subject to strong in-

fluences from nearby agglomerations outside the Alps (e.g. Munich, Augsburg or Salzburg). The population benefits economically from the flow of day visitors and overnight guests, as well as from the job opportunities in the Alpine Foreland located within acceptable commuting distances. This economically viable basis also favours the preservation of large parts of the traditional Alpine cultural landscape, despite ongoing changes in agricultural practices and land use (Mayer & Job 2014).

The perimeter of the *Alpenplan* provides an official delimitation of the Bavarian Alps, with a total area of 4,393.3 km² (excluding lakes). The area comprises 104 municipal territories with a total of around 526,000 inhabitants, representing a population density of 97 inhabitants / km² (data from LfStat 2022). This population density is low compared to the Bavarian and German averages (187 and 233 inhabitants / km² respectively) (Statistische Ämter des Bundes und der Länder 2022). However, in the context of the Alps as a whole, the Bavarian Alps represent a relatively densely populated area. This is also reflected in the extent of the area's infrastructure and settlement development, as shown by Job et al. (2022).

The *Alpenplan* perimeter is not congruent with the Alpine Convention perimeter, which is greater, covering a larger area in Bavaria / Germany while also including parts of the Alpine Foreland. The Alpine Convention perimeter is, however, congruent with the 13 southernmost Bavarian districts (*Landkreise* or *Kreisfreie Städte*), from Lindau (Bodensee) in the west to Berchtesgadener Land in the east. Of these 13 districts, official German regional statistics (BBSR 2023) classify six as *sparsely populated, rural districts*, four as *rural districts with agglomeration trends* and three as *urban districts*.

But how and why was the *Alpenplan* adopted? From the late 1950s onwards, the number of ski areas in the Bavarian Alps rose very quickly, which was massively criticized by environmentalists and the German Alpine Club (DAV). In response, and in part because of the absence of data at that time, Dr. Helmut Karl of the Bavarian State Agency for Nature Conservation presented a large-scale plan of the Bavarian Alps, based on his own cartographic fieldwork and aerial photographs (Karl 1968). In this plan, he differentiated three zones, according to the degree of infrastructure development that already existed. Underlying parameters for the designations included the landscape ecology and the potential danger from natural hazards. Recognizing that individual assessments could not protect the Bavarian Alps from the rapid expansion of mass tourism infrastructure, the basic idea of the *Alpenplan* was to coordinate transport infrastructure spatially as a key function for territorial development (Karl 1969; Job et al. 2013). Based on Karl's draft, the *Alpenplan* came into force in 1972 as a sub-section, *Recreational Landscape Alps*, of the Bavarian State Development Programme (*Landesentwicklungsprogramm*, LEP) (Speer 2008).



*Figure 1 – Example of a near-natural landscape in Zone C: view, from the south, of lake Königssee and its surroundings, in Berchtesgaden National Park. © Meyer 2021*



*Figure 2 – Example of a fairly densely populated peri-alpine area in Zones A and B: view, from the south, of lake Tegernsee and its surroundings. © Meyer 2019*

The zoning of the Bavarian Alps according to three intensity levels of transport infrastructure was a far-sighted innovation, especially in relation to its Zone C (the least developed zone), for at the time both environmental protection policies and orientation towards landscape-based recreation were in their infancy (Goppel 2003). Karl's innovative work eventually helped to enhance the field of nature conservation and formal systems of protected areas (Bender et al. 2017; Hedden-Dunkhorst 2017). As the *Alpenplan* is part of the LEP, and as stated by the Bavarian State Planning Act (BayLplG Art. 3), the *Alpenplan's* objectives in spatially significant plans and projects (e.g. as concerning municipal land use) are legally binding and must be followed by all public bodies concerned (Job et al. 2017). According to Goppel (2012), the long-standing reliability of the *Alpenplan*, and the fact that its spatial scope has hardly changed over the years, is mainly due to its clear geographical delimitation, the forward-looking steering concept, and the unambiguous and legally binding nature of it as a spatial planning instrument. It has prevented the Bavarian Alps

from over-development for tourism purposes and, at the same time, has considerably extended the protection of ecologically sensitive areas, but without preventing tourism from being economically important in the region (Job & Metzler 2005; Job et al. 2014; Mayer & Steiger 2013).

The zoning structure of the *Alpenplan* has been largely constant ever since 1972, although in the LEP 2019 / 2020, the share of Zone C grew slightly because of the reintegration of the Riedberger Horn with two neighbouring peaks in the Oberallgäu region. Based on a political decision to allow the construction of new ski lifts, the area around Riedberger Horn was initially excluded from Zone C in early 2018, and the inclusion of the other two peaks was meant as political compensation. Following the formation of a new Bavarian federal state government in 2018, this political decision was revoked in 2019, but the two *compensatory* peaks remained in the restored *Alpenplan* Zone C. An enlargement of Zone C had happened once before, when minor adjustments were made following the severe avalanche winter of 1998 / 1999: in the LEP of 2003, 12 small areas were incorporated into Zone C (Job & Meyer 2022b).

The *Alpenplan* is the instrument with the greatest continuity in the Bavarian State Development Programme (LEP). Job et al. (2017) documented the effective impact of Zone C by showcasing how the *Alpenplan* status, among other factors, resulted in 19 unrealized (ski) tourism projects (and the development of the infrastructure that would have been necessary) in sensitive areas. Moreover, the system of officially protected areas (comprising protected area categories such as e. g. national park or nature reserves) overlaps with the *Alpenplan*. Although it is not a sectoral instrument for nature conservation per se, it has considerable influence on open spaces in the Bavarian Alps. In fact, the *Alpenplan* provides an additional 15.2% of open spaces – that is, areas that are protected only by their Zone C status and not by official protected area designations (Job et al. 2014).

## Conceptual background

The proposed approach for the enhancement of the *Alpenplan* in the face of climate change is linked to two central concepts discussed in the literature: the integration of Nature-based Solutions in planning and the consideration of multiple (overlapping) spatial functions of Green Infrastructure (GI multifunctionality). According to Cohen-Shacham et al. (2019), Nature-based Solutions complement existing (conservation / planning) principles by being more extensive and ambitious with regard to social and economic challenges. They go beyond conservation, acting as tool for environmental considerations to become mainstream in policy and practice (Cohen-Shacham et al. 2019: 26). They are thus becoming increasingly important in the context of climate change adaptation (Lafortezza et al. 2018) by increasing the adaptive capacities of spatial planning (Kruse & Pütz 2014). Technical protection measures are often poor solutions as stand-alone measures to reduce disaster risk, because they may be limited by material wear and tear, constraints on financial resources, or aesthetic values. Protective forests in particular, then, are considered key elements in integrated risk management strategies, such as efficient Forest-based Solutions for Ecosystem-based Disaster Risk Reduction (Teich et al. 2022: 1). This is especially true when the planning applies to large areas, as in the present case, which covers the entire Bavarian Alps.

Multifunctionality is a central feature to be considered in spatial planning for open spaces and GI, combining different planning principles for safeguarding unbuilt areas (Meyer et al. 2022). In the literature, there is a growing interest in the development of specific tools for determining multifunctional GI elements, including ecosystem services as well as their connections in regional GI networks (see e. g. Goodspeed et al. 2022; Arcidiacono et al. 2016; Wang et al. 2021; Simion et al. 2023). Multifunctional GI needs to be defined very clearly if it is to be exploited effectively as a tool for delivering climate change adaptation (Sussams et al. 2015). This article therefore builds on six clearly definable input criteria in the field of climate change adaptation and prevention of natural hazards to determine those areas in the Bavarian Alps with a high level of GI multifunctionality and exposure to climate risk. These areas could then become intervention priorities for spatial planning in order to enhance the region's climate resilience.

As the approach to adapting the *Alpenplan* presented here does not dispute the plan's conceptual logic but merely the spatial distribution of zones, this can still be referred to as a form of Euclidian Zoning. There is no transnationally established definition of zoning, but the terms Euclidean or Exclusionary Zoning[1] are frequently used in an English-speaking context to conceptualize the spatial separation of land use types. Zoning represents a long-standing, widely-used concept (Bäing & Webb 2020), which nowadays can be challenged from various perspectives, especially in urban planning studies (see e. g. Hall 2006). Although criticized as a *top-down* planning approach, zoning should not be discarded as an outdated *relic*. This is demonstrated by the continuous and widespread societal and political appreciation of the *Alpenplan* in Bavaria, across most political parties and administrations, and by many NGOs.

## Methods

Since this research article is intended to provide concrete advice for Bavarian spatial planning policy,

[1] See https://www.planetizen.com/definition/euclidean-zoning (15.11.2023)

the specific climate risks identified in the official Bavarian Climate Report (StMUV 2021) were taken as a starting point. These include landslides, slope breaks, floods, avalanches and heat events. Since an area-based analysis was aimed for, the entire official geodata base available from public authorities in Bavaria[2] was first examined for suitable datasets. A dataset was selected as an input criterion if it was available for the entire study area, *and* represents either (a) areas of climate-related (natural) risks that may increase in frequency or spatial extent as a result of climate change, or (b) area-based functions of Green Infrastructure that contribute to the prevention or mitigation of climate-related (natural) risks.

The logic of the proposal is characterized by the *Alpenplan* concept of deliberately keeping endangered areas free of (further) development, as well as including areas with protective functions (e.g., forest for protection of soil or against avalanches). Both types of area need to be safeguarded by regional spatial planning designations in order to increase the resilience of Alpine territories.

After the initial selection of the input criteria, their relevance for climate change adaptation and natural hazard prevention was validated using scientific literature in the fields of slope stability (Chiarle et al. 2021; Wood et al. 2015; Gariano & Guzzetti 2016), protective forests (Teich et al. 2022; Lingua et al. 2020), soil functions and flood retention (Schmidt et al. 2001; Markart et al. 2021; Vrščaj 2019), avalanches (Strapazzon et al. 2021; Zgheib et al. 2022), as well as cold air flows from open spaces into settlements (Sung et al. 2021).

The workflow for the analysis is summarized in Figure 3, with Table 1 providing a detailed overview of the input datasets used, with references and details on the selected sub-features of shapefiles. The workflow is composed of two methodological strands, which are then combined: an overlay analysis of the selected input criteria and the delimitation of Analytical Landscape Units (ALU). All analytical steps were conducted in ArcGIS Pro 3.1.1 using arcpy geoprocessing modules and functions. All area-based calculations were conducted in ETRS89 / UTM zone 32N (EPSG:25832), to comply with the uniform spatial reference system for the use of geodata in Germany and Europe.

A total of 4,544 ALUs (see Figure 4a) were produced by intersecting the existing *Alpenplan* Zones with the EU-Hydro hydrological basins (to include the topographic landscape structure) and removing a selection of features from the Digital Landscape Model (ATKIS-Basis DLM), as shown in Figure 3 and Table 1. These excluded features comprised a selection of settlement areas (≥ 1 ha), roads, major farm or forest tracks, railways and water bodies. For all line features representing transport infrastructure, the buffering methodology from IÖR-Monitor[3] was applied (and buffer sizes were then doubled) to generate polygon features that are excluded from ALUs. For water bodies, only major features presented as polygons in ATKIS-Basis DLM were considered. Since the current Zone C of the *Alpenplan* is not the focus of the analytical approach of this article (but rather the potential upgrading of certain areas to Zone C), Zone C areas were also removed from the ALUs. Due to the different extents of the cartographic generalization of the features that are included or excluded, topological errors can occur at the margins of features. These had to be cleared up by excluding small *sliver* polygons of less than 1 ha from the ALUs generated.

[2] Geoportal Bayern: https://geoportal.bayern.de/geoportalbayern/seiten/dienste (17.08.2023)

[3] The operators of the IOER-Monitor developed a methodology to transform linear objects from the ATKIS Basis-DLM into polygons by assigning differentiated buffer sizes according to the different tabular attributes of the line features (IÖR 2023).

## Infobox

**Objective, functionality and impact of the Alpenplan**

The Alpenplan is based on the idea that transport infrastructure development plays a key role in overall territorial development because of its indirect effects on settlement and tourism development (Meyer et al. 2021). The Alpenplan regulates the development of infrastructure projects in the Bavarian Alps such as ski lifts and cable cars (in so far as they serve public transport), ski and toboggan runs, public and private roads and trails (with the exception of hiking trails), and airfields. Without easy access (e.g. roads, car parks, cable cars), classical tourism tends to be of low intensity in mountain areas (Schamel & Job 2017). The Alpenplan creates an area-wide and fundamental solution that is not dependent on individual case decisions; furthermore, it takes into account the various demands of tourism, the local economy and nature conservation in equal measure (Job et al. 2017). The main mechanism of the Alpenplan is the zoning of the Bavarian Alps as a whole (4,393.3 km² excluding lakes, affecting 104 municipal territories), based on how land is used, how sensitive the Alpine environment is, and what development might be suitable in the future. The zoning comprises:

- Zone A or *development zone* (35 % of the Bavarian Alps), which includes all large settlements and most areas with existing intensive land use in the valley areas.
- Zone B or *buffer zone* (22%), where projects are allowed only after detailed examination and on condition that they do not conflict with priority spatial planning requirements (especially nature conservation).
- Zone C or *quiet zone* (43%), which is designed as a generally protected zone: all transport infrastructure projects (except tracks necessary for traditional agriculture and forestry) are explicitly prohibited. Implicitly, therefore, only non-intensive, landscape-based recreational uses are permitted. Forest tracks and dirt roads for the management of traditional cultural landscapes (e.g., to reach Alpine pastures) are the only infrastructures allowed (Mayer et al. 2016/17).

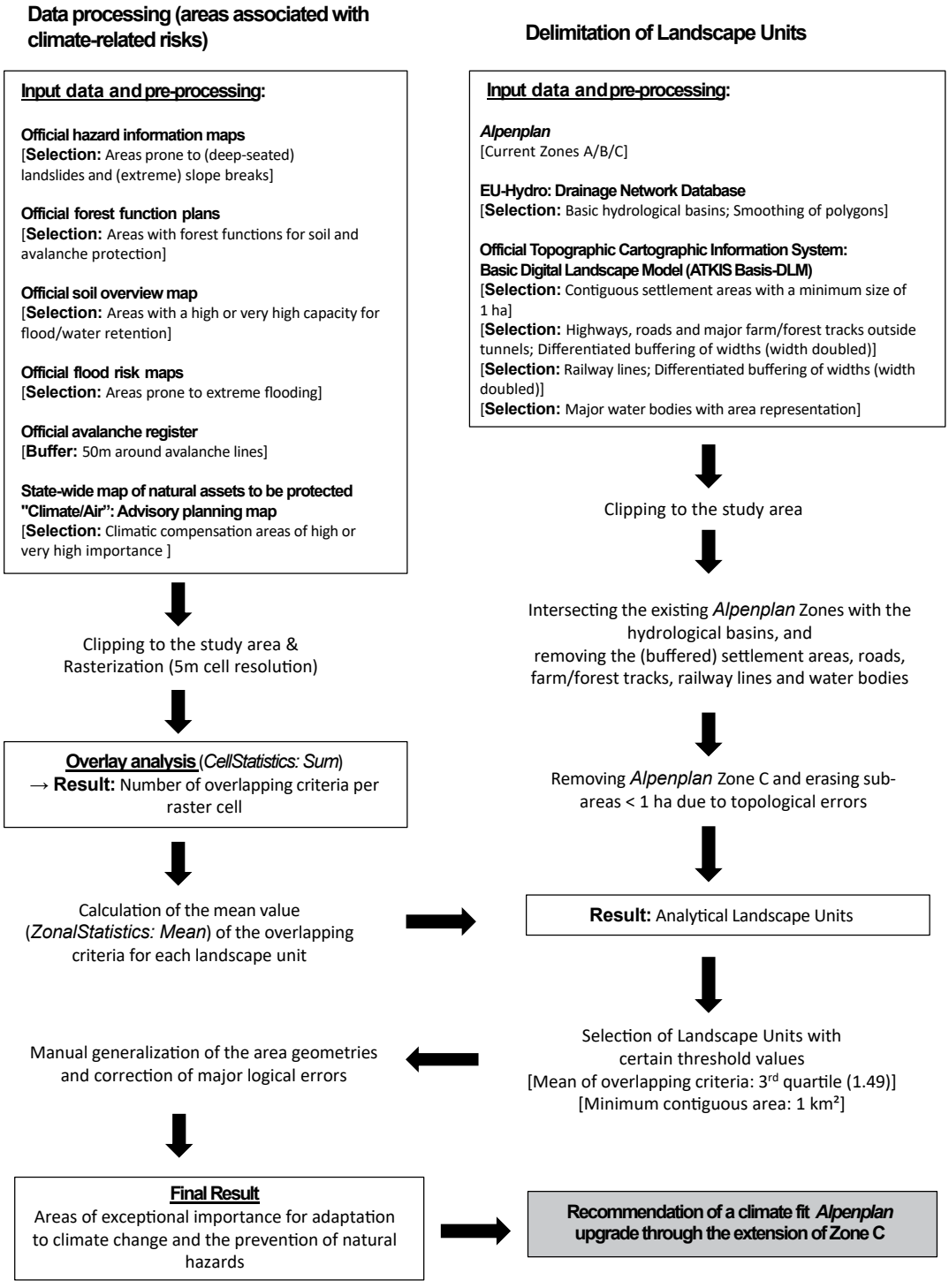



*Figure 3 – Analysis workflow. Source: Authors' figure*

For the overlay analysis, relevant components of the source datasets were first selected (e.g. areas prone to (deep-seated) landslides and (extreme) slope breaks), or buffered (50 m buffer around officially documented avalanche lines). The vector shapefiles were then converted into raster datasets with 5 m-cell resolution for analysis and cropped to the study area (see Figure 5 for the six data sets). Figure 4b shows the intermediary results of the overlay analysis – i.e., the number of overlapping input criteria per raster cell, where a maximum value of 5 and a mean value of 1.31 was observed throughout the 178,130,777 raster cells for the total study area. The overlay analysis was created using the Cell Statistics (Spatial Analyst) tool, returning the *sum* value on the location of each raster cell. The *mean* value was then identified for each ALU, using the Zonal Statistics (Spatial Analyst) tool.

