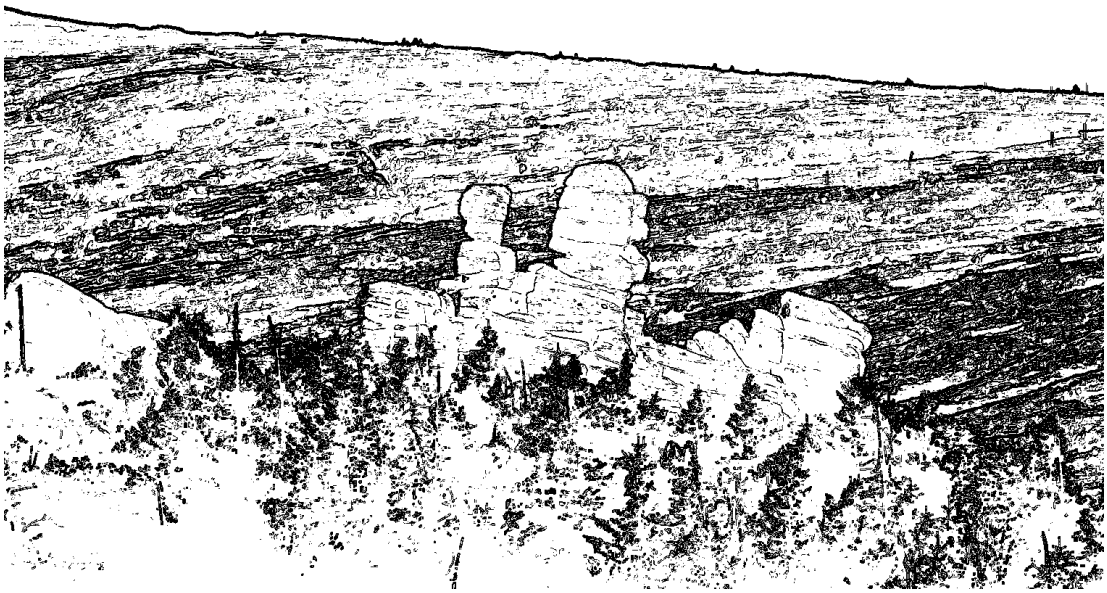
11TH INTERNATIONAL CONFERENCE
GEOECOLOGICAL PROBLEMS OF THE KARKONOSZE / KRKONOŠE MOUNTAINS

KARKONOSZE - OUTSTANDING GEODIVERSITY AND ITS IMPLICATIONS

BOOK OF ABSTRACTS



INTERNATIONAL GEODIVERSITY DAY 6TH OCTOBER 2023

JELENIA GÓRA - SOBIESZÓW

CONFERENCE PROGRAM

4th October 2023 - Wednesday

Since 17:00 - Arrival at selected hotels, registration of participants

5th October 2023 - Thursday

8:30 - 10:00 – Registration of participants
10:00 - 12:45 – Opening ceremony and invited presentations (A. Raj and invited guests)

(session chairman - M. Dobrowolski)

- P. Migoń - *Geodiversity – why important?*
- C. Kabała - *Spatial diversity of soils in the Karkonosze Mts. State of the art and future challenges*
- H. Marszałek - *Karkonosze waters and sustainable development of the region*
- D. Krause - *Geoconservation in the Krkonoše Mountains National Park*

12:45 - 13:15 – Coffee break

13:15 - 15:15 – **I Presentation session**

(presentations/discussion, session chairman - P. Migoń)

- Z. Zwoliński - *Designing a more precise geodiversity assessment standard for geoparks*
- A. Mantovani, V. Lombardo - *Enhancing geodiversity through semantic driven representation of the geosites - case study on Italian and Polish geosites*
- A. Najwer, A. Zielińska-Ligmann, P. Jankowski, Z. Zwoliński - *Geodiversity assessment of Karkonosze Mountains: A modeling approach and interpretation issues*
- A. Michniewicz – *Granite tors of the Karkonosze Mountains – the diversity of landforms and rock control implications*
- D. Krause - *Human as a key geomorphic agent of present: What does it mean for the nature?*

15:15 - 16:50 – Lunch

16:50 - 18:20 – **II Presentation session – "Cartographers Session"**

(presentations, session chairman - D. Wojnarowicz)

- Z. Jała, D. Wojnarowicz: - *Atlas Karkonoszy | Atlas Krkonoš as an effect of spatial data harmonization in Karkonosze national parks*
- W. Spallek - *Atlas Karkonoszy | Atlas Krkonoš: From the geoportal to the paper atlas - idea and designing*
- J. Potocki - *Socio-economic issues in the Karkonosze Atlas*

20:00 – Gala Dinner until late night

6th October 2023 -– Friday

9:00 - 10:40 – **III Presentation session**
(presentations and discussion, session chairman – J. Materna)

- K. Krakowski - *Integrated monitoring station in Karkonosze National Park, organization of the measurement system and selected results in the period 2017-2022*
- L. Kupkova, M. Potůčková, L. Červená, J. Lysák, J. Müllerová, S. Březina, Z. Hrázský, C. Hurford - *Towards reliable vegetation monitoring in the relict arcto-alpine tundra of the Krknoše Mts. using UAV multi-temporal data (four years of experience)*
- B. Jasiński, H. Ojrzyńska, M. Błaś - *Spatial patterns of drought episode occurrences across the Sudety Mountains*
- M. Danek, T. Danek, J. Chlapek - *Site conditions matter: Exploring the role of geodiversity and climate change on the future of larch in the Sudetes*
- V. Horáková - *Restoration of drained forests localities in the Krkonoše Mts. National Park*

10:40 - 11:20 – Coffee break + time for preparing Poster Session

11:20 - 13:40 – Poster Session

13:40 - 14:40 – **IV Presentation session**
(presentations and discussion, session chairman – V. Jansa**)**

- J. Harčarik, A. Čejková - *Interesting facts about the distribution of rare Krkonoše plants - outputs from the project "Monitoring the current distribution of vascular plants in the Krkonoše Mountains"*
- J. Harčarik - *Management of the Mountain pine plantations on the ridges of Krkonoše Mts.*
- K. Mikslová - *Conservation of the Black Grouse (Lyrurus tetrix) in the Krkonoše and Jizera mountains*

14:40 - 16:00 – Lunch

16:00 - 17:20 – **Continuation of the session IV**

- O. Kachalova, J. Houška, J. Červenka - *Large-scale remotely sensed mapping and monitoring of subalpine vegetation in the Jeseniky mountains*
- A. Sikora - *Bumblebees in Karkonosze: findings from citizen science observations*
- P. Petřik, M. Fabšičová - *The changing face of Arctic-Alpine tundra - changes in vegetation over half a century*
- M. Rogowski - *Overtourism in Karkonosze National Park - diagnosis, optimisation, prognosis*

17:20 - 18:00 – Conference summary, closing of the Conference
(chairmen: P. Migoń, A. Raj)

7th October 2023 – Saturday

9:30 - 14:30 – **Thematic field session**
(chairmen – H. Marszałek, K. Krakowski)

Szrenica Mt. (arrival by lift) - going to the top of Szrenica Mt. (presentation of the meteorological station of Karkonoski National Park), going to Twarożnik Rock, going down to the 'Pod Łabskim Szczytem' Shelter (discussion of water management issues in the context of drought in the entire Karkonosze region), return down.

15:00 - 16:00 – Lunch (at the "Siedlisko Pstrąga" restaurant in Mysłakowice Village) – participants of the field session can go there by own or organizers' cars.
16:00 – Departure of the participants

INTRODUCTION

The 11th International Conference „Geoecological Problems of the Karkonosze/Krkonoše Mountains" is a bilateral Polish-Czech scientific event with more than 30-years-long tradition. The conference is organized in the Polish part of the Karkonosze by the Karkonosze National Park, in cooperation with the Krkonošský Narodní Park and several academic partners. The main theme of the 11th International Conference is "Karkonosze – outstanding geodiversity and its implications". Emphasizing geodiversity, we want to highlight multiple values and various characteristics of the abiotic environment of the Karkonosze (geology, landforms, soils, climate, water conditions), many of which are unique on a European scale, and how they underpin biotic world, the history of human occupation and contemporary use.

By choosing the main theme and the dates of the conference we reffered to the global celebration of the World Geodiversity Day, established by UNESCO for 6 October each year and organized for the first time in 2022.

During the conference, the first two days are devoted mainly to very interesting lectures thematically related to issues such as:
- geodiversity of the Karkonosze
- geodiversity as a factor underpinning biodiversity of the Karkonosze
- geodiversity as a factor underpinning cultural heritage and contemporary use of the Karkonosze.

In addition, we familiarize you with selected aspects of work on the recently released publication - Atlas Karkonoszy/ Atlas Krkonoš, which is largely the result of cooperation between the two cross-border Karkonosze/ Krkonoše National Parks.

Organizing Committee

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PIOTR MIGOŃ

GEODIVERSITY – WHY IMPORTANT?

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Geodiversity as a scientific term was coined in the early 1990s and its first consistent use occurred in Australia. Semantically close to "biodiversity" and considered its inseparable twin (or "silent partner"), it is usually defined after Gray (2013) as "the natural range of geological (rocks, minerals, fossils), geomorphological (landform, processes), hydrological and soil features". However, it is not a mere catalogue of various features as the same author goes on to state that geodiversity "includes their [features] assemblages, relationships, properties, interpretations, and systems". "Relationships" may be considered as equivalents of "physical processes", included by other authors in their working definitions. Explained in this way, geodiversity becomes a framework to help better understanding of the abiotic world, with all spatial and causal linkages between different components that occur at or below the earth's surface. Interestingly, climatic elements and atmospheric processes are not explicitly included into definitions of geodiversity, although they are implicitly involved in many relationships, crucially influencing geomorphological processes, hydrological budgets and soil evolution.

Geodiversity has several parallels to biodiversity, which may be analysed at various spatial levels, from global to local, and means much more than simple numbers expressing how many species or habitats occur within an area of reference. Likewise, geodiversity is relevant to areas of different size, from elementary drainage basins through large geographical regions or countries to the global scale. It can also be expressed in quantitative terms, although the complexity of abiotic world and scale effects make the establishment of universal criteria and indices to be adopted everywhere very difficult, if not impossible. Therefore, geodiversity indices applicable to one area are not easily transferrable to another area, even though the individual components of geodiversity may be reasonably well known.

However, the most important parallel is that from human perspective geodiversity is no less important than biodiversity, despite being perhaps less exposed in the public debate. First, geodiversity is a vital part of "ecosystem services" ("geosystem services") and offers multiple benefits to the society. At least five categories of such

services may be recognized and these are: (a) regulatory services, (b) supporting services, (c) provisioning services, (d) cultural services, and (e) knowledge services (after Gray et al., 2013). Regulatory services are played by atmospheric and oceanic processes at the global scale, but hydrological processes, landforms and soils become important at the local scale, for example contributing to flood protection. The key example of supporting services is the underpinning of biodiversity by geodiversity, primarily via soils and water availability, in turn influenced by landforms and bedrock. Provisioning services relate to resources, many of which are non-renewable or renewable at temporal scales beyond the perspective of a singular human life and therefore require careful use. Among cultural services are the foundations provided by landforms to activities as different as the development of spiritual life at places considered sacred, art and literature, or the development of tourism and leisure activities, particularly geotourism. Finally, through understanding geodiversity we contribute to the development of geosciences and better appreciate the history of the Earth and its changes, which is more and more relevant in the current era of fast climate and environmental change.

Second, as biodiversity, geodiversity is under threat and any thoughts that the abiotic world does not suffer from irreversible alterations and hence, does not require special conservation action, are utterly wrong. Negative impacts on geodiversity may range from minor and localized to definite geodiversity loss over large areas, as occurs during large-scale mining operations, major infrastructural projects and urbanization. Common examples of action involving considerable geodiversity loss include invasive river engineering and “hard” coastal and slope protection. Less evident but no less important are impacts from excessive tourism, felt particularly in cave environments and on erodible grounds (dunes, volcanic cones). On the other hand, insufficient appreciation of geodiversity elements and their educational role may lead to the loss of visibility and restricted access if rehabilitation plans of former mining grounds are poorly designed or large-scale afforestation takes place hiding landforms of significant interest. The Sudetes are sadly a relevant example, with many localities of considerable geodiversity and geoheritage value, documented in literature and once tourist spots, being no longer accessible or visible.

