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**Biodiversity
Monitoring**

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**Surveying
South Tyrol's
biodiversity**

Long-term monitoring



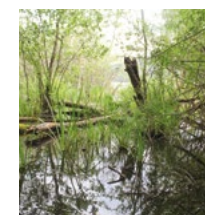
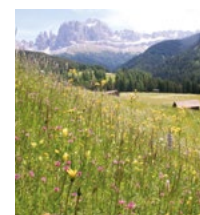
Eurac Research is a private research institution based in Bolzano/Bozen, Italy. Founded in 1992, it now comprises 11 institutes and several research centers, employing more than 750 staff members from over 40 countries. From the very beginning, the Institute for Alpine Environment (www.eurac.edu/en/institutes-centers/institute-for-alpineenvironment) has focused on scientific research related to nature, landscapes, and the environment in the Alpine region. The Biodiversity Monitoring South Tyrol is one of its key longterm research projects. It was launched on behalf of the Autonomous Province of Bolzano/Bozen-South Tyrol and is conducted by Eurac Research in collaboration with the Museum of Nature South Tyrol, the Nature Conservation Department and the Department for Agriculture of the Autonomous Province of Bolzano/Bozen.

The need for long-term regional data on biodiversity has grown rapidly in recent decades. In 2019, a permanent monitoring program for South Tyrol was set up on behalf of the South Tyrolean provincial government and lead by Eurac Research. The monitoring aims to provide the scientific basis for political decision-making, particularly in the fields of nature protection, spatial planning and agriculture, while also addressing pressing research questions.

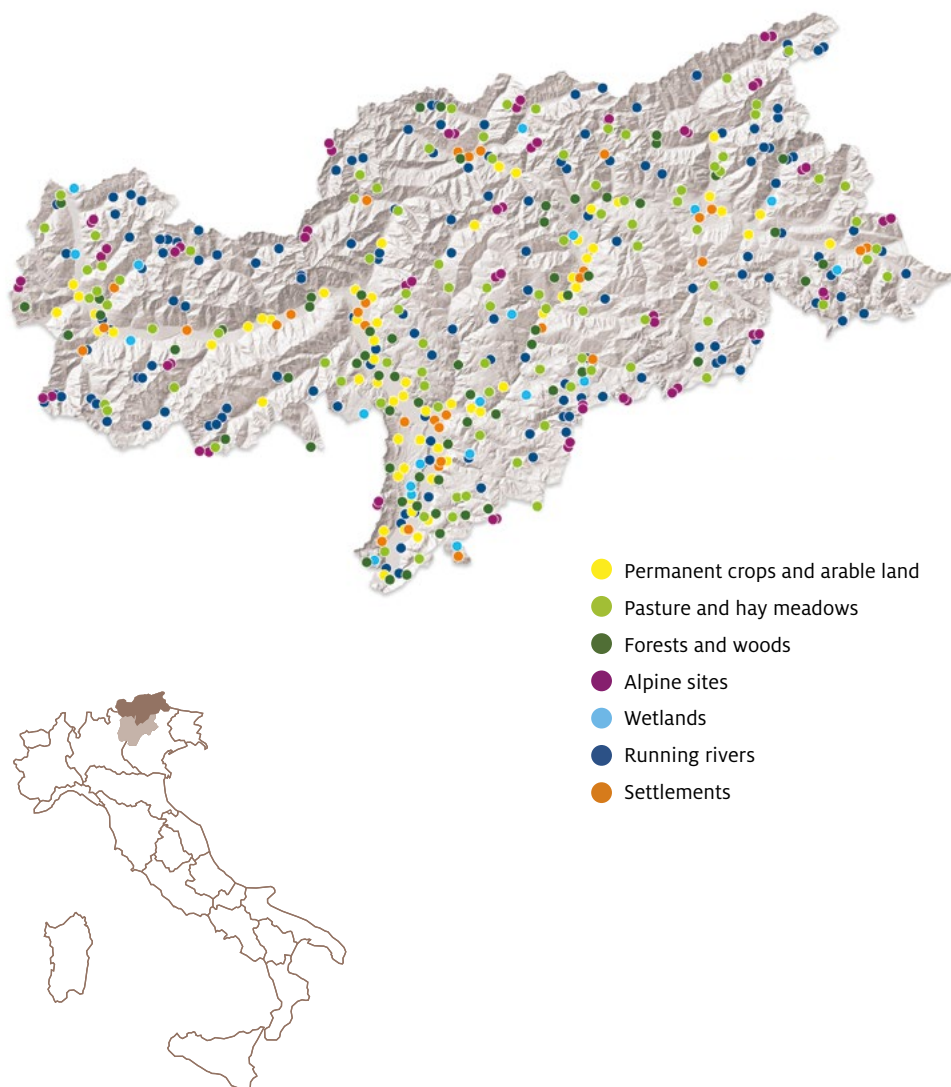
Using consistent protocols, **Biodiversity Monitoring South Tyrol** aims to survey species groups sensitive to climatic and land-use changes. In total 320 sites are being investigated over a period of 5 years as part of the project's terrestrial monitoring. For the aquatic part of the monitoring, a total of 120 individual areas of running water are surveyed over a period of 4 years. In the subsequent years, the same sites will be resampled.

