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Restoring ecosystems, advancing science: The Metschacher Moos outdoor lab

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ABSTRACT

On the occasion of the realignment of research activities at the Metschacher Moos, this article compiles key information about the natural environment, land use history, previous scientific studies, and planned initiatives. The State of Carinthia maintained a long-term lease on the site, located in a side branch of the Glan Valley (Carinthia), to restore wet meadows that were drained in the 20th century. With the acquisition of the land by the Kärntner Sparkasse Foundation, these restoration efforts and scientific activities can now be continued.

This presents an opportunity to develop a research site dedicated to restoration and the application of biodiversity technologies (BiDiTechs). The project “S.O.S. Metschacher Moos,” funded by the Austrian Biodiversity Fund, enabled initial measures to resume management activities, including control of invasive species, restoration of monitoring plots, and installation of a sensor network. Further research projects are underway, aiming to contribute to the assessment of biodiversity and ecosystem services in restoration initiatives.

*Ökosysteme renaturieren, Forschung ermöglichen:
Das Outdoor Lab Metschacher Moos*

ZUSAMMENFASSUNG

Anlässlich der Neuausrichtung der Forschungsvorhaben am Metschacher Moos werden in diesem Beitrag die wichtigsten Informationen zu Naturraum, Nutzungsgeschichte, bisherigen wissenschaftlichen Arbeiten sowie den geplanten Vorhaben zusammengestellt. Das Land Kärnten hatte das Gelände in einem Seitenarm des Glantales (Kärnten) langfristig gepachtet, um die im 20. Jahrhundert entwässerten Feuchtwiesen zu renaturieren. Mit dem Erwerb der Flächen durch die Kärntner Sparkasse Privatstiftung können diese Bemühungen und die wissenschaftlichen Arbeiten fortgeführt werden.

Es bietet sich die Möglichkeit, ein Forschungsgelände für Renaturierung und den Einsatz von Biodiversitäts-Technologien (BiDiTechs) zu entwickeln. Das Projekt „S.O.S. Metschacher Moos“ des Österreichischen Biodiversitätsfonds ermöglichte erste Maßnahmen zur Wiederaufnahme des Managements, darunter die Kontrolle invasiver Arten, die Wiederherstellung von Monitoring-Plots und die Installation eines Sensornetzwerks. Weitere Forschungsvorhaben sind im Lauf; sie sollen einen Beitrag zur Erfassung von Biodiversität und Ökosystemleistungen in Renaturierungsvorhaben leisten.

INTRODUCTION

RESTORATION NEEDS AND NEW TECHNOLOGIES (BIDITECHS)

The necessity of restoring degraded ecosystems is undisputed [1], and the UN Decade on Ecosystem Restoration 2021–2030 aims to contribute to this effort through a collective multilateral initiative. As a European contribution to this global endeavor, the Restoration Law (Regulation (EU) 2022/869) was enacted in 2024. This regulation has sparked significant discussion across Europe (e.g., [2]), which has also had an impact on Austria (e.g., [3]). The regulation obliges EU member states to ensure that, “by 2050, degraded ecosystems and habitats are restored to a good condition” [3]. As a first step, member states are required to submit restoration plans outlining the current data, planned measures, and priorities at sites.

The long-term nature and scale of this initiative present not only political, financial, and organizational challenges, but also significant ecological, technical, and scientific issues. Effective planning and monitoring of progress require appropriate technical tools. The systematic assessment of biodiversity and ecosystem services facilitates the development of new technologies. Additionally, it is essential to manage and process vast amounts of data across administrative and national boundaries and to represent them in time series.

KEYWORDS

- moor
- field lab
- restoration
- biodiversity monitoring
- technology
- sensor network

Dalton et al. [4] have categorized and described a wide range of technologies (BiDiTechs, see [5]) that are evolving at a remarkable pace. This rapid development, often referred to as a “technology leap,” is characterized by parallel advancements in different technologies that interact with one another, further accelerating progress. The most important technologies for biodiversity monitoring are found in the fields of earth observation (for ecosystems and habitats), optical and acoustic sensors (for species and populations), and genetic methods (molecular biology techniques, such as eDNA, for assessing genetic diversity and microorganisms).

