

Questionnaire

Summary of the main activities of a research institute of the Slovak Academy of Sciences

Period: January 1, 2012 - December 31, 2015

1. Basic information on the institute:

1.1. Legal name and address

Botanický ústav SAV (Institute of Botany SAS)
Dúbravská cesta 9
845 23 Bratislava

1.2. URL of the institute web site

www.ibot.sav.sk

1.3. Executive body of the institute and its composition

Directoriat	Name	Age	Years in the position
Director	Anna Guttová (from 1.10.2014); Ivan Jarolímek (till 1.10.2014)	44	2
Deputy director	Milan Valachovič (from 1.10.2014); Igor Mistrík (till 1.10.2014)	60	2
Scientific secretary	Jaromír Kučera (from 1.10.2014); Anna Guttová (till 1.10.2014)	39	2

1.4. Head of the Scientific Board

Iva Hodálová

1.5. Basic information on the research personnel

1.5.1. Number of employees with university degrees (PhD students included) engaged in research projects, their full time equivalent work capacity (FTE) in 2012, 2013, 2014, 2015, and average number of employees in the assessment period

	2012		2013		2014		2015		total		
	number	FTE	number	FTE	number	FTE	number	FTE	number	averaged number per year	averaged FTE
Number of employees with university degrees	70,0	49,460	70,0	48,430	74,0	53,350	73,0	48,370	287,0	71,8	49,903
Number of PhD students	16,0	7,500	19,0	9,880	14,0	9,080	15,0	11,000	64,0	16,0	9,365
Total number	86,0	56,960	89,0	58,310	88,0	62,430	88,0	59,370	351,0	87,8	59,268

1.5.2. Institute units/departments and their FTE employees with university degrees engaged in research and development

Research staff	2012		2013		2014		2015		average	
	No.	FTE	No.	FTE	No.	FTE	No.	FTE	No.	FTE
Institute in whole	70,0	49,460	70,0	48,430	74,0	53,350	73,0	48,370	71,8	49,903
Unit 1 Plant Physiology	24,0	15,560	25,0	16,100	25,0	16,810	20,0	14,670	23,5	15,785
Unit 2 Non-vascular plants	12,0	6,940	10,0	7,460	11,0	8,500	11,0	7,670	11,0	7,643
Unit 3 Vascular plant taxonomy	18,0	14,350	18,0	13,410	17,0	13,810	17,0	12,770	17,5	13,585
Unit 4 Geobotany	16,0	12,610	17,0	11,460	21,0	14,230	25,0	13,260	19,8	12,890

1.6. Basic information on the funding of the institute

Institutional salary budget and others salary budget

Salary budget	2012	2013	2014	2015	average
Institutional Salary budget <i>[thousands of EUR]</i>	696,820	700,111	693,362	723,952	703,561
Other Salary budget <i>[thousands of EUR]</i>	47,389	77,411	79,333	70,313	68,612

1.7. Mission Statement of the Institute as presented in the Foundation Charter

The **Institute of Botany SAS** plays a key role in research of the biota from the viewpoint of evolutionary systematics, phylogeography, phytosociology, ecology, population genetics, chorology and physiology in Slovakia. Our research **objects** are mainly naturally growing cryptogams (cyanobacteria, algae and fungi), and vascular plants and their communities, including invasive, non-native and culture species. The Institute also carries out zoological research, mostly invertebrates and fish. The **research area** covers the Carpathians and adjacent Pannonia as well as the distribution ranges of model groups (e.g. the Alps, the Mediterranean, Scandinavia, America and Asia).

Situated in the Western and Eastern Carpathians as well as in Pannonia, **the territory of Slovakia is among the richest areas in terms of biodiversity** within Europe; ca 32% of all the plant species reported from our continent grow here. It is a crossroads of biogeographic regions and migration routes of living organisms, and one of the northernmost endemism centres in Europe. Our role is to survey this unique natural heritage, to promote it and to contribute to its conservation for future generations.

The aims of our research are:

- to explain processes forming diversity of organisms and their communities, and to conserve it;
- to identify the mechanisms of plant cell ontogeny and their adaptation to unfavourable environmental conditions with an emphasis on abiotic and biotic stress; and
- to discover and document the diversity and distribution of organisms and their communities.

These findings make it possible to preserve essential functions that organisms and their communities provide to ecosystems as well as to human society, which immensely benefits from their services and economic value.

We are an **external institution for doctoral (PhD.) studies**, and we also offer topics for bachelor and master theses for the first and second level of university education.

We provide **consultation and expertise** in various areas of applied biodiversity studies and environmental monitoring.

We **keep and maintain** collections of vascular plants, lichenized and non-lichenized fungi, bryophytes, and algae, registered in the Index Herbariorum (<http://sweetgum.nybg.org/science/ih>) under the acronym SAV.

Foundation charter of 12. 2. 2010 issued by the Slovak Academy of Sciences:

The research activity of the Institute is focused on basic research in the areas of systematics, experimental and environmental botany, and ecology. The main focus is on: 1) the study of diversity and evolutionary relationships of cryptogams, vascular plants and plant communities, preferably in the territory of Slovakia, but also in the Carpathians, Pannonia, the Alps and other regions; and on 2) the experimental study of the structure and function of plant organisms on different levels of their organization and their responses to abiotic and biotic factors. The aims are to acquire comprehensive and precise knowledge of the biota (mycobiota and flora); to understand the variability and evolution of model groups of biota and plant communities; to resolve questions concerning their taxonomy/syntaxonomy and nomenclature; and to understand the mechanisms and functionality of regulating processes of plant organisms.

Our Institute generates fundamental data for complex research into ecosystems and landscapes on local, regional and international levels, and for scientifically justified protection, sustainable usage and management of nature and the landscape. The Institute provides advisory and expert services in the fields of its main scientific interests and is accredited for supervising PhD studies. The Institute builds and manages a collection of vascular plants and cryptogams, internationally registered in the Index Herbariorum under the acronym SAV, as well as a culture collection of microorganisms.

1.8. Summary of R&D activity pursued by the institute during the assessment period in both national and international contexts, (recommended 5 pages, max. 10 pages)

Biodiversity research is one of the two focal research lines of the Institute of Botany. This comprises insights into the mechanisms and principles governing (i) the origin and evolution of species, (ii) species coexistence and (iii) their distribution patterns. Research objects cover several groups of organisms – vascular plants, fungi, algae and cyanobacteria, which provide fundamental ecological functions and ecosystem services to humanity. Another line addresses physiological processes connected to stress. Global climatic change and elevated anthropogenic pressure urge us to consider how to maintain the sources of safe food and feed for the future.

I. Evolutionary processes

The most important phenomena of **(micro-)evolutionary processes** in vascular plants which we were dealing with during the evaluated period were: polyploidy (whole genome duplication), cytotype coexistence and spatial distribution, hybridization, and geographic, ecological or reproductive isolation. Within our groups of interest, these processes are often connected with cryptic speciation or apomixis. Other important phenomena responsible for shaping genetic diversity that we studied were associated with the reconstruction of the glacial and postglacial history of the European flora and vegetation. Specifically, we aimed to identify glacial refugia, colonization routes, contact zones, and interactions among taxa and genetic lineages. Studies were performed on wider **biogeographic scales**, covering entire mountain ranges or other natural regions such as the Carpathians, the Alps, Pannonia, the Mediterranean, and even the whole of Europe and parts of Asia.

Our micro-evolutionary studies were based on a **combination of several methodical approaches**, particularly employing molecular markers (expressing DNA polymorphism), analyses of chromosome numbers and their morphology, estimation of ploidy levels and DNA content (using flow cytometry), detailed morphological analyses (by multivariate morphometrics), as well as hybridization and cultivation experiments. These methods were applied to a representative number of plant specimens mostly collected by us directly in the field or in exceptional cases on herbarium

specimens obtained from European herbaria. This combination of approaches fully corresponds with current trends in plant systematics and evolutionary biology, as evidenced by papers published in prestigious journals. Research into micro-evolutionary processes, speciation and polyploid evolution has recently taken on significantly new dimensions, especially thanks to a much wider employment of (i) molecular methods, most recently of Next Generation Sequencing (NGS) and (ii) flow cytometric applications, which is also firmly established in our laboratories. We use an array of molecular methods, namely DNA Sanger sequencing (of coding and non-coding regions of ribosomal nuclear DNA, especially the ITS region; introns of nuclear genes; intergenic spacer sequences of cpDNA; single-copy genes) and DNA-fingerprinting methods (namely AFLPs and microsatellites – Simple Sequence Repeats, SSRs). Most recently, we have been introducing the novel and sophisticated genotyping approaches of RAD sequencing (Restriction site associated DNA sequencing) and the HybSeq method (the combination of target enrichment and genome skimming) using NGS. The employment of different genome regions (which are subject to various evolutionary mechanisms) and molecular techniques allows us to obtain a robust and complex picture of the evolutionary history and diversification processes within the taxa under study. Determination of chromosome numbers, ploidy levels or genome size is indispensable for characterizing karyological variability within taxa and populations as well as for the correct interpretation of morphological and molecular data. In these analyses, we mostly used flow cytometry. This technique facilitates detailed cytological screening of hundreds to thousands of individuals and allows us to reveal minority cytotypes (that would otherwise have remained undetected), which may play a significant role in evolutionary processes.

During the evaluated period, we addressed questions associated with (micro-)evolutionary processes and consequently also the taxonomy of various genera within the following **vascular plant families**: Asteraceae – *Centaurea*, *Jacobaea*, *Picris*, *Pilosella*, Brassicaceae – *Alyssum*, *Arabidopsis*, *Cardamine*; Caryophyllaceae – *Cerastium*; Poaceae – *Sesleria*, Primulaceae – *Cyclamen* and Violaceae – *Viola*. To demonstrate our research results, we present examples from the genera *Cardamine*, *Picris* and *Pilosella*.

The genus ***Cardamine*** is a subject of long-term research interests from various perspectives at the Institute of Botany. Due to its relatively recent divergence, rapid radiation, high species diversity and incidence of polyploidy, it has become a model for studying the principles of plant evolution. In the evaluated period, we have studied two species, *Cardamine flexuosa* and *C. xschulzii*, in more detail. Focusing on the molecular basis of the age-dependent flowering response of *C. flexuosa*, we found out that the floral transition in this species requires exposure to cold temperature (vernalization). The vernalization response was found to be controlled by the gene CfFLC, a homolog of AtFLC of the plant model species *Arabidopsis thaliana*. It is concluded that the integration of age and vernalization pathways gives an advantage to the perennial growth habit, as it ensures that plants do not flower until they have developed axillary vegetative shoots and sufficient biomass. Thus, the recruitment of age cues in response to environmental signals contributes to the evolution of the plant life cycle. In another study, we identified the origin of *C. flexuosa*. Using a combination of GISH, chromosome painting and other methods, it was found that diploid *C. amara* and *C. hirsuta* are the parental species of this allotetraploid. Only one reciprocal translocation between two homeolog chromosomes has occurred since the origin of *C. flexuosa*. The genome of *C. flexuosa* demonstrates that allopolyploids can maintain remarkably stable subgenomes over 10^4 – 10^5 years throughout a wide distribution range.

Cardamine xschulzii is an allohexaploid that was formed by two subsequent hybridization events within the past ca 150 years. Such recently formed allopolyploids represent an excellent system for studying the impacts of hybridization and genomic duplication on genome structure and evolution. Contrary to previous studies, we revealed that *C. xschulzii* originated from a secondary hybridization event involving *C. xinsueta* (♀) and *C. pratensis* (♂); and that the primary *C. xinsueta* triploid hybrid is derived from *C. rivularis* (♀) and *C. amara* (♂). We also identified novel rDNA loci in *C. xschulzii*, suggesting that lost loci might be slowly reinstalled by translocation (but not recombination) of genes from partner genomes. This study documents a complex case of recurrent hybridization and polyploidization events and highlights the role of triploids, which promoted the origin of trigeneric hybrids.

Molecular studies in the genus ***Picris*** revealed the presence of at least four genetic groups bound to specific geographic areas (Europe, Asia and Australia; Asia Minor; the Arabian Peninsula; North and East Africa). Interestingly, polyploid populations of *P. hispanica* from Morocco have heterogeneous nuclear sequences and chloroplast sequences display high

variability even at the population level, indicating its allopolyploid origin, a unique phenomenon in the genus *Picris*. A suite of phylogenetic analyses revealed that the closely related taxa of *P.* subsect. *Hieracioides* have undergone a highly dynamic and recent evolution, which has been especially affected by extensive and recurrent gene flow among and within the taxa studied and/or by the maintenance of ancestral variation. We have demonstrated that a combination of various phylogenetic analyses of datasets with extremely complex and incongruent phylogenetic signal may shed more light on the interrelationships and evolutionary history of different plant species groups.

Members of the ***Pilosella alpicola* group** are distributed throughout the alpine belt of European mountain ranges. Our thorough biosystematic and taxonomic survey showed that the group comprises four morphologically distinct and geographically vicariant species with contrasting cytotype patterns and variation in breeding system. This makes the *P. alpicola* group a promising model system for studying various patterns and mechanisms of polyploid speciation such as: i) the origin of polyploids – multiple independent *in situ* (neo)autopolyploidization in, until now rarely documented, primary diploid-polyploid contact zones in *P. rhodopea* vs few allopolyploidization events in the extremely rare apomictic species *P. alpicolas*.str.; ii) the dynamics of ploidy-mixed populations – in *P. rhodopea*, recurrent formation and establishment of polyploids and unrestricted intercytotype gene-flow were inferred to play a major role in maintaining the cytotype structure. These processes clearly hamper polyploid speciation, but also allow cytotype coexistence. iii) the impact of genome duplication on life traits – reduced fertility of neopolyploids due to irregular meiosis in natural populations of *P. rhodopea* is overcome by increased clonal growth induced by polyploidization, which facilitates the establishment of rarely formed polyploids and thus explains their distributional success.

Studies in **cryptogams** addressed the phylogeny, origin and diversification of selected model organisms, be it those that are clearly defined as biogeographical elements or those confined to a particular geographic area. We also studied the influence of geographic disjunctions, habitat fragmentation and climate change to distribution area of the species under study. Part of our biodiversity research was followed up in the direction of biosystematics (i.e. the classification and naming of organisms), significantly contributing to the taxonomic backbone of the Catalogue of Life and helping to formulate hypotheses for further evolutionary-targeted research.

The systematic research of **fungi** dealt with five groups. Analyses of molecular, biochemical, anatomical and morphological traits of ***Taphrina*** species (ascomycete parasites on Rosaceae, Betulaceae and Ulmaceae), revealed the existence of a so far unrecognized entity – *T. geimontani*, which we described as new to science. Investigations in the ascomycete genus ***Geoglossum*** were focused on the *G. glabrum* complex. Molecular data confirmed that North American collections represent a different species. The material and data gathered in cooperation with the Institute of Botany of the Russian Academy of Sciences, St. Petersburg suggest the existence of several species with a Eurasian distribution pattern in this complex. A robust multi-locus phylogenetic analysis of agaricoid members of the family **Clavariaceae** (biotrophic basidiomycetes) revealed the polyphyletic origin of the genus *Camarophylloopsis*. The larger part of species previously accepted in the genus *Camarophylloopsis* is now combined in the genus *Hodophilus*, and the new monotypic genus *Lamelloclavaria* has been described based on the new species *L. petersenii*. The phylogeny of North American and European members of the genus *Hodophilus* confirmed that each continent has its own authentic species diversity (there are no species with transatlantic distribution), but species from both continents are included in most well-supported phylogenetic lineages. Our initial study of the basidiomycete genus ***Camarophylloopsis*** compared morphological type studies with multi-loci molecular analyses of recent collections. Its preliminary results show inconsistencies in available names of accepted taxa and a number of phylogenetic species defined as molecular operation taxonomic units. Some species names correspond to unrelated families, others are synonyms, and a large number of species are undescribed and new to science. In the species complex of *Hodophilus* (*Camarophylloopsis*) *foetens*, four such species are defined genetically and morphologically in Europe (three new to science), and five species are recognized in North America (two new to science). The genus ***Russula*** is a hyper-diverse genus of ectomycorrhizal basidiomycetes. Type studies of more than 50 species were published, and based on this, species names were assigned to phylogenetic lineages. The molecular analysis of these lineages did not confirm the significance of cap colour and host association as reliable distinguishing characters. *Russula* studies resulted in a revision of the species concept for more than 30 species, and *R.*

cortinarioides, *R. katarinae*, *R. mansehraensis* and *R. nympharum* were described as new to science.

Despite the ample data on the evolution and ecology of the Mediterranean biota, little is known about symbiotic systems like **lichens** of the genus ***Solenopsora*** (Leprocaulales). Its members occur predominantly in temperate and subtropical regions of the world, with the centre of diversity and distribution in the Mediterranean, Macaronesian, and Madrean floristic regions. We analysed material from the entire Mediterranean area together with samples from North America and Australia. The reason was that the taxonomic treatment of several entities varied over time and the concepts lacked clarity. Focusing on multilocus sequence data, morphology, anatomy, chemistry and ecological preferences, we investigated European taxa to obtain the first insights into their genetic variation and relationships. Our results revealed a discrepancy between the number of currently recognized taxa in Europe and the number of genetic entities identified.

A new genus and a new species of **Cyanobacteria**, *Neosynechococcus sphagnicola*, was described from a peat bog in the north of Slovakia. Two new *Eucapsis* species (Cyanobacteria) were described, and two new combinations were proposed.

II. Ecological niche differentiation, species co-existence and distribution patterns

One important aspect of the speciation process and maintenance of biodiversity is ecological differentiation between taxa (species or cytotypes). However, despite intensive studies on the ecology of closely related taxa in recent years, the environmental factors affecting its distribution are still insufficiently known. Results of recent surveys provide evidence that there is no consistent trend in the eco-geographical patterns of closely related taxa and that all three possible processes, including niche expansion, niche conservatism and niche contraction, occur. Moreover, neither the mechanisms nor the timing of such divergence among species are easy to identify.

To address the the questions outlined above, we explored distribution patterns and ecological differentiation in several vascular plant groups. One of the studies dealt with ecological differentiation between the two ploidy levels (tetra- and octoploid) of an important weed species of overgrazed grasslands, ***Jacobaea vulgaris*** (Asteraceae). We revealed that these ploidy levels (recognized as a separate subspecies) occur in slightly different environments. Their separation is mostly associated with the type of habitat, habitat naturalness, substrate, altitude, precipitation and temperature. In contrast to tetraploids, octoploids are restricted to warm and dry locations at low altitudes and in areas little affected by man. Despite their ecological niche separation along habitat and climatic gradients, and the more widespread distribution of tetraploids in the area studied, the ecological niche breadths of the two ploidy levels in Slovakia do not differ significantly.

A similar study has been done also in a diploid–tetraploid contact zone of the perennial herb ***Cardamine amara*** (Brassicaceae), located north of the Alps, by assessing cytotype spatial patterns and genetic and ecological divergence. Flow cytometry was applied to screen DNA ploidy levels, and genetic variation was examined using microsatellite and AFLP markers. Environmental (landscape and climatic) data were analysed to assess ecological differentiation between the cytotypes. We identified a parapatric distribution of the cytotypes with a relatively wide (over 100 km in some regions) secondary contact zone. Mixed-ploidy populations, documented for the first time in this species, as well as triploid individuals were found along the diploid–tetraploid borderline. Different climatic requirements of the two main cytotypes were revealed, mirrored in their altitudinal separation. Tetraploids were genetically differentiated from both diploids and in silico-modelled autotetraploid genotypes, in accordance with the assumed polyploid origin and spread linked to past glaciations and largely independent evolution in allopatry. In both taxa (*Jacobaea vulgaris* and *Cardamine amara*), the observed spatial and genetic patterns likely reflect the evolutionary and colonization history of the two cytotypes and have been maintained by multiple factors such as ecological divergence, limited gene flow between the cytotypes and in the second species also by its restricted dispersal capacity.

III. Large-scale biodiversity studies

a) International activities

The Institute of Botany SAS takes part in a number of international research activities as part of EU Framework Projects, but also in collaboration with international organizations. Most of this work concentrates on building databases and online infrastructure that provide information about biodiversity and its parameters either as a background for large-scale studies or for decision makers either at the national or EU level. The Institute serves as a National Node to **Global**

Biodiversity Information Facility (<http://www.gbif.org>), which is the only global source for biodiversity distribution data. Direct data input into this online source is possible from the database of distribution data for vascular plants (DATAflos). The other project, **OpenUp!** (Opening up the Natural History Heritage for Europeana) project (CIP-ICT, EU Framework Programme for Competitiveness and Innovation), coordinated by the Freie Universität Berlin, aimed to increase the representation of natural history objects (herbarium specimens, prepared animal objects, sound records, geological collections) available from the European portal EUROPEANA (<http://www.europeana.eu/portal>), which provides the possibility to explore digital sources of European museums, libraries, archives and audio-visual collections. Our institute made available via EUROPEANA metadata and high-quality images of 6,465 herbarium specimens collected in 1909–1910 by František Nábělek in the area of current Egypt, Israel, Palestine, Jordan, Syria, Lebanon, Iraq, Bahrain, Iran and Turkey, which are currently deposited in the herbarium SAV. This collection is extremely important for researchers studying this particular region. Because of the problematic accessibility of some parts of this area, but also due to the considerable changes of the landscape over the last hundred years, these specimens often represent the only or one of a few records documenting the occurrence of particular species in the area. Apart from this, our institute coordinated the whole botanical part of the project and was responsible for checking the metadata and images quality, for which specialized software was used. The metadata and images of this collection are also available via the GBIF portal.

The Institute of Botany SAS is participating also in the ongoing FP7 **EU BON** project (Building the European Biodiversity Observation Network). EU BON proposes an innovative approach in terms of integration of a biodiversity information system for on-ground and remote sensing data, for addressing policy and information needs in a timely and customized way. The project delivers integration between social networks of science and policy and technological networks of interoperating IT infrastructures. This will enable a stable new open-access platform for sharing biodiversity data and the creation of new tools. We programmed a tool to visualize species richness within a group of organisms. A Java-based web application allows user to display the distribution of species in a supertaxon, within a specified spatial bounding box and a specified time window. The output is a series of grid overlays where each grid represents the state of records in one year and each cell in the grid is coloured according to the number of records located in the area of the cell in that year. We also carried out an extensive gap analysis of data in databases storing data on the distribution of vascular plants on the European continent in order to identify gaps in respect of taxonomic groups or particular areas in distribution data, to determine which data are incomplete and which require particular attention. We concluded that for modelling of distribution and ecological requirements, a combination of a number of different global sources is inevitable, also taking into account data in national databases, where they are available.

The Institute of Botany SAS has been contributing to the international project **Millenium Seed Bank** since 2006. The Millennium Seed Bank Partnership is the largest *ex situ* plant conservation programme in the world. It is focused on global plant life faced with the threat of extinction and plants that will be most needed in the future. Collected seeds are conserved in seed banks as insurance against the risk of extinction in their native habitats. The project partners with 80 countries, and so far has successfully banked over 13% of the world's wild plant species. It targets plants and regions most at risk from the ever-increasing impact of human activities, including land use and climate change. During evaluation period, the research team of the Institute of Botany provided the Millenium Seed Bank in Kew with 426 seed collections. The project also supported several studies focused on Carpathian elements, such as *Cyclamen fatrense*, the *Pilosella alpicola* group, *Sesleria tatrae* or *Tephroseris longifolia* subsp. *moravica*, the cytogeography of European species of *Centaurea* section *Protocyanus*, the mating system and hybridization of the *Centaurea triumfetti* and *C. montanus* groups in the Carpathians. The project also supported an **annotated survey of vascular plants endemic and subendemic to the Carpathians**, comprising 146 endemics and sub-endemics.

We participated in the project **Establishment of Red List of European Habitats**, which provided an overview of threatened habitats of the EU and adjacent regions. Our researchers contributed to basic habitat typology and description, provided national data and collated them to find trends in the extent and quality of rock, scree and volcano habitats. Seventy-four habitats were selected for Slovakia and prepared extended characteristics of their chorology and the reasons and degree of their vulnerability. One of the final results will be an **online platform providing extensive additional information** on habitat classification and definition, pressures and threats,

conservation and restorability of habitats, distribution, status and trends in individual countries, and possibly threatened sub-habitats. The provided information is valuable for the EU Nature Policy in relation to EU 2020 Biodiversity Strategy targets, while further applications include the revitalization of the EUNIS habitat classification, synergies with the MAES project and the improvement of Red List methodologies.

We participated in the preparation of the '**European Red List medicinal plants assessment 2013**' (http://cmsdata.iucn.org/downloads/iucn_european_red_list_of_medical_plants_web.pdf), coordinated by the IUCN. This assessment includes 400 vascular plants from 90 families, including large trees, aquatic plants and epiphytes, and occupying a wide range of habitats. The assessment found that 2.4% of extant medicinal plants included, for which sufficient data are available, are threatened. Twenty-five species were considered 'data-deficient', and as a result, the precise proportion of threatened species is uncertain and could lie between 2.3% and 8.5%.

Representatives of the genus *Cardamine* have been studied also during work on Brassicaceae accounts for the **Pan-Himalayan Flora**. Lectotypes of twenty-eight names of taxa currently recognized or synonymized in *Cardamine* were designated. In cases when specimen images were available online, stable identifiers of specimens, other permanent links, or links via the JSTOR Global Plants website were provided.

We contributed to the knowledge of the **lichen diversity of the Mediterranean region** and North Africa during an international expedition of The Organization for the Phyto-Taxonomic Investigation of the Mediterranean Area (OPTIMA) to Tunisia; so far we identified 23 species new to Tunisia.

b) National biodiversity projects

The multivolume **Flora of Slovakia** significantly contributes to the knowledge of the diversity of Carpathian and Pannonian plant taxa. It represents the most important reference source on the flora of Slovakia not only for scientists, but also for decision makers. In the evaluated period, we published **Volume VI/3**, which includes accounts of ca 140 taxa of the families Aizoaceae, Cactaceae, Caryophyllaceae, Nyctaginaceae, Phytolacaceae and Portulacaceae; we have also finished work on the **Volume VI/4** containing ca 180 taxa of the families Amaranthaceae, Polygonaceae, Plumbaginaceae and Primulaceae. All native (autochthonous), non-native species (allochthonous: archaeophytes and neophytes, including casual aliens and taxa often escaping from cultivation, as well as commonly cultivated plants – crops and ornamentals), and also expected species are treated there in detail. Accounts of families, genera, species and infraspecific taxa include detailed morphological descriptions accompanied by line drawings of plants and their diagnostic features as well as detailed survey of all available distribution data for the area of Slovakia, in many cases accompanied by maps. An English translation of the identification keys is included in recent volumes. All distribution data are imported into the freely accessible database DATAflos, and all published volumes are available online via the Biodiversity Heritage Library.

In 1995 we initiated work on a series of monographs entitled '**Vegetation of Slovakia**', dedicated to plant communities of Slovakia. A comprehensive vegetation survey is a work of highest national importance and is a part of international efforts under the European Vegetation Survey programme. So far, volumes on pioneer vegetation (1995), synanthropic vegetation (1997), wetlands (2001) and high mountain vegetation (2007) have been published. During the evaluated period, we focused on grassland and forest habitats. The **fifth volume**, dedicated to grasslands, was published in 2014. It summarizes the results of the syntaxonomical revision of dry grasslands (*Festuco-Brometea*), fringe communities (*Trifolio-Geranietea*), lowland and mountain hay meadows and pastures (*Molinio-Arrhenatheretea*, *Nardo-Agrostion tenuis*, *Violioncaninae*), acidophilous heathlands (*Calluno-Ulicetea*) and saline vegetation (*Crypsietea aculeatae*, *Festuco-Puccinellietea*, *Scorzonero-Juncetea gerardii*). The differentiation of vegetation units of all types of forests and shrublands was studied intensively with the aim to collect recent data for the last volume of the series, the first draft of which was prepared.

We participated in the updating of the **Red List of ferns and flowering plants of Slovakia**, the **fifth** version of which was published after more than 10 years. In total, 1,218 taxa are red listed, which represents almost 34 % of the total number of 3,619 native taxa and archaeophytes of the flora of Slovakia.

During the evaluated period, we conducted research in to **fungal, algal and cyanobacterial diversity** with the aim to document the species richness of selected geographical areas, with an

emphasis on particular habitats and biotopes important from a nature conservation perspective or serving some economic purpose (e.g. grasslands, calcareous xerotherms, deciduous forests, vineyards, gravel pit lakes and thermal springs).

Our studies into the diversity of phytopathogenic/parasitic fungi yielded four *Taphrina* species new to Slovakia; they also resulted in species lists for small-scale and large-scale protected areas. As for **geoglossoid fungi**, three new species were reported from Slovakia. Based on collections of geoglossoid fungi from Slovakia, morphological diagnostic traits were revised, and a new key to species identification was prepared. Published and unpublished data about the occurrence of endangered **macrofungi** in Slovakia were located, critically revised and registered in a database. A catalogue of **Discomycetes** dedicated to the genera *Helotium* and *Hymenoscyphus*, an essential tool for biosystematics studies, was published.

Based on data recently gathered during intensive field work, we largely updated the **checklist of lichenized fungi**, since the last version was released fifteen years ago. The list includes 1,628 species. We launched a website gathering basic knowledge of lichenized fungi recorded in the territory of Slovakia (www.ibot.sav.sk/lichens). Our research of **algae and cyanobacteria** was focused on their diversity, distribution and invasions in sand and gravel pitlakes, peatbogs, alkaline fens, travertine fields and post-glacial lakes. For the first time, phototrophic microflora was studied with focus on the formation of stromatolites. Seven species of algae new to Slovakia were recorded in alkaline fens. In total, two cyanobacteria and 31 algae species were reported as new to Slovakia during the evaluation period. The first record of cyanobacterial bloom of the invasive nostocalean species *Cylindrospermopsis raciborskii* in castlemoat water was observed in western Slovakia.

c) Biodiversity e-infrastructures (databases)

An important part of our research efforts is the development of databases, mostly available online, that serve as a tool for presenting our research results and as an infrastructure supporting both our own research and international cooperation with other scientists.

