Oleksandr Lukash

CONCEPTUAL PRINCIPLES OF PHYTODIVERSITY CONSERVATION. LECTURES AND PRACTICAL WORKS: A MANUAL

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The approaches to the phytodiversity conservation at different levels of organization are presented in the text-book. The manual consists of two thematic blocks. The first block is devoted to the theoretical foundations of phytosozology, autophytosozological and synphytosozological concepts; the second – to the scientific principles of the territorial (ecosystem) conservation of phytodiversity and *ex situ* conservation experience in the world and Ukraine. The structure and content of the manual enable the applicants to consistently acquire knowledge about the traditions and innovations of the pan-European strategy for the phytodiversity conservation, the main principles of the international environmental protection documents relating to the plant world, as well as to acquire practical skills in autphytosozology, synphytosozology, and get acquainted with the *ex situ* and *in situ* experience preservation of plantage in the world and Ukraine. The author's published results of the scientific research have been used when compiling the tasks for practical works. The references are listed separately for each lecture and practical work.

The manual is compiled for those who have obtained the educational and scientific level of Doctor of Philosophy and the educational level of Master in the 091 Biology and 101 Ecology specialties.

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Лукаш О.В.
Л 84 Концептуальні засади збереження фіторізноманіття. Лекції та практичні роботи: навчальний посібник. Чернігів: Десна Поліграф. 2023. 96 с.

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У навчальному посібнику висвітлені підходи до збереження фіторізномантіття на різних рівнях організації. Посібник складається з двох тематичних блоків. Перший блок присвячений теоретичним основам фітосозології, аутофітосозологічним та синфітосозоогічним концепціям; другий – науковим засадам територіальної (екосистемної) охорони фіторізноманіття та досвіду *ex situ* збереження в світі та Україні. Структура й зміст посібника дає можливість здобувачам послідовно опанувати знання щодо традицій та інновацій загальноєвропейської стратегії охорони фіторізноманіття, основні принципи міжнародних природоохоронних документів, що стосуються рослинного світу, а також набути практичних навичок з аутфітосозології, синфітосозології й ознайомитися з досвідом *ex situ* та *in situ* збереження рослинного світу в світі та Україні. При складанні завдань для практичних робіт використані опубліковані авторські результати наукових досліджень. Джерела інформації наведені окремо до кожної лекції та практичної роботи.

Посібник розрахований на здобувачів освітньо-наукового рівня «доктор філософії» та освітнього рівня «магістр» за спеціальностями 091 Біологія та 101 Екологія.

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INTRODUCTION

What is Plant Conservation?

"Plant Conservation is a broad group of activities which aims to prevent plants from becoming extinct. It includes the direct conservation of wild populations, collections of plants with gardens, education programmes, invasive species control, recovery and restoration work, research programmes, training..."

Botanic Gardens Conservation International (BGCI)

Why Conserve Plants?

Humans and animals are dependent on plants for their survival. Plants provide the food that we eat, our animal feed, the clothes we wear as well as the active ingredients for our medicines. In addition, living plants are essential to the healthy functioning of our biosphere – the living world which humans inhabit. Plants synthesize oxygen and carbon dioxide from the atmosphere.

Why is it important?

As well as providing food to eat, plants provide materials for our housing – wood, thatch, straw, wicker etc. They provide materials that are essential to our lifestyle – rubber, paper, oils, wine, dyes and pigments. Many modern pharmaceuticals are based on chemicals that are derived from plants. In the developing world 80% of people rely on herbs, barks, fruits and roots of plants for their natural medicines. Increasingly science is looking to biofuels as a future replacement to fossil fuels, such as oil, coal and gas.

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THEORETICAL FOUNDATIONS OF PHYTOSOSOLOGY. AUTOPHYTOSOCIOLOGICAL CONCEPTS. SYNPHYTOSOSOLOGICAL PRINCIPLES OF PLANT CONSERVATION

Lecture. Sozology – integral environmental science. Phytososology as a science of plant protection

1. The concepts of sozology.
2. A definition of sozology.
3. The object of study of sozology.
4. The specific features of sozological research.
5. Threats to biodiversity.

1. The understanding of sozology

The term "sozology" comes form the Greek word "sozo" which means "to protect", "to rescue". Walery Goetel introduced this term to Polish scientific terminology in 1965. According to him this term means the protection of the natural human environment. The term "sozology" was enriched with a new content which thereby broadened its scope. An expression of this is the rich literature on the subject and this term is used more and more frequently to define sciences concerning environment protection.

In the word "sozology" two aspects are taken into consideration: the content and the scope. In the connotational aspect the methodological and thematic elements of this name are indicated, but in the aspect concerning its scope the designations marking its range are pointed to.

From the methodological standpoint of the content of the concept of "sozology" people speak above all about methods serving to research the object of this science. Here the empirical, humanist, philosophical and systemic methods are distinguished.

From the thematic standpoint of the term "sozology" the questions and problems within the range of scientific sozological research are stressed.

The aspect of the concept "sozology" concerning its scope covers problems and questions concerning the natural and social environments, which humanity inhabits. Therefore it concerns living and non-living nature and the anthroposphere.

All these areas are considered from the viewpoint of protecting the natural properties of specific parts of nature and their influence on the life and health of humanity. In this aspect, which is characteristic for sozology, is to be found the study of the natural properties of the living and non-living parts of nature. This research also concerns the newly arisen properties of the environment and their influence on the life and health of humanity, and also their influence on the biological condition of other species living on the Earth.

