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Editorial

According to the Cambridge dictionary, an editorial is *"an article in a newspaper that expresses the editor's [= the person in charge of the newspaper] opinion on a subject of particular interest at the present time"*. In order to capture the topics of particular interest to our editors and editorial team members in mountain protected areas (PAs) in 2023, I asked them to answer four questions about their work. The answers were as varied as the mountain areas themselves, and at the same time the problems on the ground are sometimes very similar.

- *What challenges did you face in your work for mountain PAs in 2023?*

In 2023, securing finances in the midst of high inflation posed a problem to the management of at least one PA, reflecting the difficulties that businesses in general are facing globally. In addition, PA managers are facing a steady increase in the number of people visiting mountain areas, which brought its own challenges, such as overcrowding. One solution was offered by the Triglav National Park (Slovenia), who introduced a reservation system for canyoning in Koritnica Valley to limit the number of daily visitors. Importantly, this measure helps to preserve nature while at the same time allowing visitors an adequate experience of nature. In France, diversification in recreational practices raised new questions, including how to manage trampled sensitive areas, and understanding the potential impact of activities such as swimming on high-altitude lakes. In Italy, France and Slovenia, the co-existence of wild animals and livestock grazing in the parks poses a further challenge. Livestock farmers have had to adjust their practices in a relatively short space of time, for example by introducing herding and guarding dogs in response to the presence of wolves, highlighting the need for proactive conflict resolution. Incidents such as an encounter with a female bear in Trentino, Italy, which proved fatal, underscore the complexities of managing human–wildlife interactions. In this case, the challenges extended beyond the immediate incident, with public trust in park authorities becoming a focal point of discussion.
From a scientific point of view, waning interest by locals and visitors alike in participating in scientific surveys in PAs poses a threat to data quality, comparability and reliability.

- *What new issues emerged in 2023?*

Collaboration between the Gesäuse National Park and the University of Graz led to the creation of the eLTER site Gesäuse-Johnsbach Valley as part of the Austrian Society for Long-Term Ecological Research (LTER-Austria). During ongoing measurements, a 4°C increase in water temperature in the Johnsbach in 2022 and 2023 was observed. In addition, the broader discussion about NetZero and the impacts of carbon emissions on mountain landscapes became an integral part of the scientific discourse. The co-existence of wolves, mountain sports enthusiasts, hikers and environmentalists emerged as a new challenge. The opening of the hunting season in Italy, for example, saw an increase in the number of bears killed, some of which were proven to have been poisoned, raising further questions about man-made threats to wildlife.

- *What work-related success stories in 2023 can you tell us about?*

In Austria, the Gesäuse National Park successfully enlarged its area by 113 hectares after years of negotiations with the Austrian Rail Way. In Slovenia, the Triglav National Park is preserving the traditional cultural landscape in the outer zone of the park, thanks to the good relations that the park authorities maintain with local residents. Another success story, in Koritnica and the Trenta Valley, is the introduction of on-demand public transport, by electric vehicles, for both locals and tourists, an initiative co-financed by the Park. In addition, the small primary school in Soča, within the Park's boundaries, was kept open, despite the very low number of pupils (around 10).
On the scientific level, tracing the impacts of Biosphere Reserve management on tourism shed light on the type of tourists attracted by the PA. In France, the conclusion of the Birdski project in 2023 marked a milestone, with the production of a technical handbook (*"Avifauna et domaines skiables, partager l'espace"* Birdlife and ski areas, sharing the space). The aim of the project is to facilitate the creation of co-constructed quiet zones in ski areas, preventing birds from colliding with power lines by providing them with warning beacons, and thus helping to preserve avifauna.

- *What are the strengths of mountain PAs?*

Mountain PAs such as the Gesäuse National Park boast varied habitats and microclimates, offering ecological niches crucial for biodiversity, especially in the face of increasing natural dynamics. They retain a robust image of pristine nature, serving as a powerful lever for communicating new challenges to civil society and for attracting scientists. The existence of PAs limits environmental damage, underlining their essential role in preserving natural environments from over-exploitation, such as the development of new ski slopes and downhill trails. Various challenges are common to diverse mountain PAs, thus fostering the motivation to address problems collectively, and making learning from each other's experiences a particular strength.

The challenges of 2023 underscore the need for resilience, collaboration and innovative solutions, while the success stories remind us of the positive impact that dedicated efforts can have on preserving invaluable ecosystems for future generations.

Valerie Braun & members of the editorial board

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Crosses on peaks in protected areas: a functional mapping from the Apennines to the Italian Alps by altitude bands

Ines Millesimi & Antonio Pica

Keywords: peak crosses, summit symbols, Apennines, Alps, Protected Areas, citizen science, climate change

Abstract

This article examines crosses and other religious symbols on summits in the Apennines and the Alps, mapped by altimetric bands. These anthropic signs have different causes and effects on the cultural and environmental levels. Using citizen science models, after mapping the 2,000-metre peaks in the Apennines, we conducted surveys of those of 3,000 metres in the Dolomites, and of 4,000 metres in Protected Areas within the Italian Alps. We suggest that our mapping of these cultural sites should be exported as a shared practice with other Italian and cross-border Alpine associations to preserve the historical memory of the signs on the peaks. In the light of the quantitative and qualitative results, and considering the impact of the symbols on the landscape and ecosystems, it is recommended that no new artefacts should be built, in order to transmit the concepts of restraint and naturalness to future generations; the sustainable use of stone cairns should be preferred. An ecological re-purposing of some summit crosses as temporary high-altitude meteorological stations is suggested, with the aim of collecting data and increasing our knowledge of climate change.

Introduction

Crosses and other religious symbols on mountain peaks are a complex phenomenon with historical, geographical, social, anthropological and, last but not least, ecological implications. However, the phenomenon has so far not been systematically studied, because it is a sensitive topic on religious and cultural levels (Salsa 2011), and therefore divisive and potentially polarising. The phenomenon has grown considerably in the last twenty years (Corvi 2005; Dal Mas 2013; Huarte 2014; Arnu 2016; Montagna.tv 2017; Gogna 2023; Montanaro 2023), but only recently has the topic entered scientific debate and aroused keen interest (Rech 2022, 2023). From the point of view of safety (Il Messaggero 2014) and compliance with current regulations, the consequences of placing a symbolic artefact on a summit have led to a renewed interest that attempts to break out of previous conditioning, overcoming prejudices, dualisms and stereotypes. In Italy and Austria, there has recently been heated debate about the appropriateness of installing new mountain-top crosses. However, there is general agreement that existing crosses should be preserved for their cultural value and historical importance (Ardito 2023; Tirol.ORF.at 2023).

Our culturally more mature times favoured by inter-faith dialogue and a multi-ethnic society, as well as the decision to use a transdisciplinary scientific, secular and non-ideological approach, have resulted in the first mapping of summit crosses in the Apennines (Millesimi 2022). Data, observations and photographs were collected and organized into altitude bands, and the incidence of Christian symbols both within and outside Protected Areas (PAs) was assessed.

The research was carried out with the help of a team of volunteers using a citizen science approach (Vohland et al. 2021). Since 2004 in Italy, the Cultural Heritage and Landscape Code (Legislative Decree 42/2004) has been protecting mountains of 1,200 m a.s.l. and above in the Apennine chain and the islands, and of 1,600 m and above for the Alpine chain, as assets of landscape (art. 142, paragraph d). Summit crosses are psychologically significant: they mark the highest point, beyond which one can only descend. Crosses appear not only on the actual summits of mountains, but also along the ascent and access routes, on passes and hillocks, and even at the bottom of the sea. These crosses are associated with tourist visits and popular celebrations. The principal aim of this article is to assess, through the quantitative and qualitative analysis of the sacred signs on the 2,000 m Apennine mountains falling within PAs, what the erection of new markers might imply for integrated ecological conservation and protection of the landscape, one of the fundamental principles enshrined in Article 9 of the Italian Constitution. In addition to confessional (religious) symbols, secular temporal symbols at the summit also cause concern, as is the case with the 100 metal panels advertising the Graubünden cantonal bank (Switzerland), which are being dismantled (Lacrux.com 2022).

This contribution also proposes a standard classification method that can be exported to other mountain contexts, initiating new research with a citizen science approach. The hope is to involve various Alpine associations and communities in collecting data in order to learn more about the historical significance of the summits to human societies. Finally, an attempt is made to answer whether some of the existing summit crosses in PAs could be given new ecological functions.

State of the Art

In the past, summit crosses have been studied and photographed as religious, historical and ethnographic artefacts, while the ecological dimension has largely been absent. In August 2023, a sociological study was published: here, the summit cross was interpreted *"as an example of culturalized religion, where this cultural object can become a* passive religious symbol *polarizing claims for the defense of the natural environment and the sustainability of religion in the mountains"* (Rech 2023). The Austrian Alpine Club (ÖAV) decided not to erect new mountaintop crosses between 1980 and 1990, in order to conserve the already heavily anthropized alpine environment (Di Blas 2023). In Austria, where the topic is perceived in relation to the prevailing Catholic faith, the pioneering study published by Innsbruck University (Eppacher 1957) was followed by a book documenting the summit crosses in Bavaria and Tyrol, which included transcriptions of the comments left in the summit books (Mathis 2002). Some years later, a rich photographic record was published illustrating the human stories relating to one hundred of the most beautiful summit crosses in the South Tyrol and transalpine areas (Löwer 2019). In Switzerland, an article (Anker 2012) was published about Zumstein Peak (4,563 m), the third highest peak in Monte Rosa and Switzerland, where a thermometer was fixed to the cross in 1822 to record air temperatures. In Spain, 495 artefacts have been archived as a database on the Internet, with photographs and data of crosses on peaks and in public spaces (Observatorio del Laicismo 2022). The aim was to document the numerous crosses found across the country that are deemed undesirable as they were erected by Franco, making them carriers of the regime's message (Chiappalone 2022). In Italy, mapping the summit symbols of the Waldensian Lands (Valle Pellice and Germanasca, Piedmont) produced a list of crosses, bells, Marian figures and faces of Christ, with the aim of quantifying the many specifically Catholic symbols in contrast to the negligible number of signs from the Protestant tradition (Fraschia 1997). In addition, the identity and political motivation of the *conquest* in the late 19th and early 20th centuries, and the anthropic marking of the Alpine peaks in the struggle between State and Church have been examined in depth (Cuaz 2005). The Jubilee of Pope Leo XIII in 1900 was celebrated with an expensive project funded entirely by local communities: twenty monuments and crosses (one for each century since Christ's birth), some of them colossal, were erected on prominent and accessible hills and mountains. This initiative was in line with the objectives of the Catholic movement that arose after the Unification of Italy, aiming to convey a message of unity and communal identity. It also aimed to give greater importance to the more marginalized foothill regions, thus fostering their development (Gaspari 2021). One global study of sacred mountains (Mathieu 2023) has allowed further historical insight into the erection of Christian crosses, the Christianization of summits, iconoclastic controversies, and recent criticism of summit crosses. In France, inventories have been made in specific areas up to 3,000 m in altitude (Jouty 2020). Jouty has proposed their conservation because of their value as cultural heritage in Catholic Alpine areas and because of their potential artistic values (Jouty 2020).

Historical and conceptual context

Religious summit symbols are a modern anthropic phenomenon. They became widespread in the Alpine region in the early 19th century. After the Council of Trent (1563) and the debate on the didactic function of sacred images, crosses and crucifixes spread from the confines of medieval abbeys and monasteries to alpine pastures and crossroads for the protection of village communities. Mountain summits were still considered inaccessible places, spaces of the magical, the chaotic and the evil, and the first monuments were ones of the passes and waysides. Chapels, shrines and crosses came to the peaks much later, when they were Christianized at the urging of an *"enlightened Catholic clergy and religiously oriented Enlightenment thinkers"* (Mathieu 2023: 70), as attested in the accounts of early summit climbers and by the paintings of the Romantic artist Caspar David Friedrich (1774–1840). In France, however, the first record of as many as three wooden crosses dates back to 1492: these were on the summit-plateau of the Mont Aiguille in the Vercors Massif (Briffaud 1988). These crosses have been interpreted as the first evidence of thanks to God for the success of a climb, but also as a message of political propaganda (Briffaud 1988: 40–41, 59). An inscription on an ex-voto on the summit of Rocciamelone (3,538 m, Graian Alps, Italy) depicting a Madonna Regina with Child, in a triptych, attests to the fact that it was brought to and placed on the summit in 1358 (Camanni 2013). The earliest summit crosses for which there is documentary evidence were erected only a few centuries later, in Austria. These are crosses on the Kleinglockner (3,770 m), a cross erected in 1799, and one erected in 1800 on the Großglockner (3,798 m). The latter peak is the highest mountain in theHohe Tauern National Park in Austria, and the cross here had both religious and practical functions, as a sign of devotion and as a support for bulky scientific instruments (Löwer 2019). It was later replaced by the imperial cross.

With the advent of the Enlightenment, the *Weltanschauung* changed: scientific interest in altimetric measurements and the first meteorological and naturalistic investigations turned to the peaks (Cittadella 2019). Crosses, as an indirect remnant of pagan ideas (Mathis 2002: 12), could have had a magical or ritual purpose on the *Wetterberge* (mountains where thunderstorms gather), as hypothetical lightning chasers: these are patriarchal-type crosses, with two crossbars. The original wooden crosses are generally no longer found on the

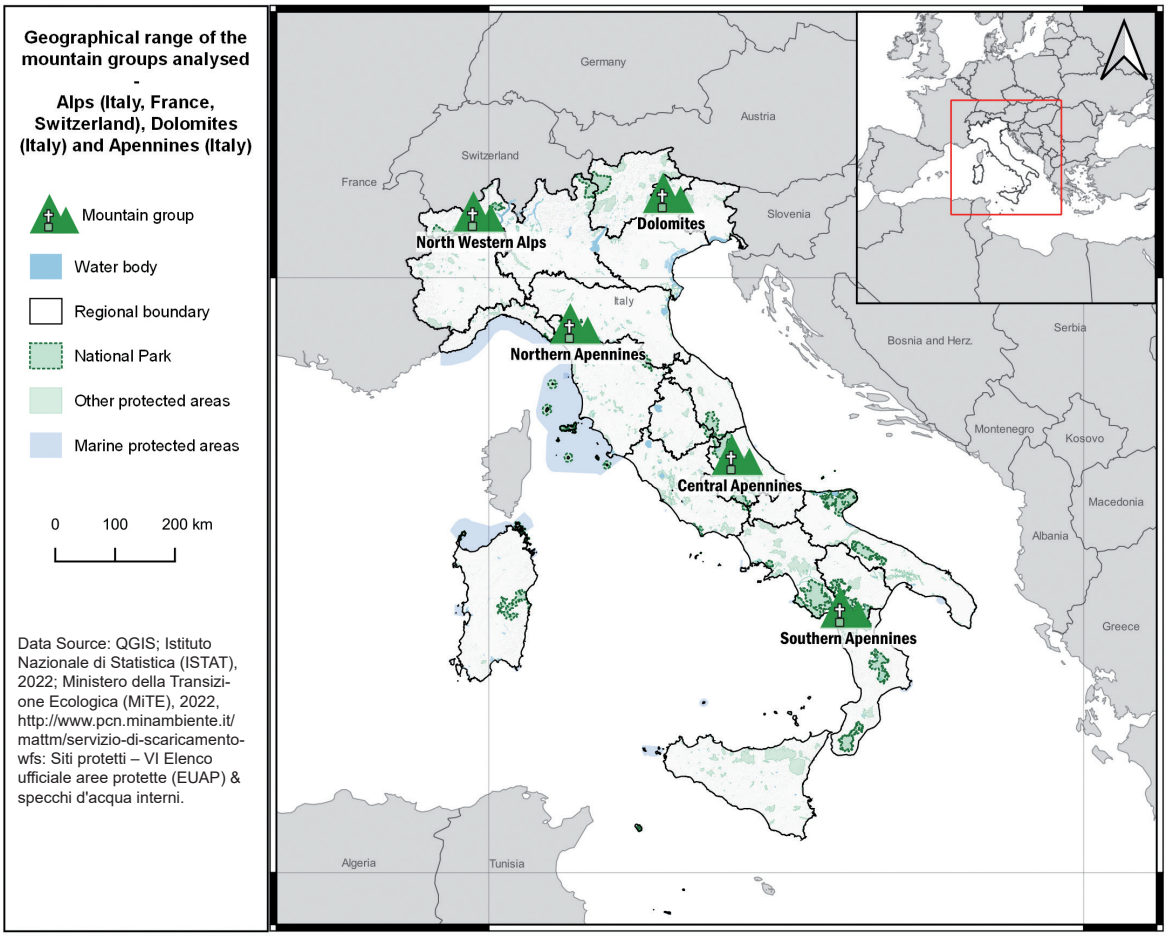

Figure 1 – Geographic area of the research in the Alps (Italy, France, Switzerland) and Apennines (Italy).

peaks, but some are preserved in Cadore in the Messner Mountain Museum Dolomites-Monte Rite (Veneto, Italy). In the wake of Nazi mysticism, there was a controversial attempt in Germany to replace summit crosses by swords. This was followed between 1933 and 1945 by the first acts of vandalism, when crosses were replaced by swastikas (Löwer 2019). However, the first criticism of mountain-top crosses came as early as 1928 from Eugen Guido Lammer, an Austrian mountaineer and journalist, who wondered what such man-made things as memorial stones, flags and crosses had to do with the wilderness. In the Alpine region, the number of summit crosses is currently estimated at several thousand, peaking in the last four decades with the spread of mountaineering. In theory, erecting crosses and other markers of a religious nature is *"a dynamic tradition in a confessional environment"* (Mathieu 2023: 71). However, it is limited by and large to periodic pilgrimages or tourist walks at lower altitudes, and the religious significance is becoming less important (Mathieu 2023). At higher altitudes, the practice is very sporadic. In France, despite the secularist impulse of the French Revolution of 1789, summit crosses spread in the northern Alps, with renewed vigour from 1950 onwards, followed by critical reactions since then. This topography of the Catholic faith in the mountains of France, or aspiration to the sacred mountain and its myth, covers the Chablais massif in the north, the Vercors, Dévoluy, Écrins and Queyras in the south, les Bornes-Aravis, les Bauges and the Chartreuse in the west, and the national borders with Italy and Switzerland to the east (Jouty 2020).

Materials and methods

The search for summit crosses (Figure 1) started from central Italy (from Monti Reatini), for peaks over 1,200 m and situated less than 120 km from both Rome and the Vatican City. The search then followed the Apennine ridge, for peaks over 2,000 m All symbols of the Christian tradition (crosses, statues of the Virgin Mary and Christ, and shrines, Figure 2) were catalogued. This article outlines our search, which was carried out with the cooperation of mountain-

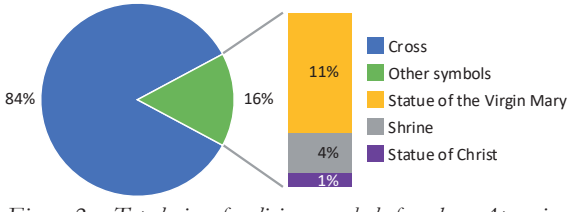

Figure 2 – Typologies of religious symbols found on Apennine peaks of over 2,000m a.s.l.

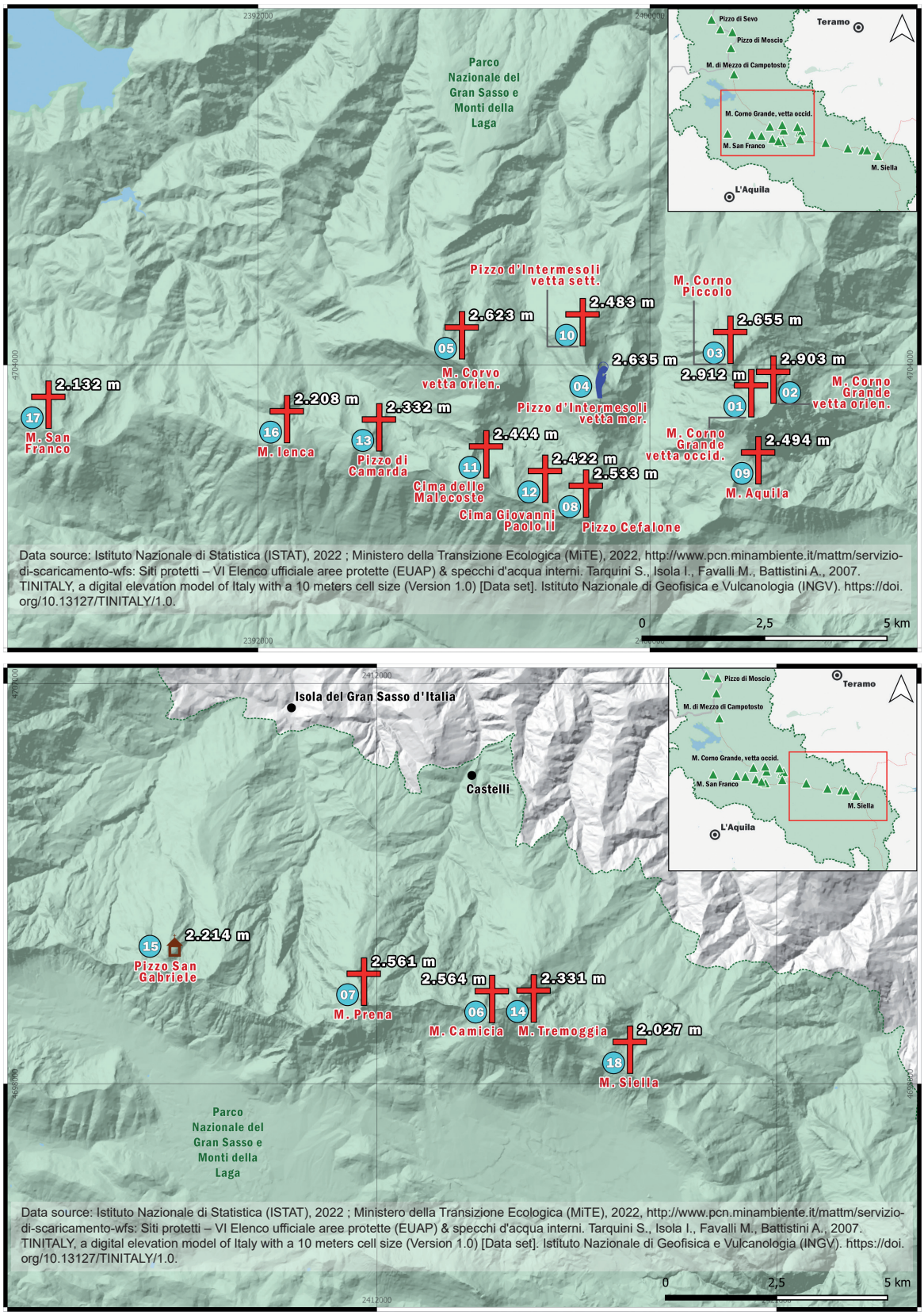

Figure 3 – Peak crosses at over 2,000 m in the western and eastern Gran Sasso Massif (central Italy), see Millesimi & Pica (2022).

eering groups and clubs (Club 2000m, Club 4000m, Club Alpino Italiano, Gruppo Dolomiti 3000m), and based on the official lists of all Alpine and Apennine peaks according to altitude and mountain group (Club 2000m 2015; Romelli & Cividini 2019; Ciri & Bernardi 2022). The study of the summits' symbols was carried out between November 2021 and August 2022. For the collection of data on the 2,000 m summits in the Apennines (Millesimi 2022) and those of 3,000 m in the Dolomites, we used the unpublished lists of identified symbols obtained from relevant associations. The extremely hot dry summer of 2022 made it impossible to complete and update the list of summits over 4,000 m due to the fast melting of ice and the danger of landslides. Currently, mountain environments and peaks represent climatic hotspots where temperature increases are occurring at almost twice the global rate (Notarnicola 2020). Our observations for the highest mountains were therefore derived from photographic evidence dating from the immediately preceding years.