Most recently, we developed a database of names, chromosome numbers and ploidy levels of the tribe Alysseae, with a new generic concept of the tribe (**AlyBase**, www.alybase.sav.sk). Alysseae is the third largest tribe of the family Brassicaceae. Its native range is Eurasia and North Africa, and the centre of its greatest diversity lies in the Mediterranean and Irano-Turanian regions. The tribe is well known for the common occurrence of polyploids and considerable variation in chromosome numbers. The work on the database included the preparation of a revised generic concept and a list of accepted names within the tribe, drawing up a key to all genera, descriptions of two new genera (*Cuprella* and *Resetnikia*) and the publication of many new nomenclatural combinations, mainly within the re-established genus *Odontarrhena*. The database and related paper provide a new baseline for further studies of the tribe.

The **Central Database of Phytosociological Relevés** (Slovak Vegetation Database) was established in 1995. Since then it is continuously supplemented with new records, and the quality of stored data has improved. The aim is to assemble all available phytosociological relevés from Slovakia and adjacent territories. The database provides the basis for national and supra-national classification overviews and other scientific studies. It can be linked to any international database and supports not only data exchange, but also enables cooperation within bi- or multilateral projects the supra-regional level (e.g. the Carpathians). By the end of 2015, the database comprised more than 40,000 published and 15,000 unpublished relevés. In 2012 our institute joined the **European Vegetation Archive (EVA)** – a centralized database of European vegetation plots developed under the patronage of The International Association for Vegetation Science (IAVS). It stores copies of national and regional vegetation plot databases on a single software platform. By mid 2015, 61 databases from all European regions have joined the EVA, contributing in total 1,027,376 vegetation plots, 82% of them with geographic coordinates, from 57 countries. The EVA provides a unique data source for large-scale analyses of European vegetation diversity both for fundamental research and nature conservation applications.

In the past century, there has been increasing concern about the consequences of the introduction and spread of alien species. Both intentionally and accidentally introduced alien species of plants may have huge environmental effects, among others, on native biodiversity through changes in community structure, nutrient cycles, trophic levels, hydrology, fire regimes, allelopathy, competition and hybridization. They may even cause high economic losses by reducing yields of crops and pastures, promoting allergic reactions and altering the natural

environment. Under the COST network project, we participated in the development of the **European Information System for Alien Species** – enabling effective and informed decision-making in relation to the IAS. We prepared a webpage providing access to the database of the alien flora of Slovakia, containing more than 880 taxa.

IV. Plant stress

Plants are exposed to several types of biotic and abiotic stress. Stress factors usually act in a synergistic way, greatly influencing the production of biomass. Global warming and problems with irrigation contribute to the increasing area of dry and saline lands. Additionally, pollution by heavy metals poses a great danger for public health both directly or through food chains, or by contamination of drinking water resources, respectively. In EU countries, an estimated 52 million hectares of soils (more than 16% of the total land area) are contaminated by heavy metals. Additionally, undeservedly little attention has been paid to the study of the impact of mycotoxins on the biological activity of plant cells. The situation has changed fundamentally with the global climate ecological conditions accompanied by increased aggressiveness of phytopathogenic fungi. The species and strains of the fungal genus *Fusarium* produce a whole array of structurally and functionally different mycotoxins, which explains the observed variability in the symptoms of plant diseases. Therefore, our research interests in 2012–2015 in plant physiology were oriented towards structural and functional responses of plants exposed to various **biotic and abiotic stress factors related to** climatic changes (drought, salinity and pathogens) or anthropogenic activity (heavy metals and toxic elements). Most of the experiments were performed on important agricultural plants like maize, barely, vine grape or wheat, although other model plant species, like *Arabidopsis* or *Noccaea* spp. are intensively studied as well.

Since the plant root system captures both water and nutrients essential for the formation of crop yield, the **improvement of root tolerance to stresses** is pivotal for maintaining sustainable crop production under changing environmental conditions. Auxin is a master regulator of root growth by modulating its development in the permanently changing environment. We examined the action of auxin in relation to its morphogenic effect on Cd-treated roots. While the auxin efflux inhibitor TIBA evoked responses similar to Cd, the auxin efflux/influx inhibitor 1-NOA attenuated and the auxin signalling inhibitor PCIB blocked these Cd-induced responses, suggesting that, apart from the elevated level of IAA in the root apex, its uptake and accumulation inside cells or tissues is a prerequisite for the induction of characteristic root responses to short-term Cd exposure. Within a few minutes, toxic Cd concentrations caused induction of superoxide generation leading to cell death and root growth arrest. This toxic superoxide generation blocked the development of low Cd concentration-activated morphogenic responses such as root growth inhibition and radial swelling of the root tip. We found that the Cd-induced morphogenic responses are dose-dependent and differ in time. While the morphogenic responses of roots to low Cd concentration are induced very rapidly and probably due to the interaction of Cd with the apoplastic space of root tissue, high Cd concentration-induced superoxide production required the entry of Cd into the symplasm. Auxin signalling is involved in the activation of Cd-induced morphogenic defence responses but not in the Cd-induced toxic superoxide generation. Recently, an antagonistic interaction **has been suggested between salicylic acid (SA) and IAA signalling**. Our results indicated that, similarly to PCIB, SA did not affect the IAA content of root tips, suggesting the action of SA on the IAA signalling pathway in barley roots. SA probably does not alleviate the toxicity of Cd in roots, but rather prevents or partially inhibits the root defence response to the presence of Cd through the inhibition of Cd-induced IAA-mediated ROS generation in roots. Studying the role of glutathione in sequestration of Cd in root tissues, we found that enhanced γ -glutamyl transferase (GGT) activity was detected in Cd-treated root tips. This indicated that mere recycling of extracellular glutathione eGSH and/or the Cd/eGSH complex by GGT and not its level in the apoplast plays a role in the sensing of toxic compounds and in the activation of defence responses. A considerable increase in NO production was detected in the transition zone of root tips already 30 min after the exposure of barley roots to Cd. Our results revealed that enhanced NO production is a very early response of barley roots to Cd stress and that it is involved in the regulation of root growth mitigating Cd-induced root growth inhibition.

Silicon has often been found to alleviate phytotoxic effects of trace elements. For that reason, the main interest was turned towards **how it can affect maize plants exposed to some abiotic stress** (Sb, Zn, Cd and NaCl). Growth parameters, membrane damage, the antioxidative response and ammonia assimilation were studied in treated plants of two hybrids differing in their

sensitivity to stress. Our results indicate that silicon differently affects the growth and development of several maize hybrids exposed to various environmental stresses, including salinity and zinc excess. Additionally, we performed several experiments to look for a possible mitigation role of silicon in plants exposed to antimony. Antimony reduced root growth, induced oxidative stress and activated antioxidant defence mechanisms in maize. Silicon addition to Sb-treated roots reduced oxidative stress symptoms documented by lower lipid peroxidation, proline accumulation and decreased activity of antioxidative enzymes. Although neither a positive nor negative effect of Si has been observed on root length and biomass production, changes in the oxidative response of plants exposed to Sb indicate a possible mitigation role of Si in Sb toxicity to plants.

Biotic stress was studied on commercially available maize cultivars with different degrees of tolerance to *Fusarium* head blight (*Fusarium*) to the action of the mycotoxin zearalenone (ZEN) and its derivative α -zearalenol (α -ZEL) and β -zearalenol (β -ZEL). When applied, mycotoxins stimulate rapid depolarization of the plasma membrane electrical potential, the extent of which correlated with the type and concentration of mycotoxin used. It has been proven that ZEN, but not its derivatives, significantly inhibited root respiration of maize cells. Leakage of electrolyte from maize cells after the application of mycotoxins revealed that the process is fully dependent on the range of action of the mycotoxin and was significantly greater for the *Fusarium*-sensitive cultivar. The mycotoxin treatment of maize root explants and suspension-cultured grapevine cells resulted in programmed cell death (PCD), which was dependent on the type and concentration of mycotoxin and was accompanied by the manifestation of critical apoptosis hallmarks, e.g. cytochrome C release, PARP cleavage, nuclear disintegration, proteolysis and DNA release/fragmentation.

V. Connection to applied research

Biodiversity can be described at the ecosystem, species and genetic levels. Previous theory assumed that these levels are congruent, amongst other reasons, because they are subjected to the same processes. According to this claim, regions with a high level of ecosystem diversity should also be rich in species, and those species should display a high level of genetic diversity. An international team of researchers grouped within the **IntraBioDiv project** (FP 6), including those from the Institute of Botany, has demonstrated for the first time that a high level of species diversity in alpine plants does not necessarily go hand in hand with a high level of genetic diversity. The researchers studied the distribution pattern of 893 alpine plants throughout the Alps. After taking the genetic fingerprints of 27 of these species, they found that species-rich areas are distinct from areas harbouring high genetic diversity. Moreover, they succeeded in pinpointing the reasons for this: In alpine plants, species diversity is influenced by local environmental conditions whereas genetic diversity is determined by processes that led to the recolonization of ice-free areas after the last Ice Age. Furthermore, a parallel study conducted in the Carpathians shows that this finding for the Alps was no 'one-off' result. These findings are highly relevant for the conservation of biodiversity in the Alps. Today's designated conservation areas are locations where rare species occur and where ecosystem diversity and thus the number of species are particularly high. However, this does not guarantee sufficient long-term protection for alpine plants because their genetic diversity is only insufficiently secured by current conservation areas. In the future, therefore, existing conservation areas should be complemented by areas characterized by high levels of genetic diversity.

At the national level, the Institute of Botany closely **cooperated with the Ministry of the Environment and State Nature Conservancy** on tasks connected with the incorporation of biodiversity research results into policy documents, guidelines and resource materials for the development of legislation. We participated in field surveys, the elaboration of nature conservation documentation, management plans and NATURA 2000 species and habitats monitoring.

The data gathered during the **Cryptogam Symposium on Natural Beech Forests**, Slovakia 2011, organized by the Institute of Botany, represent a very important contribution to the knowledge of the diversity of wood-inhabiting cryptogams in beech primeval forests in Slovakia. Based on a system of fungal indicators, the National Nature Reserve Stužica was confirmed as the beech forest with the best so far known score for naturalness in Europe. This confirms the importance of dead beech wood as an endangered habitat and confirms the appropriateness of the status of the Poloniny National Park as a UNESCO heritage area. These data also represent an important contribution to fungal indicator systems of forest naturalness at the European scale.

Regarding **lichens and cement production**, we investigated lichen diversity, element depositions, magnetic properties, physiological parameters and ultrastructural alterations in native and transplanted lichens. We found that the elemental content of native lichens was significantly enriched in Ca, Ti, Fe, V, Al and Ni around the cement plant and quarries, compared to the surrounding environment. In transplanted lichens exposed for up to 180 days in the study area, dust-related elements (Ca, Fe, Ti) rapidly (within 30 days) accumulated in the thalli, while airborne pollutants originating from combustion processes (e.g. S) progressively (from 30 to 180 days) increased. The magnetic properties of native and transplanted samples were influenced by rock mineralogy and the processes of cement production. In fact, rock quarrying, grinding and kiln operations are sources of coarse and fine particulate matter, which, transported by the wind, may deposit in the surrounding environment. In addition, dust depositions shaped epiphytic lichen communities in the surrounding environment, which shifted from acidophilous-oligotrophic (natural condition in the area) toward basi-nitrophilous communities approaching the sources.

2. Partial indicators of main activities:

2.1. Research output

2.1.1. Principal types of research output of the institute: basic research/applied research, international/regional (ratios in percentage)

- Basic – applied: 80% - 20%
- international – regional 80% - 20%

The **principal and priority forms of our research outputs** are scientific **monographs and papers in high quality impacted peer-reviewed journals registered in the WOS**. A considerable part of the research conducted at the Institute is devoted to systematic botany and mycology, as well as to the syntaxonomy of plant communities. The results of such studies are published either in the form of **monographs, which are the cornerstones of systematics** (mostly, but not exclusively, in the **series Flóra Slovenska [Flora of Slovakia]** and **Rastlinné spoločenstvá Slovenska [Plant communities of Slovakia]**), or as scientific papers. Despite financial, institutional and publishing constraints and changing opportunities provided by new digital media, the value of the monograph, as a print-on-paper record of a substantial research summary is recognized and valued. Monographs are the vehicles for circumscribing and naming biological units, determining distributions and ecology, assessing relationships for formal classification, and interpreting long-term and short-term dimensions of the evolutionary process. Nevertheless, research outputs disseminated in the form of **scientific papers published in impact factor journals** are just as important to us.

Part of our work is published as chapters in books (published in Slovakia or abroad), as articles in non-impacted factor journals and in symposium/conference proceedings. We **incorporate the outputs of our scientific work also into the educational process** through courses, individual lectures, course books/school books for university students, through presentations and specialized classes for secondary and elementary schools. We disseminate the results of our research also to the general public in the form of popular contributions in the mass-media – interviews (TV, radio), articles in journals, newspapers, web-sites, etc.

2.1.2 List of selected publications documenting the most important results of basic research. The total number of publications listed for the assessment period should not exceed the average number of employees with university degrees engaged in research projects. The principal research outputs (max. 5, including Digital Object Identifier - DOI) should be underlined

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- [2] **Hegedúšová Vantarová, K., Škodová I. (eds.), 2014: Rastlinné spoločenstvá Slovenska. 5. Travinno-bylinná vegetácia. [Plant communities of Slovakia. 5. Grassland vegetation.] Veda, Bratislava, 581 pp. ISBN 978-80-224-1355-8**

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- [40] **Vaculíková, M., Vaculík, M., Šimková, L., Fialová, I., Kochanová, Z., Sedláková, B., Luxová, M.**, 2014: Influence of silicon on maize roots exposed to antimony - Growth and antioxidative response. *Plant Physiol. Biochem.* vol. 83, 279-284. IF = **2.756**.
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- [42] **Liptáková, Ľ., Huttová, J., Mistrík, I., Tamás, L.**, 2013: Enhanced lipoxygenase activity is involved in the stress response but not in the harmful lipid peroxidation and cell death of short-term cadmium-treated barley root tip. *Journal of Plant Physiology: biochemistry*,

physiology, molecular biology and functional biotechnology of plants, vol. 170, no. 7, p. 646-652. IF = **2.699**.

- [43] **Guttová, A., Zozomová-Lihová, J.,** Timdal, E., **Kučera, J., Slovák, M., Píknová, K., Paoli, L.,** 2014: First insights into genetic diversity and relationships of European taxa of *Solenopsisora* (Catillariaceae, Ascomycota) with implications for their delimitation. *Botanical Journal of the Linnean Society*, vol. 176, no. 2, p. 203-223. IF = **2.699**.
- [44] Horsák, M., Chytrý, M., Hájková, P., Hájek, M., Danihelka, J., Horsáková, V., Ermakov, N., German, D. A., Kočí, M., Lustyk, P., Nekola, J. C., Preislerová, Z., **Valachovič, M.,** 2015: European glacial relict snails and plants: environmental context of their modern refugial occurrence in southern Siberia. *Boreas*, vol. 44, no. 4, p. 638-657. IF = **2.658**.
- [45] **Zozomová-Lihová, J.,** Malánová-Krásná, I., Vít, P., Urfus, T., **Senko, D., Svitok, M., Kempa, M., Marhold, K.,** 2015: Cytotype distribution patterns, ecological differentiation, and genetic structure in a diploid-tetraploid contact zone of *Cardamine amara*. *American Journal of Botany*, vol. 102, no. 8, p. 1380-1395. IF = **2.603**.
- [46] **Olšavská, K., Perný, M.,** Löser, C. J., Stimper, R., **Hodálová, I.,** 2013: Cytogeography of European perennial species of *Cyanus* (Asteraceae). *Botanical Journal of the Linnean Society*, vol. 173, no. 2, p. 230-257. IF = **2.589**.
- [47] **Alemayehu, A., Bočová, B., Zelinová, V., Mistrík, I., Tamás, L.,** 2013: Enhanced lipoxygenase activity is involved in barley root tip swelling induced by cadmium, auxin or hydrogen peroxide. *Environmental and Experimental Botany*, vol. 93, p. 55-62. IF = **2.578**.
- [48] **Tamás, L., Mistrík, I., Alemayehu, A., Zelinová, V., Bočová, B., Huttová, J.,** 2015: Salicylic acid alleviates cadmium-induced stress responses through the inhibition of Cd-induced auxin-mediated reactive oxygen species production in barley root tips. *Journal of Plant Physiology*, vol. 173, p. 1-8. IF = **2.557**.
- [49] Černý, T., Kopecký, M., Petřík, P., Song, J.-S., Šrutek, M., **Valachovič, M.,** Altman, J., Doležal, J., 2015: Classification of Korean forests: patterns along geographic and environmental gradients. *Applied Vegetation Science*, vol. 18, no. 1, p. 5-22. IF = **2.548**.
- [50] Kolarčík, V., **Zozomová-Lihová, J.,** Ducár, E., Mártonfi, P., 2014: Evolutionary significance of hybridization in *Onosma* (Boraginaceae): analyses of stabilized hemisexual odd polyploids and recent sterile hybrids. *Biological Journal of the Linnean Society*, vol. 112, no. 1, p. 89-107. IF = **2.535**.

2.1.3 List of monographs/books published abroad

- [1] Pliński, M., **Hindák, F.,** 2012: Zielenice - Chlorophyta (Green Algae): Flora Zatoki Gdańskiej i wód przyległych (Bałtyk Południowy) 7/2. Wydawnictwo Uniwersytetu Gdańskiego, Gdansk, 140 pp. ISBN 978-83-7326-902-6.

2.1.4 List of monographs/books published in Slovakia

- [1] **Goliašová, K., Michalková, E. (eds.),** 2012: Flóra Slovenska [Flora of Slovakia] VI/3. Angiospermophytina. Dicotyledonopsida. Caryophyllales (1.časť). Veda, Bratislava, 712 pp. ISBN 978-80-224-1232-2.
- [2] **Šrobárová, A.,** 2013: Mykotoxíny najčastejších plesní a pôvodcov chorôb [Mycotoxins of the most common fungal pathogens]. LUFEMA, Bratislava, 159 pp. ISBN 978-80-89058-40-2.
- [3] **Hegedúšová Vantarová, K., Škodová I. (eds.),** 2014: Rastlinné spoločenstvá Slovenska. 5. Travnino-bylinná vegetácia [Plant communities of Slovakia. 5. Grassland vegetation.]. Veda, Bratislava, 581 pp. ISBN 978-80-224-1355-8.
- [4] **Lizoň, P., Kučera, V.,** 2014: Catalogue of Discomycetes referred to the genera *Helotium* Pers. and *Hymenoscyphus* Gray. Institute of Botany, Slovak Academy of Sciences, Bratislava, 145 pp. ISBN 978-80-971837-4-5.

- [5] Adamcová, M., Baláž, I., Ceľuch, M., Cséfalvay, R., Findo, S., **Hrivnák, R.**, Chovancová, B., Janák, M., **Jarolímek, I.**, Kánya, M., Kaňuch, P., Kováč, V., Krištín, A., Kalivoda, H., Lasák, R., Majláth, I., Majzlan, O., Mútnanová, M., Olšovský, T., Potocký, P., Považan, R., Stloukal, E., Šácha, D., Šebeň, V., Šeffler, J., Šefflerová-Stanová, V., **Šibík, J.**, Uhrín, M., Valachovič, D., **Valachovič, M.**, Vavrová, L., **Zaliberová, M.**, 2015: Príručka metód monitoringu biotopov a druhov európskeho významu [Manual of methods for monitoring habitats and species of European importance]. Štátna ochrana prírody Slovenskej republiky, Banská Bystrica, 148 pp. ISBN 978-80-8184-024-1.

2.1.5. List of other scientific outputs specifically important for the institute, max. 10 items

- [1] McNeill, J., Barrie, F. R., Buck, W. R., Demoulin, V., Greuter, W., Hawksworth, D. L., Herendeen, P. S., Knapp, S., **Marhold, K.**, Prado, J., Prud'homme van Reine, W. F., Smith, G. F., Wiersema, J. H. & Turland, N. J., 2012: International Code of Nomenclature for algae, fungi, and plants (Melbourne Code): adopted by the Eighteenth International Botanical Congress Melbourne, Australia, July 2011. Königstein, Koeltz Scientific Books, (Regnum Vegetabile 154: 1-208).
- [2] Taberlet, P., Zimmermann, N.E., English, T., Tribsch, A., Holderegger, R., Alvarez, N., Niklfeld, H., Coldea, G., Mirek, Z., Moilanen, A., Ahlmer, W., Ajmone-Marsan, P., Bona, E., Bovio, M., Choler, P., Cieślak, E., Colli, L., Cristea, V., Dalmás, J.-P., Frajman, B., Garraud, L., Gaudeul, M., Gielly, L., Gutermann, W., Jogan, N., Kagalo, A.A., Korbecka, G., Kűpfer, P., Lequette, B., **Letz, D.R.**, Manel, S., Mansion, G., **Marhold, K.**, Martini, F., Negrini, R., Niño, F., Paun, O., Pellicchia, M., Perico, G., Piękoś-Mirkowa, H., Prosser, F., Puşcaş, M., Ronikier, M., Scheuerer, M., Schneeweiss, G.M., Schönswetter, P., Schratt-Ehrendorfer, L., Schűpfer, F., Selvaggi, A., Steinmann, K., Thiel-Egenter, C., Van Loo, M., Winkler, M., Wohlgemuth, T., Wraber, T., Gugerli, F. & IntraBioDiv Consortium, 2012: Genetic diversity in widespread species is not congruent with species richness in alpine plant communities. *Ecology Letters* vol. 15, p. 1439–1448. IF = 17,557.
- [3] Li, J., Baroja-Fernández, E., Bahaji, A., Munoz, F. J., **Ovečka, M.**, Montero, M., Sesma, M. T., Alonso-Casajus, N., Almagro, G., Sanchez-Lopez, A. M., Hidalgo, M., Zamarbide, M., Pozueta-Romero, J., 2013: Enhancing Sucrose Synthase Activity Results in Increased Levels of Starch and ADP-Glucose in Maize (*Zea mays* L.) Seed Endosperms. *Plant and Cell Physiology*, vol. 54, no. 2, p. 282-294. IF = 4.134
- [4] Nováková, S., Flores-Ramírez, G., Glasa, M., Danchenko, M., **Fiala, R.**, Škultéty, L., 2015: Partially resistant *Cucurbita pepo* showed late onset of the Zucchini yellow mosaic virus infection due to rapid activation of defense mechanisms as compared to susceptible cultivar. *Frontiers in Plant Science*, vol. 6, p. 263, eCollection 2015. IF = 3.948.
- [5] Munzi, S., **Paoli, L.**, Fiorini, E., Loppi, S., 2012: Physiological response of the epiphytic lichen *Evernia prunastri* (L.) Ach. to ecologically relevant nitrogen concentrations. *Environmental Pollution*, vol. 171, p. 25-29. IF = 3.746.
- [6] **Paoli, L.**, Corsini, A., Bigagli, V., Vannini, J., Bruscoli, C., Loppi, S., 2012: Long-term biological monitoring of environmental quality around a solid waste landfill assessed with lichens. *Environmental Pollution*, vol. 161, p. 70-75. IF = 3.746.
- [7] Hohmann, N., Schmickl, R., Chiang, T.-Y., Lučanová, M., Kolář, F., **Marhold, K.**, Koch, M. A., 2014: Taming the wild: resolving the gene pools of non-model *Arabidopsis* lineages. *BMC Evolutionary Biology*, vol. 14, p. 224. IF = 3.407.
- [8] Leong-Škorničková, J., Šída, O., Záveská, E., **Marhold, K.**, 2015: History of infrageneric classification, typification of supraspecific names and outstanding transfers in *Curcuma* (Zingiberaceae). *Taxon*, vol. 64, no. 2, p. 362-373. IF = 3.299.
- [9] Záveská, E., Fér, T., Šída, O., Krak, K., **Marhold, K.**, Leong-Škorničková, J., 2012: Phylogeny of *Curcuma* (Zingiberaceae) based on plastid and nuclear sequences: Proposal of the new subgenus *Ecomata*. *Taxon*, vol. 61, no. 4, p. 747-763. IF = 2.703.

- [10] **Paoli, L.,** Munzi, S., Fiorini, E., Gaggi, C., Loppi, S., 2013: Influence of angular exposure and proximity to vehicular traffic on the diversity of epiphytic lichens and the bioaccumulation of traffic-related elements. Environmental Science & Pollution Research, vol. 20, no. 1, p. 250-259. IF = 2.618.

2.1.6. List of patents, patent applications, and other intellectual property rights registered abroad, incl. revenues

N/A

2.1.7. List of patents, patent applications, and other intellectual property rights registered in Slovakia, incl. revenues

N/A

2.1.8. Table of research outputs (as in annual reports).

Papers from international collaborations in large-scale scientific projects (Dwarf team, ALICE Collaboration, ATLAS collaboration, CD Collaboration, H1 Collaboration, HADES Collaboration, and STAR Collaboration) have to be listed separately.

Scientific publications	2012			2013			2014			2015			total			
	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	No. / FTE	No. / salary budget	number	Averaged number per year	av. No. / FTE	av. No. / salary budget
Scientific monographs and monographic studies in journals and proceedings published abroad (AAA, ABA)	1	0,018	0,001	0	0,000	0,000	1	0,016	0,001	0	0	0	2	0,5	0,008	0,001
Scientific monographs and monographic studies in journals and proceedings published in Slovakia (AAB, ABB)	0	0,000	0,000	3	0,051	0,004	3	0,048	0,004	1	0,017	0,001	7	1,8	0,030	0,002
Chapters in scientific monographs published abroad (ABC)	2	0,035	0,003	3	0,051	0,004	1	0,016	0,001	0	0	0,000	6	1,5	0,025	0,002
Chapters in scientific monographs published in Slovakia (ABD)	8	0,140	0,011	0	0,000	0,000	6	0,096	0,009	9	0,152	0,012	23	5,8	0,097	0,008
Scientific papers published in journals registered in Current Contents Connect (ADCA, ADCB, ADDA, AADB)	45	0,790	0,065	52	0,892	0,074	44	0,705	0,063	50	0,842	0,069	191	47,8	0,806	0,068
Scientific papers published in journals registered in Web of Science Core Collection and SCOPUS (ADMA, ADMB, ADNA, ADNB)	11	0,193	0,016	13	0,223	0,019	12	0,192	0,017	4	0,067	0,006	40	10	0,169	0,014
Scientific papers published in other foreign journals (not listed above) (ADEA, ADEB)	12	0,211	0,017	9	0,154	0,013	10	0,160	0,014	10	0,168	0,014	41	10,3	0,173	0,015
Scientific papers published in other domestic journals (not listed above) (ADFA, ADFB)	16	0,281	0,023	14	0,240	0,020	17	0,272	0,025	11	0,185	0,015	58	14,5	0,245	0,021
Scientific papers published in foreign peer-reviewed proceedings (AEC, AECA)	2	0,035	0,003	3	0,051	0,004	3	0,048	0,004	2	0,034	0,003	10	2,5	0,042	0,004
Scientific papers published in domestic peer-reviewed proceedings (AED, AEDA)	28	0,492	0,040	3	0,051	0,004	10	0,160	0,014	3	0,051	0,004	44	11	0,186	0,016
Published papers (full text) from foreign and international scientific conferences (AFA, AFC, AFBA, AFDA)	0	0,000	0,000	0	0,000	0,000	0	0,000	0,000	1	0,017	0,001	1	0,3	0,004	0,000
Published papers (full text) from domestic scientific conferences (AFB, AFD, AFBB, AFDB)	0	0,000	0,000	0	0,000	0,000	0	0,000	0,000	0	0	0,000	0	0	0,000	0,000

- **Supplementary information and/or comments on the scientific outputs of the institute.**

For the period 2011-2017 (and likely also for the period 2017-2022), the Institute of Botany hosts the **Secretariat of the International Association for Plant Taxonomy (IAPT)**. Prof. Karol Marhold is the Secretary-General of the IAPT (the chief executive officer of the IAPT). The Managing Secretary of the IAPT is Dipl. Ing. Eva Senková. IAPT, c/o Institute of Botany, Slovak Academy of Sciences publishes the bi-monthly scientific journal **TAXON**. It is devoted to systematic and evolutionary biology with emphasis on plants and fungi. Taxon, along with other journals (e.g. Molecular Phylogenetics and Evolution, the American Journal of Botany or the International Journal of Plant Sciences) is among the most influential scientific journals in the field of plant evolution, phylogeny, taxonomy and systematics. Besides this, the IAPT organizes and promotes international scientific events, is authorized by the IUBS to publish the International Code of Nomenclature for algae, fungi and plants. The IAPT annually awards 20 grants to young scientists mostly from developing countries.

Research teams of the IB SAS focused on biodiversity research of non-vascular, vascular plants and plant communities publish their research outputs in a wide spectrum of scientific media. Most significant results are published in peer-reviewed, impacted international journals included in the ISI databases (WOS, SCOPUS, etc.), being the crucial indicator of fundamental research activities. Important information on the flora and vegetation of Slovakia is published in monographs (Floras, checklists, identification keys, vegetation surveys, etc.). They are related to the local flora and vegetation, for the conservation of which Slovakia has the ultimate responsibility, and as such cannot be replaced by any other publications published abroad. At the national scale, they serve as reference manuals for botanists and those working in other branches of science (e.g. zoology, ecology, forestry, etc.), for teachers and students at high schools and universities, and for practical purposes of nature conservancy. On the other hand, they serve at the international scale as important information sources on the flora and vegetation of Slovakia for researchers from abroad that either study certain plant species occurring in Slovakia or need information about the country flora and vegetation to generate a wider picture of European biodiversity. Recently, several important publications presenting syntheses of regional biodiversity information were made available for cooperating institutions, universities, libraries and nature conservancy bodies both home and abroad. Results of regional-scale biodiversity research are published in the Slovak language to cultivate national botanical terminology and to approach the main target groups of readers. Research teams oriented towards experimental research in plant physiology publish nearly all results in well-impacted international journals. At the national and international scales, the results are important to steer agricultural activities towards the production of crops suitable for the current conditions, including specific environmental burdens related mostly to soil quality.