However, there is a significant gap between the theoretically possible applications of these technologies and their practical implementation. This gap is due to challenges such as reliability, energy supply, weather resistance, insufficient and unreliable reference data, technical interfaces, and data transmission rates, among others. In general, there is a lack of reliable workflows, quality assurance tools, and user expertise. This highlights the need to test technologies, devices, and workflows in dedicated experimental sites.

The requirements for an experimental site include a relevant ecological research question— which in the case of Metschacher Moos is related to the restoration of a wetland—appropriate supporting infrastructures, favorable logistical and legal conditions including stable ownership structures, as well as high-quality and well-documented reference data.

These factors enable the swift validation of results, which is crucial for the testing and development of instruments. It is essential that the test site be available for an extended period and, ideally, can already reference historical data. This allows for better contextualization and calibration of results.

Such a test site is planned to be gradually developed at Metschacher Moos. It will serve as an outdoor lab for research and education that is conceptualized in this article.

THE RESEARCH SITE METSCHACHER MOOS: FROM WETLAND TO FARMLAND AND BACK

At the beginning of the 20th century, the extensive peatlands of the Glan Valley were considered the largest moorland in Carinthia [6]. Today, these peatlands have been almost entirely destroyed, with only a few remnant areas remaining. The Metschacher Moos, a wetland located in a side branch of the Glan Valley, was drained during the interwar period, converted into arable land, and intensively farmed. The drainage system consisted of three ditches and clay pipes laid in a herringbone pattern. Over time, the collapse of these pipes led to the gradual rewetting of the area. Between 1990 and 2020, the State of Carinthia leased this 14.6-hectare area and removed it from agricultural use. A long-term research project was initiated to observe secondary succession on the fallow wetland and to study vegetation development on former peat soils that had been used as farmland [6], [7], [8].



Figure 1: The valley floor at Metschach. The side arm of the Glan Valley between Zweikirchen and Maria Feicht is intensively used for agriculture. The Metschacher Moos has developed into an important refuge for fauna and flora; it is connected to the surrounding area through several rows of shrubs and hedges. The image shows the Metschacher Moos (elevation 520 m) behind the power pole in the middle ground of the picture, looking eastward, with the Ulrichsberg mountain (elevation 1,022 m) in the background. (Photo: Michael Jungmeier)

Abbildung 1: Der Talboden von Metschach. Der Seitenarm des Glantales zwischen Zweikirchen und Maria Feicht ist landwirtschaftlich intensiv genutzt. Das Metschacher Moos hat sich zu einem wichtigen Rückzugsort für Fauna und Flora entwickelt; es ist über mehrere Gehölzreihen mit dem Umland vernetzt. Das Bild zeigt das Metschacher Moos (SH 520 m) im Bildmittelgrund hinter dem Strommasten, mit Blickrichtung Osten, im Hintergrund der Ulrichsberg (SH 1.022 m). (Foto: Michael Jungmeier)

Fig.1

After the lease with the State of Carinthia had ended, the land changed ownership. In October 2023, the parcel owner attempted to convert the area back into farmland, partially plowing it. In response to this imminent threat, the Kärntner Sparkasse Foundation purchased the land with significant financial investment to preserve it for biodiversity conservation and research.