The surveyed taxa include vascular plants, bryophytes and lichens, birds, bats, grasshoppers, butterflies and other insect groups, soil invertebrates as well as aquatic insect larvae (macroinvertebrates) in running waters.

In addition, data on abiotic factors, landscape composition, and site management are also being collected.



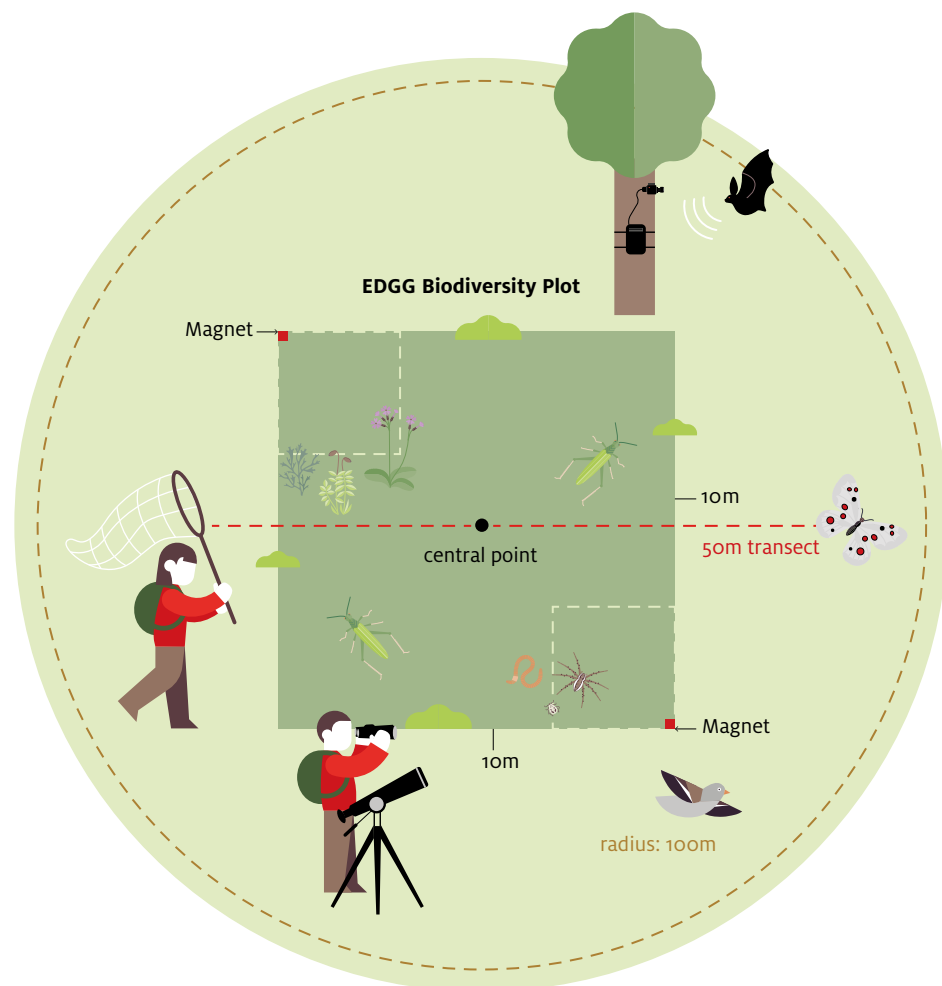
Where we survey



The focus area of our research is South Tyrol (Autonomous Province of Bolzano/Bozen). South Tyrol is the northernmost province of Italy. It is located at the transition between the Central and Eastern Alps and at the watershed of important European river systems (Adige/Etsch and Drava-Danube). Strongly contrasting altitudinal zones and climatic influences from both the southern and northern sides of the Alpine arc play an important role in this area.