In order to catalogue the crosses and other summit symbols in the Apennines, each sampler used field cards (paper and digital) to collect the necessary information, including the coordinates (WGS84) of each symbol, acquired by GPS. Collaborators involved in the data collection became co-authors of the cards (Millesimi 2022); they were recruited among experienced hikers and passionate mountaineers. This created a cooperative team of 'mountaineering scientists', who gave their services for free and responsibly provided useful information for scientific and environmental research in the mountains. The survey cards include information about: the type of symbol (cross, statue of the Virgin Mary or of Christ, shrine) and its georeferenced position in relation to the summit; measurements (height, width and thickness expressed in cm, or thickness of each arm in mm in the case of a cross); measurements of any base, together with its characteristics; material used; year erected (when specified); state of preservation; year of any restoration or modification (when specified); if plaques were present, how many, and a full transcription and photograph of each. The photographs had to document the relationship between the symbol, summit and backdrop of the

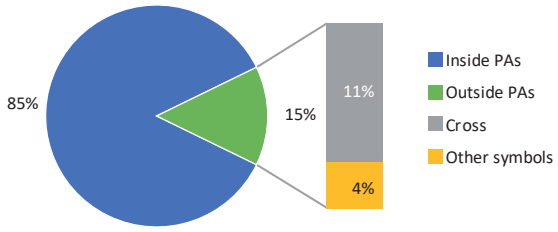

Figure 4 – Religious symbols in protected areas (PAs) found on Apennine peaks of over 2,000m a.s.l.

mountain landscape in isolation, without people. If the dating of the symbol could not be inferred, it was deduced from documentary research (bibliographical analysis, consultation of photos in the archive or available on the web, an *ante quem-post quem* year interval, or local oral sources).

Both direct and indirect measurements of the symbols were taken. For the highest crosses, the width of the arms was measured by placing a stone on the ground corresponding to the end of the arm and measuring the projection on the ground; for the height of the tallest iron lattice crosses, the pole was climbed, a stone was used to mark a point 2 metres from the top, then the height from the bottom to the marked point was calculated, and the two were added together. For the state of conservation of the crosses, three categories were used, based on direct observation: very poor (broken, crooked, unsteady, uprooted; illegible plate); poor (abraded paint; very rusty; badly deteriorated wood; damaged but readable plaque); good (good visible state or signs of maintenance; well embedded in the ground or anchored in concrete or with ropes; straight, recently painted; clearly readable plaque). Later on, the data card was completed with additional information: the mountain group in which the cross is situated, the province and municipalities in which the peak falls (it is common for a peak to fall within several municipalities), historical information on the position of the symbol, analytical description of the symbol, and recent bibliography on the mountain. The digitized cards and photographs were organized into folders by volunteer trekkers, mountain guides, and climbers from the Clubs. We then validated the data with the cooperation of experts, by comparison with

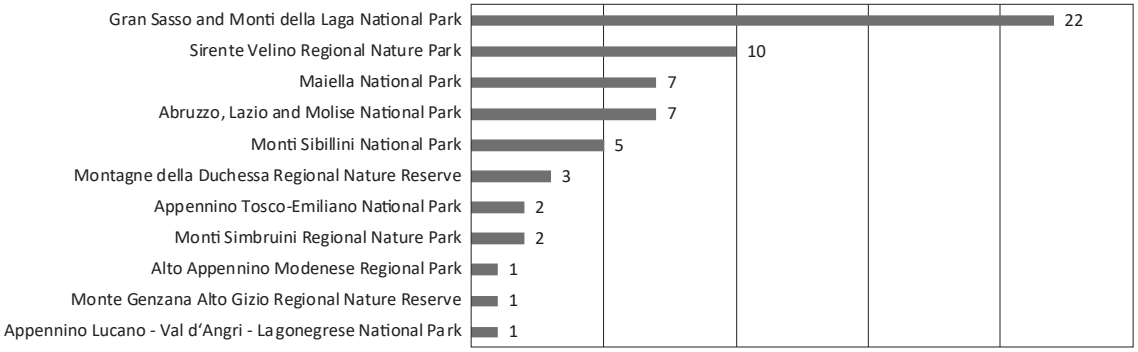

Figure 5 – Number of crosses found on peaks of above 2,000m a.s.l. in protected areas in the Apennines.

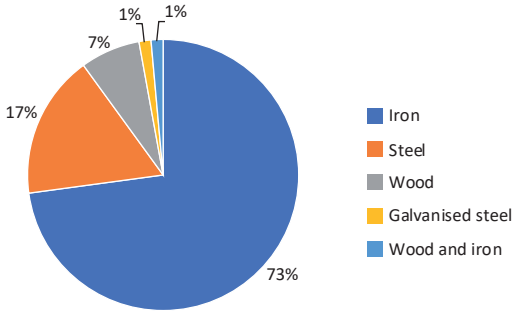

Figure 6 – Construction materials of crosses on Appenine peaks of more than 2,000m a.s.l.

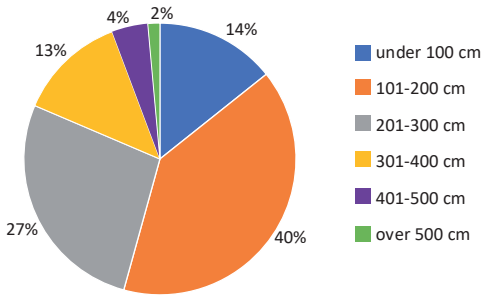

Figure 8 – Height of peak crosses in the Apennines above 2,000m a.s.l.; small (under 100 cm), medium (101–200 cm); large (from 201 cm to over 500 cm).

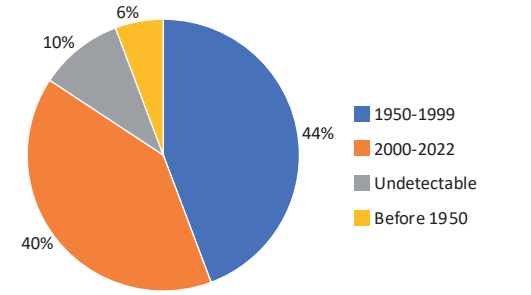

Figure 7 – Dates of earliest crosses on Apennine peaks of over 2,000m a.s.l.

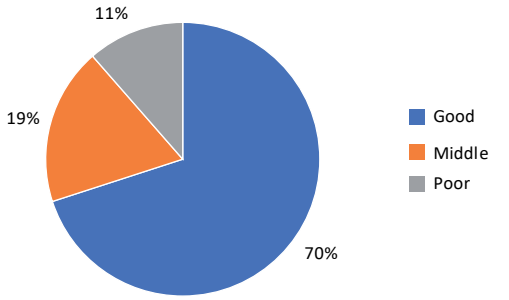

Figure 9 – Conservation status of Apennine peak crosses above 2,000m a.s.l.

already-existing data. The experts were long-term frequenters of the peaks in question, and members of the Italian Alpine Club (CAI) local to the summits where the symbol was found. All data were then organized in a database. Multiple site visits and field verifications took place to verify and validate the information given in forms that were incorrectly filled out. Finally, maps (Figure 3) were produced according to the methodology adopted in Millesimi & Pica (2022).

Results

How far back do the summit crosses in the Apennines date? The first was set in place in 1935, on the highest peak of the Central Apennines, Corno Grande of Gran Sasso (western summit, Abruzzo), on the occasion of the XI National Eucharistic Congress, at the same time as the bronze statue of the Virgin Mary in the same area (at Arapietra 2,028 m). Many other symbols followed, resulting in a stratification of anthropic signs that were sometimes removed and replaced, renewed, modified or shortened. At times, symbols were found alongside each other (e.g. cross and statue of the Virgin Mary) or were duplicated (e.g. two crosses on the northern and southern summits, or on a summit and sub-summit). The historical crosses found in situ were made of iron. In addition to the one on Corno Grande, we catalogued the following iron crosses: 1950–60, on Monte Cusna (Tuscan-Emilian Apennines, northern Apennines); 1955, on Monte Velino (Sirente-Velino Group, Central Apennines, after the destruction of two earlier crosses there); 1965–66, on Monte Prena (Gran Sasso, Central Apennines); 1967, on Monte Miletto (Matese Mountains, Southern Apennines), and on Pizzo Deta (Ernici Mountains, Central Apennines). These are all summit crosses, erected prior to the creation of the relevant PAs. (For their geographical distribution, see the maps in Millesimi & Pica 2022.)

The summit crosses database offers interesting data regarding their number, geographical distribution in PAs, materials used, state of preservation and size. In total, 68 peaks out of 236 official peaks over 2,000 m (Club 2000m 2015) were found to have religious symbols (Table 1). Of these, 85% fall within PAs (Figure 4). The average for each PA is 5.5 summit crosses. Both before and after the establishment of the PAs, new symbols, and symbol restorations and renewals have occurred. The PA with the highest number of crosses is the Gran Sasso and Monti della Laga National Park (see Figure 5), with 22 crosses: 17 in the Gran Sasso Massif, 5 in the Monti della Laga. The most recent cross was placed in the Montagne della Duchessa Regional Natural Reserve in 2022.

Overall, iron crosses prevail on the 2,000 m peaks of the Apennines (73%) (Figure 6). The coexistence of crosses with Marian figures was also recorded (8 co-occurrences, the majority of which are within PAs). Only one statue of the Risen Christ was found alongside a cross (Sirente Velino Regional Nature Park, Monte di Sevice). Three shrines were found (Gran Sasso and Monti della Laga National Park: Pizzo di Moscio and Pizzo San Gabriele; Sirente Velino Regional Nature Reserve: Monte Orsello), as well as 2 isolat-

Figure 10 – Summit cross as climate hotspot, Alphubel (4,206 m, Alps, Eastern Pennine group, Switzerland). The photo shows the consequences of melting snow in a particularly dry summer with high temperatures. The cross's supporting column, embedded in the rock, is almost completely exposed, whereas in past summers only the wooden cross itself was visible. August 2022. © W. Scarpellini.

ed Marian statues (Gran Sasso and Monti della Laga: Pizzo di Intermesoli, southern summit; Regional Park of the Modenese High Appennines: Monte Cimone). No instances of a crucifix were found. Over the years, plaques have been placed on many of the symbols in memory of the mountaineers who died making the ascent. Additionally, on some peaks, the symbol is situated next to a trigonometric or geodetic survey marker. These summit trigonometric points, also known as topographic or geodetic vertices, consist of structures such as short columns, pillars, or metal markers on the ground, and are part of the triangulation network of the national IGM (Istituto Geografico Militare), which is instrumental in accurately referencing the geographical position of a location.

The single largest group of crosses (44%) date from between 1950 and 1999 (Figure 6), are of medium height (101–200 cm) (Figure 8), and are in good condition (70%) (Figure 9).

The origins of the crosses are as follow: created anonymously (15), on the initiative of parishes and Catholic associations (13), on personal initiative (12), or on the initiative of local branches of the Italian Alpine Club (11); created by sports associations (8) and groups of friends or families in memory of individuals (5). Finally, we have those erected on the initiative of local divisions of the Alpine troops (4), local authorities (3), or others (3).

Of the 86 officially recognized 3,000 m Dolomite peaks (Ciri & Bernardi 2022), 33 have religious symbols: 30 summit crosses (of which 4 coexist with a statue of the Madonna, and 1 with another summit cross), 2 isolated statues of the Madonna, 1 statue of a Ladin deity. In total, 21 religious symbols, of which 17 are crosses, are located within National or Regional Parks (Table 2). As for the crosses, most are of average height and their state of preservation is good, because metal is the most common material. The oldest datable cross is on the summit of Catinaccio dell'Antermoia (1958), but others bear references to the First World War in the Dolomites.

Of the 82 peaks of 4,000 m in the Alps certified by the International Climbing and Mountaineering Federation (UIAA) (Romelli & Cividini 2019), 30 host symbols (Table 3): 21 summit crosses, 8 statues of the Madonna (including one bas-relief), and 1 bust of a saint (Don Bosco). Most are recent artefacts (from *c.* 2000 or later) or have been restored since 2000, and are therefore in a good state of preservation. The restored historical symbols are located on the summit of the Matterhorn (a cross built in 1902) and on the summit of Gran Paradiso (a statue of the Madonna, 1954), the latter being in the National Park. It is only in the Alps that crucifixes are found – either as bas-reliefs or in full relief (5). Seven of the peaks with symbols are located in two border countries (France, Italy, Switzerland); 2 symbols fall in National Parks; 8 are found in the Natura 2000 network and UNESCO World Heritage sites.

The three tables of the Apennines and Alps show the peaks identified by mountain group, the altitude above sea level, the types of religious symbols present, and their respective PAs.

Discussion

In terms of iconography, from a strictly numerical point of view crosses are more prevalent than Marian images. It appears that historically, in addition to their mystical, political and ritual aspects, crosses had scientific functions (Millesimi 2022), related to altimetry and accessibility of the summit, sometimes serving as a support for instruments for the first air-temperature measurements (Anker 2012).

The proliferation of anthropic signs on peaks, at both low and high altitudes, and well beyond the Catholic tradition, although tolerated by most people (Millesimi 2022), can have a deep impact on the landscape, especially if the symbol is disproportionately large or in some way inadequate in terms of its iconography, materials, building techniques and state of preservation. In addition, summit crosses are potentially dangerous for climbers because they pose problems of

criminal liability, and of safety if maintenance and repairs are not carried out regularly. Finally, if metal crosses are abandoned or destroyed, whether by vandalism or storms, they become non-biodegradable solid waste that needs to be disposed of.

In cases of intrusive or excessively large projects on summits, the construction work itself would have unsustainable environmental impacts, including impacts on the surface and soil, on plant communities or vegetation, loss of shelter and food sources for animals, and phototaxis of nocturnal insects' behaviour in the case of artificially illuminated crosses. The partial reshaping of the summits and the widening of paths for religious or other forms of tourism would have further negative impacts. In all these cases, the summit would lose its natural character. In order to mitigate the impacts, restraint should be recommended instead of the ostentation of messages inappropriate to the context, especially within or close to National or Regional Parks, and signs should be limited to those that identify official trails. In line with these considerations, two official documents have been issued in recent years: a note from the *Pastorale del Turismo* of the Archdiocese of Trento, which suggests parameters of restraint and invites people to seek the message of the mountain in natural signs (Andreatta 2009); a document from the mountaineering community (Mountain Wilderness Italia 2013) calling for greater control and binding regulations on crosses and other artefacts on Italian summits, especially within PAs.

The proposed cultural-lay-spiritual project to establish a *Sacred Mountain* in the Gran Paradiso National Park, with the freedom to choose not to climb to the symbol-free peak of Monveso di Forzo (3,322 m), fits into this perspective. The main goals are to contain human invasiveness in a PA and to encourage reflection on limits (both personal physical limits and the limits of humans as a species) while refraining from *conquering* the mountain (Comitato di Promozione *Una Montagna Sacra* per il Gran Paradiso 2021). The intention, influenced by ideas found in Asian culture or spirituality (Tibetan Buddhism has offered itself as a mountain religion worldwide), contains a broader ecological message – of greater respect for nature and its habitats, recognizing mountains for their intrinsic sacredness rather than as there to be exploited or consumed.

Conclusion

In order to pass peaks on to future generations in a more natural state, preference should be given to simple manmade artefacts that do not change the quality of the landscape or summit. As already happens in many cases, when suitable stones can be found and positioned a dry-stone stone cairn (about 40–50 cm high, visible even in fog) would be sufficient. This practice, already used in the 19th century, allows a natural, discreet and inexpensive way to mark the highest point. Based on the relationship between perceived landscape and cultural landscape (Ferrari & Pezzi 2013), the proposal is to stop the creation of any additional summit artefacts and instead to conserve the historical signs, which in Italy include the IGM trigonometric points. If they understood the cultural significance and history of the existing signs, and the transformations they have undergone, alpine communities and associations would motivated to take better care of them. It could be an educational choice to value the summit as an experience and reaching it as a *journey*, rather than focusing on the cross as a destination to be attained on foot or by cable car. In contemporary culture, the cross has become an increasingly polysemous symbol, one that can help overcome dualisms and divisions. Due to its basic shape, which can be seen as referring to orientation in space, and because the cross as a symbol is far more ancient than Christianity, today the summit cross can be considered through a different, modern, lens.

The surveying and mapping of these signs carried out by interested parties (ideally in the form of a digital project in collaboration with the Club Arc Alpin) could lead to a reflection on their impacts, and to a proposal, for the existing summit crosses, for a potential new ecological function. They could serve as indicators of climate change, making the extent of ice-melt and snow accumulation on the peaks visible (Figure 10). In cases identified as suitable and in agreement with park authorities and local communities, lattice iron summit crosses (over 2 m in height) could be fitted with temporary Automatic Weather Station equipment, following the guidelines of the World Meteorological Organization (WMO 2018). This would reinforce the role of mountain summits as *sentinels of climate change* (Quaglia et al. 2020: 12) and promote a new ecological function for the peak crosses, especially at high altitudes.

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Table 1 – Peaks above 2,000 m a.s.l. in the Apennines, Italy. PA – Protected area, NP – National Park, RNR – Regional Nature Reserve, RNaPa – Regional Nature Park, "-" – peak not situated in a PA.

N°	Group/Mountain range	Name of peak	Elevation (m a.s.l.)	Symbol	Protected area
1	Tosco-Emiliano	Alpe di Succiso	2,017	†	Appennino Tosco-Emiliano NP
2		M. Cusna	2,121	†	
3		M. Cimone	2,165		Alto Appennino Modenese Regional Park
4	Sibillini	M. Vettore	2,476	†	Monti Sibillini NP
5		Cima del Redentore	2,448	†	
6		M. Priora	2,332	†	
7		M. Sibilla	2,173	†	
8		Pizzo Tre Vescovi	2,092	†	
9	Laga	M. Gorzano	2,458	†	Gran Sasso and Monti della Laga NP
10		Cima Lepri	2,445	†	
11		Pizzo di Sevo	2,419	†	
12		Pizzo di Moscio	2,411	† ◘	
13		M. di Mezzo	2,155	†	
14	Reatini	M. di Cambio	2,081	†	-
15	Gran Sasso	M. Corno Grande, western peak	2,912	†	Gran Sasso and Monti della Laga NP
16		M. Corno Grande, eastern peak	2,903	†	
17		M. Corno Piccolo	2,655	†	
18		Pizzo d'Intermesoli, southern peak	2,635		
19		M. Corvo, eastern peak	2,623	†	
20		M. Camicia	2,564	†	
21		M. Prena	2,561	†	
22		Pizzo Cefalone	2,533	† †	

N°	Group/Mountain range	Name of peak	Elevation (m a.s.l.)	Symbol	Protected area
23	Gran Sasso	M. Aquila	2,494	†	Gran Sasso and Monti della Laga NP
24		Pizzo d'Intermesoli, western peak	2,483	†	
25		Cima delle Malecoste	2,444	†	
26		Cima Giovanni Paolo II	2,422	†	
27		Pizzo di Camarda	2,332	†	
28		M. Tremoggia	2,331	†	
29		Pizzo San Gabriele	2,214	◘	
30		M. Ienca	2,208	†	
31		M. San Franco	2,132	†	
32		M. Siella	2,027	†	
33	Montagne della Duchessa	M. Costone, eastern peak	2,271	†	Montagne della Duchessa RNR
34		Murolungo	2,184	†	
35		M. Cava	2,003	†	
36	Sirente Velino	M. Velino	2,486	†	Sirente Velino RNaPa
37		M. Cafornia	2,409	†	
38		M. di Sevice	2,355	† ₽	
39		M. Sirente	2,348	†	
40		M. della Magnola	2,220	†	
41		M. Ocre	2,209	†	
42		Capo di Pezza	2,177	†	
43		M. Puzzillo	2,174	†	-
44		M. Cagno	2,153	†	Sirente Velino RNaPa
45		Cima del Morretano	2,098	†	-
46		M. Rotondo	2,062	†	Sirente Velino RNaPa
47		M. Orsello	2,043	◘	-
48		M. San Nicola	2,012	†	Sirente Velino RNaPa
49	Maiella	M. Amaro	2,793	†	Maiella NP
50		M. Acquaviva	2,737	†	
51		M. Sant'Angelo	2,669	†	
52		Cima delle Murelle	2,596	†	
53		M. Porrara	2,137	†	
54		M. Rotella	2,129	†	
55		M. Morrone	2,061	†	
56	Simbruini Ernici	M. Viglio	2,156	†	Monti Simbruini RNaPa
57		M. del Passeggio	2,064	†	-
58		Pizzo Deta	2,041	†	-
59		M. Cotento	2,015	†	Monti Simbruini RNaPa
60	Gruppo del Monte Genzana	M. Genzana	2,170	†	Monte Genzana Alto Gizio RNR
61		M. Rognone	2,089	†	-
62	Marsicani	M. Greco	2,285	†	-
63		La Meta	2,242	† †	Abruzzo, Lazio and Molise NP
64		M. Calanga	2,168	†	
65		M. Argatone	2,149	† †	
66	Le Mainarde	M. Forcellone	2,030	† †	
67	Matese	M. Miletto	2,050	† †	-
68	Sirino	M. del Papa	2,005	†	Appennino Lucano – Val d'Angri – Lagonegrese NP

Table 2 – Peaks above 3,000 m a.s.l., in the Dolomites and the Italian Alps. NaPa – Nature Park, "-" – peak not situated in a PA.

N°	Group/Mountain range	Name of peak	Elevation (m a.s.l.)	Symbol	Protected area
1	Dolomiti di Brenta	Cima Tosa	3,173		Adamello Brenta NaPa
2		Cima Brenta	3,151	†	
3	Catinaccio	Catinaccio d'Antermoia	3,002	†	Sciliar – Catinaccio NaPa
4	Sassolungo	Sassolungo	3,181	†	-
5	Odle	Sass Rigàis	3,025	†	Puez Odle NaPa
6		La Furcheta	3,025	†	
7	Pale di San Martino	Cimon de la Pala	3,181	†	Paneveggio – Pale di San Martino NaPa
8		Cima della Vezzana	3,192		
9		Cima del Focobòn	3,054	†	
10	Sella	Piz Boè	3,152	†	-
11	Marmolada	Cima dell'Uomo	3,010	† (both fallen in situ)	-
12		Sasso di Valfredda	3,003	†	-
13		Cima Ombreta Orientale	3,011	†	-
14		Punta Penìa	3,343	†	-

N°	Group/Mountain range	Name of peak	Elevation (m a.s.l.)	Symbol	Protected area
15	Sasso Croce-Lavarella-Fanes	Sasso delle Dieci	3,026	†	-
16		Lavarela de fora	3,034	† †	-
17		Piz de Lavarela	3,055	†	Fanes – Sennes and Braies NaPa
18		Piz Conturines	3,064	§	
19	Civetta	Monte Civetta	3,220	†	-
20	Tofane	Tofana di Rozes (I)	3,225	†	Dolomiti d'Ampezzo Regional NaPa
21		Tofana di Dentro (III)	3,238	†	
22		Tofana di Mezzo (II)	3,244	†	
23	Pelmo	Monte Pelmo	3,168	†	-
24	Dolomiti di Braies	Croda Rossa d'Ampezzo	3,146	†	Dolomiti d'Ampezzo Regional NaPa
25	Cristallo	Cristallo di Mezzo	3,154	†	
26		Monte Cristallo	3,221	†	
27	Sorapìs	Croda Marcora	3,154	†	-
28		Sorapìs	3,205	†	-
29	Antelao	Antelao	3,264	†	-
30	Dolomiti di Sesto e Auronzo	Punta dei Tre Scarperi	3,145	†	Dolomiti di Sesto NaPa
31		Croda dei Toni	3,094	†	
32		Cima Undici Sud	3,092	†	
33		Monte Popera	3,046	†	

Table 3 – Peaks over 4,000 m a.s.l., in the French, Italian and Swiss Alps. PA – Protected Area, NP – National Park, "-" – peak not situated in a PA.