CEZARY KABAŁA

SPATIAL DIVERSITY OF SOILS IN THE KARKONOSZE MOUNTAINS. STATE-OF-THE-ART AND FUTURE CHALLENGES

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Some people believe that soils in the Polish part of the Karkonosze Mountains are poorly diversified if they are in majority developed from a single rock, granite. Of course, it is not "a single rock", but a set of granite varieties, as well as metamorphic rocks and basalts, but it is true that most soils in these mountains have common chemical characteristics, that is, acidic reaction (low pH values) and low saturation with base cations, especially calcium and magnesium. However, the morphology, physicochemical properties, and ecosystem services of soils in Karkonosze Mts are significantly spatially diversified in relation to environmental factors, acting now and in the past. The first clearly recognisable spatial trend is reflected in soil depth and texture related to the altitude and intensity of geomorphic processes, including surface erosion, suffosion, and mass movements. It means that soils in the uppermost mountain zone are commonly are thin or very thin (initially developed) and skeletal or rocky due to removal of fine earth particles; whereas, soils in the lowermost zone (in the foothills and fluvial cones) have thick profiles and silty-loamy texture due to accumulation of fine particles. The second spatial trend has developed as the heritage of glacial and periglacial phenomena, which allowed the development of unique soils in the upper zone of the Karkonosze Mountains, absent not only in the lower mountain zone, but also in many other mountain ranges of Europe. These are in particular stony-blocky slope covers and dense subsoil layers developed by solifluction, which drastically accelerate or drastically hamper the water cycling within slope covers. The third spatial trend is related to vertical climate zonality. This trend, in particular, the temperature decreasing with altitude, may influence the soils indirectly, through climate-related vegetation, and led to a predominance of brown soils (Cambisols) in the lower zone with deciduous forests, while Podzols in the upper mountain zone with coniferous forests. The climatic trend, as an increasing climatic water balance with an altitude, may also influence soils directly. The soils in the lower mountain zone have a 'normal' moisture status, while the soils in the upper zones are

affected by stagnant or seasonally stagnant water. In the first case, unique Stagno-Podzols develop with thick layers of undecomposed organic matter on the surface, while the unique subalpine peat soils (Histosols) develop in the second case. The specifically harsh climate of the subalpine zone led to the development of unique organic soils 'suspended' in the blocky covers. Of course, the above-mentioned trends cannot be considered separately, as they overlap spatially and produce a continuum of local biotops. Thus, apart from general altitude-related zonality, similar to latitude-related zonality in the northern hemisphere, soil cover in the Karkonosze Mountains reflects a specific spatial geo-bio-climate-related diversity. The present-day soil diversity in the Karkonosze mountains is threatened by climate change. The increase in temperature and changes in soil moisture regime may lead to decomposition of thin organic layers and disappearance of unique subalpine mineral-organic soils, such as Stagnic Histic Podzols, Hyperskeletic Histosols, and Folic/Histic Stagnosols. It may also lead to fossilisation of some Podzols and simplification of soil diversity to the Cambisol-Podzol model, typical for dry temperate mountains.

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DAVID KRAUSE[1], VLASTIMIL PILOUS[1]

GEOCONSERVATION IN THE KRKONOŠE MOUNTAINS NATIONAL PARK

[1]*The Krkonoše Mountains National Park Administration; dkrause@krnap.cz*

The non-living elements of our highest mountain ranges serve as the cornerstone of their natural wealth, featuring geological and geomorphological characteristics that are unparalleled, even when viewed on a European scale. While the non-living components of these landscapes may appear less vulnerable at first glance compared to their living counterparts, they require targeted conservation efforts, especially given that their damage is often irreversible. Recognizing this imperative, the Krkonoše Mountains National Park Administration has embarked on a project to comprehensively inventory the geomorphological phenomena within its boundaries. This initiative aims to support the future protection and preservation of these invaluable geological and geomorphological treasures for generations to come. The project was carried out from 2019 to 2023, covering a total mapping area of 550 square kilometers. In addition to well-known landforms, new information about the presence of periglacial and slope phenomena in previously undocumented areas was discovered. Furthermore, novel insights into the human impact on the Krkonoše nature were uncovered. The project is closely linked to research conducted in collaboration with universities and the Czech Academy of Sciences. Among other achievements, the project refined the retreat chronology of the Elbe Valley Paleoglacier. Currently, two popularizing publications are in preparation. The project's outcomes serve practical purposes in the conservation of the national park's natural resources, as well as in the subsequent monitoring and research efforts.

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ALIZIA MANTOVANI[1] AND VINCENZO LOMBARDO[1]

ENHANCING GEODIVERSITY THROUGH SEMANTIC DRIVEN REPRESENTATION OF THE GEOSITES – CASE STUDY ON ITALIAN AND POLISH GEOSITES

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The geosites are the representation of outstanding elements of geodiversity, and most of them are suitable to be accessible to the non-scientific community (such as tourists or students) as a showcase of the natural geodiversity of our planet. In literature, a geosite is defined as a territory with some element of geodiversity that has some interest that makes it worthy to be preserved for future generations. Hence, it is important to describe the geosite and to share the information about them in the best way possible, for allowing the users to both understand them and facilitate scientific studies. In fact, many nations have their own inventory of geosites, often accessible through GIS web applications in which the geosites are localized and queueable. Some examples are the Italian[1], Polish[2] and Brazilian[3] geoportals: in all of them, the national geosites are localised and related to a database with descriptive metadata. However, metadata are mostly textual descriptions that present two main problems: (i) ambiguous expressions that are subjectively interpreted based on individual training and experience and, consequently, (ii) a harder automatization of data processing. An example to explain the ambiguities of the textual description, we cite an example from the Piedmont region, the Conca del Pra[4] geosite. Among the numerous elements of geodiversity that are present in the geosite, there is the reference to mixed fans (of different origin) and landslides accumulations. This description mixes geometrical and genetic description of the feature, without being explicit, e.g., about the material and the precise process.

With this contribution, we show how semantics can support a different representation of the knowledge about the geosites which allows for easy sharing and interoperability of data, to support projects at a national and trans-national scale, as every item of a database would be described with a homogeneous set of rules. Hence, in the Conca del Pra geosite, each geodiversity element will be described under a set

of rules that make explicit every information: for example, for the single fan, the process, the material, and every other relevant and known information.

Moreover, we also notice that different national databases schemata are often mutually incoherent. An example of this aspect lies in the description of the material: taking as reference the Italian, Polish and Brazilian geosite databases (Fig.1), we will see that every database has its own display of lithological information. Italian and Polish databases are more similar, displaying all the info within the same field, while the Brazilian one has specific fields for every type of rock (sedimentary, igneous and metamorphic).

Fig.1 - How lithology information is displayed in the Brazilian (on the left side), Polish (on the upper side) and in the Italian (on the lower side) geosite viewers

We propose to harmonise the data representation by introducing a semantic backbone, with the final goal of wide data comparison, retrieval, and processing. Semantic formalisation has been advocated by major international organisations to improve data sharing and interoperability. Knowledge about geosites can be described leveraging on concepts that are accepted and shared by the global scientific community, through the international standard for the geosciences (GeoScienceML[5] and INSPIRE[6], and the CGI[7] standard vocabularies). Concepts, symbolising geologic features that include geodiversity elements, are encoded into ontologies, with stable, coherent and unambiguous mutual relations, that underlie a database schema in which a geosite can be described rigorously. Our base ontology is OntoGeonous ontology, an ontology for the geosciences based on the GeoScienceML standard (Lombardo et al 2018[8]; Mantovani et al 2020[9]).

The idea is that every relevant aspect concerning the geosite can be described following the rules of the ontology. For example, the fields of a database for the

geosites can be related to a coherent property of the ontology. A similar field in another database can be related to the same ontology property. In this way, those similar fields will be put into a formal relation and can be comparable. Moreover, if common vocabularies are used for similar fields, then the comparison will be easier. For example, let's consider the description of the rock type, already cited in the picture above. Despite the different title, label, approach or language used to name and fill that field, all of them can be related to the same property "has Lithology", an encoded property coming from GeoScienceML standard and adopted in OntoGeonous.

Despite the interface choices, that information will be explicitly referred to that precise topic. Finally, we suggest connecting the used term to encoded standard vocabularies, to ensure the unambiguity of description.

We apply this approach to case study that comprises geosites from Italy (chosen from Sesia Val Grande UNESCO Global Geopark) and from Poland (chosen from the Wolin and the Karkonosze National Parks), with the goal to provide a shared representation and improve mutual projects.

In conclusion, our system should be able to represent all the relevant information about a geosites, in order to support a complete knowledge when considering the single geosite. At the same time, however, it should be also able to allow the communication about different databases of geosites, supporting the comparability of information among different regions and countries.

Sitography

1 http://sgi1.isprambiente.it/GFMaplet/?map=geositi_reader&token
2 https://cbdgportal.pgi.gov.pl/geostanowiska/
3 https://geoportal.cprm.gov.br/geosgb/
4 http://www.cittametropolitana.torino.it/cms/risorse/ambiente/dwd/difsuolo-attestrat/difesa-suolo/
attivita-di-ricerca/geositi/volume1/val_pellice.pdf
5 https://geosciml.org/
6 https://inspire.ec.europa.eu/
7 https://cgi.vocabs.ga.gov.au/vocab/
8 Lombardo, V., Piana, F., Mimmo, D. (2018) - Semantics–informed geological maps: Conceptual modeling
and knowledge encoding. Comput. Geosci. 116, 12–22.
https://doi.org/10.1016/j.cageo.2018.04.001
9 Mantovani, A., Piana, F., Lombardo, V. (2020) - Ontology-driven representation of knowledge for
geological
maps. Computers & Geosciences. 104446. 10.1016/j.cageo.2020.104446.

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ALICJA NAJWER[1], ARIKA LIGMANN-ZIELIŃSKA [2], PIOTR JANKOWSKI[1,3] AND ZBIGNIEW ZWOLIŃSKI[1]

GEODIVERSITY ASSESSMENT OF KARKONOSZE MOUNTAINS: A MODELING APPROACH AND INTERPRETATION ISSUES

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[2]Department of Geography, Environment, and Spatial Sciences & Environmental Science and Policy Program, Michigan State University, East Lansing, MI, USA
[3]Department of Geography, San Diego State University, USA

The geodiversity assessment is particularly important in the mountainous regions. Recognizing the areas that are the most diversified and vulnerable to changes is a key issue in the management and planning of protected and conserved areas (PCAs). The research area selected was the Karkonosze National Park (KPN), located in southwestern Poland, on the border of Poland and the Czech Republic. The Polish part of KPN covers the northern slopes of the Karkonosze, the largest range of the Sudetes.

Geodiversity assessment methods can be divided based on data sources into direct and indirect methods, and based on the assessment procedure into qualitative, quantitative, and mixed - qualitative-quantitative. Each of these categories introduces ambiguity, relying on expert assessment or interpreted geospatial data rather than direct measurements.

The geodiversity of KPN was evaluated with two multicriteria techniques: Weighted Linear Combination (WLC) and Local Weighted Linear Combination (L-WLC) basis on selected criteria: 1) lithology, 2) relief energy, 3) geomorphology, 4) land use/land cover, 5) soils, 6) mesoclimate, and 7) hydrography. Input datasets included 1 m DEM and thematic map layers: lithological, geomorphological, hydrographical and soils features as well as CORINE Land Cover. The 1-order catchments were delineated for the research area and used as spatial units for geodiversity assessment.