STARTER PROJECT S.O.S. METSCHACHER MOOS

Upon acquisition by the Kärntner Sparkasse Foundation, parts of the Metschacher Moos were plowed, invasive species such as goldenrod (*Solidago* spp.) were spreading, individual trees had fallen, and the majority of the significant monitoring plots were lost. The project *S.O.S. Metschacher Moos: Emergency Measures for the Restoration of a Degraded Habitat* (financed by the Austrian Biodiversity Fund) enabled critical immediate actions to secure the ecological and scientific potential of the area, including the restoration of grassland habitats, monitoring and control of invasive species, rehabilitation of damaged long-term monitoring plots, continuation of monitoring, and the installation of a sensor network. Additionally, the foundations for long-term management were established through an assessment of the hydrological situation, the development of a management plan, and the creation of a monitoring concept. Selected restoration measures were implemented, such as the establishment of succession areas, the resumption of maintenance mowing, and targeted individual interventions (for example, nesting aids for birds, bats, and wild bees). By the conclusion of the project in autumn 2025, key measures will have been implemented, putting the area back on the path to restoration. A detailed management plan ensures that the site will be maintained as a grassland ecosystem through mowing and grazing [9]. A follow-up project will explore gentle rewetting measures that naturally avoid any impacts on neighboring properties [10].

OUTDOOR LAB OF I.C.E.B.

On October 13, 2023, an agreement was signed between Carinthia University of Applied Sciences and the Kärntner Sparkasse Foundation to develop research and educational infrastructure at Metschacher Moos. This agreement establishes the legal framework for the long-term restoration of the area and secures research opportunities for the future. The site will serve as a platform for developing, testing, and calibrating methods and technologies for assessing biodiversity and ecosystem services.

The outdoor lab is operated by the university's Interdisciplinary Centre for Ecosystem Services (I.C.E.B.), which was established in 2024. The center's mission is to "make biodiversity measurable" while focusing on the development and testing of relevant technologies. Together with other test sites, particularly the transnational UNESCO World Heritage site "Ancient and Primeval Beech Forests of the Carpathians and Other Regions of Europe" (<https://whc.unesco.org/en/list/1133/>), the Metschacher Moos will enable the testing and deployment of biodiversity technologies (BiDiTecs) in various environments.

RESEARCH ACTIVITIES 1990 – 2025

TIME SERIES AND INVENTORIES

During the lease period by the State of Carinthia between 1990 and 2020, the area was repeatedly the subject of scientific research, particularly in the 1990s. Long-term monitoring of vegetational succession formed the backbone of these studies and was conducted, with interruptions, from 1990 to 2025 (see [7], [8], [11], [12], [13], [14]). An early comprehensive overview of various taxa, including plants, vegetation ecology, succession,



Figure 2: Outdoor Lab at the start of the 2025 growing season: The central strip of shrubs marks a drainage ditch. The northern area (on the right) has been mulched. It displays the typical patches of fallow vegetation, which arise due to patterns of random dominance by individual species. These patterns change with the seasons. The southern area (on the left) has been rotary tilled to control invasive plant species and is now undergoing succession again. (Photo: Ilja Svetnik)

Abbildung 2: Outdoor Lab am Beginn der Vegetationsperiode 2025. Der zentrale Gehölzstreifen markiert einen Entwässerungsgraben. Die Nordfläche (rechts) ist geschlegelt. Sie zeigt die typischen Patches der Brachevegetation, bedingt durch die Muster zufällige Dominanzen einzelner Arten entstehen. Die Muster wechseln mit den Jahreszeiten. Die Südfläche (links) ist zur Bekämpfung der Neophyten geerntet und unterliegt nunmehr wieder der Sukzession. (Foto: Ilja Svetnik)

Fig. 2

mollusks, spiders, butterflies, selected ground beetles, caddisflies, macrozoobenthos, birds, amphibians, reptiles, and mammals, was provided by Wieser & Jungmeier [6]. Bogner & Golob [15] compared the biodiversity development in Metschach with other fallow areas.

Specialized studies focused on specific taxa, such as true bugs [16], [17], [18], spiders [19], bats [20], and butterflies [21]. Köstl et al. [13] presented an interim evaluation of the years 1990 to 2020, noting that the anticipated development toward wet meadow vegetation had not yet occurred. They attributed this to ecological site factors, particularly nutrient availability and water supply, which had so far prevented the establishment of ecologically significant species and communities. They emphasized that the transformation of wet farmland into ecologically valuable areas requires long timeframes (see [22]). Similarly, Steinbauer et al. [14] highlighted the long-term perspective of renaturation and showed that prior land use (e.g., maize cultivation in the northern area and mixed crops in the southern area) continued to influence the site even after decades of fallow.