Subsequently a selection of ALUs with certain threshold values had to be made, taking into account the mean of overlapping criteria and the minimum

*Table 1 – Overview of the data sources.*

| dataset | last updated | source | selection | used for | comments on processing |
|---|---|---|---|---|---|
| *Alpenplan* Zones A/B/C | 2019 | *Bayerisches Staatsministerium für Wirtschaft, Landesentwicklung und Energie* | All three layers selected | Delimitation of ALUs | - |
| EU-Hydro – River Network Database | 2020 (version 1.3) | European Environment Agency (EEA) under the framework of the Copernicus programme | Basic hydrological basins for Danube watershed | Delimitation of ALUs | Smoothing of polygon borders for vector processing |
| Official Topographic Cartographic Information System: Basic Digital Landscape Model (ATKIS Basis DLM) | 2023 | *Bayerische Vermessungsverwaltung/ Landesamt für Digitalisierung, Breitband und Vermessung* (open data) | sie02_f.shp (>= 1 ha)<br>gew01_f.shp<br>ver01_l.shp<br>ver02_l .shp ("OBJART_TXT = 'AX_Fahrwegachse' And FKT = '5211'")<br>ver03_l.shp ("OBJART_TXT = 'AX_Bahnstrecke'")<br>ver06_l.shp ("BWF = '1870'") | Delimitation of ALUs | Differentiated buffering of ATKIS Basis-DLM line features, as proposed by IÖR-Monitor (IÖR 2023); doubling of the buffer size for this analysis; extracting tunnels from line features |
| Official hazard information maps (*Amtliche Gefahrenhinweiskarten*) | 2014 | *Bayerisches Landesamt für Umwelt* | GHK_tief_rutsch.shp<br>GHK_rutschanf.shp<br>GHK_hang_extrem.shp<br>GHK_hang.shp | Input criterion: Official hazard information maps | Merging of selected hazard areas |
| Official forest function plans (*Amtliche Waldfunktionskartierung*) | 2021 | *Bayerische Landesanstalt für Wald und Forstwirtschaft* | Bodenschutzwald.shp<br>Lawinenschutzwald.shp | Input criterion: Official forest function plans | Merging of selected forest functions |
| Official avalanche register (Lawinenkataster) | 2020 | *Bayerisches Landesamt für Umwelt* | lawinenstriche_epsg25832.shp | Input criterion: Official avalanche register | 50m buffer around avalanche lines |
| State-wide map of natural assets to be protected *Climate/Air*: Advisory planning map (*Landesweite Schutzgutkarte* Klima/Luft: *Planungshinweiskarte*) | 2021 | *Bayerisches Landesamt für Umwelt* | Ausgleichsraum_r10.shp ("KL_AR_2 = 1 or KL_AR_2 = 2") | Input criterion: State-wide map of natural assets to be protected *Climate/Air*: Advisory planning map | Merging of climatic compensation areas of high and very high importance |
| Official flood risk maps - Areas prone to extreme flooding (*Hochwassergefahrenflächen HQextrem*) | 2013 | *Bayerisches Landesamt für Umwelt* | hwdfHQextrem_23_02_2023.shp | Input criterion: Official flood risk maps | - |
| Official soil overview map (*Übersichtsbodenkarte ÜBK25 – Wasserrückhaltevermögen bei Starkniederschlägen*) | 2020 | *Bayerisches Landesamt für Umwelt* | UEBK25_Wasserretention_alp.shp ("RETENTION1 ≥ 4") | Input criterion: Official soil overview map | Merging of areas with high and very high capacity for flood/water retention |

contiguous area size of the polygons. These thresholds cannot be determined on a completely objective basis: they depend to some extent on the judgement of experts. We chose to include ALUs that feature a mean value of 1.49 (representing the 3rd quartile of all ALUs) or higher. We also decided to include only ALUs with a minimum contiguous size of 1 km² as being relevant for zoning in supra-local spatial planning. Before presenting the final results, some polygon geometries were manually generalized (e.g., in proximity to settlement areas) and some logical errors (affecting the proposed future zoning of *Alpenplan* Zone C) were manually corrected. Since they are the results of a partly automated GIS-model, not all recommended extensions of Zone C comply with the current land use characteristics. To highlight these inconsistencies, potential land use conflicts generated by the proposal (e.g., Alpine ski runs, or other intensive tourism and building infrastructure) were marked on three detailed large-scale maps (see Supplementary Material No. 1–3).

## Results

The results show areas of exceptional relevance for adaptation to climate change and the prevention of natural hazards in the Bavarian Alps. These are currently inside *Alpenplan* Zones A or B, and we recommend them as an analytical starting point for an upgrade to Zone C. The areas are visualized in Figure 6, which also illustrates the current zoning structure and extent of the *Alpenplan*. Regarding their spatial distribution, it is apparent that many of these are adjacent to the existing Zone C. The total area identified for re-zoning covers 713.12 km², with individual sub-areas measuring an average of 5.19 km². The largest contiguous sub-area is a 106.30 km², near-natural landscape area between the Isarwinkel and lake Kochelsee, near the Kocheler Berge, Jachenau valley and Benediktenwand ridge. If these areas were added to Zone C, the zone would be increased by 39.4%. Zones A and B would consequently decrease by 254.10 km² (−16.3%)

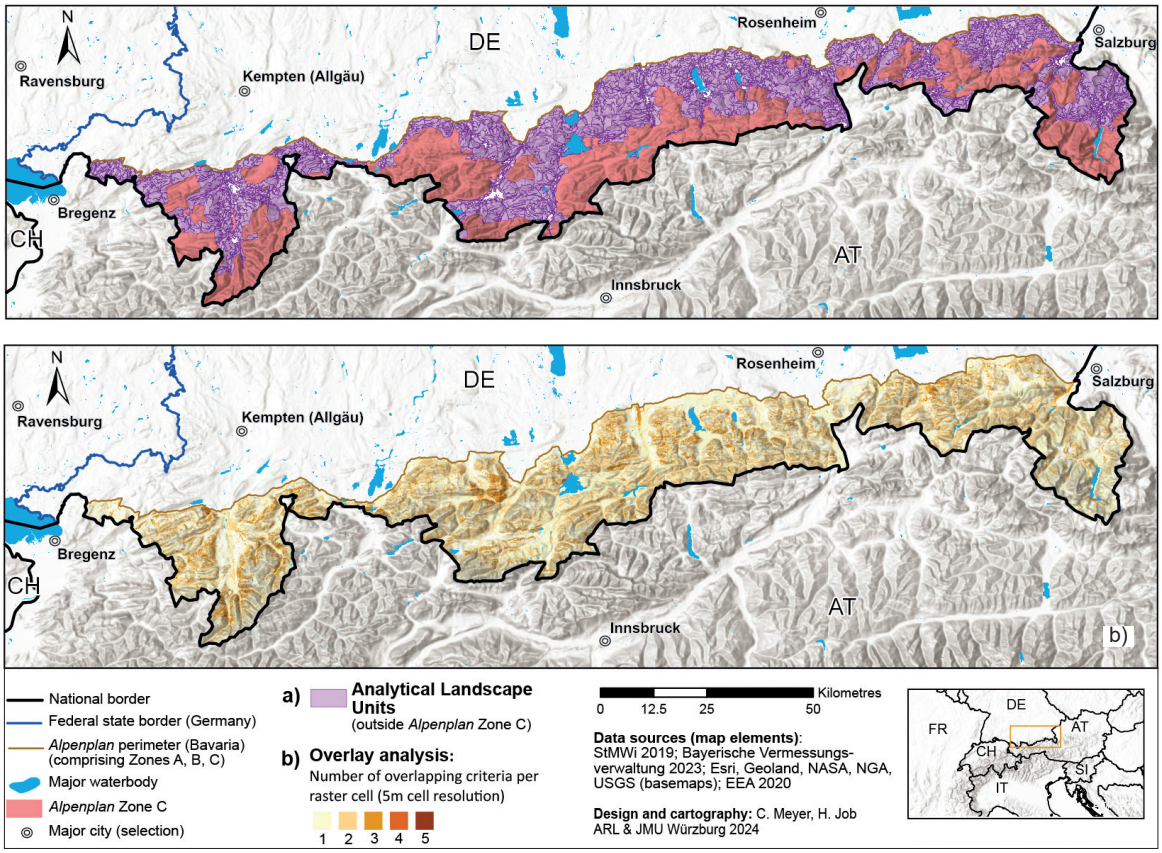



*Figure 4 – (a) Visualization of the Analytical Landscape Units (ALUs); (b) the results of the overlay analysis (the brown line shows the Alpenplan perimeter, comprising all Zones A/B/C, and outlining the northern limit of the Alpenplan). Source: Authors' figure*

and 483.01 km² (−49.6%) respectively. The new ratio between the *Alpenplan* zones would then be as follows: Zone A 29.7%, Zone B 11.1%, Zone C 59.2%.

From a nature conservation perspective, 19.2% of the areas designated for upgrading would overlap with strictly protected areas (nature conservation areas, national park, Natura 2000 areas listed under the Birds Habitats Directives), compared to a significantly higher overlap of 70.2% in the current extent of Zone C. This underlines the urgent need for additional safeguarding mechanisms by spatial planning for the designated areas. Differences in terms of elevation also exist between Zone C in its current form (mean elevation 1,388 m a.s.l.) and its potential extension areas (mean elevation 1,099 m a.s.l.).[4] This, too, is important because up to now strictly protected areas tend to be far fewer in mid-altitude areas or even Alpine valleys, thus failing to ensure ecological connectivity (ALPARC 2023).

Because of the expected land use conflicts mentioned earlier, and due to methodological limitations, not all designated areas can be included in the planning in precisely the same way. To enable a much closer examination of the identified areas, three detailed large-scale maps (scale 1:250,000) of the eastern, central and western parts of the study area are provided in the supplementary material (No. 1–3). These maps include the (manually digitized) areas at risk of erosion (*Erosionsgefährdete Bereiche*) from the original version of the *Alpenplan* (LEP 1972, available from StMLU 1980), as they are thematically related to this analysis. They overlap the current Zone C by 20.7%. Inclusion of the areas at risk of erosion recommended for upgrading to Zone C results in an even higher overlap, of 28.2%. These detailed maps are intended to provide planning stakeholders with a basis for assessment, as they cover the same map sheets as those in the official *Alpenplan*.

## Discussion

### Methodological reflections

The approach provides a data-driven and replicable method for identifying areas of high relevance for adaptation to climate risks at supra-local landscape scale. The selection of criteria and data, however, brings both advantages and disadvantages. The use of official geographic information from state authorities suggests that the results could be more widely accepted by state planning stakeholders. However, the availability of reliable geodata limits the analytical scope, because not all potentially relevant climate-related risks can be

[4] The analysis of the mean elevations was conducted using the EU-DEM v1.1 dataset at 25 m resolution (EEA 2016).

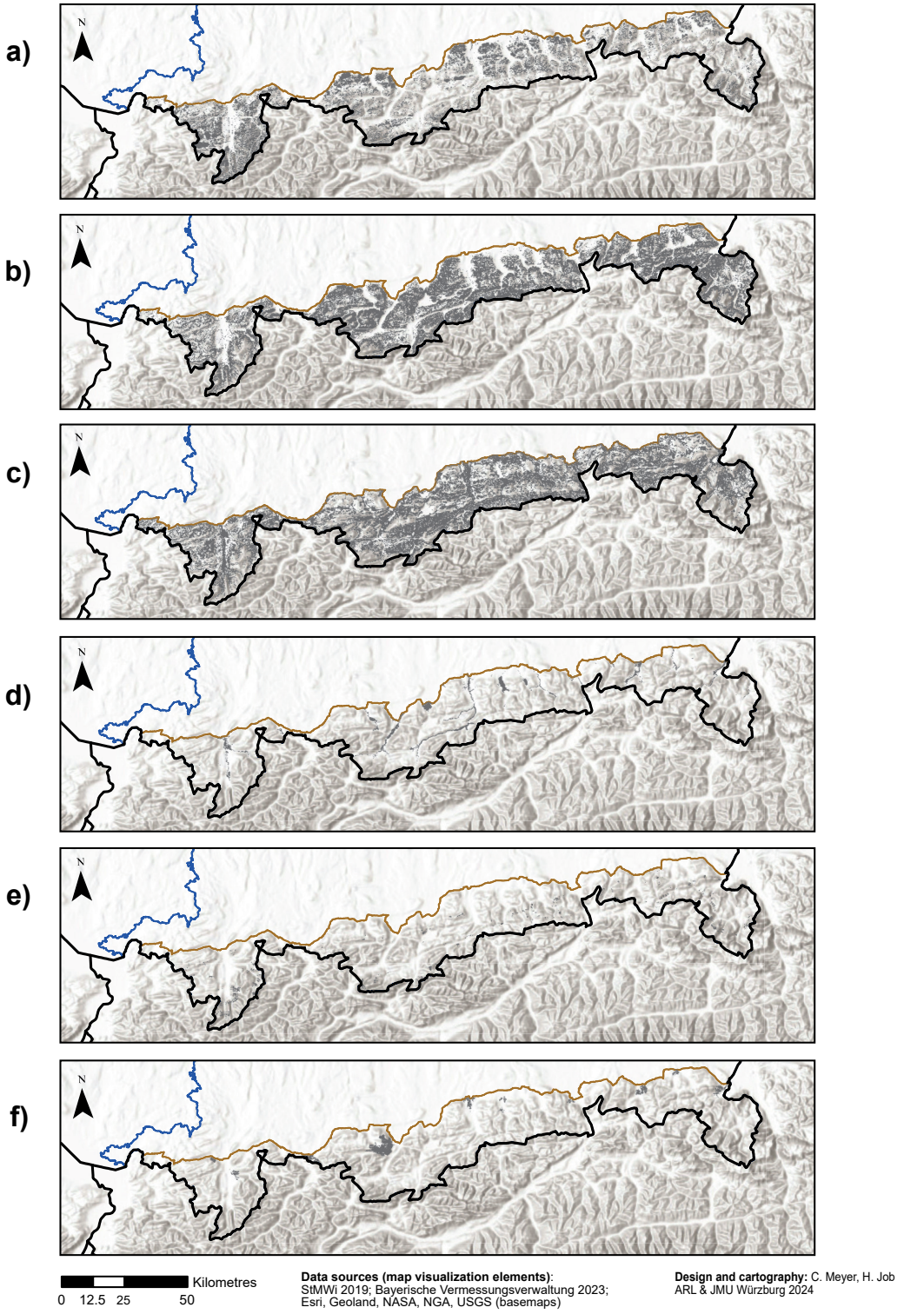



*Figure 5 – Visualization of the spatial distribution of the six input criteria (a–f) (the brown line shows the Alpenplan perimeter, comprising all Zones A/B/C, and outlining the northern limit of the Alpenplan). Source: Authors' figure*

included. For example, there is no specific geoinformation on debris flow hazards that covers the entire Bavarian Alpine region. And although information on rockfall risks is also available within the framework of the official hazard maps, this was not included. This is because climate change triggers more complex pro-

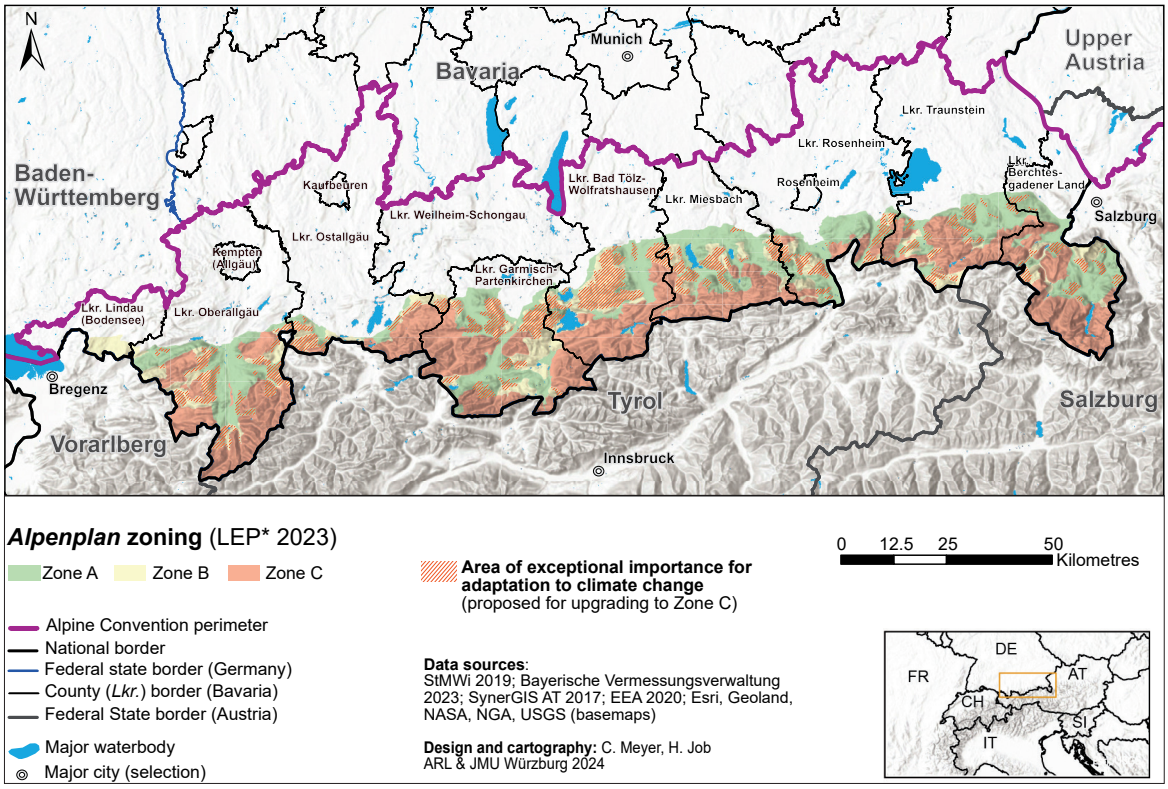



*Figure 6 – Current extent and zoning of the Alpenplan, and proposed areas for upgrading to Zone C (* LEP = Landesentwicklungsprogramm Bayern). Source: Authors' figure*

cesses and interactions through thawing of permafrost in mountain areas – a field that is currently being intensively studied by geoscientists (e.g. Viani et al. 2020; Knoflach et al. 2021) and which therefore could not be adequately considered in this article.

Where the methodological approach presented here is concerned, it should be mentioned that it shows a certain dependency on the selected threshold values regarding the area size and the average number of overlapping criteria measured in an ALU. The raster-based calculation is also influenced by the raster resolution. The 5-m resolution selected should ensure that the surface contours of the input features are preserved while keeping the calculation effort within reasonable limits. It should also be noted that the analysis, although designed with multifunctionality in mind, covers only part of the (potential) multifunctionality of open spaces – i.e., it focuses strongly on natural hazard risks. The future development of geodata-based tools to support planning could include other criteria relevant for open spaces (e.g., regarding outdoor recreation or landscape ecology) and development (settlements and infrastructure).

## Implementation in spatial planning

Due to the area's large extent (the entire Bavarian Alps) and the the lack of knowledge about how anthropogenically driven climate change will develop, uncertainty remains as a difficult framework condition for spatial planning in general (cf. Campbell 2016). With this article, we therefore propose a *no-regret* approach (Greiving 2018; Hallegatte 2009) that compensates for uncertainties and knowledge gaps by designating large areas as potentially being most affected by climate-related hazards. As a Nature-based Solution, the proposed adaptation of the *Alpenplan* is also a cost-effective alternative to the construction of technical structures for the protection of settlements and infrastructure. At the same time, this approach preserves the unique cultural landscape. Moreover, the approach would include in Zone C areas that are lower in elevation than the current average for the zone. This is relevant because in the European Alps most near-natural open spaces are found at higher altitudes (above 1,500 m a.s.l.) (Job et al. 2022), representing a severe weakness of Alpine GI networks.

