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## Editorial

First of all, there are changes in the eco.mont team. With this issue we would like to say goodbye to Mr. Martin Coy as co-editor of eco.mont, who is taking well-deserved retirement, and introduce Ms. Margreth Keiler as our new co-editor. Martin has been co-editor since 2017 and we would like to thank him for his commitment. Margreth is Professor of Geography at the Department of Geography, University of Innsbruck, Austria, and Director of the Institute for Interdisciplinary Mountain Research at the Austrian Academy of Sciences (ÖAW). As co-editor of eco.mont she represents the University of Innsbruck. As a researcher, Margreth deals with the long- as well as short-term natural hazards and risks in mountain regions in connection with global climate and land-use changes. She thus brings new expertise to the eco.mont team.

Extreme events and resulting disasters have focused the attention of the global community on susceptibility to natural hazards. Disaster risk reduction (DRR) needs therefore to be an integrated part of sustainable development strategies. Moreover, in the last decade the important role of ecosystem services as one key in DRR and strengthening community resilience has become increasingly recognized. It is therefore increasingly urgent that PAs develop their role in facilitating DDR within their boundaries and beyond.

Since eco.mont first appeared 15 years ago, there have been three articles on hazards. Bohner et al. (2010) present their research on avalanches as natural ecological process which are species-rich habitats, Thaler et al. (2021) write about flood risk management and Huber et al. (2021) describe the resilience of communities in protected mountain areas. In the News section of this issue, the international project MultiBios which together with biosphere reserve in Austria, Switzerland and Germany explores how affected communities and regions can better prepare for multiple climate risks is being introduced. We hope that research and publications about hazards and DRR in protected mountain areas will be increasing and communities will thus be strengthened in their response.

The current issue again covers a wide range of topics concerning protected areas globally. Geographically, the articles cover protected areas in the Alps, the Himalayas, Southern Siberia and the Italian island of Sardinia. The subjects discussed include anthropogenic sounds and their influence on outdoor recreation, sacred larch trees as cultural monuments, firewood as a natural resource, sustainable regional development in a natural park and Biosphere Reserve on Sardinia, a glimpse into the EuroMAB Conference 2022 in Carynthia, Austria, the influence of historic and current land-use changes on wetland habitats, the development of the small-mammal fauna in the Swiss National Park in the last 100 years, and the conservation of endemic species in the Yarlung Zangbo river basin in Tibet.

For the future we plan a special issue in 2025 on biodiversity change in mountain protected areas and we would particularly welcome papers on that topic. We would also welcome articles on risks and hazards in line with Margreth's area of expertise.

Margreth Keiler and Valerie Braun

Bohner, A., H. Habeler, F. Starlinger & M. Suanjak 2010. Avalanches keep habitats open and species-rich in the montane and subalpine belt. *eco.mont – Journal on protected mountain areas research and management* 2-1: 53–57.

Huber, L., E. Posch, R. Bell, K.M. Höferl, R. Steiger, R. Stotten, E. Tasser & G. Leitinger 2021. Two perspectives – one goal: resilience research in protected mountain regions. *eco.mont – Journal on protected mountain areas research and management* 13-2: 12–20.

Thaler, T., C. Clar, L. Junger & R. Nordbeck 2021. Opportunities and challenges for transdisciplinary research in flood risk management: some critical reflections and lessons learnt for research on sustainability. *eco.mont – Journal on protected mountain areas research and management* 13-2: 42–47.

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# Alpine soundscapes: sounds and their consequences for perceived recreational quality – A case study of two Regional Nature Parks – Beverin Nature Park and Parc Ela in Switzerland

*Ricarda Ferrari, Reto Rupf & Birgit Reutz*

*Keywords: Alpine areas, anthropogenic sounds, outdoor recreation, noise*

Abstract

Regional Nature Parks (RNPs) such as the Parc Ela and Beverin Nature Park are popular destinations for outdoor activities and recreation in the Alpine areas of Switzerland. As in many other mountain and peripheral regions, their soundscapes are being increasingly influenced by humans. Little is known about which sound types are perceived positively or negatively by visitors in Alpine areas and how sounds affect visitors' perceived recreational quality. To better understand this relationship, surveys were carried out in four areas of two RNPs, Beverin Nature Park and Parc Ela. Each area included two or three sites with different anthropogenic sound levels. Sounds with anthropogenic origins were found to be rated significantly more negatively than sounds with biophonic and geophonic origins. Using linear mixed models, this study confirmed that sound levels had the strongest effect on the perceived quality of visitors' recreation at sites with similar visual landscape features. Sites with low levels of anthropogenic sounds were perceived as having the least impact on recreational quality. However, no significant difference in the impact of sounds on perceived recreational quality was found between medium and high sound levels, indicating that there could be a threshold between 33.7 and 38.6 dBA above which noise has a negative impact on recreational quality.

Profile

Protected area

Regional Nature Parks

Beverin and Ela

Mountain range

Alps

Country

Switzerland

## Introduction

*Soundscape* refers to the interplay of all sounds perceived at a specific place and time (Schafer 1977). To standardize the widely used term *soundscape*, the definition has been given as *"[the] acoustic environment as perceived or experienced and/or understood by a person or people, in context"* (ISO 12913-1 2014). Sounds within a soundscape are classified according to their origin, either natural or anthropogenic. Natural sounds can be further divided into biophonic sounds produced by biological organisms other than humans, and geophonic sounds, which have geophysical or non-biological environmental causes (Krause 1987; Pijanowski et al. 2011a).

A tranquil soundscape is not characterized by the complete absence of sound. Low levels of biophonic and geophonic sounds enhance the feeling of tranquillity (Botteldooren & Coensel 2006). People seek natural acoustic environments that are not influenced by anthropogenic sounds as these environments have a positive effect on their health and psychological wellbeing, and help people to feel more connected to nature (Miller 2008; von Lindern 2015; Aletta et al. 2018).

Just what contributes to recreational quality when spending time in nature has been the subject of scientific research for some time and is still not yet fully understood. One explanation is the Attention Restoration Theory, according to which spending time in nature restores our ability to concentrate and perform (Kaplan & Kaplan 1989). Acoustics as an external stimulus also contribute to this effect. Natural sounds can activate our attention by creating a sense of distance from noisy everyday life.

Natural landscapes and acoustic environments are increasingly influenced by human activities. The growth of leisure activities and the resulting increase in traffic have led to natural acoustic environments becoming a scarce resource (Lynch et al. 2011). People spend more of their leisure time in nature to get away from everyday life (Iglesias Merchan & Diaz-Balteiro 2013; Leeb et al. 2020), and during the Covid 19 pandemic the trend towards outdoor recreation continued to expand (Geng et al. 2021). Since few local, easily-accessible, tranquil recreation areas remain, outdoor sports enthusiasts in search of seclusion and tranquillity are drawn to remote areas – notably to the Alps in Central Europe (Willibald et al. 2019; Leeb et al. 2020). According to the European Environment Agency (2016), the few remaining quiet areas in Europe are found mainly in mountainous regions, but tourism itself might endanger those quiet areas, especially if it is not developed sustainably (Weber & Rosenberg-Taufer 2017).

Regional Nature Parks (RNPs) are popular excursion and holiday destinations of sustainable tourism in the Alpine areas of Switzerland (Knaus 2018). Parks with the label RNP follow federal guidelines and are characterized by a sustainable approach to nature, the

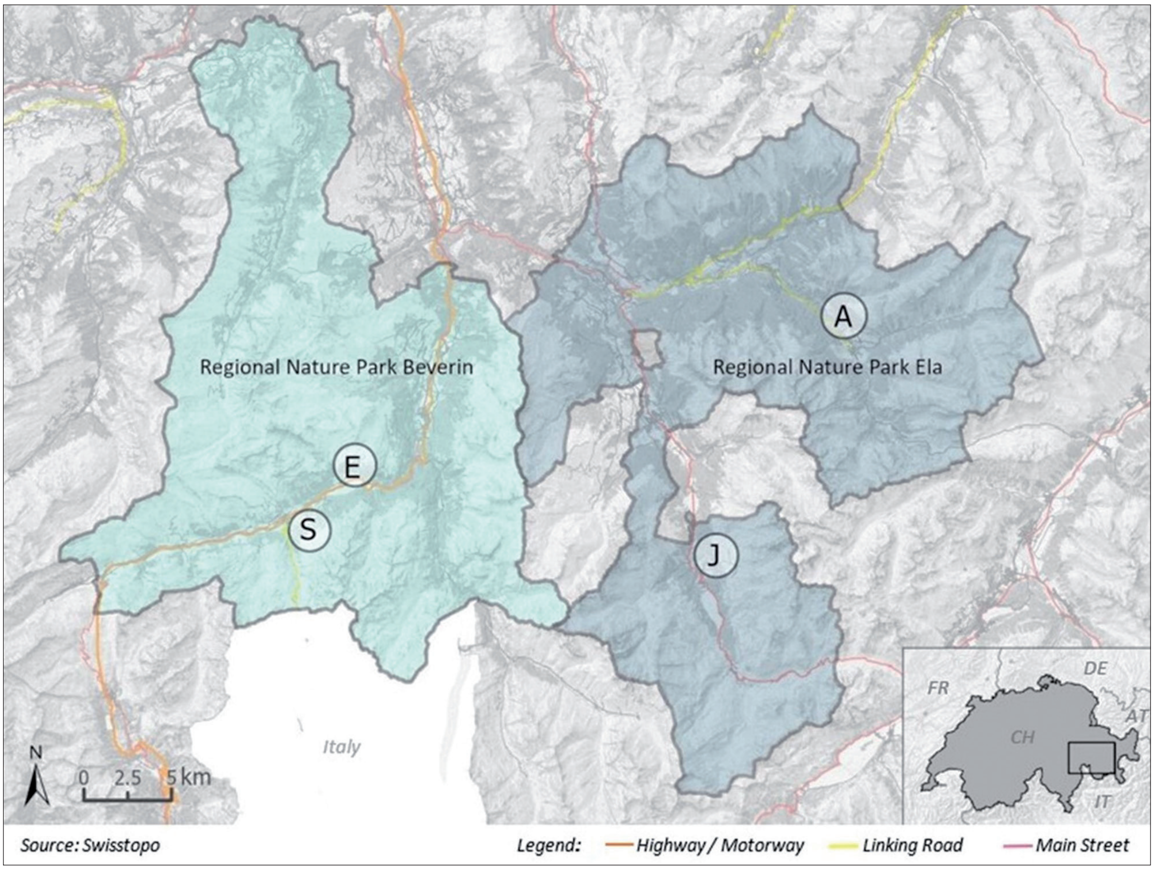


*Figure 1 – Regional Nature Parks Beverin and Ela with the four study areas Albula (A), Julier (J), Andeer (E) and Splügen (S).*

cultural landscape and the regional economy (Swiss Federal Council 2007/2018). The two largest RNPs in eastern Switzerland are Parc Ela and Beverin Nature Park (Figure 1). With a wide range of activities and cultural events as well as varied landscapes, the two parks offer ideal settings for recreation in Alpine areas (Verein Parc Ela 2021; Geschäftsstelle Naturpark Beverin 2021). At the same time, both RNPs are located in populated rural areas with transport infrastructure and are therefore excellent examples of anthropogenically influenced areas in the Alps. Parc Ela is crossed by two main Alpine passes, the Albula and Julier passes, and by the UNESCO World Heritage Albula railway line; the Beverin RNP is well connected by the A13 national highway (the Great Saint Bernard Pass) and the Splügen Pass.

In Switzerland, noise limits are regulated by the noise protection regulation (LSV), according to which noise of 55 dBA or more (decibels weighted by the sensitivity of human hearing at a given frequency) disturbs people considerably during daytime recreation. These regulations, however, are concerned with indoor protection in residential areas and are applicable to a limited extent only to outdoor activities in alpine recreation areas.

In 2002, for the protection of quiet areas within rural regions, the Environmental Noise Directive (END) proposed to use specific noise indicators and limits (European Noise Directive 2002). However, identifying quiet areas is a challenging task. According to END, a quiet area is defined as *"an area delimited by the competent authority that is undisturbed by noise from traffic, industry or recreational activities"* (European Noise Directive 2002). The difficulty is that the concept of quietness is influenced by factors such as human perception, visual interactions and expectations (European Environment Agency 2016).

The soundscape, that is to say the perception of the acoustic environment, is also context-dependent: it is never independent of non-acoustic factors such as psychological and physical aspects (Job & Hatfield 2001). Acoustics have been found to influence recreation to a similar or greater extent than visual landscape features such as the sight of a natural or open landscape (Jackson 2008; Lynch et al. 2011; Buxton et al. 2017, Leeb et al. 2020). A very important psychological factor is visitors' expectations regarding their stay in nature, including their expectations of the soundscape as a whole and of individual sounds (Bruce & Davies 2014).

In contrast to urban areas, where signal and background sounds are constantly present, individual sounds in natural areas can be heard over a greater distance (Schafer 1977). How sound is perceived also depends on spatial and topological conditions. Sound propagation decreases with increasing distance from the source, and the effect is intensified by barriers such as vegetation cover (Heimann et al. 2007). Addition-

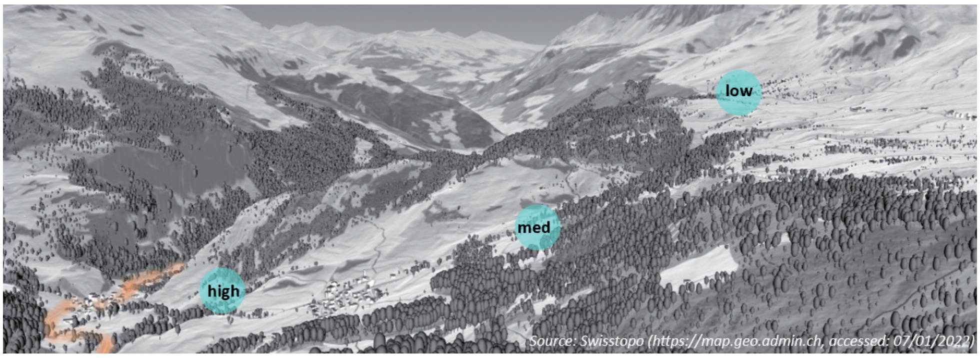


*Figure 2 – Sites with sound levels (high, medium and low) in the Julier (J) study area. The main source of anthropogenic sound is the pass road, shown in orange.*

ally, in Alpine areas sound emission propagates radially from the valley floor towards higher areas through open air, i.e. not along the ground (Heimann et al. 2007). As a result, sounds from the valley floor can still be clearly heard in elevated areas.

A number of studies have found a negative effect of anthropogenic sound in rural areas on the perceived quality of visitors' experience and recreation (Li et al. 2018; Yimprasert et al. 2021). However, there is a lack of research that specifically investigates the Alps, where the topography and the high level of human intervention in nature create unique conditions. A study in the Swiss National Park on visitors' general perception of disturbance concluded that about one in ten visitors felt disturbed by traffic sounds, especially motorbikes (Omlin & Brink 2010).

No nationwide mapping of quiet areas has been carried out by Swiss authorities. While a tranquillity map was developed by Leeb et al. (2020) for the flat Swiss midlands, there is no such map for the Alpine regions. Which sounds in Alpine areas are perceived negatively by visitors and to what extent anthropogenic sounds influence recreational quality remain largely unexplored. Through studying two different RNPs in the Swiss Alps, the aims of the present study were to analyse (i) which sounds are perceived positively or negatively by visitors, and (ii) whether the perceived negatively rated sounds affect the perceived quality of visitors' recreation.

## Methods

### Study area

This study was carried out in the Beverin and Parc Ela RNPs in the Alpine area of eastern Switzerland, in the canton of Grisons (Figure 1). Parc Ela is the largest RNP in Switzerland (660 km$^2$) and is known for its diverse landscapes, such as extensive dry meadows and pastures, floodplains and glacial forelands, as well as for its diverse culture and trilingualism (German, Rhaeto-Romanic and Italian) (Verein Parc Ela 2021). Beverin RNP (515 km$^2$) is also characterized by its diversity, with valuable alpine habitats like natural mountain streams, fens and deep canyons, as well as by two culturally and linguistically different settlement areas, German and Rhaeto-Romanic (Geschäftsstelle Naturpark Beverin 2021).

As a basis for the selection of the study areas within the Beverin and Parc Ela RNPs, a sound register was created in advance. Federal data from anthropogenic sound sources, such as roads and railways (BAFU 2018), and settlement areas (BFS 2013), were mapped in ArcGIS Pro to classify the two parks into zones of low, medium or high levels of anthropogenic sound. For each park, based on the sound register, we selected two areas (Beverin RNP: Andeer (E) and Splügen (S); Parc Ela: Albula (A) and Julier (J); see Figure 1). The conditions were that each area contained sites in a minimum of two different sound level zones (low, medium or high), forming a sound gradient. The sound gradients were produced not only by distance from the main anthropogenic sound source (pass road or highway), but also by the topographic features. Sites with low anthropogenic sound levels required the presence of a topographic knoll that acted as a barrier for sounds from the valley floor (Figure 2).

Sound measurements [dBA] and personal field observations as well as data about visitor frequency on hiking trails from the Strava Heatmap were used to finalize the selection of sites (Strava.com 2021). The aim was to keep all visual or psychological factors influencing recreational quality constant across the sites, with sound levels being the only factor to vary. Consequently, the surveys were carried out under similar weather conditions on hiking trails with similar landscape features (i.e. outside settlements, not in the immediate proximity of water elements, and in open non-forested areas) in order to ensure similar sound propagation.

### Survey

The survey was conducted from July to September 2021. Hikers were consulted on 19 different days, spread over weekdays and weekends with good weather (Table 1). The questionnaire, which was identical for both parks and intended exclusively for hikers, comprised 14 closed questions. For the assessment, the acoustic environment was broken down into relevant

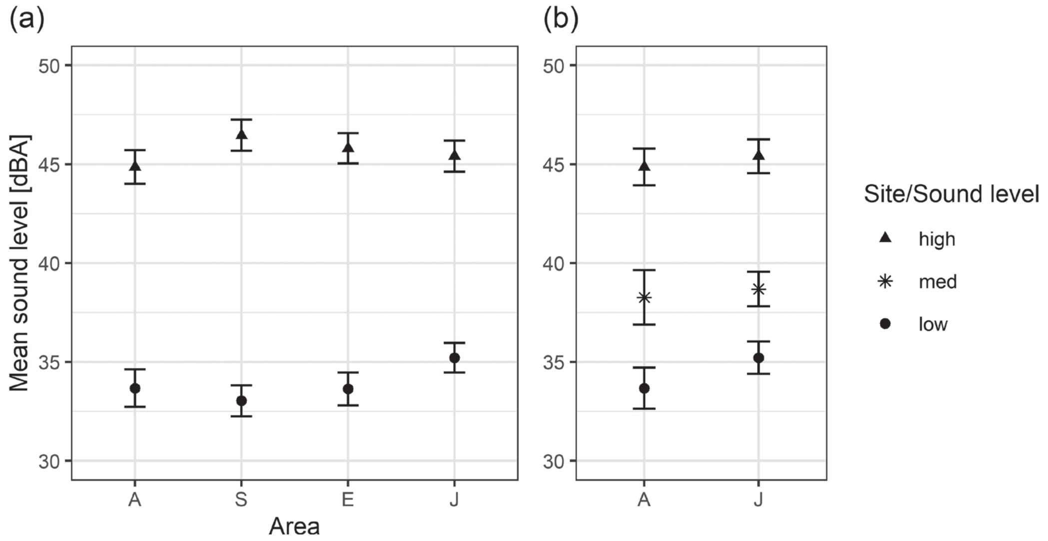


*Figure 3 – Average estimates of the recorded sound levels [dBA] in (a) four areas (A: Albula; S: Splügen; E: Andeer; J: Julier), having two sound-level sites each (low and high), and in (b) two areas, each with three sound-level sites (low, medium and high).*

sound indicators. Sound types were selected based on previous studies and the researchers' own observations (Jackson et al. 2008; Willibald et al. 2019; Leeb et al. 2020). A total of 17 sound types were included in the questionnaire; *rivers or streams, bird calls, other wildlife* and *wind* were classified as natural sounds, and the rest as being of anthropogenic origin. The respondents had to indicate whether and to what extent they had perceived and expected the 17 types of sounds on a 5-point Likert scale, from not perceived / expected at all (1), to strongly perceived / expected (5), during the last 20 minutes of their hike (Likert 1932). They then rated the sounds they had perceived on a 7-point Likert scale, from very negative (−3), to neutral (0), to very positive (3). In the final step, they indicated how much the positively and negatively rated sounds affected their recreational quality, using a Likert scale from not at all affected (1) to strongly affected (5). Questionnaires were excluded from the analysis if the respondents assessed their hearing capability as considerably reduced or their mood as bad, the latter on the assumption that psychological stress and the resulting introversion reduce the ability to perceive the acoustic environment.

In parallel to the survey, the number of passing visitors was recorded by hand in order to determine the visitor rate of response for each sound-level site per area. Sound level measurements [dBA] were also taken on site using a *UNI-T UT333-BT* sound-level meter. The recording device was placed about 100 metres away from the interview site to prevent our presence impacting the measurements. It recorded the acoustic environment between 30 and 130 dBA without differentiating between natural and anthropogenic sounds. The data were additionally validated using a calibrated *Velleman Dem 202* sound-level meter. It was therefore possible to calculate the average sound level during the 20 minutes prior to each participant starting to complete the questionnaire.