The publication of available data and their sharing with professionals, institutions and other end users is one of our priorities. For these purposes, several mostly on-line databases were designed and built. The **Database of the flora of Slovakia (Dataflos)** (<http://dataflos.sav.sk>), for example, offers an overview of occurrence data on vascular plants in Slovakia. Data are listed and displayed on different underlying types of maps. In addition, images of important voucher specimens are available, together with the tools for searching and sorting the data according to various criteria (name of the species, genus, family, community, phytogeographical district, etc.), and their export. Currently, the database contains proximately 120,000 records on the distribution of vascular plants. Looking ahead, it will be supplemented by literary records and herbarium data on the occurrence of non-vascular plants in Slovakia. The other database is that of the **Checklist of non-vascular and vascular plants of Slovakia** (<http://ibot.sav.sk/checklist>), which is a comprehensive list of representatives of the Slovak flora. The aim of the editors and authors was to create a checklist as a tool for those that work with plants not only in the field of systematic botany and taxonomy, but also in phytosociology, nature conservation, landscape ecology, and other botanical and biological disciplines. Besides accepted names, this database also includes also synonyms used in older Slovak literature and literature of neighbouring countries, allowing non-specialists to easier navigate in the nomenclature. Work is currently in progress on the preparation of a new, updated version of the checklist, also reflecting progress in computer technology. There are several databases containing chromosome number and ploidy level data. The **Karyological database of ferns and flowering plants of Slovakia** (<http://www.chromosomes.sav.sk>) includes

8,096 chromosome number records which were extracted from 578 publications and manuscripts on all autochthonous and allochthonous species and hybrids of ferns and flowering plants. Chromosome numbers of 101 taxa of the **genus *Cardamine*** (altogether 3020 records) are included in an on-line karyological database of the genus *Cardamine* (<http://www.cardamine.sav.sk>). Information about chromosome numbers from the worldwide distribution area of the genus was compiled from 234 literature sources. Each database record includes the name of the taxon, data on chromosomes, data on the origin of the material, data on the voucher specimen and the place of publication. Most recently, we developed the **Database of names, chromosome numbers, and ploidy levels of Alysseae, with a new generic concept of the tribe (AlyBase) of the family Brassicaceae (Cruciferae)**. The database also includes the revised generic concept and the list of accepted names of the tribe (24 genera and 277 species), an identification key to all genera, descriptions of the two new genera (*Cuprella* and *Resetnikia*) and many new nomenclatural combinations, mainly in the re-established genus *Odontarrhena* (77 combinations). Karyological databases represent an important tool enabling more effective national and international cooperation of scientists working in a particular area or on a particular group of plants. Another database curated by the Department of Geobotany is the **Slovak Vegetation Database** (Central Database of Phytosociological Relevés), which is indexed in the Global Index of Vegetation-Plot Databases (<http://www.givd.info>) and is among the five largest vegetation databases in Europe. The database is an important part of the European Vegetation Archive, an integrated database of European vegetation plots (<http://euroveg.org/eva-database>). Rich material collected since 1919 is stored in the global database TURBOVEG (http://www.botanik.uni-greifswald.de/561.html?&no_cache=1&L=1#search_form). Currently, the CDF TURBOVEG database programme contains more than 60,000 phytosociological relevés (situation as of 31 March 2016) from Slovakia, which puts our team at one of the leading positions in the processing and creation of vegetation databases in the world. When we look at this database as a potential source of floristic and ecological data, more than 1,300,000 records of species occurrences can be found together with other auxiliary data such as altitude, orientation, habitat type, inclination, cover of individual layers, etc. All necessary information and updates are freely available on the site dedicated database vegetation (<http://www.ibot.sav.sk/cdf/index.html>). The **Database of non-native species of vascular plants of Slovakia** contains published and unpublished data on alien species recorded for the territory of Slovakia, their geographical distribution, habitat preferences and syntaxonomical, ecology, history, dissemination, etc. Currently, the database contains information on about 880 non-native taxa.

2.2. Responses to the research outputs (citations, etc.)

2.2.1. Table with citations per annum.

Citations of papers from international collaborations in large-scale scientific projects (Dwarf team, ALICE Collaboration, ATLAS collaboration, CD Collaboration, H1 Collaboration, HADES Collaboration, and STAR Collaboration) have to be listed separately.

Citations, reviews	2011		2012		2013		2014		total		
	number	No. / FTE	number	averaged number per year	av. No. / FTE						
Citations in Web of Science Core Collection (1.1, 2.1)	976,0	17,135	1016,0	17,424	1210,0	19,382	1428,0	24,053	4630,0	1157,5	19,530
Citations in SCOPUS (1.2, 2.2) if not listed above	89,0	1,563	76,0	1,303	23,0	0,368	34,0	0,573	222,0	55,5	0,936
Citations in other citation indexes and databases (not listed above) (3.2,4.2,9,10)	0,0	0,000	0,0	0,000	0,0	0,000	0,0	0,000	0,0	0,0	0,000
Other citations (not listed above) (3, 4, 3.1, 4.1)	446,0	7,830	320,0	5,488	418,0	6,695	544,0	9,163	1728,0	432,0	7,289
Reviews (5,6)	1,0	0,018	0,0	0,000	0,0	0,000	0,0	0,000	1,0	0,3	0,004

2.2.2. List of 10 most-cited publications, with number of citations, in the assessment period (2011 – 2014).

[1] McNeill, J., Barrie, F. R., Burdet, H. M., Demoulin, V., Hawksworth, D. L., **Marhold, K.**, Nicolson, D. H., Prado, J., Silva, P. C., Skog, J. E., Wiersema, J. H., Turland, N. J., 2006: International Code of Botanical Nomenclature (Vienna Code) adopted by the Seventeenth International Botanical Congress Vienna, Austria, July 2005. Ruggell: A. R. G. Gantner, 658 pp. *Regnum Vegetabile*, 146. ISBN 0080-0694. **539 citations**

[2] McNeill, J., Barrie, F. R., Buck, W. R., Demoulin, V., Greuter, W., Hawksworth, D. L., Herendeen, P. S., Knapp, S., **Marhold, K.**, Prado, J., Prud'Homme van R., Smith, G. F., Wiersema, J. H., Turland, N. J., 2012: International Code of Nomenclature for algae, fungi, and plants (Melbourne Code): adopted by the Eighteenth International Botanical Congress Melbourne, Australia, July 2011. Königstein: Koeltz Scientific Books, 208 pp. *Regnum Vegetabile*, 154. ISBN 978-3-87429-425-6. **466 citations**

[3] **Marhold K., Hindák F.** (eds.), 1998: Zoznam nižších a vyšších rastlín Slovenska [Checklist of non-vascular and vascular plants of Slovakia]. 1. vyd. Bratislava: Veda, 687 pp. **275 citations** (including chapters citations)

[4] Baláž, D., **Marhold, K.**, Urban, J. (eds), 2001: Červený zoznam rastlín a živočíchov Slovenska [Red list of plants and animals of Slovakia]. *Ochrana prírody*. Banská Bystrica. č. 20, Suppl. 1, 160 pp. **129 citations** (including chapters citations)

[5] **Jarolímek, I., Šibík, J.** (eds.), 2008: Diagnostic, constant and dominant species of the higher vegetation units of Slovakia. 1. vyd. Bratislava: Veda, 332 pp. *Vegetation of Slovakia*. ISBN 978-80-224-1024-3. **71 citations** (including chapters citations)

[6] **Bertová, L.**, Hlavaček, A., Holub, J., **Jasičová, M.**, Šourková, M., **Zahradníková, K.**, 1984: *Flóra Slovenska* [Flora of Slovakia] IV/1. Editor Lýdia Bertová. Bratislava: VEDA, 432 pp. **66 citations** (including chapters citations)

[7] Hattori, T., Inanaga, S., Araki, H.-An. P., Morita, S., **Luxová, M.**, Lux, A., 2005: Application of silicon enhanced drought tolerance in *Sorghum bicolor*. In *Physiologia Plantarum : International Journal for Experimental Plant Biology*. - Wiley Blackwell, vol. 123, no. 4, p. 459-466. (2.017 - IF2004). ISSN 0031-9317. **49 citations**

[8] **Janišová, M.**, Hájková, P., **Hegedúšová, K.**, **Hrivnák, R.**, Kliment, J., **Micháľková, D.**, Ružičková, H., Řezníčková, M., **Škodová, I.**, Tichý, Ľ., Uhliarová, E., Ujházy, K., **Zaliberová, M.**, 2007: *Travnobylinná vegetácia Slovenska – elektronický expertný systém na indentifikáciu syntaxónov* [Grassland vegetation of Slovak Republic – electronic expert system for identification of syntaxa]. Bratislava: Botanický ústav SAV, 2007. 263 pp. *Vegetation of Slovakia*. ISBN 978-80-969265-7-2. **45 citations** (including chapters citations)

[9] **Valachovič, M., Oťaheľová, H.**, Stanová, V., **Maglocký, Š.**, 1995: *Rastlinné spoločenstvá Slovenska*. 1. Pionierska vegetácia [Plant communities of Slovakia. 5. Pioneer vegetation.]. Ed. Milan Valachovič. Bratislava: Veda, 184 pp. **45 citations** (including chapters citations)

[10] **Medvecká, J.**, Kliment, J., **Májeková, J.**, Halada, Ľ., **Zaliberová, M.**, Gojdičová, E., **Feráková, V.**, **Jarolímek, I.**, 2012: Inventory of the alien flora of Slovakia. In *Preslia*, vol. 84, no. 2, p. 257-309. (2.521 - IF2011). ISSN 0032-7786. **43 citations**

2.2.3. List of most-cited authors from the Institute (at most 10 % of the research employees with university degree engaged in research projects) and their number of citations in the assessment period (2011– 2014).

[1] Karol Marhold – 1681 citations

- [2] Milan Valachovič – 440 citations
- [3] Ivan Jarolímek – 368 citations
- [4] Igor Mistrík – 366 citations
- [5] Richard Hrivnák – 348 citations
- [6] Ladislav Tamás – 314 citations
- [7] Judita Zozomová-Lihová – 295 citations
- [8] František Hindák – 292 citations

- **Supplementary information and/or comments on responses to the scientific output of the institute.**

Full lists of responses to the scientific output of the Institute of Botany SAS are available in the annexes of its annual reports. The annual reports are available at www.ibot.sav.sk and in the annexes to this report. The Institute's scientific output is triggering increasing responses. Several monograph outputs have a steadily high number of citations. These are mainly the internationally important **International code of botanical nomenclature** and its new edition, the **International code of nomenclature for algae, fungi and plants**, which have a global audience, followed by the both nationally and the internationally important checklist of plants and fungi growing in Slovakia – the **Checklist of non-vascular and vascular plants of Slovakia**. Research teams producing detailed studies on the taxonomy and phylogeny of selected groups of flowering plants in the Carpathians, Alps, Pannonia, the Balkan Peninsula, and in some cases also at the European or worldwide scale, produce high quality research outputs which are of international importance, thus collecting increasingly high numbers of quality citations in impacted journals. Teams working in taxonomy within narrow fields of mainstream botany, mainly mycology and lichenology, receive adequate attention from teams working on similar topics abroad. A positive trend in citations is evident in the area of plant vegetation studies and plant physiology.

2.3. Research status of the institute in international and national contexts

- **International/European position of the institute**
 - 2.3.1. List of the most important research activities demonstrating the international relevance of the research performed by the institute, incl. major projects (details of projects should be supplied under Indicator 2.4). Max. 10 items.**

The importance of research activities as well as the engagement of the Institute in the international research on plant sciences can be referred from the following survey of projects revealing the scientific subjects and the results/publications resulting from international collaboration:

7th Framework Programme

EU-BON – Building the European Biodiversity Observation Network, 308454, 1.12.2012 - 31.5.2017. Responsible investigator: Karol Marhold.

EU BON presents an innovative approach towards integration of biodiversity information systems from on-ground to remote sensing data, for addressing policy and information needs in a timely and customized manner. The aim of the project is to provide integration between social networks of science and policy and technological networks of interoperating IT infrastructures, resulting in a new open-access platform for sharing biodiversity data and tools, and greatly advance biodiversity knowledge in Europe. EU BON's 30 partners from 18 countries are members of networks of biodiversity data-holders, monitoring organisations, and leading scientific institutions. EU BON is building on existing components, in particular GBIF, LifeWatch infrastructures, and national biodiversity data centres. Reliable and readily accessible biodiversity data is essential for managing biological resources sustainably and for informed decision making processes. While state-of-the-art remote sensing techniques are now able to provide highly detailed information on the biosphere, access to this information and other relevant biological data, e.g. from in situ biodiversity monitoring, remains fragmented across countries and regions, and across different disciplines and sectors. The project is creating an EU-wide network that will help to collect, analyse and provide biodiversity data in a truly integrated way. It aims to deliver a European contribution to

the global Group on Earth Observations Biodiversity Observation Network (GEO BON). Researchers and other stakeholders will be able to better retrieve relevant datasets, identify research gaps and set priorities based on real-time, on-ground and earth biodiversity observations by integrating national and regional information infrastructures. EU BON has established itself as an entity that addresses EU policy needs through the linkage to key projects, initiatives and policy processes (IPBES, CBD) and by signing of a Memorandum of Understanding with 25 (+x) associated partners. Reports, strategies and several high-level policy documents have also been produced. The project has furthermore compiled an inventory of biodiversity projects, including information technology systems and science policies for on-ground observations and remote sensing information systems. It also aims to develop a comprehensive European Biodiversity Portal – a blueprint for managing biodiversity information management in Europe. EU BON work gives local, national and global stakeholders and policymakers access to reliable and highly integrated biodiversity data. This is essential for truly adaptive environmental management and effective policy inputs and for directing European biodiversity research towards priority areas.

SYNTHESIS FP 7 projects supporting mobility of scientists in taxonomy and systematic biology:

- *Taxonomic revision of the Silene otites group (Caryophyllaceae) in the Carpathian basin, HU-TAF-3878, 5.5.2014 - 16.5.2014. Responsible investigator: Pavol Mered'a.*

Members of the *Silene otites* group are characterized by small morphological differences and large phenotypic plasticity, which may lead to taxonomical misclassification of some individuals or whole populations. Despite the fact that species of this group play a dominant role in a number of plant communities and all of these taxa are considered endangered, their morphological variation, distribution and ecological preferences are still only poorly known. It fully applies also to representatives of the group occurring in the Carpathian Basin. Our revision of the group in Central Europe (Czech Republic, Austria, Slovakia, Hungary) revealed the presence of three species of this complex (*S. borysthenica*, *S. donetzica* and *S. otites* s. str.) in this territory, out of which, *S. donetzica* is new to Hungary.

- *Evolution and spatial diversity of geographically disjunct taxa of Russula subsect. Decolorantinae in Latin and North America based on material held in the herbarium of Museum Histoire Naturelle Paris and type studies), FR-TAF-5016 Responsible investigator: Slavomír Adamčík.*

Fungi of the genus *Russula* form strikingly colourful fruiting bodies. Hundreds of species are known from the Northern Hemisphere, among them also some edible. The important role of russulas in forest ecosystems is less known. They colonise root tips of woody plants and form symbioses to support exchange of nutrition and water. To understand functioning of these ecosystems, it is necessary to know not only species diversity, but their ecological preferences and distribution areas. We focused on species delimitation and relationships of russulas with blackening flesh (section *Decolorantinae*). Our challenge was generally accepted opinion that the same species can occur in whole area of North and Latin America, even in Europe, while others are limited to geographically small areas. Based on morphological as well as phylogenetic analyses, we concluded that species from East and West coast of North America are all different and there are no European species that occur in temperate and subtropical belt of this subcontinent. Morphological, genetic and evolutionary traits of ten species was presented and two of them were introduced as new to science.

- *Disentangling the taxonomy and evolutionary history in the Alyssum montanum group in western Europe and North Africa, ES-TAF-3213, ES-TAF-3099, ES-TAF-3216, 14.4.2013 - 19.4.2013. Responsible investigators: Judita Zozomová Lihová, Karol Marhold, Stanislav Španiel.* The *Alyssum montanum* group is distributed throughout Europe and northern Africa. Multiple origin of polyploids, considerable morphological variation and presence of genetic lineages occupying distribution areas of different size from those restricted to few localities to those covering considerable parts of continent provide challenging task to anybody willing to disentangle complicated evolutionary patterns and taxonomy of this group. Recent studies of the team addressed variation patterns of this group in Central Europe, Balkan and Apennine Peninsulas the team was in a good position to interpret complex patterns of morphological, karyological and molecular variation, which was expected in a Mediterranean rich territory like the Iberian Peninsula. We gathered considerable amount of collected material from this area and we confronted it with the herbarium specimens deposited in herbarium MA and with the relevant literature, which is not

always available via digital libraries. *Alyssum* is a difficult polymorphic genus in which numerous species or infraspecific taxa have been described from the Iberian Peninsula. A number of those names have been published in not easily accessible works. Members of our group focused on different aspects of the problem. Karol Marhold, concentrated on nomenclature matters in library and herbarium collections. Stanislav Španiel focused on the study of herbarium specimens. This included not only searching for detailed distribution patterns of different taxa, but also detailed study of individual specimens, particularly their trichome morphology, and other characters that would be used in the framed of morphometric analyses.

CIP-ICT

Opening up the Natural History Heritage for Europeana (OpenUp!), 270890, 1.3.2011-28.2.2014. Responsible investigator: Karol Marhold.

European portal EUROPEANA (<http://www.europeana.eu/portal/>) provides the possibility to explore digital sources of European museums, libraries, archives and audio-visual collections. Natural history objects (herbarium specimens, prepared animal objects, sound records, geological collections) were until recently underrepresented among digitalised objects available at EUROPEANA. The project aimed to increase representation of such objects. Institute of Botany SAS made available via EUROPEANA metadata and high-quality images of 6,465 herbarium specimens from the collection of František Nábělek *Iter Turcico-Persicum*, collected during 1909-1910 in the area of the current Israel, Palestine, Jordan, Syria, Lebanon, Iraq, Bahrein, Iran and Turkey. Metadata and images were made available also via specialised portal Global Biodiversity Information Facility (<http://www.gbif.org>). Institute of Botany SAS, as part of the OpenUp! project, coordinated also botanical contributions by other partner institutions. We checked quality of metadata and images of herbarium specimens using specialised software. For checking the correctness of mapping of database fields into ABCD 2.06 schema, internal tool (Biocase Monitoring Tool) was employed, while the metadata quality were checked using Data Quality Toolkit, developed by the project partners.

Other multilateral projects

Contribution of IB SAS to the international project Millenium Seed Bank (MSB), 1.1.2007–31.12.2020. Responsible investigator: Jaromír Kučera.

The MSB project is the largest *ex situ* plant conservation programme in the world. Project focus is on global plant life faced with the threat of extinction and plants of most use for the future. The seeds we save are conserved in seed banks as an insurance against the risk of extinction in their native habitat. Working with network of partners across 80 countries, were successfully banked over 13% of the world's wild plant species. The main goal of the project is to save 25% of those species with bankable seeds by 2020 (75,000 species). IB SAS coordinate seeds collection activities in Slovakia. Target taxa for seed collecting are endemics, endangered and invasive plants. Seeds are stored at MSB Kew and at Gene Bank in Piešťany. Since 2007 were collected and stored from Slovakia 752 taxa. In future we plan to cover with cooperation of several Institutions from relevant countries whole Carpathians area as well as Balkan Peninsula.

Global Plant Initiative - Andrew W. Mellon Foundation, 1.1.2009–31.12.2015. Responsible investigator: Karol Marhold.

Herbarium collection of František Nábělek's *Iter Turcico-Persicum* currently comprises 4,163 collection numbers, altogether 6,465 specimens. It is deposited at the Institute of Botany of the SAS (acronym SAV). Whole Nábělek's *Iter Turcico-Persicum* collection was recently digitized with the support of the Andrew W. Mellon Foundation. The process of digitization was performed in compliance with JSTOR Plants Handbook. All specimens had been barcoded with a unique barcode within the institution before the scanning of the herbarium sheets. The barcode consists of letters 'SAV' followed by 7 digits. The Epson Expression Model 10000XL scanner was used for scanning, which was placed on a custom metal frame manufactured by HerbScan Engineering (London, U.K.). A scanned image is required to have, besides barcode, a scale with the herbarium abbreviation and standardised colour chart placed visibly in the area of the sheet. Each specimen was digitized according to the following specifications: resolution: 600 pixels per inch (ppi); colour

space: Adobe RGB (1998); colour depth: 24-bit; file format: uncompressed TIFF files; layout: portrait. Data about specimens were stored into the DATAflos database via internal software developed to administrate this database. The stored data include specimen name, barcode, type status, collectors, collection number, locality description, locality altitude, and name revision history. Digitized images are available via JSTOR Global Plants and Biological Collection Access Service. Nevertheless, in order to enhance the use of the digitized collection, we created also special portal that not only presents the specimens, but also digitised papers by Nábělek, and last, but not least, enables annotations of specimens (the portal is available at www.nabelek.sav.sk). Local and regional floras benefitted from Nábělek's collections, because at the time of his expedition there were no up-to-date accounts of the flora of the regions he visited; Boissier's Flora Orientalis was already becoming out of date, having been published some 35 years earlier, and there were no more recent floras of Turkey, Palestine, Iraq or Iran. Moreover, the large number of new species that he had discovered, especially from the border areas of Iraq, Iran and Turkey, meant that his catalogue remained of major importance to workers in the region for the next fifty or so years.

European Information System for Alien Species, COST TD 1209, 2.5.2013–1.5.2017. Responsible investigator: Jana Podroužková-Medvecká.

Invasive Alien Species (IAS) threaten biodiversity, society, human-health, well-being and the economy. The economic impact to Europe is estimated EUR 12.5 to 20 billion (annually). Europe has committed to tackling IAS through Target 5 of the EU Biodiversity Strategy to 2020 which is in line with target 9, COP 10 Decision X/2; an information system is a prerequisite to meet strategy through effective early warning and rapid response for prevention and control of IAS. Initiatives to collate information on IAS have resulted in the development of many databases differing in their geographic, taxonomic and ecological coverage. There are a number of constraints that might limit the effective use of existing databases: data obsolescence, lack of interoperability and uncertainties for long-term sustainability of the various tools. This COST Action facilitates enhanced knowledge gathering and sharing through a network of experts, providing support to a European IAS information system which enables effective and informed decision-making in relation to IAS. An overarching priority is to identify the needs and formats for alien species (AS) information by different user groups and specifically for implementation of EU 2020 Biodiversity Strategy. Correspondingly early warning tools and rapid response protocols are being developed.

Establishment of European Red List of Habitats, 1.1.2014–1.6.2016. Responsible investigator: Milan Valachovič.

The objective of this project is the production of an assessment of the status of all natural and semi-natural habitat types according to the criteria recommended in the feasibility study on European (as defined below) and EU28-level (28 Member States) level. In addition a certain amount of information (needed for the red list assessment and for policy purposes) is collected for each habitat type and documented in the form of fact-sheets. The Red List shall be based on the EUNIS habitats classification and will assess approximately 700 habitat types according to the suggested levels. Our tasks are to 1) provide an overview on the status of habitat types in Europe 2) help to assess the need for a potential revision of Annex I of the Habitats Directive; 3) contribute to the work on the Mapping and Assessment of Ecosystems and their Services (MAES5) as well as the restoration agenda under Target 2 of the EU Biodiversity Strategy; 4) provide background for proposals/initiatives targeted at coordinated European conservation action (e.g. future action or conservation plans); 5) improve the general understanding among policy makers, the interested parties and general public for the need of European conservation action.

Bilateral projects

Impact of land-use changes on alpine region: intercontinental comparison (High Tatras – Europe, Rocky Mountains – USA), ROMO-11027, 1.1.2012–31.12.2012. Responsible investigator: Jozef Šibík.

The decline of species-rich semi-natural calcareous grasslands is a major conservation problem throughout Europe. Maintenance of traditional animal husbandry is often recommended as an important management strategy. However, results that underpin such management recommendations were derived predominantly from lowland studies and may not be easily

applicable to high mountain areas. In temperate and Mediterranean Europe many seminatural types of grassland disappear due to cessation of traditional pasture systems. Thus, the maintenance or re-establishment of low-intensity grazing systems has become an important strategy of biological conservation throughout Europe. The main mechanism by which pasture abandonment affects vascular plant species diversity, at least during the first ca. 100 yr are believed not to be local-scale competitive exclusion processes within persisting communities. Instead, post-abandonment successional community displacements that cause a landscape scale homogenization of the vegetation cover seem to be primarily responsible for a decline of species diversity. Although the alpine flora of both, The Rocky Mountains (USA) and the Tatra Mountains (Western Carpathians, Slovakia) has many congeneric or conspecific species, the evolutionary history of the floras was different. Moreover, the grazing history is different, as well. Very little is known about the grazing history in the mountains of New World, but only a short history with non-extensive local-scale grazing is assumed. On the other hand, the grazing history in the Western Carpathians is well-documented and extensive grazing is known to take place since the Wallachian colonization in the 15th-17th century. The evolutionary history of grazing in alpine communities is not well understood but may have had only a minor role in structuring these systems. On the other hand, it was observed, that grazing can rapidly change species composition and morphology of communities. Thus, worked on determination of the differences between grazed and non-grazed alpine meadows in both regions to test the null hypothesis that the species composition, morphology (structure) and ecology of alpine meadows is not determined by the evolutionary history of grazing.

Classification of mesic grasslands of Eastern Carpathian Mountains, Ukraine-Slovakia bilateral project no. 15, 31.7.2014 – 31.12.2016. Responsible investigator: Monika Janišová

The project is focused on the study of variability of semi-natural grassland vegetation in the Eastern Carpathians in Ukraine and Slovakia. In the Slovak part of the area phytosociological research has a long tradition using the methods of Zurich-Montpellier school. From the area of Ukrainian Carpathians only sparse phytosociological material have been sampled by a dominance approach. The main aim of the planned detailed phytosociological research is to collect a large phytosociological data set to unify the national classifications of semi-natural grassland vegetation and to provide an overview of these communities in the involved countries. The next aim besides identification of grassland types is evaluation of species diversity, analysis of the main ecological gradients in species composition and estimation of the effect of environmental factors on grassland species composition. Collecting of data from the Ukrainian Carpathians and completing the phytosociological databases will also enable further large-scale comparative studies and supranational classification of grassland vegetation in the whole Carpathians.

Visegrad Fund Projects

Systematic position and delimitation of European members in *Russula* subsect. *Urentes* and *R.* subsect. *Rubrinae*, no. 51400484, 2015, responsible investigator: Miroslav Caboň

Objective of the research was phylogenetic and systematic study of *Russula* subsect. *Urentes* and subsect. *Rubrinae*. The core and basic data for study were represented by measurements of precisely defined macro- and micro-morphological traits of selected specimens and generated sequences of ITS nrDNA, mtSSU and RPB2 regions. Results of morphological and molecular studies were evaluated and allowed recognising the most reliable characters for distinguishing genetically defined species and consequently to assign them the right name based on type studies.

2.3.2. List of international conferences (co)organised by the institute.

- [1] **The future of botanical monographs** - International workshop about future of botanical monographs (supported by "The Andrew W. Mellon Foundation"), Smolenice, Slovakia, 12.03.-16.03.2012.
- [2] **Open-Up! - OpenUp!** - Opening Up the Natural History Heritage for Europeana, annual meeting of project leaders, Bratislava, Slovakia, 20.02.-21.02.2014.
- [3] **10th international symposium Vegetation of settlements**, Danišovce, Slovensko, 04.09.-07.09.2012.

- [4] **International workshop about classification and management of grassland vegetation**, Banská Bystrica, Slovakia, 22.04.-24.04.2013.
- [5] **Russulales workshop 2014** – International scientific conference, Jedľové Kostol'any, Slovakia, 08.09.-13.09.2014.
- [6] **Grassland Workshop II**, Bratislava and Banská Bystrica, Slovakia, 25.11.2014.
- [7] **Central European Lichens - a blend of biogeographic elements**, International lichenological conference, Bratislava, Slovakia, 17. 03.-17. 03. 2015.
- [8] **4th Czech and Slovak mycological conference**, Zvolen, Slovakia, 07. 09.-10. 09. 2015.

2.3.3. List of edited proceedings from international scientific conferences.

- [1] Manual to the IAVS Post-Symposium Excursion (25-30 July 2015): Monika Janišová & Jozef Šibík (eds.): **From the Pannonian Steppes to the Tatra summits**, 85 pp. (58th Annual Symposium of the International Association for Vegetation Science, Brno, Czech republic).

2.3.4. List of journals edited/published by the institute:

2.3.4.1. WOS (IF of journals in each year of the assessment period)

- [1] **Biologia (Section of Botany)** IF (2011): 0.557, IF (2012): 0.506, IF (2013): 0.696, IF (2014): 0.827, IF (2015): 0.827

- [2] **Taxon** IF(2011): 2.703, IF (2012): 2.782, IF (2013): 3.051, IF (2014): 3.299, IF (2015): 3.299 published by International Association for Plant Taxonomy, **secretariat of which is** since 2011 **currently at the Institute of Botany**, Bratislava is now an official publishing place.

2.3.4.2. SCOPUS

N/A

2.3.4.3. other databases

N/A

2.3.4.4. not included in databases

N/A

- **National position of the institute**

2.3.5. List of selected projects of national importance

- [1] **EVO-PICRIS, Taxonomy and phylogeny of the European representatives of the genus *Picris***, LPP-0239-09 2009-2012. Principal investigator: Karol Marhold.
- [2] **MICRO-EVO, Microevolutionary processes in *Asteraceae***, APVV-0320-10 2011-2014. Principal investigator: Karol Marhold.
- [3] **Biodiversity of small water biotopes: parallel, intersecting or skew?**, APVV-0059-11 2012 -2015. Principal investigator: Richard Hrivnák.
- [4] **Evaluation of cyanobacterial flora of the High Tatra Mts.**, APVV – SK-CZ-0064-11 2012-2013. Principal investigator: František Hindák.
- [5] **Plant ionome modification by silicon for improvement of the crop nutrition quality**, APVV – 0140-10 2011-2014. Principal investigator: Miroslava Luxová.
- [6] **Species and genetic diversity in the family Brassicaceae - a better understanding of the evolution of polyploid complexes**, APVV - 0139-12 2013-2017. Principal investigator: Judita Zozomová.
- [7] **Biosystematic study of the critical taxa of the families Caryophyllaceae and Asteraceae**, VEGA 2/0026/09, 01/2009 – 12/2012, principal investigator: Kornélia Goliašová.