The findings suggest that establishing near-natural vegetation units at the site requires extended time periods. To support ecological restoration, future management efforts must prioritize ensuring an adequate water supply and maintaining suitable nutrient conditions.

RECENT RESEARCH ACTIVITIES AND PROJECTS

Currently, 29 vegetation-ecological plots are established at Metschacher Moos along three transects. Furthermore, four groundwater monitoring wells have been installed, along with 40 soil TMS4 Soil Logger sensors (TOMST s.r.o., Prague, Czech Republic) to measure temperature and moisture (Figure 3). In addition, six points have been designated for acoustic sensors, and five points have been designated for physicochemical and eDNA sampling of the soil. Research activities are already underway and are planned to be gradually expanded.

Furthermore, in order to promote native species of birds, bats and insects, several nesting aids and boxes have been installed in different location both for continued monitoring and educational purposes. The fields have undergone tilling and mowing. Seeds of local



Fig. 3

natural grasses and flowering plants have been sown onto the southern area, which is more heavily impacted by neophytes than the northern area. The fields will continue to receive extensive management from local farmers—both with machinery and cattle—in order to promote local flora and prevent the spread of invasive species.

BioMonitor4CAP: The Outdoor Lab in Metschach is part of the Horizon Europe project “BioMonitor4CAP,” which addresses ways to systematically monitor agricultural

Figure 3: Installation of ground-water monitoring wells. To enable continuous long-term monitoring of the groundwater level, a total of four gauges were installed within the research area in frame of the project S.O.S. Metschacher Moos. (Photo: Ilja Svetnik)

Abbildung 3: Setzen von Grundwasserpegeln. Im Rahmen des Projekte Metschacher Moos wurden zur laufenden langfristigen Beobachtung des Grundwasserspiegels im Forschungsgelände insgesamt vier Pegel gesetzt. (Foto Ilja Svetnik)

Figure 4: Spectrogram of a call of *Carduelis carduelis*. The European goldfinch, as identified by the BirdNet algorithm and verified by experts, is a characteristic bird of the site. This call was recorded in the frame of the project BioMonitor4CAP using a Song Meter Micro acoustic recording device at Metschacher Moos on 26 May 2024 at 8:12 a.m. (Source: own data, rendered by Kaleidoscope software, Wildlife Acoustics, Inc.)

Abbildung 4: Spektrogramm eines Rufs von *Carduelis carduelis*. Der Stieglitz, identifiziert durch den BirdNet-Algorithmus und von Experten verifiziert, ist ein charakteristischer Vogel des Standorts Metschach. Dieser Ruf wurde im Rahmen des Projektes BioMonitor4CAP am 26. Mai 2024 um 8:12 Uhr im Metschacher Moos mit einem akustischen Aufnahmegerät vom Typ Song Meter Micro aufgezeichnet. (Quelle: Eigene Daten, dargestellt mit der Kaleidoscope-Software, Wildlife Acoustics, Inc.)