## Data analysis

All statistical analyses were conducted using R, version 4.1.2 (R Core Team 2021). Linear and linear mixed models were run with the lme4 package (Bates et al. 2021). The dredge function (MuMIN package (Bartoń 2020)) was used to compute both the full model and all lower-level models with fewer parameters. The models were ranked according to their AICc (Akaike

*Table 1 – Distribution of field days, survey participants and response rate of the four study areas (two or three sites per study area).*

| Regional Nature Parks | Area | Site / Sound level | Field days | Survey participants | Response rate [%] |
|---|---|---|---|---|---|
| Parc Ela | Albula (A) | Low | 3 | 21 | 84.0 |
| | | Medium | 2 | 15 | 87.5 |
| | | High | 2 | 26 | 76.5 |
| | Julier (J) | Low | 1 | 34 | 82.9 |
| | | Medium | 1 | 29 | 76.3 |
| | | High | 2 | 31 | 68.8 |
| Beverin | Andeer (E) | Low | 2 | 28 | 91.6 |
| | | High | 2 | 33 | 85.0 |
| | Splügen (S) | Low | 2 | 33 | 89.2 |
| | | High | 2 | 34 | 70.8 |
| Total | | | 19 | 277 | 81.3 |

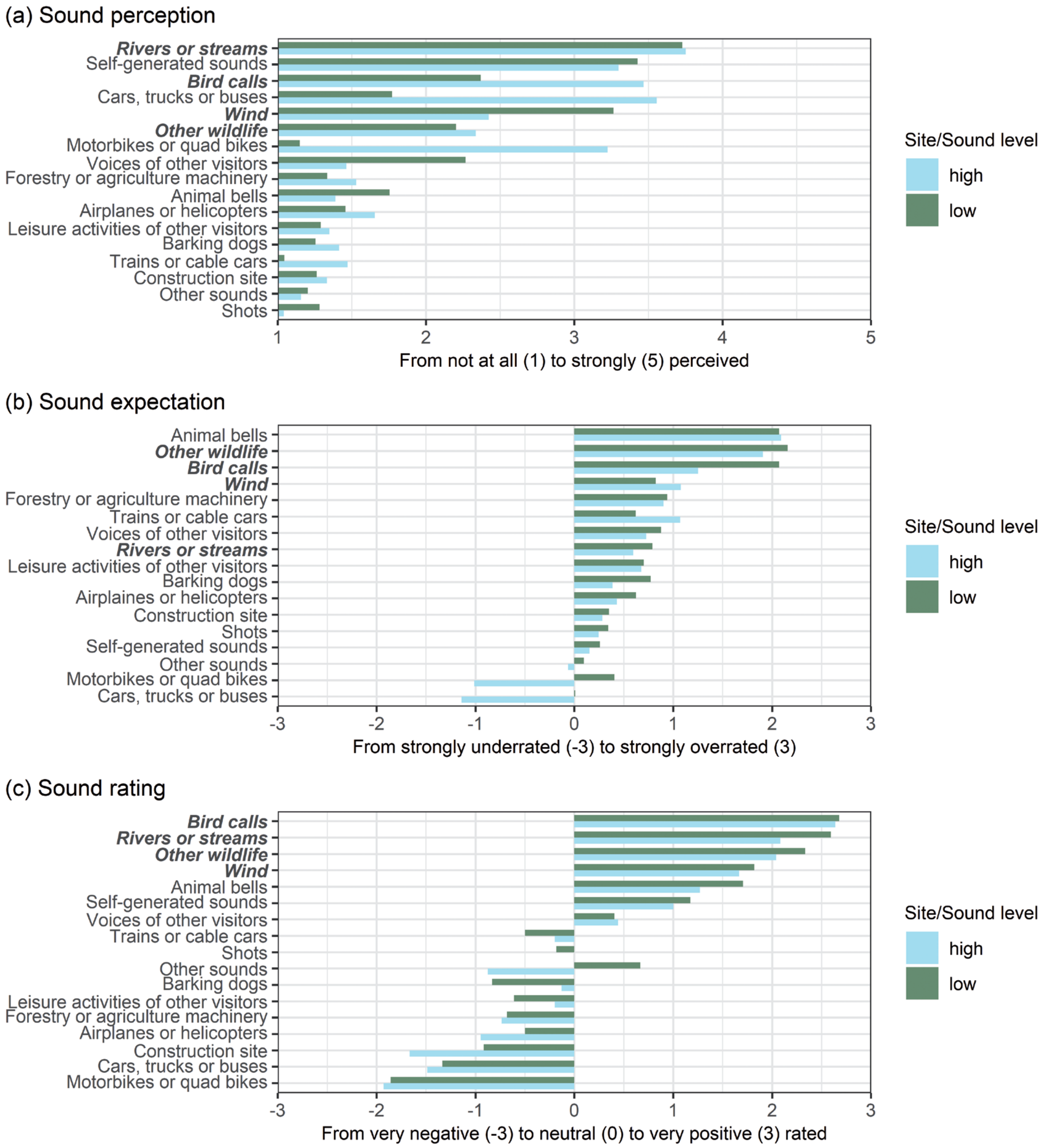


*Figure 4 – Average survey responses regarding (a) perception of natural (bold/italic) and anthropogenic sounds, (b) deviation between expected and perceived sounds, and (c) rating of perceived sounds, at sites with low or high anthropogenic influence.*

information criterion corrected for small sample size); following Grueber et al. (2011), an information-theoretic approach was used to account for uncertainty in model selection. Averaged parameter estimates (full average) were obtained by averaging across the top models (within ΔAICc of 4 from the best model) using Akaike weights. Fulfilment of model assumptions (normality and homoscedasticity of the residuals) was inspected visually.

## Results

A total of 277 questionnaires were considered fully valid, of which 92.6% were in German and 7.4% in English. The average age of the respondents was 51, ranging from 16 to 87 years, with the most-represented age group being between 60 and 70 years (23.8%). Women preponderated over men (55.6% versus 44.0%), with one person identifying as neither male nor female. The distribution of the types of residential location was relatively balanced, with 38% of the participants classifying their place of residence as very or rather urban, 39% as very or rather rural, and 21% as semi-urban or semi-rural; 2% gave no answer. For the mode of arrival, almost half (126 people) travelled at least part of the way by car, 118 used public transport, and the rest arrived on foot (59), by bicycle (6) or by motorbike (2). Asked about their current motives for hiking, the three most common answers on a 5-point Likert scale were *enjoying nature and the landscape* (mean: 4.78), *finding tranquillity and recreation* (mean: 4.48), and *being active and doing something for one's health* (mean: 4.22).

Results from linear models showed that the sound measurement data [dBA] of the selected sites con-

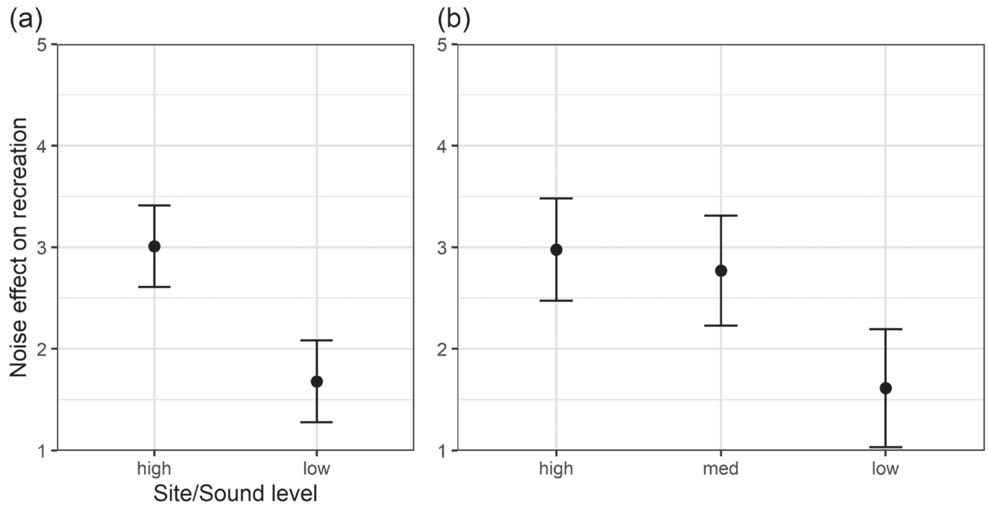


*Figure 5 – Average estimates of the influence of noise on visitors' recreation (from 1 [not at all], to 5 [strongly affected]) in (a) four areas having two sound-level sites each (low and high), and (b) two areas with three sound-level sites (low, medium and high).*

firmed the pre-defined sound level zones (*low, medium* and *high*). Across all areas, the measured mean value [dBA] differed significantly between the sites with *high* and *low* sound levels ($F=1616.3$, $df=1$ and $p<0.001$). Overall, there were no significant differences between the areas. However, a significant interaction between area and sound level (*low* and *hig*h) was observed ($F=5.96$, $df=3$ and $p<0.001$, Figure 3a), with the difference between *low* and *high* being larger in (S) than in (J).

A similar result was found when only a subset of the data was considered, namely for the areas Albula (A) and Julier (J), which each had three sound levels (*low, medium* and *high*, $F=269.4$, $df=2$, and $p<0.001$; see Figure 3b). The sites with *high* (mean: 44.6 dBA), *medium* (mean: 38.6 dBA) and *low* (mean: 33.7 dBA) sound levels differed significantly from each other (between *low – med*: mean difference of 4.59 [95% *CI*: −6.32 to −2.85] and *med – high*: mean difference of 6.60 [95% *CI*: 4.93 to 8.27]).

As suspected, both *natural* and *anthropogenic* sounds were perceived in the Swiss RNPs (Figure 4a), although *anthropogenic* sounds were perceived less strongly at sites with *low* sound levels. Across all areas, visitors in Alpine nature parks generally underestimated road traffic sounds on sites with *high* sound levels – that is, they perceived the sound to be louder than they had expected in advance (Figure 4b).

Overall, *natural* sounds were rated more positively than *anthropogenic* sounds on the 5-point Likert scale, with a mean difference of 2.51 [95% *CI*: 2.40 to 2.63]. The mean difference was estimated from a linear mixed model using sound type (*anthropogenic* or *natural*) as explanatory variable. Survey participant ID was used as random effect in the mixed model.

The noise of *motorbikes* and *quad bikes* was rated worst by RNP visitors, followed by *cars*, *trucks* and *buses*. All negatively rated sounds were of anthropogenic origin (Figure 4c). Throughout the remainder of the article, *noise* will be used as a synonym for *negatively rated anthropogenic sounds*.

It was found that the deviation between expectation and perception of the specific sound type influenced its rating (linear regression coefficient = 0.69, 95% *CI* = 0.64 to 0.76, $F=759.3$, $df=1$, and $p<0.001$). Sounds that had not been expected in the Alpine nature parks were more likely to be rated negatively by visitors.

Linear mixed models showed the average visitor assessment of how much sounds affected the quality of their recreation (given on a 5-point Likert scale) to be 3.9 for positively and 2.5 for negatively rated sounds. The full model contained the variables sound level (*high, medium* or *low*), gender and residential location, and all possible two- and three-way interactions. Data nested within area were used as random effects to correct for dependencies in the data.

When looking at how the perceived recreational quality was affected by noise, it was found that sound level was the most important factor (relative importance = 1). At *high* sound levels, noise had a stronger negative effect on recreation compared to sites with *low* sound levels (Figure 5a). The best models (within 4 ΔAICc of each other) contained the variables gender and residential location, and the interaction between gender and sound level. The relative importance of these factors, however, was considerably lower than the effect of sound level (gender = 0.36, gender : sound level = 0.17, residential location = 0.12). Similar results were found when analysing just two out of the four areas (Albula (A) and Julier (J)), but with an additional site with *medium* sound level (Figure 5b). Sound level proved again to be the factor with the highest relative importance (1), followed by residential location (0.59), gender (0.37), and the interaction between gender and sound level (0.12). No significant difference in the effect of noise on the perceived recreational quality was found between *medium* and *high* sound-level sites.

## Discussion

Swiss studies on hikers (Lamprecht et al. 2020; Fischer et al. 2021) reveal their average age (50 years), the largest age group (55–64 years) and the gender ratio (53% women), which correspond with this study. A similar picture emerges regarding preferred means of transport. In RNPs, the largest number of visitors arrive by car, followed by public transport, and only a few use other means of transport (Knaus 2018). Experiencing nature, fresh air and escaping from everyday life are cited as the main reasons for visiting the natural environment in Switzerland (Hegetschweiler et al. 2022). Our study confirmed this, as the search for *tranquillity* and *recreation* was the most-mentioned motive in the survey after *experiencing nature*.

A potential limitation of the study could be the inability to fully control for visual and psychological factors that influence the quality of recreation at the study sites. Additionally, the respondents were mainly from German-speaking areas, i. e. from similar cultural backgrounds. Surveys in other mountain areas could result in different findings. One respondent further commented that she noticed more individual sounds and nuances of sounds after completing the questionnaire, which raises the question of how consciously people perceive acoustic environments in the first place and how long they remember them.

The study examined which sounds in an Alpine acoustic environment are perceived by RNP visitors and how the soundscapes are rated. A clear pattern emerged: only anthropogenic sounds were perceived negatively and therefore as noise. The results confirm the findings of other studies according to which natural sounds elicit positive emotions in visitors of rural landscapes, while anthropogenic sounds are often associated with negative emotions (Pijanowski et al. 2011b, Li et al. 2018, Yimprasert et al. 2021). Axelsson et al. (2010) suggested that individual sound associations are often more important than the actual volume or dominance of the sound within a soundscape.

The anthropogenic sound types rated most negatively were found to be cars and motorbikes. This corroborates the observation that sounds perceived as noise in rural areas are strongly linked to traffic (Buxton et al. 2017). Furthermore, the survey revealed an ironic contradiction, namely that the respondents rated cars, trucks and buses as the second most negative sound, but also preferred cars as the means of transport to get to the starting point of their hike. A possible explanation for this could be that many visitors underestimate the impact of their own activity, including the acoustic impact (Barber et al. 2011).

Additionally, the analysis was able to show that expectations play a decisive role in sound assessment of recreational areas. Sound types that visitors had not expected in advance were rated more negatively, as noted in earlier studies by Bruce and Davies (2014) and Li et al. (2018).

The second question of interest was how soundscapes affected RNP visitors' recreation. The study was able to provide new insights into the effects of negatively rated anthropogenic sounds on recreational quality in Alpine areas. In close proximity to anthropogenic sound sources and therefore in sites with *high* sound levels, visitors assessed noise as having a medium impact on recreation. Compared to sites with *medium* or *high* sound levels, noise had a clearly weaker negative effect on the perceived recreational quality in sites with *low* sound levels. There was no significant difference in the effect noise had on recreational quality between sites with *medium* and *high* sound levels, indicating that there might be a threshold level of noise (between 33.7 and 38.6 dBA) above which noise starts to have a stronger negative effect on perceived recreational quality. In the four study areas, *low* noise levels (below the threshold) were found only behind hilltops. However, those results must be considered with caution as there were only a few data points for sites with *medium* sound levels (for just 2 of the 4 areas).

Even though the impact of noise on the perceived recreational quality was not found to be very strong at any of the sites studied, the finding that medium influences are present at all sites without topological shielding is of concern.

## Conclusion

Most quiet areas in Europe are located in mountain regions (European Environment Agency 2016). However, even Alpine soundscapes are influenced by anthropogenic sounds. Traffic noise from the valley floor can affect the perceived recreational quality of visitors even at higher altitudes, unless they are topologically shielded. Natural soundscapes including quiet areas are an essential part of park experiences and play a key role in people deciding where to spend leisure time in nature (Lynch et al. 2011). The demand for outdoor activities and recreation, and thus also traffic, will continue to increase due to demographic development (Willibald et al. 2019). It is therefore important for RNPs to take measures in advance.

Firstly, as popular destinations for sustainable tourism, RNPs should take pro-active measures to protect the natural acoustic environment by reducing noise and sensitizing visitors to the effects of noise; one possibility would be to introduce quiet areas or hours. Since sounds that had not been expected are evaluated more negatively, it would also be advisable to inform visitors on the website about possible noise exposure during a hike. Such mitigations might prevent the negative impact of unexpected noise on the quality of recreation. Second, if RNPs highlight the richness and diversity of their natural sounds, e. g. through themed trails with special listening stations, auditory walks or information boards, this could contribute to higher auditory awareness and thus to a more positive quality of experience and recreation.

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# Ancient larch trees in the Tuva Republic, land of the oldest trees in Russia

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*Keywords: sacred larch trees, natural monuments, culture, protection, tourism, preservation, Siberia, Russia, upper treeline, forest-steppe zone*

## Abstract

The ancient trees in the Tuva Republic have both cultural and scientific significance. Our study provides a synthesis of the results of the dendrochronological research carried out by the Siberian Dendrochronological Laboratory over the past 16 years in the Tuva Republic, Russian Federation. By applying state-of-the-art dendrochronological analysis, we identified the oldest dead larch tree (*Larix sibirica* Ldb.) in the study region, which had reached 1,307 years old. Living larch trees from the forest-steppe zone (1,000–1,500 m asl) and at the upper treeline (2,000 m asl) are known to have reached 779 and 662 years respectively. Such old trees are of great interest for the scientific community and society. Old living larch trees have witnessed the rise and fall of great nomadic civilizations and agricultural changes. Their identification and protection increase their attraction for tourists and enrich the cultural significance of the region. Until now, however, these trees have remained unprotected and are not registered in international and national registers of long-living trees. In this study, we aim to raise awareness of the need to develop forest protection policies and to preserve ancient living larch trees in the Tuva Republic.

## Introduction

A tree's lifespan significantly exceeds the length of a human life, and to learn about its past we can turn to tree-ring records (Fritts 1976). The longest-living tree on Earth is the Bristlecone Pine (*Pinus longaeva* D.K. Bailey), which is known to have reached an age of 4,825 years (Currey 1965). The key to such longevity is the ability of the cambium to divide indefinitely. According to the Old List database (Brown 1996), in the state of California there are 24 trees over 500 years old, registered and protected at national level.

Many European, Baltic and Nordic countries apply comprehensive measures for the inventory and protection of ancient trees. For example, since the 1900s old living trees in Germany have been under protection, while in Poland a movement for the protection of ancient trees came into existence in the 1920s and is supported not only by the State, but also by social, environmental and religious structures (Boreyko 1996). Researchers and activists are constantly working to determine the exact age of old trees. For example, a strip-bark Heldreich's pine (*Pinus heldreichii* H. Christ), the oldest dead tree found in Europe (in Italy) reached 1,062 years (955–2016 CE) (Piovesan et al. 2018). The oldest living European larch (*Larix decidua*) is also found in Italy, aged 986 years (https://www.conifers.og/pi/Larix_decidua.php).

The Russian programme *Trees – natural monuments of nature* was initiated in 2010 (Trees – Monuments of Nature 2010). This inventory contains information about long-living trees in the Russian Federation. However, the trees included in the database are distributed unevenly geographically. In general, this is due to accessibility (proximity to settlements or tourist trails). Moreover, the age of trees is determined by indirect characteristics (for example, crown height and trunk diameter), which are not accurate indicators of their real age. The oldest trees in Siberia included in the database are a 754-year-old Siberian cedar (*Pinus sibirica* Du Tour) from the Khakassia Republic, a 604-year-old Scots Pine (*Pinus sylvestris* L.), and a 775-year-old Siberian larch (*Larix sibirica* Ldb.) from the Irkutsk region. To cross-check the age of the old Siberian larch, we conducted an independent sampling of five tree cores taken from the 775-year-old larch. Because this tree stem has rot and decay, the dendrochronological analysis of the tree rings returned an age of 351 yeas only, less than half the age declared in the database. Therefore, the content of the database must be checked for accuracy.

We also discovered a number of old trees which did not figure in this database but which we were able to cross-date using a dendrochronological approach. For example, living larch trees (*Larix cajanderi* Mayr.) in northeastern Yakutia can be up to 945 years old (Sidorova et al. 2005, 2008), while in the Polar Ural region Siberian larch trees (*L. sibirica* Ldb.) can reach 486 years old (Vaganov et al. 1996). Information about old living trees is missing for the Tuva Republic, a territory located in central Asia, but old trees can provide unique paleoclimatic information about extreme events, such as droughts, over centuries and millennia. Droughts are captured by tree rings at annual resolution and can potentially be used for the reconstruction of catastrophic drought events in the steppe basins.

