PLANTA EUROPA

Papers
6th Planta Europa Conference
ACTIONS FOR WILD PLANTS
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INTRODUCTORY PART
Distinguished Guests, Ladies and Gentlemen,

Dear Friends,

It is a great honour and pleasure for me as the Chair of Planta Europa to welcome you at the 6th Planta Europa Conference in Kraków, in Poland.

We are in one of the oldest cities in Poland, a city with much history and talent over centuries and today a treasure trove of Gothic and Renaissance architecture.

Kraków is also a major centre of education. More than ten university or academy-level institutes offer courses in the city with 170,000 students.

Beautiful nature can be found both outside the city and inside. There are dozens of gardens, parks and forests in Kraków, one of the most beautiful of which is the Botanical Garden. The Botanical Garden of the Jagiellonian University in Kraków was founded in 1783.

In the coming days we will enjoy the beauty of this town and Polish nature.

We are very grateful to the Polish partners for making it possible for us to come to Kraków, for hosting the 6th Planta Europa Conference that brings together experts in the field of plant conservation from different European countries. Many thanks to the members of the Organizing Committee for the preparation work for this conference.

Since the last Planta Europa Conference in Romania, in 2007, the number of Planta Europa members has been quite stable. But I like to welcome now two new Planta Europa members from Hungary and Georgia.

Today, it is not possible anymore to organise a conference without financial support. Therefore, we are very grateful for the financial support offered by: the Planta Europa Foundation, the ArtDatabanken – the Swedish Species Information Centre, and the authorities of the city of Kraków.

In 1995, 16 years ago, the first Planta Europa Conference took place in Hyères (France) and our network was initiated. From 1995 till now a lot of progress has been made, much national and international co-operation has been achieved and a lot of friendship has developed between people working on wild plant conservation in Europe. Planta Europa is all about working together in partnership.

Constant focus on the conservation of wild plants in Europe is badly needed.

Wild plants are essential to life. Plants are a vital part of the world’s biological diversity and are an essential resource for human well-being.

Plants cover the land surface of our earth like fine skin, absorbing the energy of the sun to support the web of life on our planet.

Besides crop plants that provide our basic food and fibres, many thousands of wild plants have great economic and cultural importance and potential, providing food, medicines, fuel, clothing and shelter for vast numbers of people throughout the world and making an important component of habitats for the world’s animal life.

Plants also play a key role in maintaining the planet’s basic environmental balance and ecosystem stability, they clean our air and water. Plants are critical in the fight against climate change. But plants are also important for less tangible things such as aesthetic pleasure, artistic inspiration and recreation.

Indeed, the life support system of the planet can only be maintained by protecting plant biodiversity.

Recent research on the status of the world’s plants (by the Botanic Gardens of Kew and the Natural History Museum of London) confirms the decline of plant species worldwide. One fifth of all plant species worldwide are classified as threatened. Now a thorough understanding of the conservation of the European flora is truly needed.

There are a lot of global and European political and legal frameworks, treaties and conventions which aim to achieve the conservation of nature and wild plants, but the implementation of all these duties seems to be very difficult and may take long.

Today economic, financial, social and security problems are at the top of political agendas. Unfortunately nature conservation, including wild plants, will get now less political attention.
This means we need to use a more proactive and innovative approach to save wild plants in Europe and in the world. Neither government authorities nor private organizations can successfully protect wild plants on their own. Only together can we save our wild plants.

In my opinion it is both a privilege and a challenge for all governments, politicians, regional and local authorities, scientists, NGO’s, botanical gardens, citizens, representatives of organisations in the fields of agriculture, forestry, fisheries, tourism, recreation and health, to work together in a world in which wild plants are valued.

So, let us make an effort. Let us all work towards a greater understanding of wild plants.

A greater understanding of wild plants will lead to a better understanding of our dependence on the earth’s life support system.

This conference gives us an opportunity to exchange and share our knowledge, expertise, experiences and best practice. I wish you all a great pleasure and a very successful and fruitful conference.

Let me now officially declare the 6th Planta Europa Conference open.
I would like to welcome you all on behalf of the Nature Conservation Committee of the Polish Academy of Sciences, which I have the honour to chair, and as a member of the World Heritage Commission under the Polish Ministry of Culture. I also welcome you on behalf of the Minister of the Environment, who is unable to be with us today as he is attending another meeting abroad.

Let me start by saying a few words about the place where we are meeting. Kraków is Poland’s old former capital, one of the first World Heritage sites. The city boasts an imposing royal castle. The heart of the castle is a cathedral where Polish kings rest in magnificent tombs. Next to Warsaw, Kraków is also Poland’s leading academic centre. The city is the seat of the country’s oldest and the region’s second-oldest university, the Jagiellonian University, founded in 1364. It is only two years younger than the University of Prague. Also here is Poland’s oldest botanical garden, established 228 years ago. It is a vital part of a network of over 20 Polish botanical gardens and arboreta, playing an important role in biodiversity protection *ex situ*, and it plays an equally important role in ecological education. In addition to its several universities offering education in nature conservation, Kraków is also home to the Institute of Nature Protection of the Polish Academy of Sciences and the Institute of Botany of the Polish Academy of Sciences. We take particular pride in the fact that Kraków is the cradle of Polish nature conservation and the national centre for research on biodiversity, with the country’s largest collections documenting plant and fungi biodiversity. It has over 35% of all Polish collections and 80% of the country’s nomenclatural types gathered in its six herbaria (out of about 60 in Poland). Kraków is where two eminent botanists developed the fundamentals of nature conservation in Poland: Marian Raciborski, a nature conservation pioneer from the turn of the 19th and 20th centuries, and his pupil Władysław Szafer, Poland’s most distinguished conservationist. Szafer was rector of the Jagiellonian University before and during the second World War, director of the Institute of Botany of the Jagiellonian University and the already mentioned Botanical Garden, founder and first director of the Institute of Botany of the Polish Academy of Sciences, and founder and director of the Institute of Nature Protection of the Polish Academy of Sciences. He created two important periodicals: *Ochrona Przyrody* (*Nature Conservation*), one of the world’s two oldest scientific periodicals focusing on environmental protection, and *Chrońmy przyrodę ojczystą* (*Let’s Protect Our Indigenous Nature*), a bimonthly devoted mainly to the promotion of nature conservation and environmental education. He wrote key publications and textbooks focusing on environmental protection. He was also the creator of the State Nature Conservation Council, a body appointed by the Minister of the Environment, which has been the main environmental protection advisory body for the Polish government since the interwar period. Władysław Szafer took an active part in the establishment of Poland’s largest conservation organisation, known as the Nature Conservation League; he also played a leading role in setting up the first national parks in Poland (for example Tatra N.P., Ojców N.P. and Bialowieża N.P.), and in the founding of one of the world’s key international environmental protection organizations, the IUCN. Later he was made one of its first honorary members sharing the title with such noble persons as P. G. van Tienhoven (The Netherlands), A. Chevalier (France), Sir J. Huxley (UK), H. H. Bennett and E. L. Palmer (USA) and A. Ghigi from Italy.

Kraków and nearby Zakopane are where Jan Gwalbert Pawlikowski was active. He was one of the pillars of the already mentioned State Nature Conservation Council, the spiritual father of environmental protection, and the founder of Poland’s first conservation organization, the Tatra Protection Section, which celebrates its 100th anniversary next year. He also was responsible for the first Polish nature conservation act in the interwar period.

Kraków is the capital of Małopolska Province, one of the country’s 16 provinces. Six of Poland’s 23 national parks are located here although simple mathematics would suggest only one or two. This
shows the uniqueness and richness of our province on national scale, with our abundance of relict and endemic species, as well as many plant and fungus species not to be found elsewhere in Poland. We will have an opportunity to see three of the national parks during post-conference field sessions.

This is a time of anniversaries that are important for “understanding, documenting and protecting biodiversity”. Not long ago we celebrated the 250th anniversary of the establishment of the Linnaean rules for describing and classifying biodiversity, and also the 200th anniversary of the birth of Charles Darwin, who postulated the theory that tries to explain the creation of the biodiversity we seek to preserve today. Last year saw many events related to the International Year of Biodiversity. Besides those global-scale anniversaries and events there are others of regional importance. Next year, as I mentioned, we will celebrate the 100th anniversary of the establishment of Poland’s first conservation organisation. That is why the Committee on Nature Conservation of the Polish Academy of Sciences proclaimed it the Year of Polish Nature Conservation and decided to hold a national Nature Conservation Congress.

We are meeting at a time that confronts us with new threats and new challenges for biodiversity protection. The task for us is to understand them better and to deal with them more effectively. Here I will mention the most important ones, which are major problems not just for individual countries but for the entire European continent:

1. Deserting its ECONET idea as a protective measure and de facto satisfying itself with protected areas scattered across developed space, Europe allows the remaining natural ecological corridors to degenerate, thus increasingly turning protected areas into isolated islands, doomed (inter alia because of their typically small size) to slow but consistent biodiversity loss;

2. Despite major efforts and considerable financial involvement, the advancing invasion of alien species is becoming an unchecked and increasingly dangerous phenomenon jeopardising indigenous biodiversity and destroying the natural identity of many areas;

3. Not adequately controlled and increasingly strong, pressure stemming from tourism and recreation as well as their distorted forms are becoming an ever growing threat to the most precious protected areas, such as European mountain systems which are the natural backbone of the continent;

4. The increasingly rapid changes in land use patterns, in particular land use intensification on the one hand and abandoning traditional forms of land use on the other, coupled with landscape fragmentation, jeopardise biodiversity in vast areas of Europe and on an unprecedented scale;

5. GMOs (Genetically Modified Organisms) have been recently becoming not just a serious socio-economic and political challenge but also a health hazard and a major potential biodiversity risk, one bringing irreparable consequences. Equally dangerous is the entire ideological background which accompanies the mass-scale introduction of GMOs to the environment;

6. Despite efforts already and still being made, the loss of diversity in the case of old cultivars is a major problem, as well as their appropriation, in various forms, by large global corporations;

7. Although much has been done in this regard, the still universally declared “sustainable development” remains more of an idea and a challenge than a consistent model with refined mechanisms and economic-market tools, legal regulations or a domain of values, instruction, etc.

It seems paradoxical that new and increasingly serious environmental threats keep appearing. After all, we live in a world well aware of the importance of biological diversity as well as the value of an unpolluted and undamaged environment. More new international conventions are being signed to address these, amongst them we have a particular instrument, which is the Biodiversity Convention. So what finally are the current threats to biodiversity? Some of the dangerous ones have been just enumerated, but we realize that the list is not exhaustive, and we suspect that they are, after all, not the most important ones.

Sustainable development was supposed to be an antidote to the growing threats. It was supposed to provide an environment-friendly way for the civilization to develop. However, it remains more of an idea than a practical socio-economic model. It still lacks clearly defined characteristics. Its primary feature should be an environmental quality that maintains biodiversity and protects biotopes and the processes that support them. The second characteristic should be an environmental quality that meets our authentic biological and spiritual needs as human beings. It is easy to show that these two characteristics are not just closely correlated but they depend on each other.

The threats that we mentioned are not what is blocking the implementation of such sustainable development. The threats are only secondary. They are a by-product of something we generally do not discuss: the mistaken ideas we have about development, our wrong idea of prosperity, the ideas and perceptions that are everywhere in contemporary,
postmodern reality, despite the huge advances of science or even against such advances.

What am I driving at? I shall touch upon just one matter, but an important one. The end of biology as a life science is being proclaimed, directly or indirectly, and not only by some biologists. The number of supporters of this idea is growing exponentially. They believe that the mystery of life has been definitively explained, and that life itself has been fully explored and understood. And so to further probe into biodiversity does not make any sense. Likewise, a special respect for life in all its richness and its protection is pointless and actually gets in the way of development. The life of nature in its current form is doomed to be destroyed anyway, and this is no reason for despair. Simply, the traditional mechanisms of evolution can no longer catch up with the dynamics of anthropogenic transformation of the environment and the development of civilization. Civilization could not care less, as it has a completely different plan for solving the problem. Civilization could not care less, as it has a completely different plan for solving the problem. How does civilization want to solve it? In a (bio)technological fashion. For the proponents of this philosophy, the era of biology and exploration of present-day life has already finished. The era of biotechnology is coming, an era of creating life de novo; an era of genetically modified organisms (GMOs) and bio-robots which will produce whatever man needs, from food to medicines and cosmetics. The days of respect for life and for life’s own logic are over. The days of manipulation of life have arrived: manipulation of life to meet short-term and increasingly artificial human needs, needs driven by free-market logic and satisfied at the expense of existing life forms and their natural environment.

Such a new perception of the world is highly dangerous. Not only because it is seen as the only sensible solution that meets the challenges of the day and historical necessity; it is dangerous primarily because it is winning more and more supporters, not just amongst biologists but also politicians, who, despite their public declarations, seem not to see any alternative.

Is this threat appreciated and adequately addressed by the Global and European and National Biodiversity Protection Strategies? I am afraid not. One sometimes has the impression that, despite all the good will, all the efforts, all the steps taken, we are trying to cure only the symptoms of a terminal illness, and only prolonging the patient’s agony.

Life cannot be protected ex situ, that is, outside life itself, outside its natural environment. It cannot be protected by spending huge sums of money on the Millennium Seed Bank and hundreds of other gene banks spread all over the world. That will not work. Worse still, in the near future these banks will serve mainly the ones who shut life inside them, depriving it of a chance to develop further. These banks will soon become nothing more than a source of material for biomanipulation.

If life could explain to us the logic of its existence and development in one word, the word would be “biodiversity”. Respect for life in all its forms, all its richness, and for the environments and processes that condition and maintain this richness, is and must remain the measure of civilization. We know how important it is to learn about the richness of life and to know what it depends on. The “Strategy” stresses this importance with the words “understanding” and “documenting”.

Almost a hundred years ago, Marian Raciborski, already mentioned as the pioneer of nature conservation in Poland, expressed this with words that form the motto for the educational exhibition accompanying us here, an exhibition that helps us understand the origin of the contemporary biodiversity of the Polish flora and vegetation. He wrote: “The feeling of love for one’s homeland as well as of community with society and the Earth, engendered on the basis of tradition, reading, history and poetry only, may be very strong, but if it lacks a closer familiarity with things, it becomes nebulous and sterile.” Such “closer familiarity” means understanding.

We already know, however, that it is not enough to learn and understand, to acquire a knowledge of nature and an awareness of external threats, because the source of the latter lies in the human heart. Jan Gwalbert Pawlikowski, whom we mentioned as the spiritual father of nature conservation in Poland, stressed that environmental protection, although inspired by natural history, is not primarily science or even a product of it. What is it then? For him it was first and foremost ethics, and, like any ethics, it deals with the good, and with responsibility for the good. Nature conservation deals with the good that is life itself in all its richness, and everything that determines it. In 1913, Jan Gwalbert Pawlikowski wrote as follows: “...The idea of environmental protection has many similarities to ethics... It is not a branch of knowledge or a matter of one’s occupation, but rather a behavioural standard, which should be a general one. It is similar to ethical standards also in extending the notions of duty and responsibility as well as the sense of solidarity and love outside the sphere of human relations, to – as Adam Mickiewicz (one of our great national poets) over 150 years ago, puts it – the ‘silent kingdom’. It is only management that belongs to specialists; action belongs to all.... The notion of nature conservation, just like a moral principle, is like salt which may not make a separate dish yet should be added to each and every dish....”

Pawlikowski’s approach agrees with a conclusion reached by the French biologist Jean Dorst sixty years later. His words are a commentary on contemporary hopes that problems related to environmental threats can be overcome by technical means. Dorst writes: “No-one should be under the illusion that to maintain the human race it is enough to combat pollution; it is better to manage the Earth’s resources and stop the multiplication of harmful areas of human activity! When an illness is anchored in the patient’s heart, the doctor will not heal the patient by putting ointments on the wounds, as they would serve as a placebo only.

The reasons for our miseries lie in our souls. And that is also where reasons for hope lie, hopes that we will finally become true people. The process may move ahead only if we feel full solidarity with the world of the alive, with this Earth.”

Pope John Paul II also repeated on numerous occasions that the crisis of the natural environment is first and foremost a moral crisis.

The Canadian GAMMA Team, established in the 1970s, was intended to be the first to comprehensively address the problem of a civilizational model that would not devastate the environment or destroy the richness of life on Earth, the “zero growth model”. Surprisingly, that group of very good specialists concluded that it was impossible to build such a model on the basis of any economic mechanisms or legal regulations, even the best ones, if the central element of such a model was not the human being with a heart sufficiently sensitive to the values of life, and with a well developed inner moral motivation. This conclusion is extremely important!

What does that mean for us and for the Plant Conservation Strategy? It means that spiritual values are of strategic importance. Unfortunately, major ecological education efforts undertaken, if divorced from instruction and spiritual development and often incompatible with the generally promoted lifestyle and civilization development model, are not sufficient answers to the current challenges.

If that is the case, it is worth considering whether environmental education should be enriched with something we call spiritual development: making people sensitive to the value of the entire richness of life, and teaching respect for life and all the factors that keep it alive. Perhaps an appropriate statement about this could find its way into the Kraków Declaration which will crown our meeting. Its implementation could become one of the Actions for Wild Plants.
The participants of the sixth Planta Europa Conference on the conservation of wild plants held in Kraków, 23–27 May 2011 with the theme ‘Actions for Wild Plants’:


Reiterate the importance of the ESPC as a regional contribution to the updated CBD Global Strategy for Plant Conservation 2011-2020, endorsed by CBD COP 10 in Nagoya, and welcome this updated Global Strategy which remains an invaluable global framework for plant conservation.

Welcome the endorsement by CBD COP 10 of targets for the whole CBD strategic plan, and underline the contribution that activities carried out for both the European and global strategies for plant conservation make to the implementation of these ‘Nagoya targets’.

Welcome and support the European Union Communication ‘Our life insurance, our natural capital: an EU biodiversity strategy to 2020’ and support its objective to implement true ‘sustainable development’ in Europe, without losing biodiversity.

Highlight the ongoing commitment of the Council of Europe to the ESPC – noting its recent contribution to combating invasive alien species and the production of a code of conduct for horticultural trade.

However, noting the lack of progress with ESPC targets aimed at conserving plant diversity in production lands (target 6), through the sustainable use (target 12) and the lack of significant progress in capacity for plant conservation in Europe (target 15), as well as acknowledging the increasing contemporary threats to the diversity of wild plants, fungi and vegetation, the participants of the 6th Planta Europa conference consider more concerted efforts are needed to:

1) Strengthen the activities that support the implementation of a functioning ecological network for Europe. With core areas based on sites within Natura 2000, Emerald, Important Plant Areas and national ecological networks linked together through natural corridors in a green infrastructure. This will require preservation and enhancement of existing corridors and restoration of corridors in more fragmented European landscapes.

2) Conserve plant diversity in agricultural production lands and to urgently respond to the increasingly rapid changes in land use patterns across Europe, through land use intensification and abandonment of traditional forms of land use, coupled with landscape fragmentation; which continue to threaten plant diversity across Europe. Specifically:

- Increasing support for activities that maintain the habitat diversity associated with high nature value farmland throughout Europe (hay meadow, alpine pastures, wood pastures, grazed forest etc), that have resulted from a diversity of land management practices.
- Increasing the focus on conserving historical landscape shaped by traditional management (e.g. extensively managed orchards, vineyards, olive groves and associated old cultivars), as important elements of the diversity of European culture that supports significant plant diversity.
- Preventing further afforestation of Eastern European steppic vegetation – one of the richest grassland habitats in Europe
- Increasing pressure on European governments and institutions, in particular on the European Parliament, to undertake fundamental reform of the Common Agricultural Policy in 2013, to ensure that a significant portion of resources are diverted to those agri-environment schemes using farming practices that benefit biodiversity; under the principle of ‘public money for public good’. 
3) Improve management of protected and exploited forests to ensure the maintenance of the plant and fungus diversity that indicates high conservation value. Particularly to maintain the continuity of old growth trees and dead wood within forests, crucial to the survival of fungal and bryophyte communities.

In this context Planta Europa promotes the inclusion of these principles in the preparation of the legally binding agreement on forests in Europe, for which negotiations are to be decided upon in June 2011 in Oslo, at the FOREST EUROPE Ministerial Conference on the Protection of Forests in Europe, 2011 being the United Nations International Year of Forests.

4) Continue to help develop and promote a pan-European Invasive Alien Species policy, establishing approaches that prevent, control and monitor biological invasions that are detrimental to native plant diversity, including the introduction of biofuel species that are potentially invasive into natural habitats. In this context Planta Europa promotes the current opportunity to influence the ‘dedicated EU legislative instrument’ on invasive species.

5) Promote the importance of public participation in plant conservation through strengthening the engagement of citizens for e.g. supporting volunteer groups that monitor and act to safeguard wild plant species and their habitats, promoted during the European Year of Volunteering 2011.

6) Redouble efforts to develop plant conservation teaching methods as used in Inquiry Based Scientific Education schemes that will have lasting impact on educators and learners alike, promoting a sense of stewardship, public participation and caring for plants in younger generations.

7) Increase investment in capacity for plant conservation. Specifically through establishing on-line access to botanical and mycological data with common standards; maintaining taxonomic capacity and developing field skills in active management of wild plants and fungi. This includes enabling pan-European participation in initiatives such as the INSPIRE directive for developing standards, EDIT, PESI and Catalogue of Life (taxonomy and systematics programmes).

8) Strengthen cooperation between conservation stakeholders in all expert groups (flora, fungi and fauna) and across national borders – especially when those borders run across the same biogeographical regions.

In addition to the increased attention required for specific targets of the ESPC, the participants at the sixth Planta Europa conference also note the need to urgently address:

The lack of awareness of adaptive management regimes crucial in all areas that are important for plant diversity, to help combat climate change as a threat to habitat integrity and diversity.

The increasing threats to plant diversity from unsustainable development linked to tourism and recreation in protected areas, particularly in mountain, lake and coastal habitats, that disregard proper planning processes.

The serious socio-economic and political challenge presented by the potential introduction of GMOs into the European countryside, a potential major biodiversity risk with irreparable consequences.

The need to develop the values-concerned message for conserving our wild plant and fungal resources: we have to conserve them not only for the benefits in terms of the ecological value they bring to humans, but also in terms of their benefit to human spiritual well-being and the moral responsibility we humans have for the nature.

Finally the participants of the sixth Planta Europa conference sincerely thank the W. Szafer Institute of Botany in Kraków, Polish Academy of Sciences for hosting the sixth Planta Europa conference.

Adopted by Planta Europa Kraków, Poland, 26th May 2011.
Periodical review of progress concerning the implementation of such a basic document as European Strategy for Plant Conservation (ESPC) is an extremely important objective from the point of view of implementation of the Strategy itself, its updating, modification and continuation in its consecutive versions.

The current overview, related to an important event, which is the 6th Planta Europa Conference (6 PEC), is being made three years after formulating the Strategy and four years before the deadline set for the implementation of the Strategy’s objectives. Several targets have been already accomplished.

The overview is systematic in nature, enumerating the consecutive objectives and targets of the ESPC with brief commentary about progress in the implementation of each of them [It must be remembered that the overview presented here reflects the 2011 state – editor’s remark].

Short visual presentation of GSPC targets (T1–T16), level of progress: green – target generally completed; orange – target partly achieved; red – target with very little progress.

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TARGET 1: CHECK-LISTING

There is good progress with most elements of the target. The status on alien species within the checklists is unknown.

- Vascular Plants (Flora Europaea, RBG Kew (Target 1 Project))
- Bryophytes – European checklist complete (ECCB)
- Fungi – European checklist in progress (EMA and ECCF)
- No information on lichens and algae
- Crop Wild Relatives (ECPGR)
- No information on inclusion of alien plants and East European Regional checklist.

TARGET 2: RED LISTING

Generally there is good progress with different elements of European flora, but there is no information for lichens or algae.

- **European Red List** of vascular plants (IUCN) – the results will be published in June 2011 – based on 3 groups of plants circa 1,700 (300 more in the autumn – policy plants (HD, Bern Convention, CITES), endemics and aquatic plants)

- **European List of Threatened Plants (BGCI)** – 1,917 taxa, based on national Red Lists across Europe (http://www.bgc.org/ourwork/threatenedeurope/)

- **European Red List for Arable Plants (Rothampsted Institute (UK) and University of Göttingen (Germany))** results to be published soon

- **European Bryophytes Red List** – completed in 2005

- **European Macro-fungi Red List** – in progress

- No information on lichens and algae.

TARGET 3: PROTOCOLS

There are many good case studies in different areas. A new project coordinated by BGCI is bringing together available information and case studies for a toolkit for the GSPC, however there are much fewer examples for sustainable plant use. The European Electronic Information Platform was developed but there is very little capacity to update or develop it further.
• **GSPC Toolkit Project (BGCI)** – project in progress: please refer to any appropriate case studies or protocols

• Many species and habitat protocols/guidance documents are available in several European countries

• **FairWild Standard/ISSC-MAP** – the guidelines have been published and implemented in several case studies in Europe and other parts of the world (www.fairwild.org)

• **Invasives Rapid Assessment Tool (Plantlife)** – information on a method to assess the potential of plants to become invasive that could be used for developing trade bans and other measures (http://www.plantlife.org.uk/publications/here_today_here_tomorrow/)

• **Ethnobotany in the New Europe (2010)** – Parado-de-Santayana, Pieroni and Puri

• **TEEB** – The Economics of Ecosystems and Biodiversity – information for a range of audiences on “valuing” natural systems and biodiversity appropriately to ensure they are properly accounted for in land planning decisions (www.teeb.org)

• **European Information Platform** – the platform was developed and information collated – however there is little current capacity to update or develop this feature (http://www.plantaeuropa.org/EIP_index.htm).

### TARGET 4: ECOREGIONS

There are still major concerns with the ongoing decline or degradation of European habitats despite many European and national programmes such as Natura 2000.

• There are IPA data from circa 1,700 IPAs in 16 countries – detailed information on circa 1,100 IPAs. There has been mixed progress on getting IPA data used at national and European level


### TARGET 5: IPAS

There is good progress with identification projects, and programmes are being developed on community conservation projects.

• Information on IPA projects in Europe and around the world were published for COP 10 in 2010 – (http://www.plantlife.org.uk/about_us/news_press/europe/)

• 1,771 IPAs in 16 countries of Europe; 75% have some level of protection on some part of the site; only 7% record a management plan

• Conservation projects such as IPANET (IPA communication and community involvement networks) are being developed based on a successful project in Turkey and other rural development/conservation projects in Europe

• Plans exist to develop a series of wild flower festivals across Europe to raise awareness and develop eco-tourism related to IPAs.

### TARGET 6: PRODUCTION LANDS

Generally there is little progress with this target – the available information points to ongoing decline of grasslands and arable plants, with as yet little sign that the reforms of the EU CAP will prove beneficial to plant conservation. However there are several national and European research and practical conservation projects working on these issues.

• An **European Red List for Arable Plants** has been developed by researchers at Rothampsted Institute (UK) and University of Göttingen (DE) with the results to be published soon

• There are several projects to identify High Nature Value Farmland coordinated by EEA but EU report 2009 found only 7% of these areas in favourable conservation condition

• The ADEPT foundation in Romania has been working in high nature value farmland areas to provide support for the local farming communities and biodiversity conservation including help with applying for EU grants, setting up local markets and processing equipment, branding local products, and developing eco-tourism in the region (http://www.fundatia-adept.org/)

• European legislation on forestry is being discussed by Forest Europe (formerly Ministerial Conference for the Protection of Forests in Europe) and the EU has opened consultations on the future of forestry planning and legislation, but definite news on the future of “old growth forests”.

### TARGET 7: IN SITU CONSERVATION

There are many national and also European projects, such as National Biodiversity Action Plans and LIFE+ funded projects. However it is difficult
to collate the range of information on diverse projects. The publication of the IUCN European Red List and the BGCI list of threatened species should make this process easier.

- See above target 2 on Red Lists and threat lists
- The EC 2009 assessment of progress with the biodiversity target found 40–70% of Habitats Directive Species were in unfavourable condition.

**TARGET 8: EX SITU CONSERVATION**

Generally there is very good progress with this target, particularly through the EU funded ENSCONET project, which has now ended but the consortium are still cooperating and the results are available online.

- ENSCONET Project – consortium of 30 institutions, finished 2009
- Statistics – 41,914 accessions (9,391 taxa) in 29 institutes, 44% of HD species, 27% of BGCI threatened species list
- Recovery projects – 24 taxa in 63 programmes
- Information available online through ENSCOBASE (http://enscobase.maich.gr/data_information.html).

**TARGET 9: PLANT GENETIC RESOURCES**

Generally there is good progress on targets and actions. Less progress is evident with the establishment of genetic reserves but more reserves are planned.

- Many projects under the AEGRO Programme (ECPGR In Situ On Farm Initiative)
- New EU funded project on PGR Secure
- 1 Genetic reserve for Beta patula on Madeira
- Detailed UK reports on crop wild relatives and landraces, their importance and conservation (2010 and 2011)
- Scottish Landrace Project – scheme to support landrace conserving farmers and secure ex situ reserves of their crops (http://www.scottishlandraces.org.uk/).

**TARGET 10: INVASIVE SPECIES**

There are a range of national and regional projects and initiatives on Invasive Alien Species and the issue has increased in importance with national and EU policy makers. EU legislation on invasives is currently under discussion. It is less easy to find centralised information on ongoing management projects and frameworks or their effectiveness.

- Proposed EU legislation currently under discussion
- Council of Europe Code of Conduct on Horticulture and Invasives (currently undergoing a consultation review)
- DAISIE – ongoing information portal on Invasives in Europe (http://www.europe-aliens.org/)
- New Scottish legislation 2011 – White list (everything is banned with named exceptions) for all non-native species released into the wild; a duty to control invasives and pay for control for landowners
- Invasives Rapid Assessment Tool (Plantlife) (http://www.plantlife.org.uk/publications/here_today_here_tomorrow/).

**TARGET 11: WILD PLANT TRADE**

There is now a set of guidelines for collectors and producers, which has been tested in several case studies in Europe and beyond, promoted through the FairWild foundation but using the basis of the ISSC-MAP guidelines. There is still a lack of information on wild plant trade in CITES literature for Europe.

- FairWild Standard ISSC-MAP Guidelines – (http://www.fairwild.org/)
- Arnica montana community conservation project in Romania – a successful community conservation and research project which could be replicated in other countries and for other trade species (http://darwin.defra.gov.uk/project/13020/).

**TARGET 12: SUSTAINABLE USE OF PLANT RESOURCES**

Generally, very little information is available on this target, from very disperse sources, and also there is very little indication that the 30% level is being achieved. There are certification systems such as Fairtrade but their role in plant conservation is less well understood. Organic agriculture has an important role in the implementation of this target but numbers still seem far below 30% in most countries. The FSC trademark is widely recognised but recently there have been ongoing concerns about the types of organisations gaining certification.


TARGET 13: ETHNOBOTANY AND PLANT KNOWLEDGE

The information for this target is also highly dispersed and there are ongoing projects across a range of disciplines (botany, archaeology, history, and social studies).
• A recent publication provides a good overview of the current status of discipline and case studies from 9 countries across Europe – *Ethnobotany in the New Europe* (Pardo-de-Santayana et al. 2010)
• The EU funded RUBIA project also provides information on current methodologies and project implementation.

TARGET 14: PUBLIC AWARENESS AND EDUCATION

There are many different projects going on at local, national and regional levels which it would be impossible to list. In terms of the ESPC targets there has been little capacity for Europe-wide campaigns or the development of a photographic exhibition.
• **Wake up call** – there are between 12–14 countries working on their national wake up call projects
• BGCI developed an internet campaign for the new GSPC which attracted 2,500 signatures
• The Bohinj *Wild Flower Festival* in Slovenia attracts thousands of visitors each year and there are plans to develop wild flower festivals in other European countries.

TARGET 15: CAPACITY BUILDING

There is very little information on progress with this target, particularly for any measurable increase in government spending. There are projects in many countries which do increase capacity but there is still an urgent need for more targeted investment in this area.
• EU funded EDIT Project – Internet Learning for Taxonomy (28 institutions are involved, and there is the EDIT Platform for CyberTaxonomy) (http://www.e-taxonomy.eu/)
• An internet tool developed for online and mobile technology for recording information for botanical and other groups is available for researchers and volunteer surveyors to increase their capacity and their effectiveness – the *Observado* system (http://observado.org/index.php)
• IPANETS – communication and community groups involved in conserving IPAs have been trialled successfully in Turkey and are being developed in other European countries.

TARGET 16: NETWORKS

Many networks provide the backbone for plant and fungus conservation in Europe, which, although often under-resourced and marked with under-capacity, still play an essential role in communication and collective action.
• Planta Europa (www.plantaeuropa.org)
• ECCB – European Committee for the Conservation of Bryophytes (http://www.bio.ntnu.no/users/soder/ECCB/)
• EMA and ECCF – European Mycological Association (http://www.euromould.org/) and European Committee for the Conservation of Fungi (http://www.wsl.ch/eccf/)

CROSS-CUTTING TARGETS:

**Climate change**

It is difficult to collate accurate information on the actions under climate change. There have been several projects and research programmes at the national level.
• The TEEB (The Economics of Ecosystems and Biodiversity) Programme (www.teeb.org) has provided a fresh impetus for the conservation of biodiversity and habitats and the ecosystem services they provide. The terminology from TEEB, such as “natural capital” and “green infrastructure” are firmly entrenched in the policy language of the EU. However it is still an issue to ensure that biodiversity is not forgotten or placed in second place to more general ecosystem services.
• The controversial EU biofuels target is still in place and the unregulated change of land use...
to grow biofuels continues to be an issue for plant conservation in Europe and other parts of the world.

**Fungi, lichens, bryophytes, algae in the Strategy**

**Fungi**

The EMA and ECCF are coordinating a range of fungi conservation projects across Europe which include:

- The European macro-fungi Red List and check-list projects
- Guidance information report for conserving macro-fungi in Europe
- Mapping and monitoring of targeted fungi species
- Important Mushroom Areas in Europe.

**Bryophytes**

The ECCB continue to provide strong coordination for the many successful pan-European bryophyte research and conservation projects including red listing, check-listing, and the focus on key bryophyte hot spots in Europe. Bryophyte data have been used widely in the selection of IPAs.

**Algae**

FEPS the Federation of European Phycological Societies provides a forum to promote cooperation and regional research and initiatives (www.feps.org).

**Lichens**

There are many strong national lichen societies and organisations, and lichen data have been used as IPA selection species and habitats extensively in Italy, Estonia and the UK.