The overlap of only 19.2% of the areas identified for intervention with strictly protected areas (nature conservation areas, national park, Natura 2000 areas listed under the Birds and Habitats Directives) suggests that the recommended adaptation would not create spatial redundancies with the existing system of protected areas in the Bavarian Alps. The different regulatory status of the *Alpenplan* (which concerns transport infrastructure and thus building development) and of protected areas (with an influence on land use and habitat protection for particular species) should again be pointed out. The *Alpenplan* specifically addresses the exposure of buildings and technical infrastructure to natural hazards. This is particularly relevant in view

of the fact that the official information maps for risks of slope failure in Bavaria / Germany (LfU 2020), in contrast to many other Alpine regions (Schindelegger 2019), do not have a binding effect. They merely have to be taken into account and weighed up in the land-use planning process of municipalities, therefore creating a rather weak institutional context for adaptation to increasing climate-related hazards.

That Bavaria can learn from other Alpine regions is also evident in the availability of spatially precise geodata that is relevant to planning. Here, for example, it is worth looking at the neighbouring Austrian federal state of Salzburg, where a comprehensive area-wide soil function assessment is available, with the sub-functions of habitat, site function, soil fertility, runoff regulation and filter function (Land Salzburg, Abteilung Lebensgrundlagen und Energie 2014). Comparing spatial planning approaches across the entire European Alps, Kruse & Pütz (2014) suggest enhancing adaptive capacities by improving the knowledge base for spatial planning, and by making climate adaptation mainstream within the entire institutional framework. Schindelegger et al. (2022) have shown that many Alpine regions have made important first steps towards climate-resilient spatial planning, but major implementation gaps still persist. Their transnational research shows that Alpine regions and municipalities are increasingly using existing planning instruments to safeguard climate services and to adapt urban development in order to deal with the impacts of climate change.

## Conclusion

We argue for the significant expansion of Zone C, to almost 60% of the area covered by the *Alpenplan* (current share of Zone C: 43%). While the GIS data-driven, evidence-based approach presented here could provide an important technical impetus, it cannot replace a formal planning process. Spatial planning needs to define the designated areas precisely, taking into account current land use and settlement structure in more detail. Municipalities' exisiting major planning provisions should also be taken into consideration, in accordance with the Mutual Feedback Principle (*Gegenstromprinzip*) anchored in the German spatial planning system, which promotes vertical cooperation and coordination between the different planning levels (Kümper 2018). This is particularly relevant, because municipalities can be expected to voice some degree of opposition to strict planning provisions that come from the supra-local level and limit their own planning decisions and development options. At the same time, securing public acceptance at municipal level is necessary for the future development of the *Alpenplan*. The fact that the topic of climate adaptation is already gaining importance in Bavarian state and regional planning is also shown by the introduction of priority and reserved areas (*Vorrang- und Vorbehaltsgebiete*) for adaptation to climate change in the latest version of the State Development Programme (LEP; Bayerische Staatsregierung 2023). But, since these areas were only introduced as an optional instrument, it is questionable whether corresponding plans will be implemented in all 18 Bavarian planning regions. In the three planning regions covering Alpine areas, however, their implementation will be of particular importance.

Adjustments to the zoning in LEP 2003 due to damaging avalanche events in 1998/1999 led to a small-scale update of the *Alpenplan*. In contrast to this *reactive* measure, the proposed approach represents large-scale *proactive* adaptation – in the sense of a *no-regret* strategy. In the course of *adaptive spatial governance* (Birkmann et al. 2012), it is important to weigh up the relative importance of possible incremental or long-term strategic approaches to updating spatial planning instruments. Due to its large-scale and long-term orientation, the *Alpenplan* is certainly a special case: our arguments cannot necessarily be applied to regional and municipal planning issues everywhere. Through climate-resilient enhancement and by taking into account multifunctional Green Infrastructure and emphasizing the importance of Nature-based Solutions that also support Nature-based climate protection measures, the *Alpenplan* could take on a pioneering role for future-oriented Alpine territorial development.

Other desiderata regarding the overall Alpine arc and other mountain areas of Europe and on a global scale include, firstly, establishing a standardized management system for open spaces in mountain regions at (trans-)national, regional and local scales. Secondly, deriving *Alpenplan* Zone C-like designated areas and pro-actively safeguarding them and their ecosystem services, especially soil functions. This should include climate-resilient planning specifications as well as defining more strictly protected areas, specifically in the mid-altitude areas and valleys (under 1,000 m a.s.l. – ALPARC 2023), in order to implement the recently set 30 x 30 goal of the Convention on Biological Diversity, which will also require the consistent integration of *other effective area-based conservation measures* in spatial planning (Cook 2024).

## Acknowledgements

We would like to thank the ARL (Academy for Territorial Development in the Leibniz Association) for the continuous financial and logistical support of our research in the Alpine region since 2011, as well as the support of *AlpPlan*, the alpine spatial planning network.

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## Supplementary material

No. 1 – https://dx.doi.org/10.1553/eco.mont-16-2S1
Detailed large-scale map (1:150.000) – western part (1/3)
No. 2 – https://dx.doi.org/10.1553/eco.mont-16-2S2
Detailed large-scale map (1:150.000) – central part (2/3)
No. 3 – https://dx.doi.org/10.1553/eco.mont-16-2S3
Detailed large-scale map (1:150.000) – eastern part (3/3)

* LEP = Landesentwicklungsprogramm Bayern 2023 / Bavarian State Development Programme, 2023 edition

** LEP 1972 = Urfassung Landesentwicklungsprogramm Bayern 1972 / Original edition of the Bavarian State Development Programme, 2023) (available from StMLU 1980)

*** Area within the *Alpenplan* perimeter strictly protected by nature conservation (Bavaria): nature conservation areas, national park, Natura 2000 areas listed under the Birds Directive and the Habitats Directive / Naturschutzfachlich streng geschützte Fläche innerhalb der Alpenplan Abgrenzung (Bayern): Naturschutzgebiete, Nationalpark, Natura 2000 Gebiete (FFH-, Vogelschutzgebiete)

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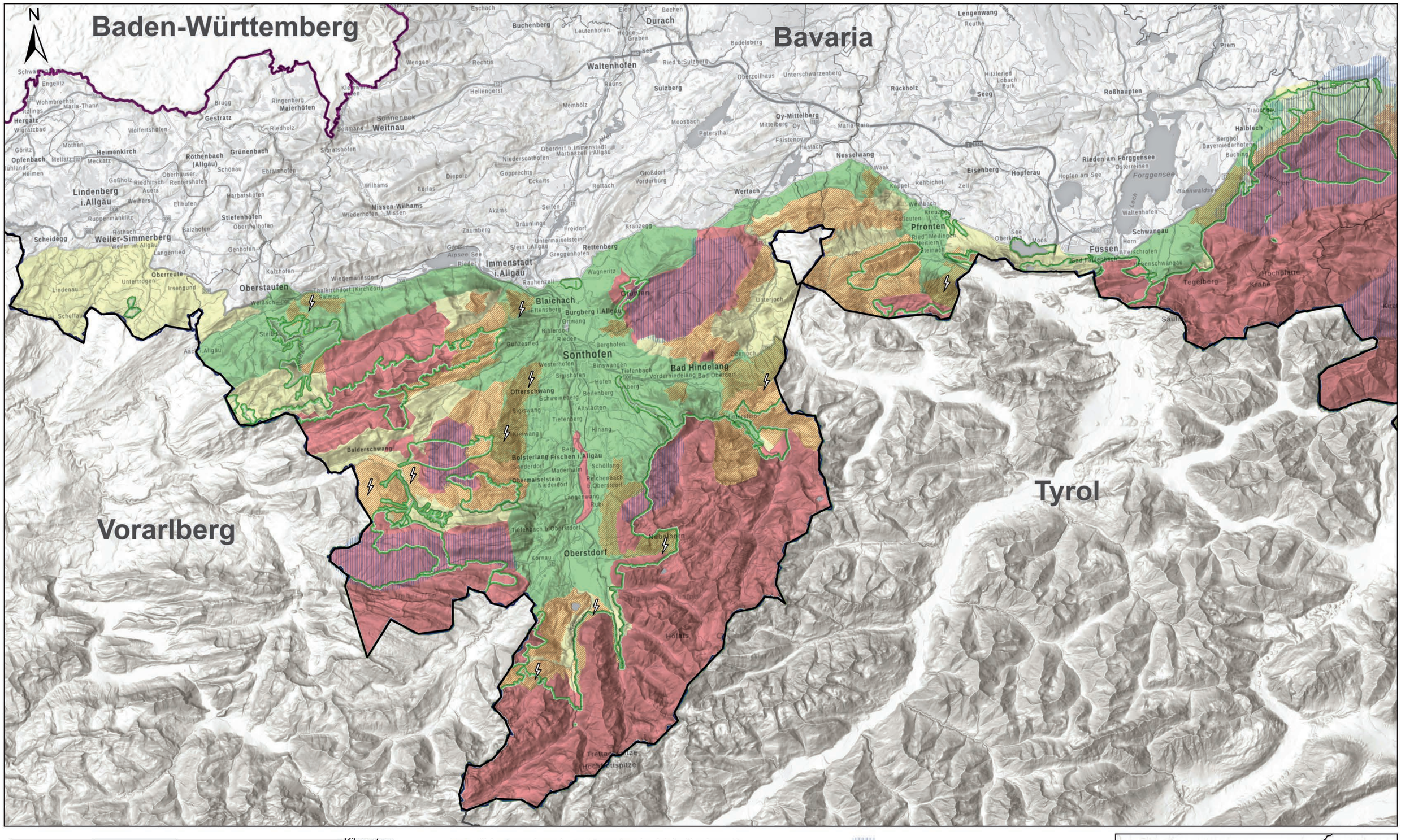
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Constantin Meyer & Hubert Job 2024. Detailed large-scale map (1:150.000) – western part (1/3). *Supplementary Figure S1 to* "Developing a data-driven approach to climate-proof a regional spatial planning instrument: the Bavarian *Alpenplan*".
https://doi.org/10.1553/eco.mont-16-2S1




***Alpenplan* zoning** (LEP* 2023)

Zone A | Zone B | Zone C

**Area of exceptional importance for adaptation to climate change**
(proposed for upgrading to Zone C) /
***Gebiet mit besonderer Bedeutung für die Anpassung an den Klimawandel***
*(Vorschlag zur Hochstufung in Zone C)*

- Alpine Convention perimeter / *Anwendungsbereich der Alpenkonvention*
- National border / *Staatsgrenze*
- Federal state border (Germany / Bavaria) / *Bundeslandgrenze (Deutschland / Bayern)*
- Federal state border (Austria) / *Bundeslandgrenze (Österreich)*

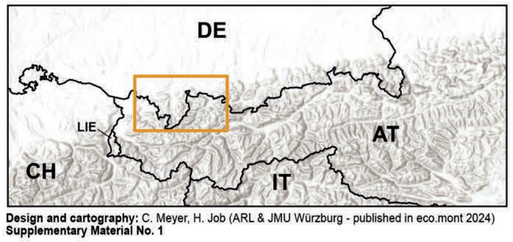
(Land use) conflicts with existing intensive infrastructural development /
*(Landnutzungs-)Konflikte mit bestehender intensiver infrastruktureller Erschließung*

Area at risk of erosion (from LEP 1972**) /
*Erosionsgefährdeter Bereich (aus LEP 1972**)*

Area within the *Alpenplan* perimeter, strictly protected for nature conservation (Bavaria)*** /
*Naturschutzfachlich streng geschützte Fläche innerhalb der Alpenplan Abgrenzung (Bayern)****

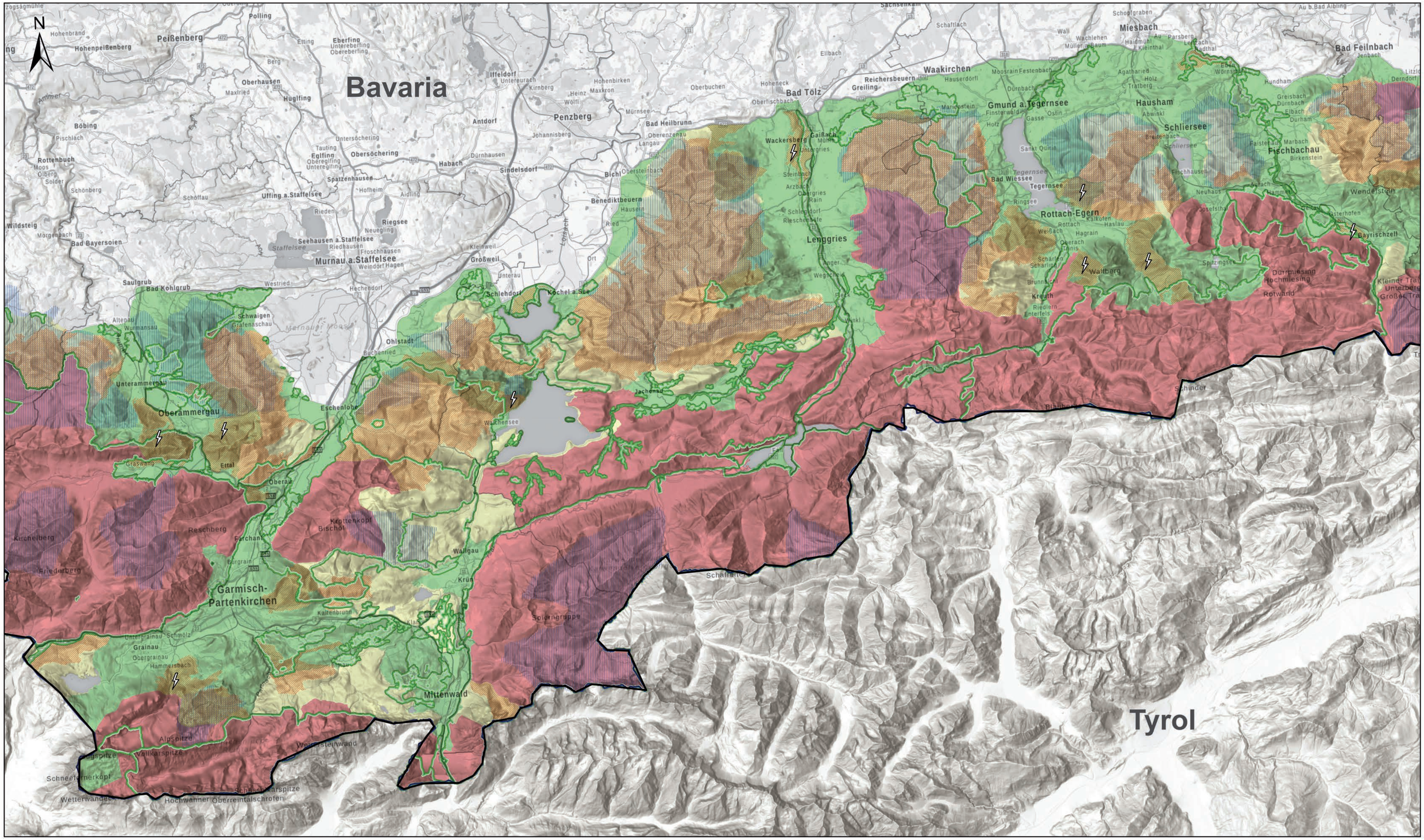
**Data sources**:
StMWi 2019; Bayerische Vermessungsverwaltung 2023 – www.geodaten.bayern.de; LfU 2022;
SynerGIS AT 2017; Esri, Geoland, Intermap, NASA, NGA, USGS

**Basemap**: WMS Webkarte Bayern
(Bayerische Vermessungsverwaltung – www.geodaten.bayern.de)




**Design and cartography:** C. Meyer, H. Job (ARL & JMU Würzburg - published in eco.mont 2024)
**Supplementary Material No. 1**

Constantin Meyer & Hubert Job 2024. Detailed large-scale map (1:150.000) – central part (2/3). *Supplementary Figure S2 to* "Developing a data-driven approach to climate-proof a regional spatial planning instrument: the Bavarian *Alpenplan*".
https://doi.org/10.1553/eco.mont-16-2S2




0 5 10 20 Kilometres

## *Alpenplan* zoning (LEP* 2023)

Zone A | Zone B | Zone C

**Area of exceptional importance for adaptation to climate change**
(proposed for upgrading to Zone C) /
***Gebiet mit besonderer Bedeutung für die Anpassung an den Klimawandel***
*(Vorschlag zur Hochstufung in Zone C)*

- Alpine Convention perimeter / *Anwendungsbereich der Alpenkonvention*
- National border / *Staatsgrenze*
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- Federal state border (Austria) / *Bundeslandgrenze (Österreich)*

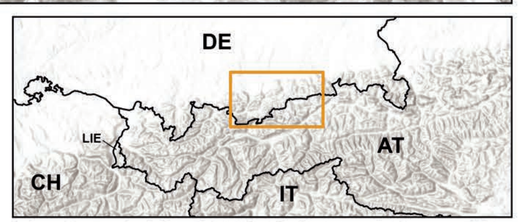
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Area at risk of erosion (from LEP 1972**) /
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Area within the *Alpenplan* perimeter, strictly protected for nature conservation (Bavaria)*** /
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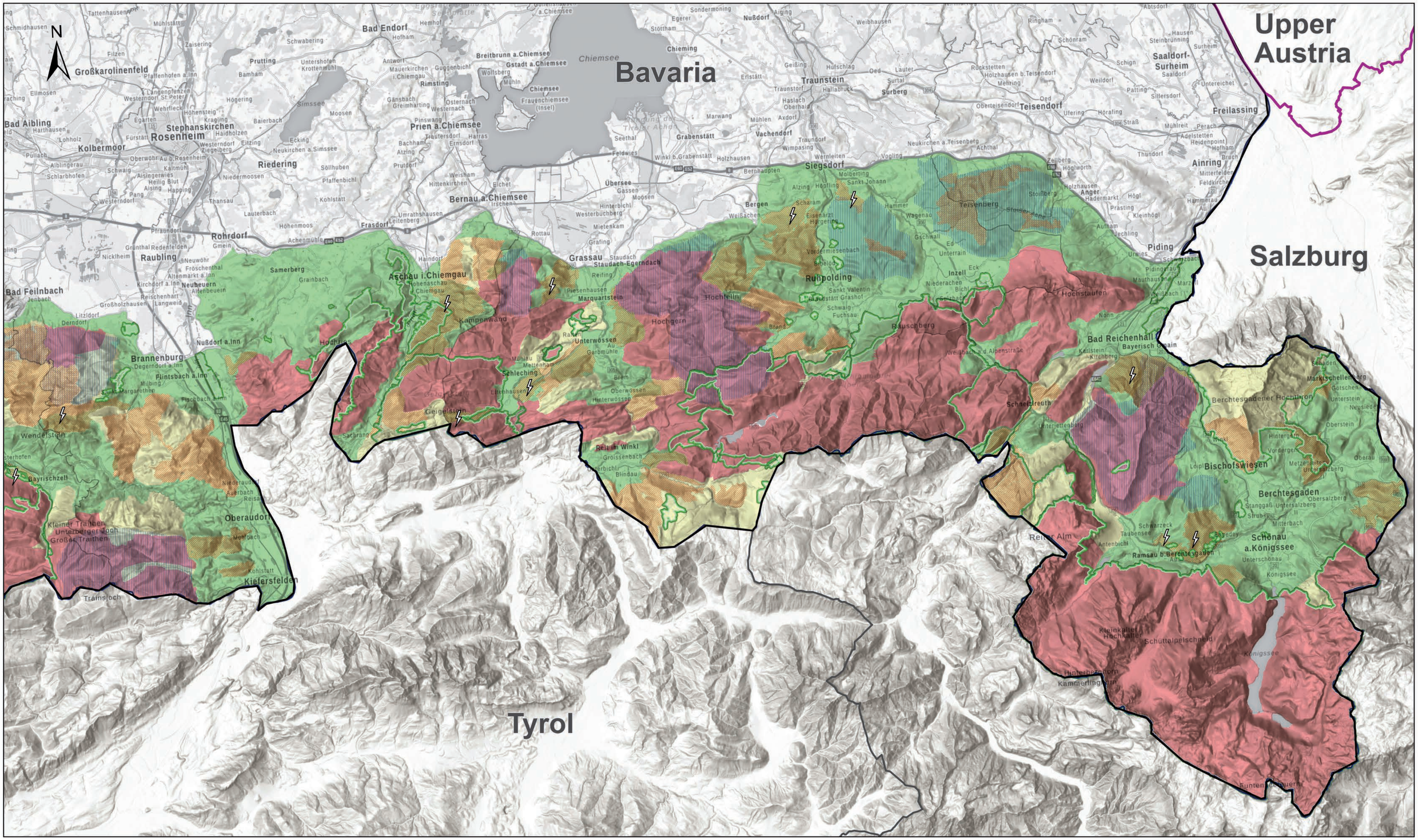
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**Design and cartography:** C. Meyer, H. Job (ARL & JMU Würzburg - published in eco.mont 2024)
**Supplementary Material No. 2**