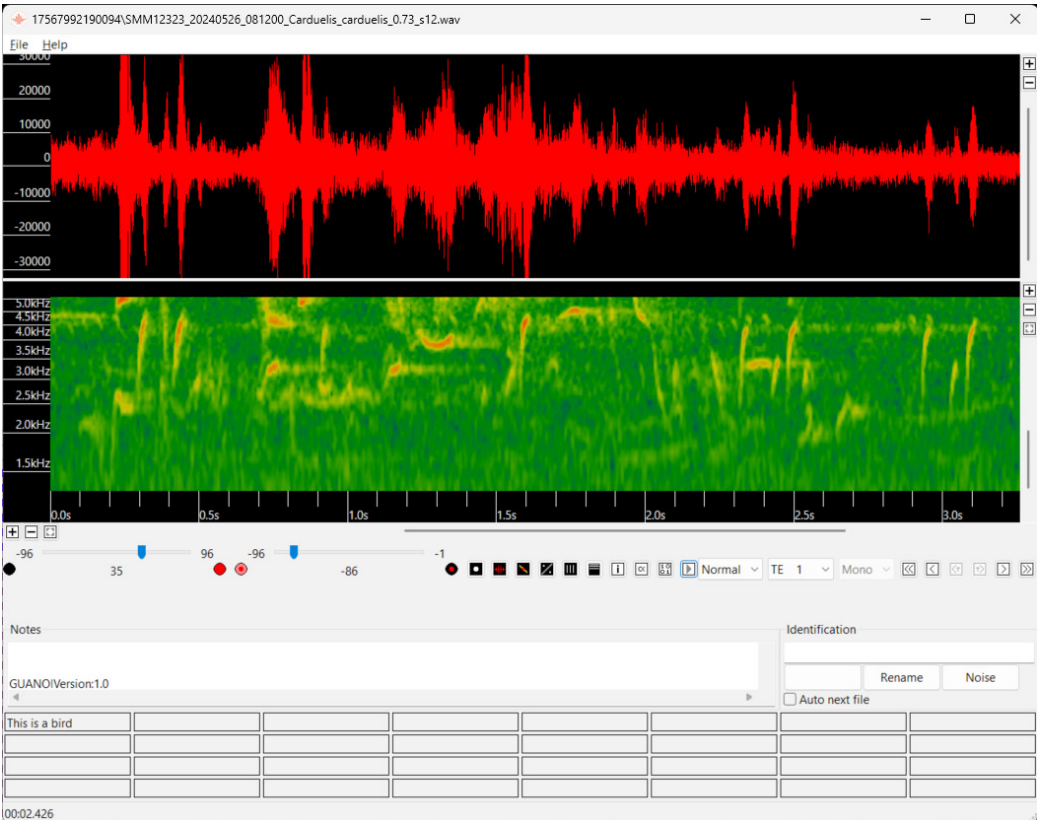


Fig. 4



Fig. 5

biodiversity and thereby contribute to the further development of the Common Agricultural Policy (CAP) of European states. The Metschacher Moos serves as a study area where various methods are employed, including remote sensing (satellites, drones), automated recording of bird songs using AudioMoth and Song Meter (Wildlife Acoustics, Inc, Maynard, MA, USA) devices (Figure 4), and insect monitoring using camera traps such as Insect Detect and Diopsis (Figure 5), as well as eDNA collection from the soil. The results are expected to be available in 2026.

BioDivTech Lab: As part of a project funded by the Austrian Research Promotion Agency (FFG), the I.C.E.B. is currently developing research infrastructure for the coming decade (see [5]). One module of this infrastructure is being implemented in Metschach. In addition to advanced biodiversity sensors, a database for species referencing and a climate station are being established. The climate station is intended to be integrated into the European LTER (Long-Term Ecological Research) network program in the medium term, thereby becoming part of a European research infrastructure [23].

Further Monitoring Efforts: Biodiversity monitoring in the area is to be continued or initiated. This aims to continuously document the overall development of the area. In addition to the continuation of vegetation ecological monitoring, plans include the continuation of the EU Grassland Butterfly Index [24], [25] (see <https://viel-falter.at/monitoring-en/>) and the establishment of a transect for the Farmland Bird Index [26]. The monitoring efforts will be designed and conducted in accordance with the international standards for biodiversity monitoring in Protected Areas and OECMs set by the IUCN [27], [28].

FUTURE PERSPECTIVES: TOWARD A COLLABORATIVE RESEARCH SITE

This article aims to provide an initial overview of the establishment of the Outdoor Lab at Metschacher Moos. The scientific results of the current research projects, particularly with regard to the BiDiTechs, are expected to be available soon and will offer deeper insights. The scientific infrastructure will continue to be developed, and the restoration

Figure 5: Automated insect monitoring. As part of the BioMonitor4CAP project, various methods for monitoring insects are being tested: Insect Detect (shown on the left), Diopsis Insect Camera (center), and the setup of a time lapse camera (in the background on the right). (Photo: Ilja Sventik)

Abbildung 5: Automatisierte Erfassung von Insekten. Im Rahmen des Projektes BioMonitor4CAP werden verschiedene Möglichkeiten zur Erfassung von Insekten getestet: Insect Detect (im Bild links), Diopsis Insect Camera (Bildmitte) und die Montage einer Zeitrafferaufnahmekamera (im Bild rechts hinten). (Foto: Ilja Sventik)

measures outlined in the management plan will be implemented step by step.