Despite the longevity of some trees, the number of old trees is steadily decreasing. Recent climate change has led to the transformation of trees' growing conditions at the upper treeline and in the forest-steppe zone (Zhang et al. 2018; Cook et al. 2020; Churakova (Sidorova) et al. 2021, 2022). It is also important to

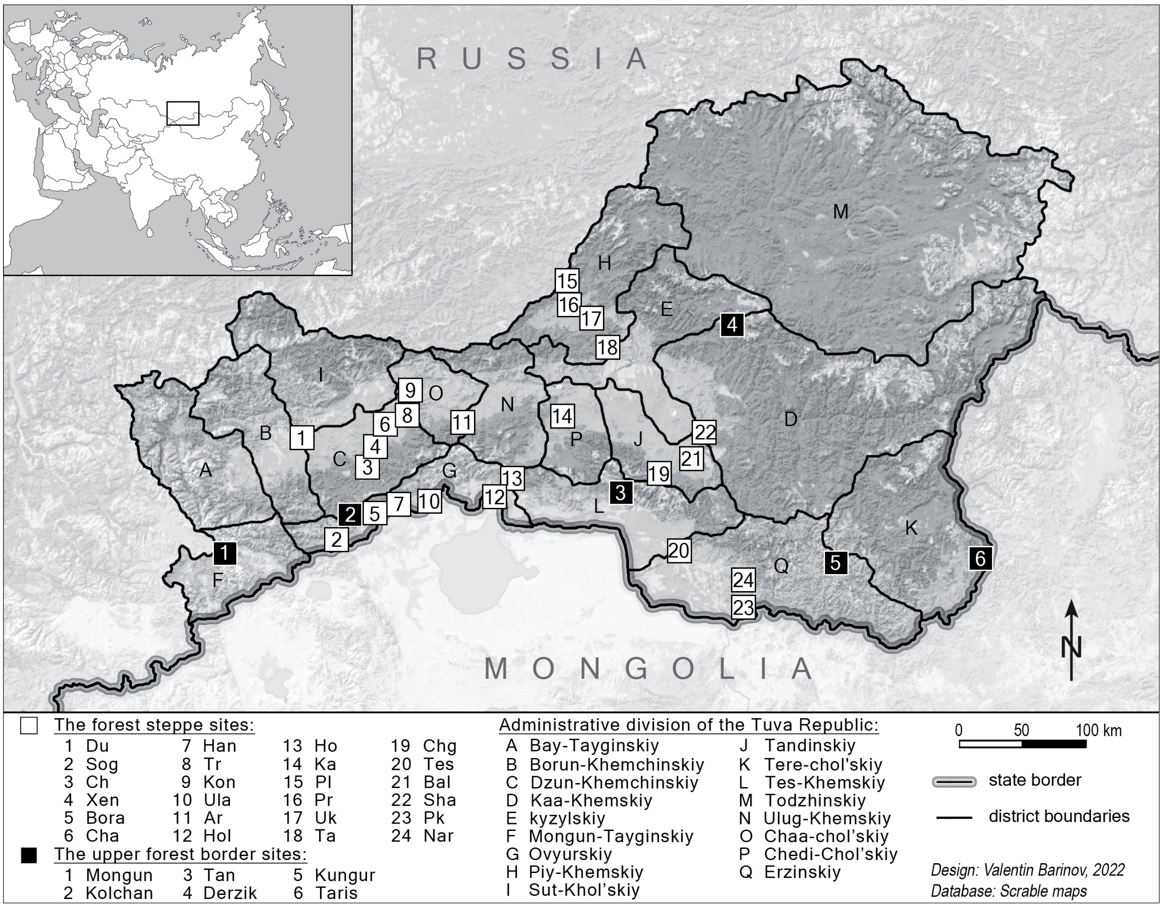


*Figure 1 – Locations of dendrochronological sites in the Tuva Republic, Russian Federation. The 24 study sites located in the forest-steppe zone are Du (1), Sog (2), Ch (3), Xen (4), Bora (5), Cha (6), Han (7), Tr (8), Kon (9), Ula (10), Ar (11), Hol (12), Ho (13), Ka (14), PI (15), Pr (16), Uk (17), Ta (18), Chg (19), Tes (20), Bal (21), Sha (22), Pk (23) and Nar (24), shown in white squares. The upper tree line is represented by 6 sites in Mongun (1), Kolchan (2), Tan (3), Derzik (4), Kungur (5) and Taris (6), shown in black squares. Administrative divisions of the Republic of Tuva: A – Bay-Tayginskiy, B – Borun-Khemchinskiy, C – Dzun-Khemchinskiy, D – Kaa-Khemskiy, E – Kyzylskiy, F – Mongun-Tayginskiy, G – Ovyurskiy, H – Piy-Khemskiy, I – Sut-Khol'skiy, J – Tandinskiy, K – Tere-chol'skiy, L – Tes-Khemskiy, M – Todzhinskiy, N – Ulug-Khemskiy, O – Chaa-chol'skiy, P – Chedi-Chol'skiy, and Q – Erzinskiy.*

mention trampling, root exposure (due to uncontrolled grazing), the increase in wildfires, and mechanical damage of trees, among other factors. Under such circumstances, ancient trees need careful protection. The Tuva Republic is of key importance for the preservation of the ecological state of Siberia and has been classified by UNESCO as one of 200 priority eco-regions on the planet (Kuzhuget 2001; Mongush & Mongush 2015).

In many cultures, long-living trees are not just natural objects but also cultural symbols, even objects of religious worship. The worship or reverence of trees is common among many peoples worldwide (Nam 2016). The connection between humans and nature plays an important role in traditional Tuvan culture, where people believed that by harming nature they harmed themselves. For this reason, they never cut down trees unnecessarily, did not kill animals, and did not catch more fish than they needed. Moreover, before taking something from nature, traditionally Tuvans would ask permission to do so, performing various rituals.

The worship of trees, which continues to the present day, was widespread among Tuvans, who recognize three type of sacred tree: (1) growing on mountain passes; (2) growing near mineral springs (Arzhans and Aryks); (3) Shamans' trees, which are widely distributed in the Tuva region. The third type differ from other trees by thick trunks and many branches of unusual shape. According to historical documents (Darzhaa 2007), Shaman's trees were taken care of, cherished and fed; people asked them to grant wellbeing, prosperity, health and a good life. They are divided into two groups: *tel yyash* and *ham yyash*. The first is a double-stemmed tree growing from one root, or intertwined trees of two different species. In the past, several generations of Tuvans who were blood relatives would gather together to perform rituals under the crown of the tree, which was held to be responsible for the health, wellbeing and cohesion of the family.

According to the Shamans, rheumatism in the hand or foot was caused by injuring a *tel yyash*. To treat diseases, ribbons of coloured paper or fabric were hung around the *tel yyash* and on all its branches. This allegedly calmed the angry spirit of the forests. The second type of Shaman's ritual tree, the *ham yyash*, is a larch with confused, unevenly distributed branches forming what Siberians call a *witch's broom*. Prayers to the forest spirits used to take place under these trees' branches.

The identifying feature of shamanism as practised in Tuva is its age-old coexistence with Buddhism. There is no fundamental dogmatic contradiction between the two, and thus Buddhism was able to adopt shamanic rituals. For centuries, Tuvans worshiped Shamans' trees, especially larches, of which two types served in cultural rituals.

The ritual of consecrating new shaman trees ensures continuity and succession. Each shaman has their own tree, which they visit annually to conduct a ritual. While the shaman carries out the ritual, which is performed in daylight in the presence of all the local people, the people bring boiled lamb, flatbread and *araga* (fermented soured milk) for consecration. They also ask the shaman's larch to bring rains, help for a good harvest, and prosperity for the shaman. After the shaman's death, their clothes and tambourine are hung on their tree's branches, because it is believed that the shaman's spirit has migrated and lives there. The tree is asked to ensure that the shaman's spirit is reborn in the same family (Dashkovsky 2015; Agency for Nationalities of the Republic of Tuva 2021).

Larch trees play an important role in Tuvan culture and in Siberian culture more widely. Shamans belonging to the Gas Turukhansk Selkups culture carve faces into them (Ozheredov 1995), while in Gilyak mythology the larch is the home of the ancestral mother, who owned the Sun and the Moon. The Ostyaks and Voguls (indigenous Siberian peoples) used larches during sacrifices, hanging their branches with the skins of the sacrificial animals. The tree as itself a sacred symbol is also found in Ostyak and Vogul culture (Simchenko 1965).

The oldest trees on Earth attract legends and tourists. The trees should be protected and could be used to educate people about past rituals and future protection measures. This would be in line with the socio-economic development strategy of the Tuva Republic (Brown 1996), where tourism is a priority sector. There is no doubt that long-living trees deserve protection as they serve as a natural archive of past economic, cultural and social practices, as well as of changes in climate. Without protection from unsustainable forest management and anthropogenic impacts, these old living trees and relict forest ecosystems risk disappearing.

In this study, we aim (i) to provide a summary of all the available information about old living trees in the Tuva Republic, and (ii) to raise awareness of the need to develop forest protection policies and to preserve the ancient larch trees in the Tuva Republic, at national and international levels.

## Material and methods

### Study region and site description

The study region is located in southern Siberia (the Asian part of Russia) in the Tuva Republic (Figure 1). The six study sites were selected at the upper treeline (2,000 m asl) in an area measuring 587 km from west to east (Figure 1, *black squares*) where tree growth is limited by summer temperatures (Taynik et al. 2016). A further 24 sites were located in the forest-steppe intermontane zone (1,000–1,500 m asl), measuring 350 km from east to west, and 240 km from north to south (Figure 1, *white squares*), where tree growth is limited by precipitation (Churakova (Sidorova) et al. 2021).

The climate throughout the study region is dry and extra-continental with severe winters and warm summers (Alisov 1956). Vegetation ranges from semi-deserts in the inter-mountain basins to mountain coniferous forests and alpine meadows, which are replaced by bare rocks and snow at higher elevations. Permafrost covers rocky screes and sandy sediments.

### Sampling

Old trees were selected based on the following criteria: a disturbed crown shape, and the absence of lower branches. Tree cores were taken from long-living trees (*L. sibirica* Ldb.) using a 6 mm increment borer, according to the standard method described by Schweingruber (1996). During the fieldwork, a significant number of well-preserved dead trunks of Siberian larch trees were found on the ground's surface from which samples were taken with a chainsaw. For each tree, we noted geographical location and coordinates, and measured the diameter using a caliper (DC). 818 samples were collected from the trunks of the dead and living larch trees from the upper treeline. From the forest-steppe zone, 507 tree cores were taken from living trees. Over a period of 16 years (2006–2022) and from 30 study sites, a total of 1,325 samples were collected.

### Tree-ring analysis

Resins, waxes and tannins in the wood were extracted from all the tree cores over a period of 40 hours in a Soxhlet apparatus containing 96% ethanol. At the end of the extraction procedure, wood samples were washed in boiling water (up to 120°C) for 10 hours; the water was changed every hour (Schweingruber 1996).

To perform tree-ring analysis, we glued tree cores on wooden bases and sanded them. Tree-ring widths (TRW) were measured using the CooRecorder 9.3 (Cybis, Sweden) software. The graphical cross-dating of the TRW was performed using the CDendro 9.3 program (Larsson 2013). Cross-correlation analysis using DPL (Holmes 1983) and TSAP V3.5 (Rinn 1996) specialized software packages for dendrochronological studies was applied. The quality of the cross-dating was assessed using Pearson correlation coefficients,

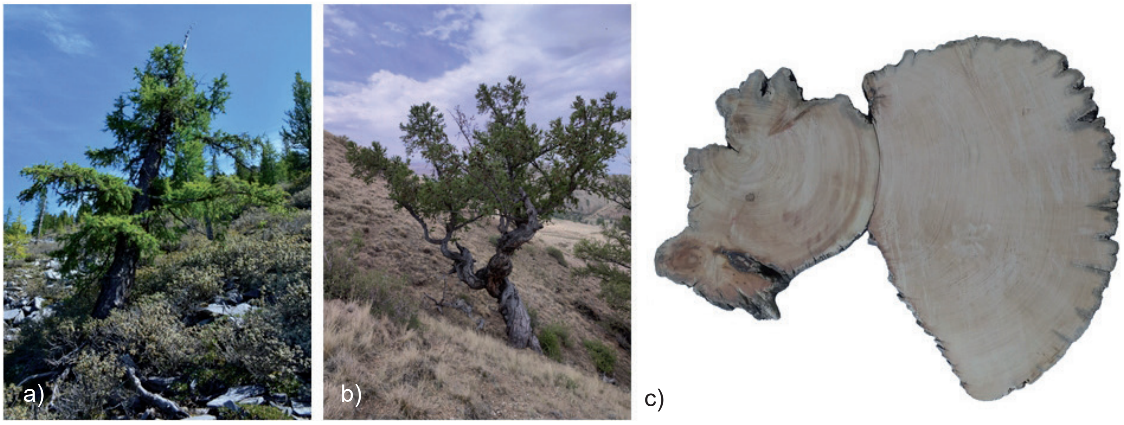


*Figure 2 – (a) The 662-year-old Siberian larch (Larix sibirica Ldb.) from the upper treeline in Tere-cholskiy District, Tar site; (b) 779-year-old Siberian larch from the steppe zone, Ovyurskiy District, Ula site; (c) Siberian larch sample from a dead trunk, 1,307 years old (184–1490 CE), Mongun-Tayginsky District, Mongun site. Photos are from the Siberian Dendrochronological Laboratory archive (2019).*

autocorrelation, sensitivity, and standard deviation (Wigley et al. 1984).

## Results

The TRW measurements and cross-dating analysis were performed for all tree cores collected and all wood discs. The samples were checked for missing rings and frost rings using reference tree-ring chronologies developed for the study region (Myglan et al. 2008; Büntgen et al. 2017). To verify the quality of the cross-dating chronologies for the forest-steppe group, the database *Tree-ring chronologies for forensic botanical examination and dating of architectural structures in the Tuva Republic* was used (Taynik et al. 2022).

818 samples from dead and living trees at the upper treeline were collected and analysed. The oldest dead Siberian larch that we found was 662 years old (1345–2006 CE) at the Kungur site (Figure 1, site 5, black square), on southern spurs of the Ulaan Taiga

*Table 1 – The oldest larch trees (Larix sibirica Ldb.) found (a) at the upper treeline in Tere-cholskiy District, Tar site, and (b) in the steppe zone, Ovyurskiy District, Ula site.*

(a)

| Sample ID* | Years [BCE, CE] | Sample specification | |
|---|---|---|---|
| | | Age | Diameter [cm] |
| Living trees | | | |
| 07 taris 003 | 1345–2006 | 662 | 32 |
| 13 kungur 021 | 1412–2012 | 601 | 30 |
| 13 tan 015 | 1413–2012 | 600 | 30 |
| 13 kungur 025 | 1420–2012 | 593 | 41 |
| 13 kungur 022 | 1425–2012 | 588 | 33 |
| 13 kungur 012 | 1430–2012 | 583 | 34 |
| 13 kungur 014 | 1441–2012 | 572 | 57 |
| 13 tan 010 | 1447–2006 | 566 | 28 |
| 07 mongun 018 | 1447–2006 | 560 | 24 |
| 08 taris 001 | 1458–2007 | 550 | 23 |
| Average | | 588 | 33.2 |
| Dead trees | | | |
| 16 mongun 033 | 184–1490 | 1,307 | 68 |
| 08 mongun 009 | 960–1818 | 859 | 58 |
| 08 mongun 301 | 969–1784 | 816 | 48 |
| 08 mongun 136 | 271–1082 | 812 | 57 |
| 08 mongun 134 | 565–1374 | 810 | 50 |
| 07 mongun 005 | 88–891 | 804 | 63 |
| 07 mongun N025 | 861–1636 | 776 | 60 |
| 13 kol 024 | 561–1303 | 743 | 42 |
| 08 mongun 099 | 968–1707 | 740 | 21 |
| 08 mongun 086 | 263BCE–465CE | 730 | 33 |
| Average | | 840 | 50 |

(b)

| Sample ID* | Years [CE] | Sample specification | |
|---|---|---|---|
| | | Age | Diameter [cm] |
| 18 ula 004 | 1240–2018 | 779 | 63 |
| 18 sog 028 | 1358–2018 | 661 | 36 |
| 14 han 017 | 1534–2013 | 480 | 22 |
| 15 tes 019 | 1559–2014 | 456 | 33 |
| 13 sog 014 | 1568–2012 | 445 | 26 |
| 18 ula 007 | 1583–2018 | 436 | 21 |
| 13 sog 011 | 1579–2012 | 434 | 25 |
| 18 sog 024 | 1589–2018 | 430 | 37 |
| 14 han 015 | 1586–2013 | 428 | 25 |
| 14 han 003 | 1587–2013 | 427 | 31 |
| Average | | 498 | 31.9 |

*Note: BCE – Before Common Era; CE – Common Era; ID* – Identifier: the first two digits indicate the year of sampling after 2000; the letters indicate the site name; the final digits are the tree number.*

mountain range (Figure 2a, Table 1a). Old living trees were also found at this same site (5 out of 10 presented in Table 1a).

The analysis showed that the maximal age of trees growing in the Mongun-Taiga Massif of Mongun-Tayginsky District (Figure 1, F) is 1,307 years (184–1490 CE), which is the absolute record for conifer trees in Eurasia (Figure 2c; Table 1a).

Ten long-living trees out of 507 collected from the forest-steppe zone were analysed using dendrochronology (Table 1b). We revealed that the oldest living larch tree is 779 years old (1240–2018 CE; Table 1b and Figure 2b), in the Ovyursky District (north of the Uvs Lake Basin). At the Sog site, 80 km west of the Ula site, we selected 4 out of the 10 oldest living trees (Figure 1, sites 2 and 10, white square). The average trunk diameter of the oldest trees is just 63 cm, while younger trees may have a diameter ≥ 80 cm. Another interesting observation is related to the height of the trees, which showed no link with age, since the average height of the oldest trees in the forest-steppe zone is just 7.4 m, while the average height in the stand is about 14 m. This is because among the old trees there are individuals with a broken or withered crown.

The average age of trees at the upper treeline is 588 years; in the forest-steppe zone it is 500 years (Table 1). We did not reveal any significant link between age and DC. There are visual factors other than diameter that indicate old living trees, such as loss of the tree's crown and growth of lateral branches, the absence or traces only of branches on the lower parts of larch trunks, and the colour and shape of the bark scales.

## Discussion

The application of tree-ring analysis is an important step in the accurate determination of tree age compared to simple tree-ring counting (Fritts 1976; Schweingruber 1996). For example, in the National registry of old-growth trees in Russia, 39 trees of more than 500 years were documented. However, dendrochronological analysis confirmed just five of these trees as being over 500 years old. The results of our study demonstrate the reliability of dendrochronology for identifying and creating a trustworthy register of old living trees at regional and international levels.

Our earlier tree-ring studies from Tuva Mountain region (Myglan et al. 2008; Taynik et al. 2016; Büntgen et al. 2017; Churakova (Sidorova) et al. 2021, 2022) showed that fallen tree trunks have been well preserved due to the permafrost and dry climate conditions over recent millennia. ID 08 mongun 086 for example (see Table 1) began to grow in 263 BCE and died in 465 CE. Long-living trees found during this study have not yet reached their maximum potential age as the average age for living trees is 588 years, while the average age of dead trees is 839 years, and the maximum age found to date is 1,307 years. This suggests that there are likely to be several trees in the Tuva Mountain region that have reached this record age (or older) for the Boreal zone.

The next step of our work is to formalize the status of old living trees as natural monuments of regional significance in order to protect them from being felled. The present publication could contr

ibute to their protection. In addition, the results, together with the consolidation of the legal status for long-lived trees, will become the basis for increasing their fame and attracting the attention of large public organizations, such as the Russian Geographical Society. In the future, this may stimulate regional authorities, the local population and guests of the Tuva Republic to organize searches for long-living trees and include the oldest specimens in the cultural heritage at Republic level.

## Conclusion

We identified a Siberian larch specimen (*L. sibirica* Ldb.) in the forest-steppe zone in the Tuva Republic as being 779 years old. This is an absolute record for living larch trees in the steppe belt of Eurasia. Such old trees are of particular importance because they allow us to assess climate changes at the regional level over a long time period, which is not possible using other data sources (weather station data, for example, go back for no more than 60 years). Thus, the forest-steppe zone affords new opportunities for paleoclimatic reconstructions with a high temporal resolution in inner Asia over millennia.

Another important result was finding the dead larch stem of 1,307 years old, which is currently the record age for the Boreal zone of the northern hemisphere.

Linking science, state and society can help to bridge the gap between the scientific and cultural values of old trees and maximize the importance of the cultural, historical, tourist, dendroclimatic, botanical, recreational, environmental and aesthetic aspects of long-living trees. Such a multiplicity of perspectives on the importance of long-living trees at the regional level in Russia is reflected in the Baikal Rare Trees inventory, created as a part of the Baikal Tree programme (Baikal Tree 2021). Such projects not only allow the preservation of known old trees but may perhaps also lead to the discovery of new natural archives, contributing to awareness-raising of these cultural and historical objects as wonders of the world.

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*tree-ring cellulose as indicator of extreme eco-hydrological changes in boreal forests (ECO-HYDROTREE).*

## Data availability statement

Datasets are available in Zenodo research data repository https://doi.org/10.5281/zenodo.7307751.

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# Dependency on national park resources of people living in a mountain protected area

*Kamal Thapa*

*Keywords: firewood, Langtang National Park, local people, national park benefit, natural resource use, Nepal*

## Abstract

National Parks can provide diverse benefits to those living in and around them, supporting livelihoods and providing opportunities to harvest natural resources and to participate in nature-based tourism. To explore the direct benefits to local people, a questionnaire-based survey was conducted in four villages in Langtang National Park, Nepal. Firewood and fodder / grasses were the main resources harvested by local people. Household size and the total number of livestock units were the only significant predictors of resource use (firewood and fodder). These findings suggest that local people are dependent on national park resources. Strategies to reduce firewood dependency and hence pressure on the national park forests are recommended.

## Profile

Protected area

Langtang National Park

Mountain range

Himalaya, Nepal

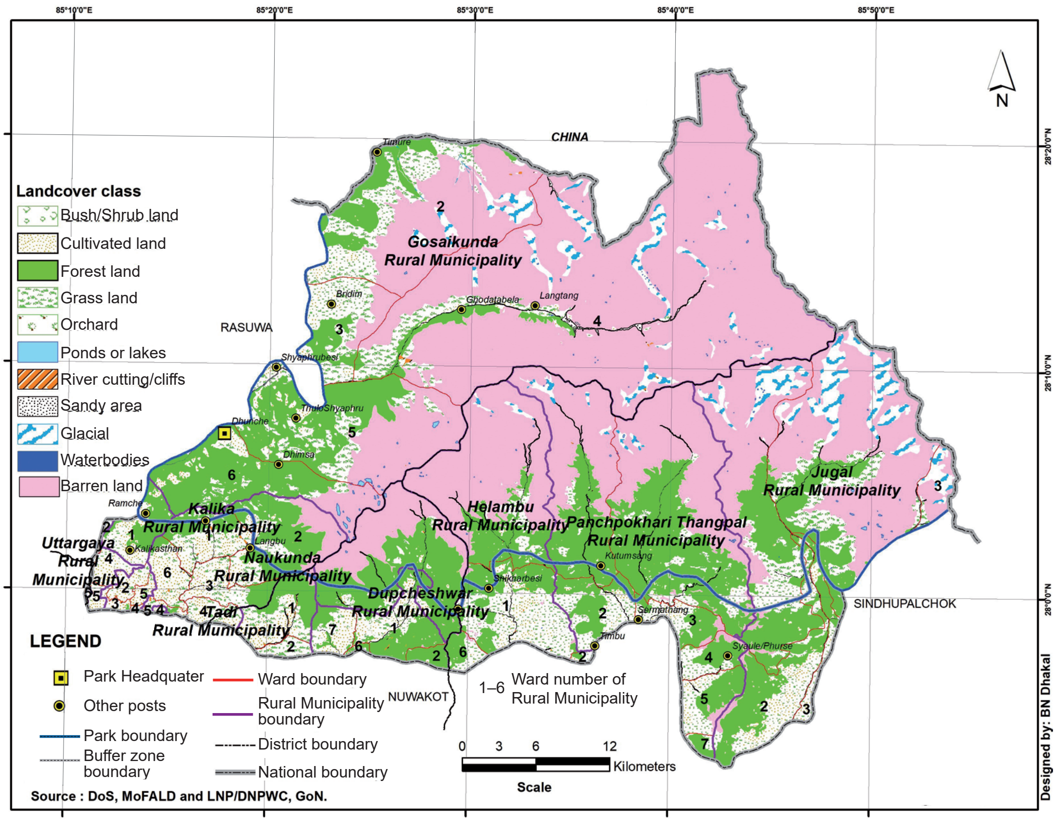
*Figure 1 – Village inside Langtang National Park. © Kamal Thapa*

## Introduction

The world's commitment through the Aichi biodiversity target of the Convention on Biological Diversity led to an increase in the total extent of protected areas (PAs) (UNEP-WCMC et al. 2018). However, this is well below the target of 17% of the world's terrestrial surface (including inland waters) to be protected as PAs. While the primary objective of PAs is to conserve biodiversity, they also help support livelihoods through providing incomes and the opportunity to harvest natural resources to meet subsistence needs (Clements et al. 2014; Getzner & Shariful Islam 2013). From the ecosystem services point of view and the values placed on PAs, benefits to people often outweigh losses (Ninan & Kontoleon 2016; Sharma et al. 2015; Shrestha et al. 2006). However, the distribution of the benefits of PAs to the public (and the costs) has always been uneven and controversial (Brockington & Wilkie 2015). While benefits extend to the regional or national and international levels, economic losses are often more pronounced in and around the protected areas themselves.