Constantin Meyer & Hubert Job 2024. Detailed large-scale map (1:150.000) – eastern part (3/3).*Supplementary Figure S3 to* "Developing a data-driven approach to climate-proof a regional spatial planning instrument: the Bavarian *Alpenplan*".
https://doi.org/10.1553/eco.mont-16-2S3




Kilometres
0 5 10 20

***Alpenplan* zoning** (LEP* 2023)

Zone A | Zone B | Zone C

**Area of exceptional importance for adaptation to climate change**
(proposed for upgrading to Zone C) /
***Gebiet mit besonderer Bedeutung für die Anpassung an den Klimawandel***
*(Vorschlag zur Hochstufung in Zone C)*

Alpine Convention perimeter / *Anwendungsbereich der Alpenkonvention*
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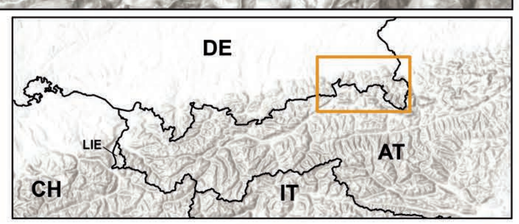
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**Design and cartography:** C. Meyer, H. Job (ARL & JMU Würzburg - published in eco.mont 2024)
**Supplementary Material No. 3**

eco.mont – Volume 16, Number 2, July 2024
ISSN 2073-106X print version – ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont
https://doi.org/10.1553/eco.mont-16-2s30

# Visitor sentiment concerning changes in backcountry permit allocation at Glacier National Park, Montana, USA

*Kelsey E. Phillips & William L. Rice*

*Keywords: rationing, distributive justice, allocation, use limits, content analysis*

## Abstract

As visitation to parks and protected areas in the USA continues to increase, many federal land management agencies have implemented visitor use limits within their respective management areas to protect the environment while also providing for visitor enjoyment. The rationing of use has become a complex task, with managers having to balance system efficiency with equality and equity concerns on numerous levels. Rationing systems such as lotteries, reservations, first-come first-served and pricing mechanisms have all been used in different contexts, with trade-offs existing within each of these systems. In February 2023, Glacier National Park (Montana, USA) proposed to transition their online backcountry permitting system from a *manually-administered* lottery to a non-lottery reservation system. This study uses the theory of distributive justice to deductively code public comments related to the proposed transition in order to determine how a sample of the public perceives changes in rationing, and how their comments are distributed amongst competing social goals. Many of these comments contain nuance, adding to a wide array of sentiments that will provide managers with a public perspective on this multifaceted issue.

Profile

Protected area

Glacier National Park

Mountain range

Rocky Mountains

Country

USA

## Introduction

Visitor use of parks and protected areas across the US has increased dramatically since the 1960s (Smith et al. 2019), prompting many federal public land management agencies to implement use restrictions in the form of reservations, permits, or other forms of managed access (Hartman et al. 2021). Frequently recommended as a *"last resort"*, access restriction is seen by many as antithetical to wildland recreation (Hendee & Lucas 1974; Lucas 1983), and many parks and protected areas struggle to balance access to recreational experiences with the protection of the environment within which these experiences occur. Different management practices have been used over time throughout US protected areas with varying degrees of success; direct approaches (e.g., closures, campfire restrictions) have been used to determine visitor behaviour directly, while indirect approaches (e.g., education, infrastructure improvements) attempt to guide this behaviour by influencing various decision factors that visitors face (Peterson & Lime 1979).

When permits giving access to a particular area are required, this is a form of direct management. If a use-permit system is implemented, permits must be allocated to visitors using rationing techniques such as lotteries, reservations or queuing (McCool & Utter 1981). Importantly, each allocation technique has trade-offs, and no particular system will perfectly meet the preferences of all users, as each user has different desires and motivations for visiting a particular area (Rice & Phillips 2023). The theory of distributive justice, a framework that involves the competing social goals of equality, equity, need and efficiency (Homans 1961), was applied conceptually in recreation research and practice during the 1970s and 80s in attempts to tease out the competing aspects and trade-offs of various allocation systems (e.g., Shelby et al. 1982, 1989). In essence, distributive justice provides a framework for researchers to explore equity (or fairness), which is often multifaceted. As Shelby et al. (1989) point out in discussing Homans's social goals, *"What is 'fair' to one person […] may not be 'fair' to the next"* (p. 62). As recreation rationing within mountain protected areas becomes more widespread – following increased visitor use – guidance is needed to help managers determine how to maximize distributive justice (McCool & Utter 1981). Recent research on public perspectives on rationing is scarce (Rice & Phillips 2023), thus perspectives stemming from recent changes in how access is rationed may hold significant implications for managers globally.

### The case of wilderness permits at Glacier National Park

Recreation.gov is one system through which reservations can be made and lotteries entered for US federal recreation opportunities. In February 2023, Glacier National Park (GNP) proposed to move its advance wilderness camping permit reservation system to Recreation.gov, away from a *"lengthy manual lottery"* administered via Pay.gov (GNP 2023a, p. 1). GNP is a 410,077-hectare protected area in the Rocky Mountains of Montana (USA) (48.776443, –113.795083). It uniquely contains terrain spanning Pacific, Atlantic and Arctic Ocean watersheds. The park offers a wide

*Table 1 – Key differences between the previous (pre-2023) backcountry permit allocation system at Glacier National Park and the proposed allocation system.*

| | Previous System | Proposed System |
|---|---|---|
| **Allocation of standard advanced permits** | "All applications submitted on opening day (March 15) between 12:00am MST [Mountain Standard Time] and 11:59pm MST will be processed in randomly sequenced order."[1] | "Wilderness camping reservations would be available on Recreation.gov beginning at 8:00 am MDT on March 15."[3] |
| **Application procedures** | "You can choose up to four (4) different itineraries […] in the order that you prefer, and on the dates that you prefer."[2] | "Applicants would book their own advance reservations (instead of park staff booking reservations for applicants)."<br>"A Recreation.gov account would be necessary to make reservations."[3] |
| **Fees** | $40 ($30 refunded if unsuccessful) + $7/person/night[1] | $10 + $7/person/night[3] |
| **Group size limit under standard permit** | 8 campers[1] | 4 campers[3] |
| **% of permits held for walk-ups from 15 June to 30 Sept. 2023** | 30%[3] | 30%[3] |

[1] https://web.archive.org/web/20190613020930/https:/www.nps.gov/glac/planyourvisit/backcountry-reservations.htm
[2] https://web.archive.org/web/20190616201552/https:/www.nps.gov/glac/planyourvisit/upload/Advance-Reservations-STEP-by-STEP-Tutorial-2016.pdf
[3] https://parkplanning.nps.gov/document.cfm?parkID=61&projectID=114545&documentID=126169

spectrum of recreational opportunities across front-country (i. e. more accessible) and wilderness settings. It is bisected by the Continental Divide National Scenic Trail (CDT) which runs north–south, and by the popular Going-to-the-Sun Road scenic parkway which runs east–west. From 2002 to 2022, annual visitation to GNP increased 52%, from 1.9 million to 2.9 million visitors. The 50-mile-long Going-to-the-Sun Road introduced a pilot vehicle entry reservation ticket in 2021 due to the congestion that occurred as the Park saw record numbers of visitors (GNP 2021), and backcountry permits to designated camping areas exist to *"minimize resource impacts while providing positive visitor experiences"* (GNP 2023c, para. 3).

GNP's original lottery system involved users submitting their desired itineraries and a range of available dates via Pay.gov, with the option of indicating whether or not these details were flexible (GNP 2019a). During the manual lottery process, GNP staff randomly selected applications and reviewed them individually, scheduling visits within the backcountry zones until those campsites and dates which were allotted for reservations were reserved for the season, at which point visitors were contacted with their final itinerary (GNP 2019b). The 2023 proposed reservation system shifted small-group permits (1–4 campers per permit) to a new proposed online reservation system, administered via Recreation.gov, with all reservations opening on 15 March at 8:00 a.m. MDT. Large-group permits (5–12 campers) would remain on the lottery system administered via Pay.gov (GNP 2023a). Importantly, the proposed new reservation system would retain the original walk-up permit availability, where 30% of spaces in *"advance reservation campsites that are not booked would still be made available for walk-up permits"* for visitors who arrive without having pre-booked (GNP 2023a).

GNP announced this proposed system in a two-page newsletter and provided a two-week public comment period from February 3–17, 2023 (GNP 2023a). The rationale provided in this document for moving to Recreation.gov was a combination of the high demand for wilderness camping permits and the administrative burden of the manual lottery system currently in place. Recreation.gov is a privately-administered website that has been used for the past decade by numerous parks and forests throughout the US to reserve campsites, entry permits, river trips and other recreation opportunities on public land. Discussion of the successes (e. g., GNP's day-use permits for the Going-to-the-Sun Road; Peruzzi 2023) and challenges (Pohle 2023) of Recreation.gov receive frequent media attention in the US. This particular move to Recreation.gov was stated to *"replace the labor-intensive lottery with a more efficient, user directed online service"* (GNP 2023a, p. 1). Importantly, the old system administered via Pay.gov would still be used under the proposed structure, but under a shorter timeframe and only for specific large-group permits. The announcement also highlighted fee changes, as detailed in Table 1.

Following the release of this announcement, a two-week comment period was allowed for public input, as outlined in the 1969 National Environmental Policy Act (NEPA). According to this Act, during agency decision-making processes federal land management agencies must inform the public of what they are proposing to do that may have significant environmental impacts; agencies must also give the public an opportunity to participate in the form of comments submitted to them. Public land management in the US is procedurally complex, and NEPA provides important aspects of information sharing, public participation, precaution and accountability in federal administrative policy as they pertain to the environment. After completing an environmental assessment or impact statement and considering public comments and other pertinent information, including alternatives to the proposed action, the agency concerned must release

its decision (National Environmental Policy Act 1969). Following the two-week comment period, GNP released the 156 public comments it had received in a 51-page document titled *Public Comments – Migration of Wilderness Permit Reservation System to Recreation.gov* (GNP 2023b). Commenters expressed a wide range of opinions, from strong opposition to strong support for the new system.

While the system was subsequently adopted and implemented by GNP in March 2023, an exploration of these public comments helps recreation scholars and practitioners to better understand what issues a subset of public users felt were important to bring to the attention of GNP. As more national parks and wilderness areas move to reservation-based permit systems (Hartman et al. 2021), an understanding of public sentiment surrounding these systems is critical if permit allocation systems are to be well-received, user-friendly, and meet the ideals of distributive justice. Accordingly, our research questions are:

1. How do public comments regarding GNP's proposed rationing transition distribute amongst the distributive justice concepts of equity, equality and efficiency?
2. Within these distributive justice concepts, in what context are they discussed: positively, negatively, offering a change, or posing a question?

## Methods

The 156 public comments that were submitted during a two-week period were analysed and coded using a *deductive* coding approach, with the theory of distributive justice as the guiding framework (Homans 1961). Homans' (1961) framework has been applied consistently in pursuit of fair recreation allocation (Ewert & Hollenhorst, 1990) and was central to the seminal work of Shelby et al. (1989). Recent work has applied Homans' (1961) concept of distributive justice to similar means (Rice & Phillips 2023; Suárez et al. 2020). During the initial research design stage, an *inductive* approach was envisioned as the appropriate method to allow themes to emerge from the data (Glaser & Strauss 1967); however, while analysing the data it became clear that the complexities of each individual comment fell generally into the theoretical framework presented in the theory of distributive justice (Homans 1961). Thus, an a priori coding approach was used to identify the underlying concepts of distributive justice within the data (Lazar 2017).

Three of the four concepts within distributive justice were explored: efficiency, equity and equality. The remaining concept, need, was not explored due to the nature of the proposed permitting system. In the context of distributive justice within social situations, *need* frequently refers to specialized access to public facilities by particular individuals or groups (Shelby et al. 1989), for example because of mobility issues or visual impairment. In the proposed system, however, visitors with additional needs are not differentiated from other visitors.

In this coding scheme, efficiency is defined operationally as addressing whether the proposed system works well; equity is defined as discussing the fairness of the system; equality is defined as discussing equal access to GNP under this system. Importantly, the distributive justice framework differentiates equity as a component of, not an equivalent to, justice. As concluded by Michel (2019), *"It is worth considering whether a differentiated use of the terms equity and justice would make sense in PA [protected area] project assessment more widely, and even more so in planning"* (p. 31). Thus, justice is *"a more comprehensive term to use than equity"* (ibid.).

Prior to coding it for the different aspects of distributive justice, each comment was coded as being overarchingly positive, negative, suggesting a change, or posing a question. Importantly, while some comments are positive overall in that they support the change, these frequently also mention negative aspects of the system, pose a question or propose a change. This nuance is crucial, as the multifaceted nature of the comments means that they cannot always be generalized simply as *positive* or *negative*. The coding scheme therefore led to breaking each comment down into subcategories, regardless of the overarching code. Each comment was then coded for thematic mentions of efficiency, equity or equality.

## Results

The public comments, which we quote verbatim in this section, without correcting for spelling or grammatical errors, reveal a wide range of sentiments surrounding the rationing of a scarce resource, in this case backcountry camping permits at GNP. While this is certainly a small subset of the public, as not all visitors (or potential visitors) to GNP participated in this public comment period, the relative frequency of each comment type within the 156 public comments reveals a general picture: 38 comments were generally positive (in favour of the transition), 59 were generally negative, 39 offered a change to the proposed system, and 20 had questions that did not reveal a particular stance. In addition, most comments also approached the different aspects of distributive justice: efficiency (i. e. does the proposed system work?), equity (i. e. is the proposed system fair?), and equality (i. e. does the proposed system provide equal access?) (Table 2).

Following initial coding for general comment positions, each comment was then coded to examine the nuanced structure of the content (see Table 2). For example, if efficiency was raised in the comment, was it in a positive, negative, change or question context? Importantly, individual comments frequently contain multiple distributive justice concepts in varying contexts. For example, Commenter 1 mentioned both efficiency and equity concepts in a negative context when they stated:

*Table 2 – Coding framework and findings for the 156 public comments, with subcategory totals and the corresponding number of mentions.*

| | Efficiency (Does the system work?) | Equity (Fairness) | Equality (Access) |
|---|---|---|---|
| | mentions | | |
| Positive (+) | 41 | 4 | 2 |
| Negative (−) | 50 | 55 | 19 |
| Change (Δ) | 45 | 21 | 25 |
| Question (Q) | 40 | 6 | 4 |
| Total | 176 | 86 | 50 |

> *This sounds like a TERRIBLE IDEA! Based on the description, for groups of 1–4, it would become a Ticketmaster-like free for all for reservations starting March 15th. While the current lottery system also has winners and losers, it at least is both civilized and feels fair. The future lottery need not be done manually – matching algorithms for this sort of thing are done by computer all the time – but please do not turn it into a death match free-for-all on March 15th every year.*

Within the public comments, a wide variety of sentiments exist in multiple contexts based on the prior experience of the individual as well as on the perceived impacts of the proposed changes. Some users were planning to visit from far away and preferred the proposed system due to the ability to reserve well in advance of the trip, so that travel accommodation could also be booked in a timely fashion. Some users thought that the proposed non-lottery-based system would be more efficient, while others preferred a lottery due to perceived fairness and non-bias towards those with faster internet speeds.

Each of the three distributive justice components utilized in this study is explored in the following sections.

## Efficiency

Of the three distributive justice components analysed, the efficiency of the proposed permit system was mentioned the most frequently in the public comments, although the sentiment within these comments was distributed almost evenly across the four sentiment options (Table 2). On the positive side, some users liked that the system would remove the waiting time for visitors to receive confirmation, one user stating that *"moving the reservation system to recreation.gov does have some advantages, such as backpackers finding out if they got an itinerary faster than with a lottery system"* (Commenter 37). Several others noted that Recreation.gov is used at many other parks across the country, which gives them confidence that this system would ultimately work well. For example, Commenter 63 states:

> *This will simplify and streamline the system and place all reservations within the same system. This will reduce confusion and eliminate needless redundancies. Recreation.gov is already successfully used across the nation by millions of users, this proposal make sense.*

Many others felt that the transition would have negative consequences for efficiency, frequently mentioning the possibility of *bots*[1] (or computer algorithms) on Recreation.gov and the release of all permits at 8:00 a.m. on one day (15 March). Yet others highlighted the very limited booking window as an issue, with *"a mad dash / scramble on March 15th at 8 am for all the reservable permits for that season"* (Commenter 52). Many users pointed out potential issues regarding building a multi-day itinerary: if one of the campgrounds in a long itinerary was already taken before a user could complete their own transaction, the user would have to start all over again and potentially lose any chance of a permit for their preferred itinerary.

Many users offered suggestions for potential changes to the proposed system. While some suggested retaining the lottery system (or some version of one) for both small- and large-group permits, others requested that there should be a way to select an itinerary before the 8:00 a.m. application start, so that multiple nights could be loaded into an itinerary prior to the *"mad dash"*, as it was called several times. One user suggested a *"modified version of the river permits lottery system through recreation.gov"* (Commenter 20), referring to several permit systems on Western rivers that allow lottery applications to be submitted in a several-week window before the lottery drawing occurs, giving applicants time to submit a request for a river permit.