### FULL LIST OF TARGETS/ACTIONS

<table>
<thead>
<tr>
<th>Target / Action</th>
<th>Progress</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td><strong>GSPC TARGET 1</strong> – a widely accessible working list of known plant species, as a step towards a complete world flora</td>
<td></td>
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<tr>
<td><strong>ESPC 1.1</strong> A widely accessible dynamic working list of all known plant and fungi species (including bryophytes, lichen, algae, and cultivated plants) available by 2010 for vascular plants and bryophytes and by 2014 for other groups, as a part of a world list including country distributions</td>
<td>Generally good progress</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Ensure coordinated activity at European level and contribute to the global activities under Target 1 of the GSPC</td>
<td>Good in some areas, little information on the level of cooperation with some groups</td>
<td></td>
</tr>
<tr>
<td><strong>Action 2</strong> Provide links from the Planta Europa Electronic Information Platform to other global initiatives under this target</td>
<td>No current capacity to update</td>
<td></td>
</tr>
<tr>
<td><strong>Action 3</strong> Checklists agreed and made available at the national level, printed where appropriate</td>
<td>Good progress in some countries but no information for all countries</td>
<td></td>
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<tr>
<td><strong>Action 4</strong> Creation of Eastern European regional checklist</td>
<td>No information</td>
<td></td>
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<tr>
<td><strong>ESPC 1.2</strong> Alien plants annotated within the working list of plant species with a risk category (low risk, spreading but weedy, damaging ecosystem “transformer”)</td>
<td>There is good information on current alien species in Europe but less on how well they are integrated into checklists</td>
<td></td>
</tr>
<tr>
<td><strong>Action 5</strong> Provide risk categories for alien species in checklist</td>
<td>Little information but see Target 10 above on Rapid Assessment Tool</td>
<td></td>
</tr>
<tr>
<td><strong>GSPC TARGET 2</strong> – A preliminary assessment of the conservation status of all known plant species at national, regional and international levels</td>
<td>Progress in many areas, still little information on progress with lichens and algae</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 2.1</strong> European Red List produced by 2014 (review of progress in 2011), vascular plants completed by 2010, Red Lists updated periodically for vascular plants and bryophytes and at least a preliminary assessment produced for fungi, lichens and algae</td>
<td>As above ongoing progress known in all groups apart from lichens and algae</td>
<td></td>
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<tr>
<td><strong>Action 1</strong> Ensure coordinated European action under the proposed lead and the utilisation of all available national data</td>
<td></td>
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<tr>
<td>Target / Action</td>
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<td>Remarks</td>
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<tr>
<td><strong>Action 2</strong> European countries with no Red List should produce at least a Rapid List of threatened plant species by 2012 to feed into the European Red List process</td>
<td>No information</td>
<td></td>
</tr>
<tr>
<td><strong>Action 3</strong> Where appropriate, national “Blue Lists” (lists of conservation successes) should be compiled at the national level, disseminated widely including through the PE website and included in any European Red List updates</td>
<td>No recent information</td>
<td></td>
</tr>
<tr>
<td><strong>GSPC TARGET 3</strong> Development of models with protocols for plant conservation and sustainable use based on research and practical experience</td>
<td>Some good examples for conservation but less on sustainable use</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 3.1</strong> Proven methods that enable delivery of each target in the European Strategy, collected and made available in one place via the online facility linked with the Planta Europa website</td>
<td>New GSPC toolkit project (BGCI)</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Provide an effective Electronic Information Platform on the Planta Europa website. Planta Europa Secretariat to develop in consultation with members and other relevant organisations</td>
<td>The platform was developed but there is currently little capacity to update or develop</td>
<td></td>
</tr>
<tr>
<td><strong>Action 2</strong> Planta Europa members should provide information to the electronic information platform – at least 2 methods per member</td>
<td>No current information</td>
<td></td>
</tr>
<tr>
<td><strong>Action 3</strong> Adaptation of habitat classifications for Eastern Europe and preparation of East European Regional checklist</td>
<td>No current information</td>
<td></td>
</tr>
<tr>
<td><strong>Action 4</strong> Profile of national progress with GSPC/ESPC targets made available through the Planta Europa Electronic Information Platform</td>
<td>Little current information</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 3.2</strong> European plant distribution data (national/regional datasets) published electronically and regularly updated to facilitate conservation activities including comprehensive conservation assessments, invasive plants and climate change research, through cross-border projects and using GBIF standards and facilities</td>
<td>No current information</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Encourage Planta Europa members and other relevant botanical organisations to use GBIF (Global Biodiversity Information Platform) as means to deliver targets which require assessments of many datasets across Europe (<a href="http://www.gbif.org">www.gbif.org</a>)</td>
<td>No current information</td>
<td></td>
</tr>
<tr>
<td><strong>Action 2</strong> Available research and policy initiatives relating to climate change in Europe publicised via the Planta Europa website</td>
<td>No current capacity</td>
<td></td>
</tr>
<tr>
<td><strong>GSPC TARGET 4</strong> At least 10% of the world’s ecological regions effectively conserved</td>
<td>PEEN network established in many areas but little information on effectiveness on the ground</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 4.1</strong> Landscape-scale conservation of Europe’s ecological regions must support the maintenance of plant diversity</td>
<td>PEEN network established in many areas but little information on effectiveness on the ground</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Identify appropriate organisations to use the IPA “Lobby Pack” in getting IPA programmes in place and using their data effectively to conserve sites, species and habitats (see target 5)</td>
<td>No current capacity</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 4.1a</strong> IPA Data – including digital boundary data (or data from equivalent programmes with a focus on plants and fungi) and micro-reserve data are used to support the following biodiversity initiatives: Natura 2000, the Emerald Network, National Protected Areas, High Nature Value Farmland, PEEN, Ramsar, Invasive Species Programmes</td>
<td>Mixed success on the use of IPA data in national and regional initiatives</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Planta Europa Secretariat to lobby the European Commission (through EHF and CEEweb) to consider the IPA network when developing and maintaining the Natura 2000 network</td>
<td>Planta Europa has a place on the forum and promotes IPA data where possible</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 4.1b</strong> The negative impacts of habitat fragmentation and climate change on plant diversity reduced by implementing Article 10 of the EC Habitats and Species Directive, the PEEN and other measures such as creating buffers and corridors or identifying Zones of Opportunity for habitat restoration around IPAs</td>
<td>EC 2009 report on the implementation of the Habitat and Species Directive is very poor for habitats and species</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Produce a report for the European IPA network to help establish ecological networks to assist in adaptation to climate change and habitats vulnerable to climate change</td>
<td>No current capacity</td>
<td></td>
</tr>
<tr>
<td><strong>Action 2</strong> Ask protected area experts in Europe, particularly IUCN WCPA for short report/guidance on long-term protection and use methods to assess the effectiveness of the IPA approach</td>
<td>No current capacity</td>
<td></td>
</tr>
<tr>
<td><strong>GSPC TARGET 5</strong> Protection of 50% of the most important areas for plant diversity assured by 2010</td>
<td>Good progress on identification and projects ongoing on different aspects of conservation</td>
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<tr>
<td>Target / Action</td>
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<tr>
<td><strong>ESPC 5.1</strong> All countries implement a national strategy (action framework) by 2014 for the conservation of IPAs (or equivalent programme with a focus on site-based conservation on plants, fungi and their habitats including genetic reserves for crop wild relatives)</td>
<td>Good progress in some countries (e.g., UK), Spain for micro-reserves, Crop Wild Relatives but no information from many countries</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Produce guidance (IPA tool kit) on national strategies for IPAs, including national targets, case studies that demonstrate good management etc.</td>
<td>Some information exists but has not yet been compiled into report – could be part of new GSPC toolkit</td>
<td></td>
</tr>
<tr>
<td><strong>Action 2</strong> Make funding information (appropriate for IPA or equivalent programmes) more easily accessible to PE members</td>
<td>No current capacity</td>
<td></td>
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<tr>
<td><strong>Action 3</strong> Showcase our work at the World Conservation Congress Barcelona (October 2008) to strengthen links to IUCN</td>
<td></td>
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<tr>
<td><strong>Action 4</strong> Each Botanic Garden/Planta Europa member to adopt or promote conservation of 1 IPA by 2010, 2 by 2012, and 3 by 2014</td>
<td>Some progress in some countries</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 5.1a</strong> IPA identification programmes (or equivalent programmes with a focus on plants and fungi and their habitats) completed in 100% of European countries by 2014</td>
<td>Currently ongoing or preliminary assessment completed in 17 countries</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 5.1b</strong> At least 50% of IPAs legally protected through national protected area systems such as EU Natura 2000 and at least 50% under appropriate management (which could be passive or active depending on conservation need)</td>
<td>Protection level is circa 75% but only 7% record management plans</td>
<td></td>
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<tr>
<td><strong>Action 1</strong> Encourage the identification of marine IPAs to contribute marine conservation objectives and link with the WCPO Marine Group and other organisations</td>
<td>No current information</td>
<td></td>
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<tr>
<td><strong>GSPC TARGET 6</strong> At least 30% of production lands managed consistent with the conservation of plant diversity</td>
<td>No evidence to suggest this is happening</td>
<td></td>
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<tr>
<td><strong>ESPC 6.1</strong> 80% of Europe’s remaining high biodiversity production lands (e.g. old growth forest, natural/semi-natural grasslands, arable plant-rich areas, High Nature Value Farmland) managed consistent with conservation of plant diversity through traditional management and other mechanisms. High Nature Value Farmland: 15–20% of total agricultural area; primary forest: circa 7% of total forest area (excluding the area of old growth forest in the Russian Federation)</td>
<td>EU (2009) report found only 7% of HNV farmland in favourable condition</td>
<td></td>
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<tr>
<td><strong>ESPC 6.2</strong> 20%* of production lands managed to maintain and restore plant diversity, reduce fragmentation and mitigate effects of climate change within the wider landscape (*20% of those production lands not already included in target 6.1)</td>
<td>Very little information to suggest this is happening</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Liaise with existing certification organisations and indicator schemes and where appropriate develop working groups/conference with the aim of including plant conservation concerns and expertise into agri-environment planning, indicator (SEBI2010) and certification schemes (such as FSC, IFOAM, Fairtrade) to ensure they are plant diversity friendly inside and outside Europe</td>
<td>No current capacity</td>
<td></td>
</tr>
<tr>
<td><strong>Action 2</strong> Develop a project to assess the effectiveness of current agri-environment for plant diversity (e.g. 4 countries inside and outside of EU) to advocate changes which improve plant diversity in 2008 Healthcheck of agri-environment and beyond, including the use of the BioScore and EnRisk biodiversity indicators</td>
<td>There is the potential to use information from existing projects (Arable Red List; basic grassland data and crop wild relative projects) to develop report to influence CAP reform (2013) - requires more capacity to complete</td>
<td></td>
</tr>
<tr>
<td><strong>Action 3</strong> Promote the use of the BioScore and EnRisk biodiversity indicators developed as a tool to assess the impact of the European Community policies on biodiversity</td>
<td>No current information</td>
<td></td>
</tr>
<tr>
<td><strong>Action 4</strong> Promote case studies showing plant conservation benefits of rural development plants</td>
<td>The Adept Foundation in Romania has the potential to provide an excellent case study for this</td>
<td></td>
</tr>
<tr>
<td><strong>Action 5</strong> Promote the use of “improved biodiversity indicators for sustainable forest management” and promote the uptake of FSC certification</td>
<td>No current capacity</td>
<td></td>
</tr>
<tr>
<td><strong>Action 6</strong> Investigate using carbon-offsetting to fund plant biodiversity projects in production lands and ensure plant diversity concerns are included in national/regional carbon-offsetting planning</td>
<td>No current capacity</td>
<td></td>
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<tr>
<td>Target / Action</td>
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<td>Remarks</td>
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<tr>
<td><strong>Action 7</strong> Advocate the benefits of maintaining wetland habitats, flood plain forest and other relevant habitats to aid in flood prevention and security or water supplies via relevant fora</td>
<td></td>
<td>There is widespread advocacy for this under new ecosystem services/TEEB projects</td>
</tr>
<tr>
<td><strong>ESPC 6.3</strong> 100% of East European countries have mechanisms (lobbying information, case studies, biodiversity/economics, benefit studies) to promote the urgent need for and the benefits of plant conservation in production lands</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>Action 1</strong> Advocate increased EU funding for agri-environment measures outside of EU</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>Action 2</strong> Develop report/case study of good practice examples which can be used for advocacy of agri-environment (or equivalent) measures in the East European Region</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>ESPC 6.4</strong> Ensure biodiversity risk assessments are a mandatory element of national and EU biofuels/biomass and development plans (to ensure that conversion of land to new uses such as urban development, infrastructure and biofuel production should only occur on low biodiversity land and should not impact connectivity functions)</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>GSPC TARGET 7</strong> 60% of the world’s threatened species conserved in situ</td>
<td></td>
<td>There is progress in many countries but difficult to collate available evidence</td>
</tr>
<tr>
<td><strong>ESPC 7.1</strong> 60% of species of European conservation priority* plant and fungus species, including crop wild relatives, conserved in situ by 2014 through the implementation of national strategies for conserving priority species (*prioritised according to their inclusion in regional and national legislation, including the EC Habitats and Species Directive, the Bern Convention and IPA programmes, and with reference to European Red Lists for all taxonomic groups as they are developed)</td>
<td></td>
<td>New European Red Lists and threatened species list make this target more achievable but the information is still dispersed</td>
</tr>
<tr>
<td><strong>Action 1</strong> Collate available information on current in situ recovery programmes in Europe and use to identify species to be considered as priority for recovery programmes and disseminate successful methods and case studies</td>
<td></td>
<td>No current capacity</td>
</tr>
<tr>
<td><strong>Action 2</strong> Develop national strategies across all plant groups</td>
<td></td>
<td>National strategies exist in many countries, but not for all plant groups</td>
</tr>
<tr>
<td><strong>ESPC 7.1a</strong> Prepare information on plants (including vascular plants, bryophytes, algae and fungi) in readiness to contribute to any scientific updates of the 2010 Biodiversity target in relation to Annexes (II, IV and V) and the EU Habitats and Species Directives; Appendix I of the Bern Convention; priority species lists associated with relevant national biodiversity legislation)</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>Action 1</strong> Identify species which should be included on the EC Habitats and Species Directives Annexes (and identify which particular annex (II, IV or V)) based on the latest results of the European Red List for vascular plants and Red Lists of other taxonomic groups by 2011</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>ESPC 7.1b</strong> Promote the development of 20 trans-boundary or multi-country species recovery projects (including cryptogamic species and fungi) to develop Pan-European cooperation and to develop methods for coping with climate change and connectivity issues</td>
<td></td>
<td>There are some under the LIFE programme and other research projects</td>
</tr>
<tr>
<td><strong>Action 1</strong> Promote trans-national programmes for 5 priority species</td>
<td></td>
<td>See above</td>
</tr>
<tr>
<td><strong>ESPC 7.2</strong> Develop database of plant micro-reserves, genetic reserves for crop wild relatives, and where relevant other small in situ protected areas</td>
<td></td>
<td>Current project on micro-reserves in Bulgaria</td>
</tr>
<tr>
<td><strong>Action 1</strong> Publicise case studies/methods of in situ recovery programmes (e.g. Micro-reserves programmes, the AEGRO genetic reserves methods etc.) via the Planta Europa website</td>
<td></td>
<td>Programmes do exist but they could be part of the new GSPC toolkit project</td>
</tr>
<tr>
<td><strong>Action 2</strong> Contribute to IUCN guidelines for the management of small plant populations</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>GSPC TARGET 8</strong> 60% of threatened plant species in accessible ex situ collections, preferably in the country of origin, and 10% of them included in recovery and restoration programmes</td>
<td></td>
<td>Good progress through the ENSCONET project</td>
</tr>
<tr>
<td><strong>ESPC 8.1</strong> Store in gene banks 60% of European threatened species or species and populations of particular interest (e.g., populations under extreme conditions, or at the edge of their distribution area, species potentially at risk from the effects of climate change, including species with a trans-European distribution) and implement restoration programmes for 50 species</td>
<td></td>
<td>Good progress through the ENSCONET project</td>
</tr>
</tbody>
</table>
### Target / Action

<table>
<thead>
<tr>
<th>Action</th>
<th>Progress</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action 1</strong> Evaluate existing <em>ex situ</em> collections, to improve their conservation benefit by evaluating the quality of associated data, such as provenance. Priority should also be given to threatened species with little information on their ecology, biology or conservation status</td>
<td>Good progress through the ENSCONET project</td>
<td></td>
</tr>
<tr>
<td><strong>Action 2</strong> Lead organisations to share information on <em>ex situ</em> organisations</td>
<td>Good progress through the ENSCONET project</td>
<td></td>
</tr>
<tr>
<td><strong>Action 3</strong> Encourage Planta Europa members and other relevant organisations to provide case studies of reintroductions for the IUCN Reintroduction Specialist Group newsletter (e.g. The Italian Botanical Society will carry out 30 reintroduction programmes)</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td><strong>Action 4</strong> Promote good practice in the transfer of germplasm in line with the access and benefit sharing provisions of the CBD using models such as the IPEN (International Plant Exchange Network) model for acquisition and exchange on living plant material, the International Treaty on Plant Genetic Resources for Food and Agriculture, and the Principles on Access to Genetic Resources and Benefit Sharing</td>
<td>Good progress through the ENSCONET project</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 8.2</strong> At least 10 priority species in each country held in conservation gardens or research institutes active in that country, and research initiated into storage methods, recalcitrant seeds, autecology, propagation methods including germination and cultivation techniques, and re-introduction methods</td>
<td>Progress unknown</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Promote tested methods for <em>ex situ</em> conservation, research and re-introduction case studies (e.g. cryopreservation of bryophytes at RBG Kew, latest research on seed containers and standards of seed preservation (see also 3.1))</td>
<td>63 recovery projects recorded in the ENSCONET project</td>
<td></td>
</tr>
<tr>
<td><strong>GSPC TARGET 9</strong> 70% of the genetic diversity of crops and other major socio-economically viable plants conserved and associated indigenous and local knowledge maintained</td>
<td>Target progressing through ECPGR work groups</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 9.1</strong> Establishment of 25 European crop wild relative genetic reserves covering the major hotspots of species and genetic diversity</td>
<td>1 reserve established and others planned</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Establish baseline of genetic diversity for priority crop complexes of European socio-economically important wild species to assist conservation prioritisation and as means for assessing genetic erosion</td>
<td>Progressing through ECPGR work groups</td>
<td></td>
</tr>
<tr>
<td><strong>Action 2</strong> Assess genetic diversity change against time for all European socio-economically important wild species</td>
<td>Progressing through ECPGR work groups</td>
<td></td>
</tr>
<tr>
<td><strong>Action 3</strong> Develop a preliminary list of crop wild relative hotspots of species and genetic diversity at national and European levels</td>
<td>Progressing through ECPGR work groups</td>
<td></td>
</tr>
<tr>
<td><strong>Action 4</strong> Prepare a gap analysis review of <em>ex situ</em> holdings of European crop wild relative species</td>
<td>Progressing through ECPGR work groups</td>
<td></td>
</tr>
<tr>
<td><strong>Action 5</strong> Prepare a European inventory of traditional, local crop landrace varieties</td>
<td>Progressing through ECPGR work groups</td>
<td></td>
</tr>
<tr>
<td><strong>Action 6</strong> Prepare a priority list of European crop wild relatives</td>
<td>Progressing through ECPGR work groups</td>
<td></td>
</tr>
<tr>
<td><strong>Action 7</strong> Promote the Crop Wild Relative Information System (<a href="http://www.pgrforum.org/cwr/s/cwr/s.asp">http://www.pgrforum.org/cwr/s/cwr/s.asp</a>)</td>
<td>Progressing through ECPGR work groups</td>
<td></td>
</tr>
<tr>
<td><strong>Action 8</strong> Assess and publicise the holdings of major ornamental species in European botanic gardens</td>
<td>No current information</td>
<td></td>
</tr>
<tr>
<td><strong>Action 9</strong> Assess the <em>ex situ</em> holdings of major Medicinal and Aromatic Plants (MAPs) in botanic gardens and gene banks</td>
<td>No current information</td>
<td></td>
</tr>
<tr>
<td><strong>GSPC TARGET 10</strong> Management Plans in place for at least 100 alien species which threaten plants, plant communities, habitats and ecosystems</td>
<td>There are many national/regional projects including proposed EU legislation but less information on the effectiveness and extent of management programmes</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 10.1</strong> Action frameworks developed and implemented for controlling and monitoring the 15 most problematic* invasive alien species in each European region (Mediterranean, Baltic, Alps, South East Europe, East Europe, Atlantic etc.) (*as defined by the latest scientific information and with reference to the EPPO, the DAISIE information service, NEOBIOTA and other relevant organisations)</td>
<td>Many programmes exist but still difficult to find information on cross-border projects or effectiveness</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Publicise the available lists of European alien invasive species (the EPPO list, the DAISIE list, the SEBI2010 list)</td>
<td>No capacity to update</td>
<td></td>
</tr>
<tr>
<td>Target / Action</td>
<td>Progress</td>
<td>Remarks</td>
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<tr>
<td><strong>Action 2</strong> Promote the national implementation of the European Strategy of Alien Invasive Species (Bern Convention 2003) and the EU communication on Invasive Alien Species (2008)</td>
<td></td>
<td>No capacity to update</td>
</tr>
<tr>
<td><strong>Action 3</strong> Promotion of trans-boundary examples of invasive alien species control (e.g. Croatia)</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>Action 4</strong> Exchange of experiences/toolkit/best practice case studies for dealing with invasive species, via the PE website</td>
<td></td>
<td>No capacity to update but could be a part of new GSPC toolkit</td>
</tr>
<tr>
<td><strong>Action 5</strong> Promote the aims and results of the European (and global) organisations working on invasive alien species (the Council of Europe, the Bern Convention, NEOBOTA, EPPO, DAISIE, NOBANIS, GISP)</td>
<td></td>
<td>No current capacity</td>
</tr>
<tr>
<td><strong>Action 6</strong> Encourage Planta Europa members to provide information on current programmes and projects for the interactive map of the Global Invasive Species Programme (GISP) and other relevant organisations</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>ESPC 10.2</strong> Action frameworks developed and implemented for controlling and monitoring 10 problematic invasive alien species in each country, with reference to information from other countries and regional initiatives (*for explanation see ESPC 10.1)</td>
<td></td>
<td>Many countries do have these but still difficult to find central information on management projects</td>
</tr>
<tr>
<td><strong>ESPC 10.3</strong> The existing EU web-based information system (DAISIE) to include at least 80% of European countries</td>
<td></td>
<td>Currently under consultation</td>
</tr>
<tr>
<td><strong>ESPC 10.4</strong> The Code of Conduct on Horticulture and Invasive Alien Plants adopted and implemented in at least 10 European states</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Publicise the Code of Conduct on Horticulture and Invasive Alien Species</td>
<td></td>
<td>There are new guidelines and some good case studies but they need wider implementation</td>
</tr>
<tr>
<td><strong>GSPC TARGET 11</strong> No species of wild flora endangered by international trade</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 11.1</strong> Action plans implemented and methods disseminated to ensure that 15 priority wild medicinal and aromatic plants and fungi traded within Europe are not endangered by trade (based on Lange 1998)</td>
<td></td>
<td>There are some new case studies and the FairWild/ISSC-MAP guidelines but not applied to all as yet</td>
</tr>
<tr>
<td><strong>Action 1</strong> Promote the use of the International Standard for Sustainable Wild Collection of Medicinal and Aromatic Plants (ISSC-MAP) and promote case studies of implementation through the PE website</td>
<td></td>
<td>No capacity to update</td>
</tr>
<tr>
<td><strong>Action 2</strong> Promote best practice for legal instruments for wild flora and MAPs trade such as documentation of origin, e.g. Bulgarian passport system, through the PE website</td>
<td></td>
<td>No capacity to update</td>
</tr>
<tr>
<td><strong>ESPC 11.2</strong> Ensure that CITES and the EC Habitats Directive are effective in protecting wild plant species from trade through updating of the annexes and appendices of CITES and the EC Habitats and Species Directive Annex V, and providing recommendations for effective implementation</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>Action 1</strong> Promote the aims, work programmes, publications and information on wild plant trade of TRAFFIC through the Planta Europa website</td>
<td></td>
<td>No capacity to update</td>
</tr>
<tr>
<td><strong>Action 2</strong> Promote available CITES training materials for plant species, e.g. the Royal Botanic Gardens Kew Publications, through the Planta Europa website</td>
<td></td>
<td>No capacity to update</td>
</tr>
<tr>
<td><strong>Action 3</strong> Promote good practice models of collection of wild resources for household consumption and trade (e.g. the WWF and Garda de Sus Community Arnica montana project) as a tool for awareness raising</td>
<td></td>
<td>No capacity to update</td>
</tr>
<tr>
<td><strong>GSPC TARGET 12</strong> 30% of plant-based products derived from sources that are sustainably managed</td>
<td></td>
<td>Little evidence to suggest this is happening</td>
</tr>
<tr>
<td><strong>ESPC 12.1</strong> 30% of plant-based products derived from sources that are sustainably managed</td>
<td></td>
<td>Little evidence to suggest this is happening</td>
</tr>
<tr>
<td><strong>Action 1</strong> Develop 5–10 case studies/projects to implement international standards for sustainable collection of MAPs (ISSC-MAP) and disseminate results</td>
<td></td>
<td>Existing, ongoing and planned projects in this area through FairWild projects and others</td>
</tr>
<tr>
<td><strong>Action 2</strong> Review and promote results of Europe’s plant product footprint, i.e. highest volume (in area of production/land take) of plant-based products used (or planned e.g. biofuels) in Europe and how this impacts on plant diversity within and outside Europe</td>
<td></td>
<td>No current capacity</td>
</tr>
<tr>
<td>Target / Action</td>
<td>Progress</td>
<td>Remarks</td>
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<tr>
<td><strong>Action 3</strong> Liaise with existing certification groups (Fairtrade, FSC, IFOAM, Fair-Wild) in the first instance and where appropriate develop working group to provide plant specific certification indicators to ensure that existing certification schemes are plant diversity friendly inside and outside of Europe</td>
<td>No current capacity</td>
<td></td>
</tr>
<tr>
<td><strong>GSPC TARGET 13</strong> The decline of plant resources, and associated indigenous and local knowledge, innovations, and practices that support sustainable livelihoods, local food security, and health care, halted</td>
<td>Some projects exist but information dispersed across different disciplines</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 13.1</strong> Projects in place in four European sub-regions demonstrating sustainable methods of conserving plant resources (crop wild relatives, land races, medicinal plants) whilst supporting European livelihoods</td>
<td>There are projects such as the Arnica montana project in Romania and ADEPT foundation; the work of ECPGR; the Scottish LandRace Project; FairWild projects</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Development and implementation of sustainable use projects including information on how they can be incorporated into national and regional action and policy strategies</td>
<td>Some case studies exist but need to be promoted and incorporated much more</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 13.2</strong> Develop a handbook/series of case studies in local languages, to provide training in methods and demonstrate the value of ethnobotanical projects to individuals, researchers, and children, in order to halt the loss of plant resources and local knowledge in Europe</td>
<td>Ethnobotany in the New Europe (Pardo-de-Santayana et al. 2010) contains chapters on ethnobotany research in 9 European countries</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Provide information through the Planta Europa website on organisations and research institutes active in the field of ethnobotany, including case studies of best practice</td>
<td>No capacity to update</td>
<td></td>
</tr>
<tr>
<td><strong>Action 2</strong> Promote the results and recommendations of the four-year study of wild plant related livelihoods (in the UK carried out by the CEB RBG Kew)</td>
<td>No capacity to update</td>
<td></td>
</tr>
<tr>
<td><strong>GSPC TARGET 14</strong> The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programmes</td>
<td>There are many national projects and a few regional projects</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 14.1</strong> Six-year sequence of targeted campaigns at the Pan-European and regional level (within the EU, within accession countries and in non-EU countries), that aim to ensure biodiversity initiatives, actions and incentives deliver sufficient plant conservation (including campaigns on climate change, agriculture, forestry and invasive species)</td>
<td>GPPC’s efforts for the new GSPC and BGCI’s GSPC e-mail campaign</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Ensure Planta Europa website delivers clear communication messages about plant diversity for different audiences</td>
<td>Little capacity to update</td>
<td></td>
</tr>
<tr>
<td><strong>Action 2</strong> Produce an information report (on the different communication ideas identified at 5th Planta Europa Conference, e.g. national and area flower emblems, Green Awards, flagship species to identify threats to accompany the new strategy and if funding/lead partner is identified, produce communication training materials and launch campaigns</td>
<td>Little capacity but there are national projects</td>
<td></td>
</tr>
<tr>
<td><strong>Action 3</strong> Planta Europa website to provide links to available training materials for school children (e.g. Plant Science Gardens, British Lichen Society school packs) and promote case studies where plant diversity is included in national or local school curricula</td>
<td>No capacity to update</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 14.2</strong> Initiate “Wake Up Call” for European Plant Conservation in all European countries</td>
<td>Initiated in 12–14 countries in Europe</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Continue to manage and promote the “Wake Up Call” for plant conservation throughout the network</td>
<td>Ongoing</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 14.3</strong> Develop a high quality touring photographic exhibition with a legacy of permanent exhibition in public gardens and arboreta. These should be produced in local languages to highlight the plight of plants in Europe</td>
<td>No current information</td>
<td></td>
</tr>
<tr>
<td><strong>Action 1</strong> Investigate the potential for sponsorship of abovementioned exhibition and identify key messages for Europe</td>
<td>No current information</td>
<td></td>
</tr>
<tr>
<td><strong>ESPC 14.4</strong> 50% of botanic gardens in Europe to display information on the GSPC and ESPC by 2010</td>
<td>Information in many botanic gardens exists but no information on current statistics</td>
<td></td>
</tr>
<tr>
<td><strong>GSPC TARGET 15</strong> The number of people working with appropriate facilities in plant conservation increased, according to national need, to the meet the targets of this strategy</td>
<td>No current information</td>
<td></td>
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<tr>
<td>Target / Action</td>
<td>Progress</td>
<td>Remarks</td>
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<tr>
<td><strong>ESPC 15.1</strong> A measurable increase in government resourcing of skill training for plant conservation at national and regional levels. Priority skills must include taxonomy, field botany, ecology, policy and advocacy, all-age education, marketing and volunteer development</td>
<td></td>
<td>No information available</td>
</tr>
<tr>
<td><strong>Action 1</strong> Publicise available information on the economic consequences of the plant conservation skills gap in the context of climate change to encourage national and regional decision makers to fund adequate skills training</td>
<td></td>
<td>No current capacity</td>
</tr>
<tr>
<td><strong>Action 2</strong> Planta Europa members compile broad range of best practice examples of skill training and capacity building, to be publicised via the PE website</td>
<td></td>
<td>Could be a part of the new GSPC toolkit project</td>
</tr>
<tr>
<td><strong>Action 3</strong> Planta Europa and botanic gardens provide information on available plant conservation training in their country which can be publicised via the PE website</td>
<td></td>
<td>No current capacity or information</td>
</tr>
<tr>
<td><strong>ESPC 15.2</strong> Identify and engage key partners to resource production of priority tools for building the capacity to deliver plant conservation at the national level. Priority tools are field guides in national languages, national Red Books or Red Lists, habitat and vegetation type maps</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>Action 1</strong> Each Planta Europa member from an European state with significant publishing facilities (commercial/academic) to establish links/explore options for production/translation of regional and national field guides</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>Action 2</strong> Used planned PE Electronic Information Platform to be a node for European funding information for plant conservation</td>
<td></td>
<td>No current capacity</td>
</tr>
<tr>
<td><strong>Action 3</strong> Planta Europa members to explore best approach at national levels to develop corporate support relationships</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>Action 4</strong> To share experience, information and skills gained in awareness raising within big projects (such as LIFE, Darwin, GEF, etc.)</td>
<td></td>
<td>No capacity to update but could be a part of the new GSPC toolkit project</td>
</tr>
<tr>
<td><strong>GSPC TARGET 16</strong> Networks for plant conservation activities established or strengthened at national, regional and international levels</td>
<td></td>
<td>Some networks working strongly, other declining in capacity</td>
</tr>
<tr>
<td><strong>ESPC 16.1</strong> Ensure ESPC targets are communicated, understood and promoted through network partnerships at national, regional and international levels</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>Action 1</strong> Identify priority network partnerships and promote the strategy (e.g. land use networks/organisations working in agriculture, forestry, marine industries, tourism)</td>
<td></td>
<td>No current information or capacity</td>
</tr>
<tr>
<td><strong>Action 2</strong> Translate European strategy into the languages of the PE network</td>
<td></td>
<td>No information</td>
</tr>
<tr>
<td><strong>Action 3</strong> Member get member by 2014 – each member recruits another member of Planta Europa</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>ESPC 16.2</strong> Identify national plant focal points to develop/support development of plant conservation networks that facilitate sharing of skills and information at the national level</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>Action 1</strong> Identify national Planta Europa focal points for each country who will be encouraged to develop/support development of plant conservation networks</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>Action 2</strong> Planta Europa members promote the European Strategy for Plant Conservation to government GSPC focal points</td>
<td></td>
<td>Mixed capacity</td>
</tr>
<tr>
<td><strong>Action 3</strong> Planta Europa Members and Botanic gardens provide details of the plant conservation organisations working within their country which can be publicised via the Planta Europa website</td>
<td></td>
<td>No capacity to update</td>
</tr>
<tr>
<td><strong>Action 4</strong> Facilitate sharing of skills and information at national and regional levels through search engine/website for plant conservationists to match skills and conservation needs</td>
<td></td>
<td>No current capacity</td>
</tr>
<tr>
<td><strong>Action 5</strong> Develop tools for financing and involving of non-EU countries in Pan-European and regional projects</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>ESPC 16.2a</strong> Network of national coordinators (or focal points) for Eastern Europe for the realisation of the new European Strategy for Plant Conservation</td>
<td></td>
<td>No current information</td>
</tr>
<tr>
<td><strong>ESPC 16.3</strong> Increase the number of ESPC projects which engage organisations from <em>in situ</em> and <em>ex situ</em> conservation, plant genetic research, wildlife conservation and sustainable use</td>
<td></td>
<td>Projects do exist but difficult to collate information</td>
</tr>
</tbody>
</table>
EXPLANATION OF ABBREVIATIONS:

ADEPT – Fundatia ADEPT [Biodiversity conservation and community development in Transylvania]
AEGRO Programme – An Integrated European In Situ Management Work Plan: Implementing Genetic Reserves and On Farm Concepts (AEGRO) Programme
BGCI – Botanic Gardens Conservation International
BioScore – [a Specific Targeted Research project funded under the EU Sixth Framework Programme for Research and Technological Development (FP6), Priority 8.1.B.1: Sustainable management of Europe’s natural resources]
CEB – Centre for Economic Botany [of Kew Royal Botanic Gardens]
CEEweb – Central and Eastern European web for Biodiversity [network]
CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora
COP 10 – the tenth meeting of the Conference of the Parties [the governing body of the Convention on Biological Diversity]
DAISIE – Delivering Alien Invasive Species Inventories for Europe
DAISIE list – [a list of invasive species of a DAISIE project]
Darwin – Darwin Correspondence Project
ECBB – European Committee for the Conservation of Bryophytes
ECBF – European Committee for the Conservation of Bryo-

Theses
EDIT – European Distributed Institute of Taxonomy
EEA – European Environment Agency
EHF – European Habitats Forum
EMA – European Mycological Association
EnRisk – Environmental Risk Assessment for European Agriculture [project]
ENSCOBASE – the ENSCONET Virtual Seed Bank
ENSCONET Project – The European Native Seed Conservation Network [project]
EPPO list – European and Mediterranean Plant Protection Organisation Alert List
ESPC – European Strategy For Plant Conservation
EU – European Union
EuroGard – European Botanic Gardens Congress[es] [of Botanic Gardens Conservation International]
Fairtrade – Fairtrade Foundation
FairWild – FairWild Foundation
FairWild Standard – [FairWild Foundation’s standards for assessing the harvest of and trade in wild plants against various ecological, social and economic requirements]
FEPS – the Federation of European Phycological Societies
FSC – Forest Stewardship Council

GEF – Global Environment Facility
GISP – Global Invasive Species Programme
GPPC – Global Partnership for Plant Conservation
GSPC – Global Strategy For Plant Conservation
HD – Habitats Directive
IFOAM – International Federation of Organic Agriculture Movements
IPA – Important Plant Areas
IPAM – [IPA communication and community involvement networks]
IPEN – The International Plant Exchange Network
ISSC-MAP – International Standard for Sustainable Wild Collection of Medicinal and Aromatic Plants
IUCN – International Union for Conservation of Nature
LIFE [programme] – the EU’s funding instrument for the environment
LIFE+ – [current phase of LIFE programme (2007–2013)]
MAPs – Medicinal and Aromatic Plants [database]
NEOBIOTA – The European Group on Biological Invasions [research consortium]
NOBANIS – European Network on Invasive Alien Species (NOBANIS)
PE – Planta Europa
PGR Secure – [collaborative project funded under the EU Seventh Framework Programme, THEME KBBE.2010.1.1-03, Characterization of biodiversity resources for wild crop relatives to improve crops by breeding]
RBG Kew – Royal Botanic Gardens, Kew
RUBIA [project] – [Name of EU project Circum-Mediterranean ethnobotanical and ethnographic heritage in traditional technologies, tools, and uses of wild and neglected plants for food, medicine, textiles, dying, and handicrafts]
SEBI2010 list – Streamlining European 2010 Biodiversity Indicators’ [Pan European initiative] list of Worst invasive species threatening biodiversity in Europe
TEEB – The Economics of Ecosystems and Biodiversity [Programme]
TRAFFIC – the wildlife trade monitoring network (coordinated by the NGO Traffic International, Cambridge)

REFERENCES

INTRODUCTION


The Habitats Directive ensures protection of 677 plant species (or subspecies) listed in one or several of its Annexes: II, IV and V. On top of that Habitats Directive Annex I lists 231 natural habitats which in many cases provide living conditions for other threatened and rare plant species. For example, several plant species protected under the national legislation or listed in the national red list occur in the habitat 6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) in France (Bensettiti et al. 2005). Thus, the potential benefit of this essential legal instrument is often not restricted to the species directly listed in the Directive.

The Habitats Directive aims at maintaining or restoring to favourable conservation status the natural habitats and species of wild fauna and flora of Community interest. The principal instrument in achieving this aim is the designation and management of protected areas which together with sites designated under the Birds Directive form the Natura 2000 network. The Natura 2000 network now includes more than 26,000 sites and covers up to 17.5% of the EU27 land territory, out of which 22,529 sites covering in total 13.7% of the EU27 territory are designated under the Habitats Directive, including almost 5,000 sites of target plant taxa (European Environment Agency 2011).

Beyond its important role in terms of biodiversity conservation through the designation and management of protected areas of the Natura 2000 network, the Habitats Directive also provides a considerably improved knowledge on targeted species and habitats, in particular through its Article 11, which obliges all Member States to undertake surveillance of the habitats and species of Community interest listed in Annexes I, II, IV and V. In addition, Article 17 of the Directive requires that Member States prepare reports every six years.
on the implementation of the Directive including measures taken to achieve or maintain favourable conservation status and results of surveillance of conservation status. The following article presents a methodology used to evaluate the conservation status of habitats and species of Community interest as it is outlined in the Habitats Directive and describes a position of this initiative in a wider context of EU biodiversity policies.

ASSESSMENT OF CONSERVATION STATUS AT COUNTRY LEVEL

Pursuant to Article 17 of the Habitats Directive, EU Member States are requested to evaluate, in six year intervals, the conservation status of the habitats and species of the Habitats Directive. This evaluation requires a set of regularly updated and standardised information about the status and trends of principal biological and ecological parameters together with information on distribution and main drivers. Thus the Article 17 reporting represents a systematic assessment of the conservation status of habitats and species protected under the Habitats Directive which should regularly provide information about changes of the status and their links to main pressures. Such a comprehensive evaluation of the conservation status of all habitats and species of Community interest was carried out for the first time for the six-year period 2000–2006.

The standardised evaluation of conservation status requires well defined concepts and standard methodology. Thus extensive work was undertaken starting from 2004 under the umbrella of “Scientific working group”, a scientific discussion forum of the European Commission’s Habitats Committee, involving experts from EU Member States. The principal aim of this initiative was to establish a methodology for the first evaluation of conservation status. The work was coordinated scientifically and technically by the European Topic Centre on Biological Diversity (ETC/BD) on behalf of the European Environment Agency. This resulted in the production of “reporting formats” for habitats and species defining the information feeding into the evaluation of the conservation status and “evaluation matrices” establishing principles of evaluation (European Commission 2005). The reporting formats and evaluation matrices had to be formally endorsed by representatives of all concerned Ministries of the Environment within the so-called “Habitats Committee”. In order to standardize the evaluations a reporting guidelines were developed describing in more detail information requested in the reporting formats (European Commission 2006).

A separate evaluation of conservation status was required for each biogeographical region in a country. Biogeographical regions are based on maps of potential natural vegetation (Bohn et al. 2004) and are adjusted to better fit political and administrative boundaries (Roekaerts 2002). Europe can be divided into nine land and four marine biogeographical regions. The biogeographical regions represent a framework for the implementation of some of the measures of the Directive, principally those linked to the Natura 2000 network.

The conservation status evaluation is based on the definition of conservation status as expressed in the Article 1 of the Directive, mainly taking into account the status and dynamics of important ecological parameters (population, habitat area, range). This basic information is used also in other conservation status assessments e.g. the IUCN conservation status assessment. According to the Article 1 definition the status of a habitat or a species is favourable, if these parameters are stable and were not eliminated or significantly reduced in the past. To evaluate the status of a habitat or species as favourable also other conditions must be fulfilled; the population of a species or a habitat should be viable in the long term and the abovementioned principal parameters should remain stable in the foreseeable future. So in comparison to, for example, the IUCN conservation status, the Habitats Directive status introduces two complementary elements, the quantitative estimation of viability of habitats and species for which the concept of “reference values” was introduced and estimation of future perspectives.

The basic principles set in the Directive are reflected in the “evaluation matrices” (European Commission 2005), which represent the fundamentals of the actual evaluation of the conservation status. The conservation status of both habitats and species is composed of four parameters: “Range”, “Population”, “Habitat for the species” and “Future prospects” for species, and “Range”, “Area”, “Specific structures and functions” and “Future prospects” for habitats. The status of each of these parameters is assessed separately based on an agreed set of rules using a three-level traffic light schema. Green represents the “Favourable” status, amber – “Unfavourable – Inadequate” and red – the “Unfavourable – Bad” status. The status of four parameters is then combined using an agreed methodology to give an overall conservation status. For quantitative parameters “Range”, “Population” of the species and “Area of habitat”
the evaluation consist of two components: trend and a comparison of the actual with favourable situation. It is precisely the magnitude of trend and the difference between the actual and the reference value (representing the favourable situation) that are determinants in the evaluation of the status of parameters. To reach a favourable status the trend cannot be decreasing and the actual value cannot be smaller than the reference value. The reference values are minimal values of a parameter which ensures long-term viability of a habitat or species and which includes its necessary variation. Other parameters, future prospects and structures and functions of habitat, were evaluated qualitatively (European Commission 2006).

It is important to note that as a part of the requested report on conservation status countries should collect and submit not only the final results of the assessments of each parameter but also a number of data needed for the assessment. These are on the one hand the data needed directly to estimate the status of parameters like range and habitat area, population size or reference values, and on the other the data feeding into the evaluation indirectly, like the distribution map or information on main pressures and threats. Hence the 2000–2006 Article 17 reporting exercise resulted in a large compilation of various data linked to the conservation status of 216 habitats and 1,182 species from 25 European countries. However, it needs to be acknowledged that even for these habitats and species of special interest numerous knowledge gaps still exist, particularly in the southern part of the EU (ETC/BD 2009a).

For many habitats this is the first time it has been possible to produce distribution maps for the European Union2 or to have an estimate of the total habitat area. For species, the reports presented an update of the existing distribution maps and the assessments of conservation status provided a useful addition to the IUCN Red Lists (ETC/BD 2009b).

COMMUNITY ASSESSMENT OF CONSERVATION STATUS

The Habitats Directive Article 17 further requires the European Commission to prepare a composite report based on the countries' reports. It was agreed that one of the elements of this report should be an assessment of the conservation status of the species and habitats of Community interest at biogeographical level. The methodology to assess the conservation status at biogeographical level based on the assessments at national level was developed within the framework of regular meetings of the Scientific Working Group supported by several workshops held by the ETC/BD in 2007 and 2008.

Three possible methods were identified: (i) aggregation of data (on trend, actual value, and reference value) provided by countries for quantitative parameters in order to estimate the biogeographical level values, (ii) weighted aggregation of status of individual parameters and (iii) weighted aggregation of overall conservation status when data on individual parameters were missing or unusable. However all the three methods relied, at least partially, on weighting the national conservation status assessments (first method – aggregation of data – can only be used for quantitative parameters, and for the remaining, qualitative parameters, weighted aggregation methods should be used). Beside the calculation of the biogeographical assessment by one of these three methods, for approximately half of the species and habitats the biogeographical assessments was equal to the national assessment(s), as the habitats/species are restricted to one single country or occurring in several countries but having the same assessment (ETC/BD 2009c).

Technically, in large majority of cases the second method – weighted aggregation of individual parameters – was used as the incompleteness of data did not allow for the more precise aggregation of data method. The conservation status of a habitat or species at biogeographical level should reflect proportionally the conservation status in the countries where it is present. Weighting is therefore a fundamental aspect of the process of assessing conservation status at biogeographical level. The biogeographical conservation status of each of the four parameters was determined using weighted conclusions from countries with a series of agreed thresholds. These thresholds worked as a series of sieves or filters, applied in a sequence starting with the first threshold for unfavourable – bad conservation status. If the proportion of a habitat/species reported as “Unfavourable – Bad” was equal or greater than 25% this was considered “Unfavourable – Bad” for the biogeographical region. If the proportion of a habitat/species reported as “Favourable” was equal or greater than 75%, the result was “Favourable”. If the proportion of a habitat/species reported as “Unknown” was equal or greater than 25%, the result was “Unknown” (XX). Any other combination led to “Unfavourable – Inadequate” status (ETC/BD 2009c).

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2 The reporting for the period 2000–2006 concerned only 25 countries, Romania and Bulgaria, which entered the EU in 2007, were not included.
When possible, the national-level conclusions were weighted by the proportion of the total biogeographical population or biogeographical area of the habitat occurring in a country. However, this information was often unavailable and so other parameters were used for weighting, like distribution area calculated from the generalised maps of distribution or range.

FURTHER IMPROVEMENT OF INFORMATION PROVIDED VIA REPORTING OBLIGATION

After the countries submitted their first conservation status evaluations in 2007, it became clear that both the reporting format and the guidance published in 2006 needed to be improved. The work on improving the Article 17 guidance started already in 2008. A new scientific discussion group was created to deal specifically with this issue – the Reporting Working Group. As a result of almost three years’ work the revised guidance for the reporting period 2007–2012 was prepared aiming to ensure a harmonised use of the reporting format by all countries, which would enable better compilation and analysis of the data received at EU level. Some other specific topics were included in the reporting formats like evaluation of conservation measures within the Natura 2000 networks. The revised Article 17 formats were published in May 2011 (European Commission 2011a) and the revised guidelines in July 2011 (Evans & Arvela 2011).

RESULTS OF THE ARTICLE 17 REPORTING

The results of the Article 17 conservation status evaluation show that only 17% of the 701 Annex I habitat and 17% of all the 2,240 species assessments were “Favourable” (Fig. 1). On the contrary, the status of more than half of the assessments (65% in case of habitats and 52% in case of species) was “Unfavourable”. In fact, these numbers may be even higher, as the status of a relatively high percentage of the assessments (31% for species and 18% for habitats) was “Unknown”. In general, for the plant species the conservation status results were slightly better than for other species (Fig. 1). The group of vascular plants was one with the lowest number of “Unfavourable – Bad” and the highest number of “Favourable” assessments (ETC/BD 2009c). This group includes a large number of endemic species and species with restricted distribution. Rare and localised species are very often a focus of conservation measures and initiatives, which can influence their conservation status positively. For example, Spain has pioneered the use of “micro-reserves” to conserve plants and for some very localised endemics such reserves can cover the entire population (Laguna 2001).

Within the large scale of Annex I habitats some ecological groups of habitats have particularly high proportion of “Unfavourable – Bad” assessments. More than a half of the assessments for habitats dependent on agriculture is “Unfavourable – Bad” in comparison to 30% in case of habitats not dependent on agriculture (Fig. 2). This statistics is based on the work of Ostermann (1998) which lists the Annex I habitats considered to be dependent on agriculture. This list was revised by Halada et al. (2011) to include habitats added to the Annex in 2004. A very high proportion of habitats dependent on agriculture in the “Unfavourable – Bad” conservation status was reported mainly in the Atlantic and Pannonian regions, which can be associated with the high intensity of agriculture in these two regions (ETC/BD 2009c).

![Fig. 1](image-url) Percentage of conservation status assessments of habitats and species of Community interest. A – conservation status of habitat types of Community interest, B – conservation status of species of Community interest, C – conservation status of plant species of Community interest. Red – “Unfavourable – Bad”, amber – “Unfavourable – Inadequate”, grey – “Unknown”, green – “Favourable”.
Yet there are also other ecological groups, where the proportion of the “Unfavourable – Bad” assessment is relatively high, for example Annex I “bogs, mires and fens”, which are threatened mainly by changes in the hydrological conditions and eutrophication often due to the atmospheric deposition of nitrogenous compounds, or coastal dunes, which, just like habitats dependent on agriculture, require active management and are additionally threatened by construction works (ETC/BD 2009c).