PAs, including national parks, provide different types of natural resources used by local people, such as dead wood, firewood, thatch, timber, fodder or grasses, and medicinal plants (Baral & Heinen 2007; Chaudhary et al. 2016; Karanth & Nepal 2012; Ninan & Kontoleon 2016; Sharma et al. 2015; Spiteri & Nepal 2008b; Vedeld et al. 2012). Firewood, fodder / grasses, leaf litter and thatch tend to be the biggest resources that local people harvest from protected areas and forests (Asfaw et al. 2013; Baral & Heinen 2007; Baral et al. 2019; Heinen 1993; Mushi et al. 2020; Sharma et al. 2015; Vedeld et al. 2012). Firewood is often the ideal – and only – source of energy, particularly for poor people, living in the developing world. For example, in the Afromontane Forest of Ethiopia, 88.9% of households identified firewood from the forest as the most important forest product, followed by grass (Asfaw et al. 2013). In Sundarbans, Bangladesh, local people depended heavily on the mangroves for firewood in order to avoid having to spend money on firewood at the local market (Getzner & Shariful Islam 2013). However, the availability of these resources can fluctuate over time, and become depleted due to long-term changes in land cover (Chaudhary et al. 2016; Karanth et al. 2012).

If local people benefit from PAs, they are more likely to have a positive attitude towards PAs (Allendorf 2007). A positive attitude contributes to achieving conservation objectives (Kideghesho et al. 2007). However, even when the majority of local people



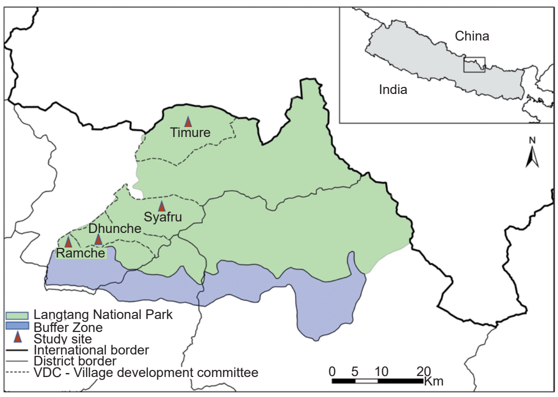




*Figure 2 – Langtang National Park – location and land-cover. © land cover: DNPWC; location map designed by Ido Fridberg and Kamal Thapa 2023: database: Hermes GIS Dataset; UNEP-WCMC and IUCN. 2023. Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-based Conservation Measures (WD-OECM). Cambridge, UK: UNEP-WCMC and IUCN*

understand the need for conservation, they still look for socio-economic opportunities arising from PAs, including national parks (Ezebilo & Mattsson 2010; Karanth & Nepal 2012).

Langtang National Park (LNP) is a Himalayan national park in Nepal. Unlike what happens in other national parks and reserves in the mid-hills and lowlands (Terai), local people are allowed to live within LNP's boundaries[1] and to carry out their traditional way of life. Earlier LNP-based studies focused on firewood consumption in the tourist destination by tourism-related businesses (e.g. hotels) and by the local population who did not run tourism-related businesses (Chapagain 2017). One study looked at firewood consumption by a yak cheese factory (Yonzon & Hunter 1991), but studies on the types and quantities of natural resources harvested by local people in areas off the trekking trail and / or tourist destinations are lacking.

In this context, the purpose of this research was (1) to investigate the resource-dependency of local people and its extent in LNP, and (2) to identify the main factors that determine the extent of their harvesting of resources.

## Materials and method

### Study site

Langtang National Park (27° 57' 36" N to 28° 22' 48" N, 85° 12' 36" E to 85° 52' 48" E) is a Himalayan protected area that covers 1,710 km$^2$ and shares an international border with Tibet (China). A buffer zone of 420 km$^2$ for conservation and development activities was added in 1998 (Figure 2). LNP is rich

1 Communities inside the national park boundary in the Nepalese Himalayas are considered legal settlements, with the same regulations as in the buffer zone. However, lowland (Terai) protected areas are free from any human settlements as these were removed from the park in the past.

in biodiversity and is home to several protected and endangered wildlife species, of which the Snow Leopard (*Panthera uncia*) and Red Panda (*Ailurus fulgens*) are the flagship species (LNP 2019). Gosainkunda and other nearby lakes inside the national park are Ramsar sites. LNP is also an Important Bird Area (IBA) of Nepal (BCN, 2020). The park comprises different forest types and has more than one thousand species of flora. In the southern zone, vegetation is characterized by Sal *(Shorea robusta*) forest at lower elevations, and by Pine forest (*Pinus roxburghii*), Rhododendrons and Nepalese alder (*Alnus nepalensis*) at higher elevations (LNP 2020). The study site consisted of broad leaf forest mixed with pine.

In the past, economic activities were based largely on traditional agricultural practices combined with livestock rearing. Two cheese factories, in Kyanjin and Sing Gumpa, have been in operation since 1953 processing yak milk from local farmers (Yonzon & Hunter 1991). Along with arable farming and livestock herding, tourism provides local residents with major economic and livelihood activities. Tourism in LNP has experienced high growth rates in the last 10 to 20 years, with the LNP now drawing more than 17,000 international visitors annually (DNPWC 2020; LNP 2019). Visitors can experience both culture- and nature-based tourism in the national park and surrounding region. A recent (2019) National Park report shows that 77,207 people from 14,963 households were residing in LNP and the buffer zone. Our study site comprised a population of 7,255 living in 1,683 households (LNP 2019).

## Data collection

A household-level survey, which is displayed at the end of this article, was conducted by the author

*Table 1 – Socio-demographic profile of the respondents.*

| Village | Ramche | Dhunche | Syafru | Timure | Total |
|---|---|---|---|---|---|
| N | 41 | 48 | 78 | 17 | 184 |
| Variables | | | % | | |
| Sex | | | | | |
| Male | 58.5 | 62.5 | 36 | 53 | 49.5 |
| Female | 41.5 | 37.5 | 64 | 47 | 50.5 |
| Age | | | | | |
| ≤ 25 | 19.5 | 10.5 | 9 | 12 | 12 |
| 26–55 | 58.5 | 66.5 | 63 | 41 | 60.9 |
| 56+ | 22 | 23 | 28 | 47 | 27.2 |
| Household Size | | | | | |
| ≤ 4 | 39 | 29 | 19 | 17.5 | 26.1 |
| 5–14 | 61 | 69 | 81 | 82.5 | 73.4 |
| 15+ | 0 | 2 | 0 | | 0.5 |
| Educational level | | | | | |
| No Schooling | 78 | 52 | 73 | 59 | 67.4 |
| Primary (grades 1–8) | 12 | 14.5 | 15.5 | 29 | 15.8 |
| Secondary (grades 9–12) | 7.5 | 31.5 | 11.5 | 6 | 15.2 |
| Bachelor's degree and above | 2.5 | 2 | 0 | 6 | 1.6 |

in villages administered by four (former) Village Development Committees (VDCs), Ramche, Dhunche, Syafru and Timure in Rasuwa district, which are inside the national park boundary. The total numbers of households in these villages were 633 (Ramche), 392 (Dhunche), 553 (Syafru), and 105 (Timure) (LNP 2019). Dhunche is the district headquarters of Rasuwa and hosts the LNP office. Timure lies on the border with Tibet (China).

The survey was carried out along the Pasang Lhamu highway. The most distant household surveyed was 30 minutes' walk from the highway (one way). Most households surveyed were involved in agriculture or livestock rearing, and subsistence dependent on nature. For Rasuwa district, I aimed to survey at least 10% of households in that part of the buffer zone which in this instance lies within the national park boundary. However, given the distance of some households from the road and the partial inclusion of Ramche VDC inside the national park boundary, only 6% of households in Ramche were surveyed. Households were selected for survey based on convenience. Only one person per household aged over 18 was asked to participate. To ensure gender balance, I aimed to target male and female respondents alternately. However, achieving a ratio of exactly 50:50 was not possible. No household denied participation in the survey. The sample size (*N*) of the study was 184 (Table 1).

## Data analysis

The local unit (*bhari*)[2] was used to estimate the quantity of resources harvested from the national park. One *bhari* of firewood can range between 25.2 and 65.5 kg (Baral et al. 2019; Chapagain 2017; Fox 1984; Karmacharya & Bhuju 2010; Nepal et al. 2011). However, the LNP office uses the *chatta* for firewood measurement, which is equivalent to 20 x 5 x 5 cubic feet and weighs about 10,470 kg (Subedi et al. 2014, 53).

I assumed that one *bhari* of firewood weighed 25.2 kg as a minimum conservative estimate for analysis purposes, as local people are allowed to collect dead wood and broken branches only, which are lighter in weight. Chapagain (2017) used 40 kg as equivalent to one *bhari* of firewood in Langtang village, LNP; therefore, 40 kg per *bhari* was used as a maximum conservative estimate. Fodder was also assigned the equivalent weight in kg per *bhari*, irrespective of the resource type. The number and types of domestic animals were converted into livestock units (LSU) for analysis. One LSU was calculated as 1 cow, or 0.66 buffalo, or 2 pigs, or 5 goats (or sheep) (Shahi et al. 2022)

Respondents' profiles were subjected to basic descriptive statistics; multiple regression was performed to show the effect of independent variables on firewood and fodder consumption. Assumptions were

[2] Bhari is a one back load usually one person can carry on his/her back by him/herself. Bhari is a common metric used for measuring (weight) goods, especially natural resources, in rural villages of Nepal.

checked for multiple regression. Data analysis used Statistical Package for Social Sciences (SPSS) (IBM SPSS Statistics 26).

### Model specification

I hypothesized that the consumption (harvest) of natural resources (firewood, fodder) by a household is a function of various socio-economic factors, such as household (family) size, area of land owned, number of livestock (calculated as LSUs), and location of the village. Although in the regression models some authors (Asfaw et al. 2013; Baral et al. 2019; Mushi et al. 2020) included other individual parameters such as age, marital status, sex, literacy etc. these parameters were not applied in this model. I was more interested in the household-level parameters, because harvesting and use of natural resources such as firewood and fodder are household rather than individual activities. Household-level income was not included in the model as income is a sensitive subject for respondents, who may respond with irrelevant or misleading figures, or income may not represent the true economic status when there is no formal job / employment. Household distance from the road was not considered in the statistical model as the road's transect was used as the basis for the survey. Although the households surveyed were situated at varying distances from the road (maximum 30 minutes on foot one-way), all households were considered, from the local Nepalese perspective, to be near the road or within easy access of it.

I used multiple regression to model the relationships between the dependent variables (firewood and fodder consumption) and the independent variables (socio-economic predictors), as represented in the following equations:

$$\text{Firewood consumption} = x0 + x1_{\text{family size}} + x2_{\text{area of land owned}} + x3_{\text{LSU}} + x4_{\text{location of the village}} + \text{error} \ldots \quad \text{equation (1)}$$

$$\text{Fodder consumption} = x0 + x1_{\text{family size}} + x2_{\text{area of land owned}} + x3_{\text{LSU}} + x4_{\text{location of the village}} + \text{error} \ldots \quad \text{equation (2)}$$

## Results

### Socio-economic characteristics

All respondents were of Tamang ethnic origin, as is typical of the northern part of Rasuwa district. There were almost equal numbers of male ($n=91$) and female ($n=93$) respondents, with a mean age of about 45.5 years (age range 18 to 85 years). The average household size was 5.92 people (range 2 to 24 people). Most respondents were from Syafru VDC ($n=78$), followed by Dhunche VDC ($n=48$). Most respondents (67%) did not have any formal schooling, and only 1.6% had a Bachelor's degree or above (Table 1).

The average area of land owned by a household in the study area was 0.483 hectare (9.5 *ropani*)[3]. On average, local people owned 2 cattle, 0.5 buffaloes and 2.5 goats or sheep per household (Table 2). However, 112 households did not own any cattle, 146 did not own any buffaloes, and 147 did not own any goats or sheep.

*Table 2 – Socio-economic characteristics of the respondents.*

| Variables | N | Min. | Max. | Mean | St. Dev. |
|---|---|---|---|---|---|
| Land area (ropani) | 178 | 0 | 97 | 9.52 | 11.75 |
| Cow/Ox | 184 | 0 | 30 | 2 | 4.74 |
| Buffalo | 184 | 0 | 7 | .49 | 1.14 |
| Goat/Sheep | 184 | 0 | 80 | 2.45 | 8.82 |
| Total LSU | 184 | 0 | 34 | 3.22 | 5.72 |
| Location of villages in relation to LNP office* | 184 | 1 | 2 | 1.74 | .44 |

** coded as 1 (near), and 2 (far)*

### Types of resource dependency and magnitude

Local people harvested two main natural resources from the national park forest: firewood and fodder. Harvest of leaflitter was negligible: only one respondent stated that they collected leaflitter from the national park forest in addition to firewood and fodder. Ninety-five households collected both firewood and fodder, 83 collected firewood only, and 6 did not collect any resources from the national park forest.

Local people were dependent on national park resources to meet their subsistence needs at household level. No-one sold firewood or fodder in the market. In total, about 97% of the respondents harvested firewood for domestic use, ranging from 252 kg to 9,198 kg per household per year (average 1,929 kg per household). Similarly, 53% of the respondents (97 households) harvested fodder / grass to feed livestock. The amount of fodder taken from the national park ranged from 504 kg to 18,396 kg per household per year (average harvest 4,509 kg). Ninety-four households harvested fodder and owned livestock, whereas only 3 households harvested fodder but did not own livestock. On the other hand, 15 households did not harvest fodder but did own livestock.

### Factors influencing resource (firewood and fodder) dependency

Only 5.9% of the variance in firewood consumption (for both cooking and heating) was explained by the regression model ($F$ (4, 173) = 2.722, $p<0.05$). Household size was the only predictor ($p<0.05$) of firewood consumption: the larger the household, the larger the harvest of firewood (Table 3).

For fodder consumption, 13.7% of the variation was explained by the regression model ($F$ (4,173) = 6.842 $p<0.001$). Household size ($p<0.01$) and total number of LSUs ($p<0.01$) were the two main predictors of fodder/grass consumption. The larger the household, the greater the harvest of fodder; and the more LSUs owned, the more fodder / grasses tended to be harvested. Households with greater holdings of land tended to harvest less fodder / grasses. The further the

[3] Ropani is the local land area measurement unit in Nepalese mountains. One hectare equals to 19.65 ropani.

villages were from the national park headquarters, the less harvesting and consumption of firewood and fodder occurred (Table 3).

## Discussion

Local people in LNP harvested only two types of resources, firewood and fodder / grasses, for their subsistence needs. While firewood was harvested by almost all households surveyed, fodder was harvested by only about half of them. Where the harvest of resources from LNP is concerned, this study made findings similar to those of others (Måren & Sharma 2018; Spiteri & Nepal 2008a, b). In Annapurna Conservation Area and Chitwan National Park, local people identified timber, firewood, thatch grass and fodder as the most important extraction benefits, with firewood the main resource harvested (Spiteri & Nepal 2008a). However, these benefits were recognized more by villagers who were not involved in tourism than by those who were. Given the protected status of national parks and the limits put on resource extraction, resources harvested from the national parks may not meet the actual requirements of local people (Spiteri & Nepal 2008a). While this study found only one case of leaflitter being harvested from LNP forest, Måren and Sharma (2018) found no cases of fodder being harvested from the LNP and government forests. This discrepancy could be due to villagers considering fodder and leaflitter as one single resource.

The harvesting of firewood and fodder / grasses could be due to the fact that almost all the people residing in LNP are subsistence farmers, and livestock rearing and farming are their main livelihood activities. However, LNP office records showed that after paying a fee determined by the national park, local people also used various other resources, such as sand, gravel, timber for construction, firewood etc. (LNP 2019).

People living in LNP did not recognize natural resources other than firewood and fodder. The reasons for this could be: 1) the special permit required from the national park office to harvest resources; 2) natural resources are controlled (allocated, and restricted in quantity); 3) the fee charged for harvesting resources. For example, if, after a disaster, local people need timber for house construction, they must apply for a permit, pay a fee to the national park, and obtain permission from the national park office (with recommendation from the buffer-zone users' group or users' committee). Harvest permits are issued for limited quantities of sand, gravel and other resources. For firewood, however, no special permit is required, and it can be harvested twice a year (during one month in winter and one in summer) through a buffer-zone users' group / committee (Chapagain 2017). This author did, however, witness harvesting of firewood in other months.

Himalayan National Park regulations prohibit the collection of sand, stone and other resources from the national park. Similarly, cutting down live trees and bushes, and harvesting foliage or branches from them, are restricted in National Parks. However, harvesting wood / timber and forest products for house construction and / or repairs is sometimes allowed after payment of a fee (GoN 2019). In the fiscal year 2018 / 2019, the national park office distributed timber, firewood (212,017 kg) and *nigaloo* (Himalayan bamboo, 857 kg), and permitted the collection of sand, stone and gravel for a fee (LNP 2019). In the current study's area, there are only two buffer-zone community forests (in Syafru VDC) for forest resource use, protected and managed by the community (LNP 2019), whereas people from the other three VDCs rely on the national park forest. In the absence of a community forest, resources taken from the national park forest cannot be ruled illegal. However, as local people have also borne losses caused by national park wildlife, including damage to their crops or predation of their livestock (Kharel 1997; Regmi et al. 2013), opportunities to harvest resources could have been offered (albeit unofficially) as indirect compensation.

The national figures for Nepal have shown that the use of firewood for energy is increasing (GoN / NPC 2019). 68.6% of the country's energy consumption comes from traditional energy sources such as firewood, followed by commercial fuel sources (28.2%) and renewable sources (3.2%) (GoN / MoF 2021). Of the traditional energy sources, 87% of household energy comes from firewood, the main source of domestic energy for cooking and heating in Nepal's rural households (Baral et al. 2019). In Rasuwa district (the study area), improved stoves have been designed and promoted to reduce the consumption of firewood and increase energy efficiency (GoN / NPC 2019). However, they have not resulted in a reduction in the consumption of firewood (Nepal et al. 2011).

*Table 3 – Multiple regression analysis of independent variables on firewood and fodder consumption.*

| | **Firewood** | | | **Fodder** | | |
|---|---|---|---|---|---|---|
| Variables | Coefficient | Std error | p | Coefficient | Std error | p |
| Constant | 72.415 | 21.777 | 0.001 | 110.973 | 63.253 | 0.081 |
| Household (Family) Size | 4.488 | 1.831 | 0.015** | 15.185 | 5.318 | 0.005*** |
| Land holdings | 0.028 | 0.391 | 0.942 | −1.797 | 1.136 | 0.116 |
| Location | −14.163 | 10.295 | 0.171 | −17.292 | 29.901 | 0.564 |
| Total LSUs | 0.596 | 0.827 | 0.472 | 7.804 | 2.402 | 0.001*** |

*Significance at ***1%, **5%*

In the high-altitude Langtang village in LNP, Chapagain (2017) found that the average consumption of firewood per household (non-hoteliers) was 6,500 kg to 7,175 kg per year (equating 6.6 kg per capita per day), which is higher than the current study found. There has been a growing trend in using firewood as the energy source in these high mountain villages (Chapagain 2017; Timmerman & Platje 1987 cited in Yonzon & Hunter 1991), where high consumption of firewood is inevitable because of the colder climate. Controlling local harvesting of national park resources such as firewood is often difficult. For example, in LNP, the yak cheese factories used more than 100% of their permitted quantity of firewood (Yonzon & Hunter 1991). Hence, there is a risk of over-harvesting national park forest resources, and thereby of reducing the overall growing stock of the forest and its biodiversity.

Requirements for firewood and fodder can also be met by planting trees on private farmland, as agroforestry. Trees on private farmland meet about 43% of the total firewood and fodder requirements of community forest users' groups in the Nepalese mid-hills. Most of the tree species grown on farmland are multipurpose fodder species (Oli et al. 2015). Encouraging farmers to plant trees on their own land may help reduce the demand for firewood and fodder from the national park in the long run, thus contributing to conservation. This study also found that households with more land are less dependent on the national park for fodder.

Baral et al. (2019) found that family size, per capita income, livestock units and literacy rate were the key predictors of firewood consumption. In another study, Mushi et al. (2020) found that distance from the forest and roads were the main predictors for the collection of non-timber forest products. Those people living close to the forest but far from the main road were the most frequent harvesters of fodder. People living far from the main road also collected more firewood, while households living some distance from the market but near the forest also consume more firewood (Asfaw et al. 2013; Oli et al. 2015). Higher levels of education could help reduce deforestation by opening up opportunities for better-paid work (Adhikari et al. 2004; Godoy & Contreas 2001, cited in Mushi et al. 2020). Easy access to markets and forests clearly leads to the accelerated extraction of forest resources. In the Langtang region, the density of cut tree stumps, a proof of human use, was higher in lower elevations and closer to settlements (Måren & Sharma 2018). In the present study, villagers near the national park headquarter were found to harvest more firewood, which could be explained, at least in part, by the ready availability of, and accessibility to, forest resources.