Finally, users had many questions about the proposed permit system. Many asked about how to string together multiple sites on a multi-day trip. Commenter 2 asks, *"Would you have to book each night individually or would there be a way to secure all the sites in one easy step?"* Others asked how duplicate applications could be weeded out, or people discouraged from applying for more permits than needed. One user wondered *"can't a computer figure out how to reserve requests with a lottery system so that staff doesn't have to work every reservation request?"* (Commenter 70). This sentiment came up multiple times, with users expressing frustration with the proposed system while also acknowledging how hard the manual lottery must be for staff to administer. Finding a balance for managers and users is clearly complex, and nuance regarding this tension exists in many comments.

## Equity

The concept of *equity* was brought up in about half of the comments, albeit in different contexts. Some users were concerned with the use of a system that favours those with high-speed internet or higher computer literacy, as Commenter 13 states:

[1] The authors are not suggesting or theorizing that bots are navigating Recreation.gov. This is an assessment of public sentiment.

> *This type of system favors fast computers and fast internet. It will make planning an itinerary a nightmare as 1000s of people are overloading the system at 8 am competing for campsites. The lottery system that allows all applications on received the first day to be treated equally is much fairer and more equitable and sustainable as numbers of applications continue to rise.*

Other users see equity or fairness within the system from a different perspective. References to *"gaming the system"* were frequent, but other users, such as Commenter 26, saw the fact that reservations open at 8:00 a.m. MST as giving *"an unfair advantage to folks in the Pacific time zone who are more likely not to be at work yet"* and those working remotely.

While only a few users perceived the proposed system as a positive step towards equity, it is still important to discuss their comments here, as all perspectives are necessary to build a just system. Commenter 34 states:

> *Although it's painful to many of us who've enjoyed GNP's backcountry for decades, we must accept that the days of unlimited free access are simply over. Now is the time to implement a system that ensures fair allocation of park access in the future, and a fully electronic system is a foundational first step to do this.*

Another user stated that *"this is a more fair option than the previous 1 day lottery method"* (Commenter 141). It is clear that equity (or fairness) in this context is perceived differently by different members of the visiting public, and these differences will require much more exploration for GNP staff.

Many users suggested changes to the proposed system to make it more equitable. Some suggested adopting systems that are already in use within the National Park Service, such as Yellowstone's lottery system, which is also administered by Recreation.gov (paraphrased from Commenter 67). Others had ideas about how to track whether users were submitting multiple applications across several years, thereby emulating a common practice in big game hunting permitting where *"successful applicants are typically put at the back of the line among applicants in future years"* (Commenter 34). Finally, several users had questions about the system pertaining to equity and fairness. The issue of multi-day itineraries was also raised frequently, but its context varied across efficiency, equity and equality. Commenter 92 asks:

> *How will equity be achieved between the advanced large-group lottery and the 1–4 small-group reservations with regard to time of reservation? [...] To maintain equity, will you be spacing the 35 large-group allotments out equally over the entire summer season? If not, the large group reservations allocated as part of the March 1 lottery could make it very difficult to secure any small group reservations in the prime hiking season.*

Questions regarding large- versus small-group treatment were also raised in the context of all three distributive justice concepts, highlighting the complexity of these comments.

### Equality

Just two mentions of equality were made with a positive sentiment. Commenter 11 felt that a perceived expansion of the number of walk-up permits would be positive, stating that *"giving people access to these wild areas can be an incredible and life changing endeavor. So expanding 'walk in' areas will help enable those with the actual drive to do so."* Commenter 22 notes that their family lives far from the park, and this system allows them to *"make wilderness camping reservations instead of relying solely on walk-up permits – THANK YOU."* Both of these comments highlight the different perspectives of visitors to GNP; some enjoy the walk-up permit option for access, while others who live far from the park enjoy the advance reservation option.

Others expressed negative sentiments. The number of campers on a small-group permit and their processing order came up frequently within these comments. Commenter 60 pointed out that *"my concern with the new system is the cap on 4 people per reservation. I have 3 kids making us a family of 5. Seems silly to need 2 reservations for my family."* Commenter 146 expressed frustration with large-group applications being processed before small groups, stating that *"this just has a feel that you are trying to accommodate the commercial guided trips that would have only one trip leader over the smaller, independent non-commercial hikers."* Other users referred to access issues more broadly. Commenter 28 states:

> *[I]t is nearly impossible to book a campsite during the height of the season, which leaves the less technologically advantaged individuals behind and effectively denies them access to public lands that are meant to be enjoyed by all. This undermines the fundamental principle of non-discrimination at the core of NPS policies.*

A number of users offered changes to the proposed system that addressed what they perceived as accessibility issues within GNP's backcountry. While some offered broad suggestions, such as *"it is imperative that the reservation system be designed to promote equal access for all"* (Commenter 28), others offered more pointed changes. Commenter 61 states:

> *I disagree that the groups should have primary access to the sites. As a general rule, groups are harder on the environment than individuals and many parks limit them to protect the natural resources. This plan gives them preferential treatment and 2 chances to obtain their permits. Groups should be limited and not be given advanced access.*

Several other users mentioned the difficulties that through-hikers on the Continental Divide National Scenic Trail would face, with Commenter 119 suggesting that while *"these changes might be helpful to those plan-*

*ning shorter trips"*, these particular through-hikers will find it *"nearly impossible to secure an itinerary under the new system"*. Finally, several users had questions about equal access for different user groups. Commenter 17 asks: *"Will reservation.gov be set up for stock reservations as well?"* (i. e. for the use of pack animals).

## Discussion

Striking a balance between the distributive justice concepts of equity, efficiency and equality is a complex task (Shelby et al. 1989); understanding a subset of the public's sentiments surrounding these concepts within this particular reservation system will help advance the field of recreation use allocation and the theory of distributive justice more broadly. While our analysis is only one way to look at this complex issue, it is clear that visitors to GNP have a wide variety of preferences and opinions regarding the proposed transition in rationing. As allocation systems throughout US protected areas become more common and move increasingly online (Hartman et al. 2021), commenters stated that concerns about equity and equality (as they relate to technological literacy, internet access, timing, etc.) will become more salient. At present, it is unclear how managers will be able to strike a balance between equity and efficiency when deciding how to allocate use within these systems: more research is needed to move these decisions beyond historical use and best judgement.

In the meantime, suggested planning principles such as the Recreation Rationing Spectrum (Rice & Phillips 2023) have begun to delve into the potential for the simultaneous use of multiple rationing systems to strike this balance, but more research is needed to guide the creation of potential frameworks. Within the recreation allocation literature, the present research is a small step towards a future framework, a tool that has been notably missing since the research of McCool and Utter (1981). Additionally, this research builds on the theory of distributive justice, and more specifically the concept of *equity* and what that means in the recreation context. As federal guidance on equity and inclusion in public land spaces and land management agencies increases, the theory will need to be investigated further and applied more extensively to better provide fair and equitable access to all public land users.

### Management implications

Four primary management implications emerge from this research which mountain protected area managers may find valuable. First, visitors appear to be generally understanding of the time, workforce and financial constraints of managers as they relate to rationing recreation. This is an important finding, as noted by Lucas (1983), because visitors are more likely to accept, comply and have positive experiences when they understand the constraints of managers and the rationale for policies. Second, visitors have concerns over the equity and equality of non-lottery-based rationing systems, on grounds of time, and of technological and geographic advantages. This adds to the proposition of Shelby et al. (1982) – that those who are able to plan ahead are advantaged by reservation-based systems as *"reservations set a premium on planning"* (p. 416). Third, visitors seem to recognize the need for diversity in rationing. Though commenters often voiced support for their preferred rationing mechanism, many also appeared to react positively to the proposed model's specific ways of splitting permits between reservations and walk-ups – in line with recommendations from McCool and Utter (1981) and Rice and Phillips (2023), who suggest the simultaneous use of multiple rationing systems. Finally, visitors have equality-framed concerns over perceived advantages in relation to activity type, length of trip and group size.

### Limitations

There are several limitations of this study, most notably that 156 public comments cannot be taken as representing the entire visiting public. This is a very small sample of potential (and not necessarily actual) GNP visitors. Furthermore, those who took part in the consultation were perhaps more keenly aware than other visitors of the proposed changes, and thus more likely to engage in the public participation process. Additionally, the specific form of *deductive* coding used, within a previously developed theoretical framework, may have limited the number of themes that emerged. It is possible that other themes might have emerged from the data if an *inductive* approach had been used (Lazar et al. 2017). Nevertheless, determining how these public comments are distributed amongst the concepts found within distributive justice is still a critical contribution to the literature on distributive justice, as well as to that on recreation use allocation more broadly. Lastly, it is critical to note that the participants' comments examined here reflect their personal perceptions. They do not necessarily reflect the realities of the present management of GNP. Thus, the views of how the system will be administered, and technical issues related to its administration, may be incorrect.

## Conclusion

Public access to public lands is not always as simple as it appears at face value, especially as agencies limit (or *manage*) this access. The commenters' perspectives presented here are useful to further our collective understanding of the complexity of how the public views impacts related to these allocation systems. This research offers key insights for mountain protected area planners as they consider various allocation systems and weigh the impacts on distributive justice. The deep nuances surrounding the connections and trade-

offs between efficiency, equity and equality may pose challenges to managers as they seek *"an ideal whereby individuals obtain what they 'ought' to have based on criteria of fairness"* (Shelby et al. 1989, p. 62). Yet, as stated by Commenter 28, *"The National Park Service has a duty to ensure that everyone has a fair and equal opportunity to enjoy the public lands that belong to all of us."*

## Endnote

On 4 December 2023, the National Park Service announced that they would be updating their backcountry permit allocation system once more. This time, they announced they would be reverting to a lottery-based allocation. More information can be found at: https://web.archive.org/web/20240127135242/https://www.nps.gov/glac/learn/news/glacier-national-park-adds-early-access-lotteries-for-2024-wilderness-permits.htm

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eco.mont – Volume 16, Number 2, July 2024
ISSN 2073-106X print version – ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont
https://doi.org/10.1553/eco.mont-16-2s38

# "The local population is not aware" of nature conservation: implementing and managing the Natura 2000 network in a mountainous area of Galicia, Spain

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*Keywords: protected natural areas, nature conservation, Natura 2000 Network, mountain, local participation*

Abstract

The Natura 2000 Network (N2000N) is the main conservation instrument of the European Union. Its implementation for the whole EU territory in the last 30 years has largely been carried out top-down, combining the local level poorly. The Queixa and San Mamede mountain ranges, located in south-eastern Galicia, have been proposed as a single natural park since at least the 1970s, although political inactivity and lack of interest in conservation by the local population have made this difficult to achieve. However, most of this mountain area has been designated as N2000N territory. This article demonstrates that the designation took place in a non-transparent manner and without public participation. As a consequence, our analysis questions the legitimacy of the Galician N2000N areas. The article addresses N2000N management and academic criticism in this respect. Finally, we recommend involvement of the local population in the future, as the only way to guarantee effective conservation and improve perceptions of the N2000N at local level. The analysis presented here is relevant for the future of this and other mountainous areas belonging to the network.

Profile

Protected area

Natura 2000 Network

Mountain range

Queixa and

San Mamede

Country

Spain

## Introduction

During the second half of the 20th century, science began to bring to light the continuing disappearance of habitats and species, leading to a massive increase in the worldwide creation of protected natural areas (Dudley, 2008). The systematic implementation of nature protection policies through networks began with the 1972 United Nations Conference on the Human Environment in Stockholm. At regional level, in 1973 the Council of Europe set up a European network of biogenetic reserves for habitat conservation, and in the early 1990s the EU agreed to set up the Natura 2000 Network (N2000N). Although it is an EU-wide initiative, Rauschmayer et al. (2009) have shown that its implementation has varied between countries.

The N2000N covers 12% of Galicia's land area (EUROPARC-España 2021). In Galicia, practically no protected natural areas had been declared prior to its implementation, and Galician conservation policy was non-existent, despite the fact that the devolved Galician Government had had full powers in the management and protection of nature since the early 1980s (Paül et al. 2015; Paül 2017). The actual implementation of the N2000N (in 2004), however, was effected quickly, without public consultation, by the Galician Government.

The aim of the present research was to decipher the local population's perceptions regarding the N2000N development process in a specific area. Despite recurring debates over the last two decades on its possible extension, the current extent within Galicia of the N2000N has been considered definitive since 2014, when all Galician N2000N areas were designated Special Areas of Conservation (SAC) (Decree 37/2014). In addition, with the approval of Galician Act 5/2019, on natural heritage and biodiversity, all SACs were given the legal status of *Natura 2000 Network protected areas*.

This article focuses on an area in Galicia formed by two adjacent mountain ranges (Queixa and San Mamede) that make up the so-called Manzaneda Massif (also known as the Macizo Central, Central Massif in English). The area has been proposed as a natural park since the 1970s. According to Section 24.1 of Galician Act 5/2019, natural parks are *"natural areas which, due to the beauty of their landscapes, the representativeness of their ecosystems or the singularity of their flora, fauna or geological diversity, including geomorphological forms, possess ecological, aesthetic, educational and scientific values whose conservation deserves preferential care"*. However, the creation of a new nature park to include the Manzaneda Massif has been postponed indefinitely, despite the announcement in around 2005 of its immediate effective implementation, and has never come to fruition (Paül et al. 2015; Paül 2017).

The total protected area that we focus on here is considerable, covering 46,986 ha (Macizo Central SAC), see Figure 1. For the purposes of this paper, the Bidueiral de Montederramo SAC located in the San Mamede mountain range (1,984 ha) is assumed as assembled with the Macizo Central SAC. The Macizo Central SAC is the largest SAC in Galicia if we take into account that the Ancares-Courel SAC (102,635 ha) consists of two separate mountain ranges that have been amalgamated administratively (Figure 1). Due to

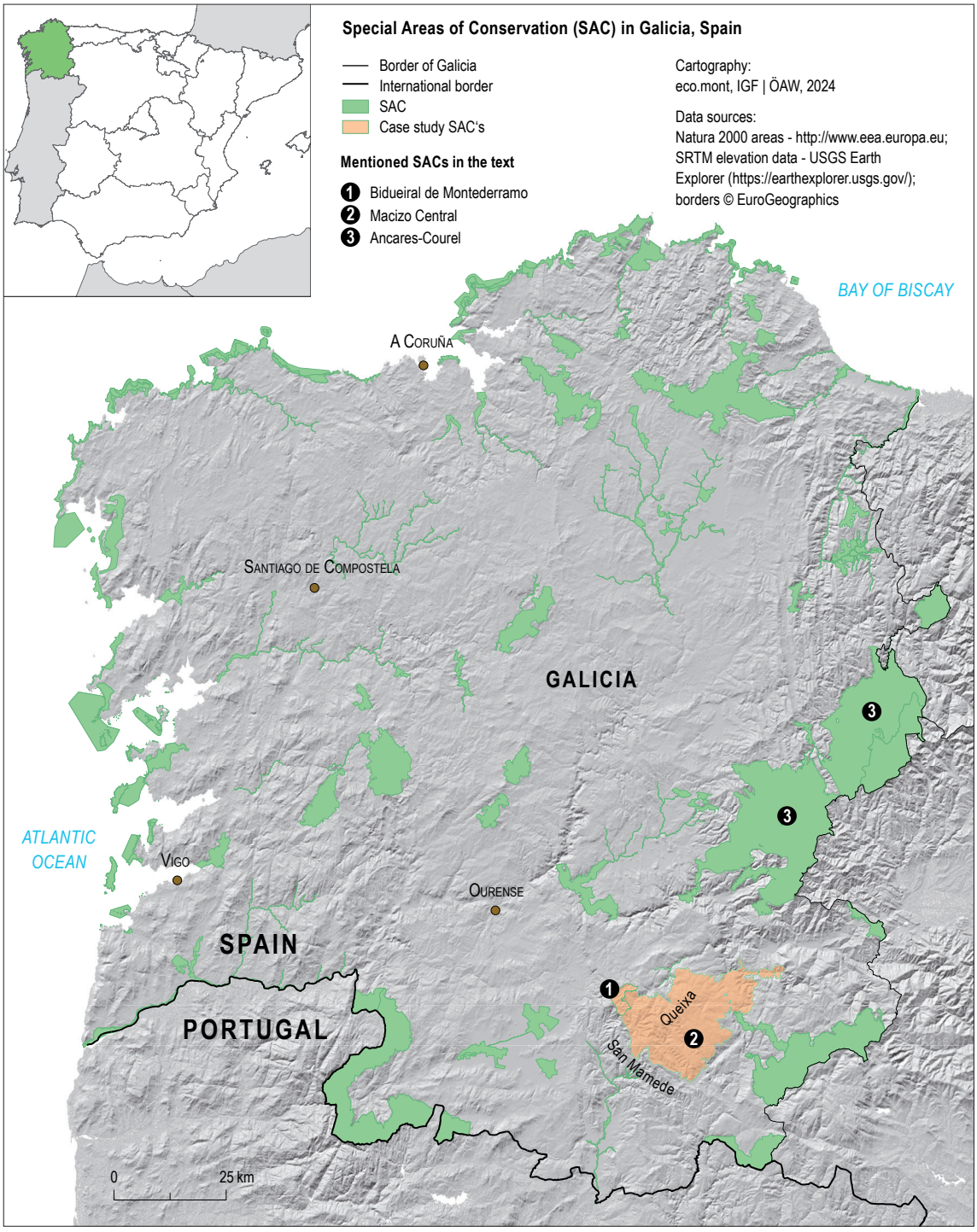



*Figure 1 – Special Areas of Conservation (SAC) in Galicia, Spain.*

its large size, Macizo Central SAC is particularly representative of the N2000N in Galicia.

## The Natura 2000 Network

The N2000N was created following the adoption in 1979 and 1992, respectively, of the Directive on the Conservation of Wild Birds (*Birds Directive* n. 79/49/EEC) and the Directive on the Conservation of Habitats and of Wild Fauna and Flora (*Habitats Directive* n. 92/43/EEC). The former imposed on EU member states the conservation of wild-bird habitats by creating Special Protection Areas for Birds (SPAs); the latter protects species and habitats. It also defines the procedures for establishing, planning and implementing the management of the network, by designating, first, Sites of Community Importance (SCIs), and then Special Areas of Conservation (SACs), which replaced the SCIs (Sundseth 2012; Orlikowska et al. 2016). Currently, the N2000N consists of 27,031 protected areas and more than 1.2 million km² (DG Environment 2022), and is considered the cornerstone

of the EU's nature conservation policy (Fontaine et al. 2007).