The main objective of the presentation is to introduce an approach to qualitative-quantitative geodiversity assessment based on spatial multicriteria analysis (S-MCA) along with a proposal to use crowdsourcing, uncertainty and sensitivity analysis to enhance the reliability of the model results. Geodiversity assessment usually involves an individual expert or a group of experts who assess the value of geodiversity factors to the overall geodiversity score for a study area. The biggest objection to methods

used so far is subjectivism. Responding to these objections, a crowdsourcing online tool called geo-questionnaire linked with an interactive map was used to obtain data from 57 Earth science researchers worldwide. These data served as the bases for a joint assessment of geodiversity. The reliability of assessment was evaluated by means of spatially explicit uncertainty analysis and then spatially explicit global sensitivity analysis (GSA). The results helped to identify highly geodiverse areas that are burdened by high uncertainty and then to investigate which specific criteria contribute to the uncertainty the most. This could be valuable in monitoring and management of PCAs and significantly contribute to improving the existing results of geodiversity assessments and some savings resulting from field work.

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ALEKSANDRA MICHNIEWICZ

GRANITE TORS OF THE KARKONOSZE MOUNTAINS – THE DIVERSITY OF LANDFORMS AND ROCK CONTROL IMPLICATIONS

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Tors are common and very characteristic landforms of the Karkonosze Mts landscape and a hundred of tors are estimated in the entire area. The granite part of the ridge abounds in various rock landforms protruding from the wide slopes and the valley sides. The genesis and distinctive morphology of the tors has been considered from geological and geomorphological point of view (e.g. Berg 1927, Jahn 1962, 1974, Dumanowski 1968, Bartošíková 1973), but until the date the problem of the conditions of the tors development remains still open. The origin of the Karkonosze tors were generally explained by two-stage model proposed by David Linton, but these results from 60 and 70 not including a regular and comprehensive research have mostly a conceptual character.

The main objective of this study was to research and analyse structural features, morphology and subsurface structure of granite tors to find more about it and to examine the previous hypothesis about chemical weathering and stripping. The research is based on several field works applying the various method – geomorphic mapping, strength and joints measurements and Electrical Resistivity Tomography. Study sites involving singular forms and groups of tors situated on the slope and watershed settings about altitude 1000 to 1400 m a.s.l. The research also included spatial analyses in GIS (Geographic Information Systems) especially the distribution of tors against the background of topographical and geological features of slopes.

In the Polish part of the Karkonosze Mts granite tors are distributed along the main ridge, mainly as singular tors or tor groups located apart from each other, protruding from convex slope breaks. Over 40 % of the tors occur on the 1000-1100 m range of altitude, on the second-ordered northern ridges. The geology of the tors represents two main type of granite – coarse-grained porphyritic and equigranular with noticeable dominant of the former. The tors built of porphyritic granite evince relatively lower strength of rock mass than landforms with equigranular texture. Regular and orthogonal joint pattern dictates similarities in the morphology of tors –

the presence of parallel elongated rock ridges, towers and blocks (mostly NE-SW direction). The ERT results indicate that protruding rock forms are embedded in massive part of granite bedrock and major vertical joint sets shaping various landforms also continue below the surface.

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David Krause[1,2]

HUMAN AS A KEY GEOMORPHIC AGENT OF PRESENT: WHAT DOES IT MEAN FOR THE NATURE?

[1]*The Krkonoše Mountains National Park Administration*

[2]*Department of Physical Geography and Geoecology, Faculty of Science, Charles University*

This poster delves into the escalating human influence on the natural terrain within the boundaries of Krkonoše Mountains National Park and its protective buffer zone. It provides specific instances of both historical and contemporary human interventions, along with quantifications of the displaced material. The Krkonoše region has witnessed surface and subsurface mining activities since medieval times. Furthermore, timber extraction and agricultural practices have compelled human alterations to the landscape. However, the infrastructure developments and recreational transformations of the last five decades have had a significantly more profound impact on the surface including valuable landforms compared to interventions spanning previous centuries. There is a noticeable increase in the extent and volume of surface modifications. In most cases, these interventions lead to irrevocable changes in the natural surface, leaving a lasting mark on the landscape for millennia. Many of these alterations also disrupt the natural water regime and modify habitat conditions. If society's objective is to safeguard the natural heritage of the national park for the benefit of future generations, it is imperative to minimize surface modifications when constructing new facilities or modifying existing ones.

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ZYGMUNT JAŁA[1], DOROTA WOJNAROWICZ[1]

ATLAS KARKONOSZY | ATLAS KRKONOŠ AS AN EFFECT OF SPATIAL DATA HARMONIZATION IN THE KARKONOSZE NATIONAL PARKS

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Atlas Karkonoszy | Atlas Krkonoš was created as one of the results of the project "*Common approach to the management of the Karkonosze National Parks*" implemented from the Interreg V-A Czech Republic - Republic of Poland program. It was a continuation former project "*Karkonosze in INSPIRE - common GIS in nature protection*", in which we started harmonizing spatial data of both parks. At that time, a number of natural data (such as tourism, Natura 2000, fauna, flora, peatland ecosystems, forests, geology, geomorphology, soils, technical infrastructure) were harmonized and then made available to the public through a joint Polish-Czech geoportal. In the project *"Common approach…"*, work on harmonizing the data continued, covering further issues: climate and hydrology, as well as the historical and economic background of the Karkonosze Mts. For the first time, an orthophotomap of both national parks was prepared using single airplane flight.

The harmonized data became the starting point for developing the first joint Strategy for managing national parks on both sides of the border. For its development, in addition to the data harmonized in accordance with the INSPIRE directive, an analysis of Polish-Czech legislation in the field of nature and environmental protection and socio-economic studies of tourist traffic were also performed. The project has thus provided the necessary knowledge to make the realization of mutual goals in nature protection and park access even more effective.

Atlas Karkonoszy | Atlas Krkonoš is a kind of summary of both the project itself and the many years of cooperation between the two Karkonosze national parks. It is aimed at popularizing the results of data harmonization and popularizing knowledge of the nature of the whole Karkonosze Mountains. In accordance with this assumption, all the cards in the atlas present transboundary maps and contain harmonized legends, arranged according to national systematics and typologies of the presented phenomena. The idea of the atlas authors was to create a publication that can be used both in education conducted by parks and in school education, so the topics are presented in the most accessible way possible.

The main topics of the Atlas are: Karkonosze region (min. physical-geographical divisions), Karkonosze on old maps, Landscape (land cover), Inanimate nature (Karkonosze relief, geology, soils, climate, waters), Animate nature (non-forest vegetation, forests, peat bogs, fauna - selected species), Nature protection (zoning of protection, Natura 2000, ecological corridors, Biosphere Reserve), Settlement (population distribution, settlement changes, transportation) and Tourism (summer and winter activities). A team of scientists who have been conducting scientific research in the Krkonoše Mountains and working with the Krkonoše National Parks for years was engaged to develop the various topics of the Atlas. They represent, among others: Wroclaw University, Poznan University of Life Sciences, Wroclaw University of Life Sciences, Wroclaw University of Economics and Charles University in Prague. It should be emphasized, however, that the authors also included a number of specialists who are employees of both national parks and who cooperate on a daily basis on specific topics.

The technical and hardware resources of both institutions were also included in the harmonization process. **Atlas Karkonoszy | Atlas Krkonoš** was created entirely on the basis of the GIS databases of the national parks, developed during many years of cooperation. All maps were made in ESRI's ArcGIS software, based on existing thematic map standards or, in the absence of such standards, on individual indications of the cartographic editor.

In 2021, the publication took first place in the 6th international competition "Best publications about the mountains", held as part of the 24th International Book Fair in Krakow. In the same year, the Atlas also received the first prize and the audience award in the "Map of the Year 2021" competition organized by the Association of Polish Cartographers in the "Other maps and atlases (printed)" category.

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WALDEMAR SPALLEK

ATLAS KARKONOSZY | ATLAS KRKONOŠ: FROM THE GEOPORTAL TO THE PAPER ATLAS — IDEA AND DESIGNING

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In the beginning of digital cartography the paper maps served as the main source of geoinformation, especially on natural components of environment, like geology, soils, biogeography, as well as relief, etc. In next decades, particularly in the 21st century we observe rapid growth of web cartography, including perhaps the most complex forms, which are geoportals. Some of them contain many thematic maps (geovisualisations) and in a matter of fact play a role of the paper atlases, both thematic and complex ones.

The paper maps and atlases are still published, though digital cartography seems to take a place of them. However, now we can notice, that the geoportals allow to prepare maps for printing, and some of them become the basis for the designing of paper atlases. One of a such example is the "Atlas of the Karkonosze | Krkonoše" (2021), joint work of Polish and Czech National Parks employees (especially GIS specialists) and cooperating with them scientists, and a cartographer amongst them.

The presentation focuses on some aspects designing the paper atlas, especially on transformation of virtual, interactive geovisualizations from the KPN | KRNAP Geoportal to static atlas tables. The main problems of that transformation are layout and colours designing, and cartographic generalisation of large scale database properly to cartographer and users need.

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KRZYSZTOF KRAKOWSKI

INTEGRATED MONITORING STATION IN KARKONOSZE NATIONAL PARK, ORGANIZATION OF THE MEASUREMENT SYSTEM AND SELECTED RESULTS IN THE PERIOD 2017-2022

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Integrated Monitoring of the Natural Environment, operating as part of the Polish State Environmental Monitoring, aims to provide information on the condition and development trends of selected geoecosystems in Poland and to indicate the types of threats to their natural environment. The basic task of integrated monitoring is to monitor selected elements of the environment based on concentrated and intensive stationary research. The scope of research conducted within Integrated Monitoring refers to the European Integrated Monitoring program (International Co-operative Program on Integrated Monitoring on Air Pollution Effects), which supports the implementation of the United Nations Economic Commission for Europe Convention on Long-range Transboundary Air Pollution (1979).

The integrated monitoring of geoecosystems refers to the simultaneous measurement of physical, chemical and biological properties of an geoecosystem over time and across compartments at the same location. In practice, monitoring is divided into a number of compartmental subprogrammes which are linked by the use of the same parameters (cross-media flux approach) and/or same/close stations (cause-effect approach).

Natural resources constitute a basic value, the good of monitored geoecosystems, important for the societies of the country, the continent, the Earth - for their existence and development. We appropriately monitor and document emerging conflict situations regarding the relationship between humans and natural resources. A very important issue in the monitoring of natural resources is the recognition of feedbacks occurring between various manifestations of human activity and natural resources.

Integrated monitoring station "Karkonosze" was established in 2015, and the implementation of the full research program began in 2017. The institution managing the station is the Karkonosze National Park. The IM station "Karkonosze" station is one of the 12 currently operating IM stations in Poland.

The catchment area of the Wrzosówka river with an area of 11.49 km^2 is the basic research facility where the integrated monitoring program is implemented by the IM station "Karkonosze". The buffer zone of the research catchment of the Wrzosówka river is the entire area of the Polish Karkonosze National Park together with the park's buffer zone.

The Wrzosówka catchment is representative of the entire area of the Karkonosze Mountains and combines mountain and boreal elements. The first undoubtedly include the geomorphology and the developed climatic and plant levels - from the lower mountain range to the subalpine level. Boreal elements are represented by a number of plant communities and species of plants and animals, many of which ae glacial relics. Numerous plant communities constitute Natura 2000 habitats, including priority ones.

It is also worth highlighting little human interference in the nature of the upper part of the Wrzosówka catchment, because unlike other high parts of the Karkonosze Mountains, in this area, apart from a few small mountain huts, there are no concentration of tourist facilities. The human impact becomes more and more noticeable as the altitude of catchment decreases, but it is relatively small. The catchment closure is located in a built-up area, in the Jelenia Góra-Jagniątków district.

The paper presents selected results from the implementation of integrated monitoring research programs at the IM “Karkonosze” station in the period 2017-2022. The obtained results are the basis for assessing the initial state of the geoecosystem of the Wrzosówka river research catchment. Based on these results, the current condition of the geoecosystem of the Wrzosówka river catchment can be described as good.

However five years of full operation of the Karkonosze integrated monitoring station is still too short to draw far-reaching conclusions on this basis. Measurements carried out in the coming years will allow in the future to determine development trends and formulate forecasts of short- and long-term changes in the natural environment of the research catchment of the Wrzosówka river and its buffer zone.