We survey the most important habitats in South Tyrol using a stratified site selection approach. The habitats range from the valley floor at 213 m to high mountain areas up to 3,060 m and include sites from highly managed to near-natural. Thus, we survey agricultural habitats such as pastures and meadows, vineyards and apple orchards, and arable land. We also survey settlements, ranging from small villages surrounded by greenery (e.g. private gardens and peri-urban agriculture) to industrial sites and cities. The most important forest types in South Tyrol are also monitored. In addition, near-natural sites are surveyed, including Alpine habitats with the most important substrate types, as well as wetlands such as lake shores and bogs. Finally, running waters across different elevations, discharge regimes, and geological settings are investigated. Across the full range of individual habitat types, survey points were in most cases selected randomly, ensuring an even spatial distribution of study sites across the region. Randomization was not applied to habitat types located in remote and partly hazardous terrain (e.g. alpine grasslands and mountain forests).

What we survey



How we survey

At our research sites, selected plant and animal groups are surveyed that have been identified as excellent bioindicators of environmental change.

The investigations are conducted using established standard scientific methods, selected and adapted for the respective taxa. All methods are described in detail in a comprehensive handbook, ensuring that the studies and results are reproducible.

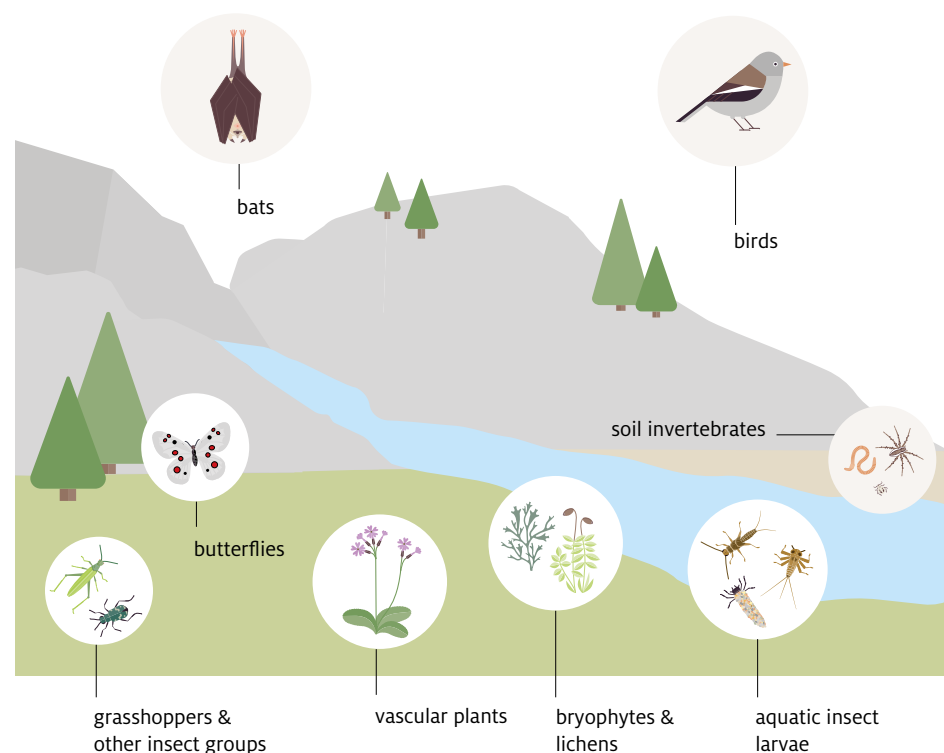
Hilpold A, Anderle M, Guariento E, Marsoner T, Mina M, Paniccia C, et al. (2023). Handbook Biodiversity Monitoring South Tyrol 10.57749/2qm9-fq40



The handbook is
freely available
for download



Our survey methods in detail



The methodology for the plant survey is based on the protocol of the Eurasian Dry Grassland Group (EDGG): It combines a floristic assessment along nested plot series with an estimation of vegetation cover within 10 m² plots. For forests, the plot size is 1,000 m². In settlement areas and along lake shores, a transect-based survey is used instead. Bryophyte and lichen samples are collected in four different subplots.