Sundseth and Creed (2008) define the N2000N as the largest network of protected areas in the world, and Rosa and da Silva (2005) as the most innovative and ambitious nature conservation initiative ever undertaken. McCauley (2008) and Apostolopoulou and Pantis (2009) view the N2000N as being designed for both the protection of biodiversity and the development of anthropogenic activities which facilitate conservation. The N2000N can therefore be seen as a European strategy for sustainable development. In fact, Ferranti et al. (2014) have distinguished three successive management paradigms in its implementation:

- a technocratic-scientific approach that favoured ecological problems over socio-economic ones (1990s), characterized by the idea that complex problems can only be tackled through scientific and technical means;
- a participatory perspective (2000s), which seeks to involve those who are affected by a specific problem in policy deliberations; and
- the economic view of sustainable development (2010s), which includes the concept of ecosystem services and focuses on the application of quantitative concepts and measures such as cost-benefit analysis, willingness-to-pay and market value.

Yet the N2000N has been widely criticized for its preference for a top-down approach. Following a review of the literature, this top-down approach can be described as follows:

- an asymmetrical distribution of power, characterized by an over-presence and over-action of governmental bodies, and a lack of participation on the part of civil society (Blicharska et al. 2016);
- a lack of encouragement for local participation (Dimitrakopoulos et al. 2010; Crofts 2014; Blicharska et al. 2016). When it has occurred, it has been selective, has been developed only in the advanced stages of a project's implementation, and has allowed the participation only of actors predefined by the government (Bouwma et al. 2008, 2010; Blicharska et al. 2016).
- the process of designating a protected area leads almost invariably to local opposition, and local communities are rarely given the opportunity to voice their views (Rosa & da Silva 2005; Grodzinska-Jurczak & Cent 2011; Sarvasová et al. 2013; Winkel et al. 2015). It is assumed that the population, in general, will oppose protection by default (Hiedanpää 2002), because government authorities do not believe that people understand the limits that should be placed on the use of nature (Garde 2005);
- site selection is limited to scientific habitat and species criteria (Turnhout et al. 2015), without the involvement of the local population (Cent et al. 2013; Ferranti et al. 2014), and carried out in a technocratic manner (Liefferink et al. 2011);
- decision-making takes place at national level, to respond to the EU framework, and is implemented in regional and local contexts without dialogue between the different levels (Lindstad et al. 2015); and
- a preference for unilaterally imposed regulatory policy, without conciliatory channels based on dialogue and negotiation (Pinton et al. 2006; Marquette 2007; Bouwma et al. 2010; Apostolopoulou et al. 2012).

According to Liefferink et al. (2011), the implementation of the N2000N could in fact have been carried out in bottom-up fashion, involving decision-making based on a network of relationships between mainly local actors, and at various scales (Liefferink & Jordan 2004; Niedzialkowski et al. 2015). Rauschmayer et al. (2009) argue that a bottom-up approach has only recently (since the late 2000s) – and tentatively – started to be put into practice.

## Methodology

This research is based on interviews which sought to ascertain social perceptions of the N2000N in the study area.[1] The specific interview technique used favours open dialogue between the interviewee and the researcher, allowing visions about the object of analysis to emerge (Jennings 2005). The interviews were conducted face to face and involved 30 people from various stakeholder groups, from the public and / or private spheres. The group comprised:

- political representatives of the area (1);
- hunters (2);
- business owners (2);
- public officials (2);
- researchers (2);
- environmentalists (2); and
- members of the local population *strictu sensu* strongly connected to the place (19).

A representative sample was not sought, in either statistical or spatial terms. Rather, opinions and ideas were collected from actors who had a good knowledge of, or relationship with, the study area, until the saturation threshold was reached, i. e. when the successive contributions made by the interviewees no longer contributed anything new to the research (Jennings 2005; Valentine 2005). The structure of the interviews encouraged dialogue, using phrases such as *"Tell me about …"*. It also included alternative direct questions when more specific information was needed. This structure facilitated the systematic collection of information covering:

- perception of the natural values of the place, using the phrase "*Tell me about the main values that exist in the*

[1] Interviewees' words are quoted verbatim (in translation). The quotation in the title of the article is from participant E9. Participant anonymity has been respected in line with current data protection policy.

*area…"*, and two alternative direct questions: "*Can you describe the values that exist in the area?*" and "*What is your opinion of them?*";
- opinions concerning the existing (lack of) protection, using the phrase "*Tell me whether the area we are talking about is protected…*", and three alternative direct questions: "*What means of protection are you aware of?*", "*Do you think they are working well?*" and "*Do you consider that they have effects, limitations, incentives, etc.?*";
- assessment of the management of protected natural areas in the region, avoiding specific terms such as "N2000N" (Morange & Schmoll 2016), asking "*Tell me about whether the area we are talking about is well managed…*", and two alternative direct questions: "*What management actions have you noticed?*" and "*How do you perceive them?*"; and
- environmental changes and the future of the area, using the phrases "*Describe for me what the area you are talking about and/or these mountains were like 40 years ago, and what they are like now...*" and "*Tell me about the future for this area and these mountains...*", and three alternative direct questions: "*What changes have occurred in the last 40 years?*", "*Throughout your life, what changes and/or continuities have you noticed?*" and "*How do you see the future of these mountains?*".

The interviews were conducted between 1 October 2018 and 31 December 2020, and lasted approximately one hour each. Everyday language was used, adapting the conversation to the profile of the interviewee. The interviews were intended to elicit honest subjective responses. In order to guarantee anonymity, the code *E* was used for each of the interviewees. In some cases, conversations were recorded with their permission, and in others systematic notes were taken. Subsequently, recordings were transcribed and all responses were coded and analysed. The responses were translated from Galician into English.

Open coding resulted in the identification of two clusters. Behind Table 1, there are 23 individual codes related to the perceived problems and threats of the N2000N in the case study, and their implied consequences. The codes are an abstract interpretation of the key issues raised by participants. They include both *emic codes* (taken directly from informants' words) and *etic codes* (derived from latent content analysis from the researchers' external perspective) (Crang 2005; Cope 2010) – i.e. the two *clusters* referred to above.

## Results

The results are presented in terms of the two clusters, which can be summarized as how local people view the N2000N, and their role.

### Legitimized vulnerability? The local vision of Natura 2000 Network

According to those interviewed, nature protection in this area of Galicia is restricted to a small natural park (O Invernadeiro NP), in the southeast of the Queixa mountain range (Figure 2). For some, it should be extended to protect the whole massif within a large nature park. However, one person stated that such an expansion would be unnecessary, because "*this [wider] area is self-preserving, nothing more is needed*" (E7).

It is very significant that, of the 30 interviewees, only 6 spontaneously mentioned the N2000N. Hence, it can be inferred that perception of nature protection in the mountains studied is very limited. However, in getting our interviewees to reflect on the N2000N through the use of more pointed questions (see Methodology), we were able to identify what they viewed as specific problems of N2000N in Queixa-San Mamede and current threats that affect the protected area. These are summarized analytically in Table 1.

The first perceived problem is that protection is too generic. Interviewees perceive a lack of protection in Queixa-San Mamede, which, according to some, is because politicians do not see the defence of nature as leading to electoral gains. Another aspect that stands out is the lack of governmental interest at regional level in nature conservation, leading to generic protection on paper, without it being put into practice. According to E6, "*They consider these mountain ranges as something marginal... [where] the actions are only ones of destruction [and] permissiveness.... Here, care and conservation never existed [because] they don't care.*"

*Table 1 – Local actors' criticisms of Natura 2000 in Queixa-San Mamede.*

| **Problems** | **Consequences** |
|---|---|
| Protection too generic | - Fraudulent use of conservation policies<br>- Lack of effective protection<br>- Land-use conflicts<br>- Natural degradation |
| Extreme rigidity; limitation of activities | - Need to obtain permits from the relevant government levels, which are located far away from where the affected citizens live<br>- People feel discouraged about nature protection |
| Lack of planning, investment and funding | - Few direct benefits to local people of area being designated N2000N<br>- Little compensation for local people |
| Unfulfilled promises of socio-economic development | - Frustration |
| **Perceived threats** | |
| Competitive motorized and non-motorized sporting activities, construction of dams, firebreaks, forest fires, forest tracks, hunting, livestock, mining, timber extraction, wind farms | |




*Figure 2 – Queixa and San Mamede SACs: municipalities involved and O Invernadeiro Natural Park.*

Secondly, extreme rigidity and limitation of activities are widely highlighted. Although this may seem to contradict the problem just outlined, there is also talk of too much bureaucracy, and too many obstacles and prohibitions linked to N2000N which prevent traditional activities from being carried out: "*The government does not let you do anything […]: you cut a tree and you have to ask for permission […]. The rules and traditional use do not coincide*" (E15), implying that "*People do not want protection because of the prohibitions […]. They want to do things the way they always have [and] they do not want regulation*" (E10).

Finally, interviewees point out the unfulfilled promises of socio-economic development. Environmental policy lacks planning and financial resources and is seen as outdated; it also fails to include adequate environmental education. All this generates frustration among the participants. Ignorance of, and opposition to, conservation were also mentioned: "*People didn't understand it [conservation] and didn't even know about it*" (E9); "*People here were initially opposed to protection*" (E6).

## The role of the local population

Interviewees also talk about their lack of participation in environmental decisions. Some believe that the government is not interested in knowing people's opinions, which justifies the government's neglect and abandonment of projects with a view solely to "*maintaining a very profitable patronage network*" (E2). Forest management, for example, according to E15, "*has been totally abandoned*".

The different levels of government are perceived as both authoritarian and lacking in leadership, at the broader (Galician Government) and local levels (Ourense Provincial Council, and the ten municipalities mapped in Figure 2). The sole exception is Manzaneda Municipal Council, which has allegedly tried to do things differently, albeit in isolation, as indicated by E7: "*Manzaneda is a leader, with a completely different vision […] to help, […] to give a boost, quite the opposite of the rest who [only] see problems, […] with typical narrow, short-sighted views.*" This particular impression possibly has to do with the efforts of local governments in Manzaneda from 2007 to 2019,[2] who gave great importance to the local and territorial development agenda. Others blame the situation on the population itself for its lack of engagement and failure to voice any dissent; according to E3: "*There is and they have what they want.*"

[2] The vast majority of local governments in the case-study area are, and have been, in the hands of the two major Spanish political parties. From 2007 to 2019, however, the Manzaneda Municipal Council was led by the Galician Nationalist Bloc or a political splinter group of the Bloc.

## Discussion

With the creation of the N2000N, Galicia increased the extent of its protected areas considerably. Queixa-San Mamede is evidence of this: in the 1990s, the protected area of Invernadeiro Natural Park covered just 5,722 ha and included just one municipality (Vilariño de Conso) and a small part of the Queixa range (Figure 2), but it went on to have almost 50,000 ha designated as N2000N , a ten-fold increase. According to the statements made by our interviewees, however, the protection of these mountains through its N2000N status is weak, limited and fragile, echoing what Paül et al. (2015) and Paül (2017) say of Galician protected natural areas as a whole.

Arguably, the absence of opposition during the implementation of N2000N in Queixa-San Mamede was due to the government's failure to provide the local population with sufficient information about the implementation process itself – a failure which is common according to Cent et al. (2013) and Ferranti et al. (2014). Locally, then, people were not in a position to put forward any alternative visions and the implementation occurred differently here compared to the rest of Europe (Grodzinska-Jurczak & Cent 2011; Winkel et al. 2015). The majority of the population is still, in 2024, unaware of the protection that is in place, which echoes what some authors indicated decades ago in relation to the creation and public recognition of other protected natural areas (Troitiño 1995; Hiedanpää 2002; Garde 2005; Dowie 2009). In Queixa-San Mamede the real meaning of the N2000N is still largely unknown.

Because processes that involve the population in conservation, such as those defined by Nogué et al. (2010), have been lacking in Queixa-San Mamede, its designation as a protected area can be considered as lacking legal foundation, as well as real usefulness in terms of both environmental and socio-economic benefits. For example, politicians gain scant political profit from defending the environment, and so potential socio-economic gains to the local communities fail to materialize. The political lack of interest in placing value on conservation roles seems to stem from the worry that any limitations imposed on natural resources might well be rejected by the local populations (see e.g. Dowie 2009).

The different levels of government justify their *secretive* actions by citing a loss of control in decision-making. Moreover, the exclusion of the local population from the processes of creating protected areas has contributed to the decades-long standstill. Contrary to what has happened in many European countries (Beunen & de Vries 2011; Cent et al. 2013; Borrass 2014), the arrival of the N2000N was not a consequence of social pressure. Although in our case study the population acknowledges that existing natural values are worth protecting (as seen in the results section), there is no active local motivation for the designation of natural areas in general or of the N2000N in particular. Rather, we see an attitude that is both sceptical and passive about the relevance of belonging to these natural areas.

In comparison with the first designations in Europe of N2000N sites, implementation in Galicia was characterized by delay. The site was first identified when the list of SCIs for the Atlantic biogeographical region was published in 2004, about 14 years after the earliest SCIs (early 1990s). Furthermore, unlike what happened in most N2000N sites (Turnhout et al. 2015), the techno-scientific criteria of the 1990s do not seem to have been the basis for the protection of these mountains. Neither the participatory approach of the 2000s nor the sustainable development approach of the 2010s (as discussed by Ferranti et al. 2014) characterized the implementation of the network in Queixa-San Mamede. Rather, it was the political-technical criterion that was decisive and predominant in complying with EU requirements. As Liefferink et al. (2011) discuss, there was no negotiation between the regional government and local actors, despite the fact that there could in this case have been a more bottom-up approach.

The N2000N in Queixa-San Mamede is not based on pre-existing protected areas, which differentiates it from other places (Herrero 2008); excluding the Invernadeiro NP, it was created entirely ex novo. Conversion of the entire N2000N area into a single NP, a project proposed in 2005–2009, and discussed at the time in the local press,[3] was finally rejected politically. The interviewees, in fact, had no recollection of this initiative. This potential (expanded) area, if designated specifically as a Natural Park, would correspond more closely in geographical extent and scientific interest with what is possibly the most common protection instrument in Spain (Troitiño 1995; Paül 2017; Cidrás & Paül 2021). Given the undeveloped socio-economic character of these mountains, as an NP the area would have been an undoubtedly valuable asset, as has proved to be the case for similar areas throughout the Iberian peninsula.

## Conclusions

Despite the fact that protected areas have been the main conservation instrument for 150 years, in Galicia their incidence has been very low, mainly due to a lack of political interest. However, the arrival of the N2000N brought in changes, notably the creation of Macizo Central SAC. Nonetheless, the protection of these mountains is seriously inadequate, as is openly acknowledged by many of the participants interviewed in this research.

The analysis of the case of Queixa-San Mamede, moreover, shows that the local population is largely de-

[3] The archives of the Ministry of the Environment house an unpublished document, dated 2009, which proposed designating the NP (SAYFOR 2009).

tached from environmental policies, and the top-down manner in which policies were implemented means that the policies lack impact in terms of local development. While the implementation of the N2000N in Queixa-San Mamede passed off unopposed, it did, theoretically allow for possible alternatives, but none were put forward. The main consequence is that the N2000N remains largely unknown today. While the populations living in these mountain ranges used to decide their daily lives, their futures are now directed by (mainly regional) politicians.

This mountain massif represents an area that is protected on paper. Ironically, however, protected status is perceived by the local population as limiting, while the area itself is perceived by environmentalists as still unprotected. In this context, the recognition and any further extension of the NP are potential sources of both conflict and ambivalent attitude. The potential (expanded) NP could, however, be an interesting option for this territory as a catalyst for revitalization.

While the implementation of the N2000N came late to this part of Galicia, it introduced a new paradigm for the region. However, although the EU requirements *helped* these mountains, the decision-makers seem unable to meet the socio-environmental and cultural needs that would favour the conservation and consolidation of a territorial identity that is in decline and in danger of disappearing.

For all these reasons, this article opens the door to rethinking conservation in a declining area of mountains in Europe. In Queixa-San Mamede, alternatives for re-designing the N2000N could be studied in depth. This would require a combination of substantial locally-based academic research coupled with a key role for local communities.

## Acknowledgements

This paper was undertaken in the context of a PhD research programme by the first author, at the University of Santiago de Compostela and within the broader framework of the research project *Collective Approach of Research and Innovation for Sustainable Development in Highland* (Doi: 10.3030/872328), funded by EU H2020 EXCELLENT SCIENCE — Marie Skłodowska-Curie Actions and led in Spain by the second author. We thank all the interviewees for their time and their precious, insightful views. We are also grateful for the helpful comments and criticisms made by the referees. Last but not least, we thank Roberto Vila-Lage for his support producing the second map and Carmel Sherrington for her work editing the English in various versions of this paper. The usual disclaimers apply.

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eco.mont – Volume 16, Number 2, July 2024
ISSN 2073-106X print version – ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont
https://doi.org/10.1553/eco.mont-16-2s47


# Threats to, and conservation of, biodiversity in the Siling Co National Nature Reserve, Tibetan Plateau, China

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*Keywords: Tibetan Plateau, biodiversity conservation, endangered species, wetlands, Siling Co*

Abstract

Due to its unique climate and geographic location, Siling Co National Nature Reserve, located in the northwest of the Tibet Autonomous Region of China, is an important natural habitat, a hotspot of endemism, and sustains numerous endangered species. Climate change and warming temperatures, invasion by non-native species and human disturbance are serious threats to the Tibetan Plateau's local biodiversity and specialized ecosystems. To better protect biodiversity and ecosystem functions in the specialized endemic habitats of the Plateau, we summarize the status, threats and protective conservation measures in the Reserve. It is hoped that this study will provide useful information and strategies for biodiversity conservation for the Tibetan Plateau and other highland regions.

Profile

Protected area

Siling Co National Nature Reserve / Tibetan Plateau, China

## Introduction

Mountainous regions support a high level of species richness and unique habitats. They also provide essential resources such as food, wood and medicine for human survival and sustainability (Körner 2004; Payne et al. 2020). Unfortunately, climate change, ecological disruptions caused by non-indigenous species, human disturbance and habitat fragmentation pose great threats to biodiversity, ecosystem services, and human wellbeing in many highland regions (Sala et al. 2000; McCain & Colwell 2011; Rahbek et al. 2019).

Among China's many mountainous regions with a great diversity of species (Tang et al. 2006), the Tibetan Plateau, a relatively young mountain range from a geological perspective (Zhang et al. 2002), hosts diverse habitats for endangered and endemic species. Recognized as a global biodiversity hotspot, it has become a priority area for conservation efforts (Myers et al. 2000). However, the number of endangered and/or endemic species has historically been greatly underestimated by researchers due to the challenges of accessing its remote areas and its vast size (Wang & Li 1982; Zhang & Zhang 2019). For instance, the first scientific investigation of the Tibetan Plateau in the 1970s identified nearly 1,000 new species (Zhang & Zhang 2019). Since 2017, a number of further new species have been observed and reported, during the second Tibetan Plateau Scientific Expedition and Research Program (Li et al. 2024). Nevertheless, information regarding biodiversity in many regions of the Plateau is still limited, hindering effective conservation efforts.