Furthermore, Article 17 showed that some of the recently recognised drivers influencing biodiversity are already having an impact on EU biodiversity. Climate change was reported as one of the reasons for the decline of a half of habitat types from the ecological group “bogs, mires and fens”. In addition, four more habitats reported in other ecological groups are also wetlands, suggesting that wetlands in general are being influenced by climate change more than any other group of habitats (ETC/BD 2009c).

ARTICLE 17 REPORTING INFORMING EU BIODIVERSITY POLICIES

In July 2009, the European Commission published the Composite Report on the Conservation Status of Habitat Types and Species (European Commission 2009) summing up the principal outcomes of the 2000–2006 Article 17 reporting. The report also underlined the need for comprehensive and reliable measures of biodiversity status, to which the Article 17 reporting largely contributes. Regarding the still persisting important gaps in knowledge revealed during the 2000–2006 reporting the Commission stressed the importance of investing sufficient resources in monitoring and reporting.

Six months after the adoption of a Global Strategic Plan to combat biodiversity loss at the Nagoya Conference of the Parties of the CBD, the European Commission published on 3 May 2011 a new biodiversity strategy until 2020 (European Commission 2011b) aiming to improve the state of Europe’s biodiversity over the next decade.

The strategy includes six mutually supportive and inter-dependent targets linked to the 2020 headline target to “halt the loss of biodiversity and degradation of ecosystem services in the EU and restoring them as far as feasible”. Each of these targets address a specific issue: maintaining and restoring the status of habitats and species covered by EU legislation and ecosystem services (Targets 1 and 2), enhancing the positive effect of EU agricultural, forestry and fishery policies and reducing key pressure to biodiversity (Targets 3–5) and stepping up EU contribution to averting global biodiversity loss (Target 6). The targets are supported by series of targeted actions.

Within the six targets, Target 1 specifically addresses the conservation status of the habitats and species of Community interest:

Target 1. To halt the deterioration in the status of all species and habitats covered by EU nature legislation and achieve a significant and measurable improvement in their status so that, by 2020, compared to current assessments: (i) 100% more habitat assessments and 50% more species assessments under the Habitats Directive show an improved conservation status; and (ii) 50% more species assessments under the Birds Directive show a secure or improved status.

In preparation for this strategy and to underpin some of its targets, the European Council had specified the need to set a baseline outlining the criteria against which achievements would be assessed in future. To respond to this need the European...
Environment Agency and its European Topic Centre on Biological Diversity developed the EU 2010 Biodiversity baseline (European Environment Agency 2010). The baseline is based on the available EU data like the Article 17 assessment of conservation status, European Red Lists as well as existing European sets of indicators, for example SEBI 2010. The report analyses the status, trends, main drivers and services of major European ecosystem types: agro-ecosystems, grasslands, heath and scrub, forests, wetlands, lakes and rivers, as well as coastal and marine ecosystems. Although the conservation status assessment plays an important role in the abovementioned analysis of ecosystem types, the baseline also includes a dedicated chapter summarizing the results of the conservation status of habitats and species of Community interest.

The strategy further stressed the importance of an integrated framework for monitoring, assessing and reporting on progress achieved in implementing the strategy and further underpinned the essential role of EU biodiversity indicators and an EU 2010 biodiversity baseline.

CONCLUSIONS

The article 17 reporting for the period 2000–2006 included for the first time a comprehensive evaluation of the conservation status of all habitats and species of Community interest. Beside the conservation status assessment the Article 17 reporting exercise has provided a valuable source of other types of information related to trends, main pressures and distribution.

The results of the conservation status assessment represent an important component in monitoring and evaluating the progress in EU biodiversity policies as it is stressed in the EU biodiversity strategy until 2020 (European Commission 2011b). Furthermore, it helps, together with other EU-level data sources, to identify main pressures on biodiversity within the EU (European Commission 2009). Together with the EU biodiversity indicators and European Regional IUCN Assessments they represent the most important sources of information on threatened components of biodiversity within the EU.

REFERENCES


PLANTA EUROPA AWARDS – GENERAL INFORMATION

The Jean-Paul Galland Award is Planta Europa’s top award. It commemorates the French botanist and conservationist Jean-Paul Galland, who was one of the founders of Planta Europa and who died tragically during a plane crash in 1996. Each Planta Europa Conference presents a single Jean-Paul Galland Award to an individual or organisation for outstanding achievements in plant conservation.

Silver Leaf Awards are presented in recognition of excellence in plant conservation in Europe. Up to five Silver Leaf Awards are being presented at each Planta Europa Conference.

The award winners receive a golden (Jean-Paul Galland) or silver medal (Silver Leaf Award) with inscription and certificate.

Both awards were presented for the first time at the 2nd Planta Europa Conference in Uppsala, Sweden, in June 1998.

Linnaeus Award was set uniquely for the 2007 Conference to celebrate the 250th Anniversary of Carolus Linnaeus. It recognized important works in plant taxonomy.

Award winners

2nd Planta Europa Conference
(Uppsala, Sweden 1998)

Jean-Paul Galland Award:
Cyrille de Klemm, France
Silver Leaf Awards:
Tatyana Andrienko, Ukraine,
Andy Byfield, United Kingdom
Tomas Hallingbäck, Sweden.

3rd Planta Europa Conference
(Průhonice, Czech Republic 2001)

Jean-Paul Galland Award:
Jan Čeřovský, Czech Republic
Silver Leaf Awards:
František Procházka, Czech Republic
Viera Feráková, Slovakia
Victor Parfenov, Belarus.

4th Planta Europa Conference
(Valencia, Spain 2004)

Jean-Paul Galland Award:
David Bellamy, United Kingdom
Silver Leaf Awards:
Cesar Gomez-Campo, Spain,
Adrian Darby, United Kingdom
Emilio Laguna, Spain.

5th Planta Europa Conference
(Cluj–Napoca, Romania 2007)

Jean-Paul Galland Award:
Richard Sandbrook, United Kingdom (posthumously)
Silver Leaf Awards:
Antoaneta Petrova, Bulgaria;
Jane Smart, United Kingdom/Switzerland
Ioan Pop, Romania
Michael Scott, United Kingdom
Oleg Maslovsky, Belarus.
Linnaeus Awards:
Vernon Heywood, United Kingdom
Gavril Negrean, Romania
PLANTA EUROPA AWARDS – CEREMONY 2011

Jan Willem Sneeple

Ladies and Gentlemen,

As members of Planta Europa you were invited to make nominations for the Planta Europa Awards 2011 by 10th January 2011.

I like to thank you for your nominations.

As you know, Planta Europa knows two awards: the Jean-Paul Galland Award and the Silver Leaf Award.

The Jean-Paul Galland Award is Planta Europa’s top award. The Award commemorates the French botanist and conservationist Jean-Paul Galland, who was one of the founders of Planta Europa and who died tragically during a plain crash in 1996.

Each Planta Europa Conference presents a single Jean-Paul Galland Award to individual or organisation for outstanding achievements in plant conservation in Europe.

The Planta Europa Silver Leaf Awards are presented in recognition of excellence in plant conservation in Europe.

Up to now, at least three Silver Planta Europa Leaf Awards were being presented at each Planta Europa Conference.

Both awards were presented for the first time at the 2nd Planta Europa Conference in Uppsala, Sweden, in June 1998.

Ladies and Gentlemen,

Based on the received nominations for both awards, the Planta Europa Steering Committee decided to give at the present 6th PE Conference, one Jean-Paul Galland Award and five Planta Europa Silver Leaf Awards to individuals for their outstanding achievements in the European plant conservation.

The Jean-Paul Galland Award is a golden medal and the Silver Leaf Award is (so the name said) a silver medal, of course both medals with an inscription.

I would like to thank the Art DataBanken Swedish Species Information Centre for the financial support to produce these PE-Awards.

Well, and now the “moment suprême”.

Before the medals will be handed over by the President of Planta Europa, prof. Anca Sârbu, I would like to give a short introduction to each of the award winners.

I will start with the Planta Europa Jean-Paul Galland Award.

JEAN-PAUL GALLAND AWARD 2011

Torleif Ingelög

The Jean-Paul Galland Award 2011 will be given to a person who is an appreciated member of the Planta Europa family and served as a member of the Steering Committee for twelve years starting from the first Planta Europa Conference. For six years he was the President of Planta Europa. During all these years he was a very active member, contributing a lot to the development of the organisation.

He arranged the second Planta Europa Conference in Uppsala, which was very successful.

For more than twenty years he has been the director of The Swedish Species Information Centre in Uppsala. He has built it from scratch to a very efficient, successful and important institution. He provided through this Centre also a considerable economic support to Planta Europa Conferences and to several other Planta Europa activities.

He is an important European plant conservationist and he has had a large positive impact on the development of plant conservation, especially in the Nordic countries.

With great pleasure, the Planta Europa Steering Committee had decided to give the Planta Europa Jean-Paul Galland Award 2011 to Torleif Ingelög.

PLANTA EUROPA SILVER LEAF AWARDS 2011

1. Eladio Fernández-Galiano

The first Planta Europa Silver Leaf Award 2011 will be given to a person who is an ecologist and environmentalist by training.

He worked nine years at the Madrid University as research fellow and assistant professor in ecology where his main interest was grassland ecology, models on spatial distribution and conservation.

He has been working since 1985 for the Council of Europe mainly on environment and disaster risk reduction issues, first as the Secretary of the Convention on the Conservation of Wildlife and Natural
Habitats (The Bern Convention), then as the Head of the Environment Division and as Executive Secretary of the European and Mediterranean Major Hazards Agreement (EUR-OPA). The latter, 1987 international agreement, is a platform of cooperation between European and Southern Mediterranean States in major natural and technological hazards.

Within the framework of his responsibilities in the environment sector, since 1988 he has been in charge of the Unit of Biological Diversity.

Now he is the Head of the Biological Diversity Unit of the Council of Europe, whose actions in this field focus on threatened species, biodiversity and climate change, invasive species and building of ecological networks.

Among others, he helped to prepare the European Landscape Convention, and, in the framework of the Bern Convention, he prepared over a hundred recommendations related to the European nature.

He developed a lot of policy documents on European plant and animal conservation and was responsible for the preparation of Ministerial Conferences in biodiversity and sustainable development issues.

With great pleasure, the Planta Europa Steering Committee gives the first Planta Europa Silver Leaf Award 2011 to Eladio Fernández-Galiano.

2. Romuald Olaczek

The second Planta Europa Silver Leaf Award will be given to geographer and botanist (specialized in geobotany), involved for many years in nature protection, primarily in conservation of plant species and vegetation.

In 1976–1981 he was the director of the Institute of Environmental Biology, in 1981–1993 – the head of the Chair of Botany and in 1993–2004 – the director of the Institute of Ecology and Environmental Protection at the University of Łódź, Poland.

In 1991 he created there – a novelty in the Polish higher education – an university course of Environmental protection including, besides natural history subjects, also legal and economical aspects of the environment protection; this course was accepted as a template for all universities in the country that subsequently established similar studies.

He was a main supporter to include a notion of “ecological land use area” („użytek ekologiczny”) into Polish nature conservation law and practice.

He disseminated the ideas and strategies of nature conservation elaborated in Poland when participating in international congresses and scientific conferences.

He gave a series of lectures as a visiting professor at universities in Finland and Germany.

As a distinguished plant expert, along with his scientific work, he excels also in dissemination of the knowledge among various groups of the society, taking advantage of his pedagogical education as well as his writer’s, nature photographer’s and editor’s gifts.

His official functions in the field of nature conservation included (or still include):

- membership of the Man and Biosphere Committee of Polish Academy of Sciences (PAS),
- membership of the Committee of Ecology PAS,
- membership of the Committee of Botany PAS,
- membership of the Committee of Nature Protection PAS,
- membership of the Steering Committee of Nature Protection League (LOP) – an all-country NGO (for many years managing all editorial activities of the organization);
- membership of the scientific councils of: Institute of Nature Protection PAS, Institute of Botany PAS, and Kampinoski National Park;
- membership of the State Council of Nature Protection (since 1988; in the years 1991–1994 he was the President of the Council);

He acted also as an editor or a member of editorial councils for several periodicals dealing with botany and nature protection issues:

- Acta Universitatis Lodzensis – Folia Szoologica,
- Monographiae Botanicae,
- Aura,
- Fragmenta Floristica et Geobotanica,
- Ochrona Przyrody [“Nature Conservation”].

He is an author of more than 150 publications in the field of nature protection, both scientific and popular, as well as handbooks, e.g.:

- Polish translation of the Global Strategy of Nature Conservation (1985);
- Monograph of the Załęczański Landscape Park (1986);
- Główne problemy ochrony zasobów genowych roślin [“Main problems of plant genetical resources protection”] (1986);
- Projekt ekologicznego systemu obszarów chronionych Polski Środkowej [“Project of ecological system of the protected areas of Central Poland”] (1987);
- Zasoby glebowe i roślinne – użytkowanie, zagrożenie, ochrona [“Soil and plant resources – use, endangerment, protection”] (editor, 1988);
3. Ilya Smelansky

The third Planta Europa Silver Leaf Award will be given to the person who is co-founder, coordinator and chief editor of popular science journal *Stepnoi Byulleten* ("Steppe Bulletin") which informs scientists and public about problems of steppe conservation and about sustainable development in steppes of Eurasia since 1998.

He is an author and co-author of eight monographs and six analytic reports about problems of biodiversity conservation in Russia.

He was a participant and main organizer of more than ten long-term expeditions for study of steppes.

He was an initiator of many (more than ten) projects for creation of new protected areas in the steppe zone of Russia.

He is a member of working groups in more than ten projects for creation of new protected areas in the steppe zone of Russia.

Some of his analytic reports are:

- High Nature Value farming in the EECCA countries,
- Background report for Workshop on High Nature Value farming in the EECCA countries 16-17 November 2006,
- Compendium of Regional Templates on the Status of Temperate Grasslands Conservation and Protection.


He published reports on:

- Conservation Prioritization and Conservation Status of Steppe Biome in Russia, 2008

Some of his main publications are:

- Ecological information in Russia, 1998,
- Biodiversity of agricultural lands in Russia: current state and trends, 2003,
- Important Bird Areas in Kazakhstan, priority sites for Almaty, Kazakhstan, 2008,
- Zetomotrichidae from the Southern Urals, a family of Oribatei (Acari: Acariformes) newly found in Russia, 1997,
- Structure of saprophagous invertebrate community on a catena in the steppe of Trans-Volga region 1999,
- Spatial structure of soil-and-litter dwelling microarthropod community on catena in Trans-Volga steppe region, 2000,
- several publications on Oribatida, Oribatid mites of the superfamilies Gymnodamaeoidea and Plateremaeoidea (Acari: Oribatida) in (East) Kazakhstan and Russia.

Now he is a coordinator and member of Council of Interregional Charitable Public Organization Siberian Ecological Center.

With great pleasure, the Planta Europa Steering Committee had decided to give the third Planta Europa Silver Leaf Award 2011 to Ilya Smelansky.

4. Ljupcho Melovski

The fourth Planta Europa Silver Leaf Award will be given to a person who has been working within the field of ecology, botany and nature conservation in Macedonia for over twenty five years.

Working as an university professor on different ecological subjects and environmental protection he had a huge role in supporting young people in taking all aspects of ecological scientific study and secondly encouraging them to go on and use their skills for nature conservation.

He is incredibly knowledgeable and extremely passionate about the nature of Macedonia.

He works with organisations across the country (national and local government, international bodies, NGOs and academic institutes) to improve...
Macedonia’s capacity to respond to nature conservation issues.

He has been president of the Macedonian Ecological Society since 2000 and has had a major role in the Society’s growth. The Society is now recognised as the default “go-to organisation” for data and information on biodiversity within Macedonia; its staff of eleven of enthusiastic and committed individuals, several volunteers and around 150 members, are working on national and international conservation projects for birds (vultures) mammals (lynx and bear), plants (IPAs identification and conservation), protected area networks and education.

He had a key role in ensuring that the staff of the Society develops the skills needed to run large projects including international ones with foreign donors and to continue to learn and develop both scientific and conservation skills.

With great pleasure, the Planta Europa Steering Committee has decided to give the fourth Planta Europa Silver Leaf Award 2011 to Ljupcho Melo-vski.

5. Jacques Zaffran

The fifth Planta Europa Silver Leaf Award will be given to a person who is a living example of a botanist dedicated to wild plant conservation.

He is among the most important, well known and respected botany specialist for the wild plant of the island of Crete.

Since 1960 he has been studying Cretan flora and was among the first persons to raise awareness of the extinction of its endemic species.

He has collected more than 9000 specimen of Cretan wild plants and he donated that unique collection to the people of Crete for educational and plant conservation purposes, in spite of having received lucrative proposals from other countries. In 2008 he opened officially his Herbarium and Museum of Cretan Flora at the Institute of Theology and Ecology of the Orthodox Academy of Crete.

He has discovered new species of wild plants (some of them, described by other authors, were named in honour of him) e.g. *Thlaspi zaffrani* Greuter & Burdet, *Asperula crassula* Greuter & Zaffran, *Asplenium creticum* Leis, Reichenstein & Zaffran, *Myosotis solange* Greuter & Zaffran. He is continuing his taxonomic research every year.

With his inspiration on wild plant conservation, since the beginning of his collaboration with the Orthodox Academy of Crete he helped organizing botanical conferences and seminars on the protection and valorization of Cretan wild plants, a.o. the International Seminar on Cretan Botany and Gastronomy (CBG), the Conference on the Conservation and Sustainable Use of Wild Plants Diversity (CSUWPD) and the Conference on Ecological Theology and Environmental Ethics (ECOTHEE).

He offers free botanical courses (http://yona.z.free.fr/) and free research facilities (www.oac.gr) at the Museum of the Institute of Theology and Ecology in order to promote the study and conservation of wild plants (mainly on the island of Crete).

He is collaborating with many botanical and environmental organizations to study and protect wild plant worldwide (e.g. with Planta Europa, MAICH, TAXON, Countdown2010.net) and he has written numerous botanical books and helped editing press articles and botanical conference proceedings.

He has left his domestic places (Algeria and France) and decides to spend the rest of his life on the Island of Crete (Chania) just to fulfill his dedication and love for wild plants as independent botany researcher.

He has never asked for remuneration and offers his expertise on plant conservation benevolently to any institution or individual that may need his help.

He works voluntarily at the Museum of Cretan Flora of the Orthodox Academy of Crete until today.

With great pleasure, the PE Steering Committee had decided to give the fifth Planta Europa Silver Leaf Award 2011 to Jacques Zaffran.

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2 As the nominated person was not present at 6th PEC, the medal was handed over to Elizabeth Radford of the Plantlife International.

3 As the nominated person was not present at 6th PEC, the medal was handed over to Lucas Andrianos of the Orthodox Academy of Crete.
Yet another, sixth conference of the Planta Europa society entitled *Actions for Wild Plants* was organised by its Steering Committee with co-participation of the Committee on Nature Conservation of the Polish Academy of Sciences and the W. Szafer Institute of Botany of the Polish Academy of Sciences (the president of the Organisational Committee was Professor Zbigniew Mirek). The conference took place on 23–27 May 2011 at the W. Szafer Institute of Botany PAS in Kraków. The subjects covered included a wide spectrum of issues related to the threats to and protection of Europe’s flora in the light of the tasks formulated in the European Plant Conservation Strategy, EPCS. As planned, both the invited introductory papers and the papers in oral sessions have been organised on the basis of three groups of issues stemming from the objectives formulated in the aforementioned Strategy: 1) EPCS Objective 1: Understanding and documenting plant diversity; 2) EPCS Objective 2: Conserving plant diversity; 3) EPCS Objectives 3–5: Using plant diversity sustainably, promoting education and awareness about plant diversity and increasing capacity for plant conservation. In total, 22 papers were delivered during the conference. Some offered summary analyses of nature and landscape protection at European scale (e.g. *Improved knowledge on European plant species in relation to reporting obligations under policy instruments, The rural landscapes of Europe*), while some other focused on domestic issues (e.g. *Ex situ plant conservation in Ukraine, Conservation of vascular plant diversity in Bulgaria – current state*) or presented case studies which illustrated some examples of problem areas (e.g. *Large-scale surveys of polypore fungi in Finnish conservation areas, Plant succession in old fields in Mediterranean saline steppes*). The full spectrum of the themes covered is presented in the agenda and the set of abstracts comprised in the conference abstract book (Mirek et al. 2011a) – Fig. 1. A number of detailed issues have also been presented during a successful poster session (posters were also available throughout the duration of the conference), which met with a keen interest and the themes of the posters served a base for fruitful discussion. 28 posters were presented in total, thematically fitting into the conference theme blocks (see above). After each series of papers panel discussions took place which facilitated exchange of experiences and promoted attempts at formulating further specific measures on which European flora protection should focus in the years to come. A tangible result of the discussion was the drafting and adoption of an official Planta Europa document called the *Kraków Declaration* (see the previous text in this publication) which is also going to be presented at European bodies (e.g. the Council of Europe) during the proceedings dealing with biodiversity protection.

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1 This is an English translation of the text originally issued in Polish in the *Bulletin of the Committee on Nature Conservation of the Polish Academy of Sciences* 3–4/2012–2013: 115–117 [editor’s note].
Three thematic field sessions (Tatra National Park, Pieniny National Park, Ojców National Park) were organised as part of the conference, in the context of which issues were highlighted related to biodiversity and nature protection in those areas (against the background of the Małopolska Province and the entire country) as well as the nature of the threats and the implemented strategies and forms of protection. A guidebook was prepared for the participants of the field sessions (Mirek et al. 2011b) – Fig. 2, where both the National Parks visited and their protection as well as the general topic of nature conservation in the Małopolska Province were discussed.

The conference brought together participants dealing with various aspects of European flora and mycobionta protection from most European countries, thanks to which it played well the role of a Pan-European forum for exchange of experiences, summing up actions and discussions to date concerning further perspectives for the implementation of the European Plant Conservation Strategy.

80 participants, including 51 from abroad, took part in the conference, representing 19 European countries in total. The event also attracted representatives of the National and Regional Environmental Protection Directorate, the Nature Conservation Institute PAS and many key academic centres in Poland. Foreign organisations were represented by, *inter alia*, the Council of Europe, the European Topic Centre on Biological Diversity, Plantlife International, the European Council of Conservation of Fungi, ArtDatabanken – Swedish Species Information Centre, Fédération des Conservatoires Botaniques – France, as well as numerous research university institutes and representatives of national academies of sciences.

Incidentally, the other (next to the Committee on Nature Conservation PAS) co-organiser of the Conference, the W. Szafer Institute of Botany PAS, has so far been the only national Planta Europa member organising several national and international scientific meetings on an annual basis, concerning themes including those covered by the conference.

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² ISO 9 transliteration: A. Ševkunova
³ ISO 9 transliteration: B. Teterük
PHOTOGRAPHS FROM THE CONFERENCE

PLANTA EUROPA AWARDS 2011
(24 MAY 2011)

JEAN-PAUL GALLAND AWARD

for Torleif Ingelög (phot. K. Romeyko-Hurko)

SILVER LEAF AWARD

for Eladio Fernández-Galiano (phot. K. Romeyko-Hurko)
for Romuald Olaczek (phot. K. Romeyko-Hurko)

Galina Pronkina receives the award on behalf of Ilya Smelansky (phot. K. Romeyko-Hurko)
Elizabeth Radford receives the award on behalf of Ljupcho Melovski (phot. K. Romeyko-Hurko)

Lucas Andrianos receives the award on behalf of Jacques Zaffran (phot. K. Romeyko-Hurko)
ORAL SESSIONS – LECTURERS AND CHAIRMANS
(24–26 MAY 2011)
Victor Melnyk (phot. K. Romeyko-Hurko)

Zbigniew Mirek (phot. K. Romeyko-Hurko)
Aulikki Alanen (from the left) and Elizabeth Radford (phot. K. Romeyko-Hurko)

Mora Aronsson and Claudia Perini (phot. K. Romeyko-Hurko)
ORAL SESSIONS – AUDIENCE
(24–26 MAY 2011)

phot. K. Romeyko-Hurko
Anna Medwecka-Kornaś (Jagiellonian University, Kraków) (phot. K. Romeyko-Hurko)

POSTER SESSION
(24 MAY 2011)

phot. K. Romeyko-Hurko
DURING BREAKS OF THE CONFERENCE
(24–26 MAY 2011)
GALA DINNER
(26 MAY 2011, KRAKÓW, THE FRANCISCAN MONASTERY)
FIELD SESSIONS
(27 MAY 2011)

In the Ojców National Park (phot. from archive of Z. Mirek)
In the Ojców National Park (phot. Z. Mirek)

In the Pieniny National Park (phot. G. Vončina)
In the Pieniny National Park (phot. W. Paul)

In the Pieniny National Park – rafting on the Dunajec river (phot. W. Paul)
THE POSITIVE EFFECT OF SOME PHYTOREGULATORS ON THE GERMINATION OF RESEDA COMPLICATA SEEDS IS PRESERVED BY LOW TEMPERATURES

Manuel Díaz-Miguel¹ & Pedro Antonio García²

Abstract. The construction of ski resorts in alpine ecosystems has a harsh environmental impact. The ski station of Sierra Nevada (southeast of Spain) has more than 100 km of ski slopes and is still expanding. Although it lies within the geographical limits of a national park, and as such enjoys the highest degree of legal and environmental protection, the restoration of the plant cover does not seem to be a priority even though many of the 80 endemic taxa can be found in the park. The loss of biodiversity in these cases is not easy resolved, given that the seeds of many species of these habitats have very low germination rates; moreover, the soil temperature under the compact snow is also very low. In this paper, data is presented on the seed germination of endemic species, Reseda complicata Bory, used in restoration processes on the slopes of Sierra Nevada. This study has shown positive results against certain pretreatments with several plant growth regulators, effects preserved when the seeds were frozen at -20°C for 3 months. Germination was carried out ex situ under controlled conditions. The results of these experiments let us conclude that pretreatments like the ones used could be effective in increasing germination and could facilitate the restoration of the skiable surface on the ski slopes of Sierra Nevada.

Key words: Reseda complicata Bory, seed germination, ski slopes, Mediterranean high mountains, Sierra Nevada, Spain

¹Departamento de Fisiología Vegetal, Facultad de Ciencias, Universidad de Granada, Avenida de Fuente Nueva s/n, Granada, CP-18071, Spain; e-mail: diazmig@ugr.es
²Departamento de Estadística e Investigación Operativa, Facultad de Ciencias, Universidad de Granada, Campus Fuentenueva s/n, Granada, CP-18071, Spain; e-mail: pgarcia@ugr.es

INTRODUCTION

The Sierra Nevada massif forms part of the Betic Mountains which can be found in the southeast of the Iberian Peninsula covering 200,000 hectares extending some 90 km from east to west. It has some of the highest mountains in Europe, reaching 3482 m (Mulhacen Peak) and is also the southernmost mountain range of the continent, 37°N. With regard to flora, over 2,000 vascular plants, including 80 endemic taxa, can be found (Blanca et al. 2002), making this zone one of the most important hotspots for biodiversity in Europe (Médail & Quézel 1999; Myers et al. 2000; Vogiatzakis et al. 2006). This was one of the motives behind the decision in 1999 to extend the area of the National Park by 90,000 hectares leading to a higher level of legal and environmental protection. Within the limits of the park, the Sierra Nevada ski-slopes occupy a surface area of 350 hectares with a skiable distance of more than 100 km between 2,100 and 3,325 m a.s.l., and still expanding (Fig. 1). Although it lies within the geographical limits of a national park, the restoration of the plant cover does not seem to be a priority even though many of the 80 endemic taxa can be found in the park. The construction of ski resorts results in the destruction of ecosystems and landscapes (Urbanska 1995; Van der Straaten 2000) and the construction of a ski slope has serious consequences such as: loss of vegetation cover, disappearance of the soil seed bank and removal of the upper layers of soil where the nutrients for the growth and development of the plants are found. In order to avoid soil erosion, ski slopes are revegetated in one of the following ways: by sowing wild seed mixtures instead of non-indigenous seeds, by sowing plant seeds for agricultural use or by seed sowing of indigenous species. The restoration of the original vegetation cover on bare soil is very difficult and slow due to the low ability of germination of many high mountain species. On the other hand, the growth and development suffer very low temperatures because the activity of skiing requires compact snow and under these conditions the snow loses its thermoinsulating capacity (Rixen et al. 2004). The germination is controlled, among other factors, by phytohormones (Bewley & Black 1994), and the possibility of using certain plant growth regulators can be seen as a valuable instrument, both for breaking dormancy, and for stimulating germination (Kucera et al. 2005). Actually,
previous experiments carried out in the laboratory have shown that these substances act positively on the germination of some species found in the Sierra Nevada ski area (Díaz-Miguel et al. 2007, 2011). Bearing in mind that the introduction of shrubby species is considered an excellent form of avoiding long term soil erosion (Densmore 1992), we have decided to study, firstly, the germination response to different pretreatments in seeds of shrubby species endemic to the Baetic Mountains, such as Reseda complicata Bory. This species is used in the restoration procedure of the vegetation on the Sierra Nevada ski-slopes. On the other hand, one has to bear in mind that as a general rule seed hydrosowing on the slopes occurs at the end of October, so the seeds remain below the snow at low temperatures facilitating the breaking of dormancy (Vleeshouwers et al. 1995). In this context, it is important to emphasize that the preparation of the slopes in the winter and the ski activity that takes place there compacts the snow causing it to lose its capacity as a thermal insulator. Thus, the vegetation under these conditions remains exposed to temperatures similar to those in the open, in contrast to the areas of loose snow in which the temperature rarely drops below 0°C (Rixen et al. 2004). Due to this, the other objective of the study is to test whether the pretreatments maintain their efficacy when the seeds are subjected to low temperatures before putting them to germinate. Compliance with these objectives is considered necessary as a preliminary step to any type of action at the field level.

MATERIAL AND METHODS

Seeds of Reseda complicata Bory (Resedaceae) were used, collected from a natural population in Sierra Nevada at coordinates 37°05′44″N and 3°23′14″W and at an altitude of 2,500 m a.s.l. The seeds were collected from more than ten individual plants and all of them were mixed thoroughly to minimize effects of single parental plant germination. Before the germination test, the seeds were disinfected in a 1% sodium hypochlorite solution for 10 minutes and then washed thoroughly in distilled, sterilized water. In all the experiments, the seeds were sown in Petri dishes with a diameter of 5.5 cm. 50 seeds per dish were placed on two layers of filter paper resting on glass beads (6 mm in diameter). All of the Petri dishes contained 5 ml of distilled, sterile water or the same amount of different tested solutions. For every treatment four replicates were used and in these and in all subsequent experiments, the dishes were placed in an environmentally controlled chamber – 14h/10h light/dark and 25°/5° day/night.

In the first experiment, before germination, the seeds were placed in separate vials with different solutions for six hours. One vial contained seeds with GA₃ (gibberellic acid, type 3), another with BAP (benzylaminopurine) and a third with ethrel (2-chloroethylphosphonic acid). In all experiments, concentrations of 10⁻⁶ and 10⁻⁵M were used. Similarly, another batch of seeds remained in distilled water for the same amount of time before being seeded using the same method as described above.

Fig. 1. Panoramic view of the slopes of the Sierra Nevada ski resort in the summer (phot. M. Díaz-Miguel).
A second experiment was conducted to analyze the effect of the same pretreatments that were studied in the first experiment, but the seeds were frozen at -20°C for three months before being sown. In this case, the concentrations and incubations were the same as in the previous experiment. Germination was recorded at radical emergence and was monitored daily for a period of 15 days. On the other hand, for each treatment and in the two experiments, it measured $t_{50}$ as the time required to germinate 50% of the maximum germination obtained; which represents a measure of germination speed.

The data were submitted for an analysis of variance and the means were compared using Duncan’s test.

RESULTS

Fig. 2 shows accumulated germination percentages observed when the seeds were soaked for six hours with the three plant regulators used (see material and methods). At $10^{-6}$M the different pretreatments did not have any effect in comparison to the control group ($F=1.653; p=0.178$). However, at $10^{-5}$M the three pretreatments had a statistically significant effect ($F=31.839; p<0.0001$), with BAP being the most effective, followed by GA$_3$ and finally ethrel. The germination grades of these pretreatments were 74%, 60% and 47%, respectively. This represents an 85%, 45% and 17% over 40% control group. These results were similar to those obtained by this species in other experiments under similar conditions (Díaz-Miguel 2010; Díaz-Miguel et al. 2011). On the other hand, the values of $t_{50}$ show that all the pretreatments and the two concentrations used have a higher germination rate than the control; although it is greater at $10^{-5}$M than at $10^{-6}$M (Fig. 3). When the seeds were frozen (Fig. 4), the pretreatments were not able to get the same germination percentage obtained by the unfrozen seeds. However, when we compared these results with those of the control seeds, the

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**Fig. 2.** Effect of different pretreatments on the germination of *Reseda complicata* seeds. Each point represents the average of four replicates and vertical bars indicate ±SE.

**Fig. 3.** Effect of different pretreatments on the germination velocity ($t_{50}$) of *Reseda complicata* seeds.

**Fig. 4.** Effect of different pretreatments on the germination of *Reseda complicata* seeds, previously frozen at -20°C. Each point represents the average of four replicates and vertical bars indicate ±SE.
pretreatments were significantly more effective (F=29.427; p<0.0001). Thus, the germination percentages were: 5%, 14%, 48%, 47%, 33%, 14%, and 29% by BAP 10^{-6}, BAP 10^{-5}, GA3 10^{-6}, GA3 10^{-5}, ethrel 10^{-6} and ethrel 10^{-5}M, respectively. In this experiment, except with the seeds pretreated with gibberellins, the concentration 10^{-5}M was more effective, too. An analysis of a50 revealed that all pretreatments, in this second experiment, presented higher rates of germination when compared with the control group, except in the case of BAP 10^{-5}M (Fig. 3). However, this result may be insignificant due to the very low germination percentage of the control seeds.

**DISCUSSION**

The construction of a ski resort is one of the major causes of environmental degradation in mountain regions (Urbanska 1995; Titus & Tsuchuzaki 1998; Ruth-Balaganskaya & Myllynen-Malinen 2000; Wipf et al. 2005) and one of the most common consequences is the formation of large areas of bare soil (Tsuchuzaki 1995; Urban ska & Fattorini 2000). Therefore, revegetation of the affected areas is essential to prevent erosion (Muller et al. 1998). Non-native species, mainly grasses, are often used because they are easier to acquire on the market; it is cheaper to obtain the seeds and they also have the ability to establish a vegetative cover sufficient to control the erosion. However, the use of these non-native species is considered a serious threat to these ecosystems and, in general, for the maintenance of biodiversity (Vitousek et al. 1997; Sala et al. 2000). The restoration of Mediterranean mountain ecosystems has not been studied as much as the Alpine mountains (Grabherr et al. 2003), but it is important to do so because the Mediterranean mountains are different in that they have dry summers and cold winters, creating two distinct stress periods for the plants (Giménez-Benavides et al. 2007). Sierra Nevada (SE Spain) is an example of high mountains with these weather patterns and has the southernmost ski resort in Europe. With regard to its climate, temperatures can be reached with a low of -14°C in the coldest month and a high of 26°C in the warmest. Moreover, the average annual precipitation is 925 mm, mainly in the form of snow, reaching a thickness of more than 2 m in the ski resort. However, in some areas, 5 m of thickness can be reached (Gómez Ortiz 2002).

Snow is an excellent insulator (Sturm et al. 2005), so in areas with warm climates, soil freezes during the winter, if it is not insulated by snow (Groffman et al. 2001; Venäläinen et al. 2001; Stieglitz et al. 2003; Öquist & Laudon 2008). Even if the soil is covered by snow, it may change its quality; likewise it is in the case of snow that is more compact due to changing wind patterns or the formation of an ice sheet due to thawing and freezing processes intensified in the winter (Arctic Climate Impact Assessment 2004). In these cases, there is less insulation from the ground and therefore the soil reaches lower temperatures (Körner 2003). These conditions may have important consequences for recruitment of seeds and influencing seed germination (Vleeshouwers et al. 1995; Baskin & Baskin 1998). Milbau et al. (2009) showed that soil with colder temperatures during the winter suffered a delay in the germination of several species and lower rates of germination. This is what happens on ski slopes due to the preparation and the skiing itself that compacts the snow exposing the underlying vegetation to very low temperatures for several months (Rixen et al. 2004). Hydroseeding procedures have been taking place on the Sierra Nevada ski slopes since 2002. In all cases, the procedures have taken place during the fall, around October, before the first snowfall. A mixture of the native seeds have been used and among them *Reseda complicata* represented almost 20% of the total (Lorite et al. 2010), and although the results after eight years were not the worst ones, the percentage of germinated seeds was low thus making it necessary to use higher seeding or optimize seed germination of many of the species used. The pressure from the important social sectors in favour of expanding the skiable surface in Sierra Nevada continues to grow and in fact, in the present year of 2011, the ski area has increased by 15 kilometers. The difficulties in restoring the Sierra Nevada ski slopes could seriously affect the vegetation and landscape integration which could create greater environmental damage in the near future. The data obtained in the experiments presented here confirm that the use of certain plant growth regulators with seeds of *R. complicata*, mainly BAP and GA3, can be effective in increasing its germination and are equally effective in the specific case of ski slopes, where the seeds remain at low temperatures. Studies on other species, similar to the ones presented here, could facilitate the restoration of the skiable surface at Sierra Nevada but it would be necessary to test these results in field conditions.

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FLORA GUARDIANS

Margareta Edqvist¹ & Charlotte Wigermo²

Abstract. Flora Guardians is the main monitoring scheme for vascular plants in Sweden and, since it started 1987, it has expanded to cover nearly all threatened vascular plants and all of the territory. The project is driven and coordinated by botanical NGOs. In 2010, there were nearly 6,000 sites for threatened vascular plants visited and, additionally, 1,000 sites for Near Threatened species.

Key words: monitoring, vascular plants, citizen science, NGO

¹Flora Guardians national coordinator, Syrengatan 19, Nässjö, SE-571 39, Sweden; e-mail: margareta.edqvist@telia.com
²Flora Guardians regional coordinator, Fästningsgatan 19B 4 tr., Kristianstad, SE-291 34, Sweden; e-mail: charlotte.wigermo@gmail.com

BACKGROUND

Project Linné. In 1972, Örjan Nilsson and Lars-Åke Gustafsson started a project for the documentation of some rare and threatened vascular plants in Sweden financed by World Wildlife Fund WWF Sweden and the Swedish Environmental Protection Agency (SEPA) (Nilsson & Gustafsson 1976). Until 1985, a substantial amount of data was collected for about 150 species. This data was the underpinning for the red listing of vascular plants in Sweden and for the Flora Guardians project.

Flora Guardians. It was launched in 1987 on the initiative of WWF (then under the changed name World Wide Fund for Nature) Sweden and the Swedish Species Information Centre (SSIC). At the beginning it was a small project in one county and 30 sites. Already in the following year tree more counties were involved and in 1998 the whole of Sweden was covered by the Flora Guardians except some areas in the mountain range.

Today, the project is financed by the SEPA and the SSIC and since 2005 it has been coordinated by the Swedish Botanical Society (until 2004 by SSIC).

THE PROJECT

Flora Guardians is an NGO network of people interested in nature, botany and/or nature conservation who monitor threatened vascular plants in Sweden by regular visits on the sites of such species (Fig. 1). Both amateurs and professional botanists (both young and old) are interested in the project. What all of them have in common is an interest in the long-term survival of our rarest plants and their sites.

Fig. 1. Flora guardians in action (phot. M. Edqvist).
The organisation is led by a national coordinator (employed part-time by the Swedish Botanical Society), 24 regional coordinators (members of regional botanical societies) and about 500 flora guardians.

Besides administrative coordination, the national coordinator’s main task is to give feedback to the people doing the work by organizing regular meetings and courses as well as issuing publications.

Flora guardians are mainly recruited by means of personal contact, articles in local newspapers and magazines and information disseminated during fairs or similar events.

The first step is to be interested. If someone is interested but does not have any profound botany knowledge he/she can monitor easily recognisable species of such genera as *Pulsatilla*, *Thesium* and *Salvia*. For more cryptic species like those from the *Taraxacum* genus, amateurs need much more skill (professionals are very rare among the flora guardians).

To keep project activities coherent, one meeting a year is organized on average (in some parts of Sweden meetings are held more often or irregularly). The aims of such meetings are sharing of experience, calibration of methods/knowledge, courses in field methods and IT reporting.

**PURPOSE OF THE PROJECT**

The purpose of the project is to monitor the known sites of threatened vascular plants, the number of their individuals, and the state of the site as well as to detect trends. The flora guardian’s duty is also to inform the landowners on what species of threatened vascular plants have sites within their property and to be in touch with the authorities, if some action is needed. The guardian reports back to the regional coordinator and digitize the results of site monitoring at the Species Gateway (see below).

In some cases the flora guardian performs some action for the preservation of some threatened sites by e.g. mowing or cutting shrubs. This sort of activity is becoming increasingly popular.

Another important task is the dissemination of knowledge concerning red-listed species. The Flora Guardians project issues annual fact sheets that can be used to inform interested parties (including landowners and stakeholders) and are also distributed at National Park information centres, fairs and exhibitions. More information and fact sheet downloading opportunities can be found on the Swedish Botanical Society’s website (http://www.sbf.c.se).

Mapping and monitoring Swedish threatened plant species is very important for the conservation of our flora’s richness and diversity.

**WHICH SPECIES SHOULD BE MONITORED?**

All nationwide threatened species (Critically Endangered – CR, Endangered – EN and Vulnerable – VU) that occur within indigenous populations in particular counties are targets for regional flora guardians. The number of species of interest (see Table 1) varies considerably between different counties in Sweden (Fig. 2) and the workload for different regional projects varies accordingly. At county level, some species in the Near Threatened
Species or populations that have “escaped” from gardens are not targeted.

To ensure the quality, there are frequent calibration meetings held and field excursions made. Specialists collaborate with the Species Gateway to validate all finds of red-listed plants.

### HOW OFTEN SHOULD A SPECIES OR A SITE BE MONITORED?

Ideally, every site should be monitored on an annual basis (at least once a year), yet this is hardly possible for all the monitored sites because some parts of the country have very few flora guardians in relation to the number of sites of threatened plants. In this situation, it is assumed that the most threatened plant species and sites are monitored yearly and the rest of them should be visited every third or fifth year. The prioritising is done mainly on a regional scale with some national recommendations. Additionally, there are national campaigns for selected species organized every year.