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TOWARDS RELIABLE VEGETATION MONITORING IN THE RELICT ARCTO-ALPINE TUNDRA OF THE KRKONOŠE MTS.: DEVELOPMENT OF A METHODOLOGY BASED ON UAV MULTI-TEMPORAL DATA

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The Central European relict arctic-alpine tundra (alpine treeless) is a rare ecosystem consisting of a combination of arctic-subarctic and alpine landforms and biota. It is characterized by harsh climatic conditions, pedological, geological and geomorphological diversity and high species diversity, including endemic species and glacial relicts (Soukupová et al., 1995). Due to its unique characteristics, alpine tundra is one of the most valuable natural phenomena. Habitats above the treeline are adapted to specific conditions and are therefore highly sensitive to disturbances and environmental changes such as warming, atmospheric pollution, drought and anthropogenic disturbances (Grabherr et al., 2010; Verrall and Pickering, 2020; WRI, 2005; Hejcman et al, 2009).

Accurate and reliable monitoring methods are essential for effective protection of vegetation above the treeline. In addition to traditional field monitoring, remote sensing technology (RS) represents a promising alternative. RS is advantageous because of its ability to monitor small and large areas at different spatial and temporal scales in a repeatable manner (Beamish et al., 2020; Kupkova et al., 2017; Suchá et al., 2016; Wakulińska and Marcinkowska-Ochtyra, 2020; Zagajewski et al., 2005).

The reliability of RS technology is essential for effective operational use in conservation practice. Therefore, for the purpose of UAV based methodology development, four years of testing of different types of UAV RS data (multispectral, hyperspectral, LiDAR data) for monitoring of 4 permanent plots with different vegetation/habitat types in the Krkonoše tundra was carried out within the project

"Development of methods for monitoring vegetation changes in the Krkonoše tundra using multispectral, hyperspectral and LIDAR sensors from UAVs 2019-2023". The pilot project was carried out in cooperation with botanists from the Botanical Institute of the CAS in Průhonice, who provided field mapping of vegetation as ground support for the analysis of the UAV data. For each permanent plot, data were acquired by all sensor types (RGB, multispectral - MSS, hyperspectral, LiDAR) four times per season (approximately mid-June, July, August and September) in all 4 years by RS specialists from Charles University, Faculty of Science and the Krkonoše Mts. National Park Administration. Different methods of data analysis were tested and the methodology was proposed based on the results obtained in the project.

The purpose of the methodology is to contribute to the protection of the desired species composition and biodiversity in the Krkonoše National Park above the upper forest boundary.

The aim of the methodology is to quantify the areas of selected vegetation types in defined permanent areas of the eastern and western arctic-alpine tundra at regular time intervals and to determine the extent and form of changes in these vegetation types/habitats using UAV data and supporting botanical data collection.

While some vegetation types (dwarf pine, spruce stands - Picea abies (L.) H. Karst.) and their changes are reliably distinguishable from orthophotomaps or satellite images with high spatial and temporal resolution (e.g. PlanetScope satellites), extremely high spatial resolution data, i.e. data from UAV imagery, are necessary to accurately identify and detect changes in most vegetation types/species occurring in habitats above the treeline.

The developed methodology takes into account the following key monitoring parameters:

- very high classification reliability (repeatability)
- high spatial resolution (capturing changes)
- easy feasibility (sustainability)
- affordability (sustainability)

The methodology is divided into analytical and implementation parts. The analytical part provides the background and arguments for the decision on the final form of monitoring. It is based on current literature sources and on the experience and results obtained during the 4 years of work on the above-mentioned project. The implementation part is based on the findings and conclusions of the analytical part. It contains concrete proposals for the different aspects and steps of the monitoring.

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BARTOSZ JASIŃSKI [1], HANNA OJRZYŃSKA [1], MAREK BŁAŚ [1]

SPATIAL PATTERNS OF DROUGHT EPISODE OCCURRENCES ACROSS THE SUDETY MOUNTAINS

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In many areas around the world, including the Sudetes, we are witnessing climate changes. Winter seasons are shortening, the frequency of hot days is increasing and heat waves become longer. The duration of precipitation gets shorter and its average intensity increases. This translates into increased risk of atmospheric drought, but also of soil drought, which creates a significant threat to, among others, forest ecosystems, with particular emphasis on spruce ecosystems. Due to their shallow root system, spruces are more exposed to this type of weather anomalies than other species.

The purpose of the study is to analyze the frequency and intensity of atmospheric drought in the Sudetes. Therefore, data on precipitation from 71 stations and air temperature from 25 meteorological stations were collected. The analysis covers period 1961-2020 and was carried out with a decadal resolution. The collected data were used to calculate 7 drought indices, four of which have a climatologically dimension. They are based on precipitation (SPI - Standardized Precipitation Index and RPI - Relative Precipitation Index) or combined precipitation and air temperature (SPEI - Standardized Precipitation Evapotranspiration Index and HTC - Hydro-thermal Coefficient of Selyaninov). The remaining three indices characterize the growth conditions of coniferous/spruce ecosystems: AI (De Martonne Aridy Index), EQ (Ellenberg index) and MT (Mayr Tetratherm Index). The series of air temperature, precipitation and index values were tested using regression analysis, then linear trends were determined together with their equations, R^2 and *p* level with R pacages. Then the data series were additionally tested for the presence of trends by the Mann–Kendall test.

In the first stage of the study, for each of the 25 analyzed stations in the Sudetes, an increase in the average decadal air temperature was found, ranging from 1.1°C to 2.6°C. The increasing trend in temperature was statistically significant in all analyzed stations. The average difference between the decade 1961-1970 and 2011-2020 was

1.8°C. Taking into account the average vertical temperature gradient (0.6°C/100 m), this value indicates a shift of thermal climate zones by approximately 300 m upwards. An analysis of the temporal variability of annual and monthly sums of precipitation was also carried out. On an annual basis, no statistically significant trends and high variability from year to year were found. The largest negative anomalies occurred in the decade 2011-2020 and were observed mainly in the Western Sudetes. Karpacz station stands out the most in this respect (reduction reaching 12%). On a monthly basis, the most downward trend in precipitation totals (statistically significant) was observed in April and November and was very visible in the area of the Western Sudetes.

Due to the use of various drought indices, it was shown that in the Sudetes there are no significant changes in the frequency of drought occurrence when taken into account indices based only on precipitation data. The situation is different if, in addition to precipitation, thermal conditions are taken into account. In this situation, a statistically significant increase in the number of dry and very dry months is observed. This means that the risk of atmospheric drought in the Sudetes has increased mainly due to the increase of the air temperature and, consequently, the increasing role of evapotranspiration. The values of drought indices are characterized by high variability in individual decades of the 1961-2020 period, while a significant increase in the frequency of dry and very dry months was observed mainly in the decade 2011-2020. Taking into account the altitude, the risk of drought increases as altitude decreases. On an annual basis, the highest risk of drought occurs in the spring months (April, May and June), especially in the Western Sudetes.

Drought indices relating to coniferous ecosystems indicate that the most unfavourable conditions for spruce growth occur in the area of the Sudetes Foothills, mainly due to the highest and constantly growing threat of drought. The altitude belt with optimal conditions has moved up by about 300 m and currently covers the zone between 600-900 m above sea level. In the higher parts of the Sudetes, although the conditions are less favourable mainly due to the shorter growing season, they are gradually improving due to the increase in the air temperature and the shortening of the snow and winter season.

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SITE CONDITIONS MATTER: EXPLORING THE ROLE OF GEODIVERSITY AND CLIMATE CHANGE ON THE FUTURE OF LARCH IN THE SUDETES

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Larch trees in the Sudetes are sensitive to drought, and comparative studies with larch growing in the Carpathians indicated that their sensitivity to certain climatic factors is higher. Our previous findings suggested that site conditions are important factors influencing the climate-growth response of larches in Polish Sudetes. Furthermore, it was found that the larch growth response to particular climatic factors, and the influence of site conditions on this response, is a subject of on-going change.

Current research efforts, incorporating data from the Polish sections of the Sudetes and the Jeseníky Mountains in Czechia, aim to further understand the interactions between site conditions, climate, and larch growth in this region. By examining these complex interactions, it may be possible to identify potential limitations that this species could encounter in the future.

Recent findings suggest that the growth response of larch to specific climatic factors is substantially changing over time. It is especially visible for the most important factors like May temperature and July precipitation, where their correlations with tree-ring growth are vary over time. Furthermore, site conditions have a significant influence on this evolving relationship. This implies that the complex interaction between site condition and climatic factors affect larch growth patterns and its responses. It appears that although the larch trees from Jeseníky exhibit a similar climate response as those from the Polish Sudetes, however some differences can be observed. Our study indicates that in general, altitude is the most important response differentiating factor. The other site conditions, like landform, latitude etc., have less pronounced, but important impact. However, there's an observed increasing uniformity in the larch's response to dominant climatic factors, with recent trends suggesting potential growth limitations of this species in this region in the future due to changing climatic conditions, and increasing drought risk. Our findings may offer valuable information for managing and conserving the larch stands amidst the challenges of climate change.

This study was supported by AGH University of Krakow, Faculty of Geology, Geophysics and Environmental Protection, as a part of research subvention no 16.16.140.315.

Key words: tree rings, *Larix decidua* Mill., site-related factors, climate-growth relationship, climate change, Sudetes

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VIERA HORÁKOVÁ

RESTORATION OF DRAINED FORESTS LOCALITIES IN THE KRKONOŠE MTS. NATIONAL PARK

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The implementation of the project was made possible thanks to the allocation of funds from the Environmental Operational Program. The project runs in 2017-2023 (CZ.05.4.27/0.0/0.0/17_078/0005869; CZ.05.4.27/0.0/0.0/20_142/0014092)

The main idea of project of water regime revitalization in selected areas covers survey the conditions of drained forests of Krkonoše Mts. National Park and starting their restoration processes. The project was distributed over time into two parts.

The first part of the project included the preparation of documents and a field survey of the selected area, which resulted in material containing a detailed description of each area together with specific procedures for revitalization measures. Long-term monitoring was also set up at selected localities with the aim of obtaining information on the impact of the implemented revitalization measures on the natural environment. Part of the monitoring is the continuous measurement of the groundwater level, its temperature and pH, and a chemical analysis of the water is also carried out. Permanent plots and transects were also established to record changes in the vegetation of these communities.

During the second part of the project, revitalization of drainage system is implemented. A damming system is built on the drainage canals using small and large dam types, supplemented by the method of soil backfilled of canals. Dams serve to slow down or even eliminate the outflow of water from the wetland. Their clogging and overgrowth gradually lead to the destruction of the entire drainage system and the subsequent restoration of the wetland habitat. A total of 24 locations have been revitalized by the end of 2022. The revitalization of another 11 locations will be implemented by the end of 2023. So far, more than 40 km of drainage canals have been blocked.

Although it is not yet possible to confirm the effect of revitalized areas using measured values, changes in their character can be observed directly on individual

areas. The retention of water by means of the installation of overflows led to the formation of small pools on the areas, and the surroundings of the drainage canals is significantly wetter compared to the original state and acquires a wetland character. Amphibians began to reproduce in these pools the following year after the revitalization, and insects bound to wetlands appeared. The initiated changes in the revitalization process should help improve the condition of the originally bog woodland, lead to stabilization and better structure of the natural environment and water retention in the landscape associated with the improvement of the local microclimate.

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VÁCLAV TOMÁŠEK[2, 3], KAROLINA MIKSLOVÁ[1],ONDŘEJ VOLF[4], JIŘÍ FLOUSEK[1,†]

BLACK GROUSE CONSERVATION IN THE KRKONOŠE AND JIZERA MOUNTAINS

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INTRODUCTION

In less than 35 years, the number of the black grouse (*Lyrurus tetrix)* in the Czech Republic has decreased by 60-80%, and this trend continues. Sub-populations are already isolated and only the Jizera – Krkonoše mountains and Krušné mountains may have a chance of longer-term existence separately. Our project determined key factors limiting black grouse in the Czech Republic and field results are unique.

MATERIAL AND METHODS

Since 2018 there are in progress professional studies focused on the most significant factors threatening the Krkonoše-Jizera population of the black grouse such as biotope loss, population genetics, habitat fragmentation, disturbance by tourism, predation of black grouse nests and the risk of collisions with different types of structures. During our project each artificial lek site in Krkonose-Jizera population was monitored to identify occurrence of black grouse using camera traps and collecting droppings for DNA analysis. Predation was studied with camera traps placed next to artificial nests on every artificial lek site in Krkonose mountains. Each study was carried out according to recent scientific knowledge.