## Conclusion

The livelihoods of the local people in LNP are typical of a hill-farming system in which livestock rearing, traditional agriculture and forest resources complement each other. Because local people are dependent on national park resources to support their livelihoods, strict conservation measures to prevent people harvesting resources could generate negative attitudes towards the national park. It is significant that local people who are able to extract resources are more likely to have positive attitudes towards protected areas and conservation (Allendorf 2007). However, allowing local people to harvest resources without controls can result in over-harvesting, and it is therefore important to find a win-win solution for the national park and local people.

Dependency on national park resources can be reduced by promoting alternative energy sources, and encouraging local people to plant multipurpose and fast-growing tree species on their own farmland. Strategies to ensure sufficient nutritious fodder throughout all seasons should be a major target for livestock production. Unproductive livestock can also be reduced through improved breeding techniques and more efficient use of animal feed while obtaining the same or increased outputs that suit the local environment (Khanal et al. 2022). While some level of dependency by local people on national park resources is inevitable, it is important to manage the national park for the conservation of biodiversity. By increasing people's understanding of the need for conservation and providing alternative resources to those of the national park, the balance between conserving biodiversity and meeting the needs of local communities will be easier to achieve.

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## Survey questionnaire

Natural Resource Benefits from Langtang National Park in the Nepalese Himalayas

Household ID:

1. Demographic profile

Household size:
Age:
Ethnicity:
Education:
Village:
Occupation:
Sex:

2. Please mention the top three natural resource products that you often harvest from Langtang National Park.

3. For the Natural Resource product that you harvested given in (a) above, how much do you harvest per year, on average in bhari?

4. For the Natural Resource product that you harvested given in (b) above, how much do you harvest per year, on average in bhari?

5. For the Natural Resource product that you harvested given in (c) above, how much do you harvest per year, on average in bhari?

6. Do you own any livestock?

a) Yes
b) No

If yes, how many of the following do you own?

a) Cattle
b) Buffalo
c) Goats/Sheep

7. Do you own any land?

a) Yes
b) No

If yes, please state how much you own in ropani.

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# From the mountains to the sea: The Tepilora Natural Regional Park, Sardinia

*Domenico Branca, Andreas Haller & Marianna Mossa*

*Keywords: Nature Park, Biosphere Reserve, regional development, Italy, Mediterranean mountains*

## Abstract

Protected areas are no longer focused solely on conservation and protection needs but play a central role in promoting sustainable development in local socio-territorial systems. The Tepilora Natural Regional Park (TNRP) in Sardinia offers an example of this phenomenon. This paper highlights the significance of the TNRP in balancing conservation needs with the sustainable development of local populations – an effort that resulted in the establishment of the Tepilora, Rio Posada and Montalbo Biosphere Reserve.

## Profile

Protected area

Tepilora Natural Regional Park & Tepilora, Rio Posada and Montalbo Biosphere Reserve

*Figure 1 – The Rio Posada. © D. Branca*

## Introduction

The massive growth in the number of protected areas globally since 1980 (Zimmerer et al. 2004), reaching a terrestrial coverage of more than 17% (Rodríguez-Rodríguez et al. 2017; Protected Planet 2023), was accompanied by a paradigm shift from strict conservation and protection towards the consideration of local populations' needs and sustainable regional development. Far beyond being exclusively natural areas, protected areas are manifestations of the inseparable relationship between nature and culture. Protected area managers thus also respond to an area's cultural-historical and social-economic changes (Zupančič-Vičar 2006), including variations in land use, which are increasingly directed towards urban society and its leisure activities (Beltran-Costa 2022). The Tepilora Natural Regional Park (TNRP) in Sardinia is a case in point because it connects cultural-historical and social-economic dimensions with the need for environmental conservation and protection. Moreover, the TNRP stands out because it connects mountains and coastal areas along an integrated socio-territorial system that follows a river from the mountains to the sea.

This article presents a general profile of the TNRP, showing its natural and cultural characteristics. In particular, it describes the geographical context, the establishment process of the TNRP, and some of the actions taken by the TNRP management regarding issues such as conservation, public and heritage use, and the relationship with local communities (see Martínez-Fernández et al. 2022) – efforts that eventually led to the creation of the Tepilora, Rio Posada and Montalbo Biosphere Reserve.

## Between the mountains and the sea

Located in the Mediterranean biogeographic region, in the north-eastern part of the island of Sardinia (European Commission 2016), Italy, the TNRP covers over 7,877 ha and falls within the territory of four municipalities (Bitti, Lodè, Torpè and Posada) (Figure 2). What makes this area stand out is the integration of mountains and coast, from the sea up to the highest peak of Nodu Pedra Orteddu (978 m), across a variety of ecosystems.

The area is characterized by Paleozoic intrusive rocks, particularly granites, and the presence of the so-called *serras* (characteristic ridges). In Crastazza-Tepilora and Sos Littos-Sas Tumbas, the mean annual temperature is 12.9 °C; the mean annual precipitation reaches about 1,050 mm (SardegnaForeste s.d.a; SardegnaForeste s.d.b). While the upland areas are covered by Mediterranean forests (including broadleaf forest, coniferous forest, maquis and garrigue), the mouth of the Rio Posada – a Ramsar site since 2018 (site number 2452) – represents a complex socio-ecological wetland system (Figure 1), characterized by traditionally used agricultural land, marsh vegetation

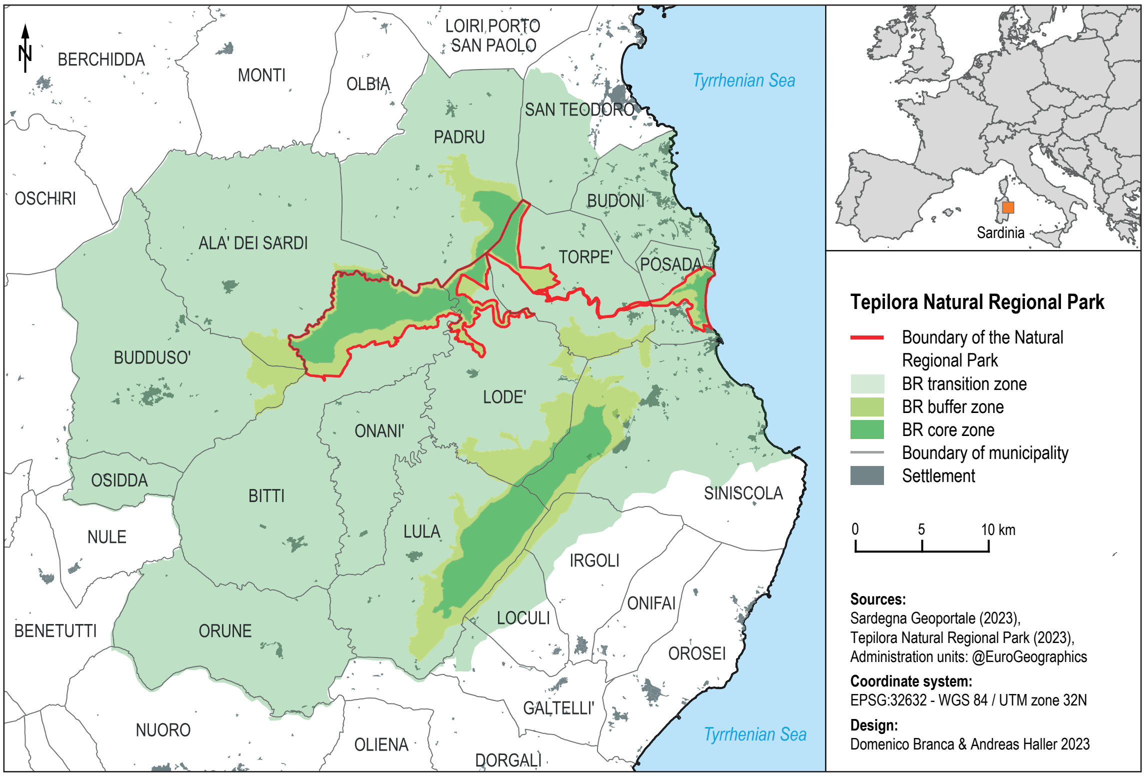


*Figure 2 – The Tepiora Natural Regional Park and the Rio Posada and Montalbo Biosphere Reserve.*

and rich avifauna (Ruiu 2013; Sulas 2017; French et al. 2017). Typical river-mouth flora can be found along the gradient of fresh, brackish and salt water, including *Phragmites australis* reedbeds, riparian tamarisk and willow communities, and saltwater species such as glassworts (*Sarcocornia* spp.), seepweeds (*Suaeda* spp.) and sea purslane (*Halimione portulacoides*) (Ramsar Site Information Service 2021). In general, the fauna of the TNRP is typical of the Mediterranean islands. It includes the wild boar (*Sus scrofa meridionalis*), Sardinian hare (*Lepus capensis mediterraneus*), fox (*Vulpes vulpes ichnusae*), wild cat (*Felis lybica sarda*), fallow deer (*Dama dama*) and mouflon (*Ovis ammon musimon*) (Figure 3).

Important in the establishment of the TNRP, in addition to the diversity of its natural features, was the pre-existence of several forest conservation areas in the park's municipalities. These forested areas include Crastazza-Tepilora and part of Sos Littos-Sas Tumbas in Bitti (SardegnaForeste s.d.a; SardegnaForeste s.d.b), the forest of Sant'Anna in Lodè (SardegnaForeste s.d.c), and the Usinavà forest in Torpè (SardegnaNatura s.d.).

## From the establishment of the Tepilora Natural Regional Park to the Biosphere Reserve

The process of establishing TNRP took place within a complex cultural and regulatory context. In the late 1980s, an important debate took place at regional and national levels concerning the creation of protected areas. The debate, which resulted in Regional Law No. 31 (7 June 1989), was keen and defined the rules


*Figure 3 – Mouflon (Ovis ammon musimon), female (a) and male (b). © Parco di Tepilora*

*Table 1 – Timeline of the establishment of the Tepilora Natural Regional Park and the Biosphere Reserve (BR). MAB – Man and the Biosphere*

| Date | Event | Remark |
|---|---|---|
| 07.06.1989 | Regional Law on Protected Areas and Parks | Regional Law No. 31/1989 |
| 06.12.1991 | First Italian framework law on protected areas | National Law No. 394/1991 |
| 24.10.2014 | The Tepilora Natural Regional Park was officially established | Regional Law No. 21/2014 |
| 12.06.2017 –15.06.2017 | UNESCO designated the Tepilora, Rio Posada and Montalbo BR | International Coordinating Council of the MAB Programme (29th session) (UNESCO 2017) |
| 25.02.2021 | Designation of the *"Foce del Rio Posada"* (Posada River mouth) as a Ramsar site | Ramsar Site Information Service |

for establishing and managing protected areas. The debate stands as a milestone in the regulatory framework on parks in Sardinia. Two and a half years later, this law was complemented by (national) Law No. 394 (6 December 1991), the first Italian legislation to cover protected areas, concerning the protection of nature. (For a critical analysis of the Parliamentary debate on the framework law, see Paradiso 2022, chapter 5.) Despite this, it took several more years before work on establishing the TNRP started.

The initial idea consisted of plans for two different parks: one fluvial, encompassing the municipalities of Alta Baronia, and one mountainous, around Bitti (Parco di Tepilora s.d.). Another critical step in establishing the park coincided with a 2005 bill (*Disegno di Legge*) presented by the then Councillor for Environmental Protection, Antonio Dessì. This bill merged three previous bills on the establishment of three regional parks, including the *Oasi di Tepilora*, approved by the Regional Council between October and November 2005. The bill specified that the Bitti Municipal Council had expressed its support for establishing a regional natural park in the area and that on 3 January 2005 the Municipal Council had made arrangements with the Desertification Research Centre of the University of Sassari to prepare a preliminary study for establishing a park due to the significance of the area from a biodiversity conservation point of view. Hence, Bitti played a central role in the creation of the TNRP, as reflected in the Memorandum of Understanding (*Protocollo d'Intesa*) between the Regional Councillor for Environmental Protection, the President of the Province of Nuoro, the Mayor of the Municipality of Bitti, and the President of the Forestry Authority of Sardinia. The objective was to agree on the establishment of a *"Regional Natural Park of the Tepilora Oasis aimed at the conservation and protection of natural resources and the creation of opportunities for sustainable development with positive economic effects on the entire surrounding area."* (Resolution of 27 December 2005, No. 62/76)

In the years that followed, references to the park frequently appeared in the regional press. In 2011, for example, *La Nuova Sardegna* reported on the local debate regarding the establishment of the park and possible effects. Further municipalities – Lodè, Posada and Torpè – joined the project, laying the foundation for linking mountains and coastal areas, which were already connected by rivers, in a single park (Anonymous 2011), a particularity made visible in a logo presented the following year (Merlini 2012; Figure 4). Soon after, the process gathered pace, first with public assemblies in each of the four municipalities and, later, with discussions by municipal councils (Secci 2013). According to the interviews collected about this historical phase, anti-park positions emerged during public meetings, mainly relating to the use of the natural resources of the forest and the traditional practice of hunting (Merlini 2014). The press began to get behind the project and presented the park to the public (Merlini 2013a, b; 2014) when it was officially established by Regional Law No. 21 on 24 October 2014 (Infobox 1).

Following the park's establishment, preparations began to apply for UNESCO Biosphere Reserve (BR) status. The zoning process for this ended in 2016 (Asproni 2016), with 17 municipalities joining, and the application was submitted in September of the same year (Secci 2016). In June 2017, UNESCO designated the Tepilora, Rio Posada and Montalbo Biosphere Reserve as Sardinia's first BR (Secci 2022b), with its own governance structure (Infobox 2). As during the establishment of the TNRP, the common thread of this project was the Rio Posada, which connects mountains and coast through a composite socio-territorial system in which the human dimension was and continues to be closely connected with the environmental one (French et al. 2017; UNESCO 2019; see Figure 1). Today, the Park Authority of the TNRP is the administrative authority of the Tepilora, Rio Posada and Montalbo BR, and the TNRP covers a central part of

*Figure 4 – Linking mountains and coastal areas connected by rivers. © Parco di Tepilora*

the core and buffer zones of the whole BR. In total, the BR encompasses an area of 165,173 ha. According to the administrative authority, *"The goal* [of the BR] *is to consolidate the relationship between the mountains and the sea, the characteristic symbols of the area, and to find a balance between biodiversity, creating awareness in the population, but also enhancing the sustainable growth of the whole area, equally promoting agriculture and crafts, culture and landscape*" (Parco Naturale Regionale di Tepilora 2023).

Finally, on 25 February 2021, the Posada River mouth was designated a Ramsar site as a *"rare example in the Mediterranean of a near-natural river delta"* (Ramsar Site Information Service n.d.; Secci 2021).

## Cultural landscape and territorial construction

The connection of mountains and coast by the Rio Posada, and the land uses since the Bronze Age along this gradient have shaped the area of today's TNRP and the larger BR, creating a particular cultural landscape. Historically, and with altitudinal variations, the area has been created by humans practising agriculture and animal husbandry, especially sheep and goat farming. Until recently, breeders in the inland areas of Bitti (Figure 5) practised transhumance, taking their flocks to the coastal area of Gallura and Baronia (Le Lannou 1979; Mannia 2014). The actual territories of the TNRP and the BR are thus a tapestry of cultural history, social relations and ecological connections between the populations of the different areas – links threatened by societal changes that have emerged over the last six decades.

In the 1960s, Sardinia, like other regions of southern Italy, was affected by rapid socio-economic changes and, in particular, by strong migratory movements – towards the industrial hubs of northern Italy and countries such as Germany, France, Switzerland and Belgium, as well as towards the coastal areas of the island itself. For instance, the population of the TNRP municipality of Bitti – a town in the inland mountainous area – decreased from 5,774 to about 2,500 between 1961 and 2021 (Figure 5). In contrast, during the same period the population of the coastal TNRP municipality of Posada increased from 1,265 to approximately 3,000. In general, there was a substantial population increase in all the island's coastal areas, partly due to the development of seaside tourism. In the TNRP area, these societal changes had two major impacts on the cultural landscape: on the one hand, there was urban growth of coastal towns and the emergence of holiday resorts (although to a lesser degree than in other areas of Sardinia); on the other hand, there was a steady depopulation of mountain areas and a reduction in the use of pastures, followed by shrub encroachment (Ruiu 2017). Here, it becomes clear that establishing the TNRP and the related BR was driven not only by the need for environmental conservation, but also – and perhaps foremost – by

*Figure 5 – Bitti – a town in the inland. © Parco di Tepilora*

efforts to preserve the area as a whole as a place worth living in for people.

## Conservation and development initiatives

In consultation with the local population, the aims of the TNRP and the BR include spatial interventions of various kinds, from those more closely related to environmental conservation, to those related to the sustainable development, enhancement and enjoyment of the cultural and environmental heritage.

Notable among the conservation actions undertaken within the TNRP and the BR is the AQUILA a-LIFE project, funded by the European Commission, the Italian Ministry of the Environment, and the Autonomous Region of Sardinia, including ISPRA and Forestas, in addition to French and Spanish partners. The project aims to reintroduce and repopulate the western Mediterranean, particularly Sardinia, with Bonelli's Eagle (*Aquila fasciata*) (Ruiu 2018), a bird of prey whose relationship with humans – like the Golden Eagle – has historically been ambivalent due to competition for resources, specifically lambs. The shepherds suffered attacks from the eagles, which, for this reason, were often killed. Nevertheless, there were

### Infobox 1

The management bodies of the Park Authority of the Tepilora Natural Regional Park (adapted from Parco Naturale Regionale di Tepilora 2023).

*The President:* represents the Body and oversees its smooth operation. He/she is elected by the Assembly and holds office for three years. The President convenes and presides over the Assembly.
*The Assembly:* the political-administrative policy and controlling body of the park. The Assembly elects its President and formulates the guidelines regarding the technical-administrative activities of the Park Authority.
*The Board of Auditors:* the supervisory body overseeing the accounts and financial affairs of the Park Authority. The Board assesses compliance with rules and principles, and gives financial feedback on the acts of the Park Authority.

*Figure 6 – On the charcoal burners' trail with the Tepilora mountain on the right. © D. Branca 2022*

individual people capable of weaving relationships with eagles using various ritual practices, including *sos verbos*, a series of prayers aimed at foiling attacks. Ruiu states, *"All these different rituals had in common that the man who used* sos verbos *had in turn to respect both the eagle and the goods of other people"* (Ruiu 2017: 89–90), preventing raptors from being killed. The reintroduction of Bonelli's eagle is taking place within a distinct socio-economic context, thanks to a change in attitude on the part of livestock farmers (Ruiu 2017) and a process of reconstruction of nature (Beltran & Vaccaro 2011) that also aims to enhance environmental heritage.

The TNRP and the BR are particularly active in enhancing and valorizing the natural and cultural heritage of the municipalities of the park, especially through tourism. In concert with the regional agency Forestas, they are investing in the maintenance of thematic trails, one of the fundamental ways for learning about the TNRP through nature tourism. In December 2022, for instance, the four park municipalities organized *Foreste aperte* (open forests), which consisted of hikes through the municipal areas, tasting regional products, and learning about local traditions (Anonymous 2023). The municipality of Lodè organized hikes along the old charcoal burners' trails (Figure 6). Numerous other itineraries allow one to visit the TNRP and the BR at different altitudes and, interestingly, offer the possibility of discovering the entire territory via a route connecting the mountains and the sea by following the river.

Considerable importance is given to awareness-raising by the Centres for Environmental Education and Sustainability and their educational work, especially with schools and the general population, since one of the main problems is the identification of the population as a whole with the TNRP and the BR. Schools are a paramount interlocutor for the successful involvement of younger generations. In addition to the more specific environmental dimension, the TNRP and the BR also promote knowledge of the area's tangible and intangible cultural heritage, which is particularly rich in archaeological evidence (from the Su Romanzesu complex dating from the Bronze Age, in the municipality of Bitti, to the medieval Castello della Fava in the historic centre of Posada, to name but two sites). The presence of very distinctive social and cultural practices – from the *cantu a tenore*, declared a UNESCO Intangible Cultural Heritage, to the bonfires on the feast of St Anthony, carnivals and Holy Week celebrations – represent central elements in the life of local communities, but, at the same time, they also attract tourism. In this regard, the TNRP and the BR are destinations mostly for family tourism. To a much lesser extent, the area attracts sports tourism (e.g., kayaking on the Rio Posada), hiking related to local cultural traditions and gastronomy, or activities such as birdwatching (Secci 2022a). For the most part, visitors come from Sardinia but also, increasingly, from other regions of Italy and Europe.

Some years ago, in the conclusion of an article on the Alta Murgia region in Puglia, Ferdinando Mirizzi pointed out that conservation actions would have to consider the *"development of productive activities connected with the vocations of use of the environment [...] and to the living needs imposed by contemporary society"* (Mirizzi 1996: 477) – in other words, active participation and exchange between local communities and the park would be required. In the case of the TNRP and the BR, the various municipalities have implemented strategies to improve the population's identification with the protected area. Budoni, for example, has provided economic operators with the BR's logo, which they display on their premises. Another example is agritourism

## Infobox 2

Bodies assisting the Tepilora Natural Regional Park in the management of the Tepilora, Rio Posada and Montalbo Biosphere Reserve (BR) (adapted from Parco Naturale Regionale di Tepilora 2023).

*The Management Committee:* a decision-making and operational body of the BR, established immediately after recognition as a BR. Comprises a balance of representatives of the municipalities participating in the BR, and of the socioeconomic sphere, other protected areas (e.g., Tepilora Natural Regional Park, Historical and Environmental Geomining Park of Sardinia, SCI *Monte Albo* ITB 021107), the regional government and its agencies (Forestas), and educational institutions.
*The MAB Office:* a technical body supporting the Management Committee, composed of the Centres for Environmental Education and Sustainability. Active in the municipalities of the BR and includes staff members of the Tepilora Natural Regional Park. The MAB (Man and the Biosphere) Office is headed by the park Director.
*The Technical Scientific Committee*: has the task of supporting and stimulating the Management Committee from a technical and scientific point of view. It represents the BR in international fora organized by UNESCO.
The Consultative Assembly: aims to ensure the participation of the local community. It is an open body, without defined structure, which is called upon for the most significant of the BR's decisions, as in 2020 for the definition of the Action Plan (albeit only remotely, due to the pandemic).

in Bitti, which has hosted a photographic exhibition on the TNRP (Deiana 2022).