For vascular plant species there is often a need of long-term monitoring before a change trend in the population/site is verified as the fluctuation between the years is often considerable. It is therefore important that the visits are carried out in the same circumstances every year so the data collection can be as uniform as possible.

Ideally one person monitors the same site for a long time to avoid differences in the results caused by the monitoring being carried out by different persons, but in some cases a group of people are responsible for all the localities in the municipality and share the work or different persons monitor the same site in subsequent years (however the Flora Guardians coordinators try to avoid the latter situation).

### SPECIES GATEWAY

All the data from flora guardians is deposited in the national database for species observation called Species Gateway (http://www.artportalen.se), a public repository for observations on species. The site is hosted by the SSIC and is developed in cooperation between national biological NGOs and the SEPA.

### RESULTS

In 2010, nearly 6,000 sites of threatened (CR, EN, VU) vascular plant species and 1,000 sites of Near Threatened (NT) ones were visited. *Botrychium simplex* E. Hitchc. (a species of Annex 2 of the Habitat Directive), all Swedish sites of which are monitored in the framework of the Flora Guardians project, can be given as an example (Figs 3 & 4).

### ECONOMY

The national coordinator is financed by the Swedish Species Information Centre. His total costs, including salary, travelling, information collection and materials, is about 45,000 euros annually. The county coordinators and flora guardians work on a voluntary basis and are not paid.

The SEPA supports the programme with 86,000 euros yearly. This sum is distributed among regional organisations according to the amount of the work done. The regional coordinators can use the money to finance information activities, courses, literature, maps, GPS equipment, and travel.
CONCLUDING REMARKS

Our organisation considers that with our small budget we can regularly monitor the majority of the sites for threatened species in Sweden.

The collaboration between the government and the non-governmental organizations involved has worked without considerable problems.

Two facts have importantly contributed to the success of the project: that the National Botanical Society has taken the leadership in this work and that it has been possible to engage the flora guardians to work voluntarily.

ACKNOWLEDGMENTS. The authors wish to thank Torleif Ingelöf for the bright idea of initiating the Flora Guardians and to Mora Aronsson for all the work to establish the network and all the support since the Swedish Botanical Society took over the coordination.

The authors are also thankful to all the flora guardians who do all the work in the field, and – last but not least – to all landowners who help our species to survive.

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THE DIAGNOSTIC FEATURES OF DEVELOPMENTAL PHASES IN *BOTRYCHIUM LUNARIA*, A RARE OPHIOGLOSSACEAE FERN IN LITHUANIA

Sigitas Juzėnas & Jonas Remigijus Naujalis

**Abstract.** Archaic ferns of the Ophioglossaceae family are rare in Europe. Recently a rapid decline of those ferns has been observed in many countries. Unfortunately, the demographic structure of Ophioglossaceae fern populations is poorly understood. Two groups of sporophyte developmental phases were distinguished in the study of *Botrychium lunaria* (L.) Sw. - Hust. populations in Lithuania: active (elevated above the soil surface) and passive (subterranean) demographic groups. The active demographic group was divided into the following developmental phases: virgin (v), fertile (f1, f2 and f3) and sub-senile (ss). The passive one was likewise divided into: sprouts (sp), juvenile (j) and secondary dormant sporophytes (sd).

The main discriminating criteria of the developmental phases were: the relationship with the gametophyte, leaf differentiation into trophophore and sporophore, the degree of trophophore and sporophore development, and the degree of sporophore sporification. An additional criterion was the biological age of the sporophyte (determined by the counting of roots).

**Key words:** Ophioglossaceae, *Botrychium lunaria* (L.) Sw., developmental phases

**Vilnius University, Department of Botany and Genetics, 21/27 M. K. Čiurlionio St., Vilnius, LT-03101, Lithuania; e-mails: sigitas.juzenas@gf.vu.lt; jonas.naujalis@gf.vu.lt**

INTRODUCTION

Archaic ferns of the Ophioglossaceae family are rare in Europe. Even one the most widespread species in Europe – *Botrychium lunaria* (L.) Sw. – is included in a number of European Red Lists: least concern (Wind & Pihl 2004), near threatened (Király 2007; Rassi et al. 2010), and threatened (Holub & Procházk 2000; Colling 2005; Mirek et al. 2006). In Lithuania, *B. lunaria* is rare in the western part of the country but quite common in its southeastern part. Unfortunately, the demographic structure of Ophioglossaceae fern populations is poorly understood, because it is difficult to distinguish their demographic components. The first attempt to separate the developmental phases of ferns from the Ophioglossaceae family was published by J. Naujalis in 1995. Two groups of the developmental phases of the sporophytes were distinguished in studies of populations of Ophioglossaceae ferns in Lithuania – an active demographic group (i.e. plants elevated above the soil surface) and a passive demographic group (plants of the subterranean phase). The active demographic group was divided into the following developmental phases: virgin (v), fertile (f1, f2 and f3) (Fig. 1) and sub-senile (ss). The passive one was likewise divided into: sprouts (sp), juvenile (j) and secondary dormant sporophytes (sd).

The main exclusion criteria of the developmental phases, proposed by J. Naujalis (1995), were: the relationship with the gametophyte, leaf differentiation into trophophore and sporophore, the degree of trophophore and sporophore development, and the degree of sporophore sporification.

**MATERIAL AND METHODS**

The material for this research was collected in Varėna district (the southeastern part of Lithuania) in July 2007. An anthropogenic biotope on a sandy roadside in a forest was chosen. 120 individuals of *Botrychium lunaria* were dug out from an area of 3×4 meters. Only two individuals from the sub-senile (ss) group were found in this population, so that it was not enough to make conclusions related to the morphological features of this group. They were excluded from the following analysis.

Research on the morphological polymorphism of the developmental phases of the sporophytes in the population was carried out. The pressed specimens were scanned with 600 dpi resolution and then the resultant colour images of the individuals were analysed applying IMAGEJ (ver.1.43) software (Abramoff et al. 2004). The evaluated morphological features of *B. lunaria* developmental phases are shown in Fig. 2.
A statistical analysis of the morphological data was performed using PAST (ver.2.05) software (Hammer et al. 2001).

RESULTS AND CONCLUSIONS

ANALYSIS OF CONTINUOUS CHARACTERS

A principal component analysis (PCA) of the measured and counted features of the Botrychium lunaria developmental phases was performed (Fig. 3). The first component, combining all features related to the plant size, showed a gradient of size, which made it possible to separate individuals from different developmental phases. All dimensions of the ferns increased from virgin (v) to fertile (f3). However, a one-way ANOSIM analysis applying Euclidean distance on z-transformed continuous characters did not detect any statistically significant (p>0.05) differences between the developmental phases. Therefore, the continuous features related to size of B. lunaria ferns are not sufficient to differentiate between the developmental phases.

The evidence of a relation between the biological age (number of roots) and continuous or ordinal characters was checked applying Spearman’s rank correlations. Only the number of trophophore pinnae correlated statistically significantly (p = 0.034) with the number of roots (in the pooled group of

Fig. 1. Typical individuals of Botrychium lunaria from different groups of developmental phases (active demographic group).

Fig. 2. Evaluated morphological features of Botrychium lunaria developmental phases.
individuals from all the developmental phases, but the relation between those characters was very weak – rs = 0.194. Relations between continuous characters and the biological age were also tested separately in groups of ferns from different developmental phases. A statistically significant correlation was found only in the virgin (v) group: counts of roots strongly correlated with trophophore length (rs = 0.828, p = 0.03).

**ANALYSIS OF SELECTED DIAGNOSTIC FEATURES**

Non-metric multidimensional scaling (nmMDS) using Gower distances was performed to select an optimal set of quantitative and qualitative characters discriminating *Botrychium lunaria* individuals from different developmental phases. The best separated groups of individuals from different developmental phases were obtained using the following set of morphological characters: the ratio of sporophore to trophophore length, the degree of sporophore pinnation, the number of roots, the number of trophophore pinnae and the number of clefts in basal pinna pair (Fig. 4). One-way ANOSIM applying Gower distances was performed to test the differences between the developmental phases using the aforementioned morphological features. Individuals from all developmental phase groups (except fertile (f2) – fertile (f3) pairs of groups) differ significantly. Further investigation using material from different populations will show whether it is reasonable to exclude independent groups of fertile

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**Fig. 3.** Principal component analysis (PCA) of quantitative features of *Botrychium lunaria* developmental phases (active demographic group).

**Fig. 4.** Non-metric multidimensional scaling (nmMDS) applying Gower distance of diagnostic morphological features of *Botrychium lunaria* developmental phases (active demographic group).
(f1), fertile (f2) and fertile (f3) individuals (proposed by J. Naujalis (1995)) or only two groups of fertile ferns – f2 and f3.

The developmental phases separated using the same criteria can be adapted to other fern species from the Ophioglossaceae family.

REFERENCES


DIVERSITY AND SELECTED FUNCTIONAL TRAITS OF VASCULAR PLANTS ON HISTORICAL STRUCTURES OF AGRICULTURAL LANDSCAPE IN SOUTH-WESTERN SLOVAKIA

Róbert Kanka

Abstract. Historical structures of agricultural landscape (HSALs) represent a mosaic of small-scale arable fields and permanent agricultural cultivations (grasslands, vineyards, fruit and chestnut orchards) and non-forest vegetation. Three pilot areas were chosen for in-depth research: the cadastral district of the towns of Svätý Jur and Hriňová and the Liptovská Teplička village. Research covering abiotic, biotic and socioeconomic components of HSALs took significant part of the project. 205 taxa of vascular plants were determined in 16 phytosociological relevés covering representative HSALs, including 6 threatened and protected taxa and 8 invasive ones. Species richness, Shannon index of diversity, Pielou index of evenness life forms, synanthropisation and intensity of hemeroby were calculated for each representative site. The results show a high importance of agricultural landscape, especially historical structures, not only for supporting the diversity of vascular plants and functioning as refugia for threatened and protected species, but also as areas with a high degree of synanthropisation and intensity of hemeroby providing suitable niches for invasive species. The main aim of this contribution is bringing together the most essential information covering flora, vegetation and habitats of HSALs in the pilot area of the Svätý Jur town cadastral district.

Key words: historical structures of agricultural landscape (HSALs), diversity of vascular plants, functional traits, habitats, Svätý Jur town, Slovakia

Institute of Landscape Ecology of the Slovak Academy of Sciences, 3 Štefánikova St., Bratislava, SK-81499, Slovakia; e-mail: robert.kanka@savba.sk

INTRODUCTION

The agricultural landscape is a mosaic of natural and human-managed patches of varying size, shape and arrangement. Besides its major functions related to provisioning, supporting and regulation services agricultural landscape represents an important platform for occurrence of small forest islands and other valuable habitats offering suitable conditions for plant and animal taxa (Chmiel 1998; Banaszak 2000; Duchoslav 2002; Simonová 2008). Agricultural landscape formed mainly by vineyards not only represents an important economic aspect but also belongs to the cultural-historical heritage of Slovakia. The flora and vegetation of medieval settlements and castles are documented in works of Brandes (1996), Celka (2011) and Kamiński (2004, 2006). Detailed research focusing on plant diversity in vineyards and their surrounding has been done by Eliáš (1980, 1983, 1995, 1997).

The project Research and maintenance of biodiversity in the historical structures of agricultural landscape of Slovakia (2009–2011) was focused on the elaboration of a strategy aimed at the conservation and management of the historical structures of agricultural landscape (HSALs), the identification of landscape types as a basis for improving the knowledge about the landscape as well as increasing the stakeholders’ awareness of the value of the landscape. Detailed research of abiotic, biotic and socioeconomic components of landscape was carried out, whereby the evaluation of the diversity of vascular plants brought essential information within the biota assessment. The historical structures of agricultural landscape in Slovakia represent a mosaic of small-scale arable fields and permanent agricultural cultivations (grasslands, vineyards, high-trunk orchards) and non-forest vegetation. As main sources of local biodiversity, they are linked to balks and margins of cross-field tracks, original meadows and pastures, grass-covered former arable fields abandoned after collectivization, small wetlands or other low production or unfavourable areas. They are unique islands of species-rich plant and animal communities, originated by continuous succession over the centuries. They are a result of a long-term, mutual relationship between man and the landscape and they depended on continuous agricultural activity (Dobrovodská & Štefunková 1996). Most of the HSAL sites are characterised by the presence of soil/stone features (balks) – forms of anthropogenic relief (FAR) – which are
distinguished by origin, skeleton parts content, different shape and size (length, width, high), continuity, degree of habitat dominance, which has been created and developed on FAR, a horizontal canopy of shrubs and trees, as well as plant species composition (Dobrovodská et al. 2010).

The case study area of the Svätý Jur town cadastral district (Fig. 1) is located 14 km north-west from Bratislava, in the foothills of Small Carpathians and a flat of the Podunajská nížina lowland at an altitude of 130–370 m. a.s.l. The vineyard landscape is made of faulted slopes and plains, covered predominantly with cambisols and rankers on crystalline subsoil. The area belongs to a moderately warm climate region: the average temperature in July is over 16°C and the average annual rainfall amounts to 600–850 mm. Vine-growing use of the area of Small Carpathians was documented already in Roman times and was one of the most productive economic sectors since the Middle Ages, due to the favourable natural conditions and a relatively small distance from strong trade centres such as Bratislava, Vienna and Budapest. The tradition of viti- and viniculture has been known for approximately 1,200 years (i.e. systematic planting of vine, confirmed in written documents), and planting of chestnut (Castanea sativa Mill.) for 900 years. The flora of the Svätý Jur town cadastral district belongs to that of the district of West Carpathians – Carpaticum occidentale, the Praecarpaticum division and the Malé Karpaty [=Small Carpathians] region (Futák 1980).

HSALs in the Svätý Jur town cadastral district are represented by the following types of land use and anthropogenic relief forms: (a) orchards without or with terraces, (b) vineyards – intensively or extensively managed or abandoned; stake or wire, (c) stone mounds (walls) freely built of field-stones removed from the arable land, (d) stone heaps (cairns) built of field-stones removed from the

Fig. 1. Map of Slovakia and the Svätý Jur town (base map: Turistický atlas Slovenska 1:50 000 (2007)).
arable land, (e) dry stone walls (stone fences) built from natural stone without mortar, (f) built stone walls (mortared stone fences) and (g) stone heaps and mounds deposited into step bounds.

The main aim of this contribution is to present the results of research related to the evaluation of diversity, synanthropisation, life forms and the intensity of hemeroby on the historical structures of agricultural landscape in the cadastral district of the Svätý Jur town as a typical representative of the vineyard agricultural landscape in south-western Slovakia.

MATERIALS AND METHODS

16 representative HSAL sites were selected and established for detailed research (Table 1), the majority of them with a mosaic structure and a high habitat diversity. Line stands of native and invasive broadleaved tree species, blackthorn (*Prunus spinosa* L.) shrubs and secondary scree and rocky habitats on stone mounds, a mosaic of thermophilous ruderal vegetation outside settlements, fallows and extensively managed fields are typical for extensively managed vineyards.

The classification and nomenclature of bio-
topes, following a detailed phytosociological field research, were carried out using the Catalogue of habitats of Slovakia (Ružičková et al. 1996; Stanová & Valachovič 2002). Phytosociological relevés were taken in compliance with classical methods of the Zürich-Montpellier school (Braun-Blanquet 1964; Moravec et al. 1994). Abundances of species were estimated by the 7-aggregated combined Braun-Blanquet scale for abundance and dominance. The taxa of vascular plants were determined according to Dostál & Červenka (1991, 1992). The data obtained from the field were stored in the TURBOVEG database (Hennekens & Schaminee 2001). The basic arrangement of the phytosociological table was made with the JUICE 6.2 software (Tichý 2002). The nomenclature of the vascular plants followed Marhold et al. (1998).

The number of taxa does not represent diversity sensu stricto – diversity includes also the distribution-relative taxa number and the evenness of space distribution. Taxonomic diversity is dependent mainly on the ecological quality of habitats (Jurko 1990).

Taxonomic diversity was evaluated in three ways: (1) Number of taxa (α-diversity), (2) Shannon index of diversity and (3) Pielou index of evenness.

The formula for the calculation of Shannon index:

\[ H' = -\sum_{i=1}^{S} \left( \frac{n_i}{N} \right) \log_2 \left( \frac{n_i}{N} \right) \]

where: \(^{n_i}\) – abundance of each of \(S\) species, \(N\) – sum of the abundances of all species, \(^i\) – index of summation.

The formula for the calculation of Pielou index:

\[ J' = \frac{H'}{H'_{\text{max}}} \]

where: \(H'\) – Shannon index, \(H'_{\text{max}}\) – the maximum value of \(H'\).

The scales for the evaluation of Shannon and Pielou indices are given in Tables 2 & 3.

<table>
<thead>
<tr>
<th>Code</th>
<th>Name of site</th>
<th>Type of HSAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>SJ1a</td>
<td>Podhradie</td>
<td>Stone mound</td>
</tr>
<tr>
<td>SJ1b</td>
<td>Podhradie</td>
<td>Stone heap</td>
</tr>
<tr>
<td>SJ2a</td>
<td>Podhradie</td>
<td>Stone mound</td>
</tr>
<tr>
<td>SJ2b</td>
<td>Podhradie</td>
<td>Fruit orchard with terraces</td>
</tr>
<tr>
<td>SJ2c</td>
<td>Podhradie</td>
<td>Managed pinned vineyard with terraces</td>
</tr>
<tr>
<td>SJ3a</td>
<td>Podhradie</td>
<td>Abandoned pinned vineyard with terraces</td>
</tr>
<tr>
<td>SJ4ab</td>
<td>Pitvory</td>
<td>Stone mound</td>
</tr>
<tr>
<td>SJ5a</td>
<td>Pitvory</td>
<td>Intensively managed wire vineyard with terraces</td>
</tr>
<tr>
<td>SJ5b</td>
<td>Pitvory</td>
<td>Abandoned wire vineyard with terraces</td>
</tr>
<tr>
<td>SJ6</td>
<td>Pitvory</td>
<td>Stone mound</td>
</tr>
<tr>
<td>SJ7</td>
<td>Pitvory</td>
<td>Extensive managed pinned vineyard with terraces</td>
</tr>
<tr>
<td>SJ8</td>
<td>Malé Nové Hory</td>
<td>Extensive managed pinned vineyard with terraces</td>
</tr>
<tr>
<td>SJ9</td>
<td>Malé Nové Hory</td>
<td>Stone mound</td>
</tr>
<tr>
<td>SJ10</td>
<td>Malé Nové Hory</td>
<td>Stone mound – dry stone wall</td>
</tr>
<tr>
<td>SJ11</td>
<td>Malé Nové Hory</td>
<td>Very high</td>
</tr>
<tr>
<td>SJ12</td>
<td>Malé Nové Hory</td>
<td>Very high</td>
</tr>
</tbody>
</table>

Table 1. List of sites studied in the Svätý Jur town cadastral district and HSALs they represented.

Table 2. Scale for the evaluation of the Shannon index.

<table>
<thead>
<tr>
<th>Verbal description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>extremely low diversity</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>very low</td>
<td>0.5–1</td>
</tr>
<tr>
<td>medium-low</td>
<td>1–1.7</td>
</tr>
<tr>
<td>low</td>
<td>1.7–2.5</td>
</tr>
<tr>
<td>low-medium</td>
<td>2.5–3.3</td>
</tr>
<tr>
<td>medium</td>
<td>3.3–4</td>
</tr>
<tr>
<td>semi-high</td>
<td>4–5</td>
</tr>
<tr>
<td>high</td>
<td>5–7</td>
</tr>
<tr>
<td>very high</td>
<td>7–10</td>
</tr>
<tr>
<td>extremely high</td>
<td>&gt;10</td>
</tr>
</tbody>
</table>

The evaluation of synanthropic and invasive species follows the classification of Halada (1996). The following categories were used: A – proanthropophytes (native taxa, growing in natural stands and communities), A1 – proanthropophytes with a documented state of occurrence, A2 – proanthropophytes with an undocumented state of occurrence, B – apophytes (native taxa growing in disturbed land, such as in abandoned fields), B1 – taxa occurring mainly in natural communities, B2 – taxa occurring in both natural and synanthropic communities, B3 – taxa occurring mainly in synanthropic communities, C – archaeophytes (taxa introduced into the country from elsewhere in the world before the entirely arbitrary date of 1500 AD), D1 – neophytes occurring only in synanthropic communities, D2a – neophytes growing in seminatural and natural communities but not changing the structure of the community, D2b – neophytes growing in seminatural and natural communities, essentially changing the structure of the community (invasive species); F1 – taxa belonging to the category C or D, F2 – taxa belonging to the category B or C, F3 – taxa belonging to the category B, C or D.

The term “hemeroby” comes from the Greek ήμερος (“hemeros” – cultivated, tamed and refined). It was introduced in ecology by Jalas (1955) in order to classify plant species according to the degree of their share in neophytic species. The degree of hemeroby is “an integrative measure for the impacts of all human interventions on ecosystems, whether they are intended or not. The degree of hemeroby is the result of the impact on a particular area and the organisms which inhabit it” (Sukopp 1976). It increases with growing human impact (Sukopp 1969, 1972, 1976; Kowarik 1988; Jackowiak 1993). The evaluation of hemeroby intensity is according to Steinhardt et al. (1999) (Table 4). Six degrees of hemeroby were used: ahemerobe (a), oligohemerobe (o), mesohemerobe (m), β-euhemerobe (b), α-euhemerobe (c), and polyhemerobe (p).

RESULTS

16 phytosociological relevés including 205 determined taxa of vascular plants were taken on all the representative HSALs. Consequently, biotopes, their mosaics and phytosociological units were evaluated and classified (Table 5). The HSALs are situated in the area with two potential primary vegetation units: oak-hornbeam Carpathian forests and acidophilous oak forests.

ECOSOZOLOGICAL SIGNIFICANCE – THREATENED AND PROTECTED SPECIES

The ecosozological significance of the vascular plants on the representative sites of the Svätý Jur town cadastral district is relatively high. Several species recorded in European and national red lists were found here. Lonicera caprifolium L., a species of national importance according to Appendix no. 4 of Regulation no. 24/2003¹, occurs on stone mounds and abandoned pinned vineyards. Protected taxa: Orchis pallens L., O. mascula (L.) L. subsp. signifera (Vest) Soó and Platanthera bifolia (L.) Rich. were recorded in chestnut orchards and under stone mounds. Cerasus fruticosa Pall. (VU) and Epipactis helborine (L.) Crantz (LR:nt), species included in the Red List of the ferns and vascular plants of Slovakia (Feráková et al. 2001), occur on stone mounds and heaps. Another species from the Red List, Papaver dubium L. (LR:nt), grows in managed pinned vineyard.

DIVERSITY OF VASCULAR PLANTS

The diversity of vascular plants depends on (a) the type of HSAL, (b) the type and structure of the habitat, and (c) the type and intensity of management. The number of taxa recorded within

<table>
<thead>
<tr>
<th>Verbal description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>extremely low evenness</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td>very low</td>
<td>0.1–0.2</td>
</tr>
<tr>
<td>medium-low</td>
<td>0.2–0.3</td>
</tr>
<tr>
<td>low</td>
<td>0.3–0.4</td>
</tr>
<tr>
<td>low-medium</td>
<td>0.4–0.5</td>
</tr>
<tr>
<td>medium</td>
<td>0.5–0.6</td>
</tr>
<tr>
<td>semi-high</td>
<td>0.6–0.7</td>
</tr>
<tr>
<td>high</td>
<td>0.7–0.8</td>
</tr>
<tr>
<td>very high</td>
<td>0.8–0.9</td>
</tr>
<tr>
<td>extremely high</td>
<td>0.9–1</td>
</tr>
</tbody>
</table>

the HSAL sites varied from 21 in wire vineyard (SJ5) to 51 on stone heap with a vast abundance of shrubs (SJ1b). The value of Shannon index ranged from 2.66 (SJ12) to 3.39 (SJ2a), so it has indicated shrubs (SJ1b). The value of Pielou index ranged from 0.63 (SJ5b) to 1 (SJ5a), that is to the maximum value of the index (Fig. 2).

**Table 4. Scale of hemeroby (Steinhardt et al. 1999).**

<table>
<thead>
<tr>
<th>Degree of hemeroby</th>
<th>Degree of naturalness</th>
<th>Human impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>a-ehemerobe (a)</td>
<td>natural</td>
<td>none</td>
</tr>
<tr>
<td>oligohemerobe (o)</td>
<td>close to natural</td>
<td>limited removal of wood, pastoralism, immissions through air and water</td>
</tr>
<tr>
<td>mesohemerobe (m)</td>
<td>semi-natural</td>
<td>clearing and occasional ploughing, clear cut, occasional slight fertilisation</td>
</tr>
<tr>
<td>β-ehemerobe (b)</td>
<td>relatively far from natural</td>
<td>application of fertilizers, lime and pesticides, ditch drainage</td>
</tr>
<tr>
<td>α-ehemerobe (c)</td>
<td>far from natural</td>
<td>deep ploughing, drainage, application of pesticides and intensive fertilisation</td>
</tr>
<tr>
<td>polyhemerobe (p)</td>
<td>strange to natural</td>
<td>single destruction of the biocenosis and covering of the biotope with external material at the same time</td>
</tr>
<tr>
<td>metahemerobe (t)</td>
<td>artificial</td>
<td>biocenosis destroyed</td>
</tr>
</tbody>
</table>

**Table 5. Habitats and phytosociological units in the examined HSALs of the Svätý Jur town cadastral district.**

<table>
<thead>
<tr>
<th>Code of sampling site</th>
<th>Habitats / phytosociological units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SJ1a</td>
<td>Line stands of the broadleaved native tree species / Querco petraeae-Carpinetum Soó et Pócs 1957</td>
</tr>
<tr>
<td>SJ1b</td>
<td>Blackthorn shrubs / Berberidion Br.-Bl. 1950</td>
</tr>
<tr>
<td>SJ2a</td>
<td>Secondary scree and rocky habitats / Galeopsion segetum Oberd. 1957; Cymbalario-Asplenion Segal 1969 em. Mucina 1993</td>
</tr>
<tr>
<td>SJ2b</td>
<td>Mosaic of the lowland hay meadows (Natura 2000), thermophilous ruderal vegetation outside settlements, fallows and extensively managed fields / Arrhenatherion elatioris Koch 1926; Sisymbrium officinalis R. Tx., Lohmeyer et Preising in R. Tx. 1950; Convolvulo-Agropyron repentis Görs 1966</td>
</tr>
<tr>
<td>SJ2c</td>
<td>Mosaic of the thermophilous ruderal vegetation outside settlements, fallows and extensively managed fields / Sisymbrium officinalis R. Tx., Lohmeyer et Preising in R. Tx. 1950; Convolvulo-Agropyron repentis Görs 1966; Veronico-Euphorbion Sissingh ex Passarge 1964</td>
</tr>
<tr>
<td>SJ3a</td>
<td>Mosaic of the thermophilous ruderal vegetation outside settlements, fallows and extensively managed fields / Sisymbrium officinalis R. Tx., Lohmeyer et Preising in R. Tx. 1950; Convolvulo-Agropyron repentis Görs 1966; Veronico-Euphorbion Sissingh ex Passarge 1964</td>
</tr>
<tr>
<td>SJ4a</td>
<td>Mosaic of the line stands of the broadleaved native and invasive (Robinia pseudoacacia) tree species / Querco petraeae-Carpinetum Soó et Pócs 1957; Robinietea Jurko 1963</td>
</tr>
<tr>
<td>SJ4b</td>
<td>Line stands of the broadleaved native tree species / Querco petraeae-Carpinetum Soó et Pócs 1957;</td>
</tr>
<tr>
<td>SJ5a</td>
<td>Mosaic of the thermophilous ruderal vegetation outside settlements, fallows and extensively managed fields / Sisymbrium officinalis R. Tx., Lohmeyer et Preising in R. Tx. 1950; Convolvulo-Agropyron repentis Görs 1966; Veronico-Euphorbion Sissingh ex Passarge 1964</td>
</tr>
<tr>
<td>SJ5b</td>
<td>Mosaic of the thermophilous ruderal vegetation outside settlements, fallows and extensively managed fields / Sisymbrium officinalis R. Tx., Lohmeyer et Preising in R. Tx. 1950; Convolvulo-Agropyron repentis Görs 1966; Veronico-Euphorbion Sissingh ex Passarge 1964</td>
</tr>
<tr>
<td>SJ6</td>
<td>Mosaic of the blackthorn shrubs on a secondary scree and rocky habitats / Berberidion Br.-Bl. 1950; Galeopsion segetum Oberd. 1957; Cymbalario-Asplenion Segal 1969 em. Mucina 1993</td>
</tr>
<tr>
<td>SJ7</td>
<td>Mosaic of the thermophilous ruderal vegetation outside settlements, fallows and extensively managed fields / Sisymbrium officinalis R. Tx., Lohmeyer et Preising in R. Tx. 1950; Convolvulo-Agropyron repentis Görs 1966</td>
</tr>
<tr>
<td>SJ8</td>
<td>Mosaic of the thermophilous ruderal vegetation outside settlements, fallows and extensively managed fields / Sisymbrium officinalis R. Tx., Lohmeyer et Preising in R. Tx. 1950; Convolvulo-Agropyron repentis Görs 1966</td>
</tr>
<tr>
<td>SJ9</td>
<td>Mosaic of the blackthorn shrubs and secondary scree and rocky habitats / Berberidion Br.-Bl. 1950; Galeopsion segetum Oberd. 1957; Cymbalario-Asplenion Segal 1969 em. Mucina 1993</td>
</tr>
<tr>
<td>SJ10</td>
<td>Mosaic of the line stands of the broadleaved native tree species and thermophilous ruderal vegetation outside settlements / Querco petraeae-Carpinetum Soó et Pócs 1957; Sisymbrium officinalis R. Tx., Lohmeyer et Preising in R. Tx. 1950; Convolvulo-Agropyron repentis Görs 1966</td>
</tr>
<tr>
<td>SJ11</td>
<td>Line stands of the broadleaved native tree species / Querco petraeae-Carpinetum Soó et Pócs 1957</td>
</tr>
<tr>
<td>SJ12</td>
<td>Blackthorn shrubs / Berberidion Br.-Bl. 1950</td>
</tr>
</tbody>
</table>

**Life forms**

The life forms reflect the adaptation of particular species to the ecological conditions of the habitat. The spectrum of life forms is a very important trait reflecting the structure of the plant community, the intensity of management, and the stage of succession; it can often point out to...
some anthropogenic disturbances in the vegetation. In the representative sites of the pilot area in the Svätý Jur town cadastral district the following plant life forms were recorded: therophytes (T1 – annual and T2 – biennial), hemicryptophytes (H), geophytes (G), herb- (Cb) and shrub (Cd) chamaephytes, shrub- (Fk) and tree (Fs) phanerophytes and epiphytes (E). Hemicryptophytes, therophytes, and shrub phanerophytes were dominant in the HSALs. Hemicryptophytes prevailed in the herb layer in some representative sites (SJ2b, SJ3a, SJ5a, SJ5b, SJ6, SJ7, SJ10, SJ8); annual and biennial therophytes dominated in managed pinned and wire vineyards, abandoned wire ones and stone mounds (SJ2a, SJ2c, SJ5b, SJ7, SJ8); while tree and shrub phanerophytes on stone mounds and heaps (SJ1a, SJ1b, SJ4ab, SJ6, SJ9, SJ10, SJ11, SJ12) (Fig. 3, Table 6).

**SYNANTHROPISE**

Synanthropic vegetation is dependent on the impacts and activities of man. The HSALs in the pilot area are typical for the strong and numerous human impacts, past and present, a fact significantly reflected in the species composition of the vegetation. All the HSALs in the pilot area of the Svätý Jur town cadastral district are more or less synanthropised and synanthropic species represent a significant part of the species spectrum. The lowest synanthropisation and the highest prevalence of proanthropophytes (A) is on stone mounds and heaps with tree line stands, i.e. in higher successional phases synanthropisation decreases. Proanthropophytes (A, A1, A2) occur very sporadically in vineyards, which show a higher degree of synanthropisation, prevailing over apophytes (B, B1, B2, B3) and archaeophytes (C) on stone mounds (SJ1a, SJ4ab, SJ5a, SJ11 and SJ12) (Fig. 4, Table 7).


**Fig. 2.** Number of taxa, Shannon and Pielou indices of the vascular plants in the HSALs of the pilot area of the Svätý Jur town cadastral district. For the explanation of the abbreviations used on the X axis see Table 1.

**Fig. 3.** Life forms of the vascular plants in the HSALs of the pilot area of the Svätý Jur town cadastral district. Cb – herb chamaephyte, Cd – shrub chamaephyte, G – geophyte, H – hemicryptophyte, Fk – shrub phanerophyte, Fs – tree phanerophyte, T1 – annual therophyte, T2 – biennial therophyte, E – epiphyte. For the explanation of the abbreviations used on the X axis see Table 1.
Table 6. Life forms of the vascular plants in the HSALs of the pilot area of the Svätý Jur town cadastral district. Cb – herb chamaephyte, Cd – shrub chamaephyte, G – geophyte, H – hemicryptophyte, Fk – shrub phanerophyte, Fs – tree phanerophyte, T1 – annual therophyte, T2 – biennial therophyte, E – epiphyte. For the explanation of the site codes see Table 1.

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Fig. 4. Synanthropisation and invasive species of the vascular plants in the HSALs of the pilot area of the Svätý Jur town cadastral district. A – proanthropophytes, A1 – proanthropophytes with a documented state of occurrence, A2 – proanthropophytes with an undocumented state of occurrence, B – apophytes, B1 – taxa occurring mainly in natural communities, B2 – taxa occurring in both natural and synanthropic communities, B3 – taxa occurring mainly in synanthropic communities, C – archaeophytes, D1 – neophytes occurring only in synanthropic communities, D2a – neophytes growing in seminatural and natural communities but not changing the structure of the community, D2b – neophytes growing in seminatural and natural communities, essentially changing the structure of the community (invasive species); F1 – taxa belonging to the category C or D, F2 – taxa belonging to the category B or C, F3 – taxa belonging to the category B, C or D. For the explanation of the abbreviations used on the X axis see Table 1.
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Robinia pseudacacia L. (SJ4a, SJ4b, SJ5a, SJ7), and Stenactis annua (L.) Nees (SJ1b, SJ2a, SJ2b, SJ3a, SJ5ab, SJ7, SJ8).

### Intensity of hemeroby

The taxa in the HSALs of the pilot area indicated six degrees of hemeroby: ahemerobe (a), oligohe -merobe (o), mesohemerobe (m), β-euhemerobe (b), α-euhemerobe (c), and polyhemerobe (p). The highest degree of hemeroby – t-metahemerobe – was not found. Plant taxa indicating a natural, native, ahemerobe degree occurred sporadically on stone mounds and heaps with trees. Mesohe-merobe, β-euhemerobe and α-euhemerobe species were dominant in the HSALs. In managed and extensively managed vineyards (SJ2c, SJ7, SJ8), the polyhemerobe degree was also strongly represented (Fig. 5, Table 8).

### DISCUSSION

For man agricultural landscape represents an irreplaceable resource. The primary purpose of agriculture is food production but also focus on other objectives (e.g. wildlife, conservation, biodiversity, recreation and scenery), which have a long history and are of increasing importance. However, works describing the diversity of vascular plants in agricultural landscape are not as common as contributions dealing with the same topic in forest, subalpine or alpine landscape. This study brings together the results related to the diversity, life forms, synanthropisation and the intensity of hemeroby of habitats in agricultural landscape of south-western Slovakia. The research was carried out in the historical agricultural land-scape structures as an important source of landscape diversity.

### Table 7

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The taxa in the HSALs of the pilot area indicated five degrees of hemeroby: ahemerobe (a), oligohe -merobe (o), mesohemerobe (m), β-euhemerobe (b), and α-euhemerobe (c). The highest degree of hemeroby – t-metahemerobe – was not found. Plant taxa indicating a natural, native, ahemerobe degree occurred sporadically on stone mounds and heaps with trees. Mesohe-merobe, β-euhemerobe and α-euhemerobe species were dominant in the HSALs. In managed and extensively managed vineyards (SJ2c, SJ7, SJ8), the polyhemerobe degree was also strongly represented (Fig. 5, Table 8).
diversity and biodiversity. Stone mounds and heaps with tree taxa represent forest islands in agricultural landscape and are occupied by species of a natural, native, a-hemerobe degree. Chmiel (1998) and Banaszak (2000) documented the high value of such habitats and emphasised the need for their preservation. The vegetation of stone walls, mounds and heaps is represented by secondary rocky and scree habitats. The common feature of these habitats is the high diversity and heterogeneity of vascular plants (e.g. Duchoslav 2002; Simonová 2008), frequently including rare and protected species, but also invasive alien ones (e.g. Cymbalaria muralis, Conyza canadensis). The flora and vegetation of vineyards is well documented in works of Eliáš (1980, 1983, 1995, 1997). The author deals with vineyards on different types of bedrock, varied intensity of management and undergrowth vegetation in various successional stages. The species composition of extensively managed vineyards within the historical structures

Fig. 5. Intensity of hemeroby of the vascular plants in the HSALs of the pilot area of the Švätý Jur town cadastral district. a – ahemerobe, o – oligohemerobe, m – mesohemerobe, b – β-euhemerobe, c – α-euhemerobe, p – polyhemerobe, 0 – species with an unassigned value of hemeroby intensity. For the explanation of the abbreviations used on the X axis see Table 1.

Table 8. Intensity of hemeroby of the vascular plants in the HSALs of the pilot area of the Švätý Jur town cadastral district. a – ahemerobe, o – oligohemerobe, m – mesohemerobe, b – β-euhemerobe, c – α-euhemerobe, p – polyhemerobe, 0 – species with an unassigned value of hemeroby intensity. For the explanation of the site codes see Table 1.

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of agriculture landscape in the Svätý Jur cadastral district shows several similarities with the first two successional stages after abandonment documented by Eliáš (1983) e.g.: Lactuca serriola L., Artemisia vulgaris L., Tanacetum vulgare L., Agropyron repens (L.) P. Beauv., Arrhenatherum elatius (L.) P. Beauv. ex J. Presl & C. Presl, Calamagrostis epigeios Roth, etc. Also, the author mentioned areas of vineyards as potentially very important spots for the occurrence of some rare and protected species. This is one of the main reasons for further research and cataloguing of HSALs in Slovakia which continues in more than 300 sites with their high incidence.

CONCLUSION

Areas with preserved historical landscape structures represent a significant part of Slovakia’s national cultural heritage. Even though a large proportion of HSALs has been destroyed since the 2nd half of the 20th century and they are currently small-scaled, their high number and diversity of the natural and cultural-historical conditions favour a high heterogeneity of HSAL types.

The research performed in agriculture landscape focused on the diversity of vascular plants has brought several interesting results:

The sites of historical landscape structures increase significantly the alpha diversity of particular areas and contain a wide spectrum of species creating new ecotopes.

The sites of HSAL include habitats offering suitable niches for several threatened and protected species.

The sites of HSAL offer suitable habitats for invasive species, but the later successional stages show a spectrum of life forms close to natural stands and the hemeroby degree there is ahemerober and oligohemerobe.

The diversity of vascular plants on stony walls and in vineyards represents a significant value in agricultural landscape (Eliáš 1983, 1995; Duchoslav 2002; Simonová 2008) and detailed research related to the diversity of vascular plants enriches knowledge about the occurrence and distribution of rare, protected and invasive species. This scientific knowledge can support the development of relevant legislative measures for the conservation of the biodiversity and cultural heritage of this precious agricultural landscape. It is necessary to support projects focused on the study of vascular plants in agricultural landscape as they can bring valuable results related to the vegetation and flora of particular regions and/or countries as well as improve the information base for the inventory of important vascular plant species.

ACKNOWLEDGMENTS. This article was supported within the project of the Slovak Research and Development Agency (Project no. APVV-0866-12 Evaluation of ecosystem functions and services of the cultural landscape).

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THE HABITAT DIVERSITY AND GENETIC VARIABILITY OF CYPRIPEDIUM CALCEOLUS IN LATVIA

Dace Kļaviņa¹, Dace Grauda², Agnese Priede³ & Isaak Rashal²

Abstract. This study aimed at investigating the growth conditions, genetic composition and variability of Cypripedium calceolus L. populations in Latvia. In order to ensure an appropriate level of protection of a species, knowledge of its habitat diversity and genetic diversity is crucial. The species in question occurs in different habitats on mesic soils, in deciduous broadleaved, mixed and coniferous forests. The genetic composition and variability of populations might define the relative differences in the environmental response of C. calceolus. To address these aspects, a novel, recently developed universal method of DNA fingerprinting was applied for the first time for the Cypripedium genus. 22 specific PCR primers were tested to select those which reveal the highest level of genetic polymorphism. The three selected primers (yielding 40 loci) were applied to estimate the genetic variability among the plants within a site and between different sites. A rather high genetic diversity within sites was found, while the geographical distance between localities was not the major factor affecting the genetic variability. On the basis of the results it can be speculated that all the sites belong to a single population with possible differentiation at the level of subpopulations.

Key words: Cypripedium calceolus L., genetic diversity, populations, retrotransposons

¹National Botanic Garden of Latvia, 1 Miera St., Salaspils, LV-2169, Latvia; e-mail: dace.klavina@nbd.gov.lv
²Institute of Biology, University of Latvia, 3 Miera St., Salaspils, LV-2169, Latvia; e-mails: dace@email.lubi.edu.lv, izaks@email.lubi.edu.lv
³Nature Conservation Agency, 7 Baznīcas St., Sigulda, LV-2150, Latvia; e-mail: agnese.priede@daba.gov.lv

INTRODUCTION

Cypripedium calceolus L. is a rare, endangered orchid species occurring in temperate and boreal zones subjected to high conservation priority in Europe. The species features on the protected plant lists of Bern and Washington conventions as well as in Annex II of the European Council Habitats Directive 92/43/EEC.