N°	Group/Mountain range	Name of peak	Elevation (m a.s.l.)	Symbol	State and/or Protected area
1	Massiccio des Ecrins	Barre des Écrins	4,101	†	Écrins NP (FR)
2	Gran Paradiso	Gran Paradiso	4,061		Gran Paradiso NP (IT)
3	Mont Blanc	Mont Blanc du Tacul	4,248	†	- (FR)
4		Dente del Gigante/Dent du Géant	4,014		- (IT, FR)
5	Pennine Occidentali	Combin de Valsorey	4,184	†	- (CH)
6		Monte Cervino/Matterhorn	4,478	†	- (CH)
7		Dent Blanche	4,357	†	- (IT, CH)
8		Weisshorn	4,506	†	- (CH)
9		Zinalrothorn	4,221	✞	- (CH)
10		Pollux/Polluce	4,092		The symbol of the Virgin Mary is located along the Italian normal track on the pre-summit at 3,991 m, Natura 2000 network: Aosta Valley (IT)
11		Castor/Castore	4,228	⊕	The symbol is located at about 20 m under the peak. Natura 2000 network: Aosta Valley (IT, CH)
12		Lyskamm/Lyskamm vetta orientale	4,527	†	Natura 2000 network: Aosta Valley (IT, CH)
13	Pennine-Monte Rosa	Punta Giordani	4,046		Natura 2000 network: Aosta Valley/Alta Val Sesia and Alta Val Strona Natural Park (IT)
14		Corno Nero	4,322		
15		Punta Gnifetti/Signalkuppe	4,554		The symbol is placed on the outside wall of the refuge Capanna Margherita. Natura 2000 network: Aosta Valley/Alta Val Sesia and Alta Val Strona Natural Park (IT, CH)
16		Zumsteinspitze/Punta Zumstein	4,563		- (CH)
17		Dufourspitze/Punta Dufour	4,635	†	- (IT, CH)
18	Pennine Orientali	Strahlhorn	4,190	†	- (CH)
19		Rimpfischhorn	4,199	†	
20		Allalinhorn	4,027	✞	
21		Alphubel	4,206	✞	
22		Täschhorn	4,491	✞	
23		Monte Dom	4,545	✞	
24		Lenzspitze	4,294		
25		Nadelhorn	4,327	†	
26		Stecknadelhorn	4,241	†	
27		Dirruhorn	4,035	†	
28		Lagginhorn	4,010	†	
29	Oberland	Aletschhorn	4,195	†	UNESCO-Welterbe Swiss Alps Jungfrau-Aletsch (CH)
30		Finsteraarhorn	4,274	†	
Not officially listed					
31	Pennine-Monte Rosa	Balmenhorn	4,167	₽	- (IT)

Key to symbols used in the tables:

†	Cross
	Virgin Mary
◘	Shrine

₽	Risen Christ
§	Ladin deity
⊕	Bust of a Saint (Don Bosco)

✞	Crucifix

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Apuseni Nature Park, a park for nature and people

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Keywords: Romania, Apuseni, nature park, Natura 2000, karst, landscape, biodiversity

Abstract

Together with a number of other protected areas, Apuseni Nature Park forms one of the largest continuous protected areas in Romania. The total area comprises 1 nature park, 3 Natura 2000 sites and 55 small protected areas of national interest. The integration of the sites with each other provides the framework to preserve landscapes, natural values and biodiversity, in the context of sustainable development and of increasing the resilience of local communities, by using an adaptative management plan to face social and economic challenges.

Profile

Protected area

Apuseni Nature Park

Mountain Range

Carpathians, Romania

Figure 1 – Land of the Moți. © Alin Moș

Introduction

The Apuseni Mountains are a branch of the Carpathian Mountains, located in the west of Romania, in Transylvania. Not being connected by to the rest of the Carpathian chain, the Apuseni have the appearance of an island. This makes them more memorable but, at the same time, perhaps more vulnerable. The maximum altitude is 1,848 m a.s.l. (Bihor peak), so compared to the Carpathian Mountains as a whole, the Apuseni are of moderate altitude. Their slopes are less pronounced, making the highest areas easily accessible. Geologically, limestones are widely distributed, which, in the presence of abundant precipitation, have over millions of years formed the most important karst area of Romania.

In the very heart of these mountains, the Apuseni Nature Park (ANP) was created in an area where the abundance of unique natural values determined the creation of other protected areas (55 nature reserves and natural monuments, and 3 Natura 2000 sites). By overlapping, these various protected areas form an integrated and unitary surface. Their most important natural values that argued the need for protection and conservation and determined the protected areas' creation were the karst areas.

More than 1,500 caves, which form a well-preserved subterranean environment, fossil ice blocks in some caves, and a large number of boglands have preserved the remains of ancient plants, including pollen, and animals that lived tens of thousands of years ago. These are unique environments that are of inestimable value to science, contributing to knowledge of the evolution of life and of climate dynamics. Caves have created and maintained the best conditions for preserving evidence of human presence, such as footprints, artefacts, ritual arrangements, cave paintings, and fossils of now-extinct creatures.

The local communities preserve their traditional values and lifestyle; the Moți are recognized today nationally as a characteristic population of the Apuseni mountains, whose long-term interaction with nature has created a distinctive landscape, known as the Land of the Moți (Figure 1).

Historical evolution

The most crucial evidence of the more distant past has been preserved in the caves as fossils of animals that have been extinct for thousands of years, such as the cave bear (*Ursus spelaeus*), the Eurasian cave lion (*Panthera leo spelaea*), the cave hyena (*Crocuta crocuta spelaea*) and many others. The caves also preserve the oldest traces in Romania of human presence: the footprints of the Neanderthal man in the Vârtop Glacier Cave (Onac et al. 2005) is among the oldest known human footprints in caves in the world (Figure 2); the paintings from Coliboaia cave are thought to be the oldest in the area between the Alps and the Urals (Clottes et al. 2011, 2013). For further details, see Infobox 1.

Roughly two thousants years ago, the Dacian tribes who lived in the lower areas of the Apuseni mountains began to exploit the gold that was found in abundance in the eastern part. This led the Romans to conquer Dacia and to develop the gold mining in Apuseni, thus increasing the local population by supplementing the labour force.

Figure 2 – Neanderthal footprint from Vârtop Cave. © O. Guja

Figure 3 – The Fortress of Ponor Cave. A karst phenomena. © Peter Lengyel

However, until the middle of the second millennium of our era, the higher central areas of the Apuseni mountains were uninhabited. The first human settlements began to appear in what is now the ANP area at the end of the 16th century; thus, we can talk about a permanent human presence only from that period (Netea 1977).

The resources necessary for the first communities were the gold for which they panned in certain rivers, the wood from the forests, and meadows for raising animals. With the depletion of accessible gold resources, the local economy became based more on exploiting and processing wood and animal breeding, and the small human communities began to move from the cold, humid valleys to warmer, drier areas at higher altitudes with southern exposure. Because forests initially covered about 95% of the territory, areas had to be cleared to establish habitation. Land for livestock – for grazing or hay – was also required, and thus meadows appeared.

The villages in the high areas of the Apuseni Mountains have preserved their early structural characteristics: typically, successive generations of a family cleared new areas of forest next to the original family home's land, to build new houses and create secondary meadows. The result is landscapes comprising forests spread over hilltops sprinkled with meadows, and households at some distance from each other, a pattern that is typical of the Land of the Moți (Figure 1).

Establishment of the Apuseni Nature Park and operationalization of management

The terrain and the lack of roads in the higher mountain areas limited the access of people from outside the local communities. It was only in the 19th century that the first descriptions highlighting the area's beauty and uniqueness appeared, attracting the attention of a hiking enthusiast, Czaran Gyula, at the end of that century. He spent an important part of his fortune creating the first visitor infrastructure which, at the beginning of the 20th century, facilitated the general public's access to the places of natural beauty that he had discovered.

Shortly after, the area was visited and researched by the great Romanian scientist Emil Racoviță (Onac & Murariu 2016), the father of biospeleology worldwide and President of the Romanian Academy in the interwar period. He understood the vulnerability of these places, especially the caves, and their importance for understanding evolution. He also understood the need for the development of human society in the 20th century, and at the First Congress of Romanian Naturalists, which took place in Cluj in 1928, he formulated the first proposal for a national park in the

Infobox 1

Karst superlatives from Apuseni Nature Park

- *Scărişoara Glacier Cave*
  The largest underground block of ice in the world, with a volume of over 130,000 m^3.
- *Vârtop Glacier Cave*
  The oldest footprints of Neanderthal man in Romania and among the oldest in the world, over 62,000 years old (Onac et al. 2005).
- *Coliboaia Cave*
  The oldest cave paintings between the Alps and the Urals, over 35,000 years old.
- *The cave of Bad valley*
  The presence of more than 35 minerals in the speleothems place the cave among the top 10 of its kind on Earth.
- *Fortress of Ponor Cave*
  The highest cave entrance in Romania, with a height of over 76 m, see Figure 3.
- *Onceasa Cave*
  One of Europe's most important paleontological sites, containing tens of thousands of fossils of Ursus spelaeus.
- *Cold Cave*
  Archaeological remains, consisting of the ritual placement of four Ursus spelaeus skulls, among the oldest in Europe.
- *Altar Stone Cave*
  The most beautiful and diverse speleothems in Romania.
- *Sighiştel Valley*
  The highest density of caves in Romania: over 200 large caves in an area of less than 10 km^2.
- *Hodobana cave*
  The most labyrinthine cave in Romania, with a total known length of 22.142 m over an extension of 820 m.

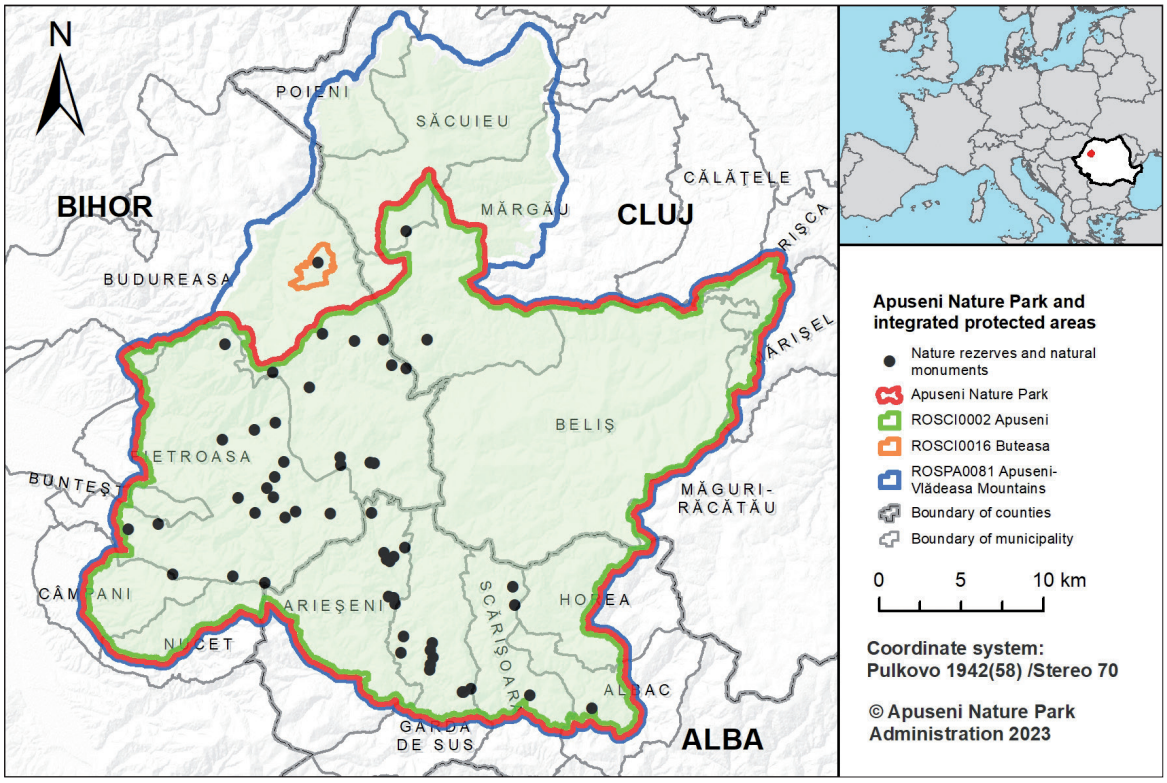

Figure 4 – Apuseni Nature Park and integrated protected areas.

Infobox 2

Management structures

- *Apuseni Nature Park Administration*
  The Administration was formed in 2004, based on a Law and a Government Decision, by which the Ministry of the Environment, as the responsible authority, decided that the National Forests Administration – Romsilva should ensure the human, material and financial resources necessary for the Park to function. The Administration ensures the management of the Park based on a Management Plan and a Regulation, carrying out mainly inventory, monitoring, analysis, planning, supervision and control activities.

- *Scientific Committee (Consiliul Științific)*
  The Scientific Committee comprises scientists and specialists in fields relevant to the management of the Park; it guides and supervises the Park Administration. The Committee's composition is proposed by the Park Administration, endorsed by the Romanian Academy – Committee for Nature Monuments. Finally, both the Committee and its rules of operation are approved by ministerial order. The decisions adopted by the Scientific Committee must be enforced by the Park Administration.

- *Advisory Board of Administration (Consiliul Consultativ de Administrare)*
  The Advisory Board brings together key stakeholders who own or manage land, or who have interests in the Park or its immediate vicinity, and who are interested in implementing management measures. The Board's composition is proposed by the Park Administration, and both its composition and its rules of operation are approved by ministerial order. Its decisions carry weight as advice only for the Park Administration.

Apuseni. However, the unfavourable sociopolitical context at the time led to the postponement of the declaration of the park. Later, in 1947, with the installation of the communist regime in Romania, the conservation of nature and the creation of protected areas were considered counterproductive and in contradiction with the need for unrestricted access to the natural resources necessary for economic development.

The initiative of Emil Racoviță was taken up in the 1950s by the great Romanian geologist Marcian Bleahu, the father of Physical Speleology. Following systematic research and exceptional discoveries (especially in the underground environment), both personal ones and ones made by others whose work he directed (Pătrașcu et al. 1990; Bleahu et al. 1984), Bleahu became the most fervent, and lifelong, promoter of the ANP's creation.

Until Romania's return to a democratic regime in 1989, there were occasional initiatives to create national parks, but none came to fruition. The most important of these initiatives occurred in the mid-1970s, when the state appointed the forest management specialist Zeno Oarcea to prepare the documentation for the declaration of the first national parks (NFA Romsilva 2023). Unfortunately, this further proposal for ANP again remained on paper, along with 12 other park proposals.

In 1990, Order No. 7 was drawn up by the Ministry of Water, Forests and the Environment in an endeavour to create one or more national parks. This, however, failed to ensure all the legal conditions necessary

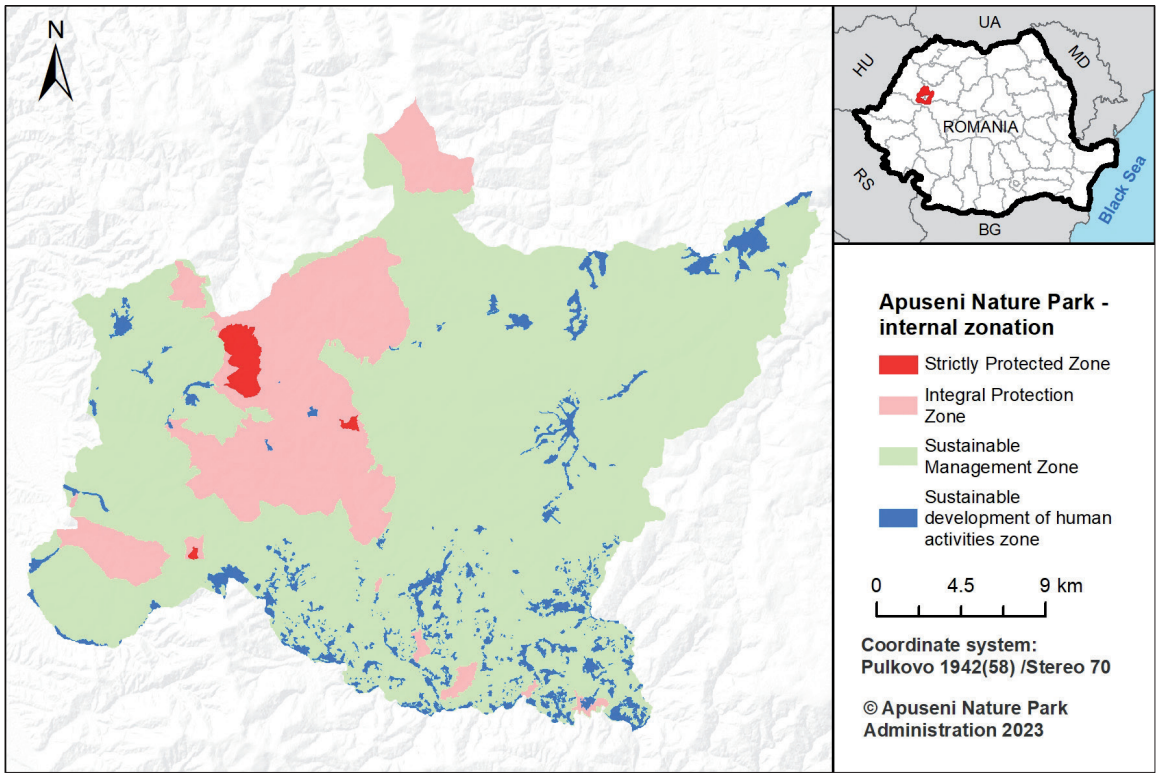

Figure 5 – Apuseni Nature Park – internal zoning.

to create the parks. Hence, the Apuseni park had to wait another ten years, until Law No. 5 of 2000, by which it was declared a protected area of national interest, but as a *natural* and not a *national* park, following the recommendations of the IUCN, notably because of the presence of human communities on its territory (Romanian Parliament 2000). This law established the surface area and the management category, but not the precise location and limits. For these to be agreed, there was a further wait, of three years, until Government Decision No. 230 of 2003 (Romanian Government 2003), when the ANP finally came into existence, no less than 75 years after the first initiative. Also in 2003, Order No. 552 of the Ministry of Agriculture, Forests, Water and the Environment established the first (provisional) internal zoning of the ANP until the approval of the management plan (Ministry of Agriculture, Forests, Water and the Environment 2003).

The ANP is a protected area of national interest, with a total area of 75,784 hectares, the third largest of Romania's 29 nature and national parks. It is categorized as a Nature Park to protect its particular landscape, which is the result of the long-term interaction between man and nature, equivalent to IUCN management category V. The ANP includes areas from 3 counties (Bihor, Cluj and Alba), and 17 territorial administrative units (Figure 4). One third of its territory belongs to the state. As the ownership of the remaining two thirds is in various other hands (including local communes, owners' associations and private individuals), biodiversity conservation is a great challenge for management.

Infobox 3

Functional zoning of the Park

- *Strictly Protected Zone - 0.89%*
  Includes scientific reserves and wilderness areas. Scientific research activities, ecological education and ecotourism are allowed in this zone only exceptionally.

- *Integral Protection Zone – 22.10%*
  Protects the most important values of the natural capital of the Park, including all nature reserves and nature monuments. Activities permitted inside this area include research, education, ecotourism, use of meadows for grazing and mowing by members of local communities under certain conditions, ecological reconstruction, forest pest control and firefighting.

- *Sustainable Management Zone – 71.98%*
  Scientific and educational activities, ecotourism, and sustainable use of resources through traditional activities are allowed inside this zone subject to approval by the Park Administration.

- *Zone for Sustainable development of human activities – 5.03%*
  Urbanization of the territory is permitted in line with the principles of sustainable development; negative impacts on species and natural habitats must be avoided. Activities allowed include traditional agricultural practices, animal husbandry, fish farming, forestry and hunting, as well as the controlled exploitation of non-renewable mineral resources, construction, and investments on a larger scale.
  This area is the only one where building is permitted. In all other zones, they are allowed only under exceptional conditions, mainly in the interests of managing the Park.

Figure 6 – Traditional settlement. © ANP archives

In 2004, the conditions were created for the establishment of the administrative structure and the operationalization of the ANP's management. The Ministry of the Environment decided that most parks would be administered and financed by the National Forests Administration – Romsilva, a structure within the same Ministry. The ANP Administration was formed in 2004 as a unit within Romsilva; in addition, a Scientific Committee was established. This Scientific Committee has a guiding role in relation to the ANP Administration, and supports management decisions. Alongside the ANP administration is the Advisory board, which is made up of key stakeholders. The Advisory board provides analysis, facilitates debate, and formulates proposals regarding the management of the ANP. The ANP's ten-year management plans and the regulations are drawn up in collaboration with the Advisory Board, are then analysed and approved by the Scientific Committee, and subsequently given final approval by the relevant Minister. (See Infobox 2.)

Apuseni Nature Park and integrated protected areas. New challenges for the management

The first proposal for a management plan for ANP was developed in 2005–2006 as part of a project with European funding within the Phare CBC programme. It was the first exercise to involve local communities directly in establishing the purpose and objectives of the plan and, as a result, of incorporating their vision for the future. It was also then that the first internal zoning was carried out (see Infobox 3 and Figure 5).

Following scientific data and studies, the internal zoning combines the needs of local communities with the protection and conservation of a wealth of valuable or unique elements of the natural capital: no fewer than 55 nature reserves and nature monuments have been declared in this area, most of them being endokarst and exokarst elements, with areas ranging from 1.23 ha to 1,609 ha. It is therefore no coincidence that the ANP includes 54 of these, which fall within the most heavily protected zones, namely the zone with strict protection and the zone of integral protection. Only one nature reserve is located outside the ANP, but it is in the ANP's immediate vicinity. This particular site was later included in the Natura 2000 site ROSCI0016 Buteasa (EEA 2023b).