## Conclusion

Worldwide, protected areas are increasingly positioning themselves as central actors in the sustainable development of local socio-territorial systems. The TNRP and the Tepilora, Rio Posada and Montalbo BR are undoubtedly cases in point. The conservation and reintroduction of species within this protected area, the rich material and immaterial heritage, and the relationship with the population demonstrate the connections between actors operating in this composite territory which, through the river, connects the sea to the mountains.

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# EuroMAB Conference 2022: "Tying cultures. Crossborder cooperation between societies and generations", Salzburger Lungau und Kärntner Nockberge Biosphere Reserve, Bad Kleinkirchheim, 12–16 September 2022

*Günter Köck & Heinz Mayer*

*Keywords: Man and the Biosphere Programme, UNESCO, EuroMAB, MAB Youth, transboundary cooperation, sustainability*

Abstract

From September 12 to 16, 2022, the 13th EuroMAB meeting took place in Bad Kleinkirchheim in the Carinthian part of the Salzburg Lungau and Carinthian Nockberge Biosphere Park in Austria. This conference of the UNESCO-EuroMAB regional network, originally planned for 2021 but postponed due to the covid pandemic, was attended by about 150 delegates from 27 countries.

*Figure 1 – Conference participants enjoying the* on top of the mountain *social evening. © Nockberge Management*

## Introduction

The conference of the UNESCO-EuroMAB regional network, which usually takes place every two years, was held 12–16 September 2022 in Bad Kleinkirchheim, in the Carinthian part of the Salzburger Lungau und Kärntner Nockberge Biosphere Reserve (BR) in Austria (see Figure 1). Austria is thus the first country to host two EuroMAB meetings (the first was held in 2005, in the Wienerwald BR; ÖUK 2005).

The EuroMAB network includes all countries in Europe and North America that participate in the UNESCO Man and the Biosphere (MAB) Programme and its World Network of Biosphere Reserves (WNBR). EuroMAB is the largest and oldest of the eight regional and seven thematic MAB networks. Currently comprising 308 BRs in 41 countries, it represents almost half of the BRs in the WNBR. The WNBR itself currently consists of 738 model regions (including 22 transboundary sites) in 134 countries.

EuroMAB is a platform for sharing knowledge, know-how and experience in the field of sustainable development and biodiversity conservation between BR managers, scientists, national MAB Committees, UNESCO representatives and partner organizations. EuroMAB conferences have so far taken place in České Budějovice (Czech Republic, 1986), Minsk (Belarus, 1997), Cambridge (Great Britain, 2000), Rome (Italy, 2002), Hernstein (Austria, 2005), Antalya (Turkey, 2007), Stará Lesná (Slovakia, 2009), Lundsbrunn (Sweden, 2011), Brockeville (Canada, 2013), Haapsalu (Estonia, 2015), Sarlat-la-Canéda (France, 2017), and Dublin (Ireland, 2019). The EuroMAB conferences are an excellent networking opportunity for European and North American BR managers, as well as for representatives of MAB National Committees and UNESCO Commissions – i.e. for all people involved in the concept and concerns of the World Network of Biosphere Reserves. At the same time, the conferences present a perfect opportunity to advocate for biodiversity conservation and sustainable development around the world.

## The meeting

The EuroMAB 2022 Conference, originally planned for 2021 but postponed due to the Covid pandemic, gathered together around 150 delegates from 27 countries.

Under the theme *Tying cultures. Crossborder cooperation between societies and generations*, the topics discussed by conference participants in a plenary session and 14 workshops included how cooperation and communication in and between BRs, various stakeholders and institutions can be improved across national, generational and societal borders.

EuroMAB 2022 started with a public plenary session with two keynote speeches and a round table on the conference theme. The first keynote speaker, Valentin Inzko, a native Carinthian Slovene and former High Representative for Bosnia and Herzegovina, explained that the location of the Nockberge mountains in southern Austria, close to the border with Slovenia and the Italian region of Friuli Venezia Giulia, has enabled a vibrant cultural exchange between the ethnic groups

*Table 1 – Workshops at the EuroMAB Conference 2022.*

| Workshop title and main subjects of discussion | Chair/Co-Chair(s) |
|---|---|
| *Cooperation between Biosphere Reserves across national and regional borders* | Barbara Engels (Germany), Michael Jungmeier (Austria) |
| *Large carnivores in Biosphere Reserves – challenges and conflicts:* How to deal with challenges and conflicts; methods for herd protection. | Anatolie Risina (Moldova), Stefan Lütke (Germany) |
| *Neobiota in Biosphere Reserves:* How to deal with the challenges; methods for prevention/ removal/ coexistence | Angelika Abderhalden (Switzerland), Harald Brenner (Austria) |
| *Status of Mountain Biosphere Reserves:* Challenges; partnerships; research strategy. | Pam Shaw (Canada) |
| *Sustainable agriculture and food in Biosphere Reserves:* (Re-)use of traditional knowledge for agricultural production and food preparation; agrobiodiversity; Biosphere Reserves and new EU Strategies (Farm to Fork Strategy; EU Biodiversity Strategy for 2030); biocultural heritage. | Anna Agostini (Itay), Catherine Cibien (France) |
| *Renewable energies in Biosphere Reserves:* Challenges and opportunities; possible conflicts with nature conservation. | Kari Natland (Norway), Ed Forrest (Ireland) |
| *Urban sprawl/settlement development, land use and demographic changes in Biosphere Reserves* | Katharina Gugerell (Austria), Alicia May Donnellan Barraclough (Norway) |
| *Mobility in Biosphere Reserves:* Challenges, solutions (examples of good practice), and the role of Biosphere Reserve management. | Andy Bell (England), Annette Schmid (Switzerland) |
| *Biosphere Reserves products and services:* Branding/labelling; role of entrepreneurs. | Eve Ferguson (Canada), Ryo Kohsaka (Japan) |
| *Promoting research in Biosphere Reserves:* Partnerships between Biosphere Reserves and universities; how to promote the benefits of research for both Biosphere Reserves and universities. | Petr Cupa (Czech Republic), Erik Aschenbrand (Germany) |
| *Biosphere Reserves as living laboratories for combatting climate change* | Gaëlle Tavernier (Luxemburg), Johannes Prüter (Germany) |
| *Responsible tourism in Biosphere Reserves:* Codes of practice; visitor management and monitoring; how to measure whether people visit an area because it is a Biosphere Reserves; role of ecotourism; role of Biosphere Reserves as a resource for human health and wellbeing. | Simone Beck (Luxemburg), Kelly L. Cerialo (USA) |
| *Female beekeepers in Biosphere Reserves* | Ivana Kovačević (Slovenia) |

and regions over many centuries. The parties involved continue to expand and deepen these exchanges.

The second keynote speaker, Gordana Beltram, from the Slovenian Ministry of Environment and Spatial Planning, used the example of the five-country, transboundary Mura-Drava-Danube BR (TBR MDD), recognized by UNESCO in 2021 and connecting Austria, Slovenia, Hungary, Croatia and Serbia (Köck et al. 2022), to show how intensive cooperation in the nature conservation sector across state borders can also overcome decades of political disputes. Drawing on their extensive experience of cross-border cultural relations, the two keynotes showed that the Nockberge region offers the perfect setting for the conference theme, namely the discussion of challenges and opportunities of cross-border cooperation between societies and generations.

The plenary event also marked the 50th anniversary of the founding of the Austrian MAB National Committee in a round table discussion on the Committee's past and future work. The Austrian MAB Committee was established in 1972, just one year after the founding of UNESCO's MAB Programme, on the basis of a contract with the Austrian Ministry of Science and Research at the Austrian Academy of Sciences (ÖAW). Austria was thus among the first nations to participate in the MAB Programme (Köck & Grabherr 2014; Köck 2022).

The plenary event was closed by a further round table discussion on *Cross-border cooperation: challenges and best practice examples*, with representatives of the Triglav National Park (Slovenia), the Julian Alps Biosphere Reserve (Italy), the UNESCO Karawanken/Karavanke Geopark (transboundary between Austria and Slovenia), and the Nockberge region (Austria). This session also included the presentation of the international cooperation project *Transdisciplinary Education Collaboration for Transformations in Sustainability* (TRANSECTS).

A key element of EuroMAB conferences are of course their workshops, in which current important topics for BRs are discussed. A total of 14 workshops were held (see Table 1). With the support of the EuroMAB Steering Committee[1], the organizers' aims were dual: to follow up on open questions from the previous EuroMAB meeting in Dublin, and to select current topics that are both important for the Nockberge region and concern other BRs in the EuroMAB group.

Participants were particularly keen on the new workshop concept devised by the organizers, which encouraged them to leave the conference rooms and interact directly with the region and its inhabitants. For example, the workshop *Status of Mountain Biosphere Reserves* (Figure 2) was held in a farmer's bath house, the *Karlbad*. The Karlbad, an old mountain hut which dates back to the second half of the 17th century, is considered the last of its kind in the eastern Alps, is located at 1,693 m asl and has no electricity. The seven presentations therefore had to be made orally and with hand-outs. The discussions with representatives of the region and the excursions to see the best-practice examples encouraged lively discussion and were received with great enthusiasm by the 28 workshop participants.

[1] EuroMAB Steering Committee Members 2019–2022: Günter Köck (Austria), Catherine Cibien (France), Leslie Moore (Ireland), Anatolie Risina (Moldova), Szymon Ziobrowski (Poland), Meriem Bouamrane (UNESCO / MAB, France).

*Figure 2 – Participants of the workshop* Status of Mountain Biosphere Reserves. © *Nockberge Management*

*Figure 3 – Conference participants sign the youth programme's* Call4Action © *Nockberge Management*

During the last day of the conference, the workshop moderators presented a brief summary of the workshop outcomes. *BRs as living laboratories for combatting climate change* is certainly worth mentioning in this context. Indeed, the 20 workshop participants summarized the results in a catchy slogan: *„Act local, shout loud!".* Another slogan, *„We cannot manage what we cannot measure!"* describing a key finding of the *Responsible tourism in Biosphere Reserves* workshop, emphasizes the urgent need to monitor visitor use in order to reduce the negative social and environmental impacts of tourism on a host community. To summarize the results of another workshop, *Cooperation between Biosphere Reserves across national and regional borders*, the moderators used an African proverb: *"If you want to go fast, go alone; if you want to go far, go together."* Other workshops made very precise recommendations for future actions in their summaries. For example, the participants of *Renewable energies in Biosphere Reserves* recommended that the EuroMAB group should adopt a position stating that the core and buffer zones should not be considered appropriate areas for the development of renewable-energy projects. The transition area, however, could be considered favourable if the community showed support.

The workshops generated excellent ideas, approaches to solutions and future actions, but also identified future challenges. The reports of the workshop chairs, most of which include the presentations given in the workshops, can be downloaded from the conference homepage (http://www.euromab2022.at). The organizers are also preparing a comprehensive conference report, which will be published on the EuroMAB homepage (http://www.euromab2022.at) in the near future. The same website will continue to publish relevant topics until the next EuroMAB conference, scheduled for 2024.

A traditional highlight of all EuroMAB conferences, the popular so-called *Ethnic Evening*, provided the opportunity for delegates from the various BRs to bring, present and share their culinary, musical or festive specialities. In 2022, this evening turned out to be a very special occasion of friendship and *joie de vivre*, doubtless because participants were finally able to meet in person again after three years, following the Covid pandemic.

It was also important for the organizing team to give young people a voice, a key concern of the UNESCO-MAB Programme. For the first time at a EuroMAB conference, a separate Youth Programme was therefore organized. Nine young adults from eight countries were able to participate in this international conference without any costs and to contribute with their creative ideas regarding BRs. The aim of this particular event was for more experienced colleagues and young people together to develop ideas, visions and possibilities for how young people can be meaningfully involved and engaged in the development of BRs. The last day of the conference gave these younger participants the possibility to present their concrete ideas and results to the plenary. They also presented a *Call 4 Action* to UNESCO, for the active and meaningful involvement of teenagers and young adults in BRs, including in decision-making processes. In order to highlight the dedication of this young generation, we quote from their *Call 4 Action* (Figure 3):

*"We call on the attendants of EuroMAB Conference, delegations from Biosphere Reserves, National Committees and UNESCO representatives to ensure the genuine and meaningful participation of young people in the governance and management of Biosphere Reserves and MAB programme, through the appointment of young representatives who can take part in decision-making processes at a local, national, and international level; by electing young members in BR coordinating bodies and councils, MAB National Committees and Regional Network Steering Committees."*

*"Moreover, we call on the EuroMAB Steering Committee to create a seat for a youth representative, who will represent the EuroMAB Youth Network in discussions, coordination, and preparation of the next EuroMAB Conference. We recommend this be an extra seat given to the next hosting country. This will ensure true and meaningful participation of young members of the MAB Programme and in the activities of the Regional Network and beyond."*

In order to support the message of this *Call 4 Action* and as a sign of appreciation for the work of the youth group, the Call was signed by all conference attendees. The Call is part of the 44-page report on the youth programme, which can also be downloaded from the conference homepage (Schäfer et al. 2022).

A large poster exhibition, which could be visited throughout the conference, offered representatives the opportunity to present their BRs and to share their scientific work and other projects.

It was important to the organizers to include people and businesses from the surrounding region as well as BRs from neighbouring countries, with whom the Nockberge Management has been cooperating closely for many years. For example, a group of about 30 representatives from the Triglav National Park and the Julian Alps BR (Slovenia) participated in the opening plenary event.

To round off the EuroMAB meeting, a post-conference tour led a group of participants from Canada, Japan, Switzerland and Austria to the Julian Alps, where Slovenian and Italian BRs cooperate closely across their state borders. Among other places, the group visited the Slovenian Soča Valley and the National Park Centre in Trenta (Slovenia) as well as the Italian village of Venzone. The visits generated a lively exchange of views with colleagues from both BRs.

In closing the conference, Meriem Bouamrane, the representative of the MAB Secretariat in Paris (France), expressed her sincere gratitude on behalf of all conference participants to the people and institutions without whom the conference would not have been possible: the Nockberge Management team coordinated by Heinz Mayer and Marlies Mayer; a core group of the Austrian MAB National Committee consisting of Günter Köck, Marianne Penker, Arne Arnberger, Therese Walder-Wintersteiner (Youth Affairs Coordinator of the Austrian Commission for UNESCO) and Jörg Böckelmann; the hosts of the external workshop events, and a large group of local volunteers.

The organizing committee is indebted to the Carinthian Provincial Government for funding the EuroMAB conference and the social evening *on top of the mountain* (Figure 1); to the Federal Ministry of Education, Science and Research for covering the costs of the conference dinner at Landskron Castle, and to the Austrian Commission for UNESCO for funding the youth programme. Many thanks are also due to Kati Heinrich from the Institute for Interdisciplinary Mountain Research (IGF) in Innsbruck (Austria) for setting up and maintaining the conference homepage, and to Lisa Wolf (E.C.O. Klagenfurt) for her professional moderation of the plenary events.

The next EuroMAB conference will be held in Germany in 2024. The newly formed EuroMAB Steering Committee[2] will provide expertise in the strategic planning of the conference.

## Conclusion

In summary, this year's EuroMAB conference was a great success. The efforts to organize an environmentally friendly and resource-saving event with short walking distances were successful, as were the measures taken to make the conference affordable for practically all people interested in participating.


*Figure 4 – Workshop participants are „Crazy about Tomorrow". © Nockberge Management*

Both the participants and the moderators of the workshops were very positive about the new workshop format devised by the organizers. The feedback from local stakeholders also showed that by holding the workshops in various locations in the region, local people showed greater interest in the conference and became more aware of the international significance of their region. Furthermore, residents could see not only the immediate local benefits of such an event, but also its much wider promotional effect. In consequence, this workshop format can be recommended wholeheartedly for future EuroMAB conferences.

The organizers' concern to give young people a voice was also realized. The successful youth programme demonstrated the importance of meaningful participation by young people in the decision-making processes of BRs, and of inter-generational collaboration for learning from each other mutually. The results of the youth workshop were remarkable and extremely helpful: they will inform future work of the MAB programme and its BRs. Nevertheless, it would probably be preferable not to separate young people out in a special youth programme, but to integrate them directly into all conference events.

Finally, the extremely positive spirit at this conference showed that nothing can better face-to-face meetings, whatever the sophisticated online conference tools we may have at our disposal.

## Acknowledgements

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[2] EuroMAB Steering Committee Members 2022–2024: Günter Köck (Austria), Katrine Dietrich (Denmark), Barbara Engels (Germany), Leslie Moore (Ireland), Anatolie Risina (Moldova), Meriem Bouamrane (UNESCO/MAB, France).

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# Protected Areas in the Middle Styrian Enns Valley – From the past to the future

*Renate Mayer*

*Keywords: Natura 2000, land use change, extensively managed wetland habitats, multifunctional areas*

Abstract

Rare habitats and animal and plant species in the Middle Styrian Enns Valley are protected in sites belonging to the EU-wide Natura 2000 network. The area at the foot of Mount Grimming has changed considerably over the centuries. For a favourable conservation status of the protected habitats and species to be achieved, consistent measures are required. The *Rekult Iris project* shows how agriculture and nature conservation can work together to create multifunctional areas, for agriculture, local recreation, education and research, through collaboration between regional services, practitioners, and educational and other bodies.

Profile

Protected area

Natura 2000 Middle Styrian Enns Valley

Mountain range

Alps, Austria

*Figure 1 – Straightened run of the Enns starting on the left corner; wetland meadows between the Enns and Mount Grimming. The recultivation area can be seen between the railway and the main high way in the lower center of the picture (orange dot, see also Figure 3, 4 & 5). © M. Mayerl 2022*

## Introduction

The Middle Styrian Enns Valley (Figure 1) has been shaped by landscape changes and economic transformation for thousands of years. The Enns River with its wetlands provides different habitats for a variety of protected animal and plant species of EU interest. At the beginning of the 19th century, the population became poorer due to the decline of mining and the cattle trade, and the loss of second incomes derived from providing horse-drawn transport, timber rafting and charcoal burning. The valley floor became swampy due to the increase in flooding caused by local large-scale deforestation. The expansion of the Eastern Alpine railway network necessitated the regulation of the Enns (1860–1960); the first cutting was made at Trautenfels Castle, in today's municipality of Stainach-Pürgg (Figures 2 and 3), in 1860. Until then, the Enns had meandered through the valley, and even moderate rainfall led to major flooding (see Figures 2 and 3).

The basis of food production, not only for the farmers' own needs but also for the regional population, was livestock breeding and fodder production. The first cattle breeding cooperative was founded in 1901 in Gröbming. In other areas, the feed conditions had already been improved by the regulation of the Enns. Livestock breeding was boosted significantly when the Gröbming cheese cooperative was established in 1902; the founding of the *Ennstal Landgenossenschaft* (rural cooperative) , which included a dairy, in Stainach in 1921 was also of great importance (Güntschl 1960). Today, the cooperative is still characteristic of the region and exports of agrarian products worldwide.

Encroachment on the landscape increased significantly with the creation of commercial areas, settlements and infrastructure (the Enns valley railway line, and the Ennstal federal road B320). Litter meadows that had historically been cut only once a year and horse pastures that had never been fertilized became multi-cut meadows; maize fields for the production of cattle fodder were also created. Many sections of the Enns are now straight (Figure 1).

Today, some areas continue to be affected by large floods (approximately every 10 years, see Figure 6). The characteristic wetlands are therefore mainly used for grassland management. Arable farming preferably maize, is increasing in the less wet areas (flat hills, slopes or well- drained sites) (Mayer & Plank 2017).