For bird surveys, we follow the protocol of the Pan-European Common Bird Monitoring Scheme (PECBMS), using vocal point counts. Listening time at each point is standardized to 10 minutes. Surveys are conducted in the early morning from the beginning of the breeding season until mid-July to exclude most migratory birds. Bird data are collected within a 100 m radius around each survey point. Per season, three survey repetitions are generally carried out at each point, depending on habitat type (two at alpine sites). Another method, particularly suitable for monitoring elusive and nocturnal species, is passive acoustic monitoring (PAM), in which environmental sounds and bird vocalizations are recorded over extended periods.

For surveying bats, we use ultrasonic recording devices (batloggers®): Species, or at least genera, are identified based on acoustic signals. To this end, the calls of passing individuals are recorded during summer over three consecutive nights. Acoustic signal also allow us to distinguish between passing and feeding individuals, enabling an assessment of an area's suitability as a foraging habitat.

Butterfly monitoring follows a two-step approach combining transect sampling with time area counts: During the first five minutes, a 50 m transect is surveyed, recording all butterflies either resting or flying within an imaginary rectangle extending 2.5 m to each side and 5 m ahead of the observer. After that, the sampling area is expanded to 10 m on both sides of the transect, thus covering an area of 1,000 m². In this second step, an additional 25-minutes time-area survey is conducted within this area. At each site, four 30-minute sampling events are conducted per survey season, while high-mountain sites are surveyed with only three replicates.

The grasshopper survey scheme combines sweep-netting and active searching. Surveys begin with sweep-netting along a diagonal transect, followed by an exhaustive search within a 100 m² plot. Surveys are conducted once per year in late summer, when most species are present as adults. In settlement areas and along lake shores, a transect-based survey is used instead.



To survey invertebrate communities from selected strata (shrub layer, herb layer, soil surface, litter and soil), different methods are applied. Invertebrates inhabiting woody vegetation are collected by **beat-netting**, while those in the herb layer are sampled using **sweep netting** following standard protocols. Surface-active invertebrates are collected using **pitfall** traps, which are installed twice per year (or once at alpine sites). At forest sites, two **litter samples** per site are collected in early autumn to sample invertebrates from the leaf-litter layer. Soil faunae are sampled by taking four **soil-core samples** per site during late spring and summer. Litter and soil samples are processed in the laboratory, where invertebrates are extracted by heat in a modified Kempson apparatus.



For benthic macroinvertebrates, field surveys follow the Swiss sampling methodology. This method is applied across different elevations and under varying climatic and hydrological conditions, as well as across different macroinvertebrate phenological stages. The sampled stream reach roughly corresponds to ten times the width of the wetted perimeter. Within this stream reach, eight sub-samples per site are collected, preferably covering as many combinations of substrate type and flow velocity as possible. All samples, consisting mainly of aquatic insect larvae (e.g. Ephemeroptera, Trichoptera, and Diptera), are identified to genus or species level in the laboratory. In addition, abiotic water parameters are measured.





Scientific output

The project is carried out by a team of biologists. They are not only responsible for the fieldwork and surveys but are also analyzing and publishing the data. The scientific output ranges from the publication of floristic and faunistic novelties for the area, over the description of biodiversity patterns for single habitat types and single taxonomical groups, to ecological patterns depending on landscape characteristics. The data is combined with remote sensing data and model species distribution for the territory and beyond. This scientific work is also the fundamental basis for both dissemination and stakeholder consultations.

An updated list of all scientific publications is available on the website: biodiversity.eurac.edu/results



Report

Following the completion of the first survey cycle (2019–2023), a comprehensive results report was prepared. It contains detailed summaries of the research findings, first records and new discoveries, as well as recommendations for targeted measures to protect biodiversity.

This five-year report is available for download in German and Italian.

Hilpold, A., Anderle, M., Guariento, E., Marsoner, T., Mina, M., Obwegs, L., Paniccia, C., Seeber, J., Strobl, J., Vanek, M., Bottarin, R., & Tappeiner, U. (2025). Biodiversitätsmonitoring Südtirol – Ergebnisbericht I 10.57749/08CE-CW08 / Monitoraggio della Biodiversità Alto Adige – Rapporto I 10.57749/7nvz-r102



German version



Italian version



Database, Specimen Management and Data Use

All data collected within the Biodiversity Monitoring programme are stored in our dedicated BMS database. Selected datasets are also made available in simplified form through an interactive map on the BMS website.