- [8] **Phylogenetic relationships in the *Alyssum montanum* - *A. repens* polyploid complex (Brassicaceae)**, VEGA 2/0087/09, 01/2009 – 12/2012 principal investigator: Judita Zozomová Lihová.
- [9] **Flora of Slovakia: Cyanobacteria/cyanophytes I., thermophilic species**, VEGA 2/0130/10, 01/2010 – 12/2012, principal investigator: František Hindák.
- [10] **Taxonomic revision and species circumscription of European members of *Russula* section *Maculatinae***, VEGA 02/0028/11, 01/2011 – 12/2013, principal investigator: Slavomír Adamčík.
- [11] **Plant Communities of Slovakia. Forest and shrub vegetation**, VEGA 2/0059/11, 01/2011 – 12/2013, principal investigator: Milan Valachovič.
- [12] **Determinants of rarity within *Tephrosieris longifolia* agg.: biosystematic and population-biological approach**, VEGA 2/0074/11, 01/2011 – 12/2014, principal investigator: Monika Janišová.
- [13] **Evolutionary and ecological significance of polyploidy in genera *Cyanus* and *Pilosella* (Asteraceae) – study on two systematic levels and two spatial scales**, VEGA 2/0075/11, 01/2011 – 12/2014, principal investigator: Iva Hodálová.
- [14] **The catalogue of non-native species of vascular plants and the analysis of the level of invasion across habitats of Slovakia**, VEGA 2/0098/11, 01/2011 – 12/2014, principal investigator: Mária Zaliberová.
- [15] **Diversity and taxonomy of diatoms of selected gravel and sand-pit lakes in Slovakia with respect to invasive species**, VEGA 2/0113/11, 01/2011 – 12/2014, principal investigator: Alica Hindáková.
- [16] **Habitats with occurrence of halophytes in the Pannonian lowland – vegetation, ecology, dynamics and possible options for restoration**, VEGA 2/0003/12, 01/2012 – 12/2015, principal investigator: Daniel Dítě.
- [17] **Vegetation changes in alpine areas – the causes, trends and comparisons**, VEGA 2/0090/12, 01/2012 – 12/2015, principal investigator: Jozef Šibík.
- [18] **Catalogue of Ascomycetes described and/or referred to the genera *Hymenoscyphus* Gray and *Helotium* Pers. (Ascomycota, Helotiales)**, VEGA 2/0150/12, 01/2012 – 12/2014, principal investigator: Pavel Lizoň.
- [19] **Speciation and polyploid evolution in *Alyssum* (Brassicaceae): elucidating evolutionary processes in diversity hotspots**, VEGA 2/0004/13, 01/2013 – 12/2016, principal investigator: Judita Zozomová.
- [20] **Flora of Slovakia – orders Caryophyllales, Polygonales and Ericales: biosystematic study of critical taxa**, VEGA 2/0008/13, 01/2013 – 12/2016, principal investigator: Kornélia Goliašová.
- [21] **The role of plant hormones and reactive oxygen species in abiotic stress-induced morphogenic response in barley root tips**, VEGA 2/0019/13, 01/2013 – 12/2015, principal investigator: Ladislav Tamás.
- [22] **Zinc and silicon influence on growth, physiological and metabolic symptoms of salt stress in maize (*Zea mays* L.) plants**, VEGA 2/0022/13, 01/2013 – 12/2016, principal investigator: Miroslava Luxová.
- [23] **Perception and transduction of stress signals, structural and physiological responses of root cells to high heavy metal concentrations**, VEGA 2/0023/13, 01/2013 – 12/2016, principal investigator: Ján Pavlovkin.
- [24] **Analysis of origin and diversification of Western Carpathian elements of the genus *Solenopsora* (lichens, Catillariaceae)**, VEGA 2/0034/13, 01/2013 – 12/2016, principal investigator: Anna Guttová.
- [25] **Biosystematics of *Taphrina* fungi (Ascomycota) in Western Carpathians and Pannonia**, VEGA 2/0051/13, 01/2013 – 12/2016, principal investigator: Kamila Bacigálová.

- [26] **Flora of Slovakia Cyanobacteria/cyanophytes II. Acidophilic species**, VEGA 2/0073/13, 01/2013 – 12/2015, principal investigator: František Hindák.
- [27] **Biosystematics of the *Geoglossum glabrum* complex (Fungi, Ascomycota, Geoglossaceae)**, VEGA 2/0088/13, 01/2013 – 12/2016, principal investigator: Viktor Kučera.
- [28] **Management, restoration and diversity of grassland vegetation**, VEGA 2/0099/13, 01/2013 – 12/2016, principal investigator: Katarína Hegedúšová.
- [29] **Alder forest vegetation – the role of zonal and micro-site gradients in azonal vegetation**, VEGA 2/0019/14, 01/2014 – 12/2017, principal investigator: Richard Hrivnák.
- [30] **The genus *Camarophyllopsis* in Europe and North America**, VEGA 02/0075/14, 01/2014 – 12/2017, principal investigator: Slavomír Adamčík.
- [31] **Screening and transformation of data of model centers of biodiversity for understanding of ecological and phylogenetical relationships of rare and endangered species of fungi**, VEGA 2/0008/15, 01/2015 – 12/2018, principal investigator: Pavel Lizoň.
- [32] **Diversity and classification of European grassland vegetation**, VEGA 2/0027/15, 01/2015 – 12/2018, principal investigator: Monika Janišová.
- [33] **Synanthropisation of the forest communities: Analysis of factors affecting distribution of alien plants in forests**, VEGA 2/0051/15, 01/2015 – 12/2018, principal investigator: Ivan Jarolímek.
- [34] **Cyanobacteria and accompanying algae in formation of recent freshwater stromatolites**, VEGA 2/0060/15, 01/2015 – 12/2018, principal investigator: Alica Hindáková.
- [35] **Bioecological study of the genus *Soldanella* section *Soldanella* (Primulaceae) in the Carpathians, the Hercynian Mts. and Eastern Alps**, VEGA 2/0088/15, 01/2015 – 12/2018, principal investigator: Marek Slovák.
- [36] **Why are some species narrowly endemic while their congeners are geographically widespread? Role of biological traits and genetic variability studied in the three groups of the closely related taxa from the family Asteraceae**, VEGA 2/0096/15, 01/2015 – 12/2018, principal investigator: Barbora Šingliarová.

2.3.6. Projects of the Slovak Research and Development Agency (APVV)

EVO-PICRIS, Taxonomy and phylogeny of the European representatives of the genus *Picris* LPP-0239-09 2009-2012. Principal investigator: Karol Marhold.

We have studied taxonomic relationships of two subspecies of highly polymorphic *Picris hieracioides*, particularly subsp. *hieracioides* and subsp. *umbellata*, and their phylogenetic relatedness to closely allied species, *P. hispidissima*, *P. japonica*, *P. olympica* and *P. nuristanica*. Karyological analyses involving direct chromosome counting, estimation of DNA ploidy level and absolute DNA content; and genetic analyses, particularly sequences of coding and non coding regions of nuclear and chloroplast DNA were applied to resolve outlined questions. Concerning the karyological variation all studied species are diploids with $2n=2x=10$. The exception presented two populations of *Picris hieracioides* subsp. *umbellata* which harboured triploid ($2n=3x=15$) and tetraploid individuals ($2n=4x=20$). Absolute DNA contents of diploids, triploids and tetraploids varied considerably. Genetic markers revealed large and complex variation within both subspecies of *P. hieracioides*, which most probably reflects evolution of this species during and after Pleistocene glaciations. In addition, hybridisation between both subspecies and among their internal genetic lineages was proved. Genetic and karyological variation of other analysed taxa (*P. hispidissima*, *P. japonica*, *P. olympica* and *P. nuristanica*) indicated very close relationship of all those species to polymorphic *P. hieracioides*.

MICRO-EVO, Microevolutionary processes in Asteraceae APVV-0320-10 2011-2014. Principal investigator: Karol Marhold.

The aim of the project was to address principal questions concerning microevolutionary processes, including speciation and polyploid evolution in selected representatives of the family *Asteraceae*. We addressed also confusing taxonomic treatments of the studied species complexes and proposed new taxonomic concepts reflecting their evolutionary history. Molecular methods and flow cytometric applications, together with the methods of multivariate morphometrics and hybridisation experiments were employed in the course of the project. We obtained significantly new insights and a comprehensive view on the evolution of the studied representatives of the genera *Cyanus*, *Jacobaea*, *Picris*, *Pilosella* and *Taraxacum*. The results obtained have a broader impact beyond the individual study cases, contributing towards a better understanding of various aspects of evolution in this highly variable plant family.

Biodiversity of small water biotopes: parallel, intersecting or skew? APVV-0059-11 2012 - 2015. Principal investigator: Richard Hrivnák.

The project focused on biodiversity of natural and anthropogenic small size aquatic biotopes with stagnant water (ponds) in Slovakia. In Europe, ponds form a significant part of the continental freshwater resource with an enormous natural and social value. Ponds often represent "hot spots" of biodiversity and usually dwell more species than larger water bodies. The project had an ambition to reflect the all-European call for research of small water biotopes (European Pond Conservation Network manifesto), to which no appropriate attention have been paid both in Slovakia and worldwide. The main objective of the project was complex description of the diversity of macrophytes and important groups of invertebrates (Odonata, Ephemeroptera, Trichoptera, Plecoptera and Diptera) inhabiting various types of ponds in Slovakia. Practical objective of the project was to characterize conditions, which will assure preservation of the highest biodiversity of ponds and to identify indicator taxonomic group or groups with potential to represent the overall biodiversity of these biotopes. We proposed a series of guidelines for conservation practitioners to preserve and maintain high biodiversity of ponds.

Evaluation of cyanobacterial flora of the High Tatra Mts. APVV – SK-CZ-0064-11 2012-2013. Principal investigator: František Hindák.

Within the project a complete evaluation of old published data on cyanobacteria in the High Tatra Mts was provided. Natural materials were collected from different biotopes, documented by micrographs and cultures. The main attention has been focused on microflora of peat-bog littoral of tarns, and sub/aeric localities. Populations of *Scytonematopsis* (*S. starmachii*), *Stigonema* (*S. informe*) and *Phormidium* (*P. favosum*) from calcic streams and *Katagnymene accurata* from tarns were studied in details.

Plant ionome modification by silicon for improvement of the crop nutrition quality APVV – 0140-10 2011-2014. Principal investigator: Miroslava Luxová.

The main objective of the project was to find out the effect of silicon on ionome of plants and to broaden the knowledge and practical application of the protective role of silicon against toxic effect of some mineral elements. We focused mainly on the already known alleviating function of Si in toxicity of cadmium and increased concentration of zinc and we investigated this ability in other potentially toxic mineral elements (As, Sb). Important crop species represent experimental material (*Zea mays*; *Sorghum bicolor*) and eventually some additional selected model species. In evaluation of the effect of silicon on toxic influence of selected mineral elements we will investigate the following parameters: growth parameters, concentration of investigated elements, and other macro and microelements in relation with the changes of ionome in plant organs, tissues, cells and cell walls; physiological conditions of plants; structural characteristics and conditions of plants; oxidative status; deposition of Cd in plant cell walls and changes in expression of proteins under influence of silicon.

Species and genetic diversity in the family Brassicaceae – a better understanding of the evolution of polyploid complexes APVV - 0139-12 2013-2017. Principal investigator: Karol Marhold.

The proposed project addresses polyploid evolution by conducting a comparative study of polyploid complexes from three different tribes of Brassicaceae. Polyploidy is an evolutionary significant phenomenon widespread in the angiosperms, but still poorly understood especially when considering non-model species. Our main aim is to get insights into the patterns and processes of polyploid evolution in natural populations. We focus on diversity centres of the studied polyploid complexes, representing hotspots of genetic and species variation and highly dynamic systems from a micro-evolutionary perspective. We aim at reconstructing main evolutionary forces and speciation processes acting in these crucifers, and in polyploid complexes in general. Particular topics and hypotheses, addressed in the project, concern (a) the rate of auto- and allopolyploidy in the studied species complexes, and independent/recurrent origins of the polyploids; (b) micro-evolutionary processes and population history of the polyploid complexes in the current centres of diversity, testing the “refugia-within-refugia” concept; (c) common and different patterns and mechanisms of the evolution in related diploid and diploid/polyploid species complexes evolving in the same area and environmental context; (d) invasive behaviour of plants of different ploidy levels within the same species/species groups; and (e) species circumscriptions and taxonomic concepts in the polyploid complexes.

2.3.7. Projects of the Scientific Grant Agency of the Slovak Academy of Sciences and the Ministry of Education (VEGA)

Plant Communities of Slovakia. Forest and shrub vegetation, VEGA 2/0059/11, 01/2011 – 12/2013, principal investigator: Milan Valachovič.

The development of syntaxonomical survey of all vegetation units from the forest and shrubby vegetation occurred at territory of Slovakia. The project represents a last part and finalization of long-term program Plant Communities of Slovakia, which started at the beginning in last decade of twentieth century. The result of whole program will be a comprehensive Slovak vegetation survey – a work of highest national importance. At the same time this work will be a part of international efforts under the program European Vegetation Survey and modern tool and practical instrument for nature conservation and landscape management. The aims of project are (i) differentiation of vegetation units with application of relevant approaches and statistical methods, (ii) analyses of floristical and ecological variability and chorological characteristics, (iii) solution syntaxonomy of forest and shrubby communities in broadly Central-European region under international co-operation and by help of case studies. The main output of project will be a monography Plant Communities of Slovakia 6, presenting the result of classification and description of all recognized units including the occurrence (distribution), ecology, dynamics (succession) and threat. Large synoptic tables will be enclosed. This publication has ambition to be basic syntaxonomical work completing almost one hundred yearlong phytosociological research of forests in Slovakia and endeavours of several generations of botanists.

Vegetation changes in alpine areas – the causes, trends and comparisons, VEGA 2/0090/12, 01/2012 – 12/2015, principal investigator: Jozef Šibík.

The species richness of the plant communities varies significantly in alpine regions. The interactions among plant species in various abiotic environments determine the productivity, vegetation structure and species composition of the communities, as well as the diversity of functional types. Human activities play a significant role in all the ecosystems on Earth, including alpine. In many cases, it is difficult to decide whether and which changes of biodiversity were caused by human impacts and which by natural processes. The study of the impacts of both could help us to understand the complicated relationships within high-altitude ecosystems. The main targets of the research are: I) the study of diversity and species interactions on both, species and population level, and their interactions with abiotic environment; and II) the study of impacts of grazing on presence and diversity of functional types in selected alpine plant communities along environmental and geographical gradients. The main targets of the research are: I) the study of diversity and species interactions on both, species and population level, and their interactions with abiotic environment; and II) the study of impacts of grazing on presence and diversity of functional

types in selected alpine plant communities along environmental and geographical gradients. The interactions will be evaluated considering other habitat characteristics, paying particular attention to determining their role in individual plant communities across various mountain ranges, in relation to intensity of the interactions and their relative significance. **This project has been evaluated by VEGA committee as a project with significant results.**

Speciation and polyploid evolution in *Alyssum* (Brassicaceae): elucidating evolutionary processes in diversity hotspots, VEGA 2/0004/13, 01/2013 – 12/2016, principal investigator: Judita Zozomová.

In the project we concentrate on *Alyssum* populations in diversity hotspots of the (Sub-) Mediterranean areas, addressing the polyploid *A. montanum*-*A. repens* complex, high-alpine polyploid *A. cuneifolium* s.l., and the predominantly diploid *A.* sect. *Odontarrhena*. Our goals are to revise species circumscriptions, reconstruct phylogenetic relationships and evolutionary history, identify and understand major processes that have driven diversification and speciation of the studied groups. We generated an online-available database of all chromosome number reports published so far in *Alyssum*, which was necessary to stimulate further evolutionary studies in the genus. We expect to obtain a first general picture of the evolution of *Alyssum* and confront it with other predominantly Mediterranean plant groups. Our studies will contribute to better understanding of plant diversity and evolution in the regions identified as Mediterranean biodiversity hotspots, as well as to effective biodiversity conservation.

Flora of Slovakia – orders Caryophyllales, Polygonales and Ericales: biosystematic study of critical taxa, VEGA 2/0008/13, 01/2013 – 12/2016, principal investigator: Kornélia Goliašová.

The proposed project is focused on taxonomic revision of representatives of the orders Caryophyllales (families Amaranthaceae, Caryophyllaceae), Polygonales (families Polygonaceae, Plumbaginaceae) and Ericales (family Primulaceae) in Slovakia. Special attention will be given to several polymorphic groups in the genera *Cerastium*, *Chenopodium*, *Kali*, *Persicaria*, *Polygonum*, *Primula*, *Rumex*, *Silene* and *Soldanella* in Central Europe. We will address their nomenclature, infrageneric and infraspecific morphological and karyological variability, systematic relationships, and current distribution, applying both traditional and modern taxonomic methods. The main output will be the monograph Flora of Slovakia VI/4. Papers in CC and other journals, and an update of the database Dataflos are planned as well. Slovak botanical nomenclature will be comprehensively revised, improving inadequate names and proposing new names. An open access database of Slovak current and historical names of vascular plants will be developed.

The role of plant hormones and reactive oxygen species in abiotic stress-induced morphogenic response in barley root tips, VEGA 2/0019/13, 01/2013 – 12/2015, principal investigator: Ladislav Tamás.

As sessile organisms, plants have to cope with their ever-changing environment. To survive, they evolved a large variety of distinct morphological and physiological adaptation mechanisms in order to overcome the toxic effects of numerous unfavourable external stimuli. In addition, hormones have been recently identified as a crucial and integral component of stress response. Reactive oxygen species (ROS) are very important signals mediating developmental and stress responses through the regulatory action of plant hormones. In order to gain more insight into the role of hormones and ROS in abiotic stresses-induced morphogenic response, the aim of the present proposal is the analysis of potential relationships between stress-induced morphogenic response, altered hormone homeostasis and ROS accumulation under abiotic stresses in barley root tip.

Analysis of origin and diversification of Western Carpathian elements of the genus *Solenopsora* (lichens, Catillariaceae), VEGA 2/0034/13, 01/2013 – 12/2016, principal investigator: Anna Guttová.

The project aims to explore genetic variation patterns of the populations of placodioid species of the lichen genus *Solenopsora* occurring in the Western Carpathians. The research will look at this variation across European part of the distributional areas with a focus on the status of the populations situated on the periphery of the distributional range (e.g. Western Carpathians), at the distribution of the variation across various spatial scales and at the identification of significant breaks in gene flow and any geographical features which correspond to them. The results will also bring social profitability, as they will contribute to the assessment of total diversity of the studied

habitats. The scientific goal of our project is to explore the genetic variation patterns of the placodioid species of the lichen genus *Solenopsora* A. Massal. which occur in the Carpathians with specific aims to: 1) disclose genetic variation of the populations of the Carpathian *Solenopsora* species in European part of their distributional area(s), with a specific focus on the status of the populations situated on the periphery of the distributional range (Western Carpathians, Belgium, Germany, Great Britain) – does it reflect e.g. genetic impoverishment due to restricted gene flow into the small and fragmented populations, or a) do the genetic patterns suggesting recent dispersal (range expansion) or b) suggesting presence of old, relict, isolated populations, or c) does the genetic differentiation take place due to random processes operating in small, peripheral populations - i.e., genetic drift; 2) find out how is the genetic variation distributed across various spatial scales (population, region, biomes) in European continent and whether we may observe any specific patterns in its distribution; 3) to find out whether there are any significant breaks in gene flow and hypothesize whether there are any geographic features (e.g. also barriers) which correspond to them. Important scientific issue will be to address the question whether the secondary substance profiles in the studied *Solenopsora* species, including difficult-to-identify or accessory substances, can provide an insight into diversification processes across their distributional range in Europe.

Biosystematics of *Taphrina* fungi (Ascomycota) in Western Carpathians and Pannonia, VEGA 2/0051/13, 01/2013 – 12/2016, principal investigator: Kamila Bacigálová.

The project is aimed at studying the systematics of the phytopathogenic fungi of the genus *Taphrina*. The goal of this project is to evaluate the genetic variability of the taxa occurring on the species of the families Rosaceae, Ulmaceae and Betulaceae in ecosystems of the Western Carpathians and the adjacent Pannonian area. Regarding the irregularity of their natural occurrence, it will be necessary to specify the knowledge of their biology, ecology, the area of occurrence and their host plants, in context with ongoing global changes and their impact on ecosystems. The obtained results will have the society-wide contribution, since they will contribute to knowledge of the total diversity of the studied fungal taxa, not only in the Western Carpathians but also in European and world context.

The genus *Camarophylloopsis* in Europe and North America, VEGA 02/0075/14, 01/2014 – 12/2017, principal investigator: Slavomír Adamčík.

Camarophylloopsis is insufficiently known genus of basidiomycetes without a consumer and commercial value. Recently, 10 species are described from the area of Europe, 8 from area of North America (USA) and 9 more from other parts of the world. In area of central Europe are often reported only *C. atropuncta*, *C. foetens* and *C. shulzeri*, *C. foetens* is the only species reported from Slovakia. There are other six unreported species in the area of Slovakia according to our preliminary field observations (unpublished data). The aim of proposed project is, therefore, the preparation for a modern European identification guide covering *Camarophylloopsis* taxa (based on collections from the area of Europe and North America). Other aim of the project is confirm or disprove transatlantic distribution pattern of some species. The first phylogenetic study revealed polyphyly of the genus, part of the species have been combined in the genus *Hodophilus* and one species is described in a new genus *Lamelloclavaria*. Multi-locus phylogenetic analyses of European and North American material of *Hodophilus* species with naphthaleneodours reveal no species with transatlantic distributions. Five species of this group are recognised in North America, including two new to science.

Synanthropisation of the forest communities: Analysis of factors affecting distribution of alien plants in forests, VEGA 2/0051/15, 01/2015 – 12/2018, principal investigator: Ivan Jarolímek.

Invasion of alien species, especially during the last decades, represents growing threat for the diversity of natural habitats, including forests. While considerable attention was already paid to anthropogenic and ruderal vegetation in the urban environments and built-up areas, only very few studies focused on the alien species in forest habitats, as forests appeared to be more resistant to invasions by alien plants. Recent studies revealed that it was only a temporary phenomenon and many forest habitats are continually being invaded by alien species, what is negatively affecting their biodiversity. The aim of the project is to evaluate the level of invasion of various types of forest habitats and to characterize the effect of selected environmental factors, type of forest

management and changes in horizontal and vertical structure of the stands on the level of invasion of the stands.

Why are some species narrowly endemic while their congeners are geographically widespread? Role of biological traits and genetic variability studied in the three groups of the closely related taxa from the family Asteraceae, VEGA 2/0096/15, 01/2015 – 12/2018, principal investigator: Barbora Šingliarová.

The project aims at study of determinants of species rarity in the three model groups from the family Asteraceae (*Tephrosia longifolia* agg., *Cyanus napulifer* group and *Pilosella alpicola* group) by comparing various biological traits and genetic diversity of the rare (often endemic) and widespread congeners. A combined approach including genetic analysis and use of highly variable molecular markers (AFLP, SSRs) as well as analyses of fitness, ecological niche and spreading potential (by common garden experiments, GIS digital layers, soil analyses) will be applied. Results of the project will bring valuable information on specific factors determining range size in selected plant groups from Asteraceae family, but also help to find common features and more general regularities in unravelled patterns and processes. Moreover, outputs of this project will serve as a baseline for conservation recommendations as each of systematic groups investigated harbours also taxa endangered by recent human activities.

2.3.8. Projects of SAS Centres of Excellence

N/A

2.3.9. National projects supported by EU Structural Funds

In monitoring period: EU structural funds – OP Science and research (OP Veda a výskum): KRA-BIO Center of excellence for protection and use of landscape and for biodiversity, NFP26240120010, 2009–2011, IB SAS co-investigator. Coordinator: Karol Marhold.

The Institute of Botany SAS participated in the following project activities. 1.1. building-up the centre for Geographic Information Systems and remote sensing; 2.1 building-up Identification and Documentation Centre for Biodiversity; and 3.1. building-up the centre for systematic, taxonomy, phylogeny, phylogeography and evolution biology. The project supported creation of uniform network of institutions focused on biodiversity research, and nature and landscape protection. It strengthened research infrastructure and facilities, particularly through equipment for biosystematic and ecological studies.

2.3.10. List of journals (published only in the Slovak language) edited/published by the institute:

2.3.10.1. WOS (IF of journals in each year of the assessment period)

N/A

2.3.10.2. SCOPUS

N/A

2.3.10.3. Other databases

N/A

2.3.10.4. Not included in databases

Bulletin Slovenskej botanickej spoločnosti (<http://sbs.sav.sk/SBS1/content.html>)

Spravodajca Slovenskej mykologickej spoločnosti

Catathelasma

Limnologický spravodajca (<http://www.sls.sav.sk/spravodajca.html>)

- **Position of individual researchers in an international context**

2.3.11. List of invited/keynote presentations at international conferences, as documented by programme or invitation letter

- [1] **Marhold K.** Future of botanical monographs in context of modern research activities. In Botany 2012, the next generation, Columbus, Ohio, USA, 7. –11.7.2012.
- [2] **Čiamporová M., Kenderešová L.** Root growth and morphology responses to Cd and Ni of two maize hybrids differing in metal tolerance. Seminary „Effects of heavy metals on physiological processes and surface lipid composition in selected plants“, Plant physiology and Soils biology department, Kryvyi Rig botanical garden NAS of Ukraine, Krivoj Rog, Ukraine, 22.8.2012.
- [3] **Marhold K., Kolarčík V., Kučera J., Slovák M., Španiel S., Zozomová-Lihová J.** Revision of taxonomic position of rare species and infraspecific taxa with examples from the genera *Alyssum*, *Cyclamen* and *Onosma*. Utilization of genetic approaches for effective conservation of endangered species, Regional workshop of the ConGRESS project, Zvolen, 25.–27.1.2012.
- [4] **Galvánek D.** Dry grasslands in Slovakia – current state, restoration and management. Concepts for modern management of xeric grasslands between nature conservation and agriculture, Criewen, Germany, 26.–27. 9. 2013.
- [5] **Hindák F.** Thermal cyanobacteria from Slovakia. 32nd Conference PFS, Konin-Mikorzyn, Poland, 20.–23. 5. 2013.
- [6] **Janišová M.** The role of surrounding landscape in determining species richness of mesic grasslands in Pannonian Basin and Carpathian Mts. VIII. Carpathian Basin Biological Symposium. I. Sustainable development in the Carpathian Basin, Budapest, Hungary, 21.–23. 11. 2013.
- [7] **Marhold K.** Basic rules of plant nomenclature. Brassicaceae – An Introduction to family-wide Biodiversity II, Workshop within the DFG Priority Programme, Adaptomics‘ 1529, University of Heidelberg, Germany, 24.–25.10.2013.
- [8] **Marhold K.** Current studies in the genus *Cardamine*. Brassicaceae – An Introduction to family-wide Biodiversity II, Workshop within the DFG Priority Programme, Adaptomics‘ 1529, University of Heidelberg, Germany, 24.–25.10.2013.
- [9] **Šibík J.** Why Turboveg? The advantages of time-tested and widely used software package for managing vegetation databases. Alaska Arctic Vegetation Archive Workshop, Boulder, Colorado, USA, 14.–16.10.2013.
- [10] **Čiamporová M., Nadubinská M., Banášová V.:** Characteristics of the selected metalliferous and non-metalliferous localities in Slovakia: biotopes and populations of *Arabidopsis* species. Final Seminar of the Excursion 300472 Cell Imaging and Ultrastructure Research University of Vienna, Austria, 1.7.2014.
- [11] **Janišová M.:** Diversity of European grassland vegetation. NASSTEC Summer School 2015, Gijon, Spain, 12.9.2015.
- [12] Breen A. L., **Šibík J.**, Druckenmiller L., Boggs K., Boucher T., Chasníková S., Cooper D. J., Ebersole J. J., Epstein H. E., Gould B., Hennekens S. M., Jorgenson T., Kade A., Lee M., Peet R., Reynolds M. K., Schickhoff U., Talbot S., Tweedie C., Villarreal S., Wirth L., Walker M. D., Webber P. J., Walker D. A.: The Alaska Arctic Vegetation Archive (Alaska-AVA): A report on the status of the AVA and an application in northern Alaska, focusing along the Dalton Highway. 21. 7. 2015, Ecoinformatics: demonstration of new software developments and analytical methods. 58th Annual Symposium of the IAVS, Brno, Czech republic, 19-24.7.2015.
- [13] Fér T., Schmickl R. E., Závěská E., Pospíšilová M., Leong-Škorničková J., Šída O., Poulsen A.D., Newman M. F., Kress J. W., **Marhold K.:** Reconstruction of the phylogeny of the family Zingiberaceae using Hyb-Seq approach. In: Mohanan K.V., Dan M., Devipriya V.,

Sabu M., Aishwarya K., Sreejith P.E., Aswathi P., Linu N. K., eds., *Advancements in Angiosperm systematics and conservation*, University of Calicut, India, 19-21.11.2015.

2.3.12. List of researchers who served as members of the organising and/or programme committees

- [1] **Slavomír Adamčík**, International Symposium „Fungi of Central European Old-Growth Forests“ Český Krumlov, Czech republic, member of programme committee, 2015.
- [2] **Daniel Dítě**, Floristic course in Ružomberok, Slovakia, member of organization committee, 2015.
- [3] **Zuzana Fačkovcová**, Central European Lichens – a blend of biogeographic elements, Bratislava, Slovakia, member of organization committee, 2015.
- [4] **Anna Guttová**, Central European Lichens – a blend of biogeographic elements, Bratislava, Slovakia, member of programme committee, 2015.
- [5] **Monika Janišová**, 12th European Dry Grassland Meeting, Mainz, Germany, member of organization committee, 2015.
- [6] **Monika Janišová**, 58th Annual Symposium of IAVS, Brno, Czech republic, member of organization committee, 2015.
- [7] **Monika Janišová**, 10th European Dry Grassland Meeting, Zamosc, Poland, member of programme committee, 2013.
- [8] **Ivan Jarolímek**, The 11 International Conference Synanthropization of Flora and Vegetation, Poznan and Obrzysko, Poland, member of scientific committee, 2014.
- [9] **Alica Košuthová**, Central European Lichens – a blend of biogeographic elements, Bratislava, Slovakia, programme and organisation coordinator, 2015.
- [10] **Viktor Kučera**, 4th Czech and Slovak scientific mycological conference, Brno, Czech republic, programme and organisation coordinator, 2015.
- [11] **Anna Lackovičová**, Central European Lichens – a blend of biogeographic elements, Bratislava, Slovakia, member of programme committee, 2015.
- [12] **Pavel Lizoň**, 3rd Czech and Slovak scientific mycological conference, Olomouc, Czech republic, programme and organisation coordinator, 2013.
- [13] **Karol Marhold**, *Advancements in Angiosperm systematics and conservation*, Calicut, India, member of organisation & programme committee, 2015.
- [14] **Karol Marhold**, *Botany 2015 – Science and Plants for People*, Edmonton, Alberta, Canada, member of programme committee, 2015.
- [15] **Karol Marhold**, *Botany 2014 - New frontiers in botany*, Boise, Idaho, USA, member of organisation committee, 2014.
- [16] **Slavomír Adamčík**, *Russulales workshop 2014 – International scientific conference*, Jedľové Kostolány, Slovakia, member of organisation and programme committee, 2014.
- [17] **Miroslav Caboň**, *Russulales workshop 2014 – International scientific conference*, Jedľové Kostolány, Slovakia, member of organisation and programme committee, 2014.
- [18] **Karol Marhold**, *Botany 2013 – Celebrating Diversity!*, New Orleans, USA, member of organisation committee, 2013.
- [19] **Karol Marhold**, XIV OPTIMA Meeting, Palermo, Italy, member of programme committee, 2013.
- [20] **Karol Marhold**, *Botany 2012 – The next Generation*, conference of American botanical societies, Columbus, Ohio, USA, member of organisation committee, 2012.
- [21] **Karol Marhold**, *The Future of Botanical Monography: an international workshop*, Smolenice, Slovakia, member of organisation and programme committee, 2012.
- [22] **Michal Martinka**, *Microscopy Conference 2013*, Regensburg, Germany, member of programme committee, 2013.