In 2007, with Romania's integration into the European Union, the Natura 2000 network was established in Romania, when all the component sites were declared protected areas by law. Thus, within the ANP itself, due to the high biodiversity values according to the Habitats Directive 92/43/EEC, two Sites of Community Importance were declared: ROSCI0002 Apuseni, with an area of 75,943 ha (EEA 2023a), which includes the entire ANP; and ROSCI0016 Buteasa, with an area of 396 ha, which is located near the ANP (EEA 2023b). At the same time, according to the Birds Directive, a Special Protection Area was declared, ROSPA0018 Apuseni Mountains – Vlădeasa, with an area of 93,082 ha. This covers the entire ANP, and in the north extends beyond it into the Vlădeasa Massif (EEA 2023c).

In 2014, the Ministry of Environment, Water and Forests decided that the ANP Administration would take over the management of the 55 natural reserves and nature monuments, as well as the 3 Natura 2000 sites, in addition to the ANP, by integrating all their surfaces with each other, a total area of 96,608.40 ha resulting from the overlap of the polygons that represent their limits. At the same time, an Integrated Management Plan and the Regulation become applicable to the entire area. In some situations, as many as 4 management categories overlap (for example, a nature reserve, a natural park, a site of community importance, and a special protection area). In cases of overlap, the most restrictive of the relevant categories' requirements are applied. Thus, if we consider the restrictions imposed by the ANP's internal zoning, the ANP's management requirements apply to the entire surface, regardless of the management categories of the territories with which it overlaps.

As a management category and as a protected area of national interest, the ANP is therefore an umbrella area for protected areas of community interest in the Natura 2000 network. However, it has not always worked; thus, as a result of monitoring the application of measures regarding the restoration and maintenance of the favourable conservation status for species and habitats of community interest, the requirements of the European Commission have often led to the appearance of an attitude of the authorities by which they consider Natura 2000 sites taking priority for protection over protected areas of national interest.

Natural and cultural capital

The ANP is located in the Alpine biogeographical region, of which the Carpathian Mountains are also a part. The ANP is in vicinity of 2 of the 5 biogeo-

graphical regions of Romania, namely Continental and Pannonian.

The area's particular characteristics have determined the existence of a vast number of plant and animal species, in a wide variety of ecosystems and natural habitats, especially forests that often include grassland areas, giving a mosaic appearance. The mountains range from relief with altitudes located between 340 m in the western area in the Beiuş depression to 1,785 m at the peak of Păltiniş in the northern extremity; much of the relief is karst; climatic conditions vary according to altitude, with average annual temperatures between 2 and 10 °C, and relatively high levels of precipitation (800–1,400 mm).

The most recent inventory of biodiversity carried out by the ANP Administration (2021–2022) with the involvement of more than 100 specialists, within a project financed by the European Union, resulted in the identification of 5 categories of ecosystem, and 33 natural habitats of community interest, 8 of which are priority in terms of protection and conservation. 1,550 plant species were inventoried, of which 6 are of community interest, 1 species being priority; 96 are species protected at various levels. 1,380 animal species were identified, of which 32 are of community interest, 5 are priority, and 147 are protected at various levels (Apuseni Nature Park Administration 2023a).

The karst relief, which includes numerous sinkholes, and narrow, deep valleys, favour a thermal inversion specific to these areas. The heavier cold air that remains captive in the lowlands during the warm season determines an inversion of the vegetation, such that the coniferous forests are located at lower altitudes than the deciduous ones – one of the main characteristics of the karst landscape in the ANP.

The water courses are relatively numerous. The main springs are in the central area of the ANP and most flow radially to the east, south and west. The most important form the rivers Arieş, Someşul Cald, Crişul Băiţei and Crişul Pietros. Some watercourses located in the Padiş and Ocoale karst plateaus, due to the presence of karstifiable rocks such as limestone, go underground after flowing just a few hundred metres on the surface, via *sinkholes* (*ponoare*), returning to the surface as springs known as *outbursts* (*izbucuri*). Some of these watercourses go underground and resurface two or three times, making the areas' hydrogeology extremely complex. In addition to a few small karst lakes, the eastern part of the ANP also fully includes the Fântânele reservoir, with a total area of up to 10 km², on the course of the Someşul Cald river.

The evolution of the species found in the Apuseni was affected when these mountains became separated from the rest of the Carpathian chain. Certain species, including some birds, bats and large carnivores, have maintained connectivity with neighbouring areas using corridors for occasional or seasonal migration. However, many species of fish and invertebrates have evolved in isolation. Thus, species that are endemic to the Apuseni mountains appeared, such as the Idle Crayfish (*Austropotamobius bihariensis*) (Pârvulescu 2019), or the Biharian barbel (*Barbus biharicus*) (Antal et al. 2016). There are also numerous species of troglobitic invertebrates that are dependent on life in the underground environment of caves. Their isolation makes them highly vulnerable to environmental changes, including those caused by human activities.

Figure 7 – Traditionally exploited pasture. © Alin Moş

The local climatic conditions influenced by the karst relief favoured the continuity here of some species that disappeared in neighbouring areas with the last glaciation, the best example being the Transylvanian lilac (*Syringa josikaea*) (Lendvay et al. 2016), which grows here in the southernmost location in the northern hemisphere and has a population of only a few hundred individuals. Another example is the Banatian snail (*Drobacia banatica*). However, there are also species that, even if they have a broader regional distribution, are present in population sizes that are minimal, which makes them highly vulnerable. An example of this is the yellow forest lily (*Lilium jankae*), which grows here in the northernmost location of the entire distribution area in the Balkan region. Various carnivores – such as the bear (*Ursus arctos*), the wolf (*Canis lupus*), the lynx (*Lynx lynx*), and the otter (*Lutra lutra*) – are present in high enough numbers for them to be indicators of balanced, well-functioning ecosystems.

The main ecosystem categories throughout the ANP are: forests 74.05%, meadows 19.03%, wetlands 1.24%, cliffs, grottoes, and subalpine vegetation 1.16%, and permanently inhabited areas 4.52%. Land use categories correlate closely with the main areas of activity in the local economy.

A unique and well-represented cultural capital at the territory level complements the variety of natural capital elements. The Moți inhabitants of the Apuseni Mountains have a cultural and historical identity related to living in these mountains that is recognized at national and international levels. The human-inhabited areas spread from the medieval period onwards, especially in the south of the ANP in the upper Arieş basin, up to altitudes of 1,400 m. Here, we find 43 settlements, mostly of traditional type, with households

spread along the slopes. The majority have fewer than 100 inhabitants. Settlements also developed in the north-eastern area as more compact villages (just 7 in number) with several hundred inhabitants. There are only 6 localities in the western part, but they are much more highly developed. They are located in the marginal areas of the ANP up to 400 m above sea level; 2 are completely inside the ANP and 4 partially so. These permanently inhabited areas are integrated into the sustainable development zone of the ANP, where the rules regarding human activities have been adapted to the needs of the communities.

In recent decades, the local populations have decreased. In 2010–2020, the phenomenon became more marked, with a decrease of up to 1% per year. According to the statistics, in 2010 there were 41,042 inhabitants, in 2015 there were 39,424, and in 2020 there were 37,386. Approximately 10,000 live within the ANP's territory, in 55 localities. Population decline is driven mainly by three closely related factors: the migration of young people to large urban centres in search of well-paid employment opportunities, declining birth rates, and the ageing of the resident population (Apuseni Nature Park Administration 2023b).

The local economy: pressures, threats and opportunities

The main pillars of the local economy are the exploitation and processing of forest resources, animal husbandry and tourism. Tourism has been developed mainly in the last three decades.

Because forests have always covered the most significant area, wood was the primary local resource exploited by local communities, forming a so-called *wood culture* over time. Buildings and most everyday domestic objects were made of wood. The Moți gained fame as producers of the best and most durable wooden barrels (called *ciubere*). Their fame in past centuries often exceeded the territory of today's Romania, with a vast market for their goods in the Balkans and central Europe. The spruce wood (*Picea abies*) used in the production of wooden vessels has a unique quality here due to the ecological conditions in certain karst areas, which result in a higher wood density and better resistance over time. Thus, a family needed approximately five spruce trees per year for the production of wooden vessels, the sale of which ensured their livelihoods for the whole year.

With the widespread emergence of materials such as metal, glass and plastic, the demand for wooden vessels decreased until the market for these products disappeared. As a result, the crafts had to reorient themselves, and starting in the 1990s a new category of demand appeared: wood for construction. However, this generated much less added value, resulting in as much as 10 times more wood needing to be exploited to ensure a family's livelihood. At the same time, private companies appeared with the capacity for exploitation on an industrial scale. In most cases, these big companies were in competition with the local communities, or even eliminated them from the market.

The exploitation of wood both from forests belonging to local communities and from those owned by the state has increased massively, significantly increasing the pressure on forest habitats, which until the arrival of mechanization and technology were in an excellent state of natural preservation. Because these pressures on forests could lead to a significant deterioration of the natural capital and an unprecedented erosion of the primary local resources, with severe effects on the socio-economic development of local communities, state authorities have taken measures in the last decade to reduce the pressures significantly.

Unfortunately, from an ecological point of view, the pressures are still felt in imbalances of the water regime, degradation of the natural composition of the forests, reduced vitality of the trees, and exposure to extreme meteorological phenomena such as gales, mainly generated by climate change. As elsewhere in Europe, climate change has resulted in ecological conditions favouring species considered harmful, such as the spruce bark beetle (*Ips* sp.) (Netherer et al. 2019). One of the main challenges for forest management in vulnerable karst areas is to adapt management measures to a constantly changing reality in order to restore or maintain a high degree of resilience of forest habitats.

Livestock breeding still takes place mainly to provide food for the families of local farmers. The continued viability of this sector is due largely to subsidies from the European Union. Unfortunately, the limited opportunities for the sale of animal products are not favourable for the sustainability of this field in the medium and long term; the decrease in animal numbers in conjunction with the decrease in the local population have led to significant transformations in the composition and distribution of natural habitats through the abandonment of secondary meadows.

According to the results of the latest studies (Apuseni Nature Park Administration 2023a), there are almost 3,000 hectares of abandoned secondary meadows where the succession of vegetation has led to a change of species composition and the loss of essential populations of characteristic plants. Many of the grasslands, especially hayfields, are endangered in the absence of the owner's interest in raising livestock in the future or even abandoning the settlement in favour of large urban centres on the plains. Traditional properties are being sold to buyers outside the local communities to use as holiday homes, guesthouses, or simply as real estate speculation.

The development of built-up areas must take into consideration the need to provide both living spaces and those related to work that ensure the sustainable use of resources without irremediably eroding the natural capital. The number of residential and commercial constructions in karst areas is primarily limited by the availability of water, a resource whose volume has

been decreasing in recent years due to climate change and unsuitable long-term management solutions in the case of the forests located in karst areas. New pressure on biodiversity must be managed by measures that limit the total area of development to approximately 5% of the ANP's area so as not to affect the integrity of the natural habitats or to degrade their state of conservation.

The first initiatives regarding the enhancement of exceptional local natural resources took place at the beginning of the 20th century, as we have seen, through the private actions of nature enthusiast Czaran Gyula. Initially, the groups of visitors were small and few in number due to inadequate infrastructure. Only in the 1960s and 1970s, with the construction of roads, did the development of visitor infrastructure and related services begin, but without the direct involvement of the local communities.

After 1990, numerous initiatives, especially from outside Romania, supported the development of local tourism as an alternative to the tendency to overexploit resources. In the first decade of the 21st century, which saw the development of knowledge of the natural values of the area and their sustained promotion in conjunction with the improved living standards of the urban population, investments in the infrastructure for accommodation and hospitality increased. In some areas, the need for development was overestimated and speculation on property generated high pressures on the natural environment, threatening the very values of the destination that currently attract visitors. In recognition of the efforts to prevent the deterioration of the area's natural values, and of initiatives that contributed to the promotion of sustainable development and responsible tourism, in 2009 the ANP was awarded the title of European Destination of Excellence (EDEN) by the European Commission.

Tourism, the youngest sector of the local economy, can ensure a constant infusion of financial resources into local communities, especially when tourism services are provided by local companies using local human resources and products. Thus, tourism can become a tool through which visitors can materially contribute to the development of the local communities while helping them to maintain the beauty of the ANP and the local economy for the future.

In support of traditional and sustainable ways of using resources, the ANP Administration may offer the right to use the ANP logo for products that sustainably use local raw materials, or services that sustainably enhance local natural values and maintain environmentally friendly traditional activities. Further, the ANP Administration facilitates the creation of partnerships between local actors to establish the production of local goods. Examples of traditional products include those using plants (infusions, tinctures, syrups, ointments and jams). Other sustainable services include tourist guides, or even the organization of major events such as the Smida Jazz Festival, which uses the image of the ANP as a marketing tool to attract spectators.

Conclusions

Local communities' access to forest resources must be a priority to ensure the needs of households or small wood-processing businesses. The resumption of old, less invasive methods of exploitation, such as the use of horses to remove wood from the forest, can help to ensure the long-term sustainability of the exploitation of forest resources.

Future practice and policies should be informed by the results of studies on the carrying capacity of ecosystems and on ecosystem services to ensure the sustainable consumption of local resources and development of the local economy, and to prevent erosion of natural capital. These studies should be updated periodically by monitoring the use of resources and reassessing their status. As two thirds of the protected area does not belong to the state, it follows that private landowners should be compensated for any losses resulting from the limitation or prohibition of the use of resources due to management measures.

Replacing the local population by new occasional residents from urban areas areas, the so called gentrification phenomenon, is not a viable solution, because the loss of continuity of traditional activities results in significant transformations of the landscape and of the composition and distribution of natural capital, entailing the potential loss of species and natural habitats.

The development of tourism must continue to take place within a considered management framework in order to ensure the protection of species and natural habitats. Development plans must take into account the capacity of the ecosystems, and direct the benefits derived from tourism to local communities.

The vision of the stakeholders formulated in 2006 still remains the guideline for the co-management of the ANP: *The ANP should be an internationally important area, with a mountain karst landscape, with well-preserved biodiversity, a specific and quality tourism, sustainable use of resources, an infrastructure that supports sustainable development and local communities that maintain their unique traditions and a good standard of living.*

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C.S.I. PhenoBiota – Research with Plant Newcomers from all over the World – A citizen science project to study the phenology of invasive plant species under aspects of climate change

Martin Gebeshuber, Renate Mayer, Alina Jenšac, Christina Remschak, Thomas Hübner, Ulrike Mittermüller & Klaus Wanninger

Keywords: citizen science, invasive plant species, phenology, climate change

Abstract

In a unique Europe-wide approach, students and other citizen scientists in Styria (Austria) were involved in researching and documenting the phenological development of invasive plant species under the influence of climate change. Supported by experts, they tested modern field research instruments and educational tools, laying the foundation for a long-term, nationwide Citizen Science network. The observations could be used to help make the management of invasive plant species more efficient and to raise awareness about their effects.

Introduction

In the project name *C.S.I. PhenoBiota – Research with Plant Newcomers from all over the World*, C.S.I. stands for Climate Science Investigation. The project deals with the phenology of invasive plant species in connection with climate change. Its aim, in a unique Europe-wide approach, was to collect data about the phenological development of six invasive plant species in particular, with the help of citizen scientists, to raise awareness about invasive species and to gain knowledge about their individual growth phases. The data collected should lead to more efficient neophyte management. Furthermore, the project allows citizen scientists – especially students – to gain insights into the cycles of nature and to become familiar with modern research methods combined with practical scientific work. The citizen science project was realized by the Eisenwurzen Nature and Geopark (Styria) in collaboration with eight educational institutions and five research and corporate partners, from May 2020 to April 2023. Partners were the Agricultural Research and Education Centre Raumberg-Gumpenstein, GeoSphere Austria, *Berg- und Naturwacht* (Mountain and Nature Guard) Styria, the *Regionalmanagement Bezirk* Liezen, and LACON Consulting.

The plant species investigated were the Canadian and giant goldenrod (*Solidago canadensis*, *Solidago gigantea*), ragweed (*Ambrosia artemisiifolia*), Himalayan balsam (*Impatiens glandulifera*), giant hogweed (*Heracleum mantegazzianum*), robinia / black locust (*Robinia pseudacaciae*), and Japanese knotweed (*Fallopia japonica*) (Figure 1). For the purposes of this project, the two species of goldenrod were considered together. They were selected because most of them are already widespread in Styria (and Austria more widely), and they are easily recognizable for the general public. Four of these species were introduced as ornamentals; robinia / black locust is of forestry importance, while ragweed was introduced accidentally. Ragweed pollen causes respiratory problems, and giant hogweed causes serious burns to the skin when touched (Land Steiermark 2023). All invasive neophytes displace native plant species and ultimately change entire ecosystems. This causes problems not only for nature conservation, but also for agriculture and forestry, resulting in financial losses (Land Steiermark 2023). Japanese knotweed can even lead to the destruction of infrastructure such as roads and protective walls along water bodies. Two of the invasive plant species chosen for the project are on the current list of EU Regulation No. 1143/2014 – namely, giant hogweed and Himalayan balsam.

Figure 1 – Flowering Himalayan balsam (Impatiens glandulifera). © Claudia Plank

While there is already a relatively large amount of research on invasive neophytes, the phenological growth phases – from seedling to fruiting, leaf fall, and death of what is above ground – remain relatively unknown. To date, there has been no phenological observation of neophytes in the Pan-European Phenological (PEP) Network, *"a European infrastructure to*

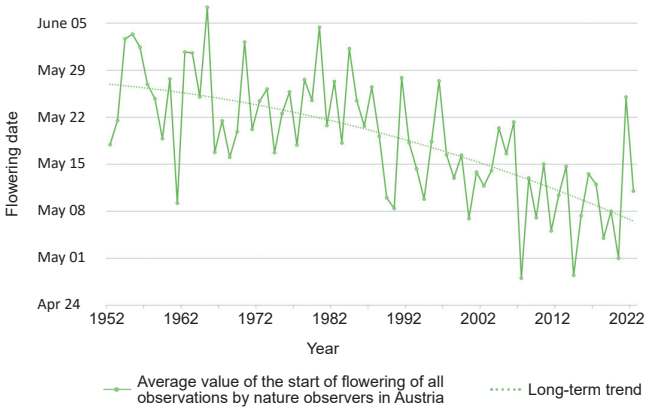

Figure 2 – Phenological observations for black elder (Sambucus nigra), from 1952 to 2022. The long-term trend shows an earlier onset of flowering of almost three weeks. Unpublished data by Geosphere Austria 2023

promote and facilitate phenological research, education, and environmental monitoring. The main objective is to maintain and develop a Pan European Phenological database (PEP725) with open, unrestricted data access for science and education" (Templ et al. 2018). Austria is part of this network. In Austria, phenological observation data have been systematically collected since the foundation of the *Zentralanstalt für Meteorologie und Erdmagnetismus* (Central Institute for Meteorology and Geomagnetism) in 1851. Thanks to this long history of data, for example for black elder (*Sambucus nigra*), the trend towards earlier flowering, which is related to climate warming, can be observed (Figure 2).

Within the C.S.I. PhenoBiota project, partners developed comprehensive, age-appropriate school lessons, and analogue and digital observation materials, which they took into schools. Pupils were allowed to develop their own research questions and project ideas. They observed and documented the phenological phases of selected plant species over the course of the year, related them to the climate, and learned to draw professional conclusions.

The C.S.I. PhenoBiota school projects

School lessons

The project partners developed lesson plans and teaching folders for the individual school levels.

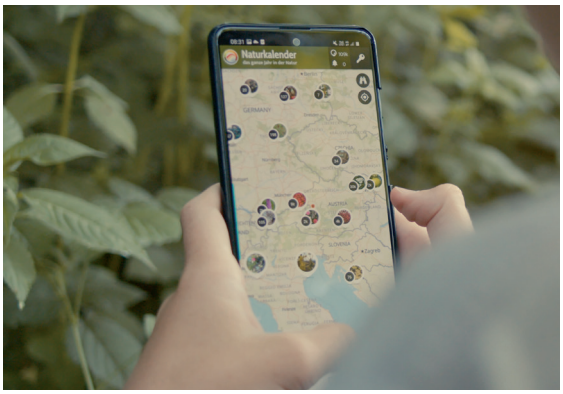

Figure 3 – Nature Calendar app for observation of invasive neophytes and native plants. © Marco Schupfer

The *Berg- und Naturwacht* Styria, HBFLA Raumberg-Gumpenstein Research Institute, and Styrian Eisenwurzen Nature and Geopark visited seven schools in the district Liezen (Styria) several times and introduced them to the world of neophytes and phenology in a playful way. For example, the terms *neobiota*, *neophyte* and *neozoic* were explained using the well-known game Hangman and a memory game, as well as by searching for traces in the open air.

The folders compiled for the educators contain information on neophytes (their origin, benefits, risks, and phenology), experiment plans, handicraft and game instructions, and even cooking recipes. The students planted hedges at their schools with native shrub species such as black elder, alder buckthorn (*Frangula alnus*) and dog rose (*Rosa canina*), and used them as living, native, sources for phenological data. They then looked for connections between the phenological growth stages of invasive plant species and climatic conditions in order to draw conclusions about climate change.

Throughout the project, various experts organized field excursions for the school students and provided exciting insights into their professions. Students also visited research institutions in the region and gained valuable insights into their working environments.

Phenological observations

To deduce the different growth stages of the neophytes, the students had to count the number of leaves on individual plants as well as to note the onset of their flowering and fruiting. These data were recorded on observation sheets specially developed for the six neophytes and for native reference plants (e. g. black elder). In addition, the onset of each of the 10 phenological seasons (early spring, first spring, full spring etc.) was recorded by observing living reference plants, including hedges. There is only one phase in winter (GeoSphere Austria 2023). Initial observations were made and data collected (May 2021 to April 2023); more data are needed to be able to draw conclusions about the phenological phases of the invasive neophytes.

The project partners provided older students with the Nature Calendar app for use on smartphones, which was designed specifically for the phenological

Figure 4 – The kit for investigating invasive neophytes. © Marco Schupfer

Figure 5 – The kit for relating findings to climate change. © BAfEP Liezen

monitoring. Within our project, we developed a new function specifically for observing invasive neophytes (Figure 3). All data gathered from the observation sheets and the Nature Calendar app were forwarded to GeoSphere Austria and are currently being stored in a database for future analysis as the data density and observation period increase. The information gathered will be of interest to a range of stakeholders, from climate scientists to biologists and medical professionals.

Tutoring

An important aspect of the project was the involvement of students at the *Bundes Bildungsanstalt für Elementarpädagogik* Liezen (BafEP, Federal Training Institute for Elementary Education) who were training as early-years (pre-school, kindergarten) teachers. Together with their tutors, they developed experiments and illustrative materials for neophytes and climate change, which were included in two kits (Figures 4, 5). Over the course of several sessions, the BAfEP students introduced their educational materials to kindergarten children and subsequently improved them in collaboration with specialists in early-childhood education and project team experts.

The BAfEP students wrote their final-year dissertations in parallel to the development of the kits, as the

Figure 6 – From left to right: Goldenrod, Himalayan balsam, Japanese knotweed and roots/rhizome and stems of goldenrod & Japanese knotweed on 21 June 2023; Japanese knotweed and goldenrod, showing roots and leaves © Renate Mayer

Figure 7 – Planting invasive neophytes, and monitoring their growth. Left: Japanese knotweed; right: Himalayan balsam. © Renate Mayer

young children tried out the experiments and games in school: *"Discovering climate change with children aged 3–6 with the help of planning, observations and experiments in the Styrian Eisenwurzen region"* (Jug et al. 2023), and *"What's blooming? Research using plant newcomers from all over the world with children aged 3–6"* (Gindel et al. 2023).

