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The research framework of Austria's National Parks

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Abstract

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

Who we are

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

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

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

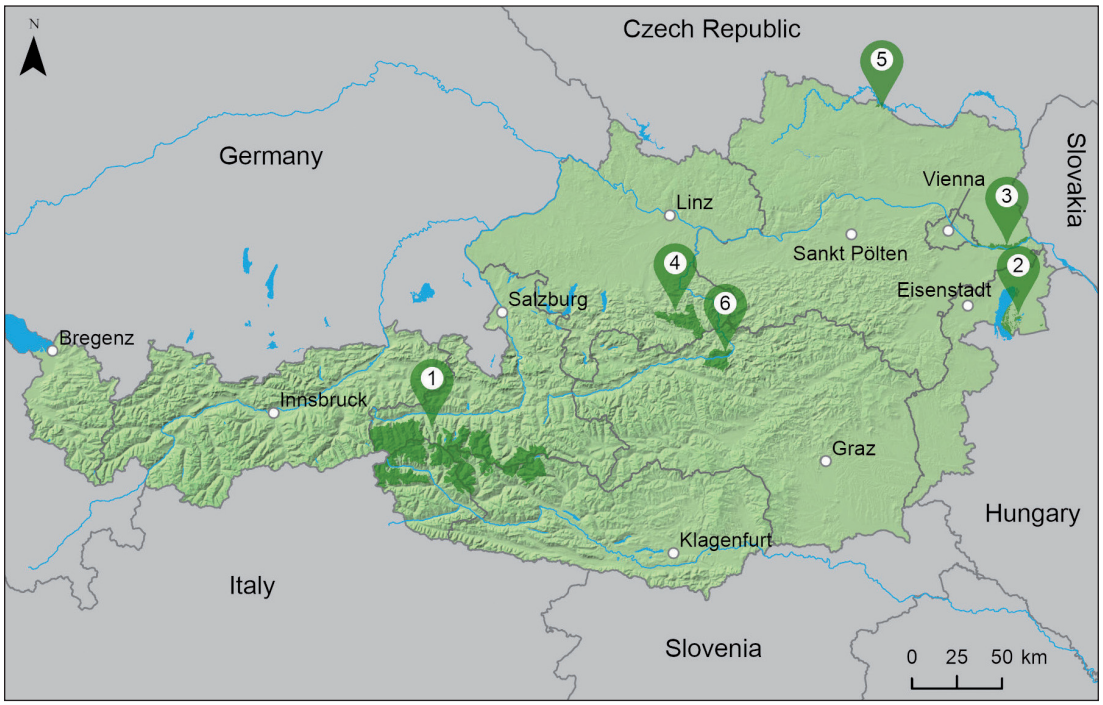

Figure 1 – Austria's six National Parks: (1) Hohe Tauern, (2) Neusiedler See – Seewinkel, (3) Donau Auen, (4) Kalkalpen, (5) Thayatal, (6) Gesäuse. Design: Matthias Prüggler, Database: GIS Steiermark, BEV, ESRI.

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

The six Austrian National Parks

Donau Auen National Park

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

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

Gesäuse National Park

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

Hohe Tauern National Park

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

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

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

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

Kalkalpen National Park

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

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

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

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

Neusiedler See – Seewinkel National Park

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

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

Thayatal National Park

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

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

Latest challenges

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

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

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

Research networks and data accessibility

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

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

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

Work with Austria's National Parks

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

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

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

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

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