- [23] **Katarína Olšavská**, Setkání systematiků 2015, Terchová – Šípková, Slovakia, member of organisation committee, 2015.
- [24] **Mária Zaliberová**, The 11 International Conference Synanthropization of Flora and Vegetation, Poznan and Obrzysko, Poland, member of Scientific committee, 2014.

- **Position of individual researchers in a national context**

2.3.13. List of invited/keynote presentations at national conferences, as documented by programme or invitation letter

- [1] **Májeková J.:** Invázne rastliny v agroceenózach Slovenska [Invasive plants in Slovakian agroceenoses]. Slovensko a globálne výzvy: invázne rastliny [Slovakia and Global challenges: invasive plants], Mlyňany, Slovakia, 12.12.2013.
- [2] **Goliašová K.:** Futák a jeho prínos pre vznik diela Flóra Slovenska. [Futák and his contribution to the creation of Flora of Slovakia]. Spomienková konferencia k 100. výročiu narodenia doc. RNDr. Jána Futáka, CSc. [Memorial conference for 100th birth anniversary of doc. RNDr. Jána Futáka, CSc.], Zvolen, Slovakia, 20.5.2014.
- [3] **Goliašová K.,** Feráková V., Peniašteková M., Zahradníková K.: Spomienky na Jána Futáka ako vedúceho Oddelenia systematiky vyšších rastlín Botanického ústavu SAV, externého učiteľa Katedry botaniky PríFUK v Bratislave a ako školiteľa ašpirantov. [Memories of Ján Futák as head of Department of vascular plant systematic of Institute of Botany SAS, external teacher of Department of Botany PríFUK in Bratislava and as aspirants supervisor]. Spomienková konferencia k 100. výročiu narodenia doc. RNDr. Jána Futáka, CSc., [Memorial conference for 100th birth anniversary of doc. RNDr. Jána Futáka, CSc.], Zvolen, Slovakia, 20.5.2014.
- [4] **Hegedúšová, K.:** Flóra Veľkej Fatry a potenciálny vplyv klimatických zmien [Flora of Veľká Fatra Mts. And the potential impact of climate changes], Konferencia klimatické zmeny a ich vplyv na existenciu života (Klimatické zmeny na faunu a flóru v podmienkach nášho regiónu) [Conference of Climate changes and their impact to the existence of life (Climatic changes on flora and fauna in condition of our region)], Martin, Slovakia, 27.11.2014.
- [5] **Mereďa P., Hodálová I.,** Feráková V., **Perný M., Šípošová H.:** Taxóny spojené s menom Jána Futáka [Taxa associated with the name Ján Futák]. Spomienková konferencia k 100. výročiu narodenia doc. RNDr. Jána Futáka, CSc., [Memorial conference for 100th birth anniversary of doc. RNDr. Jána Futáka, CSc.], Zvolen, Slovakia, 20.5.2014.

2.3.14. List of researchers who served as members of organising and programme committees of national conferences

- [1] Adamčík, S.: 2012
- [2] Fačkovcová, Z.: 2015
- [3] Hindák, F.: 2012
- [4] Hindáková, A.: 2012
- [5] Košuthová, A.: 2015
- [6] Kučera, V.: 2015
- [7] Letz, D.R.: 2014
- [8] Mereďa, P.: 2014
- [9] Valachovič, M.: 2014

- **Supplementary information and/or comments documenting the international and national status of the Institute**

Membership of Institute of Botany SAS in Consortium of European Taxonomic Facilities (CETAF)

Institute of Botany together with Comenius University, Faculty of Natural sciences created a consortium National Taxonomic Facility (NATAF) in 2005. In the framework of this joint unit,

Institute of Botany is a member of Consortium of European Taxonomic Facilities (CETAF, www.cetaf.org). CETAF is a European network of Natural Science Museums, Natural History Museums, Botanical Gardens and Biodiversity Research Centres with their associated biological collections and research expertise. The aim of the network is to promote training, research and understanding in systematic biology and palaeobiology, and facilitate access to information (collections) and the expertise of its member institutions across Europe. The CETAF network comprises 33 members representing 57 of the largest taxonomic institutions from 20 European countries. Its member institutions include Natural History Museums, Natural Sciences Museums, Botanical Gardens and other research institutions, with their associated collections and research expertise. Altogether, the collections comprise an estimated 1.5 billion specimens and represent more than 80% of the world's described species.

Beyond hosting major European collections, and housing research centres of excellence in taxonomy via its members, CETAF provides a platform for researchers from a wide variety of scientific disciplines who carry out pioneering research and develop innovative knowledge exchange pathways. From the digitalisation of collections to the use of digital media to stimulate the sharing of data, CETAF fosters the development of information services for scientific and public use.

The consortium actively participates on implementation of European legislation in the sphere of "Access and Benefit Sharing", which is linked to the conservation of genetic resources (plants and animals) on international as well as national level.

Institute of Botany – host of foreign researchers

Institute of Botany hosted several foreign researchers, who carried out their research activities under the support of different schemes – e.g. Visegrad fund (Post-master's In-coming Scholarships), Slovak Academic Information Agency (SAIA). In 2015 we also performed preparatory steps to host a colleague financially supported by the University of Northern Colorado due to his sabbatical leave (the stay was realized in the first half of 2016 aimed at the topic of Clonal Plant Response to Disturbance in the Tatras, part of a broader project The Effects of Interactions Between Wild Herbivores and Vegetation on Processes in Alpine Ecosystems). We understand that international research mobility encourages personal and academic development of individuals during their research careers, enlarges their skills needed for future international academic success.

Our colleagues performed research in the following directions:

- **Rare parasitic lichens in alpine habitats as global climate change early indicators: their phylogeny, host specificity, Visegrad Fund no. 51100753, 2012, responsible investigator: Anna Guttová, visiting scientist: Jan Vondrák, University of South Bohemia, České Budějovice, Czech Republic**

The research was performed by Mgr. Jan Vondrák, Ph.D., junior scientist of the Faculty of Science, University of South Bohemia, České Budějovice, Czech Republic. We analyzed ITS nrDNA regions in species of the genus *Caloplaca* and present evidence for five such examples: the *Caloplaca cerina* group, *C. obscurella*, the *C. servitiana* group, the *C. xerica* group and the *C. variabilis* group (*Pyrenodesmia*). In some cases, loss of anthraquinones is observed only in individuals within ordinarily pigmented populations, but sometimes the loss covers whole lineages containing one or more species. Both situations are observed in the *C. servitiana* group. Loss of anthraquinones is always followed by the synthesis of 'alternative' pigments (often Sedifolia-grey). In the specimens with anthraquinone-containing apothecia studied, these pigments are not visible in apothecial sections after dissolving anthraquinones in K. Fully unpigmented apothecia have not been observed. The *Caloplaca xerica* group was a newly established, infraspecific grouping of species related to, and similar to, *C. xerica*. The *Caloplaca servitiana* group is also newly established and represents an isolated lineage covering two rather different, but related species. *Caloplaca neotaurica* was described as a new species with apothecia of two colour variants; orange-red (with anthraquinones) and grey (with Sedifolia-grey). The genus *Huea* represents another taxon lacking anthraquinones within *Teloschistaceae*. The genera *Apatoplaca* and *Cephalophysis*, which lack anthraquinones, were tentatively placed in *Teloschistaceae*, but their phylogenetic identity has not been recognized. *Hueidea* was reported to have no anthraquinones, but its secondary metabolites should be studied further and its possible placement in *Teloschistaceae* assessed. We suggest that *Caloplaca abbreviata* var. *lecideoides* and *C. celata* represent variants of *C. stillicidiorum*

lacking anthraquinones. We developed and tested approach to get successful DNA extracts and subsequently sequences of ITS nrDNA regions from the material of *Caloplaca* species originated from historical material from herbarium collections.

- **Molecular phylogeny of the European members of *Cladonia* section *Cocciferae*, Visegrad fund no 51401150, 2014, responsible investigator: Alica Košuthová, visiting scientist: Jana Steinová, Charles University, Prague, Czech Republic**

The research was performed by Mgr. Jana Steinová, Ph.D. student of Charles University, Prague, Czech Republic. The main aim of the project was to study the diversity of mycobionts and photobionts associated in *Cladonia* lichens in a central European and global context. The project was divided into the three sub-projects: 1) distribution and ecological preferences of the *Cladonia coccifera* group in the Czech Republic. We studied the distribution of seven species of the *C. coccifera* complex (*C. borealis*, *C. carneola*, *C. coccifera*, *C. deformis*, *C. diversa*, *C. pleurota* and *C. straminea*) and discussed their morphology, chemistry and ecological preferences. 2) Study on photobionts in zeorin-containing *Cladonias*. Diversity of photobionts in zeorin-containing *Cladonias* was studied using a molecular approach as well as mycobiont diversity in two sorediate (*Cladonia deformis* and *C. pleurota*) and two esorediate species (*Cladonia coccifera* and *C. diversa*). Sorediate species were found to be significantly more selective towards their photobiont partner than the esorediate species. This suggests a possible coevolution between mycobiont and photobiont in sorediate species. 3) Diversity of genus *Asterochloris*. *Cladonia* species associate with algae belonging to genus *Asterochloris*. We participated in research on the diversity of this ubiquitous photobiont. Six new species (*A. echinata*, *A. friedlii*, *A. gaertneri*, *A. leprarii*, *A. lobophora*, and *A. woessiae*) were described and characterised, and presence of isogamous sexual reproduction in *Asterochloris* was demonstrated, disputing the current symbiotic dogma of the loss of sexual reproduction in algal symbionts.

- **Biomonitoring atmospheric pollution and environmental recovery with sensitive indicators – lichens, SAIA no. ID 9030, 2014, garant: Anna Guttová, visiting scientist: Luca Paoli, University of Siena, Italy**

Research programme aimed at contributing to the development of biomonitoring techniques in Slovakia and in particular, of a biomonitoring method to assess the effectiveness of environmental recovery actions and a rapid assessment of the biological effects of pollution leading to habitat eutrophication. Specific case-studies were activated as described in the next section: the transplant technique consisting in taking lichens from a relatively unpolluted site and exposing them to the study sites to record chemical and physiological responses was used to detect the effects of environmental stresses. Lab techniques were used to investigate lichen responses and reach the goals of the programme (chlorophyll a fluorescence emission is an indicator of sample vitality, chlorophyll a degradation and the content of photosynthetic pigments, reduction of 2,3,5-triphenyltetrazolium chloride to triphenyl formazan as overall indicator of mycobiont viability, TBARS assay, ergosterol content and electric conductivity as indicators of membrane integrity). Lichen diversity to assess the effects of eutrophication (nitrogen and dust pollution), lichen diversity in mountain spruce forests with purpose of detecting threatened and rare species were investigated. Dr. Luca Paoli gave seminars and teachings to students at the Comenius University in Bratislava and the Slovak Academy of Sciences.

- **Taxonomy and chorology of the genus *Aconitum* in Slovakia. 15. 11. 2012 - 14. 2. 2013. SAIA exchange stay. Visiting scientist Dr. Andriy Novikov, Department of Biosystematics and Evolution, State Natural History Museum of NAS of Ukraine, Lviv, Ukraine**

Revision of the material kept in the collections of the Institute of Botany SAS (acronym SAV), Department of Botany, Comenius University Bratislava (acronym SLO), and Natural History Museum Bratislava (acronym BRA).

- **Revision of the material assign to the lichen genus *Cladonia*. Prof. Teuvo Ahti, University of Helsinki, Helsinki, Finland. Short-term (one week) visit in 2014.**

Revision of the material kept in the collections of the Institute of Botany SAS (acronym SAV), Department of Botany, and Natural History Museum Bratislava (acronym BRA).

Editorial boards of scientific journals:

Anna Guttová:

Bryonora – Czech Republic

Bulletin Slovenskej botanickej spoločnosti pri SAV (member of the editorial board) – Slovakia

František Hindák:

Biologia (editor in chief) – WOS, Slovakia

Monika Janišová:

Agriculture, Ecosystems & Environment (guest editor of SF Grassland diversity) – WOS, Netherlands

Biodiversity & Conservation (guest editor of SF Grassland diversity) – WOS, Netherlands

Bulletin of the European Dry Grassland Group (executive editor) – Germany

Phytocoenologia (editor in charge) – WOS, Germany

Pavel Lizoň:

Catathelasma (executive editor – till 29.2.2015) – Slovakia

Plant Systematic and Evolution (associated editor) – WOS, Austria

Spravodajca Slovenskej mykologickej spoločnosti pri SAV (executive editor – till 29.2.2015) – Slovakia

Karol Marhold:

Biologia (member of "Advisory editorial board") – WOS, Slovakia

Folia Geobotanica (associate editor) – WOS, Czech Republic

Neilreichia (member of "Advisory Editorial Board") – Austria

Phytokeys (editor for Brassicaceae family) – WOS, Bulgaria

Phytotaxa (editor for Brassicaceae family) – WOS, New Zealand

Plant Diversity and Evolution (editor for taxonomy) – WOS, Austria

Plant Systematics and Evolution (editor in chief) – WOS, Austria

Taxon (column editor) – WOS, Slovakia

Igor Mistrík:

Biologia (executive editor) – WOS, Slovakia

Katarína Olšavská:

Plant Systematics and Evolution (managing editor) – WOS, Austria

Jozef Šibík:

Biologia (member of editorial board) – WOS, Slovakia

Phytocoenologia (member of editorial board) – WOS, Germany

Bulletin Slovenskej botanickej spoločnosti pri SAV (member of the editorial board) – Slovakia

Barbora Šingliarová:

Biologia (member of editorial Board) – WOS, Slovakia

Plant Systematics and Evolution (managing editor) – WOS, Austria

Milan Valachovič:

Biologia (member of editorial Board) – WOS, Slovakia

Bulletin Slovenskej botanickej spoločnosti pri SAV (chairman of the editorial board) – Slovakia

Judita Zozomová:

Folia Geobotanica (editor in chief) – WOS, Czech Republic

Members of other bodies:

Anna Guttová: Organization for the Phyto-Taxonomic Investigation of the Mediterranean Area OPTIMA (member of the Lichen Committee)

Monika Janišová: European Dry Grassland Group (member of the Steering Committee and Executive Editor of EDGG Bulletin); International Association for Vegetation Science (IAVS) (Vice President, Member of the Board)

Matúš Kempa: International Association for Plant Taxonomy (member of the Web Development Committee and member of the Editorial Committee)

Karol Marhold: Euro+Med PlantBase (member of the Steering Committee); Global Biodiversity Information Facility (member of the Governing Board representing Slovak republic); Global Taxonomy Initiative (National focal point for the Slovak Republic, member of the "GTI coordination mechanism" for Middle and East Europe); International Association for Plant

Taxonomy (Secretary-General, Member of the General Committee for Nomenclature and Member of the Editorial Committee for the International Code for Nomenclature of Algae, Fungi and Plants); International Organization for Plant Information (member of the Steering Committee and member of the Editorial Committee of project IOPI "Species Plantarum - Flora of the World"); International Organization for Systematic and Evolutionary Biology (IOSEB) (council member); International Organization of Plant Biosystematists (President), Linnean Society (London) (Fellow (FLS)); Organization for the Phyto-Taxonomic Investigation of the Mediterranean Area (Member of the International Board and, Member of the Executive Council)

Jana Podroužková Medvecká: Working group for harmonisation and integration of information on alien species (Deputy Head of the working group)

Eva Senková: International Association for Plant Taxonomy (Managing Secretary)

Jozef Šibík: Working Group for Phytosociological Nomenclature (GPN) (member)
Vegetation Classification Working Group (member)

Experts evaluating international projects:

Monika Janišová: Latvian Science Council

Karol Marhold: 7 RP EÚ; FP7, E-Infrastructures (CP-CSA); Grant agency of University of South Bohemia in České Budějovice, Czech republic; Grant agency of the Charles University in Prague, Czech republic; Grant agency FWF, Austria

Galváneek Dobromil: LIFE + Nature/Biodiversity

Igor Mistrík: Fulbright Scholar Program

Jozef Šibík: Bilateral mobility project

2.4. Tables of project structure, research grants and other funding resources

- **International projects and funding**

2.4.1. **Major projects within the European Research Area and other important project – Framework Programmes of the EU, ERA-NET, European Science Foundation, NATO, COST, INTAS, etc. (here and in items below please specify: type of project, title, grant number, duration, total funding and funding for the institute, responsible person in the institute and his/her status in the project, e.g. coordinator “C”, work package leader “W”, investigator “I”),**

	Project title	Typ / Project number	Duration in months	Funding for the Institute (EUR)	Role of the Institute / Responsible person
2012	EU-BON - Building the European Biodiversity Observation Network	7RP 308454	12/2012 - 5/2017	140 854 €	co-investigator / Karol Marhold
	Opening up the Natural History Heritage for Europeana (OpenUp!)	CIP-ICT 270890	03/2011 - 02/2014	74 220	co-investigator / Karol Marhold
	Global Plant Initiative - Andrew W. Mellon Foundation	without number	01/2009 - 12/2015	25 093	co-investigator / Karol Marhold
	Impact of land-use changes on alpine region: intercontinental comparison (High Tatras – Europe, Rocky Mountains – USA)	ROMO-11027	01/2012 - 12/2012	0	investigator / Jozef Šibík
	Contribution of IB SAS to the international project Millenium Seed Bank	without number	01/2007 - 12/2020	102 992	co-investigator / Jaromír Kučera
2013	Disentangling the taxonomy and evolutionary history in the <i>Alyssum montanum</i> group in western Europe and North Africa	ES-TAF-3213, ES-TAF-3099, ES-TAF-3216	04/2014	0	investigator / Judita Zozomová Lihová, Karol Marhold, Stanislav Španiel
2014	Establishment of European Red List of Habitats	without number	01/2014 - 06/2016	3 000	co-investigator / Milan Valachovič
	Taxonomic revision of the <i>Silene otites</i> group (Caryophyllaceae) in the Carpathian basin	HU-TAF-3878	05/2014	0	investigator / Pavol Mered'a
2015	Developing of the Arctic Vegetation Archive and synthesis of Arctic vegetation	SAIA 12629	03/2015 - 06/2016	1 306	investigator / Jozef Šibík
	Evolution and spatial diversity of geographically disjunct taxa of <i>Russula</i> subsect. <i>Decolorantinae</i> in Latin and North America based on material held in the herbarium of Museum Histoire Naturelle Paris and type studies)	FR-TAF-5016	05/2015	0	investigator / Slavomír Adamčík

2.4.2. Other international projects, incl. total funding and funding for the institute

- [1] **Changing the niches in lichens: they are real or merely the result of cryptic speciation? Research for example boreal lichen *Cladonia botrytes***, 2013-10-15-0005, Action project, 2014-2015, total funding 1,484 EUR, funding for the organisation 1,484 EUR, Responsible investigator Alica Košuthová.
- [2] **Establishment of European Red List of Habitats**, multilateral project, 2014-2016, total funding 7,500 EUR, funding for the organisation 3,000 EUR, Responsible investigator Milan Valachovič, status – co-investigator.

- [3] **Utilisation of RAD sequencing in plant systematics and evolution. A case study of the genus *Soldanella***, 2015-05-15-001, SAIA project, 2015-2016, total funding 1,505 EUR, funding for the organisation 1505 EUR, Responsible investigator Marek Slovák.
- [4] **Developing of the Arctic Vegetation Archive and synthesis of Arctic vegetation**, 12629, SAIA project, 2015-2016, total funding 1306 EUR, funding for the organisation 1,306 EUR, Responsible investigator Jozef Šibík.
- [5] **Rare parasitic lichens in alpine habitats as global climate change early indicators: their phylogeny, host specificity and phenotype characters**, 51100753, International Visegrád Fund, 2011-2012, total funding 2,060 EUR, funding for the organisation 2,060 EUR, Responsible investigator Anna Guttová.
- [6] **Systematic position and delimitation of European members in *Russula* subsect. *Urentes* and *R. subsect. Rubrinae***, 51400484, International Visegrád Fund, 2015, total funding 3,800 EUR, funding for the organisation 3,800 EUR, Responsible investigator Miroslav Caboň.

2.4.3. Other important, international projects and collaborations without direct funding (max. 10 projects)

- [1] Impact of land-use changes on alpine region: intercontinental comparison (High Tatras – Europe, Rocky Mountains – USA), ROMO-11027, bilateral project, 2012, responsible investigator Jozef Šibík.
- [2] Delimitation, transatlantic distribution and phylogenetic relationships of taxa within the genus *Camarophyllopsis* (Fungi, Agaricomycotina) in Europe and North America, Slovak American Foundation (SAF), bilateral project, 2013, responsible person Slavomír Adamčík.
- [3] Monitoraggio dello Stato degli Ecosistemi Centro Olio Val D'Agri, Componente lichenica, Università degli studi di Siena, Dipartimento di Scienze Ambientali, Sezione di Ecologia e Sistematica Animal e Vegetale, Unità di Ricerca di Lichenologia, Siena, Italy; 2013–2014, responsible investigator Anna Guttová.
- [4] Effetti biologici delle polveri emesse durante la produzione del cemento sui licheni. Università degli studi di Siena, Dipartimento di Scienze Ambientali, Sezione di Ecologia e Sistematica Animal e Vegetale, Unità di Ricerca di Lichenologia, Siena, Italy; 2011–2012, responsible investigator Anna Guttová.
- [5] Biomonitoring atmospheric pollution and environmental recovery with sensitive indicators – lichens, SAIA project, 2014, responsible investigator: Luca Paoli.

National projects and their funding

2.4.4. Projects supported by the Slovak Research and Development Agency (APVV)

Role of the Institute e.g. coordinator "C", investigator "I".

	Project title	Typ / Project number	Duration in months	Funding for the Institute (EUR)	Role of the Institute / Responsible person
2012	Biodiversity of small water biotopes: parallel, intersecting or skew?	APVV / 0059-11	07/2012 - 12/2015	46 306	investigator / Richard Hrivnák
	Plant ionome modification by silicon for improvement of the crop nutrition quality	APVV / 0140-10	05/2011 - 10/2014	36 430	co-investigator / Miroslava Luxová
	MICRO-EVO, Microevolutionary processes in Asteraceae	APVV / 0320-10	05/2011 - 10/2014	149 676	investigator / Karol Marhold
	EVO-PICRIS, Taxonomy and phylogeny of the European representatives of the genus <i>Picris</i>	LPP / 0239-09	09/2009 - 08/2012	8 274	investigator / Karol Marhold
	Flora of Cyanobacteria of the High Tatra Mts	APVV SK-CZ / 0064-11	01/2012 - 12/2013	2 000	co-investigator / František Hindák
2013	BrassiEvo, Species and genetic diversity in the Brassicaceae family - towards understanding of evolution in polyploid complexes	APVV / 0139-12	10/2013 - 09/2017	90 401	investigator / Karol Marhold
2014					
2015					

2.4.5. Projects supported by the Scientific Grant Agency of the Slovak Academy of Sciences and the Ministry of Education (VEGA) for each year, and their funding

VEGA	2012	2013	2014	2015
Number	21	24	24	23
Funding in the year (EUR)	131 740	159 217	156 611	157 925 ¹

- **Summary of funding from external resources**

2.4.6. List of projects supported by EU Structural Funds

N/A

¹ Excluding projects for the popularisation of science

2.4.7. Summary of external resources of the EU Structural Funds (ERDF/ESF)

Role of the Institute in the project, e.g. coordinator “C”, work package leader “W”, investigator “I”.

N/A

Year	Project title	Project number	Duration in months	Funding for the Institute (EUR)	Role of the Institute
2012					
2013					
2014					
2015					

External resources	2012	2013	2014	2015	total	average
External resources (milions of EUR)	0,214	0,249	0,225	0,212	0,900	0,225
External resources transferred to cooperating research institute (milions of EUR)	0,000	0,022	0,021	0,012	0,055	0,014

- **Supplementary information and/or comments on research projects and funding sources**

We participated in other three relevant calls for EU Structural funds (e.g. OPVaV-2009/4.1/03-SORO, Centre for biological landscape elements in the context of climate change, as principal investigator), but we did not succeed in neither of them. The evaluation procedure featured elements other than standard competition.

Currently we are using an option of an open call OPVaV-VA/DP/2016/1.2.1-02 (Research and Innovations) for support of Industrial research and development centres in the area of specialization RIS3 SK and with our industrial partner we have prepared two project proposals.

2.5. PhD studies and educational activities

2.5.1. List of accredited programmes of doctoral studies, period of validity

[1] 4.2.6 botanika (botany), Prírodovedecká fakulta, Komenského Univerzita, Bratislava (Faculty of Natural Sciences, Comenius University, Bratislava)

[2] 4.2.9 fyziológia rastlín (plant physiology) Prírodovedecká fakulta, Komenského Univerzita, Bratislava (Faculty of Natural Sciences, Comenius University, Bratislava)

2.5.2. Summary table on doctoral studies (number of internal/external PhD students; number of foreign PhD students, number of students who successfully completed their theses, number of PhD students who quit the programme)

PhD study	31.12.2012			31.12.2013			31.12.2014			31.12.2015		
Number of potential PhD supervisors	23			19			20			22		
PhD students	number	defended thesis	students quitted									
Internal	12,0	3,0	0,0	15,0	2,0	0,0	14,0	4,0	0,0	15,0	0,0	2,0
External	4,0	2,0	0,0	4,0	0,0	0,0	1,0	1,0	2,0	0,0	1,0	0,0
Other supervised by the research employees of the institute	2,0	1,0	0,0	1,0	0,0	0,0	1,0	0,0	0,0	1,0	0,0	0,0

Supervised at external institutions:

K. Marhold - supervisor (2005-2012), postgraduate student Mgr. Hana Daneck-Dvořáková, Charles University, Prague, Czech Republic, Thesis: Phylogeography of temperate plant species with the focus on Central Europe (defended 2012).

K. Marhold - supervisor (2012-2015), postgraduate student Gabriela Fuxová, Charles University in Prague, Czech republic; Thesis: Evolution of the genus *Arabidopsis* in its centre of diversity.

2.5.3. Summary table on educational activities

Teaching	2012	2013	2014	2015
Lectures (hours/year) ²	213	347	270	255
Practicum courses (hours/year) ²	257	301	352	258
Supervised bachelor theses (in total)	4	6	6	7
Supervised diploma theses (in total)	16	18	4	8
Supervised PhD theses (in total)	16	11	18	9
Members in PhD committees (in total)	4	8	4	3
Members in DrSc. committees (in total)	0	0	0	0
Members in university/faculty councils (in total)	1	1	1	2
Members in habilitation/inauguration committees (in total)	2	1	1	0

2

² Do not include time spent with bachelor, diploma or PhD students during their supervising

2.5.4. List of published university textbooks

N/A

2.5.5. Number of published academic course books

N/A

2.5.6. List of joint research laboratories/facilities with universities

[1] **National Taxonomic Facility / Národné taxonomické laboratórium** – joint facility of the Department of Vascular Plant Taxonomy of the Institute of Botany SAS, Department of Botany and Department of Zoology, Comenius University in Bratislava, Slovak National Museum, and Institute of Biological and Ecological Sciences P. J. Šafárik University in Košice.

[2] In cooperation with Faculty of Natural Sciences, Comenius University Bratislava – Department of Soil Science, we prepared a **concept for a new course for students** on bachelor and master degree – **Biodiversity I** (microscopic filamentous fungi and cryptogams), which was added to the curriculum and already given to students.

- **Supplementary information and/or comments on doctoral studies and educational activities**

PhD students and their international activities

PhD students of Institute of Botany actively search possibilities to expand their experience during the stays abroad. During the evaluation period they prepared proposals under the following schemes:

- SYNTHESIS FP 7 projects supporting mobility of scientists in taxonomy and systematic biology
- Bilateral Projects Slovak Academic Information Agency (SAIA)
- SCIEX-NMS (www.sciex.ch)
- Visegrad fund

Unfortunately, students performing their study in an external institution within Slovak Academy of Sciences (that means outside the University), cannot apply for projects under Erasmus programme or apply for small research grants for PhD students (evaluated by credits), which is discriminating.

Successful stories:

Systematic position and delimitation of European members in *Russula* subsect. *Urentes* and *R.* subsect. *Rubrinae*, Visegrad fund no. 51400484, 2015, responsible investigator: Miroslav Caboň

Objective of the research was phylogenetic and systematic study of *Russula* subsect. *Urentes* and subsect. *Rubrinae*. The core and basic data for study were represented by measurements of precisely defined macro- and micro-morphological traits of selected specimens and generated sequences of ITS nrDNA, mtSSU and RPB2 regions. Results of morphological and molecular studies were evaluated and allowed recognising the most reliable characters for distinguishing genetically defined species and consequently to assign them the right name based on type studies.