Siling Co is the largest lake on the Tibetan Plateau and the second largest saline lake in China (Figure 1). It sustains the largest numbers of rare and endangered species of any lake in the surrounding alpine grassland ecosystems of the Plateau. The lake is also the world's largest natural reserve of black-necked cranes (*Grus nigricollis*), a species that is protected nationally, and provides important habitats for other nationally protected animals such as the snow leopard (*Panthera uncia*), Tibetan antelope (*Pantholops hodgsonii*), argali (*Ovis ammon*), kiang (*Equus kiang*), and Tibetan snowcock (*Tetraogallus tibetanus*). To protect these species, Siling Co Nature Reserve was established in 1993 as an autonomous regional-level nature reserve; it was upgraded to Siling Co National Nature Reserve in 2003.

This study provides a comprehensive review of the current status of biodiversity, threats, and conservation efforts in the Siling Co National Nature Reserve. We hope that this study will furnish valuable information and recommendations for managers at this and other reserves in mountainous regions.

## Study area

The Siling Co National Nature Reserve is situated in the northwestern part of the Tibet Autonomous Region, China, in the north of the Tibetan Plateau. It stretches from the East Gangdis Mountains in the south to the northern edge of the Siling Co catchment area, on the south side of the Heihe-Ali highway. In the west, it extends to the watershed between the Tangra Yumco salt lake and lakes Munico and Xurucuo; the eastern boundary is formed by the watershed between the Yinmenqu and Bobuqu rivers. The Reserve is located in an area administered by Naqu City and covers 18,936 km$^2$, with coordinates ranging from longitude 86°40' to 92°30'E and latitude 30°10' to 32°05'N (Figure 2). The Reserve's average elevation is 4,530 m a.s.l., with some peaks exceeding 6,000 m.

The Siling Co National Nature Reserve is located in a sub-alpine monsoon region with a semi-arid climate. The annual average temperature is below 0°C. There are only five months with a monthly average above



*Figure 1 – Landscape of Siling Co. © Xiong Xiong*

0°C. The average for the warmest month is about 9°C, and that of the coldest month is approximately −35°C. The annual average precipitation is about 300–400 mm.

## Biodiversity

With the support of the National Science and Technology Basic Special Project from 2014 to 2019 and the second scientific expedition to the Tibetan Plateau initiated in 2017, we conducted a more systematic and comprehensive investigation than earlier studies into the biodiversity of Siling Co National Nature Reserve. According to our field studies and literature review, there are 472 vascular plant species belonging to 147 genera and 40 families. At the family level, Compositae are represented by the greatest number of species (171), followed by Gramineae (51), Cruciferae (33), Leguminosae (28) and Cyperaceae (21). Other families contributed fewer than 20 species each.

The Reserve also supports a very rich animal biodiversity, comprising 105 birds belonging to 27 families and 15 orders, 23 non-avian animals belonging to 10 families and five orders, 10 fish species belonging to two families and one order, three reptiles belonging to two families and one order, and one amphibian species. Among these, 12 are listed as Category I protected species (Figure 3): *Grus nigricollis*, *Aquila chrysaetos*, *Aquila heliaca*, *Gypaetus barbatus*, *Haliaceetus leucoryphus, Haliaceetus albcilla, Panthera uncia*, *Pantholops hodgsonii*, *Ovis ammon*, *Equus kiang*, *Tetragallus tebetanus* and *Bos mutus*.

## Threats to Siling Co National Nature Reserve

### Global warming

Global warming poses a significant threat to biodiversity in highland habitats (Yang et al. 2022). Over the past 50 years, the Tibetan Plateau has warmed at more than twice the global average rate, increasing by 0.3°C ~ 0.4°C per decade, reaching its highest temperature in the last 2,000 years (Chen et al. 2015). Environmental changes, such as rising temperatures, altered water distribution patterns, extreme climate events and landslides, have threatened biodiversity by affecting distribution areas, the physiological status of organisms, and the relationships between flora and fauna (Li et al. 2022). Rising temperatures mean that the Tibetan Plateau now receives more precipitation as rain than as snow (Ombadi et al. 2023). Extreme precipitation leads to a higher risk of flooding, landslide hazards and soil erosion. The resulting silt causes damage to fishes' gills, and high-altitude endemic fishes, amphibians and even water birds have become excluded from small wetland sites that were formerly suitable and important to their sustenance (Aziz et al. 2021).

### Human disturbance

Human disturbance is one of the leading reasons for the decline of biodiversity in the highland ecosystem (Yang et al. 2022). The expanding human population, from 23.5 million in 1980 to 34.25 million in 2019 (Fu et al. 2021), has led to rapid urbanization and increased pressure on wildlife survival in cities like Lhasa, Shigatse and Chamdo (Wang et al. 2021; Zhang et al. 2022). Furthermore, the production of water for human consumption and everyday life has depleted water levels in lakes, rivers and wetlands, posing a threat to endemic species of fish such as *Schizopygopsis younghusbandi*, *Schizothorax o'connori* and *Schizothorax waltoni* (Wang et al. 2021; Xiong et al. 2023; Zhang et al. 2023). With its improved transport infrastructure, including the Qinghai-Tibet Railway, Tibet attracts increasingly high numbers of domestic and international tourists (over thirty million in 2022) (Statistic Bureau of Tibet Autonomous Region 2022), with Siling Co being an important scenic spot along the Lhasa to

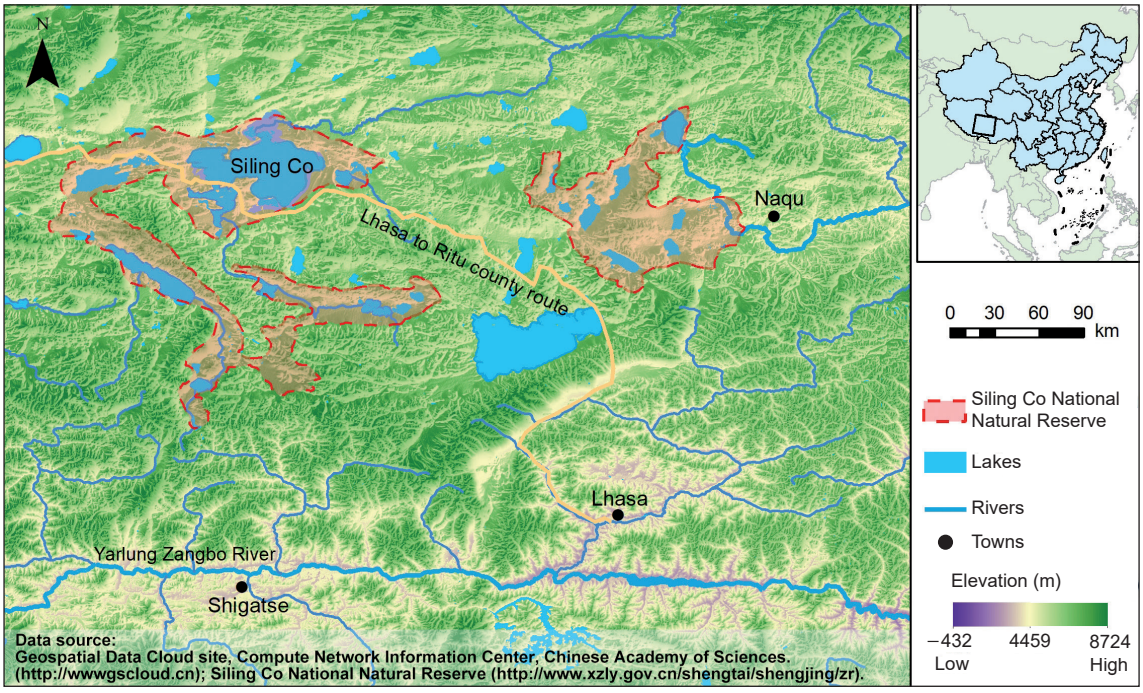



*Figure 2 – Location and spatial extent of Siling Co National Nature Reserve.*

Ritu county route (Figure 2). Unfortunately, tourists unintentionally introduce pests, such as the brown rat (*Rattus norvegicus*), which may carry parasites that are a threat to native biodiversity (Li et al. 2009).

### Non-native species

The invasion of non-native species poses a significant threat to aquatic biodiversity (Sala et al. 2000). In recent years, China has experienced a substantial increase in introductions of non-native aquatic species (Xiong et al. 2015, 2023; Wang et al. 2016, 2021). In the first scientific survey of the Tibetan Plateau (1973–1976), there were no records of established populations of non-indigenous species. Many researchers believed that the harsh environment of the Plateau was unsuitable for invasive species to thrive. However, over the past two decades, numerous non-native aquatic species, including fishes, amphibians and plants, have been intentionally introduced to the Plateau for aquaculture, the aquarium trade, and other purposes (Deng et al. 2021; Wang et al. 2023; Zhu et al. 2023). The Plateau's diverse aquatic habitats, such as freshwater lakes, salt lakes, rivers and wetlands, provide suitable conditions for these non-native species. We have observed established populations of various species, including *Carassius auratus*, *Pseudorasbora parva*, *Paramisgurnus dabryanus* and *Cyprinus carpio*, in a variety of habitats (Feng et al. 2023; Xiong et al. 2023). These non-native species have caused a rapid decline in biodiversity and have altered the structure and functioning of the ecosystem (Xiong et al. 2023).

## Protective recommendations

Ecological monitoring is crucial for the conservation of biodiversity (Martin et al. 2007). However, conducting regular monitoring on the Plateau is challenging due to the harsh environmental conditions such as low temperatures, blizzards and debris flows, and the presence of dangerous wildlife. Additionally, transport difficulties further complicate monitoring efforts in the Tibetan Plateau. To overcome these obstacles, it is essential to implement new monitoring techniques widely, such as environmental DNA, remote sensing, drone photography and automatic cameras (Nathan et al. 2015; Hill et al. 2016; Aguzzi et al. 2020); urgent action is needed to allocate more funds, equipment and resources for ecological monitoring. Furthermore, there should be a focus on providing technical training to personnel involved in monitoring, while collaboration among local government bodies, non-governmental environmental organizations, and the local community is vital to educate people and to promote biodiversity conservation.

Numerous measures have been implemented by the management of the Siling Co National Nature Reserve to protect endangered and endemic species, including the construction of fences, the creation of an ecological corridor, and the artificial propagation and release of endangered endemic species (mainly *Schizothorax* spp. and *Triplophysa* spp.). There is an urgent need to recruit highly specialized professionals for research on artificial propagation, life-history traits, and suitable habitats for these species, but the scarcity of highly qualified people is a significant constraint: in 2022, less than 0.02% of the population in the Tibet




*Figure 3 – Some of the protected animals in the Siling Co National Natural Reserve. © Wang Baoqiang*

Autonomous Region held a PhD, the lowest figure in China (Statistic Bureau of Tibet Autonomous Region 2022).

## Acknowledgements

This research was supported by the Finance Special Fund of the Chinese Ministry of Agriculture and Rural Affairs of the People`s Republic of China (Fisheries resources and environment survey in the key water areas of Southwest China), and by the National Natural Science Foundation of China (No. 31900374, 32070436). We thank Dr. Jin Gao for processing the images in this article.

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eco.mont – Volume 16, Number 2, July 2024
ISSN 2073-106X print version – ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont
https://doi.org/10.1553/eco.mont-16-2s53



# The research framework of Austria's National Parks

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*Keywords: protected area, national park, Austria, field research*

## Abstract

Austria's National Parks are home to large parts of the country's biodiversity. While following regional research interests, the National Parks are committed to a joint vision and research strategy. Experienced staff address scientific questions by conducting their own research, commissioning research or working on collaborative projects. Researchers and students are encouraged to capitalize on available long-term data and to aim for an extraordinary level of scientific outreach.

## Who we are

Austria's National Parks (NPs) cover no more than 3% of the country's total territory (Figure 1) but are known to host exceptional flora and fauna as well as irreplaceable habitats, both in alpine and in continental ecosystems. The protected areas are home to 370 species of vertebrates (89% of Austria's vertebrate species) and 2,006 native vascular plants (69% of Austria's native vascular plant species). They also comprise 57 exceptional habitats (80% of Austria's habitats listed in Habitats Directive Annex I). Zulka et al. (2022) found 88 endemic and subendemic animal species and 37 vascular plant species typical of the environments within the Austrian NPs.

Austria's NPs are assembled under the umbrella organization *Nationalparks Austria*, which fosters innovation, joint projects, public relations work and strategic decisions. The administrations of the Donau Auen, Gesäuse, Hohe Tauern, Kalkalpen, Neusiedler See – Seewinkel and Thayatal National Parks have a shared vision of preserving biodiversity through the protection and conservation of natural processes. Research creates the indispensable basis for understanding and communication and thus for protecting nature (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft 2010; Bundesministerium für Nachhaltigkeit und Tourismus 2018). All of Austria's NPs are approved by the IUCN as Category II *national parks*. In addition, parts of Hohe Tauern NP (Sulzbachtäler) are listed as Category Ib, *wilderness areas* (Salzburger Nationalparkfonds 2018).

Austria's NPs are probably the largest scientific open-air laboratories in the country. They are centres

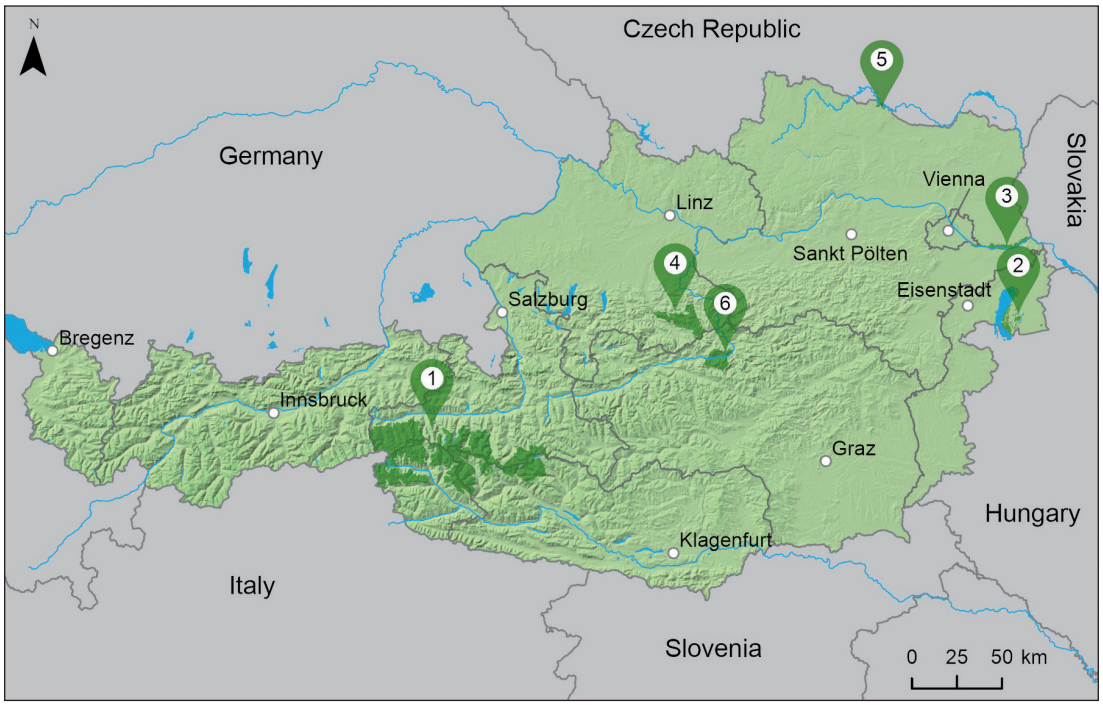



*Figure 1 – Austria's six National Parks: (1) Hohe Tauern, (2) Neusiedler See – Seewinkel, (3) Donau Auen, (4) Kalkalpen, (5) Thayatal, (6) Gesäuse. Design: Matthias Prüggler, Database: GIS Steiermark, BEV, ESRI.*

of regional competence in nature protection, environmental education and recreation, as well as promoters of sustainable development and scientific communication. These regions were important locations for the study of natural processes long before the NPs themselves were founded. The climate observatory located on the Hoher Sonnblick holds an uninterrupted data series started in 1886 (Schausberger 2017); the monastery of Admont holds a comprehensive collection of entomological and botanical specimens of the region (Chvála 2014), to name just two examples of long-term data banks which today can be accessed by the NPs. The research carried out by Austria's NPs is based on these historical records but also incorporates modern research techniques, for instance remote sensing, landscape modelling and genetic analyses. All NP administrations in Austria follow jointly developed guidelines on how research should be conducted in the parks (Nationalparks Austria 2017). Furthermore, each park has elaborated specific research concepts (Cimadom et al. 2021; Maringer & Kreiner 2012; Mayrhofer 2020; E.C.O. Institut für Ökologie 1998; Verein Sekretariat des Nationalparkrates 2021, Reckendorfer et al. 1998; Nationalpark Thayatal 2021: 67–73).

## The six Austrian National Parks

### Donau Auen National Park

The Donau Auen NP, established in 1996, covers an area of 9,600 hectares, and protects one of the last ecologically largely intact, near-natural river and floodplain landscapes in Central Europe. Despite the regulation of the Danube in the 19th century, the free-flowing section of the Danube between the capital cities of Vienna and Bratislava still has the dynamic to reshape parts of the floodplains, and there is great potential for renaturation. As a result, the Danube provides habitats for numerous animals and plants and is particularly rich in species and habitats of national and European importance (Nationalpark Donau-Auen GmbH 2019). Within Austria, the NP is a particularly important hotspot for fish and amphibian species (Zulka et al. 2022).

Research in the protected area focuses on issues that support its administration in management decisions, document the development of the area, or are of relevance to the public (Table 1). In the areas of forest and meadow, the NP's administration carries out regular monitoring of browsing by ungulates. It also monitors selected species (see Table 1) that are of particular interest for management or as indicators of the conservation status of ecosystems. The development of aquatic processes and abiotic conditions in this NP has been documented by other institutions (Nationalpark Donau-Auen GmbH 2019).

### Gesäuse National Park

Gesäuse NP, Austria's youngest NP, was established in 2002. The protected area covers 12,300 hectares and is characterized by rock, alpine meadows, forests and aquatic habitats. Dachstein limestone and fast-weathering dolomite create extensive areas of scree. Steep slopes encourage dynamic natural processes such as avalanches and landslides (Maringer & Kreiner 2016). Situated on the edge of the Alpine glacial shield during the last ice age, the area is a hotspot of endemism and has retained more than 200 endemic and subendemic species (Komposch & Kreiner 2018). Research activities in Gesäuse NP currently focus on the great diversity of species and habitats that are among the park's most important natural assets. It is an ideal location to conduct long-term monitoring of highly dynamic habitats and to investigate natural succession in a naturally wild area. In addition to the endemic species, research also focuses on flagship species such as the golden eagle, the lady's-slipper orchid and the common sandpiper. Thirteen climate stations regularly monitor abiotic parameters (Fuchsberger et al. 2023) and provide a basis for climate-related studies. The NP aims to become more transdisciplinary and to integrate socio-economic questions into its agenda. Alongside well-established monitoring of birds and habitats that figure in the EU's species and habitats directives, a comprehensive method for visitor monitoring was designed and has been implemented. All data collected favours adaptive management, supporting the NP's decision and policy making.