C. calceolus was formerly known from over 60 sites in Latvia, but nowadays it might occur at only about 30. Almost all localities are included in protected areas (18 of them in Natura 2000 sites, the rest in microreserves). The major threat for the species in Latvia is a reduced presence of suitable habitats, mainly due to intensified forestry operations and increasing fragmentation of old-growth natural forest habitats. For some sites, there is historical evidence that plants of C. calceolus have been plucked and dug out causing the extinction or decline of the populations, while in most cases the populations might be affected by changes in habitat conditions, e.g. natural succession.

The analysis of genetic diversity is one of the basics to develop an appropriate approach to species conservation as it could show diversity among plants of the same population and differences among populations. Different techniques are used for this purpose, starting with analysis of allozyme variation (Case 1993) and continued with investigations of genetic diversity based on the analysis of DNA variability. Due to the large genome of C. calceolus (it outweighs 180 times the genome of Arabidopsis thaliana (L.) Heynh.) the molecular genetics analysis of this species is complicated. The common DNA marker systems such as RAPD, AFLP or SSR (Taniguchi et al. 2008) are not useful, because the use of standard protocols of these methods underestimates the level of genetic variation (Fay et al. 2009). RFLP analysis based on the sequence of large subunit ribulose gene (rbcL) of Cypripedium was performed (Jo et al. 2005), but this method is rather complicated and is more useful for the detection of differences among species within a genus. Plastid DNA microsatellites were also used to analyse Cypripedium variability (Fay et al. 2009; Brzosko et al. 2011). Because of the uniparental nature of the marker, it offers a possibility to detect haplotypes of plastid DNA, characteristic for particular populations, inherited exclusively through female lineages, but obviously it does not reveal the genetic variability of nuclear genes, which depend on recombination during sexual reproduction.

The genetic diversity of C. calceolus has been studied in wild populations in several countries:
Austria, Denmark, Estonia, France, Italy, Poland, Spain, Sweden, the United Kingdom, Switzerland, China, and Japan (Jo et al. 2005; Walsh 2008; Fay et al. 2009; Brzosko et al. 2011). Up to now, the genetic diversity of *C. calceolus* in Latvia has not been assessed. It is not clear whether the plants from the Latvian sites isolated from each other with a probably restricted gene flow among them could be classified as belonging to the same functional population with an effective gene flow or, due to the habitat differences, the genetic differentiation is high enough to mark them as distinct populations. This is an important aspect which should be taken in consideration when developing a protection strategy for the plant.

For genetic investigations of wild *C. calceolus* populations it is important to use a relatively simple method, which gives one a possibility to analyse a sufficiently large number of samples. Recently, a universal retrotranspozone-based method IRAP (Inter-Retrotransposon Amplified Polymorphism) has been developed (Kalendar et al. 2010). The method helps reveal a high level of genetic diversity and is cost and labour effective. It has been successfully used for the investigation of genetic diversity for several species (Vukich et al. 2009; Kalendar et al. 2010; Smýkal et al. 2011). The aim of this study was adapting the IRAP method to the case of *C. calceolus* and connecting the assessment of habitats suitable for the species with the estimation of the genetic diversity of *C. calceolus* plants in different Latvian sites.

**METHODS**

Seven sites with different types of habitats (Table 1) from three regions of Latvia were investigated in the late spring (May to June) of 2010. Sites Ķemeri (Fig. 1 – No. 1), Dunduri (No. 2) and Sloka (No. 3) are located in the Ķemeri National Park close the southwestern coast of the Gulf of Riga, the Baltic Sea. The Sīļemnieki (No. 4) site is a microreserve located in the central part of Latvia. Numerne (No. 5), Katleši (No. 6) and Beja (No. 7) are protected areas in the eastern part of the country (Fig. 1).

Data on the species distribution (Fig. 1) were extracted from the data system called OZOLS (Nature Conservation Agency 2012). The distribution map was prepared using a 10×10 km grid (Laivīņš & Krampis 2004).

![Map of Latvia showing Cypripedium calceolus localities](image)

**Fig. 1.** Distribution of *Cypripedium calceolus* in Latvia within a 10×10 km grid and the location of the study sites (source of data: Nature Conservation Agency 2012).
The number of clumps, the total number of shoots or ramets and flowering shoots, as well as the number of flowers per shoot were recorded in field conditions. Sometimes when shoots or shoot groups were disposed closely together it was difficult to determine separate individuals or clumps, therefore unit shoots or ramets were used as an exact demographic, while clumps characterize shoot concentration.

In all seven sites, soil samples and plant leaves were collected for laboratory analysis. Soil samples were taken from the root zone near *Cypripedium calceolus* plants. For each sample at least five sub-samples were collected and mixed into a single sample. Soil analyses were performed in the Laboratory of Mineral Nutrition at the Institute of Biology, University of Latvia, following the laboratory’s own methodology (Rinkis et al. 1987).

The young leaves of 20 *C. calceolus* plants from each of six studied sites (Table 1, Fig. 1, except Silzemnieki) were collected for DNA isolation. Fresh leaves were put on ice, moved to the laboratory and dried at +45°C for 16 hours; the dried leaves were kept in darkness. DNA was isolated using the modified method by Friar (2005): 2×CTAB, 1% PVP-40 and 2μl mercaptoethanol with double precipitation in ice-cold 96% ethanol of DNA with incubation at -20°C for overnight. The final volume of resuspended DNA in molecular water was 50 μl. The isolated DNA quantity was determined by Eppendorf BioPhotometer. The determination of DNA quality was assessed by electrophoresis on 1.5% agarose (TopVisionTM, Fermentas) gel with a 15×15 gel track, 1×TAE buffer, at 80 V, for 5 hours. The gel was coloured for 40 minutes in water with 20 μl/1L 10% water solution of ethidium bromide and rinsed for 10 minutes in deionized water. After UV visualization the agarose gel was documented with a digital camera.

Each IRAP band was treated as a single locus. The presence (1) or absence (0) of a fragment of a given length was recorded. The data were evaluated using POPGENE software version 1.32 (Yeh et al. 1999). Nei’s gene diversity, the number and percentage of polymorphic loci as well as the genetic distances between *C. calceolus* plants from different localities were determined.

RESULTS

Habitat description

According to our observations, *Cypripedium calceolus* occurs in Latvia on mesic lime-rich soils in deciduous broadleaved, mixed or coniferous forests with the presence of broadleaved herbs in the understory vegetation, indicating soil conditions somewhat different from the typical boreal forest communities. The species prefers semi-shaded places with diffuse light and is sensitive to a rapid change of light conditions. For example, felling of trees results in changes of light intensity and expansion of highly competitive species, and subsequently in the disappearance of *C. calceolus*. Plants are concentrated in isolated groups; the number of shoots in their populations varies from year to year.

The habitat appearance at the Ķemeri site is typical for deciduous broadleaved forests on rich, mesic soils with moderate density of the understory, slight to moderate shading, and ground vegetation composed by broadleaved herbs. The other deciduous broadleaved forest habitat sub-type is characterised by a relatively high admixture of
coniferous species (mainly *Picea abies*) in the tree layer, lower light availability at the ground level and the presence of species typical of coniferous boreal forests in the ground vegetation (Beja and Sloka sites). In Numerne, the species was found on a relatively wet lower slope of an esker rich with calcareous springs in a mixed swamp forest with moderate light availability and rich herbaceous ground vegetation. Similar conditions were found in Sloka, where *C. calceolus* grows on a slight elevation surrounded by a swampy forest. Two sites, Dunduri and Katleši, represent herb-rich boreal coniferous forests with the presence of broadleaved herbs in the ground vegetation. In coniferous forest sites, gaps in the tree layer play an important role in enhanced light availability at the ground level, ensuring suitable conditions for *C. calceolus*. In coniferous forest at both sites the light conditions are moderate, soils are mesic and contain carbonates promoting the presence of species typical for deciduous broadleaved forests. In all sites the forests are old-growth or medium-aged, untouched by logging or other intensive human impacts at least over the last half of the century.

**SOIL CONDITIONS AND ABUNDANCE OF SHOOTS**

The sites differed in *Cypripedium calceolus* shoot numbers, in fertile shoot proportion (Table 1) and in the concentration of mineral elements (Table 2). The number of individuals and shoots counted year by year (since 2005) is more or less stable, while the number of flowering shoots varies from year to year. In almost all localities about one half of the shoots flowered in 2010. At the Kemerite site on soils with high pH and sufficient potassium content (Rinkis & Nollendorf 1982) plants with the highest proportion of shoots with two flowers were found.

**Table 1. Cypripedium calceolus demographic data at the study sites.**

<table>
<thead>
<tr>
<th>Site / habitat</th>
<th>Number of genets</th>
<th>Number of ramets</th>
<th>Mean number of ramets per genet</th>
<th>Flowering ramets</th>
<th>% of flowering ramets</th>
<th>% of flowering ramets with two flowers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dunduri / Boreal coniferous forest</td>
<td>70</td>
<td>271</td>
<td>3.9</td>
<td>148</td>
<td>54.6</td>
<td>22.7</td>
</tr>
<tr>
<td>Kemerite / Broadleaved deciduous forest</td>
<td>92</td>
<td>524</td>
<td>5.7</td>
<td>301</td>
<td>56.5</td>
<td>26.9</td>
</tr>
<tr>
<td>Sloka / Mixed broad-leaved-coniferous forest</td>
<td>8</td>
<td>20</td>
<td>2.5</td>
<td>17</td>
<td>75</td>
<td>17.6</td>
</tr>
<tr>
<td>Numerne / Mixed swamp forest</td>
<td>60</td>
<td>222</td>
<td>3.7</td>
<td>107</td>
<td>48.4</td>
<td>21.2</td>
</tr>
<tr>
<td>Katleši / Boreal coniferous forest</td>
<td>97</td>
<td>840</td>
<td>8.7</td>
<td>438</td>
<td>52.1</td>
<td>18.3</td>
</tr>
<tr>
<td>Beja / Mixed broad-leaved-coniferous forest</td>
<td>19</td>
<td>91</td>
<td>4.8</td>
<td>30</td>
<td>33</td>
<td>0</td>
</tr>
<tr>
<td>Silzemnieki / Broadleaved deciduous forest</td>
<td>18</td>
<td>125</td>
<td>6.9</td>
<td>62</td>
<td>49.6</td>
<td>3</td>
</tr>
</tbody>
</table>

**Table 2. Concentration of mineral nutrients [mg/l], pH and electroconductivity [EC, mS/cm] in soil at the study sites.**

<table>
<thead>
<tr>
<th>Element, parameter</th>
<th>Kemerite</th>
<th>Dunduri</th>
<th>Sloka</th>
<th>Numerne</th>
<th>Katleši</th>
<th>Beja</th>
<th>Silzemnieki</th>
<th>Kangari</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>53</td>
<td>38</td>
<td>51</td>
<td>47</td>
<td>40</td>
<td>60</td>
<td>80</td>
<td>67</td>
</tr>
<tr>
<td>P</td>
<td>65</td>
<td>47</td>
<td>59</td>
<td>56</td>
<td>67</td>
<td>60</td>
<td>146</td>
<td>92</td>
</tr>
<tr>
<td>K</td>
<td>135</td>
<td>65</td>
<td>96</td>
<td>67</td>
<td>64</td>
<td>62</td>
<td>63</td>
<td>33</td>
</tr>
<tr>
<td>Ca</td>
<td>55250</td>
<td>7838</td>
<td>7875</td>
<td>10963</td>
<td>7213</td>
<td>10463</td>
<td>5588</td>
<td>12000</td>
</tr>
<tr>
<td>Mg</td>
<td>31250</td>
<td>86</td>
<td>388</td>
<td>1013</td>
<td>725</td>
<td>750</td>
<td>500</td>
<td>4250</td>
</tr>
<tr>
<td>S</td>
<td>60</td>
<td>83</td>
<td>40</td>
<td>18</td>
<td>9</td>
<td>12</td>
<td>20</td>
<td>19</td>
</tr>
<tr>
<td>Fe</td>
<td>700</td>
<td>70</td>
<td>360</td>
<td>325</td>
<td>815</td>
<td>575</td>
<td>435</td>
<td>845</td>
</tr>
<tr>
<td>Mn</td>
<td>210</td>
<td>17</td>
<td>34</td>
<td>165</td>
<td>60</td>
<td>185</td>
<td>265</td>
<td>190</td>
</tr>
<tr>
<td>Zn</td>
<td>13</td>
<td>5.00</td>
<td>4.10</td>
<td>8.50</td>
<td>5.50</td>
<td>14.00</td>
<td>4.45</td>
<td>6.50</td>
</tr>
<tr>
<td>Cu</td>
<td>2</td>
<td>0.50</td>
<td>2.10</td>
<td>0.85</td>
<td>2.25</td>
<td>1.40</td>
<td>1.45</td>
<td>1.00</td>
</tr>
<tr>
<td>Mo</td>
<td>0.02</td>
<td>0.04</td>
<td>0.06</td>
<td>0.04</td>
<td>0.06</td>
<td>0.09</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>B</td>
<td>0.10</td>
<td>3.80</td>
<td>1.30</td>
<td>1.90</td>
<td>1.40</td>
<td>2.30</td>
<td>0.80</td>
<td>&lt;0.10</td>
</tr>
<tr>
<td>Na</td>
<td>46</td>
<td>11.50</td>
<td>15.50</td>
<td>17.50</td>
<td>15.00</td>
<td>20.00</td>
<td>11.50</td>
<td>19</td>
</tr>
<tr>
<td>pHKCl</td>
<td>7.23</td>
<td>5.86</td>
<td>5.41</td>
<td>6.42</td>
<td>5.66</td>
<td>5.68</td>
<td>6.32</td>
<td>6.90</td>
</tr>
<tr>
<td>EC</td>
<td>0.61</td>
<td>1.12</td>
<td>0.78</td>
<td>0.63</td>
<td>0.37</td>
<td>0.56</td>
<td>0.41</td>
<td>–</td>
</tr>
</tbody>
</table>
A vast range of pH and nutrient concentrations was found in different *C. calceolus* sites (Table 2). pH varies from 5.41 to 7.23. The analysis showed low levels of N and K (except at the Ķemeri site), S in Beja and Katleši and Cu at the Dunduri site. Plant supply with soil P, Ca and Mg could be characterized as optimal (except Mg at the Dunduri site). According to the analysis, *C. calceolus* occurs mainly on mineral soils, with an exception of the Dunduri site which lies on organic soil. The content of chemical elements in soil did not significantly correlate with their content in the leaves. For example K content in plants at the Katleši site with low K content in soil was the same as that in plants in Ķemeri, where the K content in soil was optimal (Rinkis & Nollendorf 1982). The same applies to Mn uptake. Nutrient availability for plants is closely related to soil pH, relation of mineral components (Ca/Mg, Fe/Mn) and other plant mineral nutrients. Ca/Mg ratio in soils of the investigated sites varied considerably (Ķemeri – 1.8, Katleši – 9.9, Numerne – 10.8, Silzemnieki – 11.8, Beja – 13.9, Sloka – 20.3, Dunduri – 91.1), suggesting the presence of different soil bedrock at different sites (e.g. dolomite and limestone). It is confirmed by the geological map of Latvia (Juškevičs et al. 1999).

**Table 3. Genetic variability of *Cypripedium calceolus* plants at different sites.**

<table>
<thead>
<tr>
<th>Site</th>
<th>Number of polymorphic loci</th>
<th>Percentage of polymorphic loci</th>
<th>Nei’s genetic diversity index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dunduri</td>
<td>18</td>
<td>45.0</td>
<td>0.16</td>
</tr>
<tr>
<td>Ķemeri</td>
<td>37</td>
<td>92.5</td>
<td>0.31</td>
</tr>
<tr>
<td>Sloka</td>
<td>22</td>
<td>55.0</td>
<td>0.21</td>
</tr>
<tr>
<td>Numerne</td>
<td>30</td>
<td>75.0</td>
<td>0.26</td>
</tr>
<tr>
<td>Katleši</td>
<td>30</td>
<td>75.0</td>
<td>0.26</td>
</tr>
<tr>
<td>Beja</td>
<td>35</td>
<td>87.5</td>
<td>0.29</td>
</tr>
</tbody>
</table>

**Table 4. Genetic distances between *Cypripedium calceolus* populations.**

<table>
<thead>
<tr>
<th></th>
<th>Dunduri</th>
<th>Ķemeri</th>
<th>Sloka</th>
<th>Numerne</th>
<th>Katleši</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ķemeri</td>
<td>0.037</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sloka</td>
<td>0.092</td>
<td>0.107</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Numerne</td>
<td>0.164</td>
<td>0.181</td>
<td>0.139</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Katleši</td>
<td>0.093</td>
<td>0.109</td>
<td>0.079</td>
<td>0.089</td>
<td></td>
</tr>
<tr>
<td>Beja</td>
<td>0.098</td>
<td>0.105</td>
<td>0.076</td>
<td>0.091</td>
<td>0.049</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Overall, species rarity is defined by the size of its geographical range, habitat specificity and local population size (Broennimann et al. 2005). *Cypripedium calceolus* is a species with broad geographical distribution (Kull 1999). In our opinion, the rarity of that species in Latvia is caused by the rarity of suitable microhabitats, small population sizes...
and relatively small patches of suitable microhabitats within the sites where the species occurs. The species is characterized by a low dispersal ability and low competitive capacity in comparison to many species present in the same habitats. Therefore, diminishing the effect of the fragmentation in suitable forest habitats plays a crucial role in the conservation of the remaining populations. Increasing isolation of suitable habitats might significantly decrease the effective dispersal of the species.

The IRAP method applied here for the assessment of genetic variability requires high quality (not fragmented) DNA. Methods of DNA isolation have limitations for plants with high amounts of secondary metabolites in tissue extracts (Warude et al. 2003), therefore obtaining high quality and good quality DNA from C. calceolus leaves is difficult. The applied method of DNA isolation by Friar (2005) provided for an effective extraction of a high quality DNA from orchids (Belogrudova et al. 2012), necessary for further analyses. The selected primers revealed a high level of polymorphism. Being dominant markers, IRAP did not allow recognizing the level of heterozygosity, but Nei’s index suggests a relatively high genetic diversity within the sites.

For the Latvian C. calceolus sites the geographical distance between localities is not the major factor affecting the genetic variability. The distances between the Dunduri, Kemerri and Sloka sites (Central Latvia) do not exceed 20 km, while the distance between the abovementioned three sites and Numerne, Katleši and Beja (East Latvia) is more than 300 km. Still, the C. calceolus individuals from Sloka (Central Latvia) are genetically closer to the plants from Katleši and Beja (East Latvia) than to those from Dunduri and Kemerri (Central Latvia). Plants from the Numerne site are the most genetically distinct among all the study sites, which may be related to the adaptation to specific growing conditions: only in Numerne do the C. calceolus plants grow in a mixed swamp forest at the lakeshore.

C. calceolus is a cross-pollinated, entomophilous and anemochorous plant species. Due to the geographical isolation of the sites, the gene flow between sites is most probably rare. High genetic variability within the sites and relatively low genetic distinction between these sites let us speculate that all the sites belong to a single population system with possible differentiation at the level of subpopulations. Further investigations are necessary with more detailed comparisons made between the localities to understand the relation between the peculiarities of genetic variation and the habitat conditions.

Unfortunately, investigations of the genetic variation of C. calceolus populations of different countries have been done using different markers, which makes a direct comparison of results quite impossible. Nevertheless, the investigations show that in different countries high levels of genetic diversity of the species could be found. The genetic diversity of C. calceolus should be preserved both in situ and, if possible, also ex situ for a collection of the most genetically distinct samples.

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INTRODUCTION

The problem of the sustainable use of plant and fungi species resources in Belarus is urgent now, the notion being included in the number of goals and objectives of the Convention on Biological Diversity as well as the Global and the European Plant Conservation Strategies.

In order to investigate the sustainable use and conservation of plant and fungi species resources, experts from the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus, in cooperation with scientists from the Institute of Experimental Botany of Belarus National Academy of Sciences, began in 2005 the practical work of creating and completing the State Plant Cadastre of the Republic of Belarus. Particular attention is paid to the economic evaluation of resource potential and the sustainable use of plant and fungi species (Maslovskij et al. 2009; Mastibrotskaya et al. 2010).

The Cadastre is a computer information system for the registration, conservation and sustainable use of useful wild plant and fungi species resources of Belarus. The Cadastre is designed to:

– provide public authorities and entities with standardized specific information about all the wild plant and fungi species;

– evaluate in economic terms the natural resources of these plants and fungi, regulate the conservation, sustainable use and reproduction of plant and fungi species;

– monitor the number and area of populations of plant and fungi species for each region and for the whole country.

The creation of The State Plant Cadastre of the Republic of Belarus is based on the Law on Plants1 and the Resolution of the Council of Ministers of the Republic of Belarus concerning the ordinance concerning the implementation of the State Plant Cadastre of the Republic of Belarus2. The National Academy of Sciences of the Republic of Belarus lends scientific support to the Cadastre. The Cadastre databases are updated every 10 years, and urgent changes introduced each year.

The objectives of the Cadastre include, primarily, the preparation of an inventory of rare and useful plant and fungi species as well as other objects: invasive

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1 Закон Республики Беларусь от 14.06.2003 № 205-3 О растительном мире. Национальный реестр правовых актов Республики Беларусь от 02.07.2003 г., № 73, 2/954.
and introduced plant species, plant communities and plant species diversity. The State Plant Cadastre of Belarus has been created for the first time and prior to it only some isolated information about few species was available. Such local research results were not applicable for the estimation of resources of all useful plant species (Nenadović 1978; Gedyh 2002; Grimaševič 2002 and others).

The aims of the investigations are: developing a methodological base for the creation the State Plant Cadastre (for useful plants and fungi), preparing information for feeding in the cadastre databases and analysis of the generated data for the estimation of the state of plant resources as well as developing recommendations for sustainable use of useful wild plant and fungi species on the territory of Belarus as a whole and in individual administrative districts. Additionally, the generated data from the plant cadastre could be the basis for investigations concerning new plant resources.

This article presents general information about the State Plant Cadastre Database and samples of information that can be obtained using the data comprised in the database.

MATERIALS AND METHODS

The computer information system of the State Plant Cadastre of the Republic of Belarus is a special computer program, originally developed using Delphi 6 and Paradox programs (Maslovskij et al. 2009). The system is a complex of several related databases:

a) plant species included in the Red Data Book of Belarus:
   – species of wild plants included in the Red Data Book of Belarus;
   – plant species to be protected in accordance with international agreements to which the Republic of Belarus is party;

b) useful plant and fungi species:
   – medical;
   – food;
   – technical;

c) plant species with harmful impact:
   – introduced;
   – invasive;
   – poisonous;

d) botanical parks, monuments and others;

e) species diversity (all plant species in a given region);

f) plant communities, according to syntaxonomical classifications.

There are also some additional databases:

1. A database of plant species characteristics (taxonomy, biology, geography, ecology, use and protection).

2. Passports of plant populations which require protection and control.

3. A map generation module (point maps in 1:100,000 scale for population distribution and cartograms in 1:3,000,000 scale for resources and density of different parameters).

The structure of the Cadastre is shown in Fig. 1.

The database of useful plant and fungi species is one of the most important in the Plant Cadastre. It contains information about the area, number of populations, occurrence of species in a given region, yield (productivity), biological resource, exploited resource, the allowable volumes of annual use, condition estimation, recommended actions on protection, and other information.

The determination of plant resources is one of the most important parameters in the Cadastral database of useful plant and fungi species. There are two kinds of resources: biological and exploited.

The biological resource of each species is calculated in accordance with the following formula (Andreeva et al. 2002):

\[ B = S \cdot (Y + 2m), \quad (1) \]

where: \( B \) – biological resource (kg), \( S \) – area of populations of the species in a given region (ha), \( Y \) – average yield (productivity) (kg per ha), \( m \) – error of mean.

The exploited resource of each species is calculated in accordance with the following formula (Andreeva et al. 2002):

\[ E = S \cdot (Y - 2m), \quad (2) \]

where: \( E \) – exploited resource (kg), \( S \) – area of populations of the species in region (ha), \( Y \) – average yield (productivity) (kg per ha), \( m \) – error of mean.

The allowable volumes of annual use were calculated in accordance with the following formula (Andreeva et al. 2002):

\[ V = \frac{E}{t_{\text{harv.}} + t_{\text{reg.}}}, \quad (3) \]

where: \( V \) – allowable volumes of annual use (kg), \( E \) – exploited resource (kg), \( t_{\text{harv.}} \) – number of years of harvesting, \( t_{\text{reg.}} \) – number of years of regeneration.

We developed a special methodology (an algorithm) to calculate both biological and exploited resources and the allowable volumes of the annual use of each species (Mastibrotskaya et al. 2010). Our methodology is based on field investigations
1. Processing of forest taxation data by specialized original software, which enables identification and summarizing the necessary information. We have developed several computer programs: Taks_4, Taksosum and Taksoptis. They help identify and summarize information about the area of plant communities, the number of populations, and the projective cover of useful plant species in different forest types for the calculation of raw plant material resources.

2. Determination of the total area of populations of useful plant species in a specific region and the area of populations in different habitats. The area of plant communities in which species of useful plants occur is determined directly in the field and by applying cartographic and forest taxation material (Andreeva et al. 2002; Mastibrotskaya et al. 2010).

If the populations of the studied species are distributed irregularly within the plant community, the percentage of the area occupied by the studied species is counted (Andreeva et al. 2002). The...
summation of areas was performed using specialized computer programs.

3. Determination of areas where harvesting of plant species is forbidden.

Excluded areas for raw material harvesting:
- territories of radioactive contamination;
- natural protected areas;
- green areas of cities and settlements with industrial pollution;
- recreation zones;
- areas of forests and woodland parks in cities;
- protective zones along roads and railways.

The excluded areas for forest plants are determined by the computer program called Taksosum.

4. Analysis of presence and projective cover of each species in different habitats.

For forest species of useful plants, their distribution in various forest types and their distribution in relation to the richness of the soil and soil moisture has been studied. When determining the environmental characteristics of habitat types, we used forest typological tables and the two-dimensional edaphic grid of Pogrebñā, based on two main factors: soil richness (trophic) and soil moisture (Pogrebñā 1963; Ìrkevič 1972).

For meadow plant species, we analyzed the distribution in meadow communities. Their distribution depends on the level of ground water. For the description of meadow plant communities we used the Blaun-Blanquet classification of grasslands of Belarus (Maslovsky et al. 2007).

The data obtained are the basis for determining the average projective cover of species.

5. Determination of the average projective cover of plant species in various types of plant communities.

Following the analysis of the field material and forest taxation data, we determined the average

![Diagram of regional cadastral estimation of resources of useful plants and fungi.](image-url)
projective cover of species in different habitats, using two approaches to determine the projective cover:

a) case 1 – the structure of forest vegetation is homogeneous: the average projective cover of the studied species in different forest types is taken into account;

b) case 2 – the structure of forest vegetation is heterogeneous: the projective cover of the studied species in the dominant plant community or for a particular type of forest is taken into account.

For non-forest species, we used the field material and land taxation data for the sustainable use of plant species resources. We processed the forest taxation data dating from 2005–2012, which make it possible to develop recommendations for the sustainable use of plant species resources.

RESULTS

In 2005–2012, we studied resources of 101 wild useful plant and fungi species in the Brest, Vitebsk, Grodno, Minsk and Mogiliev regions of Belarus. Among them:


The species names and authors were used from Gorbâ (1973), Gorlenko et al. (1980), Parfênov (1999) and Gapienko & Šaporova (2012).

For each species we evaluated: the distribution within plant communities, the occurrence and projective cover in ecosystems, the area of populations suitable for exploitation, the average yield (productivity), the biological and exploited resources, and the recommended volumes of annual use for each land user in each district of Belarus.

The data from analysing the distribution of *Vaccinium vitis-idea* (as an example among the forest species) in relation to the richness of the soil and soil moisture are presented in the article.

We analyzed 7,000 populations of *V. vitis-idea*
The maximum number of populations (4,761 populations, or 68%) of *V. vitis-idaea* is found in extremely poor essential minerals and fresh site conditions (Fig. 3). Our analysis of the results of the investigations focusing on the distribution of this species in different forest types showed that the average projective cover is 18%.

The data from analyzing the distribution of *Achillea millefolium* (as an example among the meadow plant species) in meadow plant communities are presented in the article. We investigated 67 populations of *A. millefolium*. Analysis of the data showed that *A. millefolium* is widespread in meadow communities of the following alliances: *Cynosurion, Festucion pratensis* and *Deschampsion caespitosae* (Fig. 4), and it occurs there with a projective cover of up to 5%. This species prefers the communities formed on fresh and moderately moist, fairly rich, slightly acidic soils (18 populations, or 27% of all studied populations).

In the article, we showed some results only for *A. millefolium* and *V. vitis-idaea* (as an example). Similar data were obtained for each species of useful plants. The results formed the basis for the determination of resources.

The total biological resources of wild species of all useful plants on the territory of Belarus amount to 943,061 tonnes, including medical plant species (831,840 tonnes) and food plant species (111,221 tonnes). Also, the total biological resources of fungi in Belarus amount to 39,201 tonnes. These data were calculated with computer programs as a sum of separate regional resources of each useful plant species.

The largest resources of both medical and food plant species were found in the Gomel’ and Minsk regions, the lowest in the Grodno and Mogilëv regions. The data obtained are plotted in Figures 5 (for medical plant species) and 6 (for food plant species). This type of distribution may be related to different areas and structures of forests and grasslands in different regions as well as the more intensive agricultural land use and anthropogenic impact in the Grodno and Mogilëv regions.

The allowable volumes of annual use were calculated according to the resources. These volumes on the territory of Belarus are 157,067 tonnes, including medical plant species (117,312 tonnes) and food plant species (39,755 tonnes) (Mastibrotskaya 2011). Additionally, the allowable volumes of annual use of fungi in Belarus were estimated: they amount to 26,829 tonnes (unpublished data of the State Plant Cadastre of the Republic of Belarus).

Analysis of the data showed an irregular spatial distribution of the useful plant species resources. We have identified centers of their concentration and created maps of the spatial distribution of the resources, their density and placement in the region as well as the country as a whole. As an example, the centers of concentration of the biological resource of the medicinal plant *V. vitis-idaea* are shown in Figure 7.

The maximum density of the biological resources of *V. vitis-idaea* is shown in Figure 3. Distribution of populations of *Vaccinium vitis-idaea* in edaphotop. Index of soil moisture (range of hygrotops): 0 – very dry, 1 – dry, 2 – fresh, 3 – moist, 4 – wet, 5 – very wet (bogs). Index of the soil richness (range of trophotops): A – very poor, B – relatively poor, C – relatively rich, D – rich.
resources of *V. vitis-idaea* (more than 150 tonnes per 100,000 ha) is indicated in the Ganceviči and Pružany districts of the Brest region; the Dokšicy, Miory and Rossony districts of the Vitebsk region; the Vetka, El’sk, Kalinkoviči, Leļčicy, Mozyr, Narovlā, Oktābr’skij, Petrikov and Svetlogorsk districts of the Gomel’ region; the Diatlovo and Ostrovets districts of the Grodno region; the Berezino,
Vilejka, Krupki, Stare Dorogi and Stolbcy districts of the Minsk region; the Glusk, Kličev, Slavgorod and Čerikov districts of the Mogilëv region.

The minimum density of the biological resources of *V. vitis-idaea* (less than 50 tonnes per 100,000 ha) is identified in the Dubrovno, Liozno, Orša, Senno, Toločin and Čašniki districts of the Vitebsk region; the Kopyl and Nesviž districts of the Minsk region; the Gorki, Dribin, Krugloe, Mogilëv, Msti-slavl and Šklov districts of the Mogilev region.

These data are the basis for developing regional centers for the harvesting of useful plants in the country.

Analysis of the biological resources on the territory of Belarus made it possible to divide useful plants and fungi into five groups:

1 – useful species with biological resources of more than 10,000 tonnes. It includes ten wild medical plant species (*Betula pendula, B. pubescens, Filipendula ulmaria, Frangula alnus, Pinus sylvestris, Quercus robur, Rubus idaeus, Sorbus aucuparia, Vaccinium myrtillus and V. vitis-idaea*) and four food plant and fungus species (*Cantharellus cibarius, Sorbus aucuparia, Vaccinium myrtillus and V. vitis-idaea*). These species have great resources for commercial uses.

2 – useful species with biological resources of 1,000–9,999 tonnes. It includes ten wild medical plant species (*Acorus calamus, Alnus glutinosa, Comarum palustre, Convallaria majalis, Equisetum arvense, Fragaria vesca, Juniperus communis, Ledum palustre, Menyanthes trifoliata and Urtica dioica*) and seven food plant and fungi species (*Armillariella mellea, Boletus edulis, Leccinum aurantiacum, L. scabrum, Oxycoccus palustris, Rubus idaeus and Vaccinium uliginosum*). These species have the necessary amount of resources for commercial uses.

3 – useful species with biological resources of 100–999 tonnes. It includes eleven wild medical plant species (*Achillea millefolium, Alnus incana, Arctostaphylos uva-ursi, Capsella bursa-pastoris, Centaurea cyanus, Dryopteris filix-mas, Lycopodium annotinum, Lycopus europaeus, Padus avium, Potentilla erecta, Taraxacum officinale and Tilia cordata*) and four food plant and fungus species (*Corylus avellana, Frangaria vesca, Rumex acetosa and Xerocomus badius*). The resources of these species are sufficient for harvesting.

4 – useful species with biological resources from ten to 99 tonnes. It includes 15 wild medical plant and fungus species (*Angelica archangelica, Artemisia absinthium, Bidens tripartita, Bistorta major, Cetraria islandica, Filipendula denudata, Gnaphalium uliginosum, Hypericum perforatum, Lycopodium annotinum, Plantago major, Salix fragilis, Thymus serpyllum, Valeriana officinalis, Viburnum opulus and Viola arvensis*) and five food plant species (*Amelanchier spicata, Cichorium intybus, Ribes nigrum, Rubus caesius and Viburnum opulus*).

**Fig. 6.** Resources and the allowable volumes of annual use of raw material of food plant species on the territory of Belarus. The regions of Belarus: 1 – Gomel’, 2 – Minsk, 3 – Vitebsk, 4 – Brest, 5 – Mogilëv, 6 – Grodno.
These species have a low recourse potential and can be harvested only in small volumes.

5 – useful species with biological resources of less than ten tonnes. It includes 35 medical plant and fungus species (Agrimonia eupatoria, Althaea officinalis, Arnica montana, Berberis vulgaris, Carum carvi, Centaurtium erythraea, Chelidonium majus, Crataegus curvisepala, C. monogyna, Datura stramonium, Helichrysum arenarium, Humulus lupulus, Hyoscyamus niger, Hypericum maculatum, Inonotus obliquus, Inula helenium, Leonurus cardiaca, L. quinquelobatus, Matricaria chamomilla, Melilotus officinalis, Mentha aquatica, M. longifolia, Origanum vulgare, Polemonium caeruleum, Polygonum aviculare, Primula veris, Rosa canina, R. majalis, Salix alba, S. purpura, Sambucus nigra, Tanacetum vulgare, Tussilago farfara, Urtica urens and Viola tricolor) and eleven food plant and fungus species (Carum carvi, Hierochloë australis, H. odorata, Mentha aquatica, M. longifolia, Origanum vulgare, Ribes spicatum, Rosa canina, R. majalis, Rubus saxatilis and Suillus luteus). The harvesting of these species is not reasonable.

Special recommendations for each region of Belarus were developed on the basis of the results of the investigations, and they are used by regional governments to regulate the harvesting process.

CONCLUSIONS

Our investigations indicate that the Republic of Belarus has a great potential in terms of wild plant and fungi resources. The methodological approach developed for the calculation of the resources has proved useful and can be used in other countries. The regional data on the biological and exploited resources of useful plant species have been obtained for the first time in Belarus. New investigations will help obtain more correct data. The results will be the basis for the estimation of the status, stability and dynamics of these species in specific environmental conditions.

The computer programs developed and the specialized databases of the State Plant Cadastre of Belarus make a useful system for estimating the condition of the plant and fungi resources and developing recommendations concerning their protection and exploitation. Further, this information is transferred to the Ministry, provincial committees
and district inspections of natural resources and environmental protection. They, in turn, use these data to control raw material harvesting. In case of the deterioration of the state of these objects and a significant reduction of the raw material resources, the Ministry may restrict and forbid the harvesting of a specific type of material. Thus, the State Plant Cadastre of the Republic of Belarus makes it possible to manage and rationally exploit the useful plant and fungi species of Belarus.

REFERENCES


EX SITU PLANT CONSERVATION IN UKRAINE

Viktor Mel’nik

Abstract. Ukraine is characterized by high diversity of wild flora. Ukrainian flora is one of the richest in Europe and includes 4,523 species of vascular plants. Ukraine occupies 5.7% of Europe but it houses 37% of European vascular plants. 9% of species of Ukrainian vascular plants are endemics. There are 611 species of vascular plants in the Red Data Book of Ukraine (2009). All 29 botanical gardens in Ukraine are involved in ex situ conservation of plants. The collection of rare and endangered species in the National Botanical Garden features 136 species included in the Red Data Book. Modeling of populations of rare and endangered species in artificial gardens play a major role in ex situ plant conservation. Some rare species of Ukrainian flora (Adonis vernalis, Allium ursinum, Erythronium dens-canis, Euonymus nana, Fritillaria montana, Galanthus elwesii, Galanthus nivalis, Galanthus plicatus, Leucojum vernum, Lunaria rediviva, Scopolia carpatica, Paeonia tenuifolia, Tulipa quercetorum) introduced into 60-year-old artificial beech, oak, hornbeam-oak, pine and spruce forests and meadow steppe in the National Botanical Garden formed stable populations similar to populations of these species in natural habitats.

Key words: flora, populations, rare species, conservation, Ukraine

National Botanical Garden, Ukrainian Academy of Sciences, 1 Timiryazevska St., Kyiv, UA-01014, Ukraine; e-mail: flora@nbg.kiev.ua

According to Target 8 of the Global Strategy for Plant Conservation (Sharrock & Jones 2009) botanical gardens play a major role in ex situ plant conservation. This target is very important for Ukraine as the areas around the Black Sea are among the main centers of plant diversity in Europe.

Ukraine is characterized by high diversity of wild flora. This richness in plant life owes to a wide variety of ecosystems, including coniferous pine and spruce forests, deciduous oak, beech and hornbeam forests, steppe grasslands, subalpine and alpine communities of the Carpathian Mountains and submediterranean communities of the Crimean Mountains. Ukrainian flora is one of the richest in Europe and includes 4,523 species of vascular plants from 997 genera and 189 families. Ukraine, covering just 5.7% of the area of Europe, houses 37% of European vascular plants (Melnyk & Peregrym 2004).

It was the Quaternary glaciation that determined the current flora of Ukraine. Ukrainian uplands were refuges for some species during glaciation. Many relict species (Daphne sophia Kalen., D. cneorum L., Euonymus nana Bieb., Staphylea pinnata L., Sorbus terminalis (L.) Crantz., Rhododendron luteum Sweet., Gymnospermium odessanum (DC.) Takht.) remain in these refuges until today. The old Tertiary flora of Ukraine was destroyed during glacial time. Some species have survived in Ukraine possibly from the older Pleistocene and they represent glacial relicts. Aconitum moldavicum Haçq., Alnus incana (L.) Wild., Betula humilis Schrank., Crocus hyefullianus Herb., Linnaea borealis L., Salix lapponum L., S. myrtilloides L., Woodsia ilvensis R. Br. are among them (Mel’nik 2000).

There is mixed forest zone in the north of Ukraine with the domination of pine (Pinus sylvestris L.), oak (Quercus robur L.), and alder (Alnus glutinosa (L.) Gaertn.,) also with extensive bogs. To the south of the mixed forest zone there is a zone of forests and steppe (forest-steppe zone). Much of the forests and nearly all the steppe have been transformed into cultivated lands. Oak (Quercus robur, Q. petraea L. ex Liebl.) and hornbeam (Carpinus betulus L.) on the plateau and pine (Pinus sylvestris) forests on the terraces of rivers represent forest vegetation. Here, insular beech forests are within the eastern limit of Fagus sylvatica L. distribution in Europe.

South of the forest-steppe is the steppe zone, a broad grassland zone covering about 40% of Ukrainian territory. Perennial xerophytes and grasses of such genera as Stipa, Festuca, Poa, Koeleria, Agropyron prevail in the steppes of Ukraine. Desert steppes with prevalent Artemisia species are present on the saline soil in the northern shores of the Black and Azov Seas.

The Ukrainian Carpathian Mountains have five vegetation belts from the bottom to the top: sub-montane forest, mainly of oak (Quercus robur) and hornbeam (Carpinus betulus) (200–450 m); a lower montane belt of beech (Fagus sylvatica) (450–1,450 m); an upper montane belt of spruce (Picea abies (L.) Kart.) forests (1,200–1,650 m);
a subalpine shrub belt (1,300–1,670 m) with Pinus mugo Turra, Duchekia viridis (Claix) Opiz., Juniperus communis var. nana (Will.) Syme and Rhododendron myrtifolium Shott. et Kotschy; and an alpine belt with high-mountain grassland from 1,800 m to 1,850 m.

The much smaller Crimean mountains along the Black Sea in the Crimean Peninsula, extraordinarily rich in floristic sense, have three vegetation belts, of oak (Quercus pubescens Willd.) with Mediterranean shrubs (up to 400 m), a middle forest belt of pine (Pinus pallasiana Lamb), oak (Q. pubescens), hornbeam (Carpinus orientalis Mill.), and ash (Fraxinus oxycarpa Willd.) (400–800 m), and an upper forest belt of beech (Fagus sylvatica).

Nine per cent of species of Ukrainian vascular plants are endemics. The richest centers of plant diversity of Ukraine are mountain regions: Crimean Mountains, occupying only 1.2% of Ukrainian territory, feature 2,400 species of vascular plants, and Carpathian Mountains occupying 15% the territory of Ukraine, with ca 2,050 species. Both mountain regions are characterized by high endemism. There are 240 endemic species in the flora of Crimean Mountains, and 133 endemic species in the flora of Ukrainian Carpathians (Melnyk & Peregrym 2004). The are many narrow endemics, known from single localities, for example, Lepidium turczaninowii Lipsky (Fig. 1) endemic of Crimean Mountains. It is known only from one locality close to the town of Feodosia in the extreme east of Crimean Mountains by the shore of the Black Sea. This local population amounts to just 5,000 individuals.