Effect of antimony (Sb) on growth and physiology of important crop plants. Sciex 13.024 responsible investigator: Miroslava Vaculíková, January 1, 2014 – December 31, 2014, Host mentor: Rainer Schulin, ETH Zürich, Department of Environmental System Sciences, Institute of Terrestrial Ecosystems, Zürich

The aim of the research stay was to investigate Sb effects on growth and physiology of important agricultural plants and find how exogenous application of silicon could ameliorate the negative effects of this element. While it can also be phytotoxic, it is still insufficiently known how Sb accumulation affects plants and what in particular is the role of Sb oxidation state in this context. Elevated levels of this element in edible plant parts can cause health risks to humans.

Antimony (Sb) represents a serious threat for the environment. It is released into the environment by mining, and industrial activities, waste disposal, shooting and traffic. Previous mining activity as the main source of Sb soil contamination in Slovakia causes serious health risks for people living on contaminated land. Similarly, contamination of shooting ranges is the main problem of Sb contamination in Switzerland.

Zuzana Fačkovcová

"Carlo Gaggi" award, 1st place in the international competition of lichenological doctoral research organized by international scientific society Italian Lichen Society (Società Lichenologica Italiana), 2015

Thesis: Analysis of origin and diversification of Western Carpathian elements of the genus *Solenopsis* (lichens, Catillariaceae)

Educational activities

Comenius University in Bratislava (Slovak republic)

Faculty of Natural Sciences, Department of Botany

- Semester lectures: František Hindák (2012 – 12 hr.), Anna Lackovičová (2012 – 18 hr.), Pavel Lizoň (2012 – 24), Jozef Šibík (2012 – 24 hr., 2013 – 2 hr., 2014 – 52 hr., 2015 – 52hr.)
- Semester exercise: Miroslav Caboň (2014 – 72 hr., 2015 – 48 hr.), Zuzana Ballová (2012 – 11 hr., 2013 – 24 hr.), Zuzana Fačkovcová (2013 – 26 hr., 2014 – 26 hr., 2015 – 24 hr.), Zuzana Melečková (2012 – 10 hr.), Petra Mikušová (2014 – 2 hr.), Jana Petrydesová (2012 – 18 hr.), Nikola Rybáriková (2012 – 24 hr., 2013 – 53 hr.), Jozef Šibík (2013 – 2 hr.), Eliška Štubňová (2014 – 26 hr.), Mária Zaliberová (2012 – 4 hr.), Milan Zajac (2013 – 36 hr.)
- Seminars: Miroslav Caboň (2013 – 2 hr., 2014 – 2 hr.), Jana Májeková (2012 – 13 hr., 2013 – 13 hr., 2014 – 13 hr., 2015 – 13 hr.), Pavol Mereaďa (2012 – 12 hr., 2013 – 10 hr., 2014 – 10 hr.), Jana Podroužková Medvecká (2012 – 2 hr.), Mária Zaliberová (2012 – 13 hr., 2013 – 13 hr., 2014 – 13 hr., 2015 – 13 hr.)
- Field excursions: Miroslav Caboň (2014 – 2 hr.), Zuzana Fačkovcová (2014 – 16 hr.), Petra Mikušová (2014 – 8 hr.), Jana Petrydesová (2014 – 8 hr.), Mária Zaliberová (2012 – 6 hr.)
- Individual lectures: Jana Májeková (2012 – 4 hr., 2013 – 2 hr., 2014 – 3 hr.), Zuzana Melečková (2014 – 2 hr.), Pavol Mereaďa (2012 – 2 hr., 2013 – 4 hr., 2014 – 4 hr., 2015 – 4 hr.), Jana Petrydesová (2014 – 2hr.), Andrea Plečeniková (2015 – 4 hr.), Dušan Senko (2012 – 2 hr.), Jozef Šibík (2012 – 4 hr.), Stanislav Španiel (2015 – 2 hr.), Mária Zaliberová (2012 – 4 hr.)

Faculty of Natural Sciences, Department of Zoology

- Semester lectures: Karol Marhold (2012 – 12 hr.)

Faculty of Natural Sciences, Department of Plant Physiology

- Semester lectures: Igor Mistrík (2012 - 56 hr., 2013 – 36 hr., 2014 – 18 hr., 2015 – 18 hr.)
- Semester exercise: Beáta Bočová (2012 – 20 hr.), Roderik Fiala (2015 – 4 hr.), Lucia Kenderešová (2012 – 53 hr.)

Faculty of Natural Sciences, Department of Soil Science

- Semester lectures: Anna Guttová (2015 – 6 hr.)
- Semester exercise: Zuzana Fačkovcová (2015 – 4 hr.), Anna Guttová (2015 – 4 hr.)

Faculty of Natural Sciences, Institute of Laboratory Research on Geomaterials

- Semester exercise: Petra Mikušová (2013 – 2 hr.)
- Individual lectures: Petra Mikušová (2013 – 2 hr.)

Technical University in Zvolen (Slovak republic)

Faculty of Ecology and Environmental sciences, Department of Biology and general Ecology

- Semester lectures: Richard Hrivnák (2012 – 2 hr., 2013 – 3 hr., 2014 – 3 hr., 2015 – 3 hr.)
- Seminars: Richard Hrivnák (2012 – 6 hr.)
- Field excursions: Richard Hrivnák (2012 – 8 hr., 2013 – 8 hr., 2014 – 8 hr., 2015 – 8 hr.)

Matej Bel University in Banská Bystrica (Slovak republic)

Faculty of Natural Sciences, Department of Biology and Ecology

- Semester lectures: Dobromil Galvánek (2013 – 1 hr.), Richard Hrivnák (2014 – 6 hr., 2015 – 6 hr.), Monika Janišová (2013 – 30 hr., 2014 – 30 hr.), Katarína Olšavská (2012 – 8 hr., 2013 – 30 hr., 2014 – 30 hr., 2015 – 12 hr.), Marián Perný (2012- 7 hr., 2013 – 30 hr.), Barbora Šingliarová (2012 – 2 hr., 2013 – 30 hr., 2014 – 30 hr.)
- Semester exercise: Barbora Šingliarová (2012 – 1 hr.), Katarína Olšavská (2015 – 12 hr.)
- Seminars: Richard Hrivnák (2013 - 6 hr.), Monika Janišová (2015 – 24 hr.), Marián Perný (2014 – 6 hr.)
- Individual lectures: Dobromil Galvánek (2014 – 1 hr.)

Catholic University in Ružomberok (Slovak republic)

Faculty of Education, Department of Biology and Ecology

- Semester lectures: Michal Slezák (2013 – 39 hr., 2014 – 39 hr., 2015 – 48 hr.)
- Semester exercise: Michal Slezák (2013 – 26 hr., 2014 – 26 hr., 2015 – 36 hr.)
- Field excursions: Richard Hrivnák (2012 – 8 hr., 2013 – 8 hr.), Michal Slezák (2013 – 26 hr., 2014 – 26 hr., 2015 – 24 hr.)

Charles University in Prague (Czech republic)

Faculty of Science, Department of Botany

- Semester lectures: Karol Marhold (2012 – 48 hr., 2013 – 96 hr., 2014 – 80 hr., 2015 – 80 hr.)
- Semester exercise: Karol Marhold (2012 – 24 hr., 2013 – 48 hr., 2014 – 36 hr., 2015 – 36 hr.)
- Seminars: Karol Marhold (2012 – 8 hr., 2015 – 8 hr.)

Masaryk University in Brno (Czech republic)

Faculty of Science, Department of Botany and Zoology

- Semester lectures: Alica Košuthová (2015 – 20 hr.)
- Field excursions: Daniel Dítě (2012 – 24 hr.)

University of South Bohemia in České Budějovice (Czech republic)

Faculty of Science, Department of Botany

- Semester lectures: Stanislav Španiel (2013 – 40 hr.)

University of Siena (Italy)

Department of Physical Sciences, Earth and Environment

- Individual lectures: Anna Guttová (2012 – 4 hr.)

2.6. Social impact

2.6.1. List of the most important results of applied research projects. Max. 10 items

Report to the problem of biodeterioration of cultural heritage for Istituto Superiore per la Conservazione ed il Restauro (ISCR), Roma: Favero-Longo S., Benesperi R., Bertuzzi S., Bocca E., Caporale S., Catalano I., Cristofolini F., Genovesi V., **Guttová A.**, Loppi S., Martellos S., Matteucci E., Morando M., Paoli L., Perotti M., Ravera S., Roccardi A. 2014: Progetto nazionale sul biodeterioramento lichenico di beni culturali in pietra – Adotta un monument. Notiziario Della Società Lichenologica Italiana 27: 45, 47, 59-60, 67-68.

The Working Group for Biology (Società Lichenologica Italiana) has launched the research "Adopt a monument", aimed at examining the colonization and deterioration lichen on cultural monuments of stone on the territory of Italy. These monuments represent different stone materials of national interest and different types of historical and artistic works (archaeological areas, civil and religious buildings, sculpture works). For each "adopted" site we have realized, initiated or planned investigations to: (a) detect and quantify the presence lichen on the stone surfaces; (B) examine the physical-chemical interaction between lichens and substrate, without making direct inquiries on the work, but using the same litotype materials taken from natural outcrops or surfaces quarry; (C)

provide an evaluation of the state of biodeterioration or bioprotection by lichens based on experimental measurements; (D) evaluating which may be more appropriate for physical or chemical techniques possible removal of lichens from the opera. Besides increasing and investigations in the field lichenology applied to cultural monuments, the initiative aims to encourage dialogue between the research institutions and institutions involved in the preservation, so as to support a increasing involvement of biological expertise in evaluation of the degradation problems of Cultural Heritage.

Biomonitoring study: Paoli L., Ravera S., **Guttová A., Senko D.** 2014. Rete di biomonitoraggio lichenico (biodiversità e bioaccumulo di elementi) nell'area vasta interessata dalla presenza del Centro Olio della Val d'Agri. Report finale. Dipartimento di Scienze della Vita, Università degli Studi di Siena; Institute of Botany SAS (<https://www.eni.com/eni-basilicata/ambiente/sistema-monitoraggio/biomonitoraggio-lichenico/biomonitoraggio-lichenico.shtml>).

Preparation of zoning of TANAP (Vysoké Tatry National park).

Zoning is an integral and recognized part of conservation planning and protected area management. It gained acceptance as a key strategy for combining human land use with nature conservation in cases that deserve balancing of different interests, resource expectations and management options. In the zoning process one assigns land units to specific uses (management regimes) and each zone thus represents a set of land units designed for specific purpose. Foundations and frameworks of zoning on an international scale were set in the IUCN Guidelines for Protected Area Management Categories. In the Slovak Republic, Nature and Landscape Conservation Act No. 543/2002 states that zones in protected areas are delineated and arranged according to the nature of natural values involved and that maximum number of zones is four. We thus have developed a more explicit set of zoning assumptions, priorities, principles and criteria so as to draw a scientifically valid proposal of zoning for the earliest and largest national park in Slovakia – the Tatra National Park. The proposal is intended to provide 1) the Slovak authorities with a sufficient support when negotiating, resolving and enforcing their zoning decisions, 2) scientific community with a more inclusive and consistent conceptual model of zoning whose tools (including some new or overlooked) are interpreted and applied to a specific central European case. Responsible: Jozef Šibík.

Red List of vascular plants of the Carpathian part of Slovakia: Turis P., Kliment J., Feráková V., Dítě D., Eliáš P. jun., Hrivnák R., Košťál J., Šuvada R., Mráz P., Bernátová D., 2014 – *Thaiszia, J. Bot.* 24: 35–87.

The Red List of vascular plants of the Carpathian part of Slovakia is result of the project within IUCN programme focused on preparing of Red List for whole Carpathian massif. The Red List was prepared on basis actual Guidelines for Application of IUCN Red List Criteria using also the up to now unofficial categories and additional (qualifying) criteria and contains 1 001 taxa of native plants. Out of them 46 are Regionally Extinct (category RE), 18 missing [1 taxon in the category EX?, 4 taxa in the category RE?, 13 taxa in the category CR(PE)], 461 threatened [149 taxa Critically Endangered (category CR), 141 taxa Endangered (category EN), 171 taxa Vulnerable (category VU)], 290 Near Threatened (category NT), 103 Least Concern (category LC). Seventy six taxa are assessed in the category Data Deficient (DD), and 7 taxa are listed under Not Applicable (category NA) because of their unclear taxonomic status.

European Red List of medicinal plants assessment 2013 IUCN Red List Unit Global Species, Programme IUCN (International Union for Conservation of Nature).

The European Red List is a review of the Red List status of European species according to IUCN regional Red Listing guidelines. It identifies those species that are threatened with extinction at the regional level – in order that appropriate conservation action can be taken to improve their status. This Red List publication summarises results for the selected European medicinal plants. (Allen, D., Bilz, M., Leaman, D.J., Miller, R.M., Timoshyna, A. and Window, J., 2014: European Red List of Medicinal Plants. Luxembourg: Publications Office of the European Union, 61 pp. Responsible: Viera Feráková, Iva Hodálová, Pavol Mered'a.

Preparation of documents for State Nature Conservancy of the Slovak Republic and Agency for Nature Conservation and Landscape Protection of the Czech Republic within the LIFE+

project LIFE09NAT/CZ/000364 "Integrated Protection of Rare Butterfly Species of Non-forest Habitats in the Czech Republic and Slovakia". The project LIFE09NAT/CZ/000364 is one of the 84 environmental innovation projects held in 24 countries under the LIFE+ Nature & Biodiversity programme 2009 of the European Commission. These projects demonstrate new methods and techniques for dealing with a wide diversity of Europe's environmental problems. The aims of the mentioned project, in which we participated, was to introduce, test and promote patchwork managements, which are essential for the conservation of the target 10 butterfly species and 15 habitat types of European importance. In 2013 we collected floristic data in two areas of European Importance, located in the White Carpathian mountains (Biele Karpaty) and the Považský Inovec mountains (both in Slovakia). Both areas consist of flower-rich meadows and other non-forest habitats, which host very rich fauna and provides an important refuge for rare and endangered invertebrate species (especially insects and arachnids), and are crucial for the survival of butterfly species of European importance. As a result we proposed suitable management practices, which could help to maintain and restore these habitats to a favourable conservation status. Responsible: Pavol Mered'a.

Establishment of European Red List of Habitats, multilateral project, 2014-2016, The Red List of European Habitats provides an overview of threatened marine, terrestrial and freshwater habitats in the European Union (EU28) and adjacent regions (EU28+), based on a consistent set of criteria and detailed data and expertise from involved countries. Responsible: Milan Valachovič, Jozef Šibík.

Study of the floristic structure of four permanent monitoring plots located within the area effected by the Gabčíkovo waterworks. The Gabčíkovo–Nagymaros waterworks has been planned as a large barrage project on the Danube River. Only a part of the project has been finished in October 1992 on the Slovakian part of the Danube, under the name Gabčíkovo waterworks, because Hungary first suspended then tried to terminate the project due to environmental and economic concerns. The Gabčíkovo waterworks produces 2600 GWh of electricity annually, making it the largest hydroelectric plant in Slovakia. The construction of this waterworks was predicted to have serious, long-lasting impacts on the hydrology and riparian environment of the region. To describe the effect of the waterworks on vegetation structure and species composition of the adjacent riparian floodplain forests several permanent monitoring plots has been established and monitored over a 23-year period, between 1990 and 2013. Within the monitoring, soil moisture has been directly measured on each plot. Additionally, five environmental factors frequently used in European studies on vegetation (namely, soil moisture, amount of nitrogen, soil pH, requirements for temperature and light), has been calculated from species-specific indicator values of vascular plants growing on plots. In 2013 we have studied the floristic structure on four of these plots. In 2014 and 2015 we evaluated all collected data from all monitoring plots and started to prepare publication entitled "Effect of the Gabčíkovo waterworks on riparian floodplain forest ecosystems along the Danube River: vegetation dynamics and trends". Responsible: Iva Hodálová.

2.6.2. List of the most important studies commissioned for the decision-making authorities, the government and NGOs, international and foreign institutes

Ministry of Environment SR (www.enviro.gov)

- [1] The draft list of indicators of biodiversity, 2015 – Jozef Šibík
- [2] Preparation of expert zonation of TANAP, 2012 – Jozef Šibík

Ministry of Interior – Presidium of the Police Force SR (www.minv.sk) Ministry of Interior of the Slovak Republic is a central body of state administration for protecting the constitutional system, public order, security of persons and property, protection and administration of the state's borders, the safety and fluency of road traffic, for issues related weapons and ammunition, private security services, the entry to the territory of the Slovak Republic and the stay of foreigners in its territory, identity cards, travel documents and driving licences, refugees and transmigrants, for the registration of population, for the Police Force and the Fire Fighting and Rescuing Corps.

- [1] Expert opinion on the identity of the narcotic and psychotropic substances, District Police Directory Trnava (7 cases), 2012-2014, Iva Hodálová, Jaromír Kučera, Marek Slovák.
- [2] Expert opinion to the theft of protected plant species from Devínska Kobyla, Presidium of the Police Force, 2013-2014, Dušan Senko.

State Nature Conservancy Banská Bystrica (www.sopsr.sk) – the central expert organisation for nature and landscape conservation in Slovakia for the past twelve years reporting to Ministry of Environment SR. The main tasks include work on legislation level (elaboration of policy documents, guidelines and resource materials for development of legislation and elaboration of nature conservation documentation) as well as on expert level (expert management of protected parts of nature, surveys and research provision and habitats monitoring). It also provides for environmental education and awareness activities, promotion and editorial work, operation of information centers as well as international cooperation and implementation of tasks arising from international conventions and agreements.

- [1] Wood mushrooms of Nature Reserve Dobroč, 2012 – Slavomír Adamčík.
- [2] Preparation of the Red List of endangered plant species of the Carpathians, 2012 – Daniel Dítě, Richard Hrivnák.
- [3] Documents preparation for distribution of selected taxa of Slovakian flora, 2012 – Jozef Šibík.
- [4] Inventarisation of lichens in Tematínske vrchy Mts, 2013 – Zuzana Fačkovcová.
- [5] Transfer of protected lichen species *Lobaria pulmonaria*, 2013 – Anna Guttová.
- [6] Expert assessment to the cutting of trees in the area Muráň castle ruine, 2013 – Anna Guttová.
- [7] Algae and algal flora of selected peatbogs in Malá Fatra Mts., 2013 – Alica Hindáková.
- [8] Lichen diversity of the Nature reserve Klapy in Strážovské vrchy Mts., State Nature Conservancy, 2014 – Anna Guttová, Anna Lackovičová, Zuzana Fačkovcová.
- [9] Development of management programs for selected protected areas included in Natura 2000, 2014 – Alica Košuthová.
- [10] Lichen diversity of protection zone of NPP Vrbické pleso glacial lake, 2014 – Anna Guttová.
- [11] Lichen diversity of NPR Humenský Sokol and CHA Brekovský hradný vrch, 2014 – Anna Lackovičová, Anna Guttová.
- [12] Inventarisation of vegetation in the contact area of the proposed power line route 2x400 kV Gabčíkovo - Veľký Ďur, 2014 – Jana Májeková, Dušan Senko.
- [13] Biotope monitoring of localities with European importance, 2014-2015 – Ivan Jarolímek, Jana Májeková, Mária Petrášová, Jozef Šibík, Iveta Škodová, Katarína Vantárová, Milan Zajac, Mária Zaliberová.
- [14] Floristic inventarisation of Štokeravská vápenka locality, 2014 – Milan Valachovič.
- [15] Inventarisation of lichens within NATURA 2000 localities in Slovakia, 2014 – Alica Košuthová.
- [16] Mapping of distribution of selected lichen species in CHKO Cerová vrchovina, 2015 – Zuzana Fačkovcová.
- [17] Phytosociological survey of grasslands communities in Nebrová, State Nature Conservancy, Banská Bystrica, 2015 – Iveta Škodová.
- [18] Phytosociological research of vegetation in CHA Revúca, Administration of National park Veľká Fatra and State Nature Conservancy, Banská Bystrica, 2015 – Katarína Vantárová.
- [19] Phytosociological research of non-forest vegetation in area of European importance Veľkolélsky ostrov, 2015 – Milan Zajac.
- [20] Botanical research of the species from the family Orchidaceae in the area of NP Veľká Fatra, 2015 – Milan Zajac.

Municipality of Bratislava – the capital city (www.bratislava.sk)

- [1] Expert opinion to the features concept of the Bratislava Forest Park, Bratislava, 2014 – Milan Valachovič.

[2] Expert advice for revitalization of Štrkovecké jezero lake in Ružinov, 2012 – Alica Hindáková, František Hindák.

Slovak Environmental Inspectorate (www.sizp.sk)

[1] Expert opinion for the seizure of a specimen from the genus *Solidago*, Slovak Environmental Inspectorate, Bratislava, 2012 – Pavol Mered'a.

State Forests of TANAP (www.lesytanap.sk)

[1] Expert opinion to occurrence of mass phytoplankton in Štrbské Pleso lake, State Forests of TANAP, 2013 – Alica Hindáková, František Hindák.

Regional Association for Nature Conservation and Sustainable development (BROZ) (www.broz.sk)

- [1] Devínska Kobyla - susceptibility to erosion area, 2012-2014 – Dušan Senko.
- [2] Expert scientific cooperation: Devínska Kobyla, 2012-2013 – Dušan Senko.
- [3] Expert scientific cooperation: We help to Danube river, 2014 – Dušan Senko.

Daphne – Institute of Applied Ecology (www.daphne.sk), NGO

- [1] Biotope monitoring of localities with European importance, DAPHNE, State Nature Conservancy, Banská Bystrica, 2014-2015 – Ivan Jarolímek, Jana Májeková, Mária Petrášová, Jozef Šibík, Iveta Škodová, Katarína Vantárová, Milan Zajac, Mária Zaliberová.
- [2] Devínska Kobyla - susceptibility to erosion area, 2012-2014 – Dušan Senko.
- [3] Expert scientific cooperation: Devínska Kobyla, 2012-2013 – Dušan Senko.

Národná diaľničná spoločnosť (www.ndsas.sk) (National Highway Company) – National Highway Company (NDS) provides some very important and state-regulated activities. In particular, it is planning, preparation and construction of highways, their maintenance and the repair. Provides performance of building inspection and operation of specialized accredited laboratory. It is an administrator and also the owner of superior road infrastructure in Slovakia, their property is old and enhance it. In cooperation with the tolling system provides charging of road infrastructure in Slovakia. NDS within their competencies and financial means, provide adequate motoring public services. Its activities increased level of road safety and to ensure proper comfort to the traveling public. NDS is an open society that is within their means trying to communicate with all stakeholders and interested groups and individuals. **and Dopravoprojekt a.s.** – a private joint-stock company, which provides multi-disciplinary engineering consultancy services and project work, with a particular focus on transport and transport infrastructure, land, water and environmental construction services and transport infrastructure, land, and environmental waterworks.

- [1] Consultancy for assessment of the building impact on the habitats of European and national importance in the area of the planned highway D1 (Turany - Hubová), 2015 – Milan Valachovič.
- [2] Inventarisation of the biotopes along the route of the planned highway D4 (Jarovce - Ivánka-sever - Rača), 2015 – Milan Valachovič.
- [3] Inventarisation of habitats on the planned highway R7, 2012 and 2014 – Milan Valachovič.

Branislav Molnár – Fotománia Plus (www.photomania.sk)

- [1] Expert scientific cooperation: Prohibited kingdom, 2012 - Katarína Hegedúšová.
- [2] Expert scientific cooperation: Danube - wilderness inland delta, 2012-2013 – Dušan Senko.
- [3] Expert scientific cooperation: Devínska Kobyla, 2012-2013 – Dušan Senko.
- [4] Expert scientific cooperation: Hooves in the wind, 2014 – Dušan Senko, Matúš Kempa, Eva Senková, Anna Guttová.
- [5] Expert scientific cooperation: We help to Danube river, 2014 – Dušan Senko.

Zdeno Vlach – KARPATIA

- [1] Expert scientific cooperation: Ramsar sites, 2012 – Dušan Senko.

Comenius University in Bratislava (www.uniba.sk/en/)

[1] Floristic inventarisation of the PR Čunovo and PR Topoľové hony for monitoring of impact of VD Gabčíkovo to the natural environment, 2014 – Pavol Mered'a, Iva Hodálová.

New York State Office of Parks, Recreation and Historic Preservation, NY, USA (www.parks.ny.gov)

[1] Report on *Russula* and *Camarophylloopsis* members collected in New York State in 2015 with special emphasis to species described by Charles Horton Peck, 2015 – Slavomír Adamčík.

New York State Department of Environmental Conservation, NY, USA (www.dec.ny.gov)

[1] List of *Russula* specimens in type collecting areas of Charles Horton Peck collected in New York State in 2015, 2015 – Slavomír Adamčík.

2.6.3. List of contracts and research projects with industrial and other commercial partners, incl. revenues

N/A

2.6.4. List of licences sold abroad and in Slovakia, incl. revenues

N/A

2.6.5. List of most important social discourses under the leadership or with significant participation of the institute (max. 10 items)

Official involvement in cooperation with Ministry of Environment of the Slovak Republic within preparatory works for Slovak Presidency in the Council of the European Union (SK PRES) – expertise for the topics of Regulation (EU) No 511/2014 of the European Parliament and of the Council of 16 April 2014 on compliance measures for users from the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation in the Union, transposition of the Regulation into national legislation (Act 263/2015 Z. z.). Responsible persons: Mgr. Anna Guttová, PhD., prof. RNDr. Karol Marhold, CSc.

2.6.6. Summary of relevant activities, max. 300 words

Through our popularisation activities we aim to cover wide range of spheres and sectors to secure and raise awareness about importance of science and its output for everyday life. We see gaps in this aspect nationwide. Public support of science proved extremely important at the end of 2014 and beginning of 2015 when Slovak Academy of Sciences faced difficult situation – proposed state budget cuts which would have had dramatic impact on personnel (reduction) as well as research activities. In cooperation with the Office of Slovak Academy of Sciences – Department of communication and media, we identified crucial scientific teams to be promoted, we identified top scientists whose profiles and activities to promote as well as list of success stories – scientific stories to introduce to public.

We receive direct feedback to our performance regarding PR activities and popularisation when we work with schools and students. These are direct comments, written reactions and stories published as articles in school journals, which spread information about our Institute, activities which were presented at school or interesting scientific topics and questions worthy to study and answer. The result of this feedback are offers for collaboration with schools, invitations for lectures and discussions, or field trips.

Our expertise, regularly used for different questions from government agents (see above) proves the importance of knowledge basis available at the Institute. Consultations for experts collaborating with entrepreneurs regarding diversity of microfungi during seminars and workshops carried out under the activities of scientific societies which Institute of Botany houses brought an opportunity in 2016 to collaborate in preparation of 2 project proposals for a call within Operational programme Research and Innovations in July 2016 (OPVal-VA/DP/2016/1.2.1-02).

2.7. Popularisation of Science (outreach activities)

2.7.1. List of the most important popularisation activities, max. 20 items

Here we list a selection of activities which were covered in important national media (RTVS – <https://www.rtv.s.k/> – radio and TV; private TV channels e. g. Markíza – <http://www.markiza.sk>, TV LUX; radios – Rádio Regina, Rádio Slovensko, Rádio Best FM), foreign media (Sweden – <http://www.tv4play.se>), local TVs (Pezinok, Tablet TV), print – dailies (Denník SME, Pravda), weekly (Roľnícke noviny), monthly (Železničný semafor) or press conferences organized by the Presidency of SAS. The name of the contribution is original in Slovak, followed by the name of the media and the date of either broadcast, or release, or event.

Other numerous activities, which are not listed here include lectures for general public, students of elementary and secondary schools as well as university students, excursions for students and teachers in the field, articles in a laymen form published in specialist and popular journals (Quark, Ochrana prírody na Slovensku, Záhorie), PR reports in SAS media (www.sav.sk, Správy SAV). Institute of Botany organizes regularly the event – The Open Doors Day, when mostly the students and their teachers (elementary, secondary schools, universities) are invited to be acquainted with the work of researchers in the Institute. Institute of Botany SAS uses SAS tools, e.g. SAS website or a magazine HPC Focus, to share outputs of popularisation work with SAS community as well as general public. Institute of Botany actively participates in annual event „**Science and Technology Week in the Slovak Republic**“, prepared by Ministry of Education, Science, Research and Sport of the Slovak Republic in cooperation with the Slovak Centre of Scientific and Technical Information and National Centre for Popularisation of Science and Technology in Society.

- [1] **Swedish TV presentation: Viktor Kučera, Ivona Kautmanová, Václav Kautman:** Ny svampsort hittad i dal sland, Dalsland TV 4 play (Sweden), 5.9.2012 (http://www.tv4play.se/n_yheter_och_debatt/nyh_eterna_vast?title=ny_s_ampsort_hittad_i_dal_slant&videoid=2218595); Rare find for mushroom fanciers, Sverigesradio (Sweden), 4.9.2012 and 15.9.2012 (<http://sverigesradio.se/sida/artikel.aspx?programid=2054&artikel=5268860>) and <http://sverigesradio.se/sida/artikel.aspx?programid=1027&artikel=5267039>.
- [2] **National TV presentation: Ivan Jarolímek, Podroužková Medvecká:** Invázne rastliny (Invasive plants), RTVS – Magazín VAT – Veda a technika, 2. 10. 2015.
- [3] **National TV presentation: Marek Slovák, Jaromír Kučera:** Semenná banka (Seed bank), RTVS – Magazín VAT – Veda a technika, 12. 11. 2015.
- [4] **National TV presentation: Karol Marhold:** Využitie superpočítača Aurel pri štúdiu populačnej štruktúry, hybridizácie, migrácie jedincov a populácií, pri odhaľovaní príbuzenských vzťahov a evolúcii organizmov, TV; komentár v relácii Správy RTVS; RTVS; 23. 11. 2014.
- [5] **National TV presentation: Dominik Roman Letz:** Rastliny v Biblii (Plants in Bible), TV Lux, 11.6.2013; Evolúcia (Doma je doma) (Evolution), TV Lux, 1. 10. 2014; Slovensko v obrazoch, RTVS, 3. 8. 2014.
- [6] **National radio presentation: Milan Valachovič:** RTVS „Nočná pyramída“ na tému Lesy na Slovensku (Forests in Slovakia), Radio Bratislava, 6. 6. 2015.
- [7] **Presentation for general public with on-line broadcasting: Ivan Jarolímek, Milan Valachovič:** Ako sa menia lesy na Slovensku z pohľadu botanikov, Slovak Centre of Scientific and Technical Information (www.cvtisr.sk), Bratislava, 26. 3. 2015.
- [8] **Local TV presentation: Marek Slovák:** Snežienky sú bez zákonnej ochrany, v národných parkoch však hrozí pokuta, Tablet.TV- Teraz Media, 3. 3. 2015.
- [9] **Private TV presentation and national daily: Jana Podroužková Medvecká:** Boľševník v Horskom parku nie je nebezpečný, Denník SME, 26.8.2013; Rastlinní prístahovalci, TV JOJ - Noviny o 17:00, 10.9.2013.