According to the agreement between the Kärntner Sparkasse Foundation and Carinthia University of Applied Sciences, the following priorities have been defined for research activities. In particular, the focus shall be on: a) Developing and maintaining a research site for biodiversity and ecosystem services; b) Applying, testing, and developing methods and tools for long-term environmental monitoring; c) Investigating specific aspects of biodiversity, ecosystem services, as well as ecosystem restoration and rehabilitation; and d) Making research results visible through publications and educational formats.

The Metschacher Moos is also open for activities of other research and educational institutions, with the aim of fostering the collaborative development and use of the site.

Future research activities will adhere to the following principles:

- **Open Data:** All environmental data will be made available for scientific reuse in accordance with the FAIR data sharing principles (metadata, primary data, results). Only sensitive data (e.g., nesting sites of rare species) will be excluded from this.
- **Open Access:** It will be ensured that relevant results are published and made publicly accessible. Wherever possible, this will be done through open-access publications. Access to the Metschacher Moos site will also be granted to research and educational institutions other than Carinthia University of Applied Sciences, in coordination with the university.
- **Minimum Impact:** The research site will be subjected to natural development as much as possible, based on the management and maintenance plan. Research and educational activities will be conducted with special consideration for sensitive species and habitats. New research projects must not compromise the outcomes of ongoing activities.

The Metschacher Moos thus serves as a unique platform for collaborative, open, and sustainable research and education, contributing to the understanding and preservation of biodiversity and ecosystem services.

REFERENCES

- [1] C. R. Nelson, J. G. Hallett, A. E. Romero Montoya, A. Andrade, C. Besacier, V. Boerger, et al., "Standards of practice to guide ecosystem restoration – a contribution to the United Nations Decade on Ecosystem Restoration 2021-2030," Rome, FAO, Washington, DC, SER, Gland, Switzerland, IUCN CEM, 2024, doi: 10.4060/cc9106en
- [2] A. Cliquet, A. Aragão, M. Meertens, H. Schoukens, and K. Decler, "The negotiation process of the EU Nature Restoration Law Proposal: Bringing nature back in Europe against the backdrop of political turmoil?" *Restor. Ecol.*, vol. 32, no. 5, p. e14158, 2024, doi: 10.1111/rec.14158
- [3] M. Jungmeier, "Wellen und Muster der europäischen Naturschutzpolitik in Kärnten – Das Beispiel Renaturierungsverordnung (RnV)," in *Kärntner Jahrbuch für Politik* 2024, Klagenfurt am Wörthersee: Hermagoras, K. Anderwald, K. Hren, and K. Stainer-Hämmerle, Eds., pp. 231–241, 2024, available: https://www.jahrbuchkaernten.at/fileadmin/jahrbuch/jahrbuecher/Jahrbuch_Politik_Kaernten_2024.pdf
- [4] D. T. Dalton, K. Pascher, V. Berger, K. Steinbauer, and M. Jungmeier, "Novel Technologies and Their Application for Protected Area Management: A Supporting Approach in Biodiversity Monitoring," in *Protected Area Management - Recent Advances*, IntechOpen, M. N. Suratman, Ed., 2022, doi: 10.5772/intechopen.99889
- [5] M. Jungmeier, A. Paulitsch-Fuchs, G. Paulus, and M. Schneider, "BioDivTech Lab – conceptualizing a new research infrastructure for biodiversity monitoring," *Carinthia Nature Tech*, vol. 2, no. 1, pp. 29–32, 2025, available: <https://phaidra.fh-kaernten.at/detail/o:54>
- [6] C. Wieser and M. Jungmeier, "Bracheprojekt "Metschach" – Naturschutzprogramm zur Rückführung von Ackerland in Feuchtwiesen: Ergebnisse der Jahre 1990-1992," Amt der Kärntner Landesregierung, *Naturschutz in Kärnten*, vol. 13, Klagenfurt am Wörthersee, 1994, available: https://e-c-o.at/files/publications/downloads/L02734_1994_Wieser_Jungmeier_Bracheprojekt_Metschach_compressed.pdf