Intercultural communication

Neophytes are alien plants, and in this context we tend to talk about *fighting*, *uprooting*, etc. For pupils with a migration background, however, it was important that we should use different, non-violent, language. Throughout the project, therefore, the schoolteachers and the BAfEP students were accompanied by an expert in intercultural communication. Several workshops were run, one of which was held for the BAfEP students to support them in writing their dissertations.

Observing invasive alien species in Middle and Primary schools

One of the projects developed by the primary and secondary school pupils, mentored by AREC experts, was to observe the growth and phenology of plants, grown in large plastic containers, in controlled locations at participating schools. In the summer semester of 2022, pupils at three schools in the district of Liezen observed and documented the invasive species *Solidago candensis / Solidago gigantea, Fallopia japonica* and *Impatiens glandulifera*. Plastic containers (3 per school class) were filled with loose garden soil, or partly filled with compact soil containing phyllite (local soil from the valley floor [southern bank] of the river Enns). Rhizomes of both Japanese knotweed and goldenrod, and small seedlings of Himalayan balsam were planted in separate containers, which were placed in the school grounds. The weather conditions were also recorded.

The planters at the Middle School in Irdning-Donnersbachtal were placed in the north-western area of the grounds, between the school building and a hedge. There was no overhanging roof. The plants put on very little growth (Figure 6) because of heavy rainfall and the resulting waterlogging of the containers (which were without drainage holes), as well as because of the very compact nature of the local soil.

The containers at the Middle School in Stainach-Pürgg, which were placed at the foot of one of the school's west-facing walls, overhung by the roof, showed the strongest growth. The Japanese knotweed and the Himalayan balsam developed well, while the goldenrod was stunted (Figure 7).

The plants in the containers on the south wall of the primary school Aigen im Ennstal showed different growth behaviour. The pupils' experiments showed that weather conditions (water, light, temperature) had a strong influence on the length and thickness of the plants' growth.

Field research by primary schools

At the end of the school year, neophyte eradication measures were carried out in the local municipalities in cooperation with the educational institutions (Figure 8).

The educational programme included information about the plants, including their growth behaviour and impact on the landscape and society. Pupils from the primary schools in particular were highly motivated in researching the plant species, developed interesting ideas for their containment and took part in the removal measures with great enthusiasm. It was also important to compare how the growth phases of the individual neophytes correlated with those of native reference plants (e.g. black elderberry).

Super-powers of plants observed by the Altenmarkt primary school students, St Gallen

The children at Altenmarkt, St Gallen observed Himalayan balsam both in nature and in the classroom. In nature, the same spot was visited with the teachers every three weeks from May 2022 to the end of the school year, and the growth phase was recorded on an observation sheet. Black elderberry was used as a comparative plant for phenological phases. The Al-

Figure 8 – Neophyte management with pupils at the primary school in Aigen. © *Renate Mayer*

tenmarkt primary school participants wondered what superpowers the neophytes might have – *What can the giant hogweed do?* – and designed posters, which were presented to the other students.

Lessons learned and conclusions

The C.S.I. PhenoBiota project focuses on *Talente Regional*, paving the way for pupils to pursue STEM education and careers later on. The pupils had the opportunity to formulate research questions, exchange ideas with experts, gain insights into various professions and branches of education, and thus learnt about the connections between plants, the environment and climate. It was refreshing for everyone to see the enthusiasm with which students from different school levels worked together with the scientists and developed their own research questions. Especially noteworthy was the good collaboration between school students and researchers. However, this requires motivated teachers as well as interested students. We were able to find both in our project, during which it became clear that pupils' thirst for research depends on their school level. Primary school pupils were more inquisitive and more open-minded in their approach. In contrast, the student teachers from BAfEP worked both independently and together with their tutors on their kits and dissertations.

A conference marking the end of the project was attended by pupils, headmasters, teachers, experts and decision-makers (in particular the district governor), as well as by representatives of agriculture, the media and research. The pupils from the various school levels presented their activities in demonstrations, video messages and other formats. The great importance of the topic and the relevance of initiatives was emphasized by all participants.

The greatest challenge was undoubtedly to recruit a broad mass of people interested in citizen science (interested parents, siblings of pupils and so on) for the observation of the phenological phases of invasive neophytes. We used local radio stations, press releases, social media posts, letters to parents and webinars to encourage people interested in nature to take part. The team sees the first three years of the project as development work and hopes to obtain a denser dataset via the Nature Calendar app. Success will only be measurable in a few years' time. A dense set of phenological data is needed if we are going to be in a position to make a contribution to neophyte management. The project partners disseminated the topic of phenology and neophytes successfully in the region, anchoring it sustainably through the educational activities discussed here.

However, there is still a large gap in the field of the phenology of invasive plants. More data is needed for us to draw conclusions about the growth phases of individual species. The first phenological data collected on neophytes are just the start of long-term observations of the plants. Our methods will certainly need to be refined in the future.

The aim of neophyte monitoring is to tie their development in to that of native flora – our *reference* species. In the future, effective management of invasive plants could be carried out at the appropriate developmental stage without having to observe them in situ, because we know, for example, that the native species Black elderberry puts out its first leaves approximately 14 days before the neophyte Japanese knotweed, and the cotyledons of Himalayan balsam begin to emerge at the same time as the first shoots of Japanese knotweed. The identification of such windows will allow the timely planning and implementation of control measures, *adjusted in response to the actual weather-related development of the plants in any particular year.* It is important to continue collecting data on non-native invasive plants in order to find more cost-effective and time-saving methods of control. These plants cause high economic costs and displace native species that are needed for the resilience of nature, especially in face of climate change.

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Nature calender App download

Most important results of the project

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Sharing knowledge and research outcomes from within and around the Swiss National Park – the 2023 *Research Symposium SNP+*

Stefanie Gubler, Sonja Wipf, Angelika Abderhalden & Linda M. Feichtinger

Abstract

On 2 June 2023, the first *Research Symposium SNP+* took place in Zernez, Switzerland, at the headquarters of the Swiss National Park (SNP). The symposium aimed to bring together active researchers from various scientific fields relevant to the work of the Swiss National Park, the Regional Nature Park Biosfera Val Müstair (BVM), and the overarching UNESCO Biosphere Reserve Engiadina Val Müstair (UBEVM) – all represented here by *SNP+*. Addressing subjects bridging the gap between strict nature preservation and cultivated landscape areas, the importance of ongoing monitoring over extended periods, and the influence of climate change on ecosystems and natural processes, the day unfolded as a profoundly captivating and interdisciplinary experience. This text aims to summarize the key messages of the symposium and provides a preview of upcoming events.

Profile

Protected area

Swiss National Park

Country

Alps, Switzerland

Introduction

Since the foundation of the Swiss National Park (SNP) in 1914, the first of its kind in the Alps, the systematic observation of nature, the comparison of changes inside and outside the park, and research in general have played vital roles. One of its founders, Carl Schröter from ETH Zürich, stated in 1920 that *"for science, the National Park represents an invaluable field of observation, unique in its kind due to the absolute elimination of the disturbance of the natural equilibrium by man"* (Schröter 1920, 5). An initial major task tackled since the beginning was to establish inventories of all taxa present in the park. Thus, taxa of lichens, plants, mollusks and various arthropods, mammals, fish and birds (see e.g. Baechler 1919; Bigler 1928; Bütikofer 1920) were all assembled. A second goal was to monitor the development of ecosystems, geomorphic features and climate, through the systematic and permanent monitoring of plant communities in permanent plots (Schütz et al. 2003), of rock glacier movements (Chaix 1923; Eugster 1973), and of meteorology (Uttinger 1966). In the first 30 years, around 20 research and 5 monitoring projects were carried out. Later, long-term research was explicitly listed as one of three legal roles of the SNP in the 1980 *Law on the Swiss National Park* (Swiss Confederation), along with nature conservation and communication.

Thus, over time, the number of projects has increased greatly (Figure 1). Today, in addition to the goals referred to above, topics include hydrology and hydrobiology, geomorphology and geology, climate change impacts, landscape science, sociology and socioeconomics, with over 90 research activities taking place each summer. This impressive number of projects carried out within the perimeter of the 170 km² protected area shows the great significance of the SNP as a study region. It also leads to substantial coordination, communication and networking efforts, both among the individual researchers as well as with the adjacent Regional Nature Park Biosfera Val Müstair (BVM) and the overarching UNESCO Biosphere Reserve Engiadina Val Müstair (UBEVM) (Figure 2). A particular effort has been made to make researchers aware that, by following their own research interests in the SNP region, they are contributing at the same time to fulfilling goals and visions expressed more than a century ago.

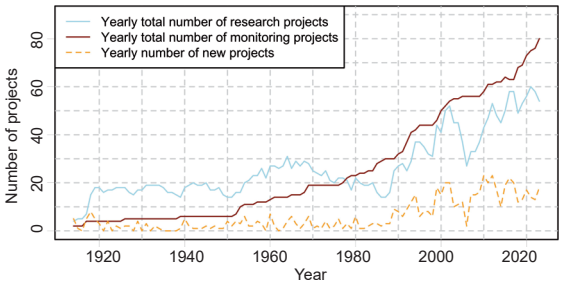

Figure 1 – Number of ongoing and new research and monitoring projects in the SNP. Data source: Swiss Academy of Sciences (SCNAT).

The Research Symposium SNP+

The research commission (*Forschungskommission* [FoK]) of the SNP, the SNP, the BVM and the UBEVM jointly organized the first SNP+ research symposium, held in Zernez on 2 June 2023. The symposium aimed at bringing a heterogeneous research community together, promoting the exchange of experience, methodologies and knowledge, and at sparking new research and monitoring ideas. The event's name, *Research Symposium SNP+*, reflects the organizations and areas involved (Figure 2), each with different protection and socio-economic development goals. It further symbolizes *"a plus in ideas, in projects, in topics, in networking and in knowledge"*, as the director of the SNP,

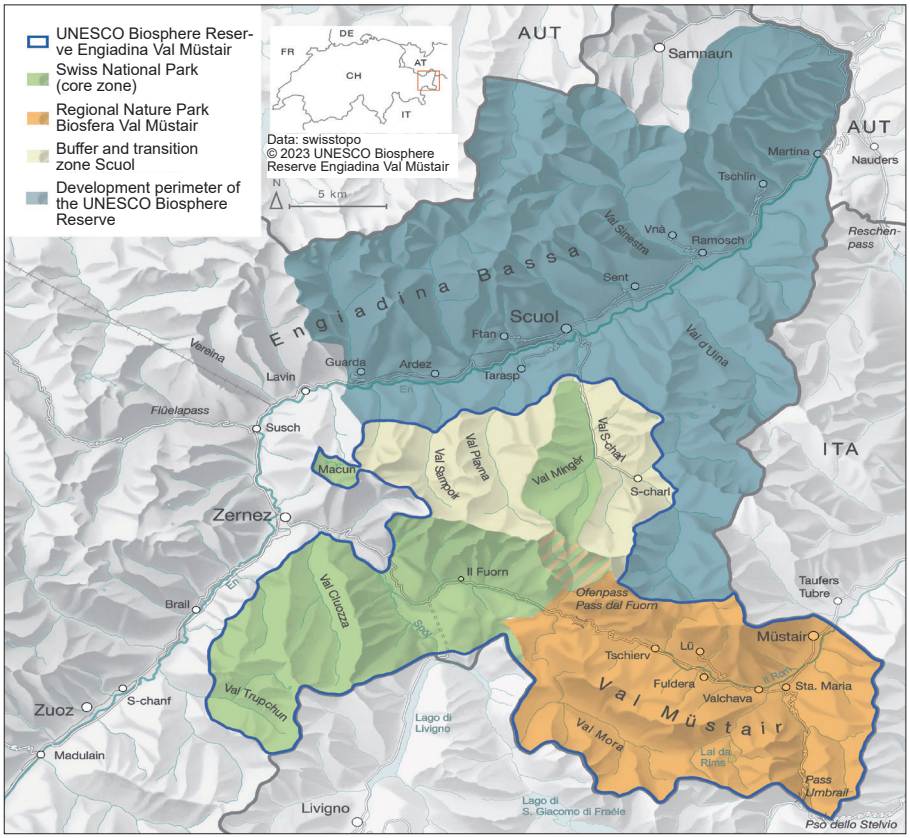

Figure 2 – UNESCO Biosphere Reserve Engiadina Val Müstair (UBEVM) with the three sub-areas: Swiss National Park; Regional Nature Park Biosfera Val Müstair; Scuol buffer and transition zone. In blue, the potential development perimeter of the UBEVM. The entire area is referred to as "SNP+". Cartography: Tamara Estermann, SNP

Rudolf Haller, emphasized in his welcome speech. Gian Cla Feuerstein, vice president of the research commission, further highlighted the importance of a platform for exchange, for promoting collaboration to strengthen interdisciplinarity, and for informing the public about the importance of research in the SNP+.

The symposium started with a keynote lecture by Michael Maroschek, co-head of research and monitoring of the Berchtesgaden National Park, on forest development and management in various national parks. He explored aspects of the development of natural forests, the differing effects of *rewilding* versus managed *forest restoration*, and discussed the effects of human-induced climate change on pristine subalpine forests. He concluded that although the SNP was considered an area where *"the disturbance of the natural equilibrium by man is absolutely excluded"* (Schröter 1920, 5), today, the effects of anthropogenic climate change on nature and natural processes call this non-influence of humans into question. Following this intriguing start, the symposium proceeded with three distinct thematic sessions.

Thematic sessions

The first session on *Wilderness and Cultural Landscape* emphasized the contrasts colliding in a small region of an IUCN Category 1a nature reserve. On the one hand, the SNP represents a *rewilding* experiment that has been ongoing for over 100 years. On the other hand, the surrounding regions are characterized by more or less intensive human use, including agriculture, tourism and economic development. Research approaches and questions vary substantially within this small region, ranging from social sciences to economics and natural sciences – and while this diversity and interdisciplinarity can be very fruitful, they also pose challenges to mutual understanding and joint progress.

The first input of the session illustrated the perception and values of nature and wilderness during the recent Covid-19 pandemic. The results of Gattiker's Master's thesis (2023) highlight the importance of relational values about nature and wilderness in the SNP, thus going beyond the frequent discussion of humans as threats to or custodians of nature. Further, this contribution also showed that in 2020 and 2021, the SNP experienced a significant increase in younger, less experienced park visitors (Wipf et al. 2023). Another presentation introduced a newly developed approach (Bürgi & Lock 2022) – an interdisciplinary combination of historical analyses, aerial photo evaluations, oral history interviews and rephotography, which will be adapted to develop a comprehensive picture of the highest continuous area of unmixed *Pinus cembra* forest in Europe, the *God da Tamangur*. The third input discussed the values of nature and farm animals to

humans, values that can act as leverage points for sustainable transformation (Chapman & Deplazes-Zemp 2023). The last input discussed the influence of human disturbance and predation risk on roe deer habitats and the important role of protected areas in the conservation of wild ungulates.

As already stated, the SNP can look back on more than 100 years of research and monitoring. The importance of monitoring natural evolution was emphasized by Schröter (1923, pp. 480–481): *"by means of exact surveys of selected areas, repeated from time to time, it is hoped to study – as the previous influence of man and his domestic animals becomes more remote – the gradual restoration of the original flora and fauna, the re-conquest of pasture by forest, and so on."* Therefore, the second session of the symposium was dedicated to the topic of *Monitoring in Protected Areas*. The presentations gave interesting insights into a variety of monitoring projects ranging from geomorphology to biodiversity. For instance, the unique records of rock glacier kinematics spanning more than 100 years (Muñoz-Torrero Manchado et al. 2023) were introduced, as well as a study on debris flow derived from tree ring records. The Swiss monitoring programme for the effectiveness of habitat conservation (*Wirkungskontrolle Biotopschutz Schweiz*) introduced its findings, with a focus on the SNP alpine floodplain site (Bergamini et al. 2019). A monitoring study on saproxylic beetles and fungi confirmed the effectiveness of forest reserves for enhancing species richness. Another input on sympatric Alpine chamois and red deer revealed a physiological stress response to drought conditions during summer and snow depth in winter, but not visitor disturbance (Anderwald et al. 2021). Finally, the potential of non-intrusive environmental DNA (eDNA) analysis as a monitoring tool was highlighted. The session clearly showed that long-term monitoring is pivotal for understanding natural processes, their dynamics and interactions, and the impact of long-term influences on nature, such as climate change.

This led directly to the last session, *Effects of Climate Change on Ecosystems and Landscapes*. Mountain areas such as the Alps are particularly affected by climate change, for instance by an increase of extreme events such as debris flows, decrease of snow and its impact on hydrology, or the shifts of species to higher altitudes. This is true for the SNP and its surroundings, both in habitats largely untouched by humans, and in cultural landscapes in the Val Müstair and the lower Engadin.

The session illustrated topics such as changes in snow cover in and around the SNP, demonstrating that snow water equivalent (SWE) in the region decreased by around 4% between the periods 1962–1990 and 1991–2020 (Danioth 2023). A further reduction of around 30 to 50% of the snow cover is predicted at elevations similar to those of the SNP throughout the Swiss Alps by 2060 under an RCP8.5 climate scenario – i. e., without any mitigation measures being taken (CH2018). Preliminary results of a long-term survey on nine mountain summits in and around the SNP (part of GLORIA) illustrated that plant species richness in extreme habitats is rising due to the influx of species from lower altitudes. Another contribution presented changes in the altitudinal distribution of ungulates and in the synchrony of plant growth and the rearing of young in roe deer, illustrating that different responses of individual species in the food chain can lead to mismatched interactions (Plard et al. 2014). In addition, it was shown that spring and headwater temperatures remain essentially constant, even though air temperatures vary significantly throughout the year and from year to year. Further, the increased melting of ice in rock glaciers can lead to the release of toxic elements into mountain rivers (Wanner et al. 2023). The session ended with a case study showing the potential effects of climate change on the cultural landscapes of Ramosch, and emphasizing the importance of climate adaptation in Alpine environments (Siegrist 2022).

Last but not least, local delicacies by Cilgia Etter from San Niclà were enjoyed during the poster sessions that took place during breaks.

Conclusions

The SNP+ 2023 research symposium attracted over 80 researchers and practitioners from all over Switzerland and abroad. A short online survey revealed that over 40% of the participants had travelled more than 3h to reach Zernez for this one-day event, demonstrating the high interest in research done in the area and the motivation for exchange among researchers.

The main benefits of participating in the symposium were identified. Gaining new insights into topics from research areas other than one's own was ranked as most important by 37%, closely followed by informal exchanges during the breaks (31%). Next, gaining new insights from research in the SNP+ region was mentioned. Less important was the fact that the event took place in Engadin (6%), and learning from one's own research area played only a minor role (3%). The survey showed that the SNP+ is a region with a lot of interesting interdisciplinary research and that there is a great need and desire for exchange between researchers working in the region.

The symposium was a lively event with vivid exchanges of experiences and ideas, and animated discussions in the courtyard of the Chastè Planta-Wildenberg during breaks. These continued during the festivities around the opening of the new visitor exhibition the following day. A large majority of participants (over 95%) indicated that they would like to attend a further similar symposium in one to two years' time. We accept the challenge posed in the survey and plan to offer a second symposium in 2025 – so look out for further information!

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New online marketing / sales system for products from the Carinthian part of the *Salzburger Lungau und Kärntner Nockberge* Biosphere Reserve (Austria)

Günter Köck & Heinrich Mayer

Keywords: Nockberge region, regional products, distribution system, online marketing, Interreg project, BANAP, agrobiodiversity

Abstract

Within the framework of the Interreg project *Balance for Nature and People (BANAP)*, the management of the Carinthian part of the *Salzburger Lungau & Kärntner Nockberge* Biosphere Reserve has developed an online Marketing/Sales/Distribution system for products from the Nockberge region. Regional producers are provided with a modern, future-proof distribution system in order to optimize internal ordering processes on the one hand, and to offer customers, both business and private, the possibility of ordering products online 24/7. In addition to the ordering option, customers can access more detailed information about the products, including availability.

Profile

Protected area

Salzburger Lungau &

Kärntner Nockberge

Biosphere Reserve

Mountain range

Alpes, Austria

Introduction

In 2018, the management of the Carinthian part of the *Salzburger Lungau & Kärntner Nockberge* Biosphere Reserve (BR) decided to submit the project *Balance for Nature and People (BANAP)* as a lead partner within the framework of the EU cooperation programme *Interreg V-A Slovenia-Austria*, which ran from 2019 to 2022. In addition to those from the Nockberge region, four other partners were involved in the project: the Institute for Nature Conservation of the Republic of Slovenia, *Naturschutzbund Steiermark* (Nature Protection Association of Styria), Business Agency Burgenland (which manages three nature parks), and the Slovenian municipality Črna na Koroškem (BANAP 2019).

The background to the cross-border project is the expected significant increase in temperatures due to climate change, which will have dramatic impacts on biodiversity affecting both the natural and the cultural landscapes. The latter especially form the basis for agriculture, tourism and society in the project regions.

The focus of the project was the common goal of preserving biodiversity in the project regions across national borders. The framework for it combined the national biodiversity strategies of the participating countries, Slovenia and Austria, which aim to preserve the diversity of plants, animals and habitats and to minimize the causes of their endangerment. Biodiversity is indispensable for sustainable agricultural production. Whether wild bees for pollinating crops, beneficial insects for controlling pests, a diverse soil fauna for maintaining soil fertility, or wild plants as a food source for beneficial organisms – all contribute to food production (Weissenbacher 2022).

Figure 1 – Some regional products from the Nockberge Region. © BSP Nockberge

The aim is that a series of pilot projects in the partner regions will all lead to achieving the common goal of the project. For example, the three nature parks in the south of the Austrian Federal Province of Burgenland worked in cooperation with the schools within the nature park on upgrading and valorizing meadow orchards, while the aim of the pilot action of the Slovenian Agency for Nature Conservation was to restore overgrown alpine and subalpine meadows on the Uršlja gora and Peca mountains by establishing appropriate management. In addition, the objective of an expansion of the environmental and educational programmes was to sensitize visitors to the protection and preservation of natural heritage. In turn, the Nature Protection Association of Styria aimed to develop nature conservation measures for neophyte-infested grassland in order to preserve the species-richness of these valuable areas. The goal of the partner activities of the municipality of Črna na Koroškem, situated in

the transboundary UNESCO Global Geopark Karawanken / Karavanke, was to establish a centre for the conservation of the natural and cultural heritage in the village of Koprivna, with a view to creating opportunities for educational, promotional and experiential projects in several domains (e.g. past rural life, peasant traditions, traditional crafts in agriculture, agricultural products). One specific project, under the title *Raziskujmo svet travišč* (Exploring the meadow world), was the production of a 34-page bilingual manual for children and young people focusing on the grasslands in the Karawanken-Karavanke Geopark (Vernik et al. 2021).

One of the main results of the project was the creation of the *Handbook of the BANAP project* (Weissenbacher 2022), for which concrete measures were developed and evaluated on the basis of all pilot projects, and proposals for the conservation of biodiversity in the pilot regions and beyond were formulated. The handbook provides suggestions for how to plan biodiversity measures and offers ideas for disseminating them (Weissenbacher 2022).