The Ukrainian natural plant cover has been greatly altered by human activity. Less that 32% of the country has natural or seminatural vegetation. Only 14.3% of Ukrainian territory is covered by forests. The number of endangered native plant species has increased while many newcomers increased in terms of numbers and distribution. The flora of Ukraine includes 190 adventive species. At the same time, eight species of Ukrainian flora have disappeared. The Ukrainian Red Data Book (last edition 2009: Diduh 2009) lists 826 species, including 611 species of vascular plants, 46 species of mosses, 60 species of algae, 52 species of lichens, and 57 species of fungi.

The history of plant conservation in Ukraine goes back to 1886, when the first Ukrainian natural reserve was founded for the protection of a virgin beech forest in Podolian Upland. The famous steppe reserve Ascania-Nova was founded in 1889. Recently, the national reserve fund of Ukraine consists of around 72,500 objects and includes 4 biosphere reserves, 17 natural reserves (zapovedniki), and 17 national parks. In total, protected areas occupy 4.7% of Ukrainian territory, a very low index for a country with high biodiversity. As a result, only half of plant species from the Red Data Book of Ukraine (Diduh 2009) are under protection in situ. Regrettably, the economical situation in modern Ukraine is not suitable for the development of in situ plant protection.

Yet in 1956 the famous Ukrainian botanist S. S. Kharkevich (Kotov & Kharkevich 1956) proposed to develop ex situ plant protection in botanical gardens. In 1970, this initiative was put into practice and the first plot of rare and endangered plants was opened in the National Botanical Garden of the Ukrainian Academy of Sciences in Kyiv. Now each of 29 Ukrainian botanical gardens has a collection of rare and endangered species.

According to Target 8 of the Global Strategy for Plant Conservation adopted by the Convention on Biological Diversity in 2002, 60% of threatened...
plant species should be accessible in ex situ collections, preferably in the country of origin (Sharrock & Jones 2005). About 81% of species from the Red Data Book of Ukraine (Dìduh 2009) are represented in collections of rare and endangered plants in Ukrainian botanical gardens.

The largest centre of ex situ plant protection in Ukraine is the National Botanical Garden of the Ukrainian Academy of Sciences in Kyiv, and rare and endangered plant 136 species from the Red Data Book of Ukraine (Dìduh 2009) are included in its collections. This collection was created for the special purpose of representing plants with at the high risk of extinction in their natural habitats. Of great value are some narrow Ukrainian endemics, species known from single localities and from margins of their geographical ranges represented in our living collection, e.g. Euphorbia volhynica Besser ex Racib., Lonicera caerulea L., Iris germanica L., Aconitum lasiocarpum (Rehb.) Gayer, Galanthus plicatus M. Bieb., G. elwesii Hook., Fritillaria montana Hoppe (Figs 2A–C, E–G).

In the National Botanical Garden in Kyiv rare and endangered species are represented not only in the plot called the “Rare and Endangered Species of Ukraine” but also in the phytogeographical plots “Forest of Lowland Ukraine”, “Ukrainian Steppe”, “Ukrainian Carpathians”, and “Crimean Mountains” occupying 52 ha. These plots are little copies of Ukrainian landscape ecosystems, where all the diversity of Ukrainian forest and steppe vegetation is represented. The 60-year-old cultivated forest and steppe phytocoenoses are very similar to natural Ukrainian forest and steppe communities. The collection of living plants in the phytogeographical plots consists of 1,178 species of Ukrainian flora, including many rare and endangered species.

An important aspect of ex situ plant protection is the modeling of the population of rare and endangered species. The unique 60-year-old cultivated forest and steppe phytocoenoses in the National Botanical Garden are suitable habitats for many rare and endangered species. Rare forest species of Ukrainian flora – Galanthus nivalis L., G. elwesii, G. plicatus, Erythronium dens-canis L. (Fig. 2D), Euonymus nana, Leucojum vernum L. (Fig. 2H), Lunaria rediviva L., Tulipa quercetorum Klokov et Zoz. and rare steppe species Adonis vernalis L., Paeonia tenuifolia L. have over many years formed stable introductive populations with a homeostatic age structure which is very similar to that of the populations of these species in natural habitats (Mel’nik 2000).

The unique achievements of the National Botanical Garden are good evidence of perspectives for plant population modelling in cultivated forest and steppe aimed at protecting floristic diversity ex situ. Special attention is given to plant reintroduction, for instance Dianthus hypanicus Andrz. and Silene hypanica Klokov. have been reintroduced from the botanical garden to their former natural habitats on the slopes of the Southern Bug river in Mikolaiv province. Populations of recovered species currently occupy a large area in the Bugskij Gard National Park in southern Ukraine.

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INTRODUCTION

According to the guidelines established by the World Conservation Union (IUCN Standards and Petitions Subcommittee 2011), the data deficient (DD) red list category should be applied to taxa in case of which there is inadequate information to make a reliable assessment of their risk of extinction, based on their presently known distribution and/or population status. This category, although not being a category of threat, and thus not informing directly of the actual degree of endangerment to a taxon, signals that a closer assessment of its situation is much needed, as some circumstances suggest e.g. that its number of populations and/or distribution range considerably decrease or its habitat might decline.

DD category taxa are rarely included into red books. Experience shows, however, that the very inclusion into a red list or a red data book is often beneficiary for the threat assessment of a taxon. This directs the attention of the wider botanical (and even general) public to the plant, leading to higher numbers of its finds, critical reassessment of locations and more reports being published, thus yielding more reliable data of its present distribution and abundance. A good example is a species that was included into the previous editions (1993 and 2001) of the Polish red data book of plants: Viola uliginosa Besser (Baryła & Kuta 1993, 2001). Allocated into the CR category, this violet was known then in the country from only three existing localities with its estimated numerosity of at most several hundred individuals. During less than a decade since the 2001 edition, at least 16 new locations were found, one of them hosting up to a million(!) individuals (Paul et al., in press). It is very likely that this influx of a wealth of new data on the species that occupies not easily accessible wet habitats, and is readily visible only during a short flowering period (April/May), was stimulated by its appearance in a widely available and well illustrated red data book.

The process of the species’ extinction is rarely observed and studied, especially if this is so-called “background extinction” (e.g. Wiens & Slaton 2012 and the literature cited therein), i.e. not a rapid, clearly visible process (usually concerning an important or well-known taxon) the causes of which are obvious. In several instances we can only acknowledge the declining number of previously known sites and decreasing size of once abundant populations, trying to hypothesize on the proximate and ultimate causes of this phenomenon (e.g. Grzyl & Ronikier 2011, concerning Pulsatilla vernalis Mill.).

In the present paper I discuss the case of Campanula cervicaria L., a species that may also represent the process of “background extinction”. It is regarded endangered or even critically endangered in several Central European countries, where it reaches a western limit of its range. Although it has not been regarded threatened in Poland thus far and there are virtually no recent studies on this species, indirect observations suggest that it is strongly declining also in our country. I have therefore prepared a chapter on C. cervicaria (Paul, in press) for the intended 3rd edition of the Polish red data book of plants.
CHARACTERISTICS OF THE SPECIES

*Campanula cervicaria* (Fig. 1) is a Central European – (Central) West Siberian species, especially in its eastern part of the range occupying parts of the southern nemoral and forest-steppe zones (Meusel & Jäger 1992a, b; Fig. 2). Also the Polish distribution as known to date (Fig. 3), with stations especially dense in areas of the highest concentration of thermophilous species suggests that this species prefers “warmer” areas. In its Central-European part of the range it occupies colline to montane altitudinal belts and its preferred habitats are those of classes *Trifolio-Geranietea*, *Querco-Fagetea* (*Quercetalia pubescenti-petraeae* order) and *Molinio-Arrhenateretea* (warmer forms of meadows of the *Molinietalia* order) (Oberdorfer 2001; Zarzycki et al. 2002; Zając & Zając 2009). Fig. 4 presents autecological characteristics of *C. cervicaria*, based on its ecological indicator values.

![Fig. 1. General habit of the flowering Campanula cervicaria.](image1)

![Fig. 2. General range of Campanula cervicaria (blue) (based on Meusel & Jäger 1992a, Hultén & Fries 1986; after Paul 2012, reprinted with permission).](image2)

![Fig. 3. Generalized distribution of Campanula cervicaria in Poland, according mostly to historical data (based on Zając & Zając 2001, after Paul 2012, reprinted with permission). 1 – areas of higher concentration, 2 – areas of scattered distribution of the species.](image3)

![Fig. 4. Graph of ecological values of Campanula cervicaria (based on data from Zarzycki et al. 2002, after Paul 2012, reprinted with permission). Axes: L – light; T – temperature; K – continentality; W – water; Tr – soil trophy; R – soil reaction; D – soil granulometry, H – soil humic matter content; all axes (apart from H and W) have values 1 to 5.](image4)
Apart from the typical, some authors distinguish two additional infraspecific taxa within the species in Central Europe (e.g. Tacik 1971), namely: *C. cervicaria* subsp. *macrostachya* (Willd.) T. Tacik (= *C. macrostachya* Waldst. & Kit. ex Willd.) and *C. cervicaria* subsp. *transsilvanica* (Schur ex André) T. Tacik (= *C. transsilvanica* Schur ex Heuff.). Both, however, occur outside of Polish territory.

*C. cervicaria* is a biennial or perennial hemicryptophyte. Several chromosome numbers are given in literature for this species: \(2n=24, 26, 34\) (Fedorov 1969; Wcisło 1983). The last one seems to prevail in literature and it is also the most frequent number in several species of *Campanula*, including the relatively common *C. glomerata* L. s.l., a close relative to *C. cervicaria*. In one of the locations where both species coexist several individuals were found showing intermediate characters (the author’s own observation), but no studies were carried out to prove if hybridization was involved.

**ENDANGERMENT ASSESSMENT**

Several locations on the western edge of the area occupied by *Campanula cervicaria* were considered extinct already on the general range map of Meusel & Jäger (1992a). This suggests that in this part of its range the species started to decline not later than in the 2nd half of the 20th century. The situation in several Central European countries, based on red lists and/or red data books of respective territories, is illustrated in the Table 1. Additionally, the abovementioned close taxon, *C. cervicaria* subsp. *macrostachya*, was included (as *C. macrostachya* Waldst. & Kit. ex Willd.) into the red lists of plants of Slovakia (Čeřovsky et al. 1999, CR category equivalent) and Hungary (Király 2007, EN).

In Poland, during the last quarter of the 20th century, the species was reported in local floras only sporadically and many previously known stations were not confirmed/re-discovered, thus it makes the impression of becoming increasingly rare.

To illustrate this trend, a randomly selected Polish natural history journal from the 2nd half of the 19th century (*Pamiętnik Fizyjograficzny*, vol. 5, Warsaw 1885) was examined in search of some data on *C. cervicaria*. Out of ten floristical papers published there, dealing with regions of central and eastern Poland (and adjacent areas of today’s Lithuania and Belarus), finds of *C. cervicaria* were reported in seven. Nowadays this species appears just in one out of approximately five floristical works in Poland, and mostly as an extremely rare element which has not been recently confirmed.

Analysis of a host of floristic data on *C. cervicaria* reported in specific years in sources accepted in the database of the Atlas of Distribution of Vascular Plants in Poland (ATPOL), when compared with data regarding its seemingly rarer congener, *C. bononiensis* L., shows that while until the mid-20th century the number of reports was comparable, and in the 1960s and 1970s data the richness on the former considerably dominated over the latter, in the 1990s that trend clearly reversed (Fig. 5). This may correlate with major changes in land use intensity that took place in Poland after the fundamental political and economic transformation.

*C. cervicaria* has been already included into local red lists in Poland: for Western Pomerania (category V – vulnerable, Żukowski & Jackowiak 1995) and Gdańsk Pomerania (category VU – vulnerable, Markowski & Buliński 2004).

**Table 1.** Endangerment categories of *Campanula cervicaria* in selected Central European countries. In the “Category” column, approximate IUCN categories are given in brackets with “~”, if another system was used in the source. Categories (in ascending order): NT – lower risk: near threatened, VU – vulnerable, EN – endangered, CR – critically endangered.

<table>
<thead>
<tr>
<th>Country / Region</th>
<th>Source</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>Kalliovirta et al. 2010</td>
<td>VU</td>
</tr>
<tr>
<td>Sweden</td>
<td>Aronsson et al. 2010</td>
<td>NT</td>
</tr>
<tr>
<td>Norway</td>
<td>Direktoratet for Naturforvaltning 1999</td>
<td>not classified</td>
</tr>
<tr>
<td></td>
<td>Elven et al. 2006</td>
<td>NT</td>
</tr>
<tr>
<td>Germany</td>
<td>Korneck et al. 1996</td>
<td>category 1 [~CR]</td>
</tr>
<tr>
<td></td>
<td>Schulz 1999</td>
<td>category 1 [~CR]</td>
</tr>
<tr>
<td>Sachsen-Anhalt</td>
<td>Frank et al. 2004</td>
<td>category 1 [~CR]</td>
</tr>
<tr>
<td>Baden-Württemberg</td>
<td>Breunig &amp; Demuth 1999</td>
<td>category 2 [~EN]</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Holub &amp; Procházk 2000; Procházk 2001</td>
<td>category C1 = CR</td>
</tr>
<tr>
<td>Slovakia</td>
<td>Maglucky &amp; Feraková 1993</td>
<td>not classified</td>
</tr>
<tr>
<td></td>
<td>Feraková et al. 2001</td>
<td>not classified</td>
</tr>
<tr>
<td>Ukraine</td>
<td>Diduh 2009</td>
<td>not classified</td>
</tr>
<tr>
<td>Austria</td>
<td>Niklfeld &amp; Schratt-Ehrendorfer 1999</td>
<td>category 3 [~VU]</td>
</tr>
</tbody>
</table>
At the moment, it is not easy to point at definite causes of this situation but, considering the habitats occupied, the processes that change these habitats and challenge their very existence can be considered most probable factors of the species’ endangerment. The most vulnerable habitats concerned are: (1) open and semi-open xerothermic communities that are being overgrown by more expansive tall-herb, bush or tree species as a consequence of gradually declining land use intensity; (2) lightful thermophilous forest communities (such as Potentillo albae-Quercetum), whose gradual disappearance is also caused by the lower intensity or abandonment of traditional forms of its exploitation (like sporadic grazing, removal of litter and fallen twigs); (3) periodically inundated meadow communities of the Molinietalia order that are endangered by the change of the species’ composition and overgrowing by expansive species from the neighbourhood, both due to the abandonment or, conversely, intensification of use and decreasing water levels.

**CONCLUSION**

The premises of the hypothesis concerning the *Campanula cervicaria* endangerment in Poland (and thus the rationale for including it into the country’s red data book) include:

– the falling number of reports on the species in domestic floristic contributions,
– the confirmed decline in the neighbouring countries,
– the currently observed negative changes in virtually all habitats preferred by the species: thermophilous (both xerophile and periodically wet) grasslands, bush and forest communities.

As a hypothetical additional (indirect) endangerment factor one may consider the introgression of other, common species of the same chromosome number and overlapping habitat demands (as *C. glomerata*).

However, it is important to note that there is no current distribution data (in particular no confirmation of the larger parts of previously known sites) for most of the country’s territory, therefore the DD category seems the most appropriate for the species for the time being. The essential conservation need, given the present situation, is thus a preparation of the most detailed possible inventory of extant populations with an estimation of the numerosity and vigour of the individuals. This concerns especially re-visiting the locations mentioned in sources which are 25 to 50 years old to estimate the demographical dynamics of *C. cervicaria* in the period when majority of the unfavourable changes in habitats were observed.

Acknowledgments. I owe my thanks to the staff at the Laboratory of Computer Chorology of the Institute of Botany, Jagiellonian University, Kraków, for providing distributional data of *Campanula* species from the ATPOL database.

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INTRODUCTION

At the end of the 1990s during the conference entitled *Italians in the History of Mycology*, the great contribution of Italian researchers to mycology, particularly in the areas of taxonomy and systematics, was discussed (Onofri et al. 1999). This tradition, going back circa a half of a millennium, is globally well-known and appreciated, just to mention P. A. Mattioli (1500–1577), P. A. Cesalpino (1525–1603) and particularly the work of U. Aldrovandi (1522–1605) who described about 80 species of fungi using relatively subjective terms. Also from that period originates the mycological codex belonging to Prince F. Cesi (1585–1630), innovative because of its reporting on observations made with Galileo’s microscope. There are various works nowadays available on-line, for instance the *Sylloge fungorum omnium hucusque cognitorum* (1882–1913) by Pier Andrea Saccardo, an important work that compiled all species known globally at that time. Also from that period originates the mycological codex belonging to Prince F. Cesi (1585–1630), innovative because of its reporting on observations made with Galileo’s microscope. There are various works nowadays available on-line, for instance the *Sylloge fungorum omnium hucusque cognitorum* (1882–1913) by Pier Andrea Saccardo, an important work that compiled all species known globally at that time.

16 new genera and more than 400 new species of fungi! were united to form the *Mycotheca Universalis* kept in the Siena herbarium (Mariotti & Chiarucci 1993; Chiarucci & Mariotti 1994; Ferri et al. 1999).

On the other hand, the numerous activities of Italian mycologists underway during the past 20 years and concerning new aspects such as biodiversity, mapping, conservation of fungi and the environment are fragmentary and often overseen by the scientific world and governmental bodies. At the end of the 1980s, the Working Group for Mycology of the Italian Botanical Society, decided to intensify the mycological investigation and the evaluation of biodiversity of fungi in Italy, with particular reference to larger fungi.

In that period, thanks to the European Council for Conservation of Fungi (ECCF) where Italy is well represented, various activities began aiming to bring the ecological importance of the *Regnum Fungi* to a wider audience. In fact, the ecological importance of fungi in all niches of ecosystems as degraders of organic material and as symbionts of plants, together with their important role in the pharmaceutical and health-care industries has been often neglected worldwide in studies concerning conservation and management. Only their negative role as agents of diseases has too often been underlined and fungi were also described as destructive...
participants of life in the ecosystem and as organisms to eliminate. At European level, a list of 33 species of fungi has been proposed for legal protection under the Bern Convention and the Habitat Directive, and recently a guidance for conservation of fungi was published by the Council of Europe (Strasbourg, France) (Dahlberg & Croneborg 2006; Senn-Irlet et al. 2007; Perini et al. 2008). Moreover, contacts outside the mycological world have increased significantly: inside the Planta Europa network, plants are considered part of a wider vision including also fungi in the European Strategies for Conservation (Smart et al. 2002; Planta Europa 2008). At global level, the Species Survival Commission of IUCN in 2009 formally recognized fungi as being fundamentally different from animals and plants and needing a fully separate representation within the Commission’s structure. In autumn of the same year at Whitby (North Yorkshire, UK) more than 30 experts from over 20 countries, representing every continent, agreed the basis for a new start in conservation of fungi and the International Society for Fungal Conservation, a global federation of fungal conservation groups, was established (http://www.fungal-conservation.org/).

However, the importance of fungi in nature conservation is still limited and has to be vigorously promoted. In fact, inside the Convention of Biodiversity some groups of organisms, such as fungi, can be called the “orphans of Rio” (Minter 2010). Similarly, among world mycologists, the Italian ones seem to be the neglected “Cinderella” in actions to safeguard the fungal kingdom.

A new Italian network has been established in order to combine the various experiences covering a large range of initiatives and to better identify steps that have to be taken. Italian mycologists try now with new energy to emerge together from the silence of the past. In this context some initiatives for the Biodiversity Assessment and Strategy concerning macrofungi are here briefly reported. More detailed descriptions regarding biodiversity and other actions such as biotechnology can be found in a special issue of the journal of the Italian Botanical Society (Plant Biosystems 145(4) issued in 2011).

THE ITALIAN MYCOBIOTA

Since the compilation, between 1905 and 1938 on Cavara’s initiative, of Flora Italica Cryptogama (Saccardo & Dalla Costa 1915–1916), which also included “Fungi”, we had to wait nearly a century to see the Checklist of Italian fungi... (Onofri et al. 2005a). In fact, the need of knowledge on the diversity and distribution of fungal species prompted in the 1990’s more and more mycologists to work seriously in this area and finally in 2000, thanks to an agreement between the Ministry of Environment and Tuscia University in Viterbo, mycologists collaborated at the national level to produce a Checklist (Onofri et al. 2005a, 2005b). The fungal species listed in that Checklist, from the class of Agaricomycetes, excluding parasitic ones commonly called “rusts” and “smuts”, amount to 4,296 (3,973 species, 6 subspecies, 263 varieties, and 54 forms) (Onofri et al. 2005a). It is 20% of the total number of species (20,391) globally known for this class (Onofri et al. 2005b).

This first and important work was followed over the last five years by other books and manuscripts highly improving the knowledge of Italian myco-diversity (Venturella et al. 2011). As far as Tuscany is concerned, a remarkable increase can be noted since the first regional checking and mapping activities at the end of the 1990s with more than 1,000 species (Tofacci & Mannini 1999), to more than 3,000 of the presently listed taxa (Venturella et al. 2011). Thanks to Tuscan projects involving governmental bodies, amateurs and universities the threat status of individual species was assessed, identifying various degrees of threat and a regional red list was published in 2012 as the only one in Italy (Antonini & Antonini 2006). The only fungus threatened at global level and listed under IUCN authority is an endemic species coming from Sicily (Montmollin & Strahm 2005): Pleurotus nebrodensis (Inzenga) Quél. It was shown in spring 2011 under the “Amazing species” on the IUCN webpage. Finally, thanks to the Italian Botanical Society, a working group was established in order to assess the threat status of selected target species and first specific report sheets detailing the IUCN criteria used and the threat category were published. Boletus dupainii Boud. and Psathyrella annomphila (Durieu & Lév.) P. D. Orton were the first analysed fungal species (Perini & Venturella 2008a, b).

THE IMPORTANT PLANT AREAS PROGRAMME FROM A MYCOLOGICAL POINT OF VIEW

Thanks to the Important Plant Areas (IPAs) programme, a target of two European Plant Conservation Strategies (2002–2007 and 2008–2014), the fungi were treated on an equal footing with plants in the actions (Smart et al. 2002; Planta Europa 2008). Various countries in Northern Europe worked on this identifying important mycological
areas. Planta Europa started with a programme in non-EU countries, in the central-east and then south-east of Europe. In this action various selected areas are identified as ones with threatened fungi inside and, importantly, become protected also from a mycological point of view (Anderson et al. 2005; Radford & Odé 2009). Within the European IPA context, Italy plays an important role with an innovative national project, funded by the Ministry of Environment and Land and Sea Protection, which goes beyond the IPA project adding other aspects such as landscape (Blasi et al. 2007; 2009). Involving various experts, the participation in this national network was fundamental for Italian mycologists. Even if there is lack of an Italian red list of fungi, the presence of a checklist of Basidiomycetes (Onofri et al. 2005a), the work towards preliminary red lists (Venturella et al. 1997, 2002), and a new list of endangered fungi proposed for the national IPA project, in addition to the 33 species of fungi proposed for the inclusion in the Bern Convention, enabled Italian mycologists to work for the Italian IPA project. Using the data concerning 42 species of fungi and 394 georeferenced records, at least 8 sites have been identified as important areas for larger fungi at the national level (Blasi et al. 2009). Further attempts to insist on the selection of important sites for fungi were made by Leonardi et al. 2009) . Further attempts to insist on the selection of important sites for fungi were made by Leonardi et al. (2010) and Perini et al. (2011) and are on the agenda of the action plan for the conservation of biodiversity of the Tuscan region.

**FUNGI OF MEDICINAL AND GASTRONOMIC VALUE: EXPERIMENTAL APPROACHES TO *IN SITU* AND *EX SITU* CONSERVATION**

Using fungi has a relatively long tradition in medicine and food production in various cultures of the world. In fact, many species have been used in folk medicine for thousands of years. Among the numerous larger fungi considered edible, there are only few species chosen as delicacies and these differ from country to country.

As for other fungi, the ones of medicinal and gastronomic value, they must be safeguarded in nature and sometimes their limited availability and/or the indiscriminate collection makes *in situ* and/or *ex situ* conservation fundamental.

Culturing of some edible mushrooms (such as *Agaricus* and *Pleurotus* among saprotrophs or *Tuber* among symbionts) has been successful and they commonly appear as commercially produced species on a regular basis in shops and supermarkets, while this is not so common for other species. In order to have enough fruitbodies of some poroid fungi with medicinal properties, not so abundant in the region Lombardia (for instance *Ganoderma lucidum* (Curtis) P. Karst., *Trametes versicolor* (L.) Lloyd, *Schizophyllum commune* Fr. and *Grifola frondosa* (Dicks.) Gray), their cultivation has started at the University of Pavia. Without compromising the natural resources, a few fruitbodies have been collected, isolated and artificially grown on suitable substrata and can be used by the research staff and studied (Altobelli et al. 2010; Varese et al. 2011).

The natural production of the most popular and precious fungi in Italy (the penny bun *Boletus edulis* Bull. s.l., also known as “porcino” and the truffles, mainly *Tuber magnatum* Picco and *T. melanosporum* Vittad.) is in decline due to ecological changes (global change) and different biological factors (i.e. the impact of humans and wild animals). Consequently, there is a strong increase in commercial prices as well as food adulteration. In addition, the number of “mushroom hunters” is growing, woodlands are trampled and niches destroyed, which is why *in situ* conservation becomes problematic. In this context, experimental studies have been undertaken and some guidelines for environmental management have been proposed. Medium thinning, intended as a mean removal of 20% of plants with respect to the standard area, increases the productivity of the penny bun while litter removal has only a negative impact, obviously reducing mycodiversity (Salerni & Perini 2004; Donnini et al. 2013). In case of some minor truffles (*Tuber melanosporum*, *T. aestivum* Vittad. or *T. borchii* Vittad.), however, various actions can be mentioned: *ex situ* and *in situ* conservation as well as re-introduction. In this regard various aspects must be taken into consideration: the selection of indigenous ascocarps, trees and appropriate natural habitats, moreover adequate planning of actions to initiate and then maintain the plantation (Bencivenga et al. 2005; Donnini et al. 2010; Salerni et al. 2010). The studies have been successful and currently highly productive artificial truffle areas are increasingly common.

**ACKNOWLEDGMENTS.** We would like to thank Italian mycologists working together and the Italian Botanical Society for support.

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C. Perini & E. Salerni: Italian mycologists together for the conservation...
INTRODUCTION

*Liparis loeselii* (L.) Rich. (fen orchid, yellow twayblade, bog twayblade, Loesel’s twayblade, yellow widelip orchid) is a small perennial species from the Orchidaceae Juss. family. It is the only European species of the genus *Liparis* L.

The species has a relatively large geographic range: it grows in Europe, West Siberia and North-eastern America except Alaska. *L. loeselii* occupies moist habitats: fens, wet and sandy lakeshores and meadows, abandoned gravel pits, ditches, as well as moist habitats in old fields and upland deciduous forests (Britton & Brown 1913; Komarov 1935; Gleason 1952; Galeniaks 1953; Natkevicaite-Ivnauskiene 1963; Voss 1972; Eichwald et al. 1984; Sobko 1989; Butlter 2007).

In Europe, *L. loeselii* is a rare and endangered species listed in Annex II of the European Directive 92/43/EEC. The species is included in the Red Data Books of the Baltic region; in the Red Data Book of Estonia it is considered as vulnerable; in western Estonia the species is not rare, in the other parts of the country it is relatively rare (Kuusk et al. 2003). In the Red Data Book of Lithuania *L. loeselii* is included in the second (Vulnerable) threat category. The species is distributed across the whole country yet due to the lack of suitable habitats it is rare in the lowlands (Rasomavicius 2007).

*L. loeselii* is included in the third (Rare) threat category in the Red Data Book of Latvia (Andrushaitis 2003). In Latvia, *L. loeselii* can be found throughout the whole territory, mostly in calcareous wetlands, especially in the Coastal Lowland. As solitary individuals and in groups it grows close to the northern limit of its distribution range. *L. loeselii* is a characteristic species of plant communities in calcareous fens of the Scheuchzerio-Caricetea fuscae class and the Caricion davallianae order (Pakalne 2008). The objective of this study was to do some groundwork for the biological-ecological characteristics of *L. loeselii* in order to halt the biodiversity loss by means of a conservation programme and to contribute to the ecological study of the species within its distribution range limits.

MATERIAL AND METHODS

SPECIES DESCRIPTION

*Liparis loeselii* is a perennial species with two glossy basal ovate to elliptic leaves. Its pseudobulbs are ovoid, sheathed by bracts and persistent leaf bases, with the previous year’s pseudobulb
usually present. The number of white to yellowish green flowers varies between two and 20. The flowering time is from May to August (Feodorov 1976; Scoggan 1978; Moore 1980; Mossberg 1992; Magrath 2002) and in Latvia it is from June to July (Cepurīte 2005). The species is generally considered to be self-pollinated and raindrops may facilitate its self-fertilization. The fruiting capsules are larger than the flowers (Rasmussen 1995). *L. loeselii* grows in habitats with scattered vegetation in places with no other large herbaceous competition, often in calcareous wet soils. Smaller individuals with fewer flowers occur in drier habitats; larger more robust individuals grow in moister habitats (McMaster 2001).

**METHODS**

Nine populations of *Liparis loeselii* were inspected from 2008 to 2010 (Fig. 1). The coordinates of *L. loeselii* localities were determined with a Magellan Explorist 210 GPS receiver. Plant communities in these localities were described following the Braun-Blanquet method (Ellenberg 1996). The taxa were named in accordance with the International Plant Names Index (http://www.ipni.org). The manual “European Union protected habitats in Latvia” (Aunins 2010) was used to classify the types of habitats (Table 1). Following the methodology, separation criteria were used for the habitat: plant communities, method of management, geological origin, and the degree of naturalness.

Six populations were monitored once during the three-year period, but three populations – (1) occurring on the eastern shore of Lake Engure by Lepste, (2) on the shore of Lake Kanieris and (3) on the Orchid Trail in Engure – were monitored four times during each growing season. The populations in the monitored localities were described as: very small (1–10 individuals), small (10–30), middle-sized (30–50) or large (50 and more individuals). Overgrowing with other species (percentage) and impact of anthropogenic and zoogenic factors on *L. loeselii* populations was visually determined in all localities. As the zoogenic factor the level of

![Fig. 1. Surveyed localities of Liparis loeselii in Latvia.](http://commons.wikimedia.org/wiki/File:Un-latvia.png)
damage to *L. loeselii* was examined. The anthropogenic impact factor was assessed as a threat to the habitat quality for *L. loeselii* to grow there. The annual cycle of *L. loeselii* and the environmental factors – water level fluctuation (cm) and sludge thickness (cm) – were determined in the above-mentioned three populations (in the remaining ones sludge formation was not observed). Nonflowering and flowering individuals as well as the flower number of each flowering individual were counted in the locality on the eastern shore of Lake Engure by Lepste.

**RESULTS**

Our investigations showed that *Liparis loeselii* grows in four habitats protected in the European Union: 2190 Humid dune slacks, 7140 Transition mires and quaking bogs, 7210 Calcareous fens with *Cladium mariscus* and species of the *Caricion davallianae*, and 7230 Alkaline fens (Table 1).

The growing season of *L. loeselii* begins rapidly in the first decade of June, initially new leaves appear and inflorescence develops afterwards. Following high water levels or drought, which delay the initiation of the development, the new leaves and inflorescence start to grow almost simultaneously. Our study showed a range of flowering from the second decade of June to the second decade of July. Seeds ripen in September – October, but they are dispersed by the wind and melting snow water in March – April.

In all localities, the high water level was in early June followed by a decrease from June to July. In the localities of the eastern shore of Lake Engure by Lepste (habitat 7210) and the Orchid Trail in Engure (habitat 7230) the water level rose from July to August and subsequently decreased until September. In the locality on the shore of Lake Kanieris (habitat 7230) the changes of water level fluctuation from July to September were relatively stable (Fig. 2).

The populations were divided according to their size: (1) very small in the localities of Pēterezera viga (habitat 2190) and the Nature trail by Lake Kanieris (habitat 7230); (2) small in the localities on the eastern shore of Lake Engure by Lepste (habitat 7210), on the shore of Lake Kanieris (habitat 7230), the Orchid Trail in Engure (habitat 7230), Peninsula in Lake Dreimanu (7230), Lake Silabebri (7140), and Lake Busnieki (7140); (3) large in the locality of the Salkas gravel-pit near the town of Ainazi (habitat 7230).

In the locality on the eastern shore of Lake Engure by Lepste (habitat 7210) the population decreased from 22 individuals 2008 to 16 individuals in 2010 (Table 2). The number of non-flowering individuals increased (eight individuals in 2008, eleven – in 2010), whereas both the number of flowering ones and the total number of flowers decreased (14 individuals in 2008 with 66 flowers decreased in total, five in 2010 with 18 flowers).

The overgrowth of trees and shrubs (*Betula pubescens* Ehrh., *Pinus sylvestris* L., *Salix aurita* L., *S. cinerea* L. and *S. pentandra* L.) were observed in the localities of Pēterezera viga (habitat 2190) and the Salkas gravel-pit near the town of Ainazi.

### Table 1. Latvian localities of *Liparis loeselii* with reference to European Union protected habitats.

<table>
<thead>
<tr>
<th>Localities</th>
<th>Coordinates of localities</th>
<th>European Union protected habitats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humid dune slack Peterezers (Pēterezera viga)</td>
<td>57°14.903′N, 22°09.006′E</td>
<td>2190 Humid dune slacks</td>
</tr>
<tr>
<td>The eastern shore of the Lake Engure by Lepste</td>
<td>57°17.175′N, 23°08.990′E</td>
<td>7210 Calcareous fens with <em>Cladium mariscus</em> and species of the <em>Caricion davallianae</em></td>
</tr>
<tr>
<td>Orchid Trail in Engure</td>
<td>57°15.813′N, 23°08.659′E</td>
<td>7230 Alkaline fens</td>
</tr>
<tr>
<td>Shore of the lake Kanieris</td>
<td>56°58.868′N, 23°27.648′E</td>
<td>7230 Alkaline fens</td>
</tr>
<tr>
<td>Nature trail by the lake Kanieris</td>
<td>56°59.542′N, 23°25.816′E</td>
<td>7230 Alkaline fens</td>
</tr>
<tr>
<td>Gravel-pit Salkas near the town Ainazi</td>
<td>57°51.506′N, 24°27.757′E</td>
<td>7230 Alkaline fens</td>
</tr>
<tr>
<td>Peninsula in the Lake Dreimanu (Svetes)</td>
<td>56°45.951′N, 26°09.093′E</td>
<td>7230 Alkaline fens</td>
</tr>
<tr>
<td>Lake Silabebri</td>
<td>56°36.280′N, 26°05.054′E</td>
<td>7140 Transition mires and quaking bogs</td>
</tr>
<tr>
<td>Lake Busnieki</td>
<td>57°26.902′N, 21°37.831′E</td>
<td>7140 Transition mires and quaking bogs</td>
</tr>
</tbody>
</table>
During the three-year period, overgrowth with *Cladium mariscus* (L.) Pohl and *Phragmites australis* Trin. ex Steud. increased by 25 percent in the locality on the eastern shore of Lake Engure by Lepste (habitat 7210) and by 60 percent in the locality of the Orchid Trail in Engure (habitat 7230) (Figs 3, 4A & 4B). In the locality on the shore of Lake Kanieris (habitat 7230) overgrowth with perennial species was not observed.

In the locality on the eastern shore of Lake Engure by Lepste (habitat 7210), sludge thickness increased from 0.4 cm in 2008 to 6.4 cm in 2010, but in the Orchid Trail in Engure (habitat 7230), it increased from 0 cm in 2008 to 8 cm in 2010 (Fig. 3). In the locality on the shore of Lake Kanieris (habitat 7230) the formation of sludge was not observed.

Impact of zoogenic factors on *L. loeselii* populations was observed only in the locality of the Salkas gravel-pit near the town of Ainazi (habitat 7230). The observed damage was likely caused by mollusks (Fig. 5). Likewise, some influence of an anthropogenic factor (recreation) on *L. loeselii* was observed only in the same locality. It is an abandoned gravel-pit, planned to be used as a shooting ground and water flooded reservoirs.

**DISCUSSION**

The following are considered as threats for *Liparis loeselii* in European countries: habitat loss, habitat fragmentation, deterioration of habitat conditions, progressive drainage and succession processes in abandoned meadows (Wheeler et al. 1998; Bednorz 2003; Krauss et al. 2004; Kull & Hutchings 2006; Pawlikowski 2008).

Our observations showed that significant changes of water level in localities occurred within and between the growing seasons (Fig. 2). The most significant water level fluctuations during the growing seasons were observed in the locality on the eastern shore of Lake Engure by Lepste (habitat 7210) – the water level there can vary within a 14 cm range during one growing season in 2009 and 21 cm between the 2008 and 2010 growing seasons in the same locality (Fig. 2). Bednorz (2003) notes that *L. loeselii* is sensitive to water stress. Similarly, our results showed that a water level change during the vegetation period is essential for the life cycle of this species. In the locality on the shore of Lake Engure by Lepste (habitat 7210) in 2010 the growing season of *L. loeselii* began two weeks later because of high water levels, as evidenced by flooded tufts of *Schoenus ferrugineus* L., an abode of *L. loeselii*. In this population, also the occurrence of prolonged high water levels in the growing season affected sexual reproduction, i.e. inflorescences did not develop at all or they had a low (1–3) number of flowers. The number of non-flowering individuals and flowering ones varied markedly from year to year (Table 2) depending on the water level, which was 18 cm in June 2008 and 32 cm in June 2010 (Fig. 2). Further, McMaster (2001) noted that in the Massachusetts wetland dramatic fluctuations in the population appeared to result from hydrological changes. Water level fluctuations may also have an impact...
on the distribution of *L. loeselii*. Most occurrences are in saturated habitats in which the water table is approximately at ground level. It is unknown whether the plant can survive prolonged periods of inundation, but it appears to tolerate regular short-term flooding (Rolfsmeier 2007).

However, it is important to note that high water levels at the beginning of the growth season caused movement of individuals of *L. loeselii* carried by the wind-induced water flow. We did indeed establish the movement of the whole plant growing directly by open water, for example in the localities of Lake Silabebri (habitat 7140) and Busnieki (habitat 7140) as well as in the collection of the National Botanic Garden (D. Smite, unpubl.). Thereby both the location of a single plant and the border of an areal are variable. Similar findings were seen in the stands of *L. loeselii* in the locality on the eastern shore of Lake Engure by Lepste (habitat 7210).

As *L. loeselii* is a light-demanding species, it needs habitats with scattered vegetation where there is no other large herbaceous competition. The overgrowth of trees and shrubs was observed in the localities of Pēterezera viga (habitat 2190) and the Salkas gravel-pit near the town of Ainazi (habitat 7230). A similar phenomenon was described by Lithuanian scientists (Rasomavicius 2007). Threats for *L. loeselii* in Lithuania are habitat drainage and overgrowth with trees and shrubs (Rasomavicius 2007).

An urgent problem in the localities on the eastern shore of Lake Engure by Lepste (habitat 7210) and the Orchid Trail in Engure (habitat 7230) is overgrowth with *Cladium mariscus* and *Phragmites australis* (Figs 3, 4A & 4B). Lake Engure belongs to the group of shallow lakes located in Coastal lowland. The high concentration of calcium and relatively low water levels of Lake Engure are important factors for the growth and spreading of *C. mariscus*. Also, the suitable temperature from -4°C to -8°C during the winter and from +16°C to +18°C during the summer promotes the growth of this species (Salmina 2006). During the three-year period overgrowth with perennial plants increased by 25% (from 50% in 2008 to 75% in 2010) in the locality on the eastern shore of Lake Engure by Lepste (habitat 7210) and by 60% (from 30% in 2008 to 90% in 2010) in the locality on the Orchid Trail in Engure (habitat 7230) (Fig. 3).

<table>
<thead>
<tr>
<th>Year</th>
<th>Non-flowering individuals</th>
<th>Flowering individuals</th>
<th>Total number of individuals</th>
<th>Flower number of flowering individuals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Minimal</td>
</tr>
<tr>
<td>2008</td>
<td>8</td>
<td>14</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>2009</td>
<td>10</td>
<td>6</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>2010</td>
<td>11</td>
<td>5</td>
<td>16</td>
<td>1</td>
</tr>
</tbody>
</table>
note that *C. mariscus* is a rare species included in the Red Books of Belarus, Estonia, Latvia, Lithuania, and the Baltic Region. In Latvia, the species grows close to the north-eastern border of its distribution area (Andrushaitis 2003) and these habitats are particularly valuable (Aunins 2010). It has been indicated that *C. mariscus* is a species with low competitiveness (Salmina 2006). During the monitoring years, the *C. mariscus* became expansive and overgrew other species; it successfully outcompeted *Schoenus ferrugineus* causing environmental disadvantages for the growth of *L. loeselii* (Figs 4A & 4B). Accumulation of *C. mariscus* biomass, which decomposes poorly, can cause sludge formation and increase eutrophication.

Another threat factor could be animal-induced damage observed in our study area only in the locality of the Salkas gravel-pit near the town of Ainazi (habitat 7230) where the number of individuals exceeded 100. The damage observed directly in those relatively large populations was likely caused by mollusks (Fig. 5). In Europe, young shoots of *L. loeselii* individuals are eaten by mollusks in many populations (Wheeler et al. 1998). Injuries such as small holes in leaves, shoots, flowers and fruits have been also reported in North America (Rolfsmeier 2007). They were caused by insects and other invertebrates as well as the deer or rabbit leading to the complete removal of shoots and stems (Rolfsmeier 2007). In the surveyed areas, except in the locality on the Salkas gravel-pit near the town of Ainazi (habitat 7230), animal-induced damage of *L. loeselii* individuals was not detected. *Epipactis palustris* Crantz and *Dactylorhiza incarnata* (L.) Soó were often damaged by animals (inflorescences and capsules of these species are edible), yet no animal trails were observed near *L. loeselii* individuals. It is possible that animal-induced damage in our surveyed areas was so insignificant because these populations are relatively small (Pianka 1996; Morin 1999; Fox et al. 2001).