- [10] **National radio presentation and presentation for general public: Pavol Mered'a:** Nepôvodné rastliny Slovenska, Slovenský rozhlas, Rádio Regina (1. 10. 2015) , Quark journal (27. 10. 2015), Bratislava, CVTI, podujatie "Vedecká cukráreň (20. 10. 2015).
- [11] **National radio presentation: Dušan Senko:** Spamätá sa Devínska Kobyla z vykrádačiek?, RTVS, Rádio Slovensko, Rádio Regina, 22. 5. 2014.
- [12] **National radio presentation and daily press: Jozef Šibík:** Vplyv globálneho otepľovania, Rádio Slovensko, 28. 5. 2014; Vedci varujú vládu pred masovým budovaním v Tatrách, Sme, 10. 10. 2014.
- [13] **National radio presentation: Anna Guttová:** Príbeh na týždeň – Čo sa deje v zime – Lišajníky, Rádio Slovensko, 29. 12. 2015.
- [14] **Local TV presentation and national radio presentation: Viktor Kučera:** Huby malokarpatskej oblasti, TV Pezinok, 5. 10. 2015; Huby okolo nás, Rádio Best FM, 24. 9. 2015.
- [15] **National radio presentation and weekly press: Ján Pavlovkin:** Stres rastlín, Rádio Regina, 7.9.2012; Pestujeme čakanku šalátovú, Týždenník Roľníckej noviny, č. 12, s. 39, 20. 3. 2013; Rez drevín a krov koncom zimy, Týždenník Roľníckej noviny, č. 3, s. 27, 16. 1. 2013.
- [16] **National daily press: Jozef Šibík:** Aké budú Tatry o 50 rokov? O tom sa rozhoduje dnes, Denník Pravda, 1. 12. 2015.
- [17] **Thematic monthly press: Eleonóra Michalková, Dominik Roman Letz, Pavol Mered'a, Ivana Kapráliková:** Unikátne rastlinstvo v okolí našich tratí, Železničný semafor. Mesačník zamestnancov Železníc Slovenskej republiky roč. 23, s. 6, 1.10.2013.
- [18] **National daily press: Slavomír Adamčík:** Huby možno raz huby zachránia svet, Denník Pravda, 22. 9. 2014.
- [19] **Thematic monthly press: Jana Podroužková Medvecká, Ivan Jarolímek:** Rastlinní prišahovalci, Quark journal, 10.9.2013.
- [20] **Thematic monthly press: Katarína Olšovská, Barbora Šingliarová:** Kvetena Balkánskeho polostrova – rozmanitosť a jej príčiny, Quark 7: 23-25, 10. 7. 2014.

2.7.2. Table of outreach activities according to institute annual reports

Outreach activities	2012	2013	2014	2015	total
Articles in press media/internet popularising results of science, in particular those achieved by the Institute	48	10	15	6	79
Appearances in telecommunication media popularising results of science, in particular those achieved by the Institute	5	2	6	11	24
Public popularisation lectures	16	13	17	39	85

- **Supplementary information and/or comments on popularisation activities, max. 300 words**
N/A

2.8. Background and management. Human resources and implementation of recommendations from previous assessment

2.8.1. Summary table of personnel

Personnel	2012	2013	2014	2015
All personnel	102,0	108,0	105,0	100,0
Research employees from Tab. Research staff	70,0	70,0	74,0	73,0
FTE from Tab. Research staff	49,460	48,430	53,350	48,370
Average age of research employees with university degree	45,8	45,7	45,2	45,2

2.8.1.1. Professional qualification structure (as of 31.12. 2015) FEMALE

FEMALE	AGE								
Number of	< 30	31 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	> 65
DrSc. / prof.	0	0	0	0	0	0	0	0	0
II.a / Assoc. prof.	0	0	1	4	3	3	0	2	5
Other researchers PhD./CSc.	0	9	6	1	0	0	0	1	0
doc. / Assoc. prof.									

2.8.1.2. Professional qualification structure (as of 31.12. 2015) MALE

MALE	AGE								
Number of	< 30	31 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 - 64	> 65
DrSc. / prof.	0	0	0	0	0	0	1	0	1
II.a / Assoc. prof.	0	1	5	4	4	1	1	2	3
Other researchers PhD./CSc.	0	2	2	2	0	0	0	0	0
doc. / Assoc. prof.									

2.8.2. Postdoctoral and mobility scheme

2.8.2.1. Postdoctoral positions supported by national and international resources

Supporting Fund of Stefan Schwarz (Jaromír Kučera, Marek Slovák, Barbora Šingliarová, Ľubica Liptáková (Halušková), Jana Podroužková Medvecká, Katarína Olšavská, Alica Košuthová, Petra Mikušová, Monika Majerová, Stanislav Španiel).

Support by United States Department of the Interior National Park Service, Rocky Mountain NP, Study ROMO-11027: Jozef Šibík, stay at Colorado State University, Department of Forest & Rangeland Stewardship, Fort Collins, Colorado, USA. July 2012, Research topic Impact of land-use changes on alpine region: intercontinental comparison (High Tatras – Europe, Rocky Mountains – USA).

Postdoctoral positions supported by Slovak American Society

Slavomír Adamčík: 2 months (University of Tennessee, Knoxville, USA). Research topic: Delimitation, trans-Atlantic distribution and phylogenetic relationships of taxa within the genus *Camarophyllopsis* (Fungi, Ascomycotina) in Europe and North America.

Jozef Šibík: 1 year of visiting scientist – 2013 (Colorado State University, Fort Collins, USA). Research topic: usage of databases, programmes and data mining to study vegetation trends in harsh climatic conditions of the Arctic and high mountain systems.

Developing of the Arctic Vegetation Archive and synthesis of Arctic vegetation, Bilateral Projects Slovak Academic Information Agency – SAIA 12629, 16.3.2015– 15.6.2016. Responsible investigator: Jozef Šibík.

Research topic: usage of databases, programmes and data mining to study vegetation trends in harsh climatic conditions of the Arctic and high mountain systems using The Alaska Arctic Vegetation Archive (Alaska-AVA). It is a prototype database for the Arctic Vegetation Archive (AVA). The goal of the AVA is to unite and harmonize vegetation data from the Arctic tundra biome for use in developing a pan-Arctic vegetation classification. This open-access database is the first to represent an entire global biome, utilizing a unique data dictionary and species list within the Turboveg database program. The Alaska-AVA prototype contains complete species lists and cover estimates for homogeneous plots in typical habitats of northern Alaska. The database contains 3156 total plots. In addition to plot data, the Alaska-AVA contains an array of ancillary data, such as original data reports, plot photographs, plant-species cover estimates, vegetation structure, key publications and, where available, soils information, site factors, geographic coordinates, aboveground phytomass, and ground-based spectral information.

Postdoctoral position to Stanislav Španiel at Department of Botany, Faculty of Science, Charles University: "Support of establishment, development, and mobility of quality research teams at the Charles University", project number CZ.1.07/2.3.00/30.0022, supported by The Education for Competitiveness Operational Programme (ECOP) and co-financed by the European Social Fund and the state budget of the Czech Republic." Period: April 2012 – December 2014

Research topic: Study of polyploid complexes in genera *Alyssum*, *Arabidopsis* and *Cardamine* from Brassicaceae family with the emphasis on microevolution and taxonomy of these groups. Methodically the project included determination of ploidy levels of studied plants by flow cytometry, analysis of polyploid origins by molecular markers and determination of morphological differences between genetically defined groups by means of multivariate morphometrics. Within the project, postdoc contributed to extension of the teaching of plant microevolution and speciation at the University of South Bohemia in České Budějovice, where he taught the methods of multivariate morphometrics for graduate and PhD students. Postdoc attended a six-month stay at Real Jardín Botánico de Madrid, CSIC (Spain) focusing on cloning of single- and low-copy genes and ITS sequences. The post-doc position resulted in 6 WOS publications, 2 manuscripts and 1 manuscript of lecture material for students.

Postdoctoral position to Barbora Šingliarová at University of Fribourg, Fribourg, Switzerland. Host mentor: Prof. Heinz Mueller-Schaerer. Supported by Sciex-NMS^{ch} – Swiss – Slovak scholarship fund. Project: ASIPOL – Adaptive Significance of Polyploidy. Period: October 2011 – October 2012.

The aim of the project was to investigate mechanisms of establishment and maintenance of mixed cytotype populations and impact of genome duplication on evolutionary success of polyploids in comparison with their diploid counterparts. The *Pilosella alpicola* group (Asteraceae) was used as a model system. It includes diploid-polyploid species *P. rhodopea*, as well as exclusively polyploid species *P. alpicolas*.str. In the Balkan species *P. rhodopea* reproductive systems of particular cytotypes were studied along with the seed set, rate of polyploid formation in seeds and their fitness. It was found out that much less polyploids are represented in seeds compared to natural conditions, but later they have higher survive and growthrate, and they spread also clonally via accessory rosettes, which was not recorded in diploids. This enables them to spread successfully and to create rather large clones. Alpine populations of *P. alpicola* s.str. are very rare (4 known populations in Swiss and 3 populations in Italian Alps). For this species the same fitness parameters were observed as for *P. rhodopea* and directly in the field a transplant experiment was

established. Its task was to clarify, if rare occurrence is caused by existence of selection mechanisms, which prevents effective spread (*selection hypothesis*), or whether the species is just evolutionary young and not enough time elapsed yet for the species to spread (*neutral hypothesis*). The results suggest presence of strong selection.

Geographical niche shifts in lichen species: exploring the effects of infraspecific genetic variation, Bilateral Projects Slovak Academic Information Agency SAIA – Akcion no. 2013-10-15-0005. Period: 1.1.2014 – 30.6.2015. Responsible investigator: Alica Košuthová.

Our study focused on the genetic structure of European and North American populations of red-listed lichenicolous fungi *Cladonia botrytes* and *Buellia chloroleuca*. The aims of the study were: 1) to discover whether “substrate drift” or geographic niche variation in lichens is real or undermined by so-called cryptic speciation; 2) to find out mechanisms involved in “enforcing” substrate fidelity in case cryptic speciation is not involved. We analysed data from the nuclear ribosomal internal transcribed spacer region to study genetic variability in relation to substrate switches. Preliminary results showed that coding regions of the sequences of *Cladonia botrytes* from both, wood, humus and soil substrate are identical, non-coding parts feature variability in c. six positions, but a clear link to habitat preferences is not confirmed. However, there is clear evidence of an additional secondary metabolite which is produced by the mycobiont in clear-cut habitats. In the case of *Buellia chloroleuca* there is a clear pattern linked to geographical range.

Large-scale and small-scale patterns in lichen assemblages of Central-European acidic Aeolian sands. Visegrad Fund no 51201038. Masaryk University Brno, Czech Republic. Period 01.09.2012 to the 30.06.2013. Responsible investigator: Alica Košuthová.

The aim of the stay and research was to investigate patterns in community composition in Central-European lichen-rich pine forests along a macroclimatic gradient, using two plot sizes – to main the vegetation data. Diversity of lichens, especially the number of boreal and subatlantic taxa per plot increased from southern Slovakia to northern Poland (Baltic Sea). The ecological indicator value for continentality was highest in two inland regions which were characterised by low winter temperatures. Principal coordinates analysis sorted the regions along two major compositional gradients of similar importance, one mirroring the south-to-north gradient and correlating with the Górczyński index of thermal continentality, and a second correlating with lowest winter temperature. Regional differences driven by macroclimate were the most important determinant of species composition even in small plots. Continentality was of primary importance in assembling terrestrial lichen communities, but its particular components acted differently. Lowest winter temperature appeared to be well connected with ecological meaning of continentality, which is expressed among others in ecological indicator values.

Utilisation of RAD sequencing in plant systematics and evolution. A case study of the genus *Soldanella*. Bilateral Projects Slovak Academic Information Agency SAIA – Akcion no. 2015-05-15-001, 1.9.2015–31.8.2016. Responsible investigator: Marek Slovák.

Crucial research objective of the project is adoption and subsequent implementation of one of the most modern and sophisticated molecular techniques, currently used in molecular evolution, systematic and ecology research of living organism. From methodological point of view this method is based on next generation sequencing and is known as Restriction Site Associated equencing (RADseq). Model system of our research interest includes morphologically similar and taxonomically complex group of taxa from the genus *Soldanella* (Primulaceae). Thus, along with implementation of new method, the important outputs of the project will be to investigate evolution, phylogeography and taxonomy of closely allied taxa from the genus *Soldanella* from European mountain ranges. Project will thus also contribute to deeper understanding of microevolutionary processes in morphologically closely related and rather recently diversified complexes of vascular plant taxa.

Karol Marhold – visiting professor at the Center for Ecological Research, Kyoto University, Japan, 2012 – 3 months.

Covered topics included: *Auto- vs. allopolyploid origin* of studied taxa; *Recurrent origins*: Does the evolution repeat itself? Are there any independent polyploid lineages originating from the same parental combinations? Are there any *parallels and differences in evolution of diploid and diploid/tetraploid complexes within the same environmental context? Polyploidy and spread into*

man-made habitats: Are there any differences in the invasive or spreading potential of plants of different ploidy levels within the same species/species group? *Polyploidy and taxonomy*: How well fit the described species concepts to the genetic relationships within polyploid complexes (is there any genetic justification for locally described endemic taxa?).

2.8.2.2. Postdoctoral positions supported by external funding

N/A

2.8.2.3. SAS stipends and SASPRO stipends

Within SASPRO Incoming scheme, Dr. Stephen Venn, Helsinki, submitted research project „Connecting Biodiversity with Ecosystem Function – Carabid predation of vascular plant seeds in grasslands CARAFUNCT“ under the third call. He personally participated at the interview (November 2015) and his application was put on a reserve list.

2.8.2.4. Internal funding - the Slovak Academy of Sciences Supporting Fund of Stefan Schwarz

Jaromír Kučera (May 2009-April 2013), 50%
Marek Slovák (May 2009-April 2013), 50%
Barbora Šingliarová (Jan. 2011-Dec. 2014), 50%
Ľubica Liptáková (Halušková) (May 2011-April 2015) 50%
Jana Podroužková Medvecká (May 2013-April 2017) 50%
Katarína Olšavská (May 2013-April 2017) 50%
Alica Košuthová (May 2014-April 2018) 50%
Petra Mikušová (May 2015-April 2019) 50%
Monika Majerová (May 2015-April 2019) 50%
Stanislav Španiel (May 2015-April 2019) 50%

2.8.3. Important research infrastructure (max. 2 pages)

Laboratory of molecular systematics

In this laboratory we generate data addressing scientific questions of taxonomy, phylogeny, phylogeography and related evolutionary processes across different groups of vascular and non-vascular plants. Methods applied are focused on the study of differences and changes on the DNA level among organisms using several methods such as AFLP (Amplified Fragment Length Polymorphism), SSRs (microsatellites – simple repetitions) or sequencing of selected loci. Most of the currently used molecular methods are based on variations of the PCR (Polymerase Chain Reaction) and the analyses of the relevant products. The laboratory is also equipped for DNA extraction from plant material dried in silica gel or from herbarium specimens. In case when direct sequencing of specific loci is problematic, we use methods such as SSCP (Single-Strand Conformation Polymorphism) or cloning of PCR products into the bacterial cells, separating different alleles from diploid and especially from polyploid individuals. Currently we implement also new methods based on the NGS (Next Generation Sequencing), such as a Hyb-Seq and RAD-Seq. Here we are sequencing only selected loci and not the whole genome, which decreases price per sample and gives the opportunity to sequence more individuals. The laboratory of molecular systematics possess all necessary equipment for standard methods used in molecular systematics such as DNA extraction, PCR based methods (PCR-RFLP, AFLP, SSR), DNA purification, as well as cloning of PCR products (centrifuges, mixer mill, PCR thermocyclers, thermoblocks, incubators, PCR and flow boxes, spectrophotometer and fluorometer, temperature controlled electrophoresis apparatus, electrophoresis power supplies, blue light and UV-transilluminators with imaging system, etc.). The Institute owns or hires licenses for all relevant programs needed for molecular data evaluation (Geneious, PAUP, MacClade, SYN-TAX, SAS, DAX).

The laboratory is equipped by following instruments:

- Thermomixers Eppendorf (type "comfort" and "compact")
- Shaking incubator N-BIOTEK (NB-205)
- Centrifuges Eppendorf (5804, 5427R, 5415R), Hettich (Rotanta 460R)
- Mixer mill Qiagen (TissueLyser II)

- Thermal cyclers Eppendorf (Mastercycler pro S and ep gradient S)
- Electrophoresis power supplies Consort (EV243), Biometra (PS305T)
- Electrophoresis apparatus Elchrom Scientific (Origins 2100E)
- Imaging system Kodak (Gel Logic 200)
- Blue light transilluminator Herolab (UVT-20 BE)
- Spectrophotometer Thermo Scientific (NanoDrop 2000)
- Fluorometer Life Technologies (Qubit 2.0)
- Reverse osmosis system Werner (RO3 PLUS)
- UV/UF ultrapure water system Werner (EASY pure II)
- Biological Safety Cabinet ESCO Class II BSC
- DNA/RNA UV-cleaner box BIOSAN (UVT-S-AR)
- Autoclave sterilizers Nüve (OT 032), Tuttnauer (3850EL)
- Incubator Binder (APT.Line)

Laboratory of karyology and flow cytometry

Regarding karyological research, the Institute possesses a karyological laboratory equipped by a microscope Axioscope 2 (Zeiss) and two flow cytometers equipped by a green laser with 488 nm excitation wave and an HBO mercury arc lamp for UV excitation, respectively. Flow cytometers allow to detect relative (DNA ploidy level) as well as absolute DNA amount in plant material. Two cytometers running in parallel offer a possibility of simultaneous measurements of relative and absolute DNA amounts of the same sample and thus i.a. estimation of the proportion of AT/GC bases in the studied genome.

Morphometric laboratory

All instrumental and software equipment required for the application of multivariate morphometrics is available. This consists of several high-quality stereomicroscopes (Olympus SZ 61) with digital cameras to output image to PC, and A3 scanner allowing observation, digitalization and subsequent evaluation of the investigated material. Software accessories comprise licenses of statistical programs and packages (SAS, SYN-TAX) needed for evaluation of the biostatistical data.

Mycological laboratory – analyses and isolation

This laboratory serves for basic analyses of anatomy, morphology and chemistry fungal material – non lichenized as well as lichenized fungi. We perform basic analysis of secondary chemistry here (thin layer chromatography – TLC), and to prevent potential and very probable contamination, also preparatory steps for DNA extraction (PCR and post-PCR steps are carried out in the Laboratory of molecular systematics). It is equipped by following instruments:

- UV lamp and UV box Camag, development tanks
- shredder Retsch MM 200
- thermal chamber: KCB 25 W
- optical instruments for micro-morphological observations and identifications of fungi: light microscopes Zeiss Axio Scope.A1 with digital camera AxioCam 105 and visualisation software AxioVision SE64 Rel. 4.9.1, light microscopes Olympus CX41 and BX51 with ARTRAY Artcam 300MI camera and visualisation software Quick Micro Photo 2.3 and Deep Focus 3.1, stereomicroscope Olympus SZ61
- digital camera Sony DSLR-A200 with Tamron 17-50 mm F/2,8 Dill and Kodak Easy Share Z 650 objectives for photo-documentation of samples
- deep-freezers for disinfection of herbarium specimens
- freezers for storage of biological material and chemical reagents

Mycological, phytopathological and algological cultivation labs

The laboratories serve for isolation of the material from the substrate (microscopic fungi from host plant tissues, algae and cyanobacteria from water), inoculation and cultivation of the material for further analyses (e. g. molecular analyses). The laboratories are equipped by following instruments:

- sterile box, Thermo Scientific MSC-Advantage and ESCO biohazard II laminar flow box for isolation of fungi and lichen photobionts and for routine lab work in sterile condition

- universal cultivation box and Biological thermostat BT120 with regulated temperature and humidity for cultivation of fungi and lichen photobionts
- laboratory autoclaves for sterilisation of culture media and lab supplies
- Hettich EBA 270 centrifuge for routine work with algae and cyanobacteria
- Lovibond thermostatically controlled cabinet for cultivation of microorganisms

Laboratories of plant physiology – abiotic stress, plant physiology, electrophysiology, cell biology and light and electron microscopy

In our laboratories we use mainly the methods as a ROS determination, electrophoresis, root respiration, determination of different enzymes activities, methods for obtaining physiological status of investigated plants, gene expression and semi-quantitative RT-PCR. The laboratories are equipped by following instruments:

- centrifuges: Eppendorf and Sartorius
- spectrophotometers: BECKMAN COULTER DU 730 and Nanodrop 2000C Thermo Scientific
- vertical electrophoresis
- Clark oxygen electrode
- fluorometer: SYNERGY HT
- hybridiser HB-2D Techne
- ultraviolet crosslinker UVC-T08 Ultra Lum
- fluorescent magnifier BellPhotonics
- high performance liquid chromatograph Bio Logics, Bio Rad
- gel documentation system 212PRO Leica Logic
- confocal microscope FV1000 Olympus
- thermocyclers Eppendorf and Biorad C1000
- DNA analyser 4300 Licor
- automatic DNA analyser Maxell Pormega
- pipetting robot: epMotion 5075 vac Eppendorf
- electrophoresis with thermal gradient DCode Biorad
- autoclave Tuttnauer 2540EL
- ultrasound USC 1700TH VWR
- distillation apparatus: Medihum
- Cryotome Leica CM 1510 S
- Fluorescence stereomicroscope Zeiss Pentafluor Discovery V12
- Rotofor System- IEF BioRad
- Electro-eluter Model 422 BioRad
- ultracentrifuge Beckman L8–M

Pedological laboratory

Chemical analyses of soil samples serve to complement datasets gathered for studies in plant communities. The results represent additional datasets for characterization of ecological requirements of particular plant assemblages.

- dryer of laboratory glass KBC G – 100/250
- dryer of plant material HS 402 A
- stereoscopic video-microscope DSTM 722 3.0

Institute of Botany – detached unit in Banská Bystrica

Laboratory for identification of plant material

The laboratory is used for study of microscopic, anatomical preparations and herbarium specimens for scientific and educational purposes.

- binocular: Olympus SZ61, 3,35-90x with digital camera 3Mpxi CMOS
- microscopes: Carl Zeiss Axioscope A1 with digital camera 5Mpxi CMOS
- USB microscope: AM 13T Dino-Lite Pro
- digital photoscanner: Pentacon Scan 6000 S

Plant systematic laboratory

The laboratory is used for detection of ecological requirements and eco-physiological properties of plants, and for preparation of karyological preparations for scientific or educational purposes.

- device for water analysis: WTW Multi 3430 SET F

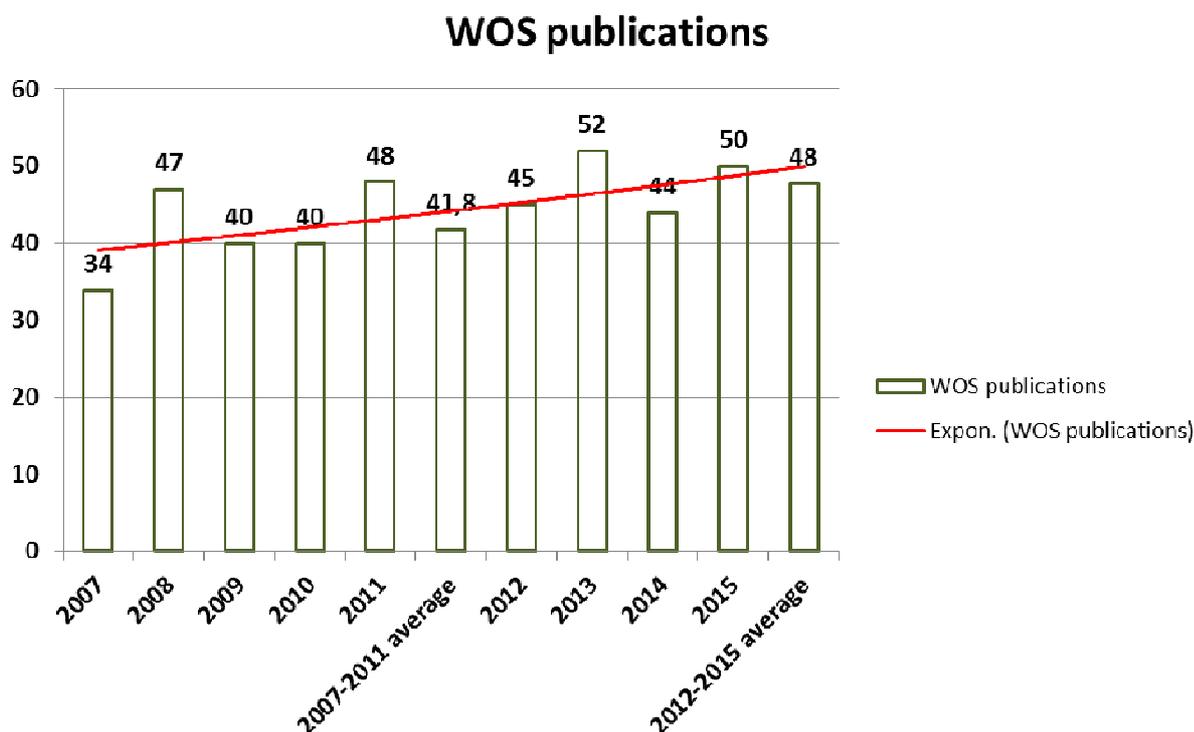
- digital meter of soil moisture: Delta-T ML2x ThetaKit, 4 ks
- digital conductivity meter Delta Porometer AP-4, 2 ks
- metal detector Minelab X-TERRA 305
- soil conductivity meter Geonics EM38-MK2
- Geographic information system (GIS) – layers: 1. Digital model of relief , 2. Average daily air temperature in 2 m, 3. Monthly rainfall, 4. Total monthly of photosynthetically-active solar radiation, 5. Soil cover, 6. Land cover

2.8.4. Description of how the results and suggestions of the previous assessment were taken into account

The latest evaluation of the institute was performed for the period 2007–2011 by the Evaluation Panel for Agricultural, Veterinary and Ecological Sciences. We received the following suggestions which we comment:

1. Research outputs: „There is still certain space to increase the quality and quantity of publications in international periodicals.“

During the evaluation period we focused on increase of both quality and quantity of WOS publications. It was one of our priorities. General trend in increase, represented on the graph below by the red exponential trend line is visible. We also made a step forward regarding the quality of these papers, which is commented in more detail below, in the section summarizing general comments, objections to organization’s activities in form of suggestions and specific tasks which must be performed by organization before next regular evaluation.



2. Response to scientific outputs: „Databases and check lists of plants are very well accepted from the relevant international community and received a wide attention and response that is not reflected in citation records appropriately.“

Current academic social networks (e.g. ResearGate) make scientific papers and works much more accessible than years ago. This fact is also reflected in distribution of our synthetic works like checklists. For the evaluation period, some of these lists fall within the list of 10 most-cited publications for the institute:

- Marhold, K., Hindák, F. (eds.). 1998: Zoznam nižších a vyšších rastlín Slovenska [Checklist of non-vascular and vascular plants of Slovakia]. 1. vyd. Bratislava: Veda, 687 pp. 275 citations (including chapters citations).
- Baláž, D., Marhold, K., Urban, J. (eds), 2001: Červený zoznam rastlín a živočíchov Slovenska [Red list of plants and animals of Slovakia]. Ochrana prírody. Banská Bystrica. č. 20, Suppl. 1, 160 pp. 129 citations (including chapters citations).
- Jarolímek, I., Šibík, J. (eds.), 2008: Diagnostic, constant and dominant species of the higher vegetation units of Slovakia. 1. vyd. Bratislava: Veda, 332 pp. Vegetation of Slovakia. ISBN 978-80-224-1024-3. 71 citations (including chapters citations).

Regarding databases, current system of citation registration (e.g. academic Advanced Rapid Library – ARL system, Web of Science) do not enable to automatize registration of citations of databases and similar internet resources that we build. The only way is manual search and collection of these citations. However, there are two international databases, build with the contribution of our Institute, and two national – institutional databases, which are cited in WOS:

- Euro+Med Plantbase - the information resource for Euro-Mediterranean plant diversity (<http://ww2.bgbm.org/EuroPlusMed/>), Karol Marhold is one of the editors, number of WOS citations: 17, other citations 3.
- The IUCN Red List of Threatened Species (www.iucnredlist.org), contributors from the Institute of Botany: Iva Hodálová, Pavol Meredža and Viera Feráková, number of WOS citations: 3
- Karyological database of ferns and flowering plants of Slovakia. Version 1.0. (www.chromosomes.sav.sk), number of WOS citations: 3, other citations 2.
- Centrálna databáza fytoecenologických zápisov (CDF) na Slovensku - GIVD ID: EU-SK-001 (www.ibot.sav.sk/cdf), number of WOS citations: 1.

3. Research status of the organization within international and national context: „*The position of different working groups, in this respect* (note: highly acknowledged research status of the institute), *is not evenly distributed*“.

Institute of Botany SAS housed and still houses different working groups on several levels – either covering particular scientific disciplines (e.g. evolution, systematics, physiology), or covering different objects of study (e.g. vascular plants, fungi, plant communities, insects). We believe that complexity allows for flexibility. During elapsed period we experienced extremely positive movement, that is networking, and connecting of these working groups. This brought along important effect – distribution of expertise, multiplication of experience and exchange of ideas. The results can be seen in increase in quality of scientific outputs. However, we are aware of the fact that there is still space for improvement and we work towards it.

4. Project structure, research grants and other external funding resources: „*It is advisable to focus on grand applications which promise a higher success and appropriate funding*“

During evaluation period we actively participated in every open general call of Slovak Research and Development Agency (APVV), which offers relatively appropriate funding. In 2012 we prepared 4 proposals as main beneficiary, in 2014 3 projects as main beneficiary and 3 projects as a project partner and in 2015 4 projects as the beneficiary and 2 projects as project partner. Out of these 16 proposals, 2 were successful.