### Hohe Tauern National Park

The Hohe Tauern NP, founded over 40 years ago, is an extensive protected area in Central Europe, spanning 185,600 hectares across three Austrian provinces. Its conservation efforts are dedicated to preserving the Alpine ecosystem, from valley bottoms to peaks, the highest of which reaches 3,798 metres. The park boasts exceptional biodiversity, with flora and fauna from the Central Asian tundra, the Arctic and Southern Europe. It encompasses sections of the Tauern Window, with its distinctive geological features, and houses the Sulzbachtäler, one of Central Europe's few wilderness areas (Figure 2). Furthermore, the park has helped to revive species on the brink of extinction in Europe, such as the bearded vulture (*Gypaetus barbatus*) (Niebuhr & Zink 1998).

The pristine high-alpine ecosystems within the park play a crucial role in scientific research, offering a unique opportunity to study nature unaffected by direct human impact such as Alpine agriculture. To detect changes, the NP has established long-term monitoring (Körner et al. 2022) and employs remote sensing utilizing orthophotos (Hauenstein & Haller 2013). In collaboration with Haus der Natur, it engages in extensive biodiversity data collection through citizen science and *Tage der Artenvielfalt* (Biodiversity Days), where experts annually survey a section of the National Park to identify species (see e.g. Gros et al. 2023). In addition to these efforts, yearly raptor monitoring and many other ongoing research projects are conducted.

*Table 1 – Key figures, main scientific topics and research interests of Austria's National Parks (NP).*

| Managing authority | Est. | Total area [ha] | % | Main habitats | Flagship species | Main scientific topics and interests |
|---|---|---|---|---|---|---|
| Donau Auen NP | 1996 | 9,615 | 65<br>15<br>20 | riparian forest<br>meadow<br>running, inland, surface water | - European pond turtle (*Emys orbicularis*)<br>- White-tailed eagle (*Haliaeetus albicilla*)<br>- Common kingfisher (*Alcedo atthis*)<br>Water soldier (*Stratiotes aloides*)<br>- Little ringed plover (*Charadrius dubius*)<br>- European mudminnow (*Umbra krameri*)<br>- Great capricorn beetle (*Cerambyx cerdo*)<br>- Black poplar (*Populus nigra*) | - Biodiversity of floodplain habitats<br>- Riverine processes (geomorphology, sedimentation, erosion)<br>- Long-term development of species and habitats<br>- Large-scale ecology of the Danube river corridor<br>- Socio-economic development of the NP region<br>- Nature experience for visitors; visitor perceptions<br>- Effects of measures and interventions |
| Gesäuse NP | 2002 | 12,300 | 52.5<br>24<br>13<br><br>10<br>0.5 | forest<br>rock and gravel<br>shrubs and wooded land<br>Alpine meadows<br>running, inland, surface water | - Golden eagle (*Aquila chrysaetos*)<br>- Lady's-slipper orchid (*Cypripedium calceolus*)<br>- Common sandpiper (*Actitis hypoleucos*)<br>- Grouse (*Tetraonidae*)<br>- German tamarisk (*Myricaria germanica*) | - Endemic species<br>- Natural dynamic processes (avalanches, windthrows)<br>- Biodiversity and long-term development of dynamic habitats<br>- Climate change in the northern limestone Alps<br>- Research on springs and caves<br>- Monitoring of endangered species<br>- Impacts of visitor pressure on wildlife; visitor management |
| Hohe Tauern NP | 1981 | 185,600 | 54<br><br><br>32<br><br><br>9<br>4<br><br>1 | glacier, rock, scree and dwarf shrubs<br>subalpine / alpine grassland and pasture<br>forest<br>shrubs (green alder and dwarf mountain pine)<br>running, inland, surface water | - Bearded vulture (*Gypaetus barbatus*)<br>- Alpine ibex (*Capra ibex*)<br>- Golden eagle (*Aquila chrysaetos*)<br>- Ipine marmot (*Marmota marmota*)<br>- Alpine chamois (*Rupicapra rupicapra*) | - Long-term monitoring of mountain ecosystem processes<br>- Biodiversity of flora and fauna, and geodiversity<br>- Monitoring of waters and alpine river ecosystems (hydrology, glaciology, geomorphology, aquatic ecology and biodiversity)<br>- Autochthonous brown trout (preservation, stocking, monitoring)<br>- Monitoring of cloven-hoofed game (spatial behaviour, health)<br>- Birds of prey (monitoring, Alps-wide bearded vulture reintroduction project)<br>- Economy and society (regional economic and social development through research)<br>- Data and knowledge management |
| Kalkalpen NP | 1997 | 20,850 | 81<br>8<br>6<br>5 | forest<br>mountain pine<br>Alpine meadow<br>rock and gravel | - White-backed woodpecker (*Dendrocopos leucotos*)<br>- Little flycatcher (*Ficedula parva*)<br>- Smooth snake (*Coronella austriaca*)<br>- Lynx (*Lynx lynx*)<br>- Alpine longhorned beetle (*Rosalia alpina*)<br>- Ash fritillary butterfly (*Euphydryas maturna*)<br>- Augsburg bear (*Arctia matronula*)<br>- Scarlet beetle (*Cucujus cinnaberinus*)<br>- Pug bat (*Barbastella barbastellus*)<br>- Lesser horseshoe bat (*Rhinolophus hipposideros*)<br>- endemic cave ground beetle (*Arctaphaenops muellneri*) | - Primeval forest relict species<br>- Species of the Habitats Directive (FFH / Natura 2000)<br>- Endemic species<br>- Monitoring of springs<br>- Integrated Monitoring by Austrian Environment Agency (UBA)<br>- Stock control of important endangered species<br>- Natural dynamic processes (e. g. avalanches, windthrows)<br>- Data and knowledge management |
| Neusiedler See – Seewinkel NP | 1993 | 9,652 | 43<br>30<br><br>27 | reed<br>meadow and pasture<br>inland, standing surface water | - Moustached warbler (*Acrocephalus melanopogon*)<br>- Kentish plover (*Anarhynchus alexandrinus*)<br>- Eurasian spoonbill (*Platalea leucorodia*)<br>- Pied avocet (*Recurvirostra avosetta*)<br>- European green toad (*Bufotes viridis*)<br>- Horned dung beetle (*Copris lunaris*)<br>- Alcon large blue (*Phengaris alcon*)<br>- Fairy shrimp (*Branchinecta orientalis*)<br>- Pygmy iris (*Iris pumila*)<br>- Sea aster (*Tripolium pannonicum*) | - Monitoring and management of soda pans<br>- Ecology of reedbeds<br>- Ecology and management of grassland habitats<br>- Bird monitoring<br>- Vegetation monitoring |
| Thayatal NP | 2000 | 1,360 | 92<br>4<br>3<br><br>1 | forest<br>meadow<br>running, inland, surface water<br>heathland and rock | - European wildcat (*Felis silvestris*)<br>- European crayfish (*Astacus astacus*)<br>- Black stork (*Ciconia nigra*)<br>- European green lizard (*Lacerta viridis*)<br>- Eurasian otter (*Lutra lutra*)<br>- Siberian melic grass (*Melica altissima*)<br>- Jersey thrift (*Armeria arenaria*)<br>- Softhaired feathergrass (*Stipa dasyphylla*) | - Record of biodiversity<br>- Research on, and conservation of, endangered species and endemic plant species (e. g. *Sorbus hardeggensis*, *Sorbus thayensis*, *Sorbus cucullifera*) and rare mosses (*Riccia gougetiana*, *Ceohaloziella stellulifera*, *Pyramidula tetragona*, *Oxymitra incrassata*, *Riccia pillosa*)<br>- Research into resilient forests |

## Kalkalpen National Park

The Kalkalpen NP is home to the largest contiguous unpopulated forest area in Austria. 32 forest communities, including the beech forests designated a UNESCO World Heritage Site in 2017 (Nationalpark OÖ Kalkalpen 2015), can be found in the 20,850-hectare protected area, as well as half of all 70 tree species found in Austria. *Back to forest wilderness* is the credo in the Kalkalpen NP forests in Upper Austria, which have been allowed to develop free from human interven-



*Figure 2 – Kleinvenediger (3,468m) with the Untersulzbachkees, which feeds the Untersulzbach, and the Schwarze Hörndl (3,100m) on the right. © Andreas Baldinger*

tion since the protected area was established in 1997. A multi-year study (Flaschberger 2018) has shown that the transformation from commercial forest to forest wilderness is taking place rapidly. The beneficiaries of this rewilding project are the xylobiont beetles (Degasperi & Eckelt 2020), bats (Pysarczuk & Reiter 2010), and mountain forest birds (Weißmair 2014). The NP is also particularly valuable to butterflies thanks to the close interlinking of very large, sparse forests with the meadows and pastures of the old mountain cultural landscape (Huemer et al.2014). These spots are preserved in a so-called *conservation zone* dedicated to exceptional species and habitat protection, for example through carefully managed grazing and mowing. The NP also contains Danube brook trout that have remained untouched by stocked fish. Their protection and the restoration of a natural fish species community in the area of the Großer Bach (Weiss & Schenekar 2021) are of great importance.

Over 1,020 plant species have been identified during biotope mapping (Mayrhofer 2015). This corresponds to around a third of all plant species in Austria, many of which are on the Red List (Schratt-Ehrendorfer et al. 2022).

## Neusiedler See – Seewinkel National Park

Neusiedler See – Seewinkel NP, founded in 1993, has an area of roughly 10,000 hectares. Located on the eastern edge of the Alps and the western edge of the Hungarian Plain, the area is characterized by a mosaic of large wetlands, reed beds, dry grasslands, pastures, sand steppes, salt marshes and soda pans. The international importance of this natural area lies in its extraordinary biodiversity and its indispensable function for birds migrating between Europe and Africa: approximately 100 migratory bird species use the area as a stop-over. Around 150 bird species regularly breed in the area. Moreover, it is the only breeding site in Austria for several rare bird species (Dvorak et al. 2020).

Research in the NP is designed for the long term, with the aim of evaluating and adapting management measures (Cimadom et al. 2021). Long-term monitoring programmes focus on bird species (e.g. Dvorak et al. 2021) and the impact of grazing on plant communities (see e.g. Euller et al. 2014). Since 2018, new methods such as remote sensing, passive acoustic monitoring, and geophysical approaches have been established, as have new monitoring programmes on, for example, dung beetles (Schernhammer & Denner 2022) and abiotic parameters of soda pans.

## Thayatal National Park

Currently measuring around 1,360 hectares, Thayatal is Austria's smallest National Park. The combination of diverse geology, river morphology and the valley's location at the intersection of two climate zones, the dry Pannonian climate from the east and the humid Atlantic climate from the west, created the conditions for very high biodiversity. Many endangered animal species as well as rare botanical species are abundant here (Bassler & Karrer 2015; Schmitzberger et al. 2010). The NP plays a major role in the survival of at least nine species of moss and is home to five others which are found nowhere else in Austria (Zechmeister & Kropik 2020). One of the main areas of research in the Thayatal NP is the ecology and habitat usage of the European wild cat (*Felis silvestris*) (Wimmer-Schmidt 2021). Understanding local population dynamics and the release of wild cat individuals

into the wild are part of the ongoing research. In another ongoing project, soil samples are analysed using innovative eDNA metabarcoding methods to determine the presence of soil fungi. The population and propagation of the endemic apomictic Sorbus species is also being studied (Schmitzberger 2020), as are xylobiont beetles. Another major focus is collaborative cross-border research with the neighbouring Podyjí NP in the Czech Republic.

## Latest challenges

The broad base of their activities and the need to tackle ongoing challenges make keeping on track and attaining their strategic goals highly demanding for managers in Austria's NPs. The parks enjoy good relationships with experts and scientists all over the world, but maintaining a well-developed national and international network can be time-consuming and requires considerable resources to keep up with state-of-the-art techniques and to qualify for prestigious projects. Europe-wide, funding research through well-defined projects with a limited timespan often works for particular research agendas and questions. However, in the case of long-term monitoring of complex (eco-)systems, this approach is inappropriate for achieving valuable, high-quality data series. Funding bodies, research institutes and NP administrations need to develop means of securing long-term funding for such cases.

Researchers are often associated with independent scientific institutions or self-employed, making long-term projects more difficult. Sometimes, activities are carried out independently of NPs' administrative bodies, posing questions of data access and storage. Agreements and common standards, for instance data management plans (Science Europe 2021), could help mitigate these limitations, although long-term collaboration is often perceived as being less important than funding opportunities. Access to research results and achieving individual NPs' management goals rely on qualified and well-trained staff, but for a holistic approach to research and monitoring activities further expertise as well as an overview of all NPs in the country's network are required.

In addition to these challenges, climate change does not of course stop at a NP's border but affects everything from habitat management and the non-intervention principle, to visitor steering, education and research. However, the absence of a common approach among Austria's NPs means that a jointly developed climate-change strategy is overdue.

## Research networks and data accessibility

Zulka et al. (2022) concluded that species numbers in Austria's NPs are much higher than might be expected given the small area protected. They have shown that the parks are represent remarkably large parts of Austria's biodiversity. Each NP is also part of a well-established research network and cooperates closely with various experts, research institutes and universities, and with other authorities and protected area administrations. Over the years, Austrian NPs have positioned themselves as indispensable research sites in the international community, engaged in a variety of collaborative projects addressing global warming and other drivers of ongoing biodiversity loss. Initiatives in which they are involved include *European Long-Term Ecosystem Research* (Mirtl et al. 2015; Zacharias et al. 2021), *Global Observation Research Initiative in Alpine Environments* (Grabherr et al. 2000), and *GZÜV* (*Gewässerzustandsüberwachungsverordnung* – Water Condition Monitoring Ordinance, implementation of the Water Framework Directive, Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft 2022). The NPs provide such projects with indispensable permanent sites to obtain long-term data and to tackle urgent research questions.

The *International Symposium for Research in Protected Areas* is held on a regular basis, and its proceedings are published in conference volumes (Salzburger Nationalparkfonds & Nationalpark Hohe Tauern 2017; Bauch 2013, 2009, 2005; Wrbka & Egger 2023).

Scientific reports and relevant literature are available freely at www.parcs.at, which can also provide project metadata, geographic information, and any kind of text in a machine-readable format. The database is harvested by the open-government platform www.data.gv.at.

## Work with Austria's National Parks

NP staff address scientific questions by conducting their own research, through commissioned research, or through collaborative projects. Academic and applied research, which are often interdisciplinary, are supported. By the nature of NPs, the research questions addressed are mainly biological, but the broader field of studies includes socio-economics, geology and history.

What makes research work in Austria's NPs exceptional is that experienced staff are present all year round. They know their areas exceptionally well and can therefore advise in selecting the right spot for fieldwork and help in acquiring permits; they can also provide data and additional complementary information such as climate or historical studies. In many cases, NP authorities provide specific equipment and infrastructure, such as measuring devices, software, vehicles or accommodation.

Austria's NPs support young researchers through grants and by offering an annual award for the best thesis conducted within an NP. Students are encouraged either to carry out fieldwork or to capitalize on existing data, such as long-term monitoring records. Moreover, researchers from various scientific institutions are invited to contact the NP authorities (Table 1) in order to find potential synergies. A particular

strength of the NP network are the collaborations and partnerships between parks that can strengthen both scientific research proposals and outreach. By communicating research results and giving the public an understanding of the importance of science and conservation, for example through school programmes and social media, NPs act as exceptional disseminators.

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eco.mont – Volume 16, Number 2, July 2024
ISSN 2073-106X print version – ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont
https://dx.doi.org/10.1553/eco.mont-16-2s61


*McDowell, G., M. Stevens, S. Marshall, et al. 2023. The Canadian Mountain Assessment: Walking together to enhance understanding of mountains in Canada. Calgary: University of Calgary Press*
*ISBN 9781773855080 (hardcover);*
*ISBN 9781773855097 (softcover);*
*ISBN 97817735103 (Open Access PDF);*
*9781773855110 (PDF);*
*ISBN 97817738551127 (EPUB)*

Canada is the fourth most mountainous country in the world; approximately one-quarter of its total surface is covered by mountainous terrain. The authors of The Canadian Mountain Assessment (CMA) assume that around 1.3 million permanent residents live in the mountains of Canada, but in general these areas are sparsely populated. The mountain systems extend from the temperate ecosystems of the southern part of the Cordilleras facing the Pacific Ocean to the Laurentian highlands on the Atlantic side of the continent, and north to the Arctic ranges of Inuit Nunangat. Although large parts are regarded by visitors as *wilderness areas* and are classified as such by government agencies, many parts are places of spiritual significance, traditional resource use, and realms of economic and cultural survival for indigenous First Nations, Métis and Inuit.

Since the mountainous areas of Canada are classified as *mountains*, *highlands* and *hills*, and the distinction between these types of landforms can be debated, it would have been helpful if the authors of CMA had included definitions of them in a glossary. This, however, is a minor criticism of this landmark publication. It is an outstanding and in many ways innovative project, the first comprehensive presentation and assessment of Canadian mountains. It is the result of three years of research, mutual learning and knowledge sharing, including both *Western* academic expertise and advice, and indigenous wisdom and knowledge. The book is a remarkable piece of scientific work, compiled by a total of 75 authors from different disciplines and backgrounds. Following the Introduction, there are five major chapters: Mountain Environments, Mountains as Homelands, Gifts of the Mountains, Mountains under Pressure, and Desirable Mountain Futures. Each chapter is co-led by indigenous and non-indigenous authors, A great merit of the work is the way in which a large number of videos are embedded, giving a vivid voice to the oral knowledge and insights of indigenous people in so-called *Learning Circle Contributions*. Many mountain scholars, including the reviewer, have already argued that *listening* to small farmers and endogenous knowledge is a key to environmental, cultural, social and economic sustainability, but never before could we listen directly to the voices, wisdom and oral testimonies of such a myriad of indigenous people. Each chapter is generously illustrated by figures and tables and contains a glossary of terms, as well as an extensive list of references.

In the initial approach of this mountain project, the research team was guided by the five major principles of Service, Inclusivity, Humility, Responsibility and Action, the provision of service to mountain communities being one of the CMA's principal mandates. The CMA is further guided by the overarching principle of taking into account the diversity of mountain environments and communities through a broad and inclusive approach. The team also pursued its work in a spirit of humility, aware of its own limitations, as well as with a commitment of responsibility towards individuals and communities. The ultimate goal of the CMA is to deepen and widen understanding of the importance of mountains, to disseminate the findings of the assessment project, and hopefully to contribute to desirable futures for mountain environments and communities.

This outstanding and in many ways pioneering project and book would certainly merit a deeper and more extensive review than is possible within the limits of this journal. It makes a major contribution to interdisciplinary mountain studies (*Montology*) in general, to the understanding of Canadian mountains specifically, and very importantly points the way towards the collaborative inclusion of indigenous and non-indigenous knowledge.

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