The entire BMS database is linked to the database of the Museum of Nature South Tyrol and is continuously synchronized. Physical reference specimens collected within the BMS are also permanently preserved in the scientific collections of the Museum. This includes herbarium specimens as well as zoological specimens, ensuring their long-term availability for verification, taxonomic research and future studies. From the Museum database, occurrence data are transferred to the FloraFauna South Tyrol portal (www.florafaua.it), where users can access species distribution maps and detailed occurrence records. The database is also connected to the provincial Geographic Information System (GIS) for the South Tyrol administration as well as to international biodiversity databases.

Upon request, we also make our data available to the scientific community. Access is granted following the signing of a Data Use Agreement. Available datasets include taxonomic data for all monitored organism groups as well as the complete set of soil parameters measured within the programme. Data requests to: biodiversity@eurac.edu





Dissemination and Stakeholder interaction

A key component of the long-term project is continuous dialogue with local authorities and stakeholders, as well as communication of results to the wider public.

Stakeholder exchange focuses on the impacts of agricultural and forest management on biodiversity and ecosystem services, the effectiveness of conservation measures, and the effects of environmental change, including extreme events and invasive species. We offer presentations, workshops, excursions, webinars, and consultancy services, and implement targeted projects addressing specific needs (e.g. pollinators or orchard meadows).

Public outreach is equally important. We regularly publish articles, engage with local media, conduct citizen science initiatives, and provide educational programs for schools. In collaboration with the Museum of Nature South Tyrol in Bolzano, we also organize scientific colloquia on biodiversity-related topics and current research findings.





Biodiversity Monitoring South Tyrol is embedded in a biodiversity research landscape comprising seven thematic research teams: plants, mammals, birds, insects, soil, limnology, and forests.

On the one hand, these teams analyze and further develop aspects of the biodiversity monitoring program and use the BMS sites for more in-depth studies. On the other hand, they address applied research questions in various specialized projects, often in close collaboration with stakeholders e.g. the “SpeciesMonitoring,” project which focuses on animal species protected under the EU Habitats Directive (92/43/EEC), and “Schneewinkel,” a project on the implementation of biodiversity protection measures in apple orchards, are conducted in cooperation with the Province of Bolzano and with apple producers.

The teams also lead and participate in a range of international projects funded by Interreg Alpine Space, Interreg Italy–Austria, Biodiversa+, and Horizon 2020. Furthermore, Eurac Research acts as a third party for the Province of Bolzano within the Biodiversa+ partnership.

Each organism group or habitat is studied by a group of experts working under the coordination of a team leader.

An up-to-date overview of all team members is available at: biodiversity.eurac.edu/the-project/team



Research teams: Organisms

RESEARCH TEAM BATS AND SMALL MAMMALS

Team leader

Chiara Paniccia
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Research line

Our research team investigates how landscape structure, land-use practices, and forest and agricultural management shape biodiversity patterns across natural (forests, grasslands) and human-modified (urban, agricultural) ecosystems. We combine large-scale passive acoustic monitoring with semi-automated analysis of echolocation calls to generate high-resolution data on species presence, activity, and community composition.

Complementary survey methods, including roost inspections and mist-netting, enable detailed assessments of species populations and habitat use. Our approach integrates habitat characteristics, anthropogenic pressures, and management interventions to inform conservation strategies and optimize biodiversity outcomes in complex mountain and urban landscapes.

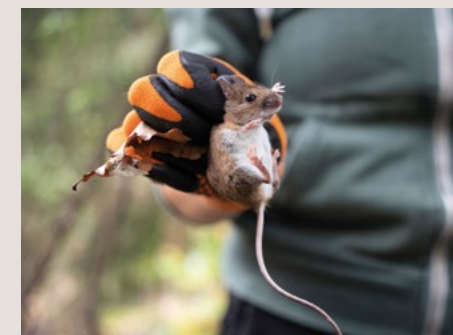
Research on small mammals, including dormice, is conducted using both direct and indirect survey techniques to support population assessments and conservation planning.