RESULTS AND DISCUSSION

Genetic analysis was made from 1006 samples of DNA, especially from feaces. Genetic confirmed 3 isolated populations in Czechia, nevertheless they are still in good condition meaning the genetic variability. Recapture of individuals (identifying DNA from droppings and feathers) showed that distance more than 5 kilometers was scarce (only 7 samples). Predation intensity varied between localities but none of the

sites in Krkonose was unpredated. Main predators identified at the artificial nests were martens, red fox, wild boar, badger and raccoon dog. Project was also focused on dangerous bird collisions with obstacles like fences, ropes etc. During our project, 5 ski lifts were provided with diverters, more than 20 fences were removed or made visible with plastic tapes. Connectivity was researched using a population genetic and GIS habitat analysis, so now it is possible to arrange stepping stones on large gaps between occupied black grouse habitat. Removing hiking paths or retraversing them is also very important for establishing the quiet zones, but it is questionable in the direction of the national park. Twenty artificial lek sites were created in Krkonose in dense spruce forests, more than 2 hectares each of them. It is important to reduce disturbation in 10 key lek sites in Krkonose and 5 sites in Jizerske hory mts. Besides that, our project focused on public education and popularization of black grouse conservation. More negotiations and networking is necessary to protect the whole population on the national and international level.

CONCLUSIONS

Our project contributed to better knowledge of the ecology of the black grouse in Czechia. Habitat loss, landscape connectivity, tourism activities, fences and predation are the main factors affecting long term population decline of black grouse in Czech republic. Presentation summarizes a five-year project financed by the European Regional Development Fund (The Operational Programme Environment) implemented from 2018 to 2023. Important part of our project was identifying suitable biotopes in each subpopulation. Project should contribute to assessing problems of black grouse in Czechia. Results will be used for preparing the Action plan – management plan for conservation of black grouse directed by the Ministry of the environment.

Key words: black gourse, demography and distribution, habitat fragmentation, human disturbance, population genetics and predation

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THE CHANGING FACE OF THE ARCTIC-ALPINE TUNDRA - CHANGES IN VEGETATION OVER HALF A CENTURY

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Current climate change in the Arctic and alpine tundra around the world is manifested by warmer temperatures, reduced snow cover, glacier retreat, melting permafrost and reduced avalanche frequency. In addition, this ecosystem is threatened by atmospheric deposition, which has recently exceeded critical nitrogen levels. This leads to acidification, base leaching and eutrophication of the soil. As a consequence, we observe that the greening of the Arctic is leading to structural changes such as shrub expansion (shrubification), a decrease in species richness and changes in species composition, accompanied by an upward shift (thermophilization), i.e. a shift of the upper limit of the tree line to higher altitudes. Although these shifts are occurring in all habitat types, it is not surprising that Arctic and alpine tundra plant communities are particularly vulnerable to these global changes, which appear to be occurring more rapidly than previously thought.

Climate change is an important driver of ecosystem productivity and is linked to changes in land use and other factors such as grazing. At present, declines in species richness and shifts in species composition reflect dynamic successional changes in tundra plant communities, caused in part by the abandonment of traditional management. The lack of traditional management has probably favoured the spread of competing species that were previously suppressed by biomass removal, such as haying, livestock grazing or mowing, which was common in mountain areas until the mid-20th century.

Global monitoring networks of Arctic and alpine grasslands (e.g. GLORIA) are important for describing short-term events or inter-annual variations. Together with long-term repeated surveys, they can provide evidence of the factors influencing changes in tundra biodiversity.

Changes in the abundance of any species, or functional traits of plants derived from species, can be used to determine whether there are losers and winners at the metacommunity level. The issue of habitat dependence has become more important in

light of the recent worldwide use and resurvey of fine-scale vegetation co-occurrence data (vegetation plots). Indeed, vegetation plots represent a complete species list for a certain area and remain the only appropriate hierarchical level over time for studying changes in species relationships and diversity measures useful for nature conservation.

The Krkonoše Mountains, a UNESCO World Heritage Site, represent a unique alpine island of diverse communities in Central Europe, ranging from alpine and subalpine grasslands to springs. These communities are the most endangered habitats that have been studied in long-term geobotanical research for almost a century. In the study, we present results based on the analysis of data from 91 vegetation plots resampled in the Arctic and alpine tundra of the Krkonoše Mts. in 2019-2020. We aimed to describe the changes in species composition in selected alpine habitat types (alpine grasslands and heaths; spring, fen and bog communities; subalpine tall forb and meadow vegetation) and to evaluate the changes from a conservation perspective by identifying winners and losers of species and communities. We approached vegetation classification by analysing plant functional traits to assess changes in different habitats. To reduce observer bias and relocation error of the semi-permanent plots, we resurveyed the selected plant communities in the presence of the original observers who recorded data at the same sites in the 1970s and 1990s.

Significant successional vegetation changes have occurred in all studied habitats and plant communities. The most dynamic changes over time were observed in alpine grasslands and subalpine tall forbs. While wind-swept alpine grasslands on base-poor soils dominated by *Cetraria* lichens and *Festuca supina* have been replaced by submontane to subalpine *Vaccinium* heaths as a consequence of ongoing shrubification and thermophilisation, subalpine tall grasslands with *Bupleurum longifolium* and *Calamagrostis arundinacea* have been transformed into grasslands with *Crepis conyzifolia* and *Calamagrostis villosa*, mainly due to persistent acidification. As for the spring and fen vegetation, the losers are the boreal bogs with *Trichophorum cespitosum* and *Sphagnum compactum*, which have been replaced by acid fens with *Polytrichum commune* and *Molinia caerulea*, or by continental and subcontinental bogs with *Eriophorum vaginatum* and *Sphagnum recurvum*.

Although species richness did not change significantly between the old and new datasets, shifts in species composition varied considerably between vegetation types; on the one hand, the winners were thermophilic and competitive generalists such as *Nardus stricta*, *Calluna vulgaris*, *Galium saxatile* or *Molinia caerulea*, which, together with *Vaccinium myrtillus*, have a competitive stress tolerant (CS) growth strategy. On the other hand, the losers were mainly Red List species with a CSR strategy, such as *Anemonastrum narcissiflorum*, *Bupleurum longifolium* or *Hypochaeris uniflora*. The Red List species were represented by habitat specialists, including light-demanding mosses and lichens.

Here we summarise significant changes in the species composition of tundra plant communities over more than 50 years. Our results show that the processes currently dominating tundra vegetation are the expansion of a few common, competing, stress-tolerant species and the subsequent disappearance of unique species and habitats adapted to the harsh tundra climate. The starting point for the protection of priority habitats and unique species of the Arctic-Alpine tundra of the Krkonoše Mts. could be the control of vegetation succession by removing the biomass of competitive species, followed by a gradual recovery of soil conditions.

MATEUSZ ROGOWSKI

OVERTOURISM IN THE KARKONOSZE NATIONAL PARK - DIAGNOSIS, PROBLEMS, OPTIMIZATION

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The Karkonosze National Park (KNP), as one of the most frequently visited national parks in Poland. KNP is a traditional tourist destination but, in recent years, has also become an increasingly popular place for active, open-air recreation, offering unique nature surroundings. Due to its high popularity, the visitor flow takes a mass form there. It is a well-known statement that mass visitor flow exerts a negative impact on the natural environment, residents and visitors, and is referred to as overtourism in the source literature (Rogowski et al. 2023). Overtourism describes destinations where hosts or guests, locals or visitors, feel that there are too many visitors and that the quality of life in the area or the quality of the tourist experience has deteriorated unacceptably (Goodwin 2019). Due to that overtourism was identified as the biggest challenge for tourism regarding national parks in the post-pandemic Covid-19 period (McGinley et al. 2020).

The purpose of the study was to diagnose overtourism in the KNP in the spatial, temporal, and quantitative sense as well as create a plan to help solve this problem. To diagnose overtourism, an attempt was made to implement the Method of Overtourism Optimization (MOO) developed for the same purpose in the Stołowe Mts. National Park (SMNP). Therefore, an additional goal was to verify the MOO for another national park. Developing the MOO involved adapting the Visitor Experience and Resource (VERP) by (Manning 2002) in the context of opinions expressed by all surveyed stakeholders. According to Mandic and Markovic (2021), VERP is more useful in the mitigation of pressures related to excessive visitation and addresses complex socioecological challenges such as overtourism in national parks. All stakeholder groups participate in the

MOO i.e.: residents, including representatives of the local tourism industry, National Park managers, National Sark Scientific Council, visitors and an external expert. The diagnosis of overtourism was preceded by: (1). Collecting quantitative and qualitative data on tourist traffic from the national park; (2). Covert observations carried out in the places and periods of overcrowding aimed at verifying the indicated problems; (3). Specifying Tourism Carrying Capacity (TCC) of the most overcrowded trail; (4). Questionnaire survey research conducted among visitors and residents in the time and places of overcrowding and assessment of the diagnosed problem.

The results show that 86.2% visitors and 94.7% residents confirm they feel that there are too many visitors and that the quality of life in the area or the quality of the tourist experience has deteriorated unacceptably. It is most noticeable between 10 a.m. and 4 p.m., in July and August as well as during holiday and weekend periods in January, February, May, June and December. The places where overtourism is most problematic include Śnieżka, Szrenica, Kamienczyk Waterfall, Szklarka Waterfall, Równia pod Śnieżką and in Mały Staw. Problems faced by the visitors include car parks and parking, crowds along the trails, queues to enter the national park and to the ski lift, garbage, noise and pollution. Residents, in turn, predominantly complain about the lack of car parks and improper parking, traffic jams and obstructions on the roads, garbage, noise and pollution, water shortages, high prices, lack of goods and queues in stores, and also inappropriate behavior resulting from alcohol abuse by the visitors. These indications and problems are confirmed by the National Park managers, adding the extremely important issue related to the destruction and degradation of the Karkonosze Mts. natural environment components and inappropriate behavior on the trails in the park. As part of the optimization methods, several measures have been proposed regarding the day-to-day management of tourist traffic in the national park area but also for the promotion of the surroundings and for education purposes. These proposals will be assessed by National Park managers. The results of diagnosing overtourism and methods of overtourism optimization were provided to the visitors and residents through the official web page, FB page of the KNP and were discussed by the Scientific Council of the KNP. Currently the opinions on optimization methods are collected.

According to the research conducted in the SMNP, the optimization method has been developed, based on the MOO, in the form of entry limits to Szczeliniec Wielki and Błędne Skały loop trail. The introduction of entry limits initiated the dispersion of visitor flow. It was noticeable in the decrease of the average and maximum values around noon and the increase of these values in the morning, late afternoon and evening hours. Stakeholders assess the introduction of entry limits positively because participated in co-decision. Will it work in the KNP are too?

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ISA BANDÁK[1], JAN TITĚRA[2], LENKA PAVLŮ[2] AND VILÉM V. PAVLŮ[1,2,3]

SUCCESSION AFTER DEFORESTATION UNDER THE DIFFERENT MANAGEMENT IN BUKOVEC NATURE RESERVE, JIZERSKÉ HORY MT.

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Question: There is lack of information about development of vegetation after deforestation**,** therefore, we established a long-term experiment, and we addressed the following questions: i) How plant species composition and soil properties were affected by the different management regimes after deforestation? ii) How these plant species composition and soil properties differed from a long-term unmanaged meadow alliance *Polygono-Trisetion*?

Location: Bukovec nature reserve, situated in the Jizerské hory Mountains, Czechia.

Methods: In total there were 18 randomized study plots 2 x 2 m (4 m^2): i) 5 plots in deforested areas where spruce branches were burnt (with layer of ash) and with consequent cut management (B), ii) 4 plots in deforested areas with a layer of spruce needle litter and with consequent cut management (FC), iii) 4 plots in deforested areas with a layer of spruce needle litter without consequent cut management (FU), iv) 5 plots in a long-term unmanaged meadow (alliance *Polygono-Trisetion*) as a control (M). The plots with cutting management were mowed once a year in mid-July. The percentage cover of individual plant species was visually estimated in mid-July before cutting from 2006 to 2015 and in 2017. Soil samples were taken at the end of October in 2006, 2008, 2010-2014, 2018 and in 2022.