However, there are still areas of near-natural fens (EU-Code 7120) and raised bogs (EU-Code 7230), and extensively used litter meadows that have not been converted to species-poor fertilized meadows (LGBI 3/2007). The characteristic species of the Middle Styr-

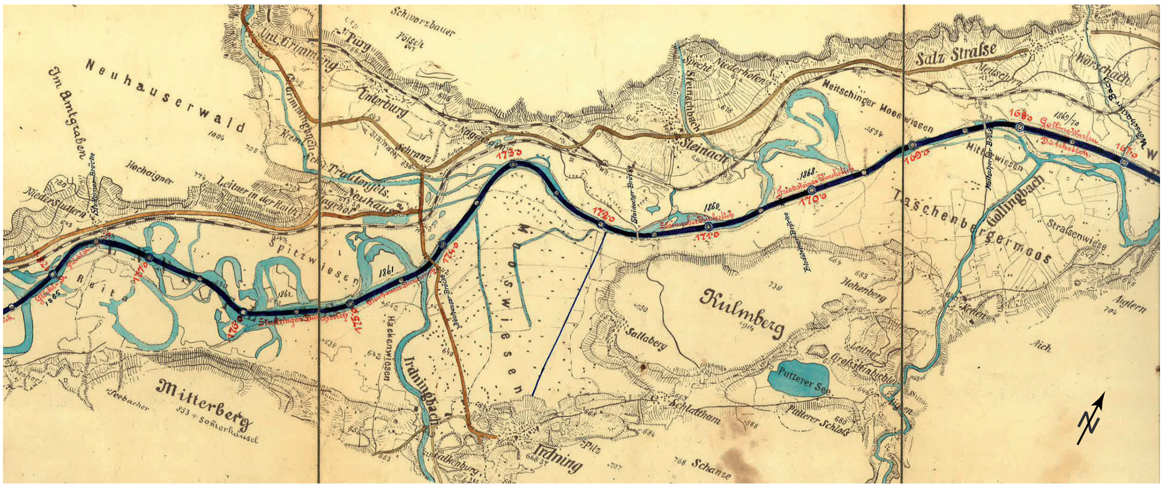

*Figure 2 – Map of the regulation of the Enns, from Niederstuttern to Wörschach (Styrian Provincial Building Directorate, Graz 1859). Black line – regulated Enns; Blue – oxbow lakes, tributaries and lake; Brown line – roads; red numbers: river cuttings, see Figure 3.*

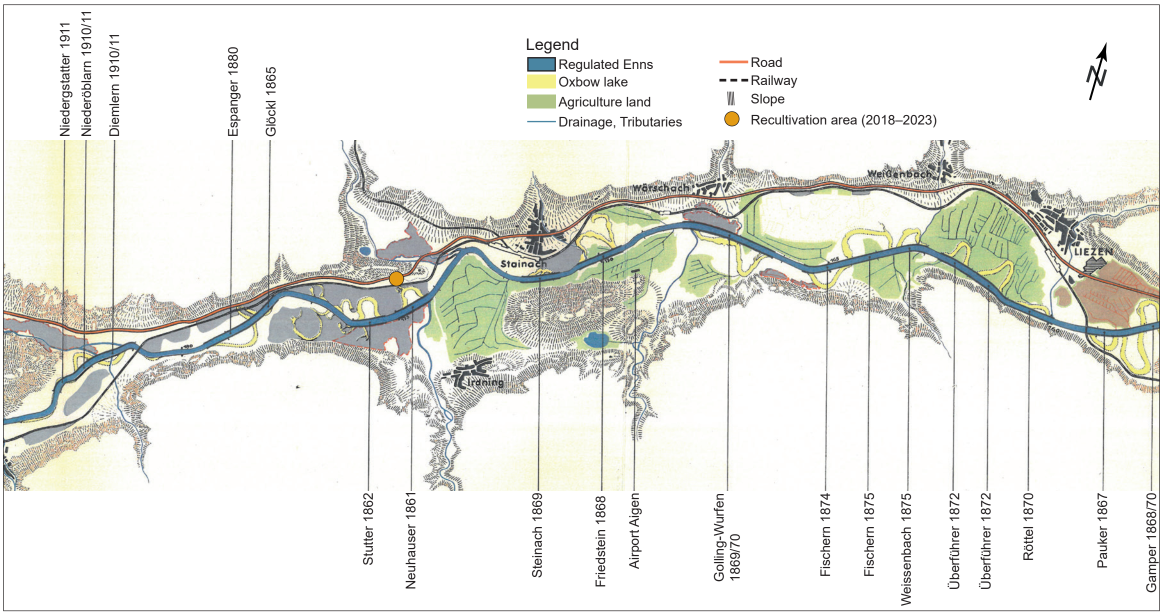


*Figure 3 – Map showing cuttings and drainage areas along the Enns (Güntschl 1960: 136–137). In regulating the Enns, large areas were drained to create new agricultural land, and land consolidation made mechanical farming possible.*

ian Enns Valley, the corncrake *(Crex crex)* (Figure 7) and the Siberian Iris *(Iris sibirica)* (Figure 8), must be preserved along with many other rare plant and animal species, and their habitats maintained (Mayer & Plank 2017). The relevant areas of the Enns valley floor are now Natura 2000 sites, belonging to the European network of protected areas under the Flora-Fauna-Habitat (FFH) and Birds Directives, see Table 1 and Figure 4.

## Conflicts of interest

The designation of these partly overlapping areas was not without conflicts between land-use and na-

*Table 1 – Relevant protected areas. The objects of protection are described in the regulations of the Federal State of Styria.*

| Protected area | Provincial law gazette | Designation | Identification code according to Styria and EU |
|---|---|---|---|
| Oxbows along the river Enns near Niederstuttern *(Ennsaltarme bei Niederstuttern)* | LGBL Nr. 86/2006 | 2006 | ESG 7: Natura 2000 AT2240000: designated under the Flora-Fauna-Habitat (FFH) Directive |
| Enns valley between Liezen and Niederstuttern *(Ennstal zwischen Liezen und Niederstuttern)* | LGBL Nr. 85/2006 | 2006 | ESG 41: Natura 2000 AT 2229002: designated under the Birds Directive |
| Dachstein-Salzkammergut | LGBl. Nr. 49/1997 | 1997 | LSG - 14a: Landscape conservation area / *Landschaftsschutzgebiet* |
| Enns valley from Ardning to Pruggern *(Ennstal von Ardning nach Pruggern)* | LGBl. Nr. 14/2007 | 2007 | LSG - 43: Landscape conservation area / *Landschaftsschutzgebiet* |

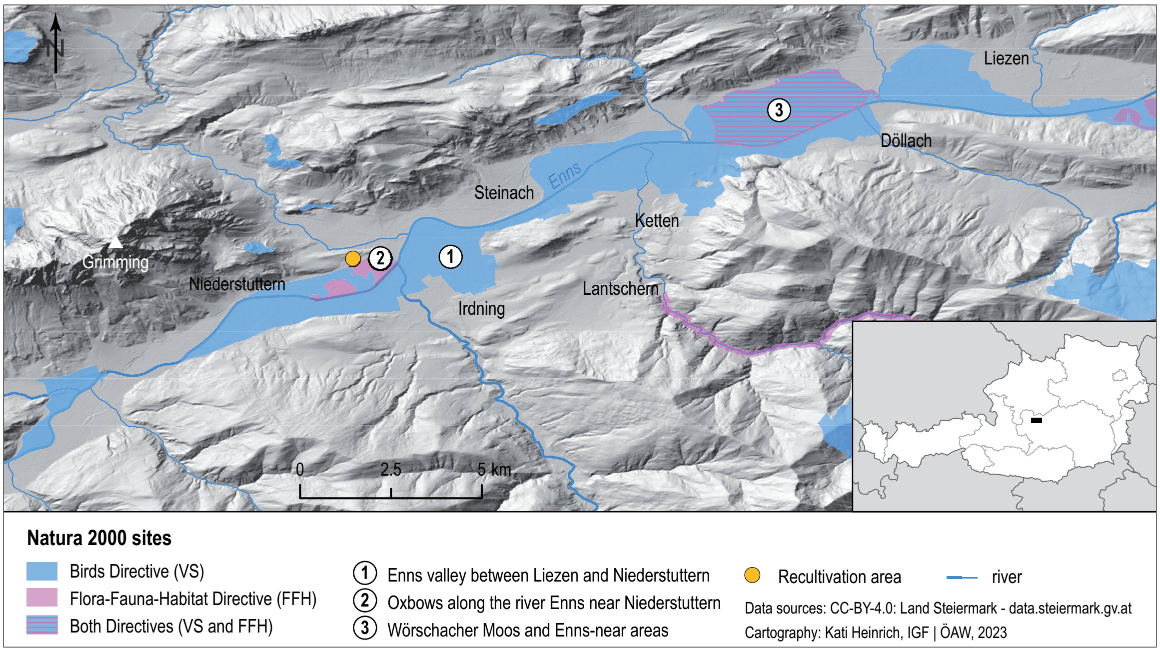


*Figure 4 – Overview map of the Natura 2000 sites in the Enns valley. The map section corresponds to the section of the river presented in Figure 3.*

*Figure 5 – Aerial view of recultivation area (orange dot & outlined in red) next to the Natura 2000 site oxbows along the river Enns near Niederstuttern, see also markings in Figure 3 and 4. © GIS Steiermark 2019*

ture conservation interests. The protection of natural habitats and wild fauna and flora is anchored in the EU's FFH Directive, while at the same time economic, social, cultural and regional requirements have to be taken into account. In each designated area, the necessary measures should be implemented in accordance with the relevant conservation objectives. However, no mandatory measures are defined in the regulations for Natura 2000 sites concerning the maintenance or restoration of a favourable conservation status of the species and habitats there. Only through contractual nature conservation (i.e. in agreement with the landowners and authorized users) can the corresponding aims and objectives be fulfilled. For this, long-term monitoring for the effects of any measures implemented needs to be in place. In addition, specific types of land use that are within the jurisdiction of the federal government (e.g. mining, rail and road transport, federal army (LGBL No. 65/2006)), are exempt from the restrictions in the Natura 2000 sites that are regulated by §9 of the Styrian Nature Conservation Act

*Figure 6 – Flooding in 2013 at the Enns. © M. Mayerl 2013*

*Figure 7 – Crex crex at Natura 2000 site Enns Valley between Liezen and Niederstuttern. © K. Krimberger 2021*

*Figure 8 – Recultivated wetland meadow at Trautenfels, Rekult Iris project site. © W. Starz 2022*

*Figure 9 – Dealing with shrubs. © W. Starz 2018*

*Figure 10 – Clearing and reactivation of drainage ditches. © W. Starz 2018*

*(Steiermärkisches Naturschutzgesetz)* from the year 2017. The protected areas and their marginal areas at the foot of Mount Grimming are confronted with precisely these conflicts of interest.

Most of the Natura 2000 sites continue to be used for agriculture, mainly as grassland for fodder production. Arable farming, especially in the form of maize for fodder, is also steadily increasing in these areas. In some places within the last few years, old floodplain forest trees have been cut down on privately owned land and by the federal railway, mainly for safety reasons, flood protection, and protection against fires along the railway line. However, this change has also resulted in much larger areas suitable for mechanized cultivation. It is also evident that the mechanical logging of riparian strips far beyond the edge of the river itself leads to large gaps and disruption in habitats, and invasive plant species such as Giant Goldenrod *(Solidago gigantea)*, Canada Goldenrod *(Solidago canadensis)*, Japanese Knotweed *(Fallopia japonica)* and Himalayan balsam *(Impatiens glandulifera)* are migrating massively into the wetland habitats along the Enns and in the surounding wetland meadows. Due to the decrease of the surrounding farmland and the associated intensification of cultivation of the remaining grassland areas for fodder production, more slurry is applied to these areas. In conjunction with the warmer weather conditions in these valley floors, this intense fertilization of the land means that farmers can cut hay up to six times a year instead of just two or three. It is not possible to control exactly how much manure is applied to what proportion of land, but managed plots that are further away from a farm are fertilized less intensively.

However, land use, landscape and nature conservation, and protection against floods are not incompatible objectives, as is demonstrated by various projects and initiatives in and immediately next to Natura 2000 sites managed by NGOs, public corporations and support programmes (e.g. ÖPUL Natura 2000), or adjacent to other protected areas (AMA 2022).

## ReKultIris Project – good practice for the renaturation of abandoned wet meadows

The *ReKultIris project* is a nature conservancy initiative to restore abandoned wet meadows and return them to agricultural use (Figure 6). The project (2018–2023) was partly funded by *Blühendes Österreich* (Blooming Austria), and an in-kind contribution from the Agricultural Research and Education Centre (HBLFA) Raumberg-Gumpenstein. Some work (e.g. protection against invasive plant species such as Himlayan Balsam) was carried out by school classes and the *Steiermärkische Berg- und Naturwacht* (Styrian Mountain and Nature Watch), with support from municipal employees.

The site is situated between the Enns valley highway (B320) and railway; it is listed as part of the landscape conservation area *Dachstein-Salzkammergut,* see

Table 1. It lies in the municipality of Stainach-Pürgg at 645 m asl and is classified biogeographically as an alpine region. The area has not been cultivated for over 40 years and has therefore lost its typical litter meadows. These meadows emerged through human influence and were mown just once a year, in the autumn. They used to be the most common type of meadow in the Middle Styrian Enns valley, characterized by the Siberian Iris *(Iris sibirica)* and Star Narcissus *(Narcissus radiiflorus)*, but are now threatened by intensive land-use practices.

The recultivation area is part of the landscape conservation area *Enns valley from Ardning to Pruggern*, next to the Natura 2000 site *Oxbows along the Enns near Niederstuttern*. It is also adjacent to the Natura 2000 site *Enns valley between Liezen and Niederstuttern* (see Table 1 and Figure 8). The recultivation area forms a green corridor between the railway and the highway.

The objective is to ensure the site's multifuncionality: agricultural benefits, natural retention areas as protection against floods, biodiversity, divers habitats for protected species, and green oases for local recreation.

### Promotion of site-specific biodiversity and habitats

- Land use management in the surrounding protected areas that belong to the nature conservation association and to the federal government is carried out by the organic farm of the HBLFA Raumberg-Gumpenstein which is situated there. The management is adapted to the various habitat types, and is subject to monitoring and modification as necessary.
- Awareness raising for all ages, and visitor guidance.
- Areas are used for research / monitoring (small mammals, insects, amphibians, plants, invasive neophytes); bird monitoring has been carried out by the same team for a number of years.
- Maintenance measures incl. monitoring by volunteers, especially annual control of invasive plant species.
- The project area is a refuge site (former flood plain). The ponds which have been reactivated through minor terrain modelling are relicts of former (i.e. cut) branches of the Enns and are therefore very suitable for amphibians, including the Alpine Great Crested Newt *(Triturus carnifex)*, Yellow-bellied toad *(Bombina variegata)*, Pond newt *(Lissotriton vulgaris)*, and Alpine newt *(Triturus alpestris)*. However, the old cut-off backwaters of the Enns river are now used as fisheries, and fish such as trout predate on the protected amphibians.

### Risks

- Intensification of agriculture; pollution from slurry from neighbouring areas.
- Deterioration of protection measures in the surrounding areas (because of changes in ownership, intensification of cultivation, pressure of use by recreationists, fishing).

*Figure 11 – Area of site for seed collection. © A. Fokter 2018*

*Figure 12 – Seed stands, Iris sibirica © A. Fokter 2018*

- Loss of soil in the construction of public infrastructure (roads, deforestation along railway and road, gravel mining).
- Arrival of invasive plant species; other unforeseen contaminants.
- Climatic changes (drought); diseases.

### Renaturation measures

Renaturation activities are time-consuming: it takes 5–10 years for a species-rich *Iris sibirica* meadow, used for litter, to be established. The first year of reclamation included the following steps: assessment of the area by district authorities; development of a reclamation concept; removal of woody plants (Figure 9); cleaning and creation of drainage ditches (Figure 10); neophyte control; mowing (Figure 11); seed preparation (Figure 12); soil cultivation; sowing and transfer of *Iris sibirica* plants from surrounding sites (Figure 13). Maintenance measures were necessary in the following years, including comprehensive ongoing neophyte monitoring and removal. *Iris sibrica* plants were also transplanted from Trautenfels, where meadows had to make way for the construction of a roundabout and bridge – so-called replacement planting to compensate for the loss of green areas.

Two students of the HBLFA Raumberg-Gumpenstein wrote a *Matura* (A-level) thesis on *Renaturation of an Iris Sibirica Meadow* and were involved in the project (Fokter & Hillinger 2019). A survey of the management of *Iris sibirica* meadows in the Styrian Enns Val-

*Figure 12 – Iris sibirica meadow at the end of May © M. Mayerl 2022*

ley showed that both farmers and local people are very positive about the local iris meadows. The students found that land users would expect about 1,050 € as a reasonable subsidy for the expenses of maintaining the flowering meadows. The meadows produce approximately 8 tonnes of dry matter per hectare. The current price of straw is about 300 €/tonne. The use of litter from these meadows as bedding material for the cattle barns at the HBLFA organic farm therefore reduces the need to purchase straw (Fokter & Hillinger 2019).

## The biodiversity area as an outdoor lab

The project area is used as an open-air laboratory for school classes and the interested local people. It is located next to the Enns cycle path, which is well used for local recreation and promoted internationally. In cooperation with the Styrian Nature Conservation Association *(Steirischer Naturschutzbund)*, an old hay barn was converted into a small visitor centre, which can be used as a research laboratory by young people. Students from the HBLFA Raumberg-Gumpenstein designed and built an observation tower. From 2017 to 2019, at the end of May, a two-day *Iris sibirica green event* was held for schools and local people to promote these wet meadows for multiple uses. Various institutions worked together and organized information stands and joint actions (HBLFA Raumberg-Gumpenstein, Austrian Federal Service for Torrent and Avalanche Control, Styrian Nature Protection Association, District offices for Water Management and Nature conservation, Styrian Mountain and Nature Watch, Water rescue service, National Park Gesäuse).

## Conclusion

The management of protected areas is often considered from the economic point of view in particular. But the *Iris sibirica* meadows, calcareous fens, meadows of whip grass, lowland hay meadows, and floodplain forest relics both within and bordering on protected sites provide many benefits, such as fodder reserves, limits on the need to purchase straw, residue-free bedding for cattle, flood protection, and preservation of the traditional cultural landscape. The meadows are also attractive to tourists. Finally, this renaturation project is an example of good practice for establishing biodiversity in agriculture, and notably for our planned restoration site on the banks of the Enns within the Natura 2000 sites *Enns valley between Liezen and Niederstuttern* and *Ennsaltarme near Niederstuttern.*

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# Small mammal Fauna in the Swiss National Park – developments over the last 100 years

*Jürg Paul Müller*

*Keywords: Insectivores (Eulipotyphla), Rodents (Rodentia), Swiss National Park, developments*


## Abstract

When the Swiss National Park was founded, taking stock of the fauna and flora was a major goal. Various efforts were made to investigate insectivores and rodents, but little was published about the findings. In this article I will analyse the existing data in terms of how the small mammal fauna has developed over the last 100 years. The data reveal that species that are rare today were rare then and the common ones were quite numerous then too. The protection status has meant that former pasturing animals, mainly sheep, were replaced by wild animals like the red deer, so that the environment of the small mammals in this distinctly dry area has changed little.


## Profile

Protected area

Swiss National Park

Mountain range

Alps, Switzerland

*Figure 1 – Forest dormouse (Dryomys nitedula). © L. Hlasek*

## Introduction

Investigating the mountain environment was clearly a goal when the Swiss National Park (SNP) was founded in 1914 and efforts to that effect started immediately. Cataloguing the fauna and flora was seen as vital (Baur & Scheurer 2014). Capturing small mammals, i. e. insectivores and rodents, started in 1916, when Gustav von Burg from Olten was commissioned with the task. Until the mid-20th century, it was mainly zoologists from the university and the natural history museum in Geneva who researched small mammals in the park and its surroundings. 12 years ago, I started to intensify my studies of small mammals in the SNP. To this day, despite extensive field work, there have been few publications on the small mammals of the SNP (von Burg 1921, 1925; Dottrens 1962; Wittker 2008; Müller 2022).

Still, existing data are interesting for identifying possible changes since or because of the establishment of the park. Possible changes are relevant in terms of climate change. Its impact can, however, only be understood if we take into account the concurrent changes in land use, including conservation. In an effort to better assess the situation in the SNP, I included its surroundings, i. e. the Val Müstair and the Lower Engadin, in the study.

## Study area

The study area (Lower Engadin and Val Müstair, without Samnaun, but including S-chanf) is 1280 km², of which 170 km² is national park (Figure 2). Geological, geomorphological and vegetation features of the study area have been described in detail, mainly by Haller et al. 2013. The Lower Engadin is drained by the River Inn, the Val Müstair by the Rombach and thus by the Adige River. Both valleys are eastward exposed, which is essential for the recolonization by the mammals after the glacial period and for the biogeography.

The area has been formed by the Eastern Alpine nappes, which were stacked and pushed towards the north and east during the Cretaceous period (c. 90–65 million years ago). The type of rock, along with the climate, is important for surface structure, soil formation and vegetation, which together provide for the basic needs of the small mammals. The crystalline rock in the area, but also the carbonate rock, weathers rather strongly. The large screes are mostly fine-grained and offer few refuge options for small mammals.

The study area is situated in a distinct inner-alpine dry zone with little precipitation, which can vary greatly depending on exposition and altitude. Apart from the creeks and rivers of the individual valleys, there are fewer small running waters, ponds, wetlands and bogs than in other parts of the Alps. In the SNP, 28% of the area is forest, mainly mountain pine. Alpine grasslands or pastures cover 21% of the area. 51% of the area is scree and rock or generally unusable high mountain without settlement.

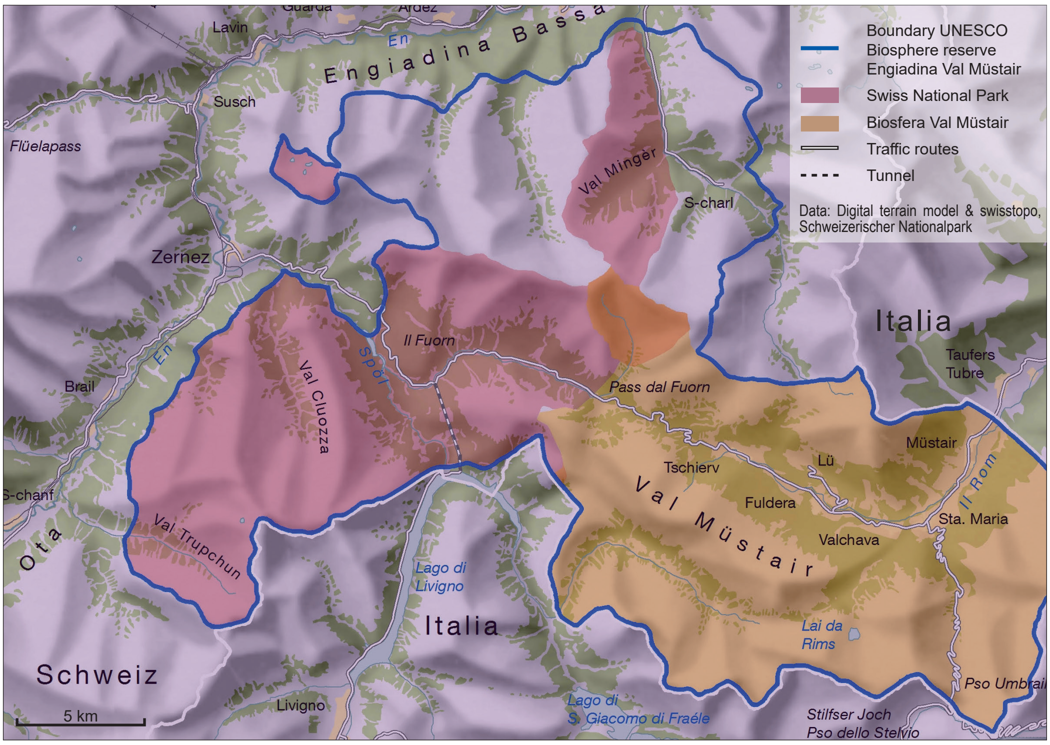


*Figure 2 – Study area in the Swiss National Park in the Unterengadin and the Münstertal. © Schweizerischer Nationalpark 2022/02*

## Data and methods of data capture

### Overview of the main capture initiatives

The capture initiatives that form the basis for this article are listed in Müller (2022) in the comprehensive Tables 1 and 2. The main initiatives are referred to below, along with the detection methods.