Examples of scientific results

Paniccia, C., Scott, M. J., Bellè, A., Marsoner, M., et al. (2025). Balancing bats and agriculture: Investigating the effects of agricultural management practices on bat species diversity in mountain ecosystems. *Agriculture, Ecosystems & Environment*, 387, 109620. 10.1016/j.agee.2025.109620

Paniccia, C., Zingg, P. E., Bellè, A., Hilpold, A., Reichegger, F., Tappeiner, U., & Ladurner, E. (2023). Bioacoustic evidence for a continuous summer presence of the greater noctule bat, *Nyctalus lasiopterus*, in the Italian Alps. *Mammal Research*, 68(3), 411–416. 10.1007/s13364-022-00668-w

O'Halloran, Q., Straka, T.S., Paterson, A., Sullivan, J., Marsoner, T., Bellè, A., Ladurner, E., Hilpold, A., Tappeiner, U., & Paniccia, C. (2026). Bats in an urbanised mountain landscape: How vegetation from settlements to surrounding forests drives bat diversity. *Global Ecology and Conservation*. e04403. 10.1016/j.gecco.2026.e04403



RESEARCH TEAM BIRDS

Team leader

Matteo Anderle

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Research line

Our research team investigates the influence of landscape structure and land use on bird communities. Emphasis is placed on farmland and alpine birds. Indeed, key research questions concern how bird communities can be conserved within intensive managed areas (e.g., intensively managed grasslands and intensive orchards) and how alpine communities cope with climate change. We also examine the relationships between birds and other taxonomical groups surveyed within the monitoring, using birds as key bioindicators to assess ecosystem integrity, habitat quality, and overall biodiversity patterns.

The team also addresses methodological aspects, particularly the application of passive acoustic monitoring and AI approaches for standardized bird surveys or for the assessment of the relationship between psychoacoustics and bio/eco-acoustic indices.

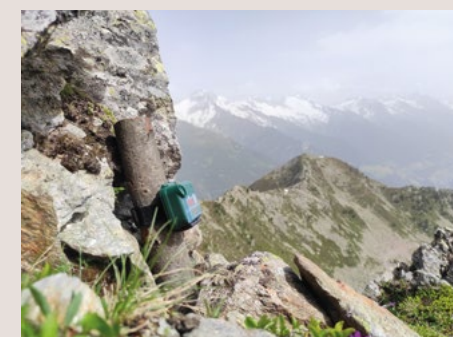
The team is actively involved in regional fauna research, nature conservation initiatives and is collaborating within bird ringing activities at Lake Kaltern/Caldaro ringing station and at other stations.

Examples of scientific results

Anderle, M., Brambilla, M., Hilpold, A., Matabishi, J. G., Paniccia, C., Rocchini, D., ... & Seeber, J. (2023). Habitat heterogeneity promotes bird diversity in agricultural landscapes: Insights from remote sensing data. *Basic and Applied Ecology*, 70, 38-49. 10.1016/j.baee.2023.04.006

Anderle, M., Brambilla, M., Angelini, L., Guariento, E., Paniccia, C., Plunger, J., ... & Hilpold, A. (2024). Efficiency of birds as bioindicators for other taxa in mountain farmlands. *Ecological Indicators*, 158, 111569. 10.1016/j.ecolind.2024.111569

Scanferla, J., Seeber, J., Brambilla, G., Brambilla, M., Hilpold, A., Tappeiner, U., ... & Anderle, M. (2026). How Passive Acoustic and Traditional Monitoring Estimate Bird Diversity Across Habitats. *Remote Sensing in Ecology and Conservation*, 10.1002/rse2.70098



RESEARCH TEAM BUTTERFLIES, GRASHOPPERS & OTHER INSECT GROUPS

Team leader

Elia Guarriento
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Research line

Our research team investigates insect groups widely used as bioindicators, enabling the detection of subtle and broad environmental patterns. Terrestrial insect communities help us to understand how biodiversity responds to ecological gradients, global change, and habitat characteristics.

We focus on butterflies that react quickly to environmental shifts; on grasshoppers as indicators of grassland conditions; on wild bees as essential provider for pollination; and on ants, that significantly influence biomass and energy fluxes. All these groups inform on ecosystem states and functions. Additionally, project-based dragonflies and damselflies, syrphids, and beetles protected under the EU Habitats Directive are investigated.

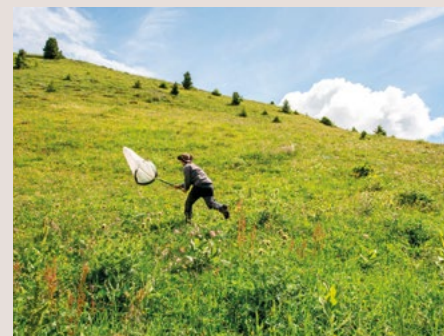
We apply a community ecology approach across multiple taxa, integrating compositional analyses, functional traits, and biodiversity metrics. Field surveys are central to our work and help address key timely questions on biodiversity change and inform conservation across complex landscapes.