Results and discussion: There were significant changes in plant species composition detected by the RDA analysis among the study treatments over the time. Three groups of treatments with similar plant species composition were distinguished on the ordination diagram: 1) M treatment, 2) B treatment and 3) FU, FC treatments. Ash had significant effect which, in turn, increased soil concentration of P, K, Ca, Mg and pH/$CaCl_2$ in the B treatment. In contrast, concentration of P, K, Ca, Mg and pH/$CaCl_2$ in both other deforested treatments (FC, FU) had the lowest value probably because of influence of spruce needle litter.

Conclusions: Presence of ash after burning had crucial effect on the development of plant species composition because of enriching the soil with nutrients and on the other hand cutting management had relatively small effect in this stage of succession.

NOTES

MAREK BŁAŚ

SPATIAL DISTRIBUTION OF CLIMATE ELEMENTS IN THE KARKONOSZE MOUNTAINS

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The aim of the study is to present the methodology for mapping the spatial distribution of selected climate elements, which constitute an important part of the „Atlas of the Karkonosze Mountains" issued by the Karkonoski Park Narodowy and Krkonošský Národni Park.

The study was based on a 30-year data set (1991-2020) provided by 4 synoptic, 7 climatological and 15 rainfall stations of the Polish and Czech weather service, as well as field measurements. The localization of each station was carefully verified by comparing station metadata and digital elevation model. For the purpose of spatial modelling of climate elements, a digital elevation model built from data acquired during airborne laser scanning (LiDAR) was used, with scanning point density of 2–7 points per 1 m^2 and measurement accuracy 0.15–0.25 m. The resolution of digital elevation model used in the analysis was 10x10 m (Migoń et al. 2013).

In this study multiple linear regression (MLR, also known as environmental correlation) with additional residual interpolation (so called Multiple Linear Regression Kriging – MLRK) was tested for mapping climatological elements in the Karkonosze Mts. The methods consider the deterministic relationships between the modelled element and environmental variables – predictors (Szymanowski et al. 2012, 2013, 2017). The spatial distribution of the predictors is represented in the interpolation procedure by raster layers with a fixed spatial resolution. The following groups of variables were included in the set of potential predictors:

- altitude above sea level (absolute and relative):
  - ✓ true elevation value represented by DEM (m a.s.l.);
  - ✓ average elevation within 100 m, 200 m, 500 m, 1 km, 2 km, 5 km and 10 km radius of a circle (Kolo_100, Kolo_200 …, Kolo_10000) – morphology compaction index (Figure 1);
- landform indicator (concavity/convexity index) – expressing cool air accumulation effects of concave terrain forms:
  - ✓ difference between true and average elevation within 100 m, 200 m, 500 m, 1 km, 2 km, 5 km and 10 km radius of a circle (H_Kolo_100, H_Kolo_200 …, H_Kolo_10000);

- landform indicator (exposure/screening index) – illustrating the thermal impact of the foehn wind:
  - ✓ difference between true and average elevation from NE, SE, SW and NW sectors, within: 5, 10, 15 and 20 km distance (H_NE_100, H_SE_100, …, H_NW_10000; Figure 2);
- slope inclination;
- raster cell coordinates (X, Y).

The values of all environmental variables were extracted from raster layers for each meteorological station and were used to specify regression models. It is generally assumed that the analysed climatological elements are characterised by a statistically significant correlation with at least one environmental variable, therefore, the deterministic component can be modelled with the regression method (Szymanowski et al. 2017). The selected predictors were examined with stepwise regression analysis to check the spatial relationships between the occurrence of key phenomena and corresponding predictors (Tab. 1). The following statistical criteria were taken into account to identify the best fitted Multiple Linear Regression model: adjusted R-squared (AdjR^2), Koenker Statistic *p* value (BP), Akaike Information Criterion (AICc), Jarque-Bera (JB) test, Variance Inflation Factor (VIF). Global Moran's I statistic *p* values were calculated to decide whether the regression residuals are spatially autocorrelated and future interpolations are required. Regression residuals were then interpolated via simple kriging. The final result was achieved by adding both the Multiple Linear Regression raster dataset and the interpolated residuals raster dataset. Error statistics including: mean error (ME), mean absolute error (MAE) and root mean square error (RMSE) were calculated to evaluate the obtained results. The calculation of the potential sunshine duration were performed with the use of the r.sun program implemented in the ArcGIS software. The r.sun program is a functionally best-developed module for calculation of radiation, which can be successfully applied to large areas and works with high-resolution terrain models (Kryza et al. 2010).

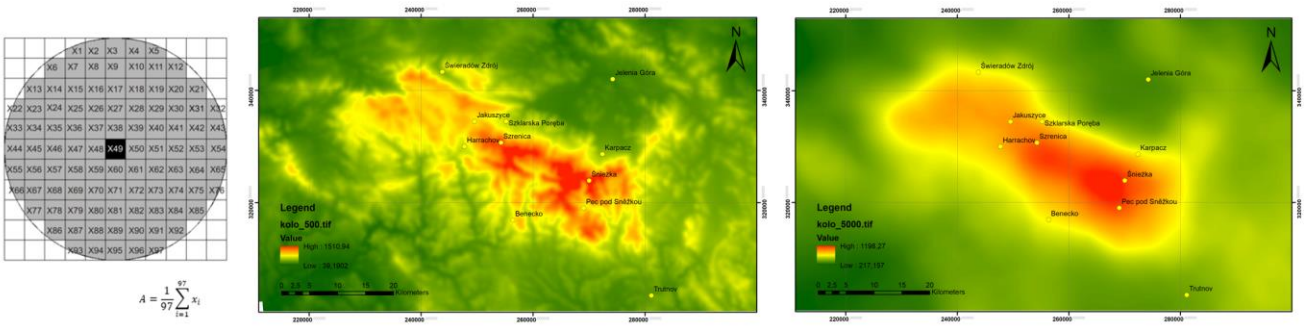

Fig. 1. Difference between true and average elevation within 500 m and 5000 m radius of a circle.

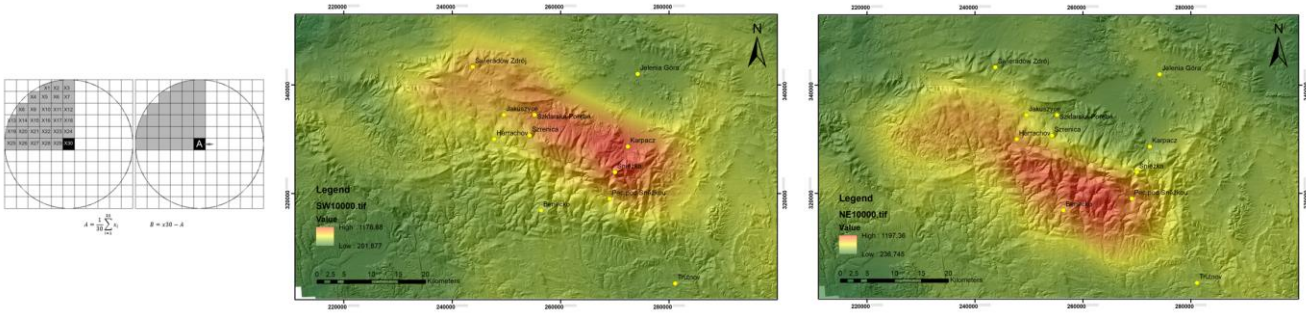

Fig. 2. Difference between true and average elevation from SW and NE sectors within 10 km radius of a circle.

Tab. 1. Summary of variables significance for temperature and precipitation analyses.

JANUARY – average temperature

Step	AdjR²	AICc	JB	K (BP)	VIF	SA	Variable 1	Variable 2	Variable 3
1	0,83	42,5	0,80	0,49	1,00	0,54	-DEM***		
2	0,87	40,3	0,88	0,98	1,71	0,65	-DEM***	-H_SW_5000***	
3	0,90	39,0	0,29	0,84	6,69	0,87	-DEM***	-H_SW_5000***	+H_Kolo_5000**

JULY – average temperature

Step	AdjR²	AICc	JB	K (BP)	VIF	SA	Variable 1	Variable 2
1	0,93	32,2	0,13	0,18	1,00	0,66	-DEM***	
2	0,97	30,1	0,77	0,02	1,04	0,39	-DEM***	+X**

JANUARY – monthly total precipitation

Step	AdjR²	AICc	JB	K (BP)	VIF	SA	Variable 1	Variable 2	Variable 3
1	0,52	858,9	0,14	0,00	1,00	0,00	+DEM***		
2	0,68	822,2	0,24	0,00	1,82	0,00	+DEM***	-H_NE_5000***	
3	0,78	788,3	0,69	0,00	1,84	0,00	+DEM***	-H_NE_5000***	-X***

JULY – monthly total precipitation

Step	AdjR²	AICc	JB	K (BP)	VIF	SA	Variable 1	Variable 2	Variable 3
1	0,65	799,2	0,07	0,53	1,00	0,00	+H_Kolo_5000***		
2	0,78	757,4	0,01	0,08	1,13	0,00	+H_Kolo_5000***	+Y***	
3	0,83	730,1	0,20	0,03	1,49	0,00	+H_Kolo_5000***	+Y***	+H_SW_10000***

AdjR² – adjusted R-squared
AICc – Akaike Information Criterion
JB – Jarque-Bera test
K (BP) – Koenker Statistic
VIF – Variance Inflation Factor
SA – Global Moran's statistic
* 0.10, ** 0.05, ***0.01 – model variable significance

NOTES

ALŽBĚTA ČEJKOVÁ [1], VIERA HORÁKOVÁ [1], EVA HOLÁ [1,2]

BRYOPHYTE SURVEY OF THE KRKONOŠE MOUNTAINS NATIONAL PARK GOES TO FINAL

[1] The Krkonoše Mountains National Park Administration, Vrchlabí
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We present data of bryophyte survey of The Krkonoše Mountains National Park (KRNAP) and its protection zones (CZ.05.4.27/0.0/0.0/17_078/0005169). We identify species diversity centres of these area and prepare a Regional Red List of Bryophytes of the Giant Mountains according to IUCN criteria (publishing by KRNAP).

Projek duration: 5 years.

Attending bryologists: Bradáčová J., Holá E., Jandová J., Kučera J, Manukjanová A, Mikulášková E., Plášek V., Štechová T., Zmrhalová M.

Localities of bryophyte survey: different type of localities is included e.g. glacial cirques, peat bogs, rich fens, walleyes and old quarries. In total, 3 300 ha (8,5% of KRNAP) were surveyed.

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OLDŘICH ČÍŽEK[1,2,3], PAVEL MARHOUL, TOMÁŠ KADLEC[2], TOMÁŠ JOR[4], ANTONÍN HLAVÁČEK & JAN MATERNA[5]

MOTHS AS KEY BIOINDICATORS FOR IMPROVEMENT OF MOUNTAIN MEADOWS AND KEY INVERTEBRATE GROUP FOR ASSESSMENT OF IMPACTS OF CLIMATE CHANGE ON BIODIVERZITY IN THE KRKONOŠE MTS

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The goal of the project was to obtain data on moths of the non-forest biotopes on the entire territory of KRNAP and its protection zone and to lay the first comprehensive frame for their systematic assessment:

(i) to evaluate the status and diversity of the species spectrum of moths in relation to the types of meadows, their status/quality and to obtain practical recommendations for current and target management,

(ii) to extent knowledge of the bionomics and ecology of moths in the Krkonoše Mts. and create distribution maps of individual species, including species of interest (including mountain species),

(iii) to assess the degree of change and threat of mountaine moth communities due to climate change,

(iv) to establish by implementation of the project a network for monitoring long-term changes in the species community of moths as a model bioindication group.