Pilot project for a marketing / sales system for a BR partner network in the Nockberge region

Agriculture and forestry are important branches of the economy in the Nockberge and shape the landscape and its inhabitants. Centuries of cultivation and grazing have contributed to the development of the typical and unique cultural landscape of the Nockberge. The preservation and development of mountain mowing and grazing are therefore important as the foundation for the preservation of biodiversity in the BR. An important goal, but at the same time also a major challenge for the BR management, is to keep the farms in the region alive while preserving the alpine pastures and mountain meadows that are characteristic of the area. Consequently, several measures (e.g. certificates for BR partner enterprises, marketing of farm products) have been taken in recent years to promote farms (Köck 2019, 2021). Although the BR management cooperates intensively with regional farms to market local products and to create networks between producers and tourism / gastronomy businesses, the cooperation between local producers and the BR management has not yet been consolidated. In fact, an overview of the situation in Austrian BRs indicates that successful regional networks between producers and catering businesses are still under-developed (Köck 2021).

The BR management was therefore confronted with the following questions, among others:

- How can local farmers continue to practise extensive agriculture in harmony with nature and thus make their valuable contribution to biodiversity in the Nockberge region without threatening their own livelihoods?
- Which producer-supporting measures are required in order to achieve significant added value for all?

The first step in this development process was the certification of BR partner enterprises. The aim of the BR management was to define quality criteria for regional products in a participative process that included many regional stakeholders and to award certificates to producers fulfilling these criteria (BRSL&KN 2018). This umbrella brand should quickly establish itself in the region and stand for regionality and quality. In addition, the BR management also supported the producers in sales and marketing, and in consultation with them developed activities that were tailored more closely both to the producers' own needs and to those of their clients.

To further develop the cooperation, the management initiated a discussion process, which has resulted in the creation of a modern online distribution system for BR products. With the approval of the BANAP project, the necessary financial means were finally available to explore the producers' needs more deeply, by means of a survey among the main businesses within the BR and several workshops. It became clear that the businesses need not only actual shop premises, but also an efficient online-based marketing / sales / distribution system in which orders, invoices/delivery notes and logistical processing are streamlined. Until now, businesses were faced with the challenge of many time-consuming processing steps, some of which had to be done twice, when handling orders. It was clear that a new automated sales system would make the ordering process much more customer-friendly, and an online marketing / sales / distribution system was developed in collaboration with an experienced IT company.

Online distribution system

This system provides regional producers as well as consumers with a modern, future-proof online tool to process orders more easily and efficiently. The primary goal was a centralized data management system that integrated the desired functionalities, was user-friendly, and permitted ongoing further development. The system addresses the following stakeholder groups:

Producers

Producers can save a considerable amount of time by using the centralized online ordering system and can also offer customers the possibility of placing orders 24 / 7. Furthermore, the coordination of order deliveries should increase efficiency and thus save costs.

Advantages

- Allows a convenient possibility to sell products online;
- visibility and traceability as a producer from the region;

- raising awareness for regional products;
- cost-effective alternative to creating own solutions;
- clear and simple solution for managing orders (B2B and B2C).

Business to Business (B2B) customers

Historically, many orders from tourism and catering businesses have been placed by phone or email. Now, with the first phase of the new system (launched in October 2022), B2B orders can be placed online. In addition, delivery dates, availability and other important information are communicated to B2B customers on a daily basis.

Advantages

- 24 / 7 ordering possibility;
- information about availability and delivery times;
- reduction of delivery costs through better-coordinated delivery service.

Business to Customer (B2C) customers

Interested customers can already find occasional opportunities to buy regional products online. However, consumers currently lack a central platform on which a wide range of products is offered regionally or trans-regionally. In the second phase of the project, the online system will make it easier for B2C customers to buy an extensive range of regional products directly from their local producers. At the same time, awareness of sustainability and of a region's distinctiveness will be raised.

Advantages

- Locating regional products that are available;
- orders or pre-orders placed directly with the producer;
- delivery and / or pick-up service;
- raising awareness and appreciation of regional products.

An additional added value for users is the fact that the system is linked to the online stores of the project partners from Slovenia, Styria and Burgenland, and thus their local specialties can be purchased in the Nockberge region.

In order to increase acceptance and uptake of the distribution system, it is being promoted via the region's leading businesses and the media work of the BR management. Further information on the online distribution system can be found on the homepage of the Nockberge part of the *Salzburger Lungau & Kärntner Nockberge* BR (BRSL&KN 2022).

Conclusion

The new online distribution system provides regional producers with a tool for marketing their valuable products regionally and trans-regionally. In addition, cooperation between producers and regional tourism / gastronomy / retailers is strengthened, allowing catering and other businesses to offer high-quality regional products. The project should not only raise local awareness of the uniqueness of their region and regional products, but also contribute to increasing the economic success of the farms. Only in this way can the cultivation of the alpine grasslands in the Nockberge and thus the preservation of biodiversity be secured in the long term.

In summary, through the stronger involvement of regional stakeholders, the BR management expects improved cooperation with producers and thus also hopes to ensure the long-lasting success of its measures both economically and ecologically.

Since the launch in October 2022 of the online platform, which is characterized by its ease of use, eight businesses, including all the leading enterprises in the BR, have registered as users, indicating that it is being accepted by producers, tourism and retailers. In this way, a regional economic cycle is being created, keeping the added value within the region.

This project is intended to serve as a best-practice example and is available to the other BANAP project partners for implementation. If successful, the distribution system could also be expanded beyond the region.

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Exploitation of an ontology in a semantic web: A case study transferring Thai lichen data into domain ontologies

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Keywords: lichens, diversity, ontology, semantic web, knowledge-based system

Abstract

More than 100 lichens have been found and identified in Thailand over the last century. Lichens perform useful environmental functions. Normally, they grow on trees, rocks and soils, in various forms and colours. They provide shelter and food for animals and plants. Lichens can also be used as indicators of air pollution, and some are researched for drugs, dyes, deodorants and extracts. This paper presents an ontology for lichens in Thailand, using lichen data from Khao Pluang, in Lopburi, Thailand. The database developed makes major contributions in the amount of knowledge on lichens that it stores, including the latitude and longitude of lichens at Khao Pluang specifically, and images of lichens. The system was implemented via web and mobile applications. The ontology knowledge consists of 6 main classes: 1) scientific name, 2) lichen type, 3) date found, 4) uses of the lichen, 5) function as an air pollution indicator, and 6) specific features of the individual lichen. Evaluation of the system was carried out by lichen and ontology specialists using the Software Usability Measurement Inventory (SUMI).

Profile

Protected area

Genetic Conservation

Project Under the Royal

Initiation of Her Royal

Highness Princess Maha

Chakri Sirindhorn

Country

Thailand

Introduction

Lichens are plant-like organisms, but their origins are different from other living things. Two types of living things, algae and fungi, coexist symbiotically, coordinated in structure and physiology as one – as a lichen. Algae produce both food by using carbon dioxide (CO_2) from the atmosphere, and water in the process of photosynthesis, resulting in organic matter which feeds fungi. On the other hand, fungi grow in a mycelial manner, which ensures moisture retention, thereby protecting the algae with which they are in symbiosis from harsh environmental conditions such as intense sunlight and heat. Each type of lichen is formed from just one type of fungus and one type of alga. Therefore, there are many different species of lichen. Lichens are consequently diverse, and specific to an area (Boonpragob & Polyaim 2007). They are often found growing on tree trunks and branches, rocks, and moist soils in forests and orchards (Boonpragob 2004).

Lichens have been used since ancient Egyptian times to the present day in many areas of the world, for dyes, food and drugs. Lichens do not have true starch or even cellulose, but there are substances such as lichenin in the cell walls of fungi hyphae which can be used as food. *Cetraria islandica*, or Iceland moss, is processed to remove its bitter taste before cooking (Hale 1983). Lichens have also been used as a soup ingredient by boiling them with milk. People believe that eating lichens as food and using them as drugs can help digestion. Lichens have an ability to form a wide range of secondary metabolites because of their slow growth and tolerance of harsh living conditions. These characteristics give lichen antimicrobial and herbicidal properties (Hale 1983; Manojlovic et al. 2005; Gupta et al. 2007). Worldwide, about 20,000 lichen species have been described so far. Those found in India represent around 10% (2,305 species) of known lichens globally.

In Northern Europe, lichens have been used in bleaching and fermentation. The French perfume industry uses lichen extracts to create pleasant and long-lasting smells. Lichens have also been used to clean (human) hair, and can be used to tell the age of stones and antiquities (Ślusarczyk et al. 2021). *Rocella tinctoria* and other species in this genus give a colour known as orchil, a purple shade. Other types of lichen can produce different dyes, such as red, brown, reddish-brown and yellow. Himalayan lichens include a large number of parmelioid species that provide excellent sources of dyes, and 157 Indian lichen species belonging to 65 genera have dyeing properties (Shukla et al. 2014).

Lichens have another useful characteristic: they readily absorb water, nutritive substances, and gases directly from the atmosphere (Nash 2006). Because they respond directly to atmospheric pollutants, they have been used successfully for biomonitoring air pollution. Biomonitoring approaches using lichens have recently been extended to a suite of other anthropogenic disturbances, such as forest management or climate change (Giordani 2009).

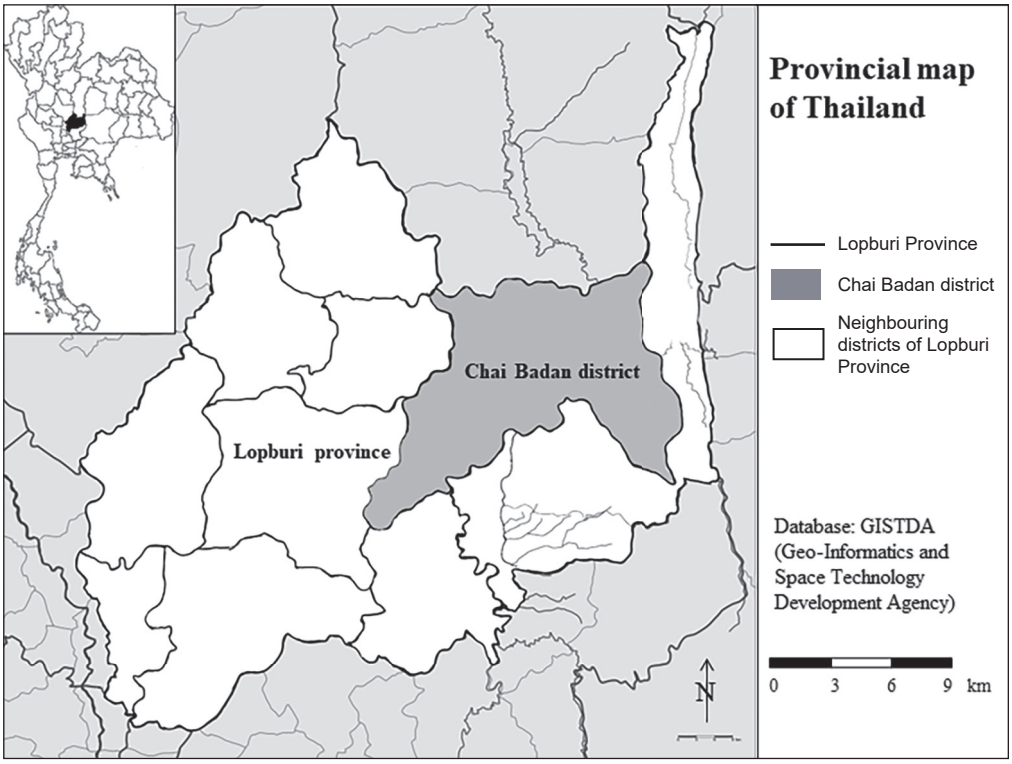

Figure 1 – Chai Badan district, Lopburi province, Thailand.

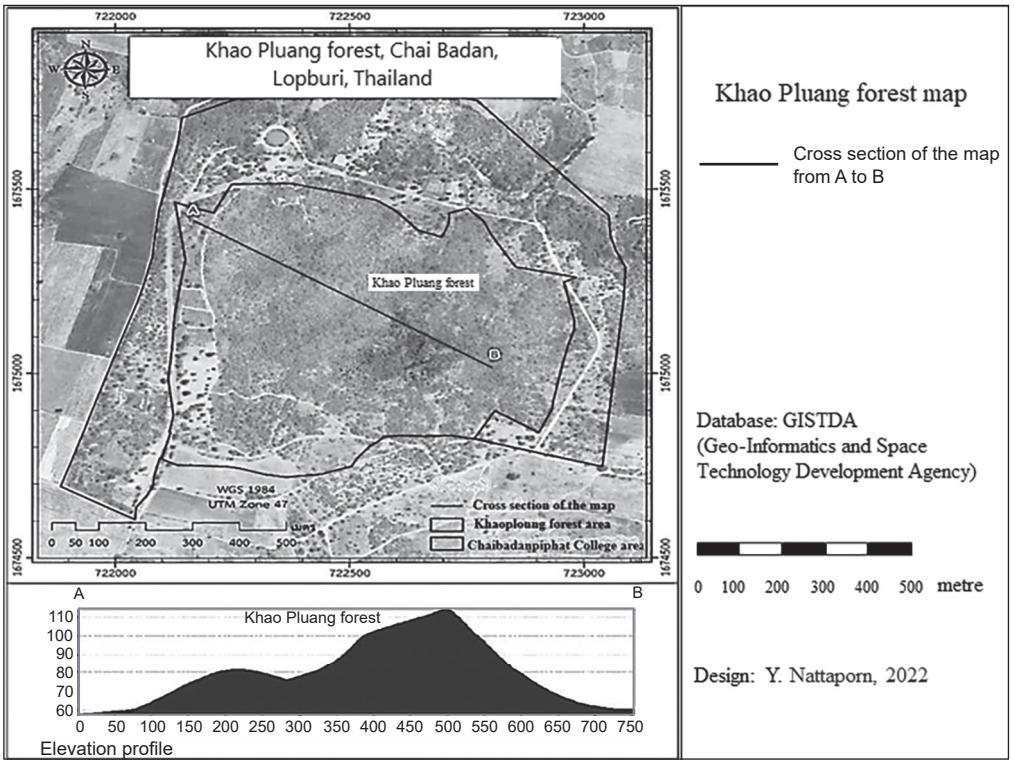

Figure 2 – Khao Pluang forest (black inner line) and Chaibadanpiphat college area (black outer line).

This paper illustrates the biomonitoring of lichens in poorly-known habitats (i.e. in a hazardous area), providing observational data from the physiological to the community levels, and providing the basis for comparable approaches to be extended to a global scale.

Research has found that lichens are susceptible to air pollution (sulfur dioxide (SO_2), fluoride gas (fluorides), and highly oxidizing chemicals such as ozone); they are not equally resistant to air pollution (Nimis & Purvis 2002). This allows us to use lichens on trees, stones, wood etc. as an indicator of air quality in pop-

ulated areas and elsewhere. For the purposes of initial air-quality monitoring, they can be categorized as weather-resistant, durable and highly durable (Wirth 1988). Further research found that lichen diversity increased along with yearly average rainfall and nitrogen oxide levels, whereas it decreased with increased levels of SO_2 (Giordani 2007).

The study of lichen biodiversity shows that each forest type is characterized by different lichen species. Functional diversity is an important tool to identify the ecological mechanisms shaping the coexistence patterns of species communities and different environmental gradients. However, there is a huge gap in knowledge regarding the ecological mechanisms that shape the composition of lichen communities (Łubek et al. 2020).

The aim of the present study is to construct an ontology for the knowledge of lichens in Thailand by using lichen data from Khao Pluang forest (part of Chaibadan Phiphat College, located in the northern part of Chai Badan district, Lopburi province, Thailand; see Figures 1 and 2), a forest area protected by the Plant Genetic Conservation Project Under the Royal Initiation of Her Royal Highness Princess Maha Chakri Sirindhorn (referred to from now on as RSPG). Khao Pluang forest is a low mountainous area (60–110 m a.s.l.) of compound forest, which consists mainly of Teng (*Shorea obtusa*), Rang (*Shorea siamensis*) and other deciduous trees. As well as Rang, the forest is home to many other outstanding plant species, including Makha (*Afzelia xylocarpa*), Tako (*Diospyros*), Pai (*Elaeocarpus serratus*), Pek (Pinoideae), Tiw (Figueroa), wild Pakwan (*Melientha suavis* Pierre), and Jujube (*Ziziphus jujuba*).

The RSPG working group on the diversity of lichens would like its knowledge to be disseminated and its approach to serve as a guideline for understanding lichens elsewhere. The findings of this study will be used in establishing a lichen trail in the Khao Pluang area. The study of lichen biodiversity in Khao Pluang forest followed a 1-kilometre nature trail. We found 28 species (LH001-LH028) of lichens, see Table 1. Most of these species belong to the durable group (Boonpeng et al. 2017).

The remainder of this paper is organized as follows. Section 2 describes the materials and methods used (knowledge acquisition, development of the ontological base, sematic search). Section 3 describes the results and presents discussion. Finally, in section 4, we present a number of conclusions.

Materials and methods

An ontology can be defined as the explicit formal specifications of the terms used in a particular domain and the relations among them (Gruber 1993). Constructing a knowledge domain can be conducted by interviewing experts and reviewing the literature. An ontology consists of four attributes: *class, property, facet* and *instance*.

- *Class* refers to the domain of interest (e.g. indigenous knowledge of using lichens as a drug); classes are the focus of most ontologies.
- *Property* covers relations within a class (e.g. *can be used as*). Properties describe various features and attributes of a class. For example, *Lichens found in the northern of Thailand can be used as a drug because of its digestive properties.*
- *Facets* are the restrictions on relations or properties. We can explain restrictions by using the relationships: Is an item (IS-A), part of (p/o) or an attribute of (a/o), e.g.
  - *to be used as food IS-A lichens' properties* or *to be used as drug IS-A lichens' properties*;
  - *digestive properties is p/o drug's properties* or *purple colour is a/o dyes colour*;
- An *instance* refers to actual data, recorded in a record or table.

Classes comprise all the terms in a domain of discourse, which are then transferred into formal explicit descriptions (e.g. sources of dyes, digestive properties, air pollution indicator).

Finally, a knowledge base is constructed by connecting the ontology (the combination of classes, properties and facets) with a set of individual instances of classes.

Recently, ontologies have been moving from the desktops of domain experts to become more widely accessible through the semantic web. Many research areas have developed their own ontologies (e.g. ontologies for agriculture, disease, biomedical investigation, and genes). In agriculture, ontology can be applied for soil- and seed-selection processes; for disease control and treatment; or for smart farming (Visutsak 2021; Bonacin et al. 2016; Li et al. 2013; Bhuyan 2021; Goldstein 2021). The disease ontology semantically integrates disease and medical vocabularies through extensive cross mapping of terms (Kurbatova & Swiers 2021; Schriml 2022). The ontology for biomedical investigation is an integrated ontology for the description of the life sciences and clinical investigations. In practice, it represents a collaborative effort to address the need for consistent descriptions of gene products across databases (Bandrowski et al. 2016; Hongjiea et al. 2019), covering information about biological processes, cellular components and molecular functions (Suntisrivaraporn 2013; Zhanga et al. 2020; Nie et al. 2021).

The most important aspects of our database are the stored knowledge on lichens generally, the latitude and longitude of particular lichens at Khao Pluang forest, and images of them. Figure 3 shows the three main stages of the ontology-development framework.

Knowledge acquisition

In this step, we collected knowledge of lichens found at Khao Pluang forest from the experts who work at RSPG and are familiar with a lichen trail in the

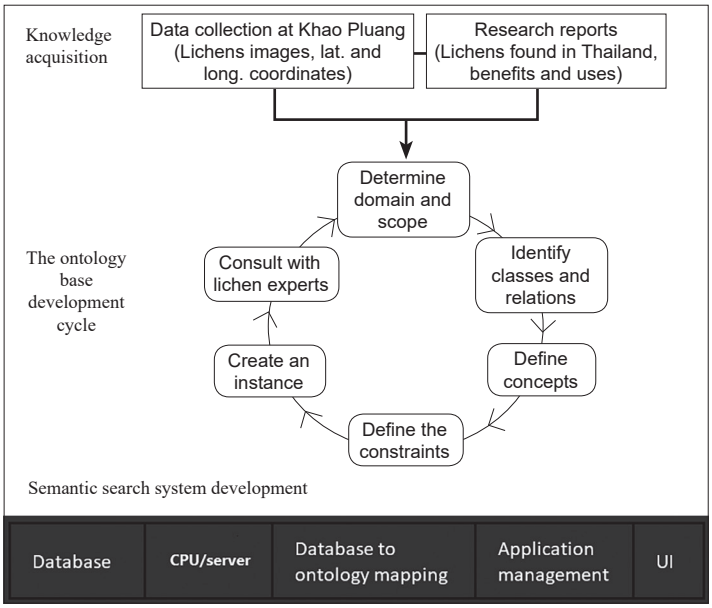

Figure 3 – Framework for development of the ontology.

Figure 4 – Data collection, Khao Pluang forest. © P. Khamweera

Table 1 – Lichens used in this study found in Khao Pluang Forest, Chaibadanpiphat College.

Sample number	Lichen	Sample site	
		Latitude (North)	Longitude (East)
LH001	*Amandinea* sp.	N 15°08′45.27″	E 101°04′10.41″
LH002	*Gyalecta* sp.	N 15°08′45.27″	E 101°04′10.41″
LH003	*Graphis* sp.	N 15°08′45.27″	E 101°04′10.41″
LH004	*Pyrenula* sp.	N 15°08′45.27″	E 101°04′10.41″
LH005	*Porina* sp.	N 15°08′45.27″	E 101°04′10.41″
LH006	*Bacidia* sp.	N 15°08′45.27″	E 101°04′10.41″
LH007	*Pyxine cocoes*	N 15°08′45.27″	E 101°04′10.41″
LH008	*Hyperphyscia adglutinata*	N 15°08′45.27″	E 101°04′10.41″
LH009	*Phydcia undulata*	N 15°08′45.27″	E 101°04′10.41″
LH010	*Graphis* sp.	N 15°08′45.27″	E 101°04′10.41″
LH011	*Chrysothrix xanthina*	N 15°08′45.27″	E 101°04′10.41″
LH012	*Dirinaria picta*	N 15°08′45.27″	E 101°04′10.41″
LH013	*Lecanora argentata*	N 15°08′45.27″	E 101°04′10.41″
LH014	*Lacanora helva*	N 15°08′45.27″	E 101°04′10.41″
LH015	*Pyrenula* sp.	N 15°08′45.27″	E 101°04′10.41″
LH016	*Fissurina* sp.	N 15°08′45.27″	E 101°04′10.41″
LH017	*Pyxine* sp.	N 15°08′45.27″	E 101°04′10.41″
LH018	*Pyrenula anomala*	N 15°08′45.27″	E 101°04′10.41″
LH019	*Peltula* sp.	N 15°08′45.27″	E 101°04′10.41″
LH020	*Peltula obscurans*	N 15°08′45.27″	E 101°04′10.41″
LH021	*Amandinea* sp.	N 15°08′45.27″	E 101°04′10.41″
LH022	*Caloplaca* sp.	N 15°08′45.27″	E 101°04′10.41″
LH023	*Pyxine* sp.	N 15°08′45.27″	E 101°04′10.41″
LH024	*Parmotrema praesorediosum*	N 15°08′45.27″	E 101°04′10.41″
LH025	*Pyxine copelandii*	N 15°08′45.27″	E 101°04′10.41″
LH026	*Lecanora subimmersa*	N 15°08′45.27″	E 101°04′10.41″
LH027	*Lecanora* sp.	N 15°08′45.27″	E 101°04′10.41″
LH028	*Moneralechia bodies*	N 15°08′45.27″	E 101°04′10.41″
LH029	*Lecanora pseudistera*	N 15°08′45.27″	E 101°04′10.41″

area. We also conducted a thorough search of the literature for information on lichens found in Thailand. The lichen images (Figure 4) were collected during a trial field trip, and we took some lichen samples for laboratory testing; the location of the lichens was identified using GPS equipment (Figure 4). Table 1 presents a list of the lichens found in Khao Pluang forest.