- [7] C. Keusch, H. Kirchmeir, and M. Jungmeier, "Vegetationsentwicklung auf Feuchtbrachen - Das Projekt Metschach 1990 bis 2006," *Carinthia II Teil 2*, vol. 199, no. 119, pp. 413–432, 2009, available: https://www.zobodat.at/pdf/CAR_199_119_0413-0432.pdf
- [8] A. Fuchs, V. Berger, K. Steinbauer, T. Köstl, D. Wuttej, and M. Jungmeier, "The long-term effects of monoculture maize cultivation on plant diversity," *Phytocoenologia*, vol. 50, no. 4, pp. 397–408, 2021, doi: 10.1127/phyto/2021/0382
- [9] Arge NATURSCHUTZ, "Managementplan Metschach – Bericht 2024," Arge NATURSCHUTZ, Klagenfurt am Wörthersee, no. PN-2025/10/675-2, 2025
- [10] eb&p Umweltbüro GmbH, "Metschacher Moos Hydrogeologische Grundlagen – Technischer Bericht," eb&p Umweltbüro GmbH, Klagenfurt am Wörthersee, no. HYMA-24, 29 p., 2024
- [11] G. Dullnig, H. Kirchmeir, and M. Jungmeier, "Zur Vegetationsentwicklung auf Feuchtbrachen - das Projekt Metschach 1990 bis 1999," *Carinthia II Teil 2*, vol. 191, no. 111, pp. 465–495, 2001, available online at https://www.zobodat.at/pdf/CAR_191_111_0465-0495.pdf
- [12] M. Jungmeier and C. Wieser, "Bracheprojekt „Metschach“ Naturschutzprogramm zur Rückführung von Ackerland in Feuchtwiesen," *Carinthia II Teil 2*, vol. 183, no. 103, pp. 223–230, 1993, available: https://www.zobodat.at/pdf/CAR_183_103_0223-0230.pdf
- [13] T. Köstl, D. Wuttej, V. Berger, K. Steinbauer, A. Fuchs, and M. Jungmeier, "Vegetationsuntersuchung Metschach – 1990-2020," E.C.O. Institute for Ecology, Amt der Kärntner Landesregierung, Klagenfurt am Wörthersee, 52 p., 2020
- [14] K. Steinbauer, V. Berger, T. Köstl, D. Wuttej, H. Kirchmeir, and M. Jungmeier, "Abgrenzung von Vegetationseinheiten anhand multitemporaler Luftbilder am Beispiel von Feuchtbrachen," In T. Lumetsberger and A. Hörtl (Eds.): *19. Österreichische Botanik-Tagung, 23–25 September 2021*, Donau-Universität Krems, p. 22, 2021, available: <https://door.donau-uni.ac.at/detail/o:1409>
- [15] Bogner & Golob KEG, "Biodiversität auf Stilllegungsflächen: Zusammenhänge zwischen Artenschutz und Landwirtschaft – Endbericht," Amt der Kärntner Landesregierung, Büro für Ökologie und Landwirtschaft, Klagenfurt am Wörthersee, 211 p., 2003
- [16] T. Friess, "Die Wanzenfauna (Heteroptera) mehrjähriger Ackerbrachen mit Saumbiotopen im Glanfeld (Kärnten)" *Carinthia II Teil 2*, vol. 189, no. 109, pp. 335–352, 1999, available: https://www.zobodat.at/pdf/CAR_189_109_0335-0352.pdf
- [17] T. Friess, "Beitrag zur Kenntnis der an Grau-, Grün- und Schwarzerlen (*Alnus* spp.) vorkommenden Heteropteren in Südosterreich (Steiermark, Kärnten)," *Beiträge zur Entomofaunistik*, vol. 1, pp. 57–71, 2000, available: https://www.zobodat.at/pdf/BEF_1_0057-0071.pdf