It has been considered that in Latvia, as well as the rest of Europe, the existence of the suitable habitats and distribution of *L. loeselii* populations are threatened by the expansion of soil draining and recultivation. Unlike some other European countries where the drainage is an important threat factor (Wheeler et al. 1998; Bednorz 2003), our research shows that in Latvia it is not such an important threat at this moment: the adjacent habitats could not be drained because of the lack of financing for agriculture. Recreation is not a threat for the studied populations of *L. loeselii* with the exception of the abandoned gravel-pits as they are adapted to become shooting grounds or flooded water reservoirs.

**CONCLUSIONS**

1. Water level fluctuation, natural succession processes: overgrowth with perennial plants, trees and shrubs (increased shading), eutrophication and recreation are the most important factors limiting
the growth and reproduction of Liparis loeselii in the studied habitats.

2. Damage from animals could not be regarded as significant.

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INTRODUCTION

Rare and threatened plant species constitute a very important aspect of biodiversity. Their conservation is one of the most important ecological problems in the world and also in Belarus. The whole flora of the Republic of Belarus includes about 1,700 vascular plant species (Parfenov 1999). Over the last 100 years more than 70 native plant species have disappeared from the flora under the influence of different anthropogenic factors. At present, 293 species of plants and fungi are protected at the national level in the Republic of Belarus (they are included in the Red Data Book) (Horuzik et al. 2005). Conservation of rare and endangered plant species is necessary for the maintenance of biodiversity in the Republic.

In order to protect biodiversity, the Convention on Biodiversity was adopted (1992, Rio de Janeiro). Also, the Global Plant Conservation Strategy (2002, the Hague), the First (2001, Pruhonice) and the Second (2007, Cluj-Napoca) European Plant Conservation Strategies were developed and implemented. The National Strategy and the Action Plan for the Conservation and Sustainable Use of the Biological Diversity of the Republic of Belarus was developed in 1997. A system of specially protected natural areas in Belarus was worked out, and the project Important Plant Areas (IPA) in Belarus and actions in aid of conservation of European threatened species and habitats was begun in 2001. The implementing programme for the European Plant Conservation Strategy in Belarus was created in 2005. In 2010 the second National Strategy for the Conservation and Sustainable Use of the Biological Diversity of the Republic of Belarus for 2011–2020 was developed.

In Belarus, among the main problems of conservation of rare and threatened plant species, included in the Red Data Book, there are: organization of the registration of their populations, adequate assessment of their state and stability, preparation of legal documents for their protection, transferring them to land users, and control of the state. Information for these documents should be prepared on the basis of modern investigations which take into account the

INVESTIGATIONS AND PROTECTION OF THE RARE AND THREATENED PLANT SPECIES NECKERA PENNATA, ANEMONE SYLVESTRIS AND MELITTIS SARMACTICA IN BELARUS

Anastasia Ševkunova

Abstract. One of the main priorities of the European Plant Conservation Strategy and the nature conservation policy in Belarus are research and practical actions focused on the prevention of extinction of rare and threatened plant species.

In Belarus much attention is paid to the investigation of populations of these species. The State Plant Cadastre, developed in the Institute of Experimental Botany of the National Academy of Sciences of Belarus, contains standardized specific information about more than 6,800 populations of 288 protected species included in the Red Data Book of Belarus. The legal passport system of these populations helps implement the effective monitoring and administrative control of their state.

In 2005–2011, about 450 populations of 69 protected plant species (including 300 populations of 13 model species) were investigated in the field. A metapopulation approach concerned with the regional species dynamics in fragmented landscapes was used in the studies. As an example, the spatial and genetic structure of the metapopulations of Melittis sarmatica Klok., Anemone sylvestris L., and Neckera pennata Hedw. model species were investigated. Such a metapopulation approach made it possible to estimate the state of complexes of local populations at regional level. Modelling the development of rare and threatened plant species metapopulations under anthropogenic transformations will help manage natural complexes effectively.

Key words: State Plant Cadastre of Belarus, threatened plant species, metapopulation

The V. F. Kuprevich Institute of Experimental Botany of Belarus National Academy of Sciences, 27 Akademicheskaya St., Minsk, RU-2200072, Belarus; e-mail: a.shevkunova@mail.ru
dynamics and structure of populations in a region. In the Republic of Belarus such work is done in the framework of the State Plant Cadastre. Some results of this work are presented in this paper.

MATERIALS AND METHODS

The investigations were performed in the framework of the State Plant Cadastre of the Republic of Belarus. This Cadastre is an IT system which contains necessary data about the distribution of plant species among land users, quantitative and qualitative descriptions of the economic and scientific value of plants as well as other information. The cadastral documentation comprises, among others, a database on wild plant species included in the Red Data Book of Belarus. This database contains data about the quantity of individuals, the area and the state of populations of rare and threatened plant species, assessment of the state of these species in each administrative district and region as a whole. The state of populations, based mainly on their vitality, was estimated using a 5-point Grossgeim scale: 1 – very poor (germination but no development of vegetative organs), 2 – poor (weakening with insufficient vegetative development and the failure to pass the entire large life cycle), 3 – satisfactory (good vegetative development yet also the failure to pass the entire life cycle), 4 – good (vegetative development, flowering and fruiting above normal), 5 – very good (lush development and increased flowering and fruiting) (Bykov 1973). The state of the species was determined on the basis of the state of its populations and their quantity.

At present, the database on wild plant species included in the Red Data Book of Belarus of the State Plant Cadastre contains standardized specific information about more than 6,800 populations of 288 protected plant species included in the Red Data Book. It also contains special legal documents, passports of populations of the species which should be protected. About 1,300 plant populations are included there. The plant population passport contains the following information: the name of the object requiring protection (the name of a plant species), the precise location of the population, a description and control parameters which are subject to monitoring during a certain period of time. The information contained in the passports makes it possible to make a prognosis concerning the dynamics of endangered species populations. Each passport is given to a land user, who should perform all the protection-related recommendations.

During field studies carried out in 2005–2011 about 450 populations of 69 plant species, which feature in the Red Data Book, were investigated. These species included e.g. *Melittis sarmatica* Klok. (70 populations), *Huperzia selago* (L.) Bernh. ex Schrank et Mart. (58), *Lilium martagon* L. (35), *Listera ovata* (L.) R. Br. (36), *Gladiolus imbricatus* L. (23), *Neckera pennata* Hedw. (15), *Gentiana cruciata* L. (13), *Iris sibirica* L. (11), and *Anemone sylvestris* L. (9 populations).

13 model plant species with different ecology (forest, meadow, swamp species, etc.), geographical distribution (boreal, temperate, multizonal species, etc.), biology (species with different life forms, reproduction characteristics, etc.), etc. were chosen for more detailed investigations. In this paper, the following species are considered: the vascular plant species *Anemone sylvestris*, a multizonal forest-steppe species, *Melittis sarmatica*, a species of broad-leaved and mixed forests, and the epiphytic moss *Neckera pennata*, a temperate species of broad-leaved forests growing only in old treestands.

In my opinion, the methodology for the conservation of specific species in a region may be based on conserving complexes of their populations. Also, different approaches should be used for different types of populations (depending on their size, density, etc.) taking into account the specificity of the species.

The following procedure of investigations of plant species in a region can be suggested:

- registration and detailed investigation of all populations in a region;
- monitoring;
- modelling;
- prognosis;
- making general conclusions about the state and survival prospects of the species;
- preparation of special documentation for the protection of populations of the species.

The investigated plant species are distributed irregularly. They occur on discrete and specific substrates, occupy ecotone plots, where the ground cover is destroyed to a certain extent and competitive relations are weakened. Since the mid-1980s, scientists have been faced with the problem that for such species the usual ways of conservation of each single population are insufficient. Thus, investigations of the whole complex of plant populations on a certain territory (metapopulations) are more useful.

Metapopulation can be regarded as a complex of local populations which are spatially separated (or relatively separated) and interact with each
other via the exchange of diaspores or other ways of genetic flow (Hanski & Gaggiotti 2004). In the metapopulation consisting of several isolated populations, some separate populations (satellites) can die out, but the species survives due to the transfer of genetic material from the surviving central populations. Therefore the conservation of these central populations and connections between them is of key importance.

The advantages of metapopulation studies are that they show the dynamics of a whole complex of local populations, take into account the fact of genetic material exchange between local populations, as well as help model and predict population extinction in fragmented landscapes. Thus, they are more useful for species understanding and management than the description of separate populations.

To estimate the state of metapopulations, to define their dynamics and to make the prognosis of their development it is necessary to identify a number of parameters on which the metapopulation model will be formulated. These parameters can be subdivided into several groups: geographical, biological, ecological, coenotic (habitat-related), structural, and anthropogenic.

1. The geographical parameters concern the origin, distribution and behavioural features of species depending on species location – within the limits of the natural distribution, on the border of the natural distribution or in island localities. For example, in Belarus Caulinia flexilis Wild. is distributed in separate localities on the southeastern border of its area.

2. The biological parameters concern the biological features, the vital strategy of a species. It was revealed, for instance, that Huperzia selago and Lilium martagon had differing reproductive potential. L. martagon aspires to occupy new places and to expand the area of the population; the growth of Huperzia selago populations stabilizes after reaching a certain size.

3. The ecological parameters concern the specificity of ecological niches and features of species existence depending on the activity of various ecological factors. So, for example, the occurrence frequency of the species Huperzia selago and Lilium martagon in forests depends on soil nutritive material content and humidity; the occurrence frequency of the moss Neckera pennata depends on soil resources; while that of Cypripedium calceolus L. depends on calcium content in the soil.

4. The coenotic parameters concern features of species “behaviour” in various coenoses. And so, Huperzia selago inhabits spruce forests to a greater extent and Lilium martagon inhabits oak forests and spruce ones; the moss Neckera pennata inhabits old broad-leaved forests and begins to settle there only when given associations reach a certain age. Melitits sarmatica prefers broad-leaved (mainly oak and hornbeam) and mixed (mainly spruce with oak or hornbeam) forests.

5. The structural parameters concern the distribution of individuals within the population and the distribution of populations within the metapopulation, and also within the limits of a geographical region. Consequently, studying metapopulations of Neckera pennata it is necessary to consider the distance between the trees on which it grows. While the State Plant Cadastre of the Republic of Belarus was being developed, it was revealed that rare species populations are distributed across the Republic irregularly. There are places of their concentration and the fact exerts influence on their state.

6. The parameters concerning stability in the face of anthropogenic influence and the ability to survive in the urbanized environment form a separate group. For example: there are no natural rock outcrops in Belarus, so the rare moss Tortella tortuosa (Hedw.) Limpr. settles on anthropogenic cement-stone constructions.

One of the objects of metapopulation research was the epiphytic moss Neckera pennata, its host trees being: Fraxinus excelsior L., Ulmus scabra Mill., Acer platanoides L., Populus tremula L., Quercus robur L., and Carpinus betulus L.

The following parameters were determined for studying the general dynamics of Neckera pennata metapopulations (Snäll et al. 2005):

1. Host tree species (physical characteristics of the bark).
2. Diameter (in cm) of the tree trunk at breast height (1.3 m).
3. Depth of bark crevices at 50 cm above the ground (in mm).
4. Condition of the substrate (tree alive or dead).
5. Trunk inclination (in degrees).
6. Relative cover of N. pennata in a 35 × 35 cm plot.

Trees with a trunk diameter of not less than 10 cm at breast height were considered as potential host trees for N. pennata.

For other model species (vascular plants) we used different approaches, considering their biological, geographical and structural characteristics. For example: big populations of Anemone sylvestris, whose area was more than 1 ha, were mapped, their area and number of individuals, age structure on experimental areas were evaluated, and the ecological factors (soil humidity and richness, light
conditions) were analyzed. For small populations of *Melittis sarmatica* investigations included mapping populations and each individual within them, plotting a pattern reflecting the distribution of individuals within populations and populations within metapopulations. Also, the distribution of potential ecotopes within one of large forests inhabited by this species was analyzed. The RAPD method was used for genetic analysis of similarity between *M. sarmatica* populations within the metapopulation.

**RESULTS AND DISCUSSION**

Below are the results of the investigations of three model species: the epiphyte moss *Neckera pennata* and the vascular plants *Anemone sylvestris* and *Melittis sarmatica*, which are included in the Red Data Book of Belarus. *N. pennata* is also under protection according to Appendix I of the Bern Convention and the *Red Data Book of European Bryophytes* (category Vulnerable) (European Committee ... 1995).

**Model species *Neckera pennata***

Three metapopulations of this species were studied in Belarus. For such an epiphyte organism, a complex of all trees covered by this moss (host trees) within one forest was considered a single metapopulation and clumps of moss on every host tree a local population (Shevkunova & Maslovsky 2009). It corresponded with the approach taken by Snäll et al. (2005). The change dynamics as regards the projective cover of the studied populations of *Neckera pennata* was non-linear. The population dynamics of one of the studied metapopulations is shown in Table 1. In some local populations the area covered by *N. pennata* increased and in some other it decreased. The general observations were: increasing metapopulation area in 2008 as compared with 2007 (by 2.1%), decreasing in 2009 against 2008 (by 0.7%) and increasing in 2010 against 2009 (by 6.1%). The dynamics of the other metapopulations was similar. The natural extinction (falling trees) was not observed during the investigation period; only four host trees were cut in one of the metapopulations. For studying such dynamics the period of investigation should be longer.

The dynamics of local *N. pennata* populations depended on the host tree species, tree trunk diameter, host tree inclination, and the depth of bark crevices. An increase in the *N. pennata* relative cover was observed on *Carpinus betulus*, *Quercus robur* and *Ulmus scabra* trees. On *Acer platanoides* trees the relative cover increased in one of the metapopulations and decreased in another one. The relative cover also increased on trees with a larger diameter of their stems and depth of bark crevices. The host tree inclination first favored the growth of *N. pennata* but other moss species (e.g. *Hypnum cupressiforme* Hedw., *Anomodon* spp., *Amblystegium* spp.) began to grow more abundantly and eventually they suppressed *N. pennata*. In addition, changing levels of anthropogenic influence can be an important destabilizing factor. The following investigations confirmed the revealed dependencies and trends of dynamics.

**Model species *Anemone sylvestris***

This species was studied in terms of its population, metapopulation and regional structure. Nine local populations included into two metapopulations (Naroč and Braslav metapopulations) were investigated in 2007–2010 (Shevkunova 2010). The pattern and dynamics of quantity in generative

| Table 1. Non-linear dynamics of *Neckera pennata* projective cover change in 2007–2010 (Osipovičy district). |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| ID number of the tree | Area [cm²] occupied by the moss *Neckera pennata* within the 35 × 35 cm plot in consecutive years | |
|----------------------|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|-------------------------------------------------|
|                      | 2007  | 2008  | 2009  | 2010  |
| 1d                   | 245.0 | 202.1 | 238.9 | 294.0 |
| 2d                   | 162.9 | 138.4 | 162.9 | 165.4 |
| 3d                   | 98.0  | 79.6  | 85.8  | 91.9  |
| 4d                   | 49.0  | 67.4  | 49.0  | 24.5  |
| 5d                   | 514.5 | 404.3 | 367.5 | 441.0 |
| 6d                   | 514.5 | 404.3 | 428.8 | 330.8 |
| 7d                   | 61.3  | 49.0  | 55.1  | 67.4  |
| 8d                   | 367.5 | 343.0 | 220.5 | 147.0 |
| 9d                   | 85.8  | 281.8 | 183.8 | 306.3 |
| 10d                  | 134.8 | 226.6 | 238.9 | 196.0 |
| 11d                  | 61.3  | 79.6  | 85.8  | 104.1 |
| 12d                  | 588.0 | 796.3 | 796.3 | 857.5 |
| 13d                  | 232.8 | 183.8 | 220.5 | 245.0 |
| 14d                  | 134.8 | 116.4 | 104.1 | 116.4 |
| 15d                  | 85.8  | 128.6 | 110.3 | 110.3 |
| 16d                  | 465.5 | 502.3 | 526.8 | 575.8 |
| 17d                  | 73.5  | 318.5 | 269.5 | 392.0 |
| 18d                  | 318.5 | 294.0 | 281.8 | 294.0 |
| 19d                  | 85.8  | 110.3 | 116.4 | 85.8  |
| 20d                  | 441.0 | 514.5 | 477.8 | 539.0 |
| 21d                  | 857.5 | 894.3 | 833.0 | 820.8 |
| 22d                  | 594.1 | 612.5 | 698.3 | 747.3 |

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individuals of one of the local populations of *Anemone sylvestris* are shown in Figure 1 (numerical data are presented in Table 2). It was considered that the great quantity of individuals and vast plot area as well as the short distance between them facilitated genetic exchange, and thus the connection between them was stronger. And conversely, small plots with large distances between them have weak connections. This local population consisted of nine plots. The change in the quantity of individuals of every plot was non-linear. From 2008 until 2010 in some plots (no. 1 and 6) the quantity of generative individuals constantly increased, in other plots (no. 7) the quantity of generative individuals first decreased and then increased. In certain plots the quantity of generative individuals was stable within all three years (plot no. 5) or within only two years (plots no. 2, 3 and 8). Also, some minor fluctuations of the quantity of generative individuals was observed (plot no. 4). Generally, in 2009 there was a small decrease in the population size (by 2.5%), and in 2010 the population size increased by 62.3%. As this general increase was recorded on three plots (no. 1, 6 and 7), in terms of dynamics this population is relatively stable, with variable quantity of generative individuals.

To learn more about the state of *A. sylvestris* metapopulations, the population size dynamics (Fig. 2), the area of local populations (Fig. 3) and the density of generative individuals within local populations (Fig. 4) were studied. The local populations 478, 685, 686 and 689 are included into the Naroč metapopulation, 708, 710, 715 and 726 into the Braslav metapopulation.

All the studied parameters changed differently in different populations. For the Naroč metapopulation, the unidirectional change of parameters of local populations was not typical. There were growing populations, where all the parameters increased (e.g. 478). Minor fluctuations in terms of area and gradual increases of size and density were observed in the local population 685. In the local population 686, the size increased, but the area decreased in 2009 and increased in 2010. In the Braslav metapopulation, the size, area, and density of the local populations 710 and 715, as well as the area of the local population 708 decreased in 2009 and increased in 2010 (but to a different extent). The size and density of the population 708 as well as the size and area of the population 726 increased in 2010 in comparison with 2009. The density of the population 726 was stable in 2010 in comparison with 2009.

The results presented show that the dynamics of local populations within metapopulations was non-linear. The size of particular populations could increase or decrease, but the stability of the population size was recorded.

| Table 2. Quantity of generative individuals of *Anemone sylvestris* population (Braslav district) in 2008–2010. |
|---|---|---|---|
| No. of plot | 2008 | 2009 | 2010 |
| 1 | 28 | 38 | 47 |
| 2 | 4 | 2 | 2 |
| 3 | 4 | 4 | 11 |
| 4 | 1 | 2 | 1 |
| 5 | 7 | 7 | 7 |
| 6 | 3 | 14 | 24 |
| 7 | 14 | 9 | 20 |
| 8 | 1 | 3 | 3 |
| 9 | 15 | n/d | 10 |

| Table 3. Quantity of generative individuals of the Naroč metapopulation of *Anemone sylvestris* (consisting of four local populations) in 2008–2010. |
|---|---|---|
| No. of population | 2008 | 2009 |
| 478 | n/d | 7867 |
| 685 | 49 | 68 |
| 686 | 173 | 205 |
| 689 | 15 | 23 |

**Fig. 1.** Population structure and dynamics of *Anemone sylvestris* population size (Braslav district) in 2008–2010. No. 1–9 — numbers of plots. Type of line refers to the strength of connection between plots (bold lines — strong connection, thin — moderate, dotted — weak). The size of the circle is proportional to the number of individuals (for scale see the figure).
Fig. 2. Dynamics of population size of *Anemone sylvestris* in 2008–2010 in eight local populations. The number of individuals in the first year of observation in a given population was regarded as 100%.

Fig. 3. Dynamics of population area of *Anemone sylvestris* in 2008–2010 in populations as in Fig. 2. The area in the first year of observation in a given population was regarded as 100%.

Fig. 4. Dynamics of population density of *Anemone sylvestris* in 2008–2010 in populations as in Fig. 2. The density in the first year of observation in a given population was regarded as 100%.
metapopulations as a whole was maintained by the stability of the size of its main centers. For example, in the Naroč metapopulation, the population 478 was the center (Fig. 5, Table 3). It occupied the largest area and was most abundant. Its state was unstable, as seen not only from the population size dynamics, but also from the dynamics of the age spectrum (Fig. 6). Generally, in 2009 the number of individuals of all the local populations increased, on average, by 36.9%. In 2010, the size increase of the populations 685 and 686 was only slight (1.5% and 2%, respectively). The size of the population 689 decreased by 34.8%, but the size of the population 478 recorded a double increase. In 2010, the size of the Naroč metapopulation increased by 97% (mainly because of the increase in the quantity of generative individuals in the population 478).

In the Braslav metapopulation, the population 726 was the center (Fig. 7, Table 4). It occupied the largest area and was the most abundant. In 2009, a dramatic decrease in the size of the population 710 (by 68.6%) was observed, but the size of the population 715 was stable. In 2010, a sharp increase in the size of all the local populations was observed, on average, by 216.6%. In total, in 2010 this metapopulation recorded double growth.

Local extinctions and colonization during the period of the investigation were not observed, but changes in terms of the size and area were relatively considerable in some cases (especially in small populations), and if the conditions are not favorable in the following years, there may be a dramatic decrease in such populations and then they may even become extinct.

The Belarusian regional population of *A. sylvestris* consists of ten metapopulations (Fig. 8). The Naroč metapopulation (no. 2) is most abundant in Belarus. The Braslav (no. 1) and Čerikov (no. 9) metapopulations are slightly less abundant.

All this information is necessary for the estimation of the actual state of the species in the country and makes it easier to make prognoses concerning its development.

**Model species *Melittis sarmatica***

The spatial and genetic structure of one of its metapopulations was studied. This metapopulation was located in Volkovysk and Slonim uplands (in western Belarus). In total, there are 94 local populations of *Melittis sarmatica* in the metapopulation, and they are mainly situated in the vast Zamkovy forest, which is a biological reserve. These populations have several centers of their concentration (Fig. 9). The RAPD analysis data obtained from

**Table 4.** Quantity of generative individuals of the Braslav metapopulation (consisting of four local populations) of *Anemone sylvestris* in 2008–2010.

<table>
<thead>
<tr>
<th>No. of population</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008</td>
</tr>
<tr>
<td>708</td>
<td>n/d</td>
</tr>
<tr>
<td>710</td>
<td>35</td>
</tr>
<tr>
<td>715</td>
<td>79</td>
</tr>
<tr>
<td>726</td>
<td>n/d</td>
</tr>
</tbody>
</table>
16 populations were used for the construction of a genetic similarity dendrogram. It was revealed that some genetic information exchange took place within the metapopulation (Shevkunova & Urbanovich 2010). Separate local populations growing in different coenoses are interconnected, both spatially and genetically. A negative linear dependence was revealed between the level of the genetic similarity of the populations and the distance between them.

The dependence was calculated using the following formula (Shevkunova & Urbanovich 2010):

$$ y = -0.33x + 67.7 \quad (p < 0.05) $$

where “$y$” is the level of genetic similarity between the populations (given in %) and “$x$” is the physical distance between local populations.

The spatial structure of the metapopulation distribution of potential ecotopes for *M. sarmatica*...
growth in Zamkovy forest was analyzed. These ecotopes were listed in the chapter “Materials and methods” (as examples of coenotic parameters).

The density of potential ecotopes (percentage in the forest block) for *M. sarmatica* within Zamkovy forest is shown in Fig. 10.

After defining the dependence of a number of *M. sarmatica* populations and individuals in the forest block on the quantity of potential ecotopes (Fig. 11), the expected spatial structure of the *M. sarmatica* metapopulation could be modelled. Analysis of the distribution of potential ecotopes within the Zamkovy forest, where *M. sarmatica* could grow, showed that there about 1,500 individuals of this species could inhabit the area. This is the maximum number of individuals in the forest, but for different reasons (competition with other species, unfavourable local conditions, animal threats, etc.) this number was only about 500. Additional investigations should be perform to ascertain the exact structure of the metapopulation.

The size dynamics of eleven local *M. sarmatica* populations in the Zamkovy forest was non-linear: in some populations the quantity of individuals increased and in some others it decreased (Fig. 12). In general, there was a dynamic stability of the metapopulation size.

**USE OF THE OBTAINED DATA FOR PRACTICAL PROTECTION OF PLANT SPECIES**

The investigations described in this paper can be the basis for the assessment of the state, detection of the main threats and formulation of recommendations concerning practical protection of plant species included in the Red Data Book of the Republic of Belarus. They showed that populations of *N. pennata*, *A. sylvestris* and *M. sarmatica* are dynamically stable, so their present state should be
maintained without performing any special activities, however the control of limits as regards the fluctuation of the main parameters (relative cover of *N. pennata*, quantity of individuals, area and density of *A. sylvestris* and *M. sarmatica* populations) is needed.

The investigations made it possible to determine the main threats for these species: e.g. decreasing habitat areas (in particular due to felling old broad-leaved forests), landscape fragmentation, anthropogenic transformation of natural complexes, related to forest management, increase in recreational pressure, plant collection (*A. sylvestris* as a beautiful flowering plant and *M. sarmatica* as a plant having medicinal value), environmental pollution, and animal threats.

The investigated parameters of the populations (quantity of individuals, area and present state) and recommendations on protection of populations (for example, forest felling as the main threat was forbidden in all places of growth of *N. pennata* and *M. sarmatica* and was allowed only in the autumn – winter period in the presence of stable snow cover in all places where *A. sylvestris* occurs) were included in the cadastral passports. They were prepared for all the investigated

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Fig. 10. Isolines of density (in %) of potential ecotopes for *Melittis sarmatica* within the Zamkovy forest (Volkovysk district) (base map: Ministry of Natural Resources and Environmental Protection of the Republic of Belarus).

Fig. 11. Dependence of the number of populations and individuals of *Melittis sarmatica* in the average forest block on the quantity of potential ecotopes with second-degree multinomial regression lines (multinomials and $R^2$ values given).
populations of the studied species and then were distributed among the local bodies of the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus in each administrative district. Then these passports were given to specific land users, who should perform all the protection-related recommendations.

The investigations of plant species populations and the preparation of special documentation (passports for all plant species populations) made it possible to make corrections in the area of forest management. Annual control of the state of the populations prevented their elimination due to forest felling or other types of anthropogenic influence.

Practical protection of the most rare and threatened plant species also included the development of management plans and proposals on conservation measures for populations and habitats within the framework of a system of monitoring of protected plant species. Such plans and proposals were developed formerly for two species, Cladium mariscus (L.) Pohl and Scorzonera glabra Rupr. Each of them grows in only one place in the Republic and so it is very important to conserve them. During the following four years the execution of these plans helped conserve these populations. It is intended that such plans be developed for all the model species.

CONCLUSIONS

Investigations of species of rare and threatened plants have shown that they have non-linear dynamics in terms of the size and area of their populations. It depends on different factors (biological, geographical, ecological, structural, coenotic, and anthropogenic influence).

Local populations and metapopulations of model species have certain structures and they remain in a relatively dynamical equilibrium. On the one hand, every component of the structure is interconnected with other components. On the other hand, their behaviour is independent of each other. As a rule, this independence is observed during a short period of time, while in longer periods the stability of the structure depends on the presence of separate components (plots or local populations) because it relies on genetic information exchange. Consequently, what should be taken into account for the assessment of the state of a population and metapopulation is not just the state of its plots and local populations, but also their general structure, connections between local populations, central populations and most remote local populations.

If a uniform decrease in the size of all parts of a population is observed, it means that it is under a great risk of extinction. The main conditions of its conservation are the presence of the central population(s), a minimum quantity of isolated parts and prospects for the growth of separate plots.

Such an approach can also be used for other rare and threatened plant species, yet investigations of populations which are in dynamic equilibrium should be continuous for order to determine the critical points and limits of fluctuation as regards the quantity of individuals and the area occupied.

The future targets of investigations are focused on finding the critical parameters of a metapopulation structure and development, which can result in some irreversible effects. Modelling the
development of metapopulations of rare and threatened plant species under anthropogenic transformations will help manage natural complexes more effectively.

REFERENCES


INTRODUCTION

The European North-East of Russia has numerous and diverse water bodies because of its specific climate and geological history (Alisov 1956; Taskaev 1997). However, the vegetation cover of the water bodies in the region is largely understudied. The literature (Zvereva 1965, 1969; Postovalova 1969; Tolmačev 1974, 1976a, b, 1977) contains only scattered data on the composition and distribution of water macrophytes which were obtained in the context of hydro-biological and general floristic studies. Going by the above-mentioned literature sources, the Donty lake, a relic of a near-glacier water body and the most ancient lake in the region, has the highest degree of floristic diversity (Zvereva 1969). Three of them (the Donty lake, the Sindor lake, and the Âmozero lake) are situated in the taiga zone, the others (among them Bol’šoj Harbej lake) in the tundra zone.

There were several glacial periods on the study area (Andreičeva 2002) and during each of them the ice covered less area than during the previous one. Consequently, the degradation of the ice sheet caused the formation of a “chain” of big lakes in different natural zones/subzones along the Timan mountain range.

Thus, the existence of ancient (i.e. of glacial origin) lakes whose vegetation cover was formed simultaneously with the vegetation cover of the area around the lakes, on the one hand, and geographical attribution of these lakes to different natural zones within one longitudinal sector on the other, create excellent conditions for revealing the formation mechanisms of the composition and structure of the vegetation cover in the lakes of the region.

The main purpose of this paper is to identify and analyze the changes of the composition and structure of the flora of the ancient lakes of the European North-East of Russia due to different natural-climatic conditions along the latitudinal gradient.

BRIEF DESCRIPTION OF THE LAKES

The flora of four lakes: the Bol’šoj Harbej lake, the Âmozero lake, the Sindor lake and the Donty lake (Fig. 1) has been investigated.

The Bol’šoj Harbej lake (67°33′N, 62°53′E) is situated in the eastern part of the Bol’šezemel’ skaâ tundra. Its water area is 19.5 km²; dominant depths are 1.0−1.5 m; the maximal depth is 17.2 m. The shoreline of the lake is even. The shores are low (0.5−1.0 m above water level) and sloping. The bottom is usually formed of sand and gravel-sand. By chemical composition, the waters of the Bol’šoj Harbej lake belong to the hydrocarbonate-sodium class. The mean values of water mineralization in the summer period are 45.0−50.0 mg/dm³ with the pH of 7.2−8.0. The water contains comparatively little organic matter.

The lake is situated within the Atlantic climatic area of the sub-Arctic belt (Alisov 1956). The mean annual air temperature around the lake does...
not exceed -6°C. The frost-free period lasts for 60 days. The mean air temperature in the warmest month (July) is +11°C and in the coldest (January) -21°C (Taskaev 1997).

According to the regional geobotanical division (Údin 1954), the lake belongs to the south sub-zone of the tundra zone. The lake is surrounded by numerous sedge and plane-hummock mires.

The Ámzero lake (65°01′N, 50°14′E) is situated on the water divide between the Mezen and Pečora river basins. The shape of the lake is almost regular round, the water area of the lake is 31 km², the prevailing depth between 1.0–1.2 m (maximum depth reaches 2.5 m).

By chemical composition, the waters of the Ámzero lake belong to the hydrocarbonate class. The mean values of water mineralization in the vegetation period are 17.2–29.5 mg/dm³ with the pH of 6.19–6.51. The water contains comparatively little organic matter, including humus. Content of total organic matter is 23.0 mg/dm³.

The lake is located outside the present zone of permafrost (Brown et al. 1997). The mean July and January temperatures are +13 and -17°C, respectively. The frost-free period lasts for 70 days. Annual precipitation is 534 mm at the Levkinskaä weather station, about 45 km southeast of the Ámzero lake. The bedrock is made up of Precambrian metamorphic rocks and Devonian sandstones (Nalivkin 1973). The present water area of the lake is about 30 km² and it has an almost circular outline with a maximal water depth of about 3 m. The small catchment area of 95 km² consists of mires near the shore and a sparse boreal forest dominated by spruce. The main inflow is from a creek entering the western side of the lake.

According to the regional geobotanical division (Údin 1954), the lake belongs to the far north sub-zone of the taiga zone.

The Sindor lake (62°44′N, 51°55′E) is situated on the watershed between the Vym’ and the Višera rivers that flow into the Vyčegda river. Its length is 12 km, width 2–4 km. The dominant depths are 1.0–1.5 m; the maximal depth is 2.5 m; water area is 28.4 km². Four rivers flow into the lake and only one flows out of it.

The shore line of the lake is uneven, formed of capes and bays. The lake has 13 big and small islands. The shores are low (0.5–1.0 m), sloping, sometime abrupt. Quantity of mires along the shore line makes 30%.

The bedrock is made up of post-Pliocene sands overlaid by deposits of allochthonous silt. The bottom in the north-eastern part of the lake has peaty and silty deposits (Burov 1967).

By ion composition, the waters of the Sindor lake belong to the hydrocarbonate-sodium class. The water mineralization values during the
vegetation period vary from 20.2 to 36.8 mg/dm$^3$ with the pH of 6.83−7.47. Content of total organic matter is 116.0 mg/dm$^3$.

The Sindor lake is situated within the Atlantic-continental forest climatic area with moderate-continental climate (Alisov 1956). The mean annual air temperature around the lake does not exceed -1°C. The frost-free period lasts for 80 days. The mean air temperature in the warmest month (July) is +15°C and in the coldest month (January) −17°C (Taskaev 1997).

According to the regional geobotanical division (Údin 1954), the lake belongs to the middle subzone of the taiga zone. The lake is surrounded by a spacious depression which is the remainder of a big lake basin. The vegetation cover around the lake is dominated by spruce forests and mires.

The Donty lake (61°36′N, 54°01′E) occupies the north-western part of the Výchegda river valley. Nowadays, the Donty lake is elongated and longitudinally-oriented. Its total length is about 18 km, width 100−200 m, the maximal width 1.8 km, dominant depths 1.2−1.5 m, the maximal depth 2.0 m, and the water area 4.6 km$^2$.

The lake is linked with the Kulomû river (the Výchegda river tributary) via the natural shallow (up to 2.5 m) Važvis channel and the Donvis canal. The shores are low (0.5−1.0 m). The proportion of mires along the shoreline is 92%.

The bottom materials are varied: sapropel, peaty silts, silty sands. By chemical composition, the waters of the Donty lake belong to the hydrocarbonate-sodium class. Water mineralization values during the vegetation period vary from 20.2 to 79.6 mg/dm$^3$ with the pH of 6.87−7.36. Content of total organic matter reaches 68.0 mg/dm$^3$.

The Donty lake is situated within the Atlantic-continental forest climatic area with moderate-continental climate (Alisov 1956). The mean annual air temperature around the lake is -1°C. The frost-free period lasts for 90 days. The mean air temperature in the warmest month (July) is +15°C and in the coldest month (January) −17°C (Taskaev 1997).

According to the regional geobotanical division (Údin 1954), the lake belongs to the middle subzone of the taiga zone. The lake is surrounded by a spacious depression which is the remainder of a big lake basin. The vegetation cover around the lake is dominated by spruce forests and mires.

The Donty lake is elongated and longitudinally-oriented. Its total length is about 18 km, width 100−200 m, the maximal width 1.8 km, dominant depths 1.2−1.5 m, the maximal depth 2.0 m, and the water area 4.6 km$^2$.

The Donty lake is situated within the Atlantic-continental forest climatic area with moderate-continental climate (Alisov 1956). The mean annual air temperature around the lake is -1°C. The frost-free period lasts for 90 days. The mean air temperature in the warmest month (July) is +15°C and in the coldest month (January) −17°C (Taskaev 1997).

According to the regional geobotanical division (Údin 1954), the lake belongs to the middle subzone of the taiga zone. The lake is surrounded by a spacious depression covered with woody-dwarf shrubby-Sphagnum mires of transitional type. In the eastern part of the lake, its shores are covered with small patches of grassy-sedge-herbaceous meadows. Sandy ridges in the neighborhood are covered by pine dwarf shrubby-Polytrichum, rarely by dwarf shrubby-lichen woods.

### MATERIALS AND METHODS

The investigations of the flora of the lakes were carried out during the vegetation period (July−August) from 1999 to 2010 applying methods developed specially for hydrobotany research (Katanskaâ 1981). Water and ground samples were collected in all the investigated lakes and researched in the Ecoanalytical Laboratory of the Institute of Biology.

The term “flora of water bodies” is used in a broad sense, including all the species that have been noted in the composition of hydrophytic and helophytic communities in the water bodies and their wet, periodically flooded banks. The floristic list is based on species lists from relevés. All herbarium material is stored in SYKO and IBIW.

In general, nomenclature for vascular plants follows Čerepanov (1995), for mosses Ignatov et al. (2006), and for hepatics Konstantinova et al. (1992).

It is well known that each natural flora is a very complex object. Usually, it unites a large number of ecologically and geographically different species.

Ecological groups of vascular plants were identified according to the standard ecological scales (Ramenskij et al. 1956). Ecocgroups of bryophytes were identified according to Železnova (1994).

The system of phytogeographical groups is based on the fact of the preferential distribution of the species within the longitudinal sectors and latitudinal zones of the northern hemisphere. Preliminary analysis of the distribution of the species was based on works by various authors (Meusel et al. 1965; Jalas & Suominen 1972, 1976, 1979, 1980, 1983, 1989, 1994; Tolmačev 1974, 1976a, 1976b, 1977; etc.).

The system of latitudinal phytogeographical groups is composed of the following elements:

1. Pluri-zonal (PL) species – widely distributed from the tropics to the Arctic.
2. Extratropical (ET) species – widespread in the temperate zone of the northern hemisphere, in the Arctic zone and not found in the tropics.
3. Northern moderate (NM) species – mainly boreal species; their distribution areas partly cover the southern edge of the Arctic.
4. Moderate (M) species – distributed within the temperate zone of the northern hemisphere.
5. Southern moderate (SM) species – mainly distributed within the temperate zone of the northern hemisphere; not present in the Arctic.

The system of longitudinal phytogeographical groups contains the following elements:

1. European (E) species – distributed in Europe.
2. Eurasian (EA) species – widely distributed in Eurasia.

3. Holarctic (H) species – distributed within all longitudinal sectors of the northern hemisphere.

4. Multiregional (MR) species – distributed within all major longitudinal sectors of the northern and southern hemispheres.

Phytogeographical groups of mosses were identified according to Šljakov (1961), while hepatics to Konstantinova (2000).

RESULTS

Vascular plants

The list of vascular plants in the lakes totals 125 species of 70 genera and 39 families. Among them, 121 species, or 96.8%, are flowering plants and four species are spore-bearing plants (Equisetum arvense L., E. fluviatile L., E. pratense Ehrh., and Isoëtes setacea Durieu). The taxonomic diversity of the flora of each lake is characterized in Table 1. Below the annotated list of species is presented.


Aiphiaceae: Cicuta virosa L. – D, S, Ya, hI, el, EA, NM; Thysanococcus palustris (L.) Raif. – D, S, hI, mt, EA, M; Stannatia latifolia L. – S, hI, ea, EA, M; Angelica archangelica L. – BKh, ms, mt, EA, M.

Araceae: Calla palustris L. – D, S, hI, mt, H, M.

Antheraceae: Lactuca sibirica (L.) Bess. – D, S, Ya, hI, ea, EA, M; Myosotis palustris (L.) Reichenb. – D, S, Ya, hI, ea, EA, M; Euphorbia palustris (L.) Bess. – D, S, Ya, hI, ea, EA, M; Lactobacillus palustris (L.) Bess. – D, S, Ya, hI, ea, EA, M.

Boraginaceae: Myositis ramosa (L.) Scop. – D, S, Ya, hI, ea, EA, MS.

Brassicaceae: Cardamine pratensis L. – BKh, hO, el, H, NM; Rorippa amphibia (L.) Bess. – D, S, hI, ea, EA, M; R. palustris (L.) Bess. – D, Ya, hI, el, EA, PL.

Callitrichaceae: Callitriche hermaphroditica L. – D, hI, el, H, ET; C. palustris L. – D, BKh, hI, ea, MR, ET.

Caryophyllaceae: Stellaria palustris Retz. – D, S, Ya, BKh, hg, ea, EA, NM.


Equisetaceae: Equisetum arvense L. – BKh, ms, hI, EA, ET; E. fluviatile L. – D, S, Ya, BKh, hI, ea, EA, ET; E. pratense Ehrh. – D, S, Ya, hI, EA, ET.

Fabaceae: Lathyrus palustris L. – D, hI, ea, EA, M; Vicia sepium L. – D, ms, ea, EA, NM.

Haloragaceae: Myriophyllum sibiricum Kom. – D, S, Ya, BKh, Hd, ea, EA, NM; M. verticillatum L. – D, hI, H, SM.

Hippuridaeae: Hippuris vulgaris L. – D, S, Ya, BKh, hI, EA, M.

Hydrocharitaceae: Hydrocharis morsus-ranae L. – D, hI, ea, EA, M.

Isoëtaceae: Isoëtes setacea Durieu – D, S, Ya, hI, EA, ET.


Lentibulariaceae: Utricularia intermedia Hayne – D, S, hI, EA, NM; V. vulgaris L. – D, S, hI, EA, ET.

Lythraceae: Lythrum salicaria L. – D, S, hI, EA, EA, PL.

Menyanthaceae: Menyanthes trifoliata L. – D, S, Ya, hI, el, EA, M.


Onagraceae: Chamaenerion angustifolium (L.) Scop. – D, ms, EA, ET; Epilobium palustre L. – D, S, Ya, BKh, hI, EA, ET.

Poaceae: Agrostis stolonifera L. – D, hI, el, EA, EA, H, NM; Arctophila fulva (Trin.) Anders. – BKh, hI, el, EA, EA, ET; Calamagrostis canescens (Web.) Roth – D, hI, ea, EA, EA, M; C. luteola (Wahl.) Hartm. – BKh, hI, ea, EA, M; C. neglecta (Ehrh.) Gaertn. – D, hI, el, EA, EA, MR; Phalaroides arundinacea (L.) Rausch. – D, S, Ya, hI, ea, EA, ET; Phragmites australis (Cav.) Trin. ex Steud. – D, S, hI, ea, EA, MR, PL; P. palustris L. – D, BKh, hI, ea, EA, ET; Scolochloa festucaefolia (Willd.) Link. – D, S, hI, ea, EA, SM.