The field part of the project took place in 2019–2021. During this time, 408 network points and 144 supplementary points were selected. UV LED ligt trap (height 70 cm, 400 lm/trap, 25 cm LED band) was exposed on each point – 4 times in vegetation season (end of May, June, July and August) on network point, one time in a season on supplementary point. The location of the traps was selected according to clearly defined criteria. Traps were placed along the height gradient, while on selected enclaves there was an effort to

place several traps in different biotopes at a given altitude. The distribution was chosen to include all significant areas from the western to the eastern parts of the mountain range, from the lowest to the highest positions.

Other standardized data were used for the evaluation: (i) obtained in 2014–2016 on 29 meadow enclaves included in the LIFE Corcontica project (LIFE11 NAT/CZ/490):188 points (all were used as so-called network points), (ii) data collected as part of the mapping of Krkonoše glacial corries in 2014–2016: 211 additional points and 11 network points and (iii) data from the study of the height gradients of night butterflies in Krkonoše in 2012–2013: 37 network points. Thus a total of 644 network and 355 supplementary points were used for analyses.

During the field surveys, the occurrence of a total of 442 species from the target groups of moths (superfamilies Hepialoidea, Cossoidea (family Cossidae), Zygaenoidea (family Limacodidae), Drepanoidea, Lasiocampoidea, Bombycoidea, Geometroidea, Noctuoidea) was confirmed in the territory of Krnap and its protection zone. Of the conservation-important species, 23 from the current Red List of invertebrates were recorded, of which 4 species are classified as endangered, 12 vulnerable and 7 near-threatened. One species is classified as highly endangered in the list of legally protected animals. One species is also included in Annex IV of the European Habitats Directive. In addition to species of conservation importance, indicator species also include taxa for the Krkonoše Mountains that are interesting from a faunistic or habitat point of view (especially species linked exclusively or primarily to the oreophytic zone in the territory of the Czech Republic). The total number of indicator species used in the assessment was 44.

The results of the analyzes show that the species spectrum at the localities is influenced by the altitude, the slope of the slope and the number of nectar-bearing species. No significant influence of management or biotope composition (according to Natura 2000) on the number of species was found.

The text of the abstract is based on the data of the final report on the implementation of the project: Čížek O., Marhoul P., Kadlec T., Jor T. & Hlaváček A. (2022): Moths as a key bioindicator group for improving the care of Krkonoše meadows from the point of view of invertebrates and for Monitoring Climate Change Impacts - Final Report (2022). MSc. depon in Správa KRNAP, Vrchlabí. 1261 pages.

The project CZ.05.4.27/0.0/0.0/17_078/0006395 "Night butterflies as a key bioindicator group for improving the care of Krkonoše meadows from the point of view of invertebrates and for monitoring the impacts of climate change" was supported within the subsidy program 11531 - Operational program environment 2014-2020.

BARBARA FIAŁKIEWICZ-KOZIEŁ

ŚNIEŻKA PEATLAND AS SABS – STANDARD AUXILIARY BOUNDARY STRATOTYPE FOR ANTHROPOCENE SERIES- IMPLICATION FOR APPLY TO BE A UNESCO GEOPARK

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In 2000 a Nobel prize awarded Poul Crutzen provided a concept of new human-driven epoch – Anthropocene to highlight the humankind as a critical factor altering the Earth. For over ten years Anthropocene Working Group was focused to find reliable and convincing evidence of existing new epoch. In 2020 AWG announced 12 possible candidates for GSSP for Anthropocene series, including Polish peatland Na Równi pod Śnieżką (NRS), located in Karkonosze.

Na Równi pod Śnieżką was selected based on publication (Fiałkiewicz-Kozieł et al., 2020), where a detailed multi-proxy analysis of peat profiles including Pu isotopes made this site the strong peatland candidate for the Anthropocene series. The $^{239+240}$Pu profile shows a marked increase from 1952 CE and a peak in 1965 ± 5 CE, which corresponds with 1963 maximum of Pu global fallout. The Pu deposition is consistent with the ^{14}C data, with the onset of the bomb-spike at 1951 ± 6 CE. Investigated profiles The lowest occurrence of selected technofossils linked to coal combustion - spheroidal aluminosilicates (SAPs) and mullite (1947 ± 7 CE) appeared in comparable time to first occurrence of spheroidal carbonaceous particles (1959 ± 6 CE). The introduction of non-native invasive ragweed (*Ambrosia artemissifolia*) in 1956 ± 3 CE is a clear neobiotic signal (Fiałkiewicz-Kozieł et al., 2023). Besides global signals distinguished in peatland profiles, the results are directly linked with cultural heritage of this region, which encompass the legacy of industrial activities in this area.

After official announcement of nomination Canadian candidate Crawford Lake as GSSP for Anthropocene, peatland Na Równi pod Śnieżką was nominated by AWG as SABS – Standard Auxiliary Boundary Stratotype for Anthropocene series to support “Golden Spike”.

NRS is the only terrestrial site with well-defined Anthropocene boundary. It is a reference site for other peatlands dealing with Anthropocene topic. Finally, it is a representative site for Europe.

The mentioned evidence underlines the NRS peatland importance as the geological heritage for future generations and has the highest educational value. It also indicates the urgent necessity of the highest protection of this site and possibility of nomination NRS as candidate for Geopark UNESCO. The initiative is supported by IGCP 732 (International Geoscience Programme under UNESCO) - LANGUAGE of the Anthropocene.

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VÁCLAV JANSA, IRENA KHOLOVÁ

UTILISATION OF THE ELITE GENETIC RESOURCES OF THE NORWAY SPRUCE TO INCREASE THE FOREST ECOSYSTEMS STABILITY IN THE GIANT MOUNTAINS

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Program: OPŽP II (nb. CZ.05.4.27/0.0/0.0/15_009/0002600)

Authors of methodology and concepts: prof. Ing. Milan Lstibůrek, MSc., Ph.D., Ing. Jiří Korecký, Ph.D., Ing. Jan Stejskal, Ph.D. (all Czech University of Life Sciences, Faculty of Forestry and Wood Sciences), Ing. Jan Leugner, Ph.D. (Forestry and Game Management Research Institute)

INTRODUCTION

Forest ecosystem stability of the Giant Mts. forests depends on spruce stands stability. The spruce species plays an important role in the vegetation of 8th forest altitudinal zone with the representation of 90 %. Autochthonous spruce stands in the Giant Mts. are significantly more vital and resistant to extreme climatic conditions, immission load, bark beetle and other stress factors compared to non-native trees.

A more recent study showed that the current distribution of Norway spruce genetic diversity in the Giant Mts. is more admixtured due to seed distribution from various companies and different areas, especially from Austria. Inappropriate planting stock distribution continued in 20th century. (Schwarz and Vašina 1997). Genetic resources preservation and gene pool restoration of mountain spruce ecotype are the priorities in sustainable forest management and ecosystem approach in the Giant Mountains.

The objective of this study is gene pool preservation and utilisation of the elite genetic resources of the Norway spruce to increase the forest ecosystems stability in the Giant mountains. The sub-objectives are: genetically valuable stool beds and cloning plants preservation, elite trees designation and evidence, genetic structure analysing, subsequent selection of the plots suitable for seed orchard establishment, taking cuttings from perspective spruce clones, cuttings cultivation and new stool bed

establishment, taking grafts from source stool beds and clone plantings, grafts planting, seed orchard preparation and establishment.

MATERIALS AND METHODS

In general, the research study includes genetic analysis (A) and new stool beds and seed orchards establishment (B).

A) Genetic analysis

The study was focused on presumably autochthonous and naturally-regenerated stands composed from trees of morphologically predominant morphotypes on the plots of stool beds in Benecko, Dvoračky and Světlá hora. Sampled trees were > 100-year-old with each tree's GPS coordinates recorded. Samples were collected, kept with silica gel in sealed plastic bags and stored at − 80 °C until further processing. Some of the clones were sampled in more ramets. (Korecký et al. 2021)

The total of 454 unique clones were collected and its genetic profile was determined. Samples homogenization and DNA isolation was carried out followed by amplification of 15 microsatellite loci. Each locus was tested for polymorphism and fluorescently-labeled using a forward primer. Genetic structure analyses generated from co-dominant markers were realized using Cervus software (Korecký et al. 2021, Mishra et al. 2021).

B) New stool beds and seed orchards establishment

New stool beds and seed orchard establishment is based on the results of genetic analysis. In this method, the dendrogram is established by the genotypes with the highest similarity. The key selection criteria was the coefficient of relationship as a measure of the degree of consanguinity between the clones. The limits of effective population size were used as a practical and operational indicator of genetic diversity trends. The clones were devided according to belonging to clone groups membership.

RESULTS

A) The consistenci of the results for the entire set of samples was confirmed. Estimating genotyping error rates is less than 0,05 % therefore the genotyping is singnificantly robust. The ratio of the absorbance at 260nm divided by the reading at 280nm proved good-quality DNA with the ratio of 1,7 to 1,9. An average DNA concentration of 31,4 ng/µl means an average concentration with a standard deviation of 24,06. Gene flow among all 3 populations (Benecko, Dvoračky, Světlá hora) rates from 5 to 44 alleles, all the primers show more polymorphic loci. The

coefficient of inbreeding determining genetic relatedness between populations is 0,018.

B) Two seed orchards – Haida and Rezek - were established based on the results of this study. Optimum neighborhood seed orchard design (ONA) was used for spatial schemes creation (Chaloupková et al. 2016). The total amount of 1000 cuttings for stool beds and 500 grafts for seed orchards were created and planted within the project. Seed orchard care plan is necessary for successful and effective continuation of the activities.

CONCLUSION

Cuttings cultivation, grafting, cloning, planting, genetic structure analysing and subsequent selection of the plots suitable for seed orchard establishment was realized in the cooperation with Czech University of Life Sciences and Forestry and Game Management Research Institute.

Conservation of genetic diversity of autochthonous or locally long-term adapted populations of Norway spruce in the Giant Mts. National Park is essential for utilisation of the elite genetic resources conception. On the other hand, pollen contamination can have a positive impact due to gene pool enrichment.

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David Krause[1,2], Jiří Fišer[3], Marek Křížek[2]

FROM PROTO-CIRQUE TO CIRQUE AND TROUGH: WHAT WE KNOW AND DON'T KNOW ABOUT GLACIAL EROSION IN THE KRKONOŠE MTS?

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Glacial cirques exhibit distinct concave longitudinal profiles that differentiate them from valley heads unaffected by glacial processes in the past. Evaluating the shape of valley heads provides valuable insights into past mountain glaciation and aids in reconstructing paleoenvironmental conditions. To study this, we conducted an analysis in two distinct regions: one in the Central Alps (Austria) characterized by well-developed glacial cirques and another in the High Sudetes including the Krkonoše/Karkonosze Mountains (Czech Republic/Poland) featuring both cirques and non-glaciated valley heads. Each valley head was meticulously characterized through c-value function fitting, utilizing detailed laser-derived digital elevation models. These profiles were then subjected to rigorous statistical testing. The results, marked by precise fitting, reveal significant disparities in c-values between glacial cirques and non-glaciated valley heads. This innovative approach holds the potential for distinguishing between valley heads shaped by fluvial processes and those formed as glacial cirques, while also facilitating assessments of cirque development levels. Meanwhile, within the Krkonoše/Karkonosze Mountains, the Labský důl valley stands as a classical palaeoglaciological site. It has been the focal point of numerous studies concerning Pleistocene glacier extent, chronology, and Holocene vegetation succession. Recent digital terrain analysis has illuminated the deepening of the Labe valley by over 160 meters due to warm-based glacier action in the pre-glacial era. In 2020, during a geomorphological mapping session, previously uncharted glacial moraines were uncovered, with a substantial portion being found extending beyond the trough limit of the Labský důl valley. These moraines' positions allowed for the

reconstruction of paleoglacier thickness, measuring approximately 220 meters in the central part of the cirque and 150 meters in the central part of the trough valley.

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M. KOČÍ, P. FILIPPOV, ZÁBOJ HRÁZSKÝ[1]& STANISLAV BŘEZINA[1]

MAPPING KRKONOŠE TUNDRA VEGETATION: DIVERSITY, THREATS, AND CONSERVATION CHALLENGES IN THE FACE OF CLIMATE CHANGE AND SUCCESSION

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This poster is dedicated to the mapping of vegetation in the Krkonoše tundra in the Czech part of the mountains, covering an area of nearly 3,000 hectares. During extensive field surveys, we successfully identified and classified a total of 56 distinct alpine community types, applying the vegetation classification system tailored for the Czech Republic. The findings unveiled the remarkable richness and diversity of the flora within this ecologically fragile habitat.