Examples of scientific results

Guarriento, E., Rüdissler, J., Fiedler, K., Paniccia, C., Stifter, S., Tappeiner, U., Seeber, J., & Hilpold, A. (2023). From diverse to simple: butterfly communities erode from extensive grasslands to intensively used farmland and urban areas. *Biodiversity and Conservation*, 32(3), 867-882. 10.1007/s10531-022-02498-3

Guarriento, E., Obwegs, L., Anderle, M., Belle, A., Fontana, P., Paniccia, C., Plunger, J., Rüdissler, J., Stifter, S., Giombini, V., Egarter Vigl, L., Tappeiner, U., & Hilpold, A. (2024). Meadow orchards as a good practice example for improving biodiversity in intensive apple orchards. *Biological Conservation*, 299, 110815. 10.1016/j.biocon.2024.110815

Puff, F., Schulze, C. H., Novella-Fernandez, R., Hilpold, A., Pinkert, S., & Guarriento, E. (2025). Artificial ponds do not support the natural functional and taxonomic composition of alpine dragon-and damselfly communities. *Global Ecology and Conservation*, 62, e03708. 10.1016/j.gecco.2025.e03708



RESEARCH TEAM PLANTS

Team leader

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Research line

Plant sciences within the Biodiversity Monitoring South Tyrol serve both as a supporting discipline and as an independent field of research. Botanical data play a key role in describing and understanding the ecological conditions at each site and help to interpret patterns observed in other organism groups.

At the same time, the team's scientific focus lies on changes in flora and vegetation driven by climate and land-use change. These changes are recorded through botanical surveys of the Biodiversity Monitoring and associated studies across a wide range of habitat types. A particular emphasis is placed on high-mountain monitoring through our collaboration within the global GLORIA network, where vegetation is studied at eight summit sites in South Tyrol. The data collected follow international standards and contribute to global research on alpine biodiversity.

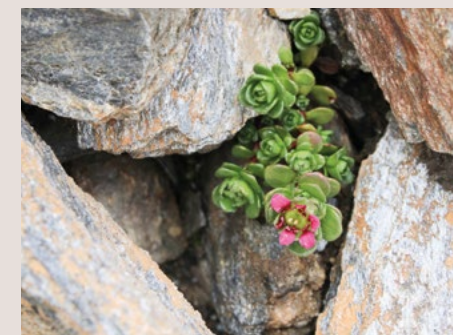
In addition, systematic plant surveys across South Tyrol and the wider Alpine region are essential for tracking endemic and alien species, not least in the context of climate change and globalization.

Examples of scientific results

Zhang J, Gillet F, Bartha S, [...], Stifter S. et al. (2021). Scale dependence of species–area relationships is widespread but generally weak in Palaearctic grasslands. *Journal of Vegetation Science* 32(3): e13044. 10.1111/jvs.13044

Wessely J, Chytry K., Gattringer A., [...], Hilpold A. et al. (2026) Rising plant extinction rates on European mountain summits. *Science* 393, pp. 1021-1026. 10.1126/science.aed2974.

Dellavedova R., Hilpold A., Wilhalm T. et al. (2025) *Notulae Florae austrotirolensis* (2). *Gredleriana*. 25:197-202



Research Teams: Habitats

RESEARCH TEAM SOIL

Team leader

Julia Seeber
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Research line

Soil—defined as the thin, active layer of the Earth's crust—consists of mineral and organic particles, as well as water and air, and forms the foundation of all terrestrial life. This vital habitat is shaped by climate, topography, parent material, vegetation, land use, and temporal processes such as weathering, decomposition, and the activity of soil organisms.

Our research includes the analysis of soil parameters and abiotic factors, alongside investigations of various groups of ground- and soil-dwelling invertebrates. Particular attention is given to taxa involved in the decomposition of plant material (e.g. earthworms, woodlice, and millipedes), as well as to species that serve as key indicators of specific habitats and their ecological composition (e.g. ground beetles).