- [18] T. Friess, "Fallow fields and nature conservation: Evaluation of protective measures on the example of the heteropteran fauna in Carinthia, Austria (Insecta: Heteroptera)," *Entomological Society of Austria*, vol. 9, pp. 8–10, 2003, available: https://www.zobodat.at/pdf/ENTAU_0009_0008-0010.pdf
- [19] C. Komposch, "Bemerkenswerte Spinnen aus Südost-Österreich I (Arachnida: Araneae)," *Carinthia II Teil 2*, vol. 190, no. 110, pp. 343–380, 2000, available: https://www.zobodat.at/pdf/CAR_190_110_0343-0380.pdf
- [20] D. Wieser, "Ergebnisse der Batcordererhebung des Kärntner Landesmuseums an heimischen Fledermäusen 2015 (Mammalia: Chiroptera)," *Rudolfinum - Jahrbuch des Landesmuseums für Kärnten*, 2015, pp. 371–383, available: https://www.zobodat.at/pdf/Rudolfinum_2015_0371-0383.pdf
- [21] P. Huemer and C. Wieser, "Neufunde von Schmetterlingen aus dem Gebiet des Bracheprojektes „Metschach“ (Zweifkirchen) (Lepidoptera)," *Carinthia II Teil 2*, vol. 187, no. 107, pp. 395–399, 1997, available: https://www.zobodat.at/pdf/CAR_187_107_0395-0399.pdf
- [22] K.-F. Schreiber, "Grundzüge der Sukzession in 20-jährigen Grünland-Bracheversuchen in Baden-Württemberg," *Forstw. Cbl.* vol. 116, pp. 243–258, 1997, doi: 10.1007/BF02766901
- [23] Directorate-General for Research and Innovation, "ERIC practical guidelines. Legal framework for a European Research Infrastructure Consortium," Revised, European Commission: Luxembourg (KI-01-25-077-EN-N), 2025, available: <https://op.europa.eu/en/publication-detail/-/publication/c8ca2717-15c4-11f0-b1a3-01aa75ed71a1/language-en>
- [24] C. M. van Swaay, R. Schmucki, D. B. Roy, E. Dennis, S. Collins, R. Fox, et al., "EU Grassland Butterfly Indicator 1990-2023 Technical report", *Butterfly Conservation Europe & EMBRACE/eBMS & Vlinderstichting report VS2025.014*, Version v3, 2025, doi: 10.5281/zenodo.17174718
- [25] J. Rüdiss, F. Barkmann, and M. Huss, "Tagfalter-Monitoring Metschacher Moos Jahresbericht 2025," University of Innsbruck, Innsbruck, 2025

- [26] N. Teufelbauer and B. Seaman, "Farmland Bird Index für Österreich: Indikator 2023 bis 2029," BMLUK, Vienna, 2024, available online at https://assets.ctfassets.net/2oszne1tuxgg/17MCMmQOSsxbYx1QhJMbOI/c46a08bb5031187124ddafdbecccc43fc/2024_Bericht_Farmland_Bird_Index_2023.pdf
- [27] D. T. Dalton, V. Berger, V. Adams, J. Botha, S. Halloy, H. Kirchmeir, et al., "A conceptual framework for biodiversity monitoring programs in conservation areas," *Sustainability*, vol. 15, no. 8, p. 6779, 2023, doi: 10.3390/su15086779
- [28] D. Dalton, V. Berger, H. Kirchmeir, V. Adams, J. Botha, S. Halloy, et al., "A framework for monitoring biodiversity in protected areas and other effective area-based conservation measures: concepts, methods and technologies," International Union for Conservation of Nature, IUCN WCPA Technical Report Series no. 7, 2024, doi: 10.2305/HRAP7908.

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