One of the most pressing revelations of this research is the alarming fact that nearly 12% of the Krkonoše tundra region in the Czech Republic faces any risk of degradation and more than 5% of the most valuable community occurrences (30/571 segments) is endangered by community extinction within the next decade. It is only area of 2,6 ha (1,4% from the 174 ha of segments with top conservation value) and so the intervention seems to be feasible, but location in the most difficult terrain of corries and disjunct distribution around both platós in small pieces makes it challenging to approach with any effective measure. This discovery carries profound implications for the preservation of this exceptionally unique natural environment. To mitigate this imminent threat, future management and conservation strategies must encompass measures aimed at conserving biodiversity and protecting these imperilled communities.

In addition to the above-mentioned challenges, this study underscores the exacerbating impacts of climate change and natural succession on the tundra's vegetation. This dynamic introduces a complex conservation dilemma, pitting the conservation of spontaneous, natural processes against the safeguarding of individual endangered species and exceedingly rare plant communities.

This comprehensive research represents a significant stride towards a more profound comprehension of the Krkonoše tundra's vegetation and can serve as an essential

steppingstone for further exploration and conservation initiatives within this invaluable natural sanctuary.

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GRZEGORZ URBAN

SNOW WATER EQUIVALENT IN THE WESTERN SUDETES

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The paper characterizes changes in the snow water equivalent (SWE) in the Western Sudetes. SWE was related to the macro-exposure and relief of the study area. The analysis was performed for the winter seasons (November–April) 1961/62–2020/21, for a total of 16 measurement stations from Poland and the Czech Republic. For some stations, the research period was shorter, depending on data availability, station operation, etc.

SWE is strongly positively correlated with snow depth (HS). This relationship is close to straight-line. Therefore it is possible to estimate the SWE value based on HS and analyze it based on the Pearson linear correlation coefficient. The adopted method of estimating SWE (based on simple regression equations) seems to be good and easy to use in snow climatological research. The method shows average point errors ranging from approximately 3% (Szrenica, Śnieżka) to approximately 25% (Benecko_2, Horní Maršov). The average overall error (from all 16 stations) was 16.8% and is comparable to the error for the Alps (15.6%). The method used, similarly to other SWE estimation models, gives the best results for high locations and with greater snow depth. Hence, due to the lower absolute heights and thinner HS, the average errors in the SWE estimation in the Western Sudetes may be larger than in the Alps. Moreover, due to the high seasonal variability of HS in the Sudetes, the obtained result can be considered satisfactory.

The average of snow depth and its SWE gradually increase during the season, reaching maximum values in February or March, after which they decrease significantly. However, snow density reaches an average maximum in April, except for the lowest located stations, where thin and usually ephemeral snow cover is

unable to provide sufficiently high SWE values. This effect corresponds to the increase of snow density caused initially by settling and later also by other processes taking place in the formed snow cover, e.g. ablation.

The estimated seasonal mean and maximum SWE values show negative trends, ranging from approximately -0.1 to -1.3 cm/decade and -0.2 to -2.5 cm/decade, respectively. In many places they are statistically significant. SWE changes with height above sea level are similar on slopes with northern and southern macro-exposure. However, SWE values at locations at similar altitudes above sea level are greater in stations with southern macro-exposure than in stations with northern macro-exposure. The estimated SWE values are characterized by positive error asymmetry. Hence, the actual SWE values are lower than the estimated ones, and the water resources contributed to the environment by the snow cover are gradually decreasing.

The obtained results correspond to those from other areas of Europe and the world, indicating a decrease in SWE due to decreasing trends in the depth and duration of snow cover. They confirm the gradual warming of the climate, especially visible in the last few decades.

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MARIE VYMAZALOVÁ[1], MARTINA FABŠIČOVÁ[2], RADIM HÉDL & MARIE MRÁZKOVÁ

RECOVERY OF DEAD SUBALPINE GRASSLANDS IN THE JESENÍKY MTS.

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Subalpine grasslands in the summit range of the Jeseníky Mountains were sustained by traditional pasturing and hay cutting management for centuries. The grazing cessation around the Second World War and subsequent strict protection through non-intervention measures resulted in a slow succession, an upward shift of the artificially lowered alpine timberline, and species richness decline. In the species-poor grasslands of the summit subalpine zone, the wind-swept grasslands of the *Cetrario-Festucetum supinae* association (*Juncion trifidi*) are changing into closed grasslands of the *Carici bigelowii-Nardetum strictae* (*Nardo strictae-Caricion bigelowii*) or *Festuco supinae-Nardetum strictae* (*Nardion strictae*) associations. At the same time, the most obvious change in these closed grasslands is the decrease in forb species (with the exception of the expanding *Galium saxatile*), which is also related to the decrease in invertebrates.

In the recent decades, nature conservation authorities have initiated active management in some areas (e.g. grazing, mowing, alien dwarf pine (*Pinus mugo*) and expanding blueberry (*Vaccinium myrtillus*) removing). Unfortunately, in 2012 and 2019, some parts of the subalpine grasslands started to die. The grasslands on shallower soils at the lowest elevations (between Břidličná and Pecný – 1330 m a.s.l.) and in middle elevation of the mountain ridge (Jelení hřbet 1367 m a.s.l. and Velký Máj 1385 m a.s.l.) were the most affected. In these places, all plants (grasses and herbs) have died, leaving only thick compact cushions of dead biomass.

In 2021, we sampled 20 permanent plots distributed across the subalpine grasslands of the whole mountain ridge. Ten plots were already part of a long-term monitoring, another 10 plots were newly established in order to cover the recently died grasslands. We also established experimental sites consisting of six Latin squares representing three pairs of Latin squares at each of the most affected sites (Břidličná, Jelení hřbet and Velký Máj). One square of each pair was always placed in died grassland and the other square was placed in healthy grassland in a close

neighbourhood. Here, we implemented three types of management regimes – burning, fertilizing, mechanical disturbance; and the control. The burning and mechanical disturbance were implemented only once at the beginning of the experiment, but fertilization was applied annually. We then monitored the dead grassland recovery and the healthy grassland response.

The grasslands dieback was probably caused by extreme weather events connected with the global climate change. Recently, spontaneous very slow recolonization or very rarely regrowth from surviving belowground organs has occurred. Among our experimental management, the burning was not as effective as expected because unfortunately the weather was not dry enough during the late spring of 2021 and only the surface of the dead biomass cushions burned. On mechanically disturbed plots, most of the plants were germinated from spontaneously dispersed seeds, because the disturbance exposed bedrock in most sites (almost no seed bank can enforce). Indeed, the rapid growth of *Avenella flexuosa* accompanied all fertilized plots (within both healthy and dead grasslands), however this pattern was not reflected in its cover due to deer grazing preferences. Deer sought out such fertilized plots and completely grazed only fresh green *Avenella flexuosa* down to the roots, even pulling up many *Avenella* tussocks.

The vegetation at the three included experimental sites differed significantly according to the PERMANOVA analysis, even though the vegetation was species poor (Fig. 1). The following species were characteristic for Velký Máj: *Luzula luzuloides*, *Potentilla erecta* and *Vaccinium myrtillus*; for Jelení hřbet only *Carex bigelowii*; while no characteristic species were found for the most species-poor site Břidličná. In 2022, the vegetation of dead and healthy grasslands at both sites Velký Máj and Jelení hřbet was still different, while at Břidličná, it was more homogeneous. In 2021, *Luzula luzuloides* and *Carex bigelowii* were recognized as characteristic species for the healthy grassland, while within the dead grassland it was *Nardus stricta* and *Calluna vulgaris*. In contrast, *Luzula luzuloides* had already germinated on some plots of dead grasslands in 2022.

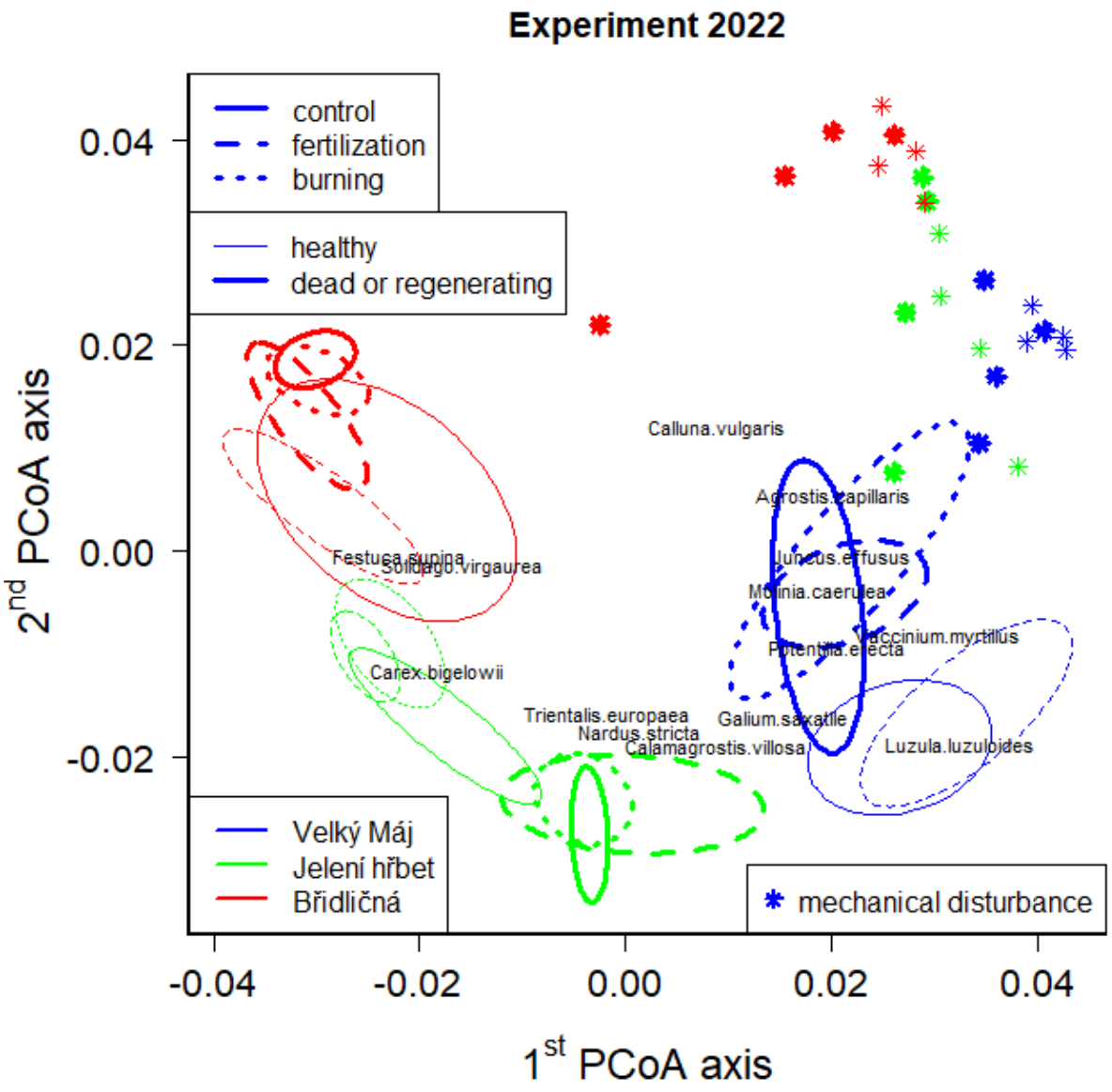

Fig.: The principal coordinate analysis (PCoA) of Hellinger transformed square rooted cover data of six experimental Latin squares on three sites with dead grasslands (one pair of dead and healthy grassland on each of sites Velký Máj, Jelení hřbet and Břidličná). Three types of experimental management were applied on each Latin square – burning, mechanical disturbance, fertilizing; and the control. In total, it was monitored 96 plots of 4 x 4 m.

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