Examples of scientific results

Praeg N., Steinwandter M., Guariento E., Seeber J. et al. (2025) Biodiversity in mountain soils above the treeline. *Biological Reviews*, 100(5), 1877-1949. 10.1111/brv.70028

Steinwandter M., Seeber J., (2023) Ground-dwelling invertebrates of the high alpine: Changes in diversity and community composition along elevation (1500–3000 m). *Applied Soil Ecology*, 190, 104988. 10.1016/j.apsoil.2023.104988

Plunger J., Guariento E., Steinwandter M., Colla F., Rief A., Seeber J. (2022) Shifts in ground-dwelling predator communities in response to changes in management intensity in Alpine meadows. *Soil organisms*, 94(3), 149-161. 10.25674/so94iss3id306



RESEARCH TEAM RUNNING WATERS

Team leader

Magdalena Vanek
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Research line

As the region of South Tyrol is both rich in water resources and characterized by pronounced altitudinal gradients with diverse climatic and geological features, a wide variety of running waters has developed. These range from ditches and slow-flowing streams on the valley floor to glacial streams at high elevations, each supporting distinct aquatic communities. Many of these species are highly specialized endemics that respond sensitively to environmental conditions and their alterations.

Our research focuses on aquatic insect larvae (benthic macroinvertebrates) as well as key abiotic water parameters, including pH, conductivity, oxygen levels, and various nutrient concentrations assessed at 120 sites.

Particular attention is also given to the impact of human activities on aquatic systems.

Examples of scientific results

Schwingshackl T., Vanek M., Vallefuoco F., Ricaldone D., Bottarin R., (2026) Rivers Run Through It – Exploring Drivers of Aquatic Macrozoobenthic Diversity in an Inner Alpine Dry Valley. *Biodiversity and Conservation*. 35, 142. 10.1007/s10531-026-03333-9

Martini J., Vanek M., Vallefuoco F., Bottarin R. et al. (2024) Rock glacier springs: cool habitats for species on the edge. *Biodiversity and Conservation*, 33(14), 4017-4042. 10.1007/s10531-024-02937-3)

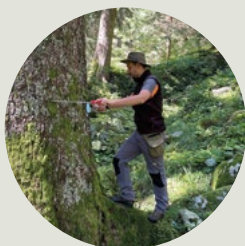
Vallefuoco F., Vanek M., Scotti A., Bottarin R., (2023). Effect of management strategies and substrate composition on functional and taxonomic macroinvertebrate communities in lowland ditches of Alto Adige/Südtirol. *Gredleriana*. 23. 10.5281/zenodo.10116146



RESEARCH TEAM FORESTS

Team leader

Marco Mina
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Research line

Our research team investigates forest habitats in South Tyrol by collecting their forest structural and compositional characteristics following forest inventory protocols.

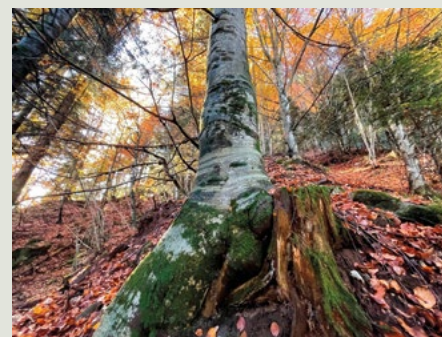
We assess qualitative and quantitative aspects such as tree species structure, dead wood, regeneration, microhabitats, and tree canopy structure. These characteristics can be linked to multitaxonomic biodiversity data to study the influence of forest features to host plant and animal diversity, but are also useful to calibrate statistical and predictive models to study climate change impacts on forests. We also carry out the monitoring of fruiting bodies of fungi in collaboration with mycological associations.

Examples of scientific results

von Meijenfeldt A., Chianucci F., Rigo F., Ottenburghs J., Hilpold A., Mina M., (2025). Reliability of canopy photography for forest ecology and biodiversity studies. *Ecological Indicators*, 172, 113293. 10.1016/j.ecolind.2025.113293

Rigo F., Paniccia C., Anderle M., Chianucci F., Obojes N., Tappeiner U., Hilpold A., Mina M., (2024). Relating forest structural characteristics to bat and bird diversity in the Italian Alps. *Forest Ecology and Management*, 554:121673. 10.1016/j.foreco.2023.121673

Hillebrand L., Marzini S., Crespi A., Hiltner U., Mina M., (2023). Contrasting impacts of climate change on protection forests of the Italian Alps. *Frontiers in Forests and Global Change* 6 1240235. 10.3389/ffgc.2023.1240235



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Bortolotti, p 25: Eurac Research/1. Valeria Scrilatti, 2. Andreas Hilpold, p 26:
Eurac Research/Martina Jaider, p 27: Eurac Research/1. Annelie Bortolotti,
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