The ontology-base development cycle

After gathering the knowledge and verifying its correctness, we developed the knowledge ontology, adapting the system used in our earlier work (Visutsak 2021) on durian pests and disease control. The development of the ontology base comprises 6 consecutive steps.

1. Determining the domain and scope of the ontology-based system – in this instance the domain knowledge of lichens in Thailand, by using the data on lichen collected from Khao Pluang forest (as in

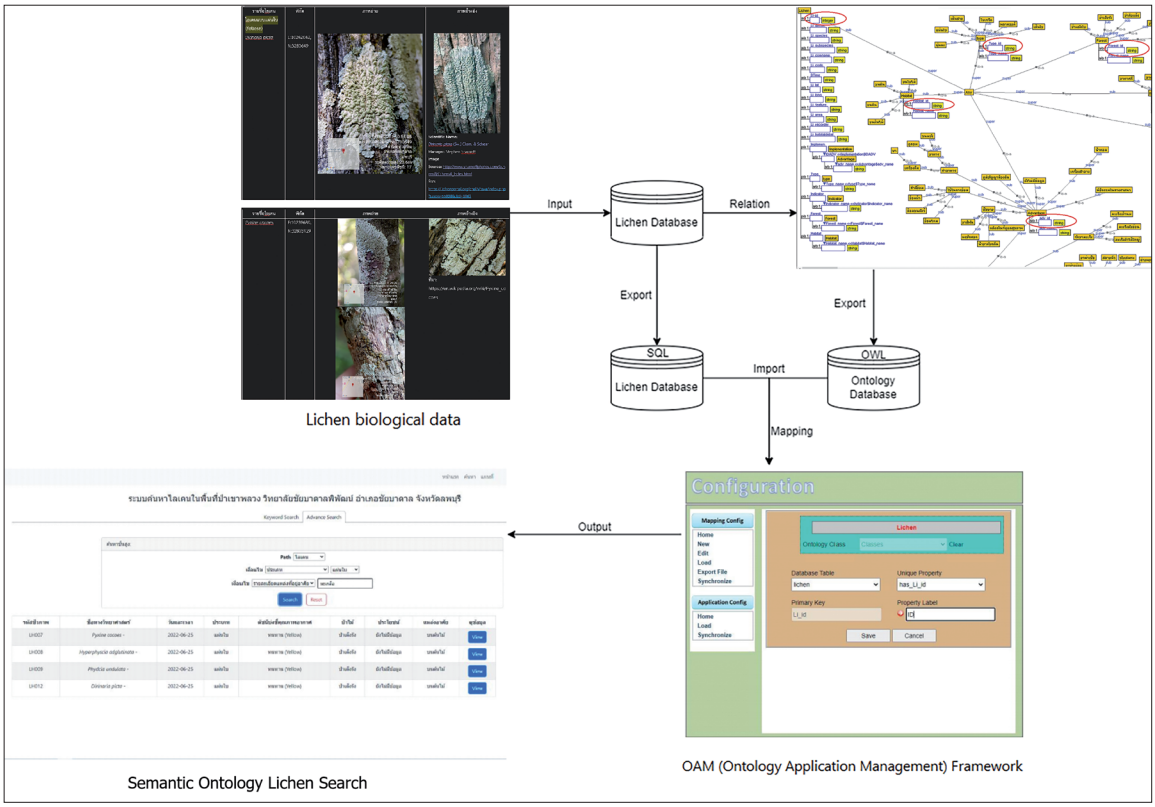

Figure 5 – The system architecture.

Table 1), images of the lichens, and their uses and benefits as detailed in the literature.

2. Identifying classes and relations. The ontological knowledge consists of 6 main classes: 1) scientific name, 2) lichen type, 3) date found, 4) uses of the lichen, 5) importance as air pollution indicator, and 6) specific features of individual lichens.
3. Defining the ontology property. We categorized the properties into 3 types (IS-A, p/o, and a/o).
4. Defining the constraints. For example, the *habitat* class has 4 constraints: rock, leaf, branch and soil.
5. Creating an instance. For example, the biological ID is the instance on the lichen's label.
6. Double-checking with experts that our method was appropriate.

We investigated two well-known ontology editors, Protégé (Musen 2015) and Hozo (Riichiro 2007), and chose Hozo for this work. Figure 5 shows the overall system architecture of our work. Table 2 shows the sample lichens implemented in the Hozo editor.

Table 2 – Lichens as an ontological class. p/o – part of, a/o – an attribute of, Li – Lichens.

Ontology Class	Relation Type	Lichen Database
Lichen		Lichen bilogical data
	a/o	Li_id
	a/o	Li_genus
	a/o	Li_species
	a/o	Li_subspecies
	a/o	Li_com_name
	a/o	Li_code
	a/o	DTime
	a/o	Li_lat
	a/o	Li_long
	a/o	Li_feature
	a/o	Li_area
	a/o	Li_recorder
	a/o	Li_habitatdetail
	p/o	Implement
	p/o	Type_id
	p/o	Indicator_id
	p/o	Forest_id
	p/o	Habitat_id

The semantic search system

After checking with the experts once again, and checking the references to the literature on lichens, the last phase was to develop the semantic search system. We used the Ontology Application Management Framework, OAM (NECTEC 2012), from NECTEC. The OAM consists of 2 main components:

1. The Database-to-Ontology Mapping Component. We used OWL (Web Ontology Language) for mapping data from the database to the ontology base. The results of the mapping were transformed into RDF (Resource Description Framework) format. The OWL for lichen data is shown in Figure 6.
2. The Search Configuration Component. This user interface (UI) can be used as the query component and shows the query results. In the web-based GUI, the user can select multiple conditions (e.g. dyed + coloured); the query results are shown on the screen.

```
<owl:Class rdf:ID="Advantage">
    <rdfs:label>Advantage</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Any" />
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:cardinality rdf:datatype="http://www.w3.org/2001/XMLSchema#nonNegativeInteger">1</owl:cardinality>
            <owl:onProperty rdf:resource="#has_adv_id" />
        </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="#has_adv_id" />
            <owl:allValuesFrom rdf:resource="#string" />
        </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:cardinality rdf:datatype="http://www.w3.org/2001/XMLSchema#nonNegativeInteger">1</owl:cardinality>
            <owl:onProperty rdf:resource="#has_adv_name" />
        </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="#has_adv_name" />
            <owl:allValuesFrom rdf:resource="#string" />
        </owl:Restriction>
    </rdfs:subClassOf>
</owl:Class>
```

Figure 6 – The OWL (Web Ontology Language) used in this work.

Results and discussion

The program works with a search engine that also displays a system-generated map with the location, a picture and a brief description of the lichen in Khao Pluang forest.

We evaluated the system by asking the lichen and ontology experts to assess it using a 10-question questionnaire based on 5 terms used in the Software Usability Measurement Inventory (SUMI) (Kirakowski 1995), see Table 3:

1. *Efficiency:* used to evaluate the overall performance of the software, such as the accuracy of the query results and the execution time.
2. *Affect:* used to evaluate the user's impression of using the software.
3. *Helpfulness:* used to assess how the system can help the user, or the benefits of the system.
4. *Control:* used to evaluate the usability of the system.
5. *Learnability:* used to evaluate the ease of use or user-friendly features.

Table 3 – The assessment of the lichen ontology using SUMI.

	Mean	S.D.	Quality level
Efficiency	2.31	0.7	Medium
Affect	2.35	0.76	Medium
Helpfulness	2.43	0.67	Good
Control	2.63	0.55	Good
Learnability	2.39	0.71	Good

Conclusion

In this paper, we used data on lichens collected from Khao Pluang forest to construct an ontology of the domain knowledge. A major benefit of our system is that it can be used for compound search queries (i.e. using multiple words). The query results returned are based on the connections between classes (i.e. relations) in the domain knowledge (domain ontology or domain of interest). The principal contributions of this work are the extent of the stored knowledge on lichens (as air pollution indicators; uses for drugs, food, dyes; sources for antibiotic substances and extracts), the latitude and longitude of lichens at Khao Pluang forest, and the lichen images (with the corresponding ID of lichens found at Khao Pluang forest). The users' assessment based on SUMI shows that our system yields medium-quality efficiency and effectiveness, and good-quality helpfulness, control and learnability.

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Avifaunal biodiversity in the Tianmu Lake National Wetland Park of Jiangsu Province, China

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Keywords: bird species, survey, biodiversity conservation, threats, Tianmu Lake, wetland

Abstract

Tianmu Lake is an important habitat for birds in the largely hilly area of Liyang city, Jiangsu Province, in southeast China. To better conserve its diverse and species-rich avian fauna, the Tianmu Lake National Wetland Park was established in 2018. Since taxonomic information about the Park's bird fauna was limited, we conducted field surveys of the site and recorded 199 bird species belonging to 17 orders in 52 families in the Park's wetlands. Anatidae are the most species-rich family present, with 23 species represented. According to IUCN criteria, 6 of the species – the Chinese egret (*Egretta eulophotes*), swan goose (*Anser cygnoides*), white-naped crane (*Grus vipio*), band-bellied crake (*Porzana paykullii*), Saunders's gull (*Larus saundersi*), and yellow-breasted bunting (*Emberiza aureola*) – are classified as endangered, and 29 species are listed in CITES Appendix II. Current knowledge suggests that human activities and the invasion of non-native species have severely threatened the biodiversity of the Park's birds. To protect avifaunal diversity, we recommend some specific measures that should be adopted and enforced. We hope that this study will provide useful information for bird conservation in the hilly areas of southeast China.

Profile

Protected area

Tianmu Lake National Wetland Park

Country

China

Introduction

Avifaunal diversity is an important component of biodiversity and a critical environmental indicator because of birds' ecological functions, including pollination, the control of problematic insects, and the dispersal of seeds and propagules (Sekercioglu 2006). Avifaunal biodiversity has experienced a severe decline due to habitat fragmentation, human activities, and the impacts of non-native species (Stanton et al. 2018). Unfortunately, the current availability of accurate and publicly accessible information regarding bird diversity in numerous regions is limited, potentially leading to a significant underestimation of losses occurring in various areas (Politi et al. 2021).

China is an avian biodiversity hotspot, with a high number of endemic and endangered species (Jiang et al. 2016). The hilly areas in the southeast of China are listed among the top 200 protection priority areas in the world (Olson & Dinerstein 1998). In addition to the rich array of non-migratory species, the area is also an important habitat for birds migrating between Siberia and Australia (Piersma et al. 2021; Kuang et al. 2022). While a number of studies have investigated the diversity and distribution of birds in some regions of the mostly hilly terrain of southeast China (Zhang et al. 2016), many important habitats that support high bird biodiversity, such as Tianmu Lake, have received little attention.

Tianmu Lake National Wetland Park (TLNWP) is situated within the city boundaries of Liyang in Jiangsu Province, China. In 1992, a dam was constructed on the Shahe River at Tianmu Mountain, forming a large reservoir that was subsequently named Tianmu Lake. The TLNWP is located in the Yili Mountain area, in the central subtropical area of Jiangsu province. This region has a rich array of wetland resources and is also an important habitat for many rare and endangered bird species (Mo 2017).

The purposes of this study were: (1) to compile an updated inventory of the bird fauna in TLNWP; (2) to review the main threats to bird biodiversity in the TLNWP; (3) to review recommendations for the conservation of bird biodiversity at the site.

Methods

Study area

TLNWP is located in Tianmu Lake Town, Liyang city, Jiangsu Province, China (31° 16' 40.03" – 31° 12' 11.67" N, 119° 23' 1.55" – 119° 26' 4.48" E). The total area of the town and protected zone is 11.54 km^2.

TLNWP has a northern subtropical monsoon climate, with abundant rainfall. The average temperature is 16.6 °C, ranging between minus 4.6 °C and 38.7 °C. The highest and lowest average monthly temperatures are 30.2 °C in July and 4.5 °C in January. The average annual rainfall is 1149.7 mm, and the average rainfall during the flood season (June–September) is 574.2 mm. The wetland types of TLNWP include river, lake, marsh and ponds. The total wetland area of the TLNWP is 7.06 km^2 (Table 1), comprising 61.20 % of the TLNWP's total area.

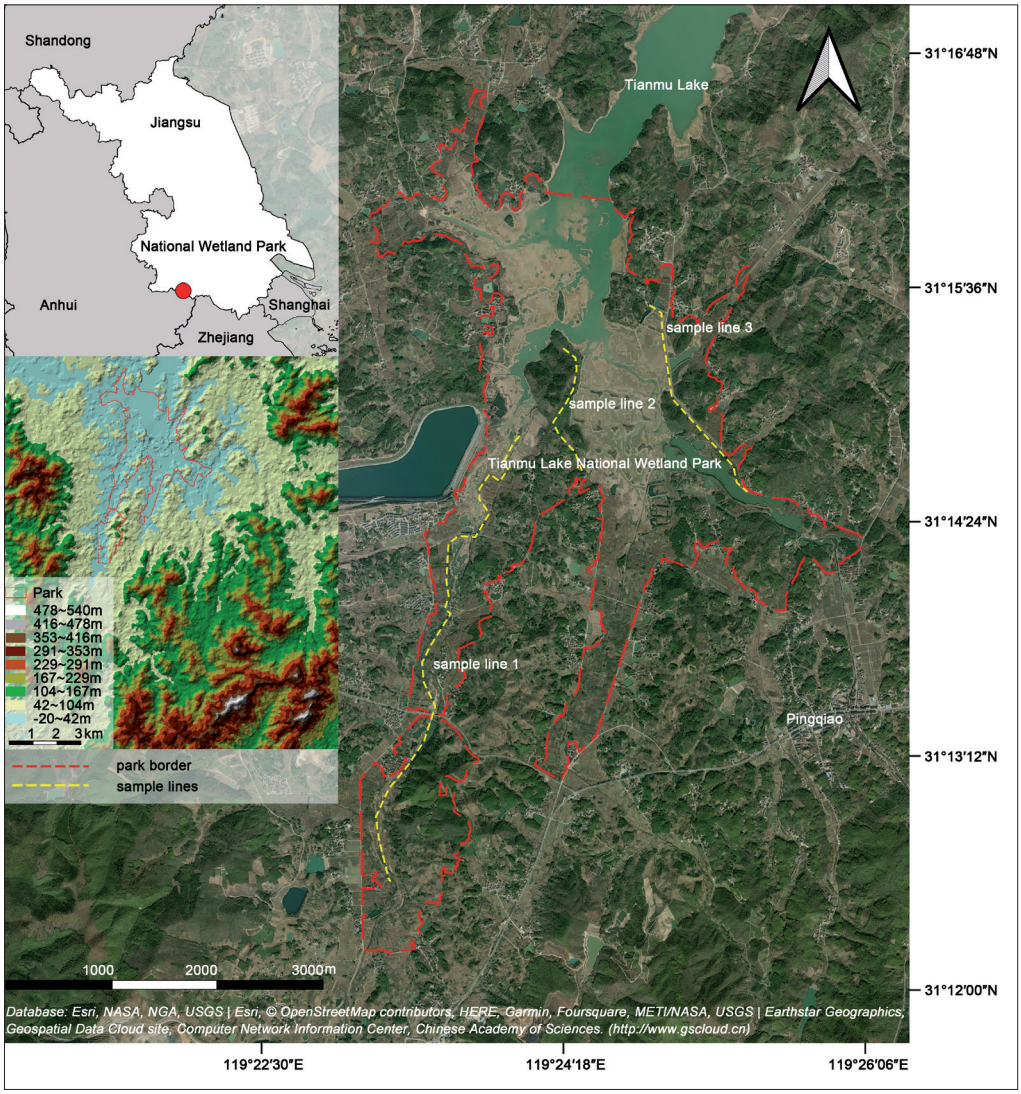

Figure 1— The geographical location and spatial extent of Tianmu Lake National Wetland Park.

Table 1 – Wetland types and their respective areas in the Tianmu Lake National Wetland Park.

Wetland type	Area (km²)	Percent (%)
River wetland	1.15	16.32
Lake wetland	2.71	38.41
Marsh wetland	2.80	39.60
Pond wetland	0.40	5.67

Field surveys

Three transect lines were established to sample the habitats in the TLNWP (Figure 1). Sample line 1 included the habitats of broadleaf forests and residential areas along the Lake; line 2 included farmland, residential areas, and habitats adjacent to the lake's shore; line 3 encompassed the remaining farmland and residential areas. In 2021, field surveys were carried out on five occasions (March 9–10, April 7–9, June 2–3, October 28–29, December 6–7), from 05:30 to 09:30 and from 16:30 to 19:30 on each day. An updated inventory of the bird species was compiled according to a field survey methodology (see Appendix), and their conservation status (IUCN Red List Categories and Criteria) was recorded according to Jiang et al. (2016).

Results

A total of 199 bird species belonging to 17 orders in 52 families were recorded in the TLNWP (see Appendix). Anatidae is the most species-rich family (23 species), followed by Ardeidae (16 species), Accipitridae (12 species), Charadriidae and Emberizidae (11 each), and Turdidae (10 species). Other families were represented by fewer than 10 species.

Discussion

This study is the first detailed inventory of bird species in the TLNWP. Tianmu Lake is situated in the northwest of the Yili Mountains, the highest peak of which reaches 611 m a.s.l. This elevation greatly exceeds the average elevation of less than 50 metres in the Yangtze River Delta region where the TLNWP is situated. The TLNWP provides habitats for many en-

Figure 2 – Some of the avian species observed during the survey. © Zhang Xuanyi

dangered and endemic avian species within this unique elevational zone. While the TLNWP accounts for only 0,00007% of China's total land area, it is home to 199 bird species (about 14.57% of the total species reported in China). Of these, 57 are endangered, including 6 according to IUCN criteria; 29 figure in the National Protected Animals List, and 27 are designated as Key Protected Animals in Jiangsu Province. The TLNWP is clearly very important for bird biodiversity conservation in China.

Human disturbance is an important threat to bird populations and their distribution (Wang et al. 2018). TLNWP is a famous tourist attraction, attracting more than 850,000 visitors annually from the nearby cities in the Yangtze River delta. Noise and discarded rubbish have potential impacts on species' ability to recognize each other, mate selection, territorial defence, population density, and the community structure of some bird species (Ji & Zhang 2011).

Non-native species and their impacts pose significant threats to the native ecosystem and to the diversity of organisms within it (Pimentel et al. 2005; Vilá et al. 2010). A broad range of non-native fishes and aquatic plant species have been introduced to China (Xiong et al. 2015; Wang et al. 2016); many non-native aquatic plants have also been introduced, establishing large areas of monoclonal feral populations in the Yangtze River basin (Wang et al. 2020; Xiong et al. 2021, 2022). This has resulted in a great decline among native plants and macroinvertebrates (Stiers et al. 2011; Brundu 2015). In turn, this has resulted in dramatic changes in community composition, and reduced the available forage plants and suitable habitats for many species of waterfowl.

Conservation

The visitor control standards followed in other wetland parks in China, such as Xixi Wetland Park, Jinghu Wetland Park, recommend the establishment of a *comfortable space* arrangement of visitors, using a maximum of 10 m^2 / person as the reference standard (Zhang et al. 2021). The length of walking tours in TLNWP is approximately 12.6 km, and the average tourist's visiting time is 8 hours if they use the TLNWP in accordance with the spacing of 10 m^2 / person standard.

The daily visitor turnover coefficient of the TLNWP is 1 (= the length of opening times of tourist attractions each day, divided by the time required for tourists to visit the attractions). A turnover coefficient of >1 means that each tourist spends less than one day in the area of interest, and more tourists visit this attraction each day. A turnover coefficient of <1 means that tourists spend more than one day in the area of interest, and fewer tourists visit this attraction each day. The number of visitors should not exceed 1,260 / day using the *comfortable space* formula (126,000 / 10 × 1 = 1,260 persons). Thus, only 1,260 tourists are allowed to visit TLNWP each day.

We have implemented several scientific educational programmes on bird and habitat conservation for local residents and tourists. A wide range of visual aids, including pictures, videos and books about endangered species, were provided to local residents as educational material on biodiversity conservation.

Conclusion

TLNWP is a representative wetland of small lakes or reservoirs in the hilly areas of southeast China. These wetlands (elevation 100–800 m) support a high level of bird-species richness, but unfortunately the populations of many bird species have greatly decreased due to human disturbance and economic development (Wang et al. 2020). Proactive measures have recently been undertaken to promote biodiversity protection in the TLNWP, including the fencing-off of sensitive areas, producing informational brochures and programmes, ecological monitoring, and research into the life histories of endangered species.