We participated in one Horizon 2020 project proposal in 2014, which was not successful.

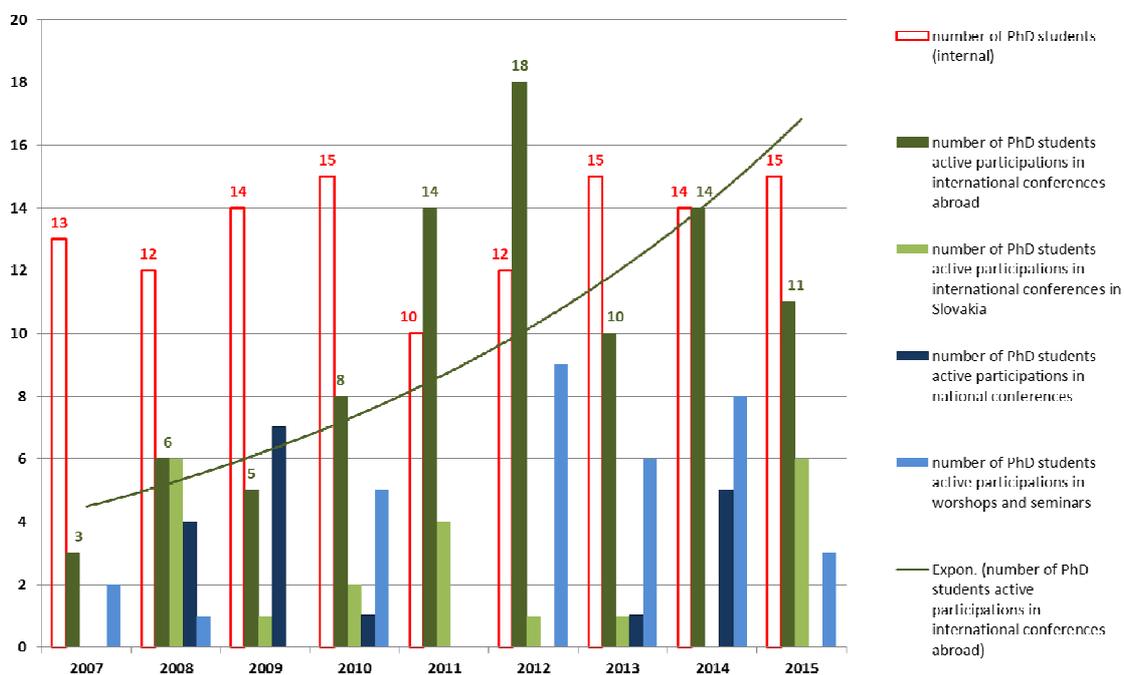
In 2013 we prepared 2 proposals for Operational Programm Research and Development – one in cooperation with Technical University Zvolen and other partners from Slovak Academy of Sciences (Institute of Forest Ecology, Institute of landscape ecology) – ENVIRO-TECH, and another one in cooperation with Presidency of SAS, Institute of Forest Ecology and Institute of Landscape Ecology EKO-GLOBKLIM. These however, were not successful.

We also participated in 3 proposals for COST projects, one of them was successful. Another international source for which we applied was NASA – in 2015 we prepared proposal in

cooperation with University of Alaska to focus on a multi scale remote-sensing analysis of Arctic-vegetation vulnerability and resilience to change. This proposal was not successful. Successful proposals for international projects were – e.g. Establishment of a European Red List of Habitats ([ENV.B.3/SER/2013/0025](#), beneficiary Alterra, Wageningen), or COST project – European System for Alien Species.

5. Organization of PhD education and other pedagogical activities: „*It is advisable to increase an engagement of PhD students in conferences, workshops and seminars within Slovakia and abroad.*“

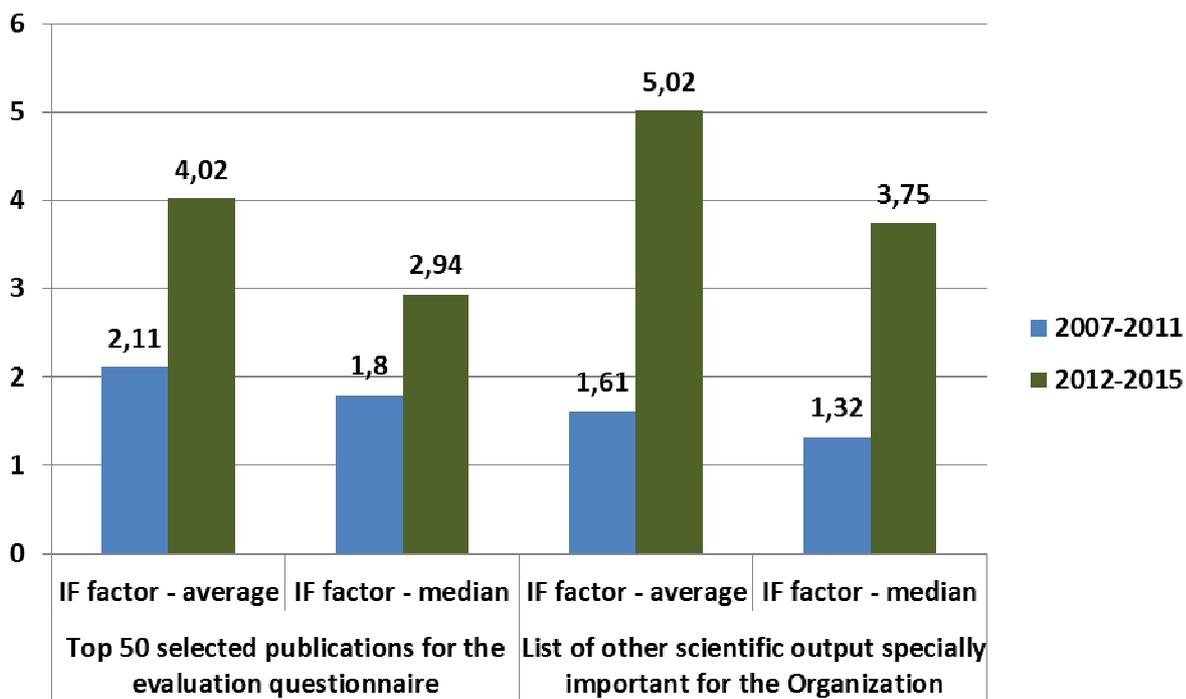
During the evaluation period we also worked on this recommendation. As we can see on the graph below, the activity of our PhD students towards participation at the international conferences abroad, international conferences organized in Slovakia and other conferences and workshops increased. The trend is summarized by the green exponential trend line. One of the drivers which certainly pushed the students and also supervisors activity forward was a credit system which recognizes wide range of scientific activities.



Comments, objections to organization’s activities in form of suggestions and specific tasks which must be performed by organization before next regular evaluation, etc.:

- 1) *It is advisable to focus publication strategy to high quality international peer reviewed journals.*

As was already commented above, during the evaluation period we focused on top-priority publication outputs – WOS papers, their quantity and also quality. Impact factor was selected here to demonstrate the increase in WOS papers quality. In the graph below, we can see a clear trend in increase, when average value as well as median of impact factor is confronted for the publication outputs during current evaluation period and the previous one (2007–2011). Our aim is to keep this rhythm of steady increase in quality. Regarding quantity, we work to reach 1 article recalculated per one researcher per year.



2) *It is necessary to work on personal management including DrSc.*

We recognize importance of personal management. During the evaluation period we revised and updated a system for internal evaluations of PhD. students as well as regular evaluations of researchers to encourage and motivate them towards excellent performance. We set a target to watch professional qualification structure and encourage researchers to increase the position (categories IIa and DrSc.) as soon as the criteria are met. During the evaluation period of 4 years 7 researchers reached category IIa (during the previous evaluation period of 5 years this number was 8).

Our weakness is coverage of very important category of DrSc., which is crucial to guarantee PhD degree programme. Currently we have only one researcher working part-time and one professor (degree awarded by Charles University, Praha). Seeing this trend, we felt, that firstly it is important to explain researchers necessity to proceed with their qualification, continuously build it and focus to meet criteria for DrSc. This is an inherent part of scientific career. Next we identified the candidates in two age groups – 55-56 and 41-50. There are 2 candidates in first group, who started to elaborate the thesis and supplementary material (one is approaching finalization) and 3 candidates in second group. With younger candidates we explored gaps in meeting criteria. One candidate meets publication and citation criteria but lacks PhD students behind. This is a longer term project, however the candidate will work towards it. Other two candidates do not meet the number of citations yet. We are regularly checking the progress with all candidates.

3) *In the future, research topics and visions should be discussed and developed by permanent discussions within the institute.*

During the evaluation period we organized several meetings when we discussed and revised mission and vision of our Institute as umbrella for our research. The main platform is Scientific board of the Institute along with the Managing board of the Institute. The output can be seen in the chapter 1.7. We also regularly discuss partial goals to focus on, mainly in the period of preparation of larger project proposals, so as they meet the scopes of national and international strategic documents as well as general trends. The main platforms are meetings of the scientific Departments.

- **Supplementary information and/or comments on management, research infrastructure, and trends in personnel development**

Institute of Botany SAS was a state budgetary organisation until 31. 12. 2015. From 1. 1. 2016 it was transformed to state contributory organisation as a mid-step on the way to public research institution (abbreviated as v. v. i.), which we expect in future (there was a plan for this transformation from 1. 1. 2016, but the act of law has not been negotiated in Parliament and approved). We believe, that this form of economy will help us to apply for other types of external funding.

In this period we kept the same organizational structure – four scientific departments and economy and technical departments, which proved effective and well performing. We invested our energy, time and resources in open, early and full communication of important elements to the staff, explanation of problems and weak points (e.g. increase in qualification, publication output and quality, search for different external resources), so as they feel the problem and they are convinced and motivated to contribute to address this problem. We consider important collective understanding, empathy and facilitative leadership.

From 1. 12. 2015 our team was enriched by 5 researchers (category IIa), which were delimited from the Institute of Zoology to the Institute of Botany. We see this as an opportunity to enlarge our biodiversity scope and strengthen the research topic connected with water, which now we are able to address from botanical, ecological as well as zoological viewpoint

We also follow the on-going processes of lumping, connecting of research institutes of Slovak Academy of Sciences into larger research units – centres (e.g. Biomedical Research Centre). We are aware of positive aspects, though we also look back to experience from the past when scientific centres were formed. We started first preliminary discussions on creation of common larger unit with the Institute of Plant Genetics and Biotechnology, which would be mutually beneficial for research in plant physiology.

3. Research strategy and future development of the institute for the next five years (2016-2020) (Recommended 3 pages, max. 5 pages)

3.1. Present state of the art in both the national and the international contexts

Biodiversity and related biological processes are the principal subjects of research that we conduct. Together with climate change mitigation, protection of international waters, prevention of land degradation, and sustainable forest management, it is a strategic area in the international context, as expressed in the Convention on Biological Diversity (CBD) Strategic Plan for Biodiversity 2011–2020 and the Aichi Targets. Biodiversity, the **key indicator of the ecosystems health**, underpins the functioning of the ecosystems on which we depend for food, fresh water, health, recreation and protection from natural disasters. European biodiversity is unique, but its loss has accelerated to an unprecedented level. Research, monitoring and scientific assessment of biodiversity are principal agents stimulating actions to safeguard it. Our activities under the presented research strategy will mostly address the following aspects:

A) Polyploidy

Genomic investigations have suggested that **genome doubling is a major evolutionary force not only in plants, but also in other eukaryotic lineages**. During the past decade, there has been a tremendous resurgence of interest in polyploidy that has, to a large degree, been stimulated by the development of increasingly powerful genetic and genomic tools. This has brought numerous new insights into the genomic and genetic consequences of polyploidy. Many of these discoveries have dramatically reshaped traditional views and revealed that polyploidy is a highly dynamic and ubiquitous phenomenon. Research into polyploidy has now diverged into two principal areas: (1) detailed experimental and genomic studies on (artificial) polyploid models in non-natural conditions and (2) detailed studies of the distribution and evolutionary patterns within various wild polyploid complexes. Overcoming the gap between artificial models and natural systems is crucial for our understanding of polyploid evolution from a complete perspective, including its practical uses.

B) Evolutionary relationships, taxonomy, diversity and distribution of biota

Effective conservation and biodiversity management largely depends on understanding taxonomy. Inadequate taxonomic information and infrastructure, coupled with declining expertise, hinders the

ability to make informed decisions about conservation, sustainable use and sharing of the benefits derived from genetic resources. Governments, through the CBD have acknowledged the existence of a 'taxonomic impediment' to the sound management of biodiversity and have developed the **Global Taxonomic Initiative (GTI)** to remove or reduce it. The **Institute of Botany is a National Focal Point for GTI**. Taxonomic decisions can be done only by taking into account the broad **evolutionary context** of the particular group. Intensive sampling and new techniques are showing that micro-evolutionary processes play important roles in species formation. Apart from homogeneous and mutually isolated gene lineages, species often consist of spaghetti-like gene trees, suggesting incomplete lineage sorting, lateral gene transfer, or maybe even persistent between-species flow.

C) Invasive alien species (IAS)

Ecological issues associated with IAS receive a substantial amount of attention from international bodies and conventions. The CBD has identified IAS as a cross-cutting issue and as **one of the biggest threats to biodiversity world-wide**. EU regulation No. 1143/2014 on IAS, effective from 2015, seeks to address the problem of IAS in a comprehensive manner so as to protect native biodiversity and ecosystem services, as well as to minimize and mitigate the human health or economic impacts that these species can have.

D) Vegetation dynamics, spatio-temporal changes and restoration, vegetation surveying

The current trend of **multi-dimensional approaches and data mining** is focal in biodiversity research. Parallel assessments of multiple components of the biota contribute to the overall knowledge of processes and trends that are ongoing in natural environments and to a more complete picture of individual groups and their interactions. **Recent vegetation surveying** shifts from local to regional classification aimed at building a **common classification system**. The international scientific journal *Applied Vegetation Science* was recently earmarked for a new section focused on vegetation surveying. The next step in supporting large-scale vegetation syntheses is the preparation of virtual special issues on supranational classification of all vegetation types. Recent decades saw increasing interest in phytosociological data with regard to their use in **applied fields for biodiversity conservation and environmental monitoring** (e.g. NATURA 2000), which aims at protecting endangered habitats and species within the EU. **Safeguarding a favourable conservation status of habitats and species** of EU importance is one of the priorities of all EU countries.

E) Plant stress responses

Survival of terrestrial plants relies on highly coordinated signalling mechanisms adjusting their morphology and metabolism to the ever-changing environment. It is well known that hormones and reactive oxygen species (ROS) play a key role in the **regulation of plant stress responses**. Recently, nitric oxide (NO) signalling was implicated in the modulation of both ROS and hormonal equilibrium in different plant species under various stress conditions. Components of the same as well as of distinct signalling pathways intensively interact among themselves, integrating internal ontogenic and external signals into morphogenic and metabolic responses in order to maximize survivability under extreme conditions.

F) Biodiversity e-infrastructures (databases)

Databases are an essential part of biodiversity science and support education and effective public policies. Effective thematic and geographically delimited databases provide a **framework for networking and collaboration among data providers and users**. Shared data and knowledge are more likely to be used for scientific development and in policies and decision support systems. A number of projects of FP6 and FP7 were devoted to this area and established infrastructures supporting research and international cooperation.

3.2. Research strategy of the institute in the national and the international contexts, objectives and methods

A) Polyploidy

We aim to investigate the evolutionary triggers and consequences of chromosomal change (polyploidy, aneuploidy, dysploidy) that may ultimately lead to speciation. The following questions will be addressed: In which phenotypic and genomic characteristics do diploid 'source' lineages (that gave rise to polyploids) differ from diploid-only lineages (e.g. geographic proximity, standing variation of genes linked to meiosis stability, habitat preferences or life history)? Which are the pathways of origin of polyploids and dysploids? What are the phenotypic consequences of polyploidy in the study groups? Does the evolution repeat itself? Are there any independent polyploid lineages originating from the same parental combinations? Are there any differences in the invasive or spreading potential of plants of different ploidy levels within the same species/species group? How well do taxonomists 'read' polyploid diversity; i.e. how well do described species concepts match the genetic relationships within polyploid complexes? Apart from the below-mentioned molecular markers, chromosome counting, flow cytometry, GISH and comparative chromosome painting will be used to address these questions.

B) Evolutionary relationships, taxonomy, diversity and distribution of biota

We plan to continue mainly in the study of the following aspects of **micro-evolutionary processes** (i.e. the formation of species and infraspecific lineages) that help us understand biodiversity patterns and improve taxonomic classifications: polyploidization, hybridization, geographic, ecological or reproductive isolation, apomictic and/or cryptic speciation, and localization of glacial refugia, colonization routes and contact zones among taxa and genetic lineages. Such research inevitably entails the combination of multiple methods, including multivariate morphometrics, molecular markers, analyses of ploidy and DNA content, and hybridization experiments. As regards molecular techniques, we plan to continue using the multi-marker approach, which is efficient and allows us to generate robust and clearly interpretable data in all model organism groups studied (algae, fungi, lichens, vascular plants and animals). We will expand this approach by including restriction site-associated DNA sequencing (**RAD-Seq**) and the **Hyb-Seq method**, which combines target enrichment of low-copy nuclear genes and genome skimming. The former technique enables the sequencing of thousands of randomly distributed regions across the entire genome, whilst the latter works with precisely chosen regions of hundreds of nuclear genes. Both methods are novel and sophisticated genotyping approaches based on high-throughput DNA sequencing (NGS) applicable in molecular ecology, evolution and biosystematic studies at reasonable cost. Testing these methods is in advanced stages in our labs.

We aim to broaden the scope of our research to include further directions and aspects of **fungal evolution**, building on molecular data, to identify processes responsible for the contemporary geographic ranges and distribution patterns of model fungi, and their population dynamics and ancestral phylogenies. Combining genetic data on mycobionts with those on photobionts will enable us to find out, for example, whether symbiotic interactions play a role in shaping the distributional ranges of model lichenized fungi, or whether photobiont diversity matches the so far unrecognized genetic diversity of mycobionts across distributional ranges. In ectomycorrhizal fungi and biotrophic fungi, we will aim to identify processes of speciation and diversification among geographically isolated areas of the Northern Hemisphere, host tree or habitats switches and phylogenetic signal for selected morphological traits.

In our studies of the biota, we will focus on geographic areas with which we have rich experience – besides the Carpatho-Pannonian region also the Mediterranean, because several elements reach their northern distributional limit in the Carpathians. Particular attention will be paid to rare and endemic organisms. In the upcoming years, we plan to develop in more detail an **ecoinformatic approach** based on Geographical Information Systems (GIS). This includes multivariate analyses of a large number of niche variables and ecological (or climatic) niche modelling. Along with genetic, karyological and morphological analyses, it could help in studies of relationships of different genetic lineages (e.g. diploid-polyploid complexes). Using these methods, it is possible to describe and compare (ecological/climatic) niches or model potential geographical ranges of organisms.

The occurrence of fungi with various trophic strategies depends primarily on the presence of a suitable substrate or associated plant (host/partner). Yet, fungal distribution areas are known not to copy the distributions of hosts/partners. Their distribution is limited by ecological, climatic and geographic factors. What is unknown, however, is how trophic strategies and corresponding adaptation mechanisms are related with the flexibility of fungi to inhabit various climatic zones or

geographical areas. These aspects will be studied on **three model fungal groups with different trophic strategies** in Europe: symbioses – lichenized fungi, ectomycorrhizal fungi and parasitic powdery mildews. We will aim to identify geographical elements within each trophic group and to assign bioclimatic and geographical factors influencing their areas of distribution.

We will continue publishing the multivolume **Flora of Slovakia**, which is of particular importance for science and the national culture. It significantly contributes to improving the knowledge of Carpathian and Pannonian diversity and represents a basic reference source on the biota of the region. Fourteen volumes have been published so far. The published results are important not only for biological disciplines, but also for schools and lawmakers (e.g. NATURA 2000), as well as for international projects and studies mapping biodiversity (e.g. Euro+MedPlantBase, Atlas Florae Europaeae). The acquired distribution data will also be used for updating the freely accessible on-line database DATAflos, which we plan to enrich with about 100,000 new chorological records. We have already started working on a **presentation of the Flora in an advanced digital form** and cross-linking the presented data to various online resources.

C) Invasive alien species and the level of invasion of individual habitats

We will continue to research the diversity, distribution, spreading, ecology and coenology of alien species of vascular plants, and the vulnerability of habitats to invasions. We will focus on evaluating the level of invasion of forest habitats and on characterizing the effects of selected environmental factors, forest management types and changes in the horizontal and vertical structure of stands on the level of invasion of habitats.

D) Vegetation dynamics, spatio-temporal changes and restoration, vegetation surveying

Many semi-natural habitats are in an **unfavourable state of conservation** due to succession induced by natural or man-made changes. We aim to test the long-term effects of different management treatments in the ecological restoration of semi-dry, mesic and wet grasslands (fens), and to set the conditions for their application. To acquire long-term data (>10 years), a series of **permanent manipulative experiments** in various habitats, established in previous years, will be used. Under various ecological conditions, we will test the elimination of expansive graminoid species using hemi-parasitic species. **Grazing**, an important management tool, can have dramatic effects on plant communities and soils in ecosystems, particularly within certain regions. Therefore, understanding the links between environmental drivers, grazing disturbance, plant functional traits and ecosystem properties is critical for understanding long-term patterns of biodiversity and ecosystem sustainability. We will study the independent and synergistic effects of two groups of wild herbivores (ungulates and large rodents) on the diversity of alpine vegetation. We will also compare the effects of indigenous and introduced ungulates on the state of mountain ecosystems and plant diversity. We will evaluate changes after large-scale restorations and monitor the **temporal dynamics and vegetation changes** in anthropogenic non-forest habitats **to estimate future trends in the composition of grassland vegetation**. Data processing and transformation into maps through GIS techniques will result in an interpretation of observed spatio-temporal changes in vegetation and in the development of **predictive models**.

We will finalize and publish the last volume of the series **Plant communities of Slovakia** on scrub and forest vegetation. The series represents a comprehensive vegetation survey of the territory that is of marked importance for science and the national culture. At the international level, we will join the effort to create a consistent classification of European habitats. We will deal mostly with grasslands and forests, using data from the European Vegetation Archive and national databases of participating countries. The most recent methods of formalized classification will be used to avoid subjectivity in the determination of vegetation units (sociological species groups, formal definitions of units, semi-supervised and supervised classification, numerical classification, gradient analysis). The results will contribute to international standardization of vegetation classification in Europe.

We will deal with **ecology of vegetation types** that are, for example, endangered or under threat of extinction (e.g. halophilous grasslands, alder forests). We will focus on the comprehensive study of ecological, vegetation and abiotic factors underlying the survival of halophytes in the current landscape conditions. Our aim is to identify effective conservation measures for these elements. Complex analyses of spatial distribution and synecology, vegetation and environmental variables, and of the structure of endangered, rare, phytogeographically important and alien

species will provide new insights into the current composition pattern of these azonal plant communities.

E) Water ecosystems – vulnerable habitats influencing the landscape

We will continue studying the diversity, species composition mutual interactions and relationships with adjoining communities, the ecology of macrophytes and important groups of invertebrates, inhabiting various water bodies in the Pannonian-Carpathian region – a European biodiversity hot-spot. We will focus on animal-plant interactions and abiotic factors related to the most important agents that influence the diversity, variability and structure of these ecosystems. Our main aims are to precisely describe the regions' biodiversity at the molecular, species and community levels, to identify groups of aquatic organisms which could serve as predictors (flagship species) of regional diversity and to characterize conditions that will ensure the preservation of the highest possible biodiversity in the area of interest.

F) Plant stress responses

The future challenge is to expand research questions regarding **the role of toxic metals** (e.g. Cd, Al, Sb or Zn) **on plant growth and development** inplant physiology, biochemistry and mitigation of these substances through protective substances such as silicon. To gain a deeper understanding of **the role of NO in the interaction of hormones and ROS**, we wish to focus on the analysis of their potential relationships in the regulation of heavy metal-induced responses in barley root tips, with potential applications in root system engineering.

In order to understand the contribution of the genetic background and adaption of plants to stress, we will phenotype maize populations and *Arabidopsis thaliana* accession lines originating from diverse environments for tolerance against toxic elements. The phenotyping part will be carried out at the IB SAS. The resulting data will be further processed in a **genome-wide association study (GWAS)** in cooperation with the Leibniz Institute of Plant Genetics and Crop Plant Research, Gatersleben to identify genomic regions significantly contributing to plant tolerance. Such analysis will allow us to narrow down the number of candidate genes for explaining phenotypical variation to a few or even a single one. The acquired list of genes will be examined for expression levels via RT-PCR in plant lines with contrasting plant tolerance also under unfavourable environmental conditions and/or for the application of plants in phytoremediation. To get a deeper understanding of the contribution of candidate genes and variations in their sequences to plant tolerance, **next-generation sequencing** will be undertaken in cooperation with the above-mentioned Institute.

Using transgenic and mutant lines in combination with the current genetic, molecular biological, histochemical and immunological, and microscopic methods, we plan to explore whether and how the presence or absence of iron and other metal elements transferred by the IRT1 protein may affect the activity of the IRT1 promoter, the process of RNA splicing, localization, turnover and intracellular dynamics of IRT1 protein varieties in **roots** of the model organism *Arabidopsis thaliana*. The findings may be useful in agricultural breeding practice, as they could help obtain higher-yielding varieties and stress-tolerant plants.

In order to **characterize the role of signalling and regulation of plant cells** affected by biotic stressors, we will use *Nicotiana tabacum* suspension cells as a model system to study the molecular, biochemical and physiological similarity (based on identification and expression of genes and proteins) and diversity of basal defence mechanism of plant/cells exposed to fusariotoxins, and pharmacological and molecular modulation of defence responses in mycotoxin-challenged cells to identify verifiable markers of plant resistance.

G) Biodiversity e-infrastructures (databases) and herbarium collection (SAV)

We will continue to publish our research results by electronic means – databases and other on-line resources. They are already widely used not only by fellow scientists, but also by the State Nature Conservancy and decision makers. Of the sources that we continuously build and improve, the following deserve special mention: (1) All published volumes of the Flora of Slovakia are available on-line via the Biodiversity Heritage Library (<http://www.biodiversitylibrary.org>) thanks to cooperation with the Real Jardín Botánico, Madrid; (2) the Checklist of non-vascular and vascular plants of Slovakia will be upgraded to reflect new taxonomic knowledge and computer technology; (3) DATAflos (Database of the Flora of Slovakia) will be further filled with plant distribution data; (4) existing chromosome number and ploidy level resources (database of ferns and flowering plants of

Slovakia; databases of the genus *Cardamine* and the tribe Alysseae) will be updated and connected with similar databases from other countries with the aim to provide a single access web portal for revised chromosome and ploidy level data; (5) the Central database of phytosociological relevés (Slovak Vegetation Database) will be updated further and contributed to the European Vegetation Archive; (6) the Database of non-native plant species; and (7) Lichens in Slovakia. We will also continue **building our internationally recognized herbarium collection** (acronym **SAV**) and living cultures. Digitalization of the collection will continue as well, and we will work together with major European natural history collections in order to achieve their recognition as ESFRI infrastructure.

H) Application of research outputs

Cooperation with relevant governmental sectors: Ministry of Environment (MoE) SR, State Nature Conservancy Agency: With regard to Slovakia's upcoming EU Presidency, researchers of the Institute of Botany SAS will provide expertise in the agenda of the Nagoya Protocol for COP MOP 2 taking place in December 2016 in Mexico; they will participate in meetings organized by the Working Party on International Environment Issues, EC or EU parties. Researchers also participate in the **Working group for biodiversity** and the **Working group for the zonation of the Tatry National Park** – both under the MoE SR.

At the European level, biodiversity data gathered for research purposes have been used for designating sites of the **Natura 2000** network (<http://www.natura.org>), aimed at protecting endangered habitats and species of the EU. **Securing a favourable conservation status of habitats and species** of EU importance is one of the priorities of European countries. We will focus on gathering and providing data on vegetation types that are under pressure or threat. The IB SAS will cooperate in monitoring of species and habitats of EU importance.

Projects with applied impact: Genetic diversity is being lost in natural ecosystems and in systems of crop and livestock production. Important progress is being made in the conservation of plant genetic diversity, especially using *ex situ* seed banks. The IB SAS cooperates with the Royal Botanic Gardens, Kew in the Millennium **Seed Bank** international project since 2006. Over the past ten years, we coordinated seed collecting activities in Slovakia (West Carpathians, Pannonia). In cooperation with relevant institutions from the countries concerned, we plan to cover the whole area of the Carpathians and at least parts of the Balkan Peninsula.

Citizen science: We will continue organizing activities such as **Floristic counseling** (teaching and assistance with identification of material) and **Floristic mini-courses**. They are aimed at a wide audience (professionals, the general public, students) interested in the wild flora.

Project proposals submitted to 7RP or H2020	2012	2013	2014	2015
Institute as coordinator	0	0	0	0
Institute as participant	0	0	1	0

Design of a European Distributed Digitisation Infrastructure for natural heritage, Number and acronym: SEP-210192950; DEDDI, **Call:** H2020-INFRADEV-1-2014-1, **Topic:** INFRADEV-1-2014, **Type of action:** RIA

4. Other information relevant for the assessment

The Academic Ranking and Rating Agency (ARRA) evaluated more than 200 research groups to identify those, that received above average and peak attributes in terms of their scientific performance and prospects in further research in the international context (Presidium of SAS, 2014). The team of the team leader prof. RNDr. Karol Marhold, CSc., focused on research in evolution of polyploid complexes in the Asteraceae and Brassicaceae families was included among Top scientific teams at the Slovak Academy of Sciences, and the team leader. The team members: Mgr. Judita Zozomová-Lihová, PhD., RNDr. Iva Hodálová, CSc., Mgr. Matúš Kempa, Ing. Jaromír

Kučera, PhD., RNDr. Pavol Mereaďa, PhD., RNDr. Katarína Olšavská, PhD., Mgr. Marián Perný, PhD., Mgr. Marek Slovák, PhD., RNDr. Barbora Šingliarová, PhD. and RNDr. Stanislav Španiel, PhD. This group met high scientific criteria and attained international acceptance of their research work.

Bratislava, 26. 7. 2016
Mgr. Anna Guttová, PhD.
Director