Polygonaceae: Bistorta major S. Fr. Gray – Ya, hI, el, EA, EA, M; B. vivipara (L.) S. Fr. Gray – BKh, hI, el, EA, EA, ET; Persicaria amphibia (L.) S. Fr. Gray – D, S, Ya, hI, EA, EA, M; Piceae nigra (Huds.) Opiz – D, hI, ea, EA, EA, M; Rumex aquaticus L. – D, S, Ya, BKh, hI, ea, EA, M.

Viola epipsila Ledeb. – BKh, ms, mt, EA, M.

Five species of the flora of the lakes (Ranunculus lingua, Scolochloa festuacea, Sagittaria natans, Nymphaea candida and Isoëtes setacea) are located near their northern distribution limit and so are included in the regional Red Data Book (Taskaev 2009).

For a number of studied species, the northern boundary of their distribution in the European North-East of Russia comes across the studied lakes: across Dony lake – the northern boundary of the distribution of S. viminalis, across Sindor lake – Ranunculus lingua, Scolochloa festuacea and Sium latifolium, across Âmozero lake – Isoëtes setacea, Potamogeton friesii, P. obtusifolius and Sagittaria natans. In turn, the southern boundary of the distribution of Potamogeton subretusus comes across Bol’soj Harbej lake.

Species richness of the flora of the studied lakes naturally decreases towards the north (Table 1) but the proportion of species in the first three families (leading by the species number) remains practically the same. This is probably associated with the long existence of the study lakes and over the course of history their floras have accumulated the maximum possible number of water and amphibious plant species.

In the studied flora, the families Cyperaceae, Potamogetonaceae, Poaceae, Salicaceae and Ranunculaceae belong to the species-richer ones (Table 2).

The number of multi-species families (containing three or more species) in the studied flora varies along the latitude gradient. It decreases in the direction from the middle taiga (Donty and Sindor lakes) to north taiga (Âmozero lake) and, then, to tundra (Bol’soj Harbej lake) subzones.

Lakes with a long history of existence gradually decrease in the diversity of habitats. As a result of this process, the number of species in the leading genera goes down, too. The genus coefficient (species genera ratio) of the flora, which is a reflection of the diversity of environmental conditions (Rebristaâ 1977), has high values for each of the studied lakes (Table 1), due to the relatively low diversity of the ecological conditions of lakes.

Ecological structure

Any natural flora presents a heterogenic system that unifies plant species different by ecological preferences. The flora of the studied lakes consist of four hydro-ecological groups (Table 3) and three trophic-ecological groups (Table 4).

The ecological range of the lakes’ flora clearly shows its association with eutrophic habitats. More than two thirds of the flora of each of the lakes (from 63.1 to 72.0%) is included in the eutrophic

Table 1. Vascular plants taxonomic diversity indices of the ancient lakes of the European North-East of Russia.

<table>
<thead>
<tr>
<th>Index</th>
<th>Bol’soj Harbej lake</th>
<th>Âmozero lake</th>
<th>Sindor lake</th>
<th>Dony lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of species</td>
<td>40</td>
<td>57</td>
<td>64</td>
<td>88</td>
</tr>
<tr>
<td>Number of genera</td>
<td>30</td>
<td>37</td>
<td>42</td>
<td>52</td>
</tr>
<tr>
<td>Number of families</td>
<td>23</td>
<td>27</td>
<td>30</td>
<td>34</td>
</tr>
<tr>
<td>Proportion of species from the first three families (leading by number of species present) [%]</td>
<td>32.5</td>
<td>33.3</td>
<td>32.8</td>
<td>29.5</td>
</tr>
<tr>
<td>Genus coefficient [%]</td>
<td>75.0</td>
<td>64.9</td>
<td>65.6</td>
<td>60.2</td>
</tr>
<tr>
<td>Proportion of multi-species families [%]</td>
<td>40.0</td>
<td>49.1</td>
<td>54.7</td>
<td>54.5</td>
</tr>
</tbody>
</table>
group of species (Table 4). Naturally, the floras of lakes are dominated by hydrophytes (17.5–26.6%) and hygrophytes (56.3–62.5%) (Table 3).

Geographical structure

The geographical structure of the studied lakes’ flora fully reflects their zonal position. Differences in the geographical position of the lakes have an impact on the geographical structure of their floras. North-distributed species (extratropical and northern moderate latitudinal groups) dominate in the flora of the studied lakes. On the latitudinal gradient from north to south in the floras of lakes the total proportion of North-distributed species decreases in general: in case of extratropical species from 45.0% (Bol’soj Harbej lake) to 15.9% (Donty lake) and in case of northern-moderate species from 50.9% (Âmozero lake) to 35.2% (Donty lake) (Table 5). And one more important point: among the North-distributed species the extratropical ones dominate in the tundra zone (Bol’soj Harbej lake), and the northern-moderate species dominate in the taiga zone (Âmozero lake, Sindor lake, Donty lake) (Table 5). As a rule, all North-distributed species are widely distributed in the Holarctic (see the annotated list).

As far as the longitudinal aspect is concerned (Table 6), one can see that the flora of each lake is entirely dominated by Holarctic species (51.0–59.7%). As we move from the north to the south from the tundra to the taiga zone, the proportion of Eurasian longitudinal distribution species in the floras of the studied lakes increases (32.5–39.9%). The increase in the proportion of Eurasian longitudinal distribution species is accompanied by a reduction in the total proportion of multiregional and Holarctic longitudinal distribution species (from 65.0% in Bol’soj Harbej lake to 57.8% in Donty lake) (Table 6).

Bryophytes

The bryoflora of the lakes includes 60 species from two classes (Bryopsida and Hepaticae). It comprises 42 species of mosses (of 23 genera and

### Table 2. Most species-rich vascular plant families in the studied lakes’ flora (only those of above one species are included).

<table>
<thead>
<tr>
<th>Plant family</th>
<th>Bol’soj Harbej lake</th>
<th>Âmozero lake</th>
<th>Sindor lake</th>
<th>Donty lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ranunculaceae</td>
<td>5</td>
<td>8</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Poaceae</td>
<td>4</td>
<td>7</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Cyperaceae</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Salicaceae</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Rosaceae</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Juncaceae</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Polygonaceae</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total:</td>
<td>16</td>
<td>28</td>
<td>35</td>
<td>48</td>
</tr>
</tbody>
</table>

### Table 3. Hydro-ecological species group composition of the studied lakes’ vascular flora.

<table>
<thead>
<tr>
<th>Hydro-ecological species group</th>
<th>Bol’soj Harbej lake</th>
<th>Âmozero lake</th>
<th>Sindor lake</th>
<th>Donty lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of species</td>
<td>7</td>
<td>13</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>Proportion (%)</td>
<td>17.5</td>
<td>22.8</td>
<td>26.6</td>
<td>22.7</td>
</tr>
<tr>
<td>Hydrophytes (hd)</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Helophytes (hl)</td>
<td>25</td>
<td>33</td>
<td>36</td>
<td>51</td>
</tr>
<tr>
<td>Hygrophytes (hg)</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Mesophytes (ms)</td>
<td>40</td>
<td>57</td>
<td>64</td>
<td>88</td>
</tr>
<tr>
<td>Total:</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 4. Trophic-ecological species group composition of the studied lakes’ vascular flora.

<table>
<thead>
<tr>
<th>Trophic-ecological species group</th>
<th>Bol’soj Harbej lake</th>
<th>Âmozero lake</th>
<th>Sindor lake</th>
<th>Donty lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of species</td>
<td>26</td>
<td>36</td>
<td>46</td>
<td>61</td>
</tr>
<tr>
<td>Proportion (%)</td>
<td>65.0</td>
<td>63.1</td>
<td>72.0</td>
<td>69.4</td>
</tr>
<tr>
<td>Eutrophic species (eu)</td>
<td>13</td>
<td>20</td>
<td>17</td>
<td>26</td>
</tr>
<tr>
<td>Mesotrophic species (mt)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Oligotrophic species (ol)</td>
<td>40</td>
<td>57</td>
<td>64</td>
<td>88</td>
</tr>
<tr>
<td>Total:</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
14 families) and 18 species of liverworts (of 13 genera and ten families). The annotated list of species is presented below.

The investigated flora contains 26 species of bryophytes among them 13 species of mosses and 13 of liverworts in the Donty lake, 23 species (11 and 12, respectively) in the Sindor lake, 14 species (13 and 1) in the Âmozero lake, and 24 species (23 and 1) in the Bol’soj Harbej lake.

Common for all the study lakes were only Calliergon cordifolium (Hedw.) Kindb. and Warnstorfia exannulata (Bruch et al.) Loeske.

Tables 7, 8, 9 present results referring to the whole group of bryophytes (mosses and liverworts) which were identified in the studied lakes. The bryoflora of the lakes is dominated by boreal and circumpolar species (Tables 7 & 8). The latitudinal pattern of the distribution of bryophytes was not found. Ecologically, hygrophytes and hydrophytes prevail over hygromesophytes and mesophytes (Table 9).

**Bryopsida:**

Sphagnaceae : Sphagnum angustifolium (C. E. O. Jensen ex Russow) C. E. O. Jensen – Ya, hd, b, c; S. flexuosum Dozy et Molk. – BKh, hg, b, c; S. girgensohnii Russow – BKh, hg, b, c; S. jensenii Lindb. – S, hg, ha, c; S. magellanicum Brid. – D, hg, b, bp; S. riparium Ångstr. – Ya, hd, b, c; S. squarrosum Crome – D, S, hg, b, c; S. subsecundum Nees – D, BKh, hg, b, c; S. teres (Schimp.) Ångstr. – Ya, hg, b, c.

Polytrichaceae : Polytrichum commune Hedw. – D, hgm, b, bp; P. strictum Brid. – Ya, hgm, b, bp; P. swartzii Hartm. – BKh, ms, ha, c.

Fissidentaceae : Fissidens osmundoides Hedw. – S, hg, b, bp.

Bryaceae : Bryum pseudotriquertum (Hedw.) P. Gaertn., B. Mey. et Schreb. – Ya, hd, b, bp; Bryum sp. – BKh.

Mniaceae : Mnium stellare Hedw. – BKh, ms, b, c;

### Table 5. Latitudinal species group composition of the studied lakes’ vascular flora.

<table>
<thead>
<tr>
<th>Latitudinal species group</th>
<th>Bol’soj Harbej lake</th>
<th>Âmozero lake</th>
<th>Sindor lake</th>
<th>Donyt lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of species</td>
<td>Proportion [%]</td>
<td>No. of species</td>
<td>Proportion [%]</td>
<td>No. of species</td>
</tr>
<tr>
<td>Extratropical (ET)</td>
<td>18</td>
<td>45.0</td>
<td>10</td>
<td>17.5</td>
</tr>
<tr>
<td>Northern moderate (NM)</td>
<td>13</td>
<td>32.5</td>
<td>29</td>
<td>50.9</td>
</tr>
<tr>
<td>Moderate (M)</td>
<td>6</td>
<td>15.0</td>
<td>14</td>
<td>24.6</td>
</tr>
<tr>
<td>Southern moderate (SM)</td>
<td>3</td>
<td>7.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total:</td>
<td>40</td>
<td>100</td>
<td>57</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 6. Longitudinal species group composition of the studied lakes’ vascular flora.

<table>
<thead>
<tr>
<th>Longitudinal species group</th>
<th>Bol’soj Harbej lake</th>
<th>Âmozero lake</th>
<th>Sindor lake</th>
<th>Donyt lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of species</td>
<td>Proportion [%]</td>
<td>No. of species</td>
<td>Proportion [%]</td>
<td>No. of species</td>
</tr>
<tr>
<td>European (E)</td>
<td>1</td>
<td>2.5</td>
<td>1</td>
<td>1.8</td>
</tr>
<tr>
<td>Eurasian (EA)</td>
<td>13</td>
<td>32.5</td>
<td>20</td>
<td>35.0</td>
</tr>
<tr>
<td>Holarctic (H)</td>
<td>23</td>
<td>57.5</td>
<td>34</td>
<td>59.7</td>
</tr>
<tr>
<td>Multiregional (MR)</td>
<td>3</td>
<td>7.5</td>
<td>2</td>
<td>3.5</td>
</tr>
<tr>
<td>Total:</td>
<td>40</td>
<td>100</td>
<td>57</td>
<td>100</td>
</tr>
</tbody>
</table>

### Table 7. Latitudinal species group composition of the studied lakes’ bryoflora.

<table>
<thead>
<tr>
<th>Latitudinal species group</th>
<th>Bol’soj Harbej lake</th>
<th>Âmozero lake</th>
<th>Sindor lake</th>
<th>Donyt lake</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of species</td>
<td>Proportion [%]</td>
<td>No. of species</td>
<td>Proportion [%]</td>
<td>No. of species</td>
</tr>
<tr>
<td>Boreal (b)</td>
<td>19</td>
<td>79.1</td>
<td>14</td>
<td>100</td>
</tr>
<tr>
<td>Hypoarctic (ha)</td>
<td>3</td>
<td>12.5</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Mountain (mon)</td>
<td>1</td>
<td>4.2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Arctomountain (am)</td>
<td>1</td>
<td>4.2</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Nemoral (n)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Total:</td>
<td>24</td>
<td>100</td>
<td>14</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 8. Longitudinal species group composition of the studied lakes’ bryoflora.

<table>
<thead>
<tr>
<th>Longitudinal species group</th>
<th>Bol’sj Harbej lake</th>
<th>Âmozero lake</th>
<th>Sindor lake</th>
<th>Donyt lake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of species</td>
<td>Proportion [%]</td>
<td>No. of species</td>
<td>Proportion [%]</td>
</tr>
<tr>
<td>Circumpolar (c)</td>
<td>21</td>
<td>87.5</td>
<td>9</td>
<td>64.3</td>
</tr>
<tr>
<td>Bipolar (b)</td>
<td>2</td>
<td>8.3</td>
<td>4</td>
<td>28.6</td>
</tr>
<tr>
<td>Cosmopolitan (cos)</td>
<td>1</td>
<td>4.2</td>
<td>1</td>
<td>7.1</td>
</tr>
<tr>
<td>Total:</td>
<td>24</td>
<td>100</td>
<td>14</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 9. Hydro-ecological species group composition of the studied lakes’ bryoflora.

<table>
<thead>
<tr>
<th>Hydro-ecological species group</th>
<th>Bol’sj Harbej lake</th>
<th>Âmozero lake</th>
<th>Sindor lake</th>
<th>Donyt lake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of species</td>
<td>Proportion [%]</td>
<td>No. of species</td>
<td>Proportion [%]</td>
</tr>
<tr>
<td>Hydrophytes (hd)</td>
<td>8</td>
<td>33.3</td>
<td>8</td>
<td>57.2</td>
</tr>
<tr>
<td>Hygrophytes (hg)</td>
<td>9</td>
<td>37.5</td>
<td>3</td>
<td>21.4</td>
</tr>
<tr>
<td>Hygromesophytes (hgm)</td>
<td>3</td>
<td>12.5</td>
<td>3</td>
<td>21.4</td>
</tr>
<tr>
<td>Mesophytes (ms)</td>
<td>4</td>
<td>16.7</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Total:</td>
<td>24</td>
<td>100</td>
<td>14</td>
<td>100</td>
</tr>
</tbody>
</table>

Plagiozoon curvatum (Lindb.) Schljakov – BKh, ms, ha, c; P. ellipticum (Bríd.) T. J. Kop. – D, S, BKh, hgm, b, c; Pseudobryum cinclidoides (Huebner) T. J. Kop. – D, BKh, hg, ha, c; Rhizomnium pseudopunctatum (Bruch et Schimp.) T. J. Kop. – S, hg, ha, c.

Fontinaliaceae: Fontinalis antipyretica var. gracilis (Lindb.) Schimp. – BKh, hd, mon, c; F. hypnoides Hartm. – BKh, hd, b, c.

Bartramtiaceae: Philonotis arnelli Husn. – S, hg, b, bp; P. fontana (Hedw.) Brid. – Ya, hg, b, c; P. caespitosa Jur. – BKh, hg, b, c; P. tomentella Molendo – BKh, hg, am, c.

Climaciaceae: Climacium dendroides (Hedw.) Weber et Mohr – S, Ya, BKh, hgm, b, c.

Amblastrogpecies: Amblastrognum serpens (Hedw.) Bruch et al. – S, ms, b, bp; Drepanocladus aduncus (Hedw.) Warnst. – D, S, Ya, hd, b, bp; D. sendtneri (Schimp. ex H. Mull.) Warnst. – BKh, hd, b, c; Leptodictyum riparium (Hedw.) Warnst. – D, BKh, hd, b, bp.

Calliernaeae: Calligeria cordifolia (Hedw.) Kindb. – D, S, Ya, BKh, hg, b, bp; C. giganteum (Schimp.) Kindb. – Ya, hd, b, c; C. megalophyllum Mikut. – BKh, hd, b, c; Straninierg n stramineum (Dicks. ex Brid.) Hedenas – Ya, hd, b, c; Warnstorfia exannulata (Bruch et al.) Loeske – D, S, Ya, BKh, hd, b, c; W. fluviarum (Hedw.) Loeske – BKh, hg, b, c.

Scorpidiaeae: Scorpidium revolvens (Sw. ex Anon.) Rubers – D, hg, ha, bp.

Brachytheciaeae: Brachythecium salebrosum (Weber et Mohr) – BKh, ms, b, c; Sciuro-hypnum oedipodium (Mitt.) Ignatov et Huttunen – D, ms, n, c.

Pyliaceae: Calliergonella lindbergii (Mitt.) Hedenas – D, S, BKh, hg, b, c.

Hepaticae:

Pelliaceae: Pellia epiphylla (L.) Corda – D, S, hg, b, c; P. neesiana (Gottsche) Limpr. – D, S, hg, ha, c.

Aneuraceae: Riccardia latifrons (Lindb.) Lindb. – S, hgm, ha, c.

Trichocoleaceae: Blepharostoma trichophyllum (L.) Dumort. – D, S, hgm, ha, c.

Lophoziaceae: Lophozia ventricosa (Dicks.) Dumort. – S, hgm, ha, c; Orthocaulis kunzeanus (Huebner) H. Buch – S, hgm, ha, c.

Scapaniaeae: Scapania irrigua (Nees) Nees – D, S, hgm, ha, c.

Geocalycaeae: Chiloscyphus fragilis (A. Roth) Schiffn. – D, hg, b, c; C. polyanthos (L.) Corda – D, ms, b, c; Lophocolea minor Nees – D, ms, b, c.

Plagiochilaceae: Plagioclia porelloides (Torrey ex Nees) Lind. – D, S, ms, b, c.

Cephaloziaceae: Odontoschisma elongatam (Lindb.) A. Evans – S, ms, ha, c; Cephalozia bicuspitata (L.) Dürrmont. – S, hgm, cos.

Cephaloziellaceae: Cephaloziella divaricata (Sm.) Schiffn. – D, hg, ha, c; C. hampeana (Nees) Schiffn. – D, S, ms, b, c; C. rubella (Nees) Warnst. – D, S, ms, b, c.

Marchantiaceae: Marchantia aquatica (Nees) Burgeff – D, hd, ha, c; M. polymorpha L. – D, Ya, BKh, hgm, cos.

CONCLUSIONS

The studied lakes are the oldest ones in the European north-eastern part of Russia. They were formed as a result of ice cover degradation after mid-Pleistocene (Donty, Sindor and Âmozero lakes) and late Valdai (Bol’sj Harbej lake) Ice Ages, and are situated in different natural zones with various climatic conditions. For this reason, the lakes differ considerably in their composition of flora.

1. The floristic diversity of the lakes diminishes northwards. The flora of the Donyt lake contains 88 species of vascular plants, of the Sindor lake 64 species, of the Âmozero lake 57 species, and the of Bol’sj Harbej lake 40 species.

2. Five species of the flora of the lakes studied (Ranunculus lingua, Scolochloa festucacea, Sagittaria natans, Nymphaea candida and Isoëtes setacea) are included in the regional Red Data Book.

3. The flora of the ancient lakes studied consist mainly of eutrophic species. The ratios in
ecological groups of species (hydro-ecological, trophic-ecological groups) in the floras of the lakes are approximately the same.

4. The geographical structure of the studied lakes’ flora fully reflects their zonal position. On the latitudinal gradient from north to south in the floras of lakes the total proportion of north-distributed species (extratropical and northern moderate latitudinal groups) decreases in general. As a rule, all north-distributed species are widely distributed in the Holarctic. Holartic species strongly dominate in the flora of each lake. From the tundra to the taiga zone in the floras of the studied lakes the share of Eurasian longitudinal distribution species increases. The higher proportion of Eurasian longitudinal distribution species is accompanied by a reduced total proportion of multiregional and Holarctic longitudinal distribution species.

5. Among bryophytes, 60 species of two classes (Bryopsida and Hepaticae) have been identified. The bryoflora of the lakes is made up mainly by broad-areal (circumpolar) species. The latitudinal pattern of the distribution of bryophytes was not found.

Acknowledgments. The research was supported by the RFBR (project 10-04-01562-a).

REFERENCES


THE ROLE OF TIMAN RANGE LIMESTONES IN THE CONSERVATION OF RARE VASCULAR PLANT SPECIES

Lúdmila Teterûk

Abstract. Outcrops of limestones in the North European part of Russia are the key habitats of many rare and protected species of vascular plants. The high degree of the fragmentation of the terrain and dissimilarity of ecological conditions within the sites of limestone outcrops resulted in high species and coenotic diversity. Among the most interesting species occurring within the Timan range are endemics having relict fragments of ranges in the Urals and the northeastern part of European Russia (*Thymus talievii* s.l., *Gypsophila uralensis*, *Pedicularis uralensis*, etc.) as well as species occurring on margins of their ranges (as *Valeriana capitata*). As a rule, they are represented by small populations. The highest diversity of these species can be observed in four locations: on rivers Soiva (South Timan), Pechora-Pizma, Myla and Belaâ Kedva (Middle Timan). In order to limit the impact of industry on the abovementioned areas and implement protection activities, these areas have been included in the System of Specially Protected Natural Territories of the Komi Republic.

Key words: limestone, rare plants, the Timan range, northeastern part of European Russia

Institute of Biology, Komi Scientific Centre, Ural Branch of Russian Academy of Science, 28 Kommunisticheskaya St., Syktyvkar, RU-167982, Russia; e-mail: teteryuk@ib.komisc.ru

INTRODUCTION

The specificity of the flora of the European North-East of Russia lies in the fact that it comprises numerous species occurring on their distribution range border. This is due to the location of the study region on the border between Europe and Asia, its large area and great extension from north to south, diverse nature zones and the orographic relief of Vyčegda-Mezen’ plain, Pechora lowland, western macro-slope of the Ural Mountains, Timan mountain range, and Bol’shezemel’skaâ tundra. The specificity of the flora of the abovementioned part of Russia also results from the fact that the study area experienced a complicated vegetation cover development in the Pleistocene period. Apart from the species with marginal or isolated relict populations, the Urals and the Timan range still preserve species of vascular plants with disjunctive ranges. Many of them are considered rare plants and included in the lists of protected species. 236 species and sub-species of vascular plants from 146 genera and 62 families are protected on the territory of the Komi Republic (the Order of the Ministry of Natural Resources and Environment of the Republic of Komi¹; Taskaev & Timonin 1993, 1995). The regional lists of protected plants contain almost 20% of the total species number in the Komi Republic.

Area protection is among important elements in the conservation strategy concerning rare species in the region. About 15% of the territory of the Komi Republic (60 million ha) was given the status of specially protected areas. The two biggest reserves of federal importance in the European North-East of Russia, the Pechora-Vlyč Biosphere Reserve and the Ûgyd Va National Park, are considered objects of the UNESCO World Heritage. To protect rare species and their habitats, over 70 reserves of regional importance were organized such as botanical and complex (landscape) reserves as well as nature monuments (Taskaev & Timonin 1993, 1995).

Some reserves are created to protect the plants on limestone outcrops. The flora on limestones of the European North-East of Russia and Ural has attracted the attention of researchers since the end of the 19th century (Gordâgin 1895; Pole 1907; Fedorov & Fedorov 1929; Govoruhin 1929; Sočava 1933; Grosset 1935; Dylis 1938; Leskov 1938; Leskov et al. 1938; Tolmačev 1938; Ûdin 1938, 1946, 1950, 1959, 1963; Doârenko 1940; Kirpičnikov 1947; Lašenkova 1959, 1962; Nepomilueva 1981; Lašenkova & Nepomilueva 1977, 1982; Lašenko & Ulle 1978, 1982; Ulle 1982; Železnova 1982, 1988, 1994; Kuliev 1986). The specific ecological conditions and insignificant competition between plants on unstable substrata

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¹ Prikaz Ministerstva prirodnih resursov i ohrany okružaûšej sredy Respubliki Komi ot 12 fevralâ 2008 г. No. 79 Ob utverždenii pereçej (spiskov) ob’ektov rastitel’nogo i životnogo mira zanesennych v Krasnuû knigu Respubliki Komi (zaregistrirovano v Administracii Glavy RK i Pravitel’stva 27 fevralâ 2008 g., reestr No. 11-407-2008).
provided for the formation and conservation of the original relict flora of rock plants in the taiga zone (Údin 1963). This complex includes numerous island populations of rare and relict species, species with relict disjunctive areas, marginal populations of nemoral flora representatives, forest-steppe, tundra and mountain-tundra species.

Particularly noteworthy are limestone outcrops of the Timan range. In the reserves formed there the specific features of the Timan range such as the development of karst relief forms, the formation of rendzina soils on limestones (Dobrovol’skij et al. 2010) and the distribution of relict coenoses of *Larix sibirica* Ledeb., *Betula humilis* Schrank can be seen etc., and the representatives of rock plants are protected (Údin 1963; Nepomilueva 1981). Due to the spatial remoteness and weak industrial interference of the area, the reserves are practically not transformed by human activity. Most significant for the conservation of rare plant species in the Timan range are outcrops of calciferous rocks at the banks of the rivers: Pečorská Pížma, Myla, Belaâ Kedva and Soiva, protected within the reserves of “Pížemskij”, “Mylskij”, “Belaâ Kedva” and “Soivinskij”, respectively.

The main aim of the article is to present the role that the four abovementioned reserves protecting Timan limestone outcrops play in the protection of rare and relict vascular plant species.

**METHODS**

The survey using the patrolling method was conducted in the abovementioned reserves in 2001–2012. Particular attention was paid to rockslides and forested areas on limestone outcrops, as well as karst valleys in the adjacent areas. When compiling the data the floristic lists of the Herbarium of the Institute of Biology, Komi Science Centre (SYKO) were taken into account. The lists of rare plants (Table 1) were based: (a) for rare and at the same time protected plants (having threat category 1–4) – on the Order of the Ministry of Natural Resources and Environment of the Republic of Komi and the Red Book of the Komi Republic (Taskaev 2009), (b) for rare but not protected ones (included in the Appendix 1 of the Red Book of the Komi Republic as “in need of monitoring”) – in accordance with the Red Book of the Komi Republic (Taskaev 2009). The Latin names of species are used according to the book of Čerepanov (1995).

**STUDY AREA**

**GENERAL INFORMATION**

The Komi Republic is located in the European North-East of Russia. Its area is about 416.8 thousand square km. It stretches 785 km from south to north and 695 km from west to east. The territory of the Republic consists of two parts. The eastern part of the Komi Republic is located in the Ural Mountains (the Polar, the Sub-polar and the Northern Ural Mountains) and the other part in the Russian platform (including the Timan range, the Pečora lowland and the Mezen’-Vyčegda platform). The territory of the Republic covers three natural zones: taiga, forest-tundra (a natural zone in which sites of forest vegetation are interspersed with those of dwarf shrubs) and tundra.

The climate of the Republic is moderate-continental: short and cool summers, long and cold winters with continuous snow cover. In the southern part of the Republic, the climate is milder than in the north. The number of days with average daily temperature above 0°C is about 180–190, above 10°C – 90–100. The duration of the frost-free period is 90–100 days. July is the warmest month with an average temperature of +16 – +17°C. December (average temperature -12 – -14°C) is the coldest. The annual precipitation sum is 700–800 mm. The climate is more severe in the north and the north-eastern parts of the Republic. Here, the number of days with average daily air temperature above 0°C is 120–130, above 10°C – less than 40–50. The duration of the frost-free period is approximately 60 days. The annual precipitation sum is 700–1000 mm. The warmest month is July (with monthly average temperature +11 – +13°C, and the coldest is December (monthly average temperature -17 – -20°C) (Atlas po klimatu … 1997).

The Timan range (or “the Timan”) is a system of strongly eroded, sometimes almost smooth elevations which cross the Komi Republic from northwest to south-east and are divided by flat depressions into the North Timan, Middle Timan, and South Timan. The Middle Timan is characterized by the highest altitudes of 350–471 m a.s.l. The South Timan is situated close to the Urals and has the highest altitudes of 325 m a.s.l. The Middle and the South Timan are located in the taiga zone.
Characteristics of the reserves

The “Pižemskij” Reserve (Middle Timan) – 1 on Fig. 1. Limestone outcrops in the Pižma River basin (a left Pečora river tributary) stretches for more than 60 km along the river-banks of the Pečorská Pižma, Svetlá, and Pižma. The first botanical studies on limestones along the Pižma river were conducted in the 1930s by scientists of the Botanical Institute of the USSR Academy of Sciences. They identified a number of species with island distribution such as *Asplenium viride* Huds.,

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**Fig. 1**. Location of the Timan Range (dashed line) in the northeastern part of European Russia. 1 – the “Pižemskij” Reserve; 2 – the “Mylskij” Reserve; 3 – the “Belaď Kedva” Reserve; 4 – the “Soivinskij” Reserve.

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**Fig. 2**. Limestone outcrops of the Middle Timan range (the “Mylskij” Reserve, on the river Myla) (phot. L. Teterük).
Table 1. Rare species of the Timan reserves occurring on limestone. A – threat status of the species (Taskaev 2009); species with threat status 1–4 are protected ones: 1 – on the verge of disappearance; 2 – declining in number, 3 – rare species, 4 – category not identified (taxa which should belong to one of the previous categories but without enough data available on their status in nature); bm – plants included in Appendix 1 of the Red Book of the Komi Republic (Taskaev 2009), as “in need of monitoring”; B – the “Soivinskij” Reserve, C – the “Pižemskij” Reserve, D – the “Mylskij” Reserve, E – the “Belâa Kedva” Reserve; + – presence of the taxon in a given reserve.

<table>
<thead>
<tr>
<th>Species</th>
<th>Family</th>
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<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<td>C. capnoides (L.) Pers.</td>
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<td>Juncus stygius L.</td>
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<td>Salix recurvignemnis A. Skvorts.</td>
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<td>Saussurea parviflora (Poir.) DC.</td>
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</table>
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Salix reticulata L., Betula humilis, Minuartia verna (L.) Hiern., Anemone sylvestris L., Hedysarum arcticum B. Fedtsch., and others (Leskov et al. 1938). Later on, the studies were carried out by botanists of the Komi Branch of the USSR Academy of Sciences (Lašenkova 1959; Ûdin 1963; Ulle 1982; Železnova 1982). At the suggestion of scientists the “Pižemskij” complex reserve was established in 1984.

The “Mylskij” Reserve (Middle Timan) – 2 on Fig. 1. The Myla river (a right tributary of the Cil’ma river) crosses the Kamennougolnaâ ridge of the Timan 7–10 km from its mouth and makes high (up to 50–70 m) limestone outcrops (Fig. 2). The first floristic findings on the Myla river limestones were made by R. Pole (Pole 1907); his work was further continued by botanists of the Botanical Institute of the USSR Academy of Sciences and the Komi Branch of the USSR Academy of Sciences. Towards the 1950s, the species-rich relict flora of rock plants was identified on the Myla river outcrops (Ûdin 1946, 1959). The undamaged state of the habitats allowed this terrain to be recommended for inclusion into the system of specially protected areas of the Komi Republic (Lašenkova & Nepomilueva 1982). The reserve was established in 1984.

The “Mylskij” Reserve (Middle Timan) – 2 on Fig. 1. The Myla river (a right tributary of the Cil’ma river) crosses the Kamennougolnaâ ridge of the Timan 7–10 km from its mouth and makes high (up to 50–70 m) limestone outcrops (Fig. 2). The first floristic findings on the Myla river limestones were made by R. Pole (Pole 1907); his work was further continued by botanists of the Botanical Institute of the USSR Academy of Sciences and the Komi Branch of the USSR Academy of Sciences. Towards the 1950s, the species-rich relict flora of rock plants was identified on the Myla river outcrops (Ûdin 1946, 1959). The undamaged state of the habitats allowed this terrain to be recommended for inclusion into the system of specially protected areas of the Komi Republic (Lašenkova & Nepomilueva 1982). The reserve was established in 1984.

The “Belaâ Kedva” Reserve (Middle Timan) – 3 on Fig. 1. Limestone outcrops stretch along the Belaâ Kedva river for over 45 km, sometimes along its tributaries Izyel’, Dintymyel’ and Kosešmes. The first data on limestone flora along the Belaâ Kedva river (a secondary tributary of the Ižma river) were collected in the 1940s (Kirpičnikov 1947). The 1970s saw the continuation of the studies started earlier undertaken by botanists of the Komi Branch of the USSR Academy of Sciences (Ûlle 1982; Lašenkova & Ulle 1978, 1982; Lašenkova & Nepomilueva 1982; Železnova 1982). In 1984, the reserve was established in the upper and middle courses of the Belaâ Kedva river.

The “Soivinskij” Reserve (South Timan) – 4 on Fig. 1. The Soiva river (a left second-order tributary of the Pečora river) has large limestone outcrops of the Carbonic and Permo-carbonic periods. They start 48 km from the river mouth and stretch upwards for more than 20 km along the river course and along its left tributary, the Nižnââ Omra river. The first data on limestone flora along the Soiva river were obtained by V. S. Govoruhin (1929) and Û. P. Ûdin (Leskov et al. 1938). They identified Asplenium viride, Aster alpinus L., A. sibiricus L., Dryas octopetala L., Gymnocarpium robertianum (Hoffm.) Newm., Minuartia verna, Rhodiola rosea L., etc. Since the late 1960s the studies were continued by botanists of the Komi Branch of the USSR Academy of Sciences. At their suggestion, the “Soivinskij” botanical reserve was established in 1984.

Table 1. Continued

<table>
<thead>
<tr>
<th>Species</th>
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<th>A</th>
<th>B</th>
<th>C</th>
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<td>Woodsia glabella R. Br.</td>
<td>Woodsiaceae</td>
<td>3</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>W. ilvensis (L.) R. Br.</td>
<td>Woodsiaceae</td>
<td>3</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td>41</td>
<td>48</td>
<td>23</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>– protected species</td>
<td></td>
<td>36</td>
<td>41</td>
<td>20</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>– species in need of monitoring</td>
<td></td>
<td>5</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Ecological features of the Timan limestones

The limestone outcrops along the rivers have the form of rock-slide slopes (Fig. 2). The weathering forms of limestones are very different: vertical walls and columns, rocks, or steep small-fragment rock-slide. They host a number of habitats suitable for plants with various micro-climatic conditions. The specificity of such biotopes lies in the original regime of direct sun radiation. At 63–65° latitude, the steep northern slopes get the minimum of sun heat in the northern hemisphere. Additionally, steep slope surfaces greatly differ in terms of heat influx depending on slope orientation. In relation to the horizontal surface, the steep (30°) slopes of southern exposition are known to get 44% more and those of northern exposition 40% less sun heat (Šerbakov 1970).

The observed differences in insolation are high.
and cause re-distribution of heat and moisture on slopes depending on their orientation. For example, the differences identified for latitude 63°N between southern and northern exposition slopes (for the period between 20 May and 20 September, 2004) equaled 292°C (for mean daily temperatures over 0°C), 310–320°C (for mean daily temperatures over 5°C), and 350–370°C (mean daily temperatures over 10°C). The well-heated southern slopes enjoy the plant vegetation period longer by more than 30 days (Elsakov & Teterûk 2012). It is important in the North because plants occurring there are often frost-damaged in early June and late August.

Limestones are development places for thin humus-carbonate soils (rendzina soils) (Dobrovolskij et al. 2010). These soils essentially differ from zonal taiga soils (acid and poor in nutrients). They have neutral medium reaction from pH 6.0–6.5 in upper soil horizons to pH 7.5–8.0 in lower soil part, and high humus content. The soils have high activity indices of bacterial and fungal microbiota (Vinogradova 2007).

RESULTS AND DISCUSSION

The “Pižemskij” Reserve has an area of 104.7 thousand ha and hosts 411 species of vascular plants of 213 genera and 71 families. Among them, there are 48 rare species, including 41 protected ones and seven that need to be monitored on the territory of the Komi Republic (Table 1). The reserve protects relict habitats of such species as Gypsophila uralensis Less. and Pedicularis uralensis Vved., endemic for the Urals, Papaver lapponicum subsp. jugoricum (Tolm.) Tolm. and Silene paucifolia Ledeb., endemic for arctic regions, and Agrostis korczaginii Sen.-Korc., endemic for the European North-East of Russia. The reserve includes the only known location of Silene nutans L. for the European North-East as well as marginal north-eastern habitats of Epilobium alsinifolium Vill. and of other species. Thanks to the “cold regime” on northern slopes they serve as habitats for isolated populations of tundra and mountain-tundra species such as Thalictrum alpinum L. (between the Ural and Scandinavian range parts), Valeriana capitata Pall. ex Link., Tofiedlia pusilla (Michx.) Pers., Saxifraga cespitosa L., Tephroseris heterophylla (Fisch.) Konechn., etc. Karst valleys and limestone slide slopes in the reserve maintain large isolated populations of Seseli condensatum (L.) Reichenb. (a mountain Asian species), Dracocephalum rutschiana L. (a forest-steppe Euro-Siberian species) and of other rare plant species.

The “Mylskij” Reserve has an area of 2 thousand ha where 285 species of vascular plants of 177 genera and 59 families grow. 23 rare species of vascular plants, including 20 protected ones and three that need monitoring in the Komi Republic, grow in this little reserve (Table 1). Of great interest are relict sites of such endemics of the Urals and other arctic areas, as Gypsophila uralensis, and Silene paucifolia.

The “Belä Kedva” Reserve covers an area of 51.5 thousand ha where 334 species of vascular plants of 186 genera and 65 families grow. 38 rare species, including 33 protected ones and five species that need monitoring, occur here (Table 1). According to Ulle (1982), about 28% of the plant species inhabiting the limestone outcrops of the Belä Kedva are geographical relicts. Many of them have here only fragments of their ranges (Carex alba Scop., Selaginella selaginoides (L.) C. Mart., Tofiedlia pusilla, Salix recurvigenmis A. Skvorts., etc.), or are situated on the northern (Viola mirabilis L., etc.) or southern (Potentilla crantzii (Crantz) G. Beck ex Fritsch, Hedysarum arcticum, etc.) distribution range borders. The only station of the relict steppe species Helianthemum nummularium (L.) Mill known in the European North-East of Russia is preserved here. Small isolated populations of Botrychium lanceolatum (Gmel.) Ángstr. which are the north-easternmost locations of the species in Europe, occur in karst meadows. In karst valleys and limestone talus slopes, just like in the “Pižemskij” reserve, large isolated populations of Seseli condensatum and Dracocephalum rutschiana are preserved.

Nowadays, the flora of the “Soivinskiy” Reserve (area of 4 thousand ha) comprises 315 species of vascular plants of 199 genera and 68 families. 41 rare species, including 36 protected ones and five species that need monitoring, occur here (Table 1). The Soiva limestones maintain large populations of the Siberian forest-steppe and south-pine-forest species Dendranthema zawadzki (Herbich) Tzvel. as well as and several orchids (Cypripedium calceolus L., C. guttatum Sw., Epipactis atrorubens (Hoffm. ex Bernh.) Bess., Gymnadenia conopsea (L.) R. Br.) The reserve plays an important role in the conservation of two species which are under the threat of disappearance (threat category “1”) in the Komi Republic. One of them is Adonis sibirica Patrin ex Ledeb., a forest-steppe and pine-forest Siberian species, which reaches here its western distribution limit. In the European part of Russia, it remained safe mostly at outcrops of calciferous rocks of the South Timan. The other species is Hypopitys monotropa Crantz. In spruce forests of
the reserve, it retains its large local population on the northern distribution border.

The importance of calciferous rock outcrops for biodiversity conservation is beyond the scope of regional interests. Highly important is their role in the distribution of another group of relict plant species, i.e. ferns with disjunctive or fragmentary ranges. Limestone outcrops of the Timan range, Pre-Urals and the Urals provide habitats for a sporadic distribution of *Woodia glabella* R. Br. in the European North-East of Russia. Limestones of the Middle and South Timan are inhabited by isolated relict populations of *Asplenium viride* disjunctive from the Ural part of the range. The Timan Museum hosts an isolated island population of *Woodia ilvensis* (L.) R. Br., one of only two known in the European North-East of Russia. The Timan locations of *Cryptogramma stelleri* (S. G. Gmel.) Prantl. are ones of the westernmost of the species. Limestone habitats ensure favourable edaphic conditions for several orchid species in the European North-East of Russia. For example, findings of *Cypripedium calceolus* and *C. guttatum* northwards of the 62°N latitude are related mainly to limestone outcrops. The same is true in case of the distribution of *Epipactis atrorubens*. The Timan range is also the main preservation place of a small island population of *Corydalis capnoides* (L.) Pers. in the North-East of Europe.

Thus, it is shown that the Timan limestone is the key habitat for many rare plant species. On a small area of four nature reserves (“Pižemskij”, “Mylskij”, “Belaâ Kedva”, and “Soivinskij”), 69 species of rare plants have been preserved (18% of all protected plants in the Republic of Komi). For some species these areas are the only or principal place of occurrence in the European North-East of Russia. Timan limestones play an important role in the conservation of biological diversity not only at regional but also European scale. It is important to remember that Timan limestones are very limited in terms of area and vulnerable: in case of an active industrial development in the region, they can be easily broken.

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