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Appendix

Appendix table 1 – Bird species in the Tianmu Lake National Wetland Park

SN	Order	Family	English name	Scientific name	Status
1	Podicipediformes	Podicipedidae	Little Grebe	*Tachybaptus ruficollis*	Δ,LC,R,1
2			Great Crested Grebe	*Podiceps cristatus*	Δ,LC,P,2
3	Pelecaniformes	Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*	LC,S,1
4	Ciconiiformes	Ardeidae	Grey Heron	*Ardea cinerea*	LC,R,1
5			Great Egret	*Casmerodius albus*	LC,P,1
6			Intermediate Egret	*Mesophoyx intermedia*	LC,S,1
7			Little Egret	*Egretta garzetta*	LC,S,1
8			Cattle Egret	*Bubulcus ibis*	LC,S,1
9			Chinese Pond-heron	*Ardeola bacchus*	LC,S,1
10			Striated Heron	*Butorides striata*	LC,S,1
11			Black-crowned Night-heron	*Nycticorax nycticorax*	LC,S,1
12			Purple Heron	*Ardea purpurea*	LC,P,1
13			Chinese Egret	*Egretta eulophotes*	II,VU,S,2
14			Yellow Bittern	*Ixobrychus sinensis*	LC,S,1
15			Schrenck's Bittern	*Ixobrychus eurhythmus*	LC,S,2
16			Cinnamon Bittern	*Ixobrychus cinnamomeus*	LC,S,1
17			Black Bittern	*Dupetor flavicollis*	LC,S,1
18			Great Bittern	*Botaurus stellaris*	LC,W,1
19			Japanese Night-heron	*Gorsachius goisagi*	DD,P,2
20	Anseriformes	Anatidae	Swan Goose	*Anser cygnoides*	Δ,VU,W,2
21			Bean goose	*Anser fabalis*	LC,W,2
22			Common Shelduck	*Tadorna tadorna*	LC,W,2
23			Ruddy Shelduck	*Tadorna ferruginea*	LC,W,2
24			Mandarin Duck	*Aix galericulata*	II,NT,W,2

SN	Order	Family	English name	Scientific name	Status
25	Anseriformes	Anatidae	Gadwall	*Anas strepera*	LC,W,2
26			Falcated Duck	*Anas falcata*	NT,W,2
27			Eurasian Wigeon	*Anas penelope*	LC,W,2
28			Mallard	*Anas platyrhynchos*	LC,W,2
29			Eastern Spot-billed Duck	*Anas poecilorhyncha*	LC,W,1
30			Northern Shoveler	*Anas clypeata*	LC,W,2
31			Northern Pintail	*Anas acuta*	LC,W,1
32			Garganey	*Anas querquedula*	LC,W,2
33			Baikal Teal	*Anas formosa*	NT,W,2
34			Green-winged Teal	*Anas crecca*	LC,W,2
35			Baer's Pochard	*Aythya baeri*	Δ,CR,W,2
36			Common Pochard	*Aythya ferina*	Δ,LC,W,2
37			Tufted Duck	*Aythya fuligula*	LC,W,2
38			Greater Scaup	*Aythya marila*	LC,W,2
39			Common Goldeneye	*Bucephala clangula*	LC,W,1
40			Red-breasted Merganser	*Mergus serrator*	LC,P,1
41			Smew	*Mergellus albellus*	LC,P,2
42			Common Merganser	*Mergus merganser*	LC,W,2
43	Falconiformes	Pandionidae	Osprey	*Pandion haliaetus*	II,NT,P,1
44		Accipitridae	Oriental Honey-buzzard	*Pernis ptilorhyncus*	II,NT,P,1
45			Black-winged Kite	*Elanus caeruleus*	II,NT,P,1
46			Black-eared Kite	*Milvus lineatus*	II,LC,R,1
47			Crested Goshawk	*Accipiter trivirgatus*	II,NT,S,3
48			Chinese Goshawk	*Accipiter soloensis*	II,LC,S,3
49			Japanese Sparrowhawk	*Accipiter gularis*	II,LC,P,1
50			Eurasian Sparrowhawk	*Accipiter nisus*	II,LC,W,2
51			Black Kite	*Milvus migrans*	II,LC,R,1
52			Northern Goshawk	*Accipiter gentiles*	II,NT,W,1
53			Besra	*Accipiter virgatus*	II,LC,S,3
54			Hen Harrier	*Circus cyaneus*	II,NT,W,2
55			Pied Harrier	*Circus melanoleucos*	II,NT,W,2
56		Falconidae	Common Kestrel	*Falco tinnunculus*	II,LC,R,1
57			Red-footed Falcon	*Falco vespertinus*	II,NT,W,2
58			Eurasian Hobby	*Falco subbuteo*	II,LC,S,2
59	Galliformes	Phasianidae	Common Pheasant	*Phasianus colchicus*	LC,R,2
60			Chinese Francolin	*Francolinus pintadeanus*	NT,R,3
61			Japanese Quail	*Coturnix japonica*	Δ,LC,W,2
62			Chinese Bamboo Partridge	*Bambusicola thoracica*	Δ,LC,R,3
63	Gruiformes	Gruidae	White-naped Crane	*Grus vipio*	II,EN,W,2
64		Turnicidae	Yellow-legged Buttonquail	*Turnix tanki*	LC,R,3
65		Rallidae	Eastern Water Rail	*Rallus aquaticus*	LC,P,2
66			Baillon's Crake	*Porzana pusilla*	LC,W,1
67			Band-bellied Crake	*Porzana paykullii*	VU,P,2
68			Watercock	*Gallicrex cinerea*	LC,S,3
69			White-breasted Waterhen	*Amaurornis phoenicurus*	LC,S,3
70			Common Moorhen	*Gallinula chloropus*	LC,R,1
71			Eurasian Coot	*Fulica atra*	LC,W,1
72	Charadriiformes	Jacanidae	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	NT,S,3
73		Recurvirostridae	Black-winged Stilt	*Himantopus himantopus*	LC,W,1
74		Charadriidae	Northern Lapwing	*Vanellus vanellus*	LC,W,2
75			Grey-headed Lapwing	*Vanellus cinereus*	LC,P,2
76			Little Ringed Plover	*Charadrius dubius*	LC,S,1
77			Kentish Plover	*Charadrius alexandrines*	LC,R,1
78		Scoiopacidae	Eurasian Curlew	*Numenius arquata*	NT,W,2
79			Common Greenshank	*Tringa nebularia*	LC,W,2
80			Green Sandpiper	*Tringa ochropus*	LC,W,2
81			Common Sandpiper	*Actitis hypoleucos*	LC,W,2
82			Pintail Snipe	*Capella stenura*	LC,W,2
83			Common Snipe	*Capella gallinago*	LC,W,2
84			Eurasian Woodcock	*Scolopax rusticola*	LC,W,2
85	Lariformes	Laridae	Black-headed Gull	*Larus ridibundus*	LC,W,2
86			Saunders's Gull	*Larus saundersi*	Δ,VU,W,2
87			Mew Gul	*Larus canus*	LC,R,1
88			Herring Gull	*Larus argentatus*	LC,W,2
89			Ancient Murrelet	*Synthliboramphus antiquus*	NT,W,1
90		Sternidae	Common Tern	*Sterna hirundo*	LC,P,2
91			Whiskered Tern	*Chlidonias hybrida*	LC,S,1

SN	Order	Family	English name	Scientific name	Status
92	Columbiformes	Columbidae	Oriental Turtle-dove	*Streptopelia orientalis*	LC,R,1
93			Spotted Dove	*Streptopelia chinensis*	LC,R,3
94			Indian Cuckoo	*Cuculus micropterus*	Δ,LC,S,1
95			Common Cuckoo	*Cuculus canorus*	Δ,LC,S,2
96			Asian Lesser Cuckoo	*Cuculus poliocephalus*	Δ,LC,S,2
97			Large Hawk-Cuckoo	*Cuculus sparverioides*	Δ,LC,S,3
98			Asian Koel	*Eudynamys scolopaceus*	Δ,LC,S,1
99	Strigiformes	Strigidae	Asian Barred Owlet	*Glaucidium cuculoides*	II,LC,R,3
100			Eastern Grass Owl	*Tyto capensis*	II,LC,S,1
101			Oriental Scops Owl	*Otus sunia*	II,LC,R,3
102			Collared Scops Owl	*Otus bakkamoena*	II,LC,R,3
103			Eurasian Eagle-owl	*Bubo bubo*	II,NT,R,2
104			Collared Owlet	*Glaucidium brod*	II,LC,R,3
105			Short-eared Owl	*Asio flammeus*	II,NT,W,1
106			Long-eared Owl	*Asio otus*	II,LC,W,1
107	Caprimulgiformes	Caprimulgus	Jungle Nightjar	*Caprimulgus indicus*	LC,S,3
108	Coraciformes	Alcedinidae	Common Kingfisher	*Alcedo atthis*	LC,R,1
109			White-throated Kingfisher	*Halcyon smyrnensis*	LC,R,3
110			Black-capped Kingfisher	*Halcyon pileata*	LC,P,3
111	Coraciformes	Alcedinidae	Crested Kingfisher	*Megaceryle lugubris*	LC,R,1
112			Pied Kingfisher	*Ceryle rudis*	LC,S,1
113		Coraciidae	Oriental Dollarbird	*Eurystomus orientalis*	LC,S,1
114	Piciformes	Picidae	Great Spotted Woodpecker	*Picoides major*	Δ,LC,R,2
115			Grey-headed Woodpecker	*Picus canus*	Δ,LC,R,1
116	Upupiformes	Upupidae	Common Hoopoe	*Upupa epops*	Δ,LC,R,1
117	Passeriformes	Pittidae	Indian Pitta	*Pitta brachyura*	II,DD,S,3
118		Alaudidae	Eurasian Skylark	*Alauda arvensis*	LC,P,2
119			Oriental Skylark	*Alauda gulgula*	LC,W,1
120		Hirundinidae	Barn Swallow	*Hirundo rustica*	LC,S,1
121			Red-rumped Swallow	*Hirundo daurica*	LC,S,1
122		Motacillidae	White Wagtail	*Motacilla alba*	LC,S,1
123			Forest Wagtail	*Dendronanthus indicus*	LC,S,2
124			Yellow Wagtail	*Motacilla tschutschensis*	LC,P,2
125			Grey Wagtail	*Motacilla cinerea*	LC,P,1
126			Richard's Pipit	*Anthus novaeseelandiae*	LC,S,3
127			Olive-backed Pipit	*Anthus hodgsoni*	LC,W,2
128		Regulidae	Collared Finchbill	*Spizixos semitorques*	LC,R,3
129			Light-vented Bulbul	*Pycnonotus sinensis*	LC,R,3
130		Bombycillidae	Bohemian Waxwing	*Bombycilla garrulous*	LC,W,2
131			Japanese Waxwing	*Bombycilla japonica*	LC,W,2
132		Laniidae	Brown Shrike	*Lanius cristatus*	LC,S,2
133			Tiger Shrike	*Lanius tigrinus*	LC,S,2
134			Chinese Grey Shrike	*Lanius sphenocercus*	LC,W,2
135			Long-tailed Shrike	*Lanius schach*	LC,R,3
136		Oriolidea	Black-naped Oriole	*Oriolus chinensis*	Δ,LC,S,3
137		Dicruridae	Black Drongo	*Dicrurus macrocercus*	LC,S,3
138			Ashy Drongo	*Dicrurus leucophaeus*	LC,S,3
139		Sturnidae	Crested Myna	*Acridotheres cristatellus*	LC,R,3
140			White-cheeked Starling	*Sturnus cineraceus*	LC,W,2
141			Red-billed Starling	*Sturnus sericeus*	LC,R,3
142		Corvidae	Red-billed Blue Magpie	*Urocissa erythrorhyncha*	Δ,LC,R,3
143			Azure-winged Magpie	*Cyanopica cyanus*	Δ,LC,R,2
144			Oriental Magpie	*Pica pica*	Δ,LC,R,2
145			Collared Crow	*Corvus torquatus*	NT,R,1
146			Rook	*Corvus frugilegus*	LC,R,2
147			Eurasian Jackdaw	*Corvus monedula*	LC,W,2
148		Cinclidae	Brown Dipper	*Cinclus pallasii*	LC,R,2
149		Troglodytidae	Wren	*Troglodytes troglodytes*	LC,W,2
150		Turdidae	Red-flanked Bush Robin	*Tarsiger cyanurus*	LC,W,2
151			Oriental Magpie-robin	*Copsychus saularis*	LC,R,3
152			Daurian Redstart	*Phoenicurus auroreus*	LC,W,2
153			Plumbeous Water-redstart	*Rhyacornis fuliginosa*	LC,R,1
154			Scaly Thrush	*Zoothera dauma*	LC,P,1
155			Eurasian Blackbird	*Turdus merula*	LC,R,1
156			Black-backed Forktail	*Enicurus leschenaults*	LC,P,3
157			Grey-backed Thrush	*Turdus hortulorum*	LC,W,2
158			Pale Thrush	*Turdus pallidus*	LC,W,2
159			Dusky Thrush	*Turdus naumanni*	LC,W,2

SN	Order	Family	English name	Scientific name	Status
160	Passeriformes	Timaliidae	Masked Laughingthrush	*Garrulax perspicillatus*	LC,R,2
161			Chinese Hwamei	*Garrulax canorus*	Δ,NT,R,3
162			Red-billed Leiothrix	*Leiothrix lutea*	Δ,LC,R,3
163		Paradoxornithidae	Vinous-throated Parrotbill	*Paradoxornis webbianus*	LC,R,1
164			Reed Parrotbill	*Paradoxornis heudei*	Δ,NT,R,1
165		Sylviidae	Reed Warbler	*Acrocephalus orientalis*	LC,S,2
166			Yellow-browed Willow Warbler	*Phylloscopus inornatus*	LC,P,2
167			Asian Stubtail	*Cettia squameiceps*	LC,P,2
168			Japanese Bush-Warbler	*Cettia diphone*	LC,P,2
169			Brownish-flanked Bush-warbler	*Cettia fortipes*	LC,R,3
170			Great Reed-warbler	*Acrocephalus arundinaceus*	LC,S,2
171			Dusky Warbler	*Phylloscopus fuscatus*	LC,P,2
172			Yellow-rumped Willow Warbler	*Phylloscopus proregulus*	LC,W,2
173		Regulidae	Goldcrest	*Regulus regulus*	LC,W,2
174		Muscicapidae	Dark-sided Flycatcher	*Muscicapa sibirica*	LC,P,1
175			Asian Paradise-Flycatcher	*Terpsiphone paradise*	Δ,LC,S,3
176		Remizidae	Chinese Penduline Tit	*Remiz consobrinus*	LC,W,2
177		Paridae	Great Tit	*Parus major*	Δ,LC,R,1
178			Long-tailed Tit	*Aegithalos caudatus*	Δ,LC,R,2
179	Passeriformes	Paridae	Black-throated Tit	*Aegithalo concinnus*	Δ,LC,R,3
180		Zosteropidae	Japanese White-eye	*Zostrops japonica*	LC,S,2
181		Passeridae	Sparrow	*Passer montanus*	LC,R,1
182			Hawfinch	*Coccothraustes coccothraustes*	LC,W,2
183		Estrildidae	White-rumped Munia	*Lonchura striata*	LC,R,3
184			Scaly-breasted Munia	*Lonchura punctulata*	LC,R,3
185		Fringillidae	Chinese Grosbeak	*Eophona migratoria*	LC,S,2
186			Japanese Grosbeak	*Eophona personata*	NT,P,2
187			Grey-capped Greenfinch	*Carduelis sinica*	LC,R,2
188			Eurasian Siskin	*Carduelis spinus*	LC,W,2
189		Emberizidae	Meadow Bunting	*Emberiza cioides*	LC,R,2
190			Chestnut-eared Bunting	*Emberiza fucata*	LC,P,1
191			Yellow-browed Bunting	*Emberiza chrysophrys*	LC,W,2
192			Pallas's Bunting	*Emberiza pallasi*	LC,W,2
193			Common Reed Bunting	*Emberiza schoeniclus*	LC,W,2
194			Yellow-breasted Bunting	*Emberiza aureola*	EN,P,2
195			Yellow-throated Bunting	*Emberiza elegans*	LC,W,2
196			Rustic Bunting	*Emberiza rustica*	LC,W,2
197			Black-faced Bunting	*Emberiza spodocephala*	LC,W,2
198			Chestnut Bunting	*Emberiza rutila*	LC,P,2
199			Crested Bunting	*Melophus lathami*	LC,R,3

Notes on status:

Conservation Status:Δ–Key Protected Animals in Jiangsu Province, II–National protection level.

IUCN Red List Categories and Criteria: CR–Critically Endangered, EN–Endangered, VU–Vulnerable, NT–Near Threatened, LC–Least Concern, DD–Data Deficient.

Occurrence Status: R–Resident, P–Passing, S–Summer, W–Winter.

Faunal type: 1–Widespread Species, 2–Palearctic Species, 3–Oriental Species.

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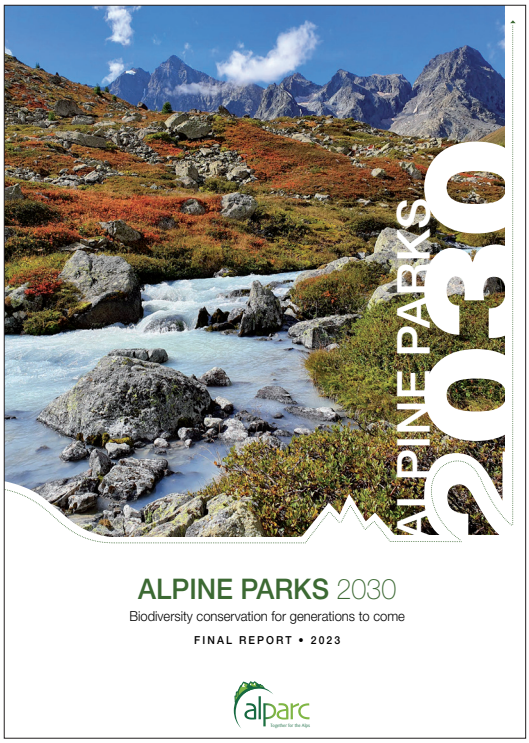
Summary Alpine Parks 2030 – Biodiversity conservation for generations to come – Final Report 2023

Guido Plassmann



The decision of the UN Biodiversity Conference (COP 15), in December 2022, coincided with the completion of work on this report. While, as of July 2022, the IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services) generally expressed pessimism about the evolution of global biodiversity, the decision of COP 15 to protect 30% of the earth's marine and terrestrial biodiversity by 2030 is a clear call for change and more effective protection of biodiversity by protected areas (PAs). For the Alps, with a large number of very heterogeneous PAs, this decision demands more coordinated strategies between the Alpine countries in favour of PAs within the framework of the Alpine Convention.

The Alpine PAs currently represent a very large mosaic of different types even within the same categories and denominations. Harmonisation of management standards has not yet been achieved and does not always enjoy strong political support. Of the 28.5% of PAs within the Alpine Convention, only a third are effectively protected, or around 10% of the entire surface area. The path to achieving the COP15 goal is still long and complex as not all PAs have an IUCN category that would facilitate the strategy. Furthermore, there are important land-use conflicts that are exacerbated by a deteriorating climate situation.

In general, the Alps are still lacking large strong PAs. Strong PAs are defined as either having a IUCN category I–IV or according to the ALPARC definition are Nature reserves, National Parks or most Italian Nature parks. According to the analysis we completed within this work, it seems difficult to establish such large surfaces with a strong protection status due to the historic and often intensive land use practices of the Alpine territory. The solution can only come from targeted strategies and measures, such as stronger protection at lower altitudes, better connection between PAs through adapted measures, and effective defragmentation (ecological connectivity). In the best-case scenario, these solutions would be negotiated with stakeholders and the local population to improve the area's protection status wherever possible through more consistent rules for Alpine land use that include the needs for intact habitats.

Expression of the *ecological significance* of the existing and future PAs was one of the most difficult features to define for the Alpine territories as Alps-wide data for biodiversity and species distribution are often not available. The integration of Key Biodiversity Areas (KBA) and Nature 2000 sites, both of which reflect ecological importance of the concerned territory, helped to fill this gap. More than two-thirds of the strong PAs of the Alps overlap with those KBA's.

Our most important conclusions are: Alpine PAs are too small, too high, and, especially in the case of the strong PAs, not well enough interconnected; they also lack sufficient common management approaches beyond regions and national borders. All of these factors contribute to inadequate ecological process protection in the Alps, and Wilderness remains an exception in the Alpine space occupying only a very low percentage of the surface area (0.4% of the Alpine Convention perimeter, IUCN Ia and Ib).

The most promising approach to maintaining biodiversity in the long run is to promote more ecological connectivity within a global planning framework of connectivity combined with local actions that include stakeholders and the local population.

To achieve the 30% goal, three essential strategies are needed: a) to identify all potentially ecologically interesting areas with potential to be protected and integrate those areas into spatial planning procedures; b) to be creative and innovative concerning the forms and types of PAs to be adapted for local or regional situations with the clear condition that they must contribute to effective biodiversity protection, and last but not least c) to incorporate the local population in the planning and management questions. We will not sustainably achieve the 30% goal in the Alpine region without our population!

The final section of the report tried to develop suggestions for a future PAs scenario in the Alps. It seems very difficult to achieve the 30% goal of effective PAs within the existing network. Success would require a significant

increase (by at least 25%) in the ecologically most valuable spaces that combine important extension, a high protection status, a well-balanced altitudinal distribution, and a high degree of connectivity criteria with a very low presence of infrastructure or settlements (open space). Furthermore, addressing the criterion of *efficient protection* requires us to provide a real protection status to all so-called *weak PAs*, to guarantee that all KBA's are also covered by the same (strong) protection status, and, finally, to ensure a high degree of ecological connectivity.

As the probability of the implementation of these important measures within the existing framework is low and unrealistic in the near future, we enhanced our approach with a final spatial planning simulation to identify areas potentially interesting for the 30x30 goal (30% of the world's terrestrial, inland water, and coastal and marine areas to be in effective protection and management by 2030) beyond the existing protected area network. The results of important projects of the last years (mainly INTERREG Alpine Space) informed our proposal for a spatial planning system to reach the 30x30 goal of COP 15. Based on the combination of areas identified as ecologically favourable by this report with areas having a low degree of fragmentation and spatial development, new areas were identified with potential for integration into the PAs network. Those with ecological significance yet lacking a strong protection status could be considered in a spatial planning strategy integrating the 30% goal of effective PAs in the Alps.

We are aware that this goal of 30% is based on national boundaries. Nevertheless, it makes perfect sense to apply it to the Alps as a common biogeographical region unified by an international treaty, the Alpine Convention.

This report illustrates the state of the PAs with their most important, primarily quantitative characteristics, delivers data for future expertise and studies, and, finally, proposes strategic intervention measures to reach the 30x30 goal of better protection of biodiversity for generations to come.

Further information

https://alparc.org/parks2030

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Call for papers: eco.mont – special issue: Biodiversity Change in Mountain Protected Areas due in March 2025

Mountains are home to an exceptionally rich biodiversity, including many endemic species. As a consequence, about one third of all terrestrial protected areas, such as national parks or biosphere reserves, are located in mountain regions. Yet the biodiversity in these areas is under threat: climate change, land use change, pollution, over-exploitation and invasive alien species are all driving biodiversity change, affecting natural and cultural landscapes. The contraction of bioclimatic belts along the elevation gradient results in a large number of habitat types. This is further enhanced by complex topography, favouring a great diversity of microclimates with different thermal and moisture conditions, and hence an extraordinarily high biodiversity. Climate change in mountains is driving species to migrate to higher altitudes. Changes in the thermal conditions, resulting in reduced snowpack periods and water availability, amplify the consequences of climate change for high mountain biota. Cold areas of alpine habitats are generally small in extent, making species adapted to them especially prone to extinction processes. Climate change is also affecting the appearance of high mountains. The melting of glaciers, for example, is creating new glacial lakes and glacier forelands. Glacier melt and seasonal changes in precipitation patterns alter the hydrology and temperature regime of alpine streams, affecting the biodiversity, structure and functioning of mountain river ecosystems.

With this special issue, we would like to highlight biodiversity changes in mountain protected areas. Additionally, we would like to present adaptation and mitigation strategies implemented by park managements as well as monitoring strategies.

If you are interested in contributing to this issue, please contact Valerie Braun (valerie.braun@oeaw.ac.at).

Editors: Valerie Braun, Günter Köck, Margreth Keiler (eco.mont, ÖAW-IGF, UIBK), Harald Pauli (Guest Editor; University of Natural Resources and Life Sciences Vienna, ÖAW-IGF)

Deadline for the submission of articles: 31.03.2024

International Workshop on Research in European UNESCO Biosphere Reserves (BRs)

The main goal of the workshop is to advance the implementation of the recommendations of the Eberswalde Declaration and the Lima Action Plan for research in BRs. This event is also part of a series of workshops supported by the Federal Agency for Nature Conservation (BfN), since 2020. The workshops aim to link European BRs practitioners and facilitate the exchange of best practices. The current workshop is, therefore, designed to promote an active exchange between managers and staff responsible for research and monitoring in different European BRs. Discussions on research progress, gaps, needs, collaboration with research managers and staff from diverse BRs are also expected.

The workshop will take place at 13–16 February 2024 at the Eberswalde University for Sustainable Development (Eberswalde, Germany). Limited funds are available to support a small number of participants.

More information available on: hhttps://www.biosphererereserves.institute/about

Parks discussed in this issue

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