- Very little exists of the supposedly comprehensive material collected mainly in the vicinity by third-party helpers for Gustav von Burg (Müller 2022). The published statements (von Burg 1921 and 1925) are difficult to interpret.
- From 1933 to 1948, Peter Revilliod, Emile Dottrens and Georges Bär collected comprehensive material in the SNP and its vicinity and stored it in the *Muséum d'histoire naturelle de Genève*. According to literature, it comprises 476 individual small mammals (Dottrens 1962).
- In the years 1971 and 1972, André Meylan and Jean-Claude Praz studied the small mammals on a transect near Ramosch and collected 566 individuals (Praz & Meylan 1973). Müller and his colleagues caught another 490 small mammals in the hedges near Ramosch in the years 1988 and 1989.
- In 1999 Regula Tester studied the dormouse fauna in the Lower Engadin, where four species occur.
- Christian Wittker (2008) studied the ecology of the field mouse in the area of Stabelchod, which is heavily grazed by red deer.
- From 2010 to 2019, I carried out 28 capture initiatives with various helpers and detected 662 animals.
- All detections, even of smaller initiatives and individual detections by third-party, were entered into the database of the CSCF (*Centre Suisse de Cartographie de la Faune*, Neuchâtel). This resulted in Table 1, which gives an overview of the species and their detection in the parts of Lower Engadin, SNP and Val Müstair.

### Detection methods

Various methods were used in the different capture initiatives, so that the results are not comparable in every aspect. However, they provide valuable indications about the occurrence and distribution of the species over time.

In the initiatives of the Geneva group (Revilliod et al.), the term *capture* denotes the number of individual animals, as they used snap traps. Meylan and Praz (1973) used live traps, first mostly and later exclusively, as did everyone in all later initiatives. They usually registered the number of captures and rarely that of the individual animals.

### Species identification

In my capture initiatives from 2010 to 2019 I focused on species identification. With cryptic species that could not be identified by external characteristics, tissue and hair samples were taken for DNA analysis. In the study area this applied to the genus Apodemus and Sorex and in some cases also to Microtus and Neomys. The samples were kept in 96% ethanol. In 2010 some samples were identified by Meret Signer of Peter Wandeler's group at the University of Zu-

*Table 1 – List of species of insectivores and rodents for the three regions of Lower Engadin (UE), National Park (SNP) and Val Müstair (MT) with the area in square kilometres with the number of insectivores. The numbers cannot be compared fully as they depend on how good a species can be observed and captured, but they give an impression of how common they are. The same information can be read off the last year of detection. Frequent and regularly occurring species will have been observed in the years from 2010 to 2019. Summary of the table: CSCF (Centre Suisse de Cartographie de la Faune, Neuchâtel).*

| Family | Species | English name | UE – 872 km² | | SNP – 220 km² | | MT – 181 km² | |
|---|---|---|---|---|---|---|---|---|
| | | | km² | Year | km² | Year | km² | Year |
| Erinaceidae | *Erinaceus europaeus* | European hedgehog | 4 | 2014 | | | 4 | 2011 |
| Soricidae | *Neomys anomalus* | Miller's water shrew | 3 | 1988 | 1 | 1933 | 2 | 2019 |
| Soricidae | *Neomys fodiens* | Water shrew | 19 | 2016 | 6 | 2016 | 4 | 2002 |
| Soricidae | *Sorex alpinus* | Alpine shrew | 8 | 2016 | 4 | 2011 | 2 | 2013 |
| Soricidae | *Sorex araneus* | Common shrew | 23 | 2014 | 12 | 2018 | 9 | 2019 |
| Soricidae | *Sorex minutus* | Eurasian pygmy shrew | 25 | 2018 | 6 | 2013 | 5 | 2013 |
| Talpidae | *Talpa europaea* | European mole | 9 | 2018 | | | | |
| Gliridae | *Dryomys nitedula* | Forest dormouse | 8 | 2019 | 5 | 2016 | 4 | 2018 |
| Gliridae | *Eliomys quercinus* | Garden dormouse | 74 | 2019 | 27 | 2016 | 24 | 2019 |
| Gliridae | *Glis glis* | Fat dormouse | 14 | 2016 | | | | |
| Gliridae | *Muscardinus avellanarius* | Common dormouse | 12 | 2019 | | | 6 | 2018 |
| Cricetidae | *Arvicola amphibius* | Water vole | 1 | 2019 | | | | |
| Cricetidae | *Chionomys nivalis* | Snow vole | 28 | 2019 | 21 | 2018 | 12 | 2018 |
| Cricetidae | *Clethrionomys glareolus* | Bank vole | 75 | 2019 | 39 | 2018 | 20 | 2018 |
| Cricetidae | *Microtus lavernedii* | Mediterranean field vole | 11 | 2014 | | | | |
| Cricetidae | *Microtus arvalis* | Common vole | 45 | 2018 | 24 | 2018 | 18 | 2017 |
| Cricetidae | *Microtus subterraneus* | Common pine vole | 9 | 2014 | 2 | 2015 | 2 | 2012 |
| Muridae | *Apodemus alpicola* | Alpine field mouse | 26 | 2016 | 14 | 2015 | 10 | 2019 |
| Muridae | *Apodemus flavicollis* | Yellow necked field mouse | 2 | 2012 | 1 | 2012 | 1 | 2019 |
| Muridae | *Apodemus sylvaticus* | Wood mouse | 3 | 2014 | 4 | 2016 | 5 | 2019 |
| Muridae | *Mus domesticus* | Western house mouse | 1 | 2014 | | | 2 | 1988 |
| Muridae | *Rattus norvegicus* | Brown rat | 3 | 2004 | | | 1 | 2019 |
| Muridae | *Rattus rattus* | Black rat | 1 | 1968 | | | | |
| Sciuridae | *Marmota marmota* | Alpine marmot | 639 | 2019 | 140 | 2019 | 179 | 2019 |
| Sciuridae | *Sciurus vulgaris* | Red squirrel | 102 | 2019 | 74 | 2019 | 26 | 2019 |

rich, later by Marilena Palmisano of the Institute of Natural Resource Sciences (IUNR) at ZHAW Wädenswil. Genus-specific markers of the cytochrome B were used for the small mammal samples and later sequenced. For some small mammal samples, for instance for the Sorex species, the cytochrome C oxidase was sequenced again with the markers of Pfunder et al. (2004). The sequence data were then compared against the Genbank NCBI.

*Table 2 – Number of genetically identified animals per species.*

| Species | Number |
|---|---|
| *Apodemus alpicola* | 61 |
| *Apodemus sylvaticus* | 14 |
| *Apodemus flavicollis* | 3 |
| *Microtus lavernedii* | 2 |
| *Microtus arvalis* | 32 |
| *Pitymys subterraneus* | 3 |
| *Neomys fodiens* | 6 |
| *Sorex araneus* | 13 |
| Total | 134 |

## Species diversity: Any changes over time?

*Forest* species regularly caught in the SNP are: Alpine field mouse (*Apodemus alpicola*), bank vole (*Clethrionomys glareolus*), garden dormouse (*Eliomys quercinus*) and the common shrew (*Sorex araneus*). The garden dormouse is quite common in the SNP. This contrasts with its unexplained decline in Central and Eastern Europe (Zanini & Blant 2021). The common shrew often is the third-most common species in northern and central Grisons. It is considerably rarer in the SNP. All mentioned forest species are among the regularly detected common species since the establishment of the park. A rare species in the area is the yellow-necked field mouse (*Apodemus flavicollis*), which is common at low altitudes. Since the alpine mouse (*Apodemus alpicola*) was only elevated to species status in 1989 and genetic species determinations were not made until 2010, it is uncertain wether *Apodemus flavicollis* was also rare in the past. To our knowledge, a morphometric determination of the museum material is still pending.

In *grassland*, i.e. the pastures of the SNP, only the common vole (*Microtus arvalis*) is a common species, in the *stone runs* it is the snow vole (*Chionomys nivalis*). This constellation has not changed since the establishment of the park.

Surprisingly, the water shrew (*Neomys fodiens*) has been detected again and again, even though the area has few bodies of water, but those are of good quality.

Along with the common species, there is a great number of species that have only been detected occasionally and must be considered rare since the establishment of the park. They will be listed below in systematic order. It is difficult to associate them with *larger habitats* because of their often very specific habitat requirements. The Miller's water shrew (*Neomys anomalus*) has only been detected once in the SNP. It is a relict species and rare across the entire Alpine space. This is also true for the Alpine shrew (*Sorex alpinus*), which probably requires very specific habitats. The Eurasian pygmy shrew (*Sorex minutus*) is widely distributed across the Alps but rarely caught. In the SNP and the neighbouring valleys, no white-toothed shrew of the Crocidura genus has ever been detected.

Of the dormice, there is the frequently found garden dormouse, but also the forest dormouse (*Dryomys nitedula*). Over the last 100 years, ever new locations have become known, but few over long periods. In the SNP, the species is at the westernmost part of a huge distribution area that reaches as far as the Caucasus and Asia Minor.

Of the voles, a few specimen of the common pine vole (*Microtus subterraneus*) have been captured. The species settles in marginal biotopes, possibly as a result of competition with the common vole.

To sum up, the composition of the small mammal fauna has not substantially changed over the past 100 years, i. e. since the establishment of the SNP. Formerly rare species have remained rare. Formerly common species still make up the largest share of the small mammal fauna. The total protection by the national park ensures a practically natural development of the ecosystems with their fungi, plants and animals. The species diversity of the small mammals is not greater than in other parts of the Alps with similar location and structure (Müller 2022). In contrast, the species diversity and stock must count as low. Even Dottrens, Revilliod and Bär came to that conclusion (cf. the annual reports of WNPK 1934, 1935 and 1945). The comparative rarity of small mammals in the SNP can be largely explained by the dryness of the area. Unlike the small mammals, large species like the red deer have increased as a result of the establishment of the SNP. Their numbers locally result in overgrazing (Wittker 2008), which means a lack of food and cover, as well as trample damage for the common vole.

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# Status, threats and the conservation of endemic species in the Yarlung Zangbo river basin

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*#These authors contributed equally to this study and share first authorship*

*Keywords: climate change, highland, biodiversity conservation, endangered species, endemic fishes*

## Abstract

The Yarlung Zangbo river extends through the southern area of the Tibet Plateau at the highest elevation of any large river in the world. It supports many unique and endemic species, but global warming, proposed and existing hydropower developments, and the invasion of non-native species are significant threats to its native aquatic biodiversity. Some endemic species, including fishes (*Glyptosternum maculatum, Schizothorax oconnori, Schizothorax macropogon, Schizophygopsis younghusbandi, Ptychobarbus dipogon* and *Oxygymnocypris stewartii*), water birds (*Grus nigricollis* and *Haliaeetus albicilla*) and mammals (*Lutra lutra*), have experienced great ecological and physical challenges. To ensure a sustainable development pathway, some specific conservation measures should be undertaken, including the establishment of natural reserves in sensitive areas, and more research and ecological monitoring. This study is a significant reference and example for managers developing strategies to conserve aquatic biodiversity in large, high-altitude river basins within mountainous settings.

## Introduction

Rivers are important habitats that support a rich freshwater biodiversity. However, in recent decades lotic aquatic biodiversity has experienced substantive losses and is at increasing risk due to fragmentation of rivers, non-native species and over-exploitation, among other factors (Clavero et al. 2010; Reid et al. 2019). This is especially true in China, where freshwater habitat loss has been particularly acute during the last forty years (Xiong et al. 2018; 2019). The Qinghai-Tibet Plateau is the largest and most recently formed massif on the planet, and it supports many endemic species (Zhang et al. 2002). The Yarlung Zangbo is the highest-elevation large river in the world, and provides special habitats for many endemic fish species (He et al. 2020). In this study, we provide a preliminary review of the status and threats to the river's biodiversity and provide recommendations for its conservation.

## Study area

The Yarlung Zangbo (28°00'–31°16'N, 82°00'–97°07'E, Figure 1) is among the headwaters of the Brahmaputra Basin. The main stem is around 2,230 km long, encompasses an area of about $2.4 \times 10^5$ km$^2$, and has a mean altitude of over 4,000 m (ranging from 132 m to 7,258 m). The river originates at the Angsi Glacier on the northern side of the middle Himalayas in Tibet. Located in the southeast of the Qinghai-Tibet Plateau, the Yarlung Zangbo has five main tributaries (the Duoxiong Zangbo, Nianchu, Lhasa, Nyang and Parlung Tsangpo). The river basin has a tropical, cold-plateau, mountain climate dominated by the South Asia Monsoon in the Indian Ocean Hydrosphere-Atmosphere System, with intense solar radiation and low temperatures. The annual average temperature is 5.2°C; the annual average precipitation ranges between 320 mm and 500 mm, falling mainly from June to September.

## Biodiversity status

From June 2019 to July 2021, we conducted geobotanical surveys at 100 sample sites in the Yarlung Zangbo river basin. At each site, we selected 1 plot (20 m × 30 m) for tree community, 5 plots (5 m × 5 m) for shrub community, and 25 plots of (2 m × 2 m) for grass community. (For precise details, see Fang et al. 2009). Fish sampling was conducted using a dip net (0.5 m in diameter, 1 m hand shank, mesh size 0.5 mm), gillnets (20 m × 5 m, mesh size 0.5 cm), and electrofishing (CWB-2000P, 12v, 250HZ). (For detailed methods for fish sampling, see Xiong Zhu et al. 2017). We conducted visual encounter surveys and acoustic surveys for mammals, amphibians, reptiles and birds. (For details of both types of survey, see Wang, Li et al. 2021).

According to previous studies, there are 232 vascular plants belonging to 80 families distributed within the Yarlung Zangbo basin. Cyperaceae are represented by 19 species, followed by Ranunculus with 14, Gramineae with 11, and Compositae with 10. The other 76 families had fewer than 10 species each. Recently, some non-native species, such as *Cosmos bipinnata* (Asteraceae), have successfully invaded and established naturalized populations in the basin (Wang, Xie et al. 2021).

The Yarlung Zangbo also supports a very rich animal biodiversity, including 19 fish, 1 amphibian, 3 reptile, 41 mammal and 117 bird species. Among these, 7 species (*Grus nigricollis*, *Panthera uncia*, *Cervus albirostris*, *Aquila chrysaetos*, *Gypaetus barbatus*, *Haliaeetus albicilla* and *Aquila heliaca*) were listed as Category I protected species; 18 species (*Ursus arctos*, *Lutra lutra*, *Lynx lynx*,

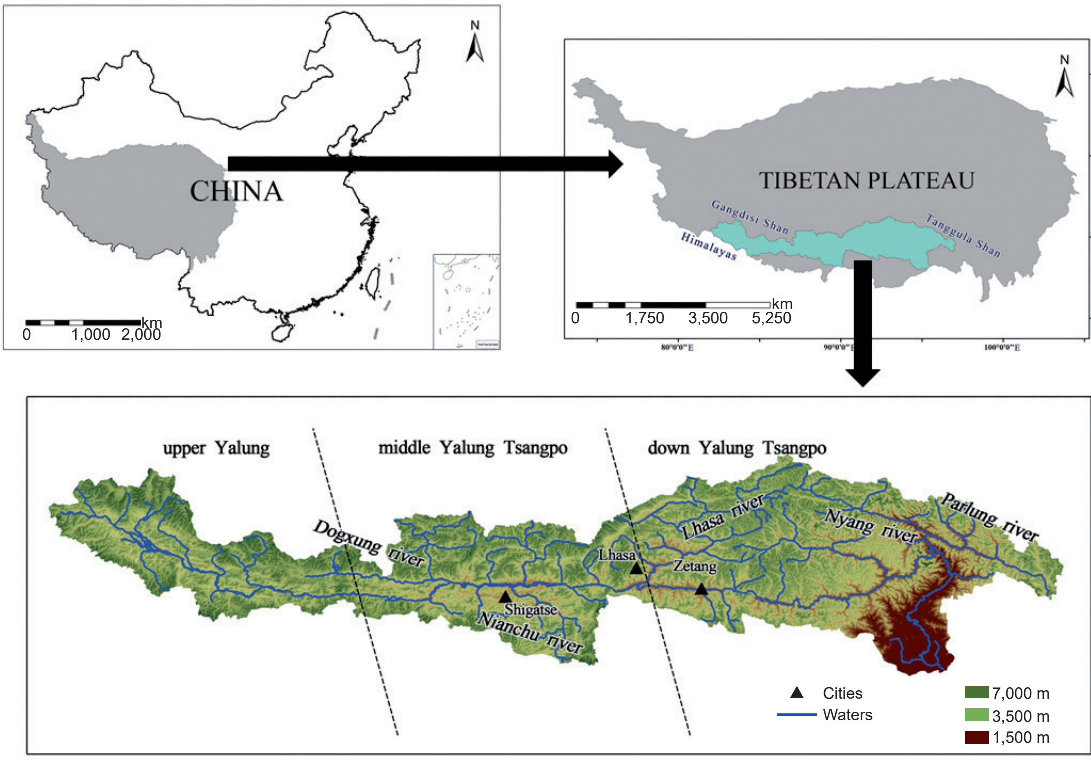


*Figure 1 – The location and extent of the Yarlung Zangbo river basin.*

*Otocolobus manul*, *Procapra picticaudata*, *Pseudois nayaur*, *Milvus korschun*, *Accipiter gentilis*, *Buteo hemilasius*, *Pandion haliaetus*, *Aegypius monachus*, *Gyps himalayensis*, *Falco cherrug*, *Falco tinnunculus*, *Falco Subbuteo*, *Crossoptilon harmani*, *Tetraogallus tibetanus* and *Grus grus*) are designated Category II protected species in China (TARFSDI 2002).

## Threats

### Global change

Many endemic species and ecosystems of the Tibetan Plateau are very sensitive to global warming (Lu & Liu 2010), and the highest temperatures in Tibet have increased sharply in the past twenty years (Wang et al. 2021). Climate change has intensified algal blooms. It has also altered historic natural water levels and hydrological status, the life-histories of certain animals, and species diversity and distributions (Payne et al. 2017). These changes in habitats and ecology have caused a decline in most of the native aquatic species.

### Hydropower

The Yarlung Zangbo has an abundant water supply with a very high hydropower potential (Cathcart 1999). According to the fourteenth Five-year Development Plan, the Chinese government proposes hydroelectric development on the Yarlung Zangbo, which has a theoretical capacity of 80 million kilowatts. Some preliminary survey and design work has been conducted to explore hydropower sites in the basin. Hydroelectric projects inevitably alter hydrological processes and influence the local aquatic plant and animal biodiversity (Reid et al. 2019). Some endemic fish species, such as *Schizopygopsis younghusbandi younghusband*, *Schizothorax o'connori* and *Schizothorax waltoni*, would be endangered, and could even face the risk of extinction (Chen et al. 2009; Ma et al. 2012; Zhou et al. 2015).

### Non-native species

China is the country most seriously threatened by non-native aquatic species and the ecological damage they can cause (Xiong et al. 2015; Xiong et al. 2017; Wang et al. 2016; Wang et al. 2021). Researchers traditionally considered that fewer non-native species could successfully invade plateau ecosystems because of their harsh environment. However, a number of highly invasive species have been observed in aquatic ecosystems in the Qinghai-Tibet Plateau (Wang et al. 2021; Xiong et al. 2021). Non-native plants, fishes and amphibians have caused significant negative ecological impacts on native biodiversity in the Yarlung Zangbo river basin as well as in many other settings in China (Liu et al. 2015; Deng et al. 2021; Xiong et al. 2021).

## Recommendations

The designation of protected areas for endangered species or ecosystems is considered one of the most effective means of preserving biodiversity (Chape et al. 2005). To date, only 47 nature reserves have been established in the Tibet Autonomous Region, most of which are focused on the protection of the terrestrial flora and fauna (MEE 2019). Most regions of the Yarlung Zangbo river basin have not received adequate

*Table 1 – List of protected species in the Yarlung Zangbo river basin.*

| No | Scientific name | Biological group | Protection class |
|---|---|---|---|
| 1 | *Grus nigricollis* | Bird | I |
| 2 | *Panthera uncia* | Mammal | I |
| 3 | *Cervus albirostris* | Mammal | I |
| 4 | *Aquila chrysaetos* | Bird | I |
| 5 | *Gypaetus barbatus* | Bird | I |
| 6 | *Haliaeetus albicilla* | Bird | I |
| 7 | *Aquila heliaca* | Bird | I |
| 8 | *Ursus arctos* | Mammal | II |
| 9 | *Lutra lutra* | Mammal | II |
| 10 | *Lynx lynx* | Mammal | II |
| 11 | *Otocolobus manul* | Mammal | II |
| 12 | *Procapra picticaudata* | Mammal | II |
| 13 | *Pseudois nayaur* | Mammal | II |
| 14 | *Milvus korschun* | Bird | II |
| 15 | *Accipiter gentilis* | Bird | II |
| 16 | *Buteo hemilasius* | Bird | II |
| 17 | *Pandion haliaetus* | Bird | II |
| 18 | *Aegypius monachus* | Bird | II |
| 19 | *Gyps himalayensis* | Bird | II |
| 20 | *Falco cherrug* | Bird | II |
| 21 | *Falco tinnunculus* | Bird | II |
| 22 | *Falco Subbuteo* | Bird | II |
| 23 | *Crossoptilon harmani* | Bird | II |
| 24 | *Tetraogallus tibetanus* | Bird | II |
| 25 | *Grus grus* | Bird | II |

protection. A series of nature reserves should be established in key areas of the Yarlung Zangbo for the conservation and protection of endemic and endangered species, such as *Glyptosternum maculatum* (Regan 1905).

Long-term, ongoing monitoring is very important for the protection and understanding of the status of endemic species (Wang et al. 2021). However, it is very difficult to conduct environmental and ecological monitoring in the Qinghai-Tibet Plateau because of its harsh conditions. New technologies such as remote sensing, automatic recording and cameras, and environmental DNA are useful in monitoring the remote and wild areas of the Tibetan Plateau. Research is also needed to explore conservation options such as artificial propagation, supplementing existing populations, establishing backup sites, and control of disease in endangered species such as *G. maculatum*.

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## Parks discussed in this issue

Abbreviations: NP – National Park; RNP – Regional Nature Park; p. – page