2. A definition of sozology

In the initial phase of the birth and development of a new science difficulties arise in defining it. Sozology too has not yet emerged from the initial phase of its development, despite the fact that the problems of environment protection had already been taken up in the 19th century, and it continues to contend with similar difficulties.

In this connection we are proposing the following definition of sozology:

"Sozology is the science of the systemic protection of the biosphere from the destructive effect on it of the anthroposphere."

Phytosozology is the science of the systemic protection of the plant kingdom as a biosphere component from the destructive effect on it of the anthroposphere

In this formulation the following expressions used in this definition require explanation: "systemic protection", "biosphere", "anthroposphere", "destructive effects".

"Systemic protection" – this expression is connected with the systemic approach to scientific research, which is characterized by seeing the problems involved as a totality and at the same time indicates the feedback arising between the elements internal to the system and between the system and its environment in the sphere of science, technology, pedagogy and didactics.

The term "biosphere" means the space inhabited by living organisms.

The term "anthroposphere" means the whole space where the various human activities take place, which come into conflict with the biosphere and all its physical elements. These activities change the natural environment of life and cause structural genetic changes in some plants and animals, including humans; they also have an influence on the chemical and biological balance in the biosphere.

3. The object of study of sozology

The object of study of sozology in a general sense is the mutual interaction of the biosphere and the anthroposhere. In traditional language this is the material object of study of this science. On the other hand the formal object of study of sozology is the protection of the biosphere from the destructive effects on it of the anthroposphere. This aspect of protection constitutes the specific features of sozology and its distinction from other sciences of the biosphere and anthroposphere.

The range of sozological research covers – using this characterization of its object of study – non-living and living nature, by which is understood the cosmo-bio-geographical environment of life, succumbing to the influence of the actions of the anthroposphere to undergo various changes, and sometimes complete destruction.

Within the scope of the object of study of sozology understood in such a way come plants and animals, their genetic structure and proper development, and also the developmental interference caused by the effects of the anthroposphere. The physical environment also belongs to the range of sozological research – in which the biosphere exists i.e. the atmosphere, the hydrosphere, the lithosphere and the cosmosphere.

Among the questions concerning the biosphere it is necessary to enumerate the problems of a biological and biologico-genetic nature. However within the range of the anthroposphere the problems concerning the state of the biological and biologico-medical human populations in specific countries and on whole continents need to be stressed as do the problems which emerge alongside the development of sozotechnology, sozopsychology, sozoeconomy, ecological law, environmental ethics.

In connection with the destructive effects of the anthroposphere on the biosphere various problems appearing in connection with the following dangers are indicated:

– the physical environment of the biosphere;

– the biological environment;

– the life and health of humanity;

– life in small, medium sized, big and huge macroregions;

– specific populations, and even whole species or breeds, both of fauna and flora;

– the landscape, groups of plants and animals.

Having all of this in mind it is necessary to stress once again, that the object of sozological research is the influence of human activity on nature and the ways and means of protecting it.

4. The specific features of sozological research

Interdiscplinariness and systemism belong to the specific features of scientific sozological research.

Bearing in mind the premise of the unity of sciences, especially the unity of their logical structure, the use of a unified system of logical methods in them, which constitutes the most permanent feature of contemporary science, and the influence of some research work on other research work and their mutual dependence, it becomes clear that interdisciplinariness is an indispensable feature of the processes scientifically creating sozology and at the same time confirms the supposed unity of the sciences.

Scientific sozological problems make interdisciplinary research a necessary thing in sozology – because their solution requires cooperation with the following sciences: ecology, geology, economics, technical sciences, ethics and pedagogy. Out of the cooperation between sozology, a science in the process of formation, and the sciences enumerated above, new areas of science are born such as sozotechnology, sozoeconomics, sozopsychology, sozoethics or environmental ethics and ecological or sozological law.

In general one can say that the problems of sozology arise in many sciences and its specific problems occur in such disciplines as: medical science, biological science, Earth sciences and spatial planning, technical science, economic science, legal and administrative science, social and humanist science. It is necessary to add in this place that faced with sozology's scientific problems philosophical and teleological science cannot remain indifferent.

Research in the field of sozology, as a science of the systemic protection of the biosphere from the effects of the anthroposphere on it, of necessity requires an interdisciplinary and systemic approach to its object of study, in order to solve its emerging problems thoroughly and comprehensively. Systemism in sozological scientific research makes possible the theoretical understanding of the protection of the socio-natural environment and provides a basis for practical systemic activities within the range of ways and means of protecting this environment. In addition this science has a character unifying research in the fields of many scientific disciplines. Theories may arise on its terrain, consolidating the achievements of various sciences.

5. Threats to biodiversity

The direct threats under the five main categories of threats to biodiversity recognized by the Convention on Biological Diversity (CBD) and conservation biologists worldwide, namely:

• Conversion, loss, degradation, and/or fragmentation of natural habitats;

• Overharvesting or overexploitation of particular species;

• Pollution or contamination that harms natural habitats or species;

• Introduced non-native species that harm native habitats or species;

• Climate change and related macro-environmental change (e.g., desertification, disruptions of floods, fires, and other natural disturbance regimes).

Ukraine's Fifth National Report to the Convention on Biological Diversity (2015) has a section on threats to biodiversity, and lists 12 types of direct threats:

• Uncontrolled use of forest resources;

• Excessive exploitation and fragmentation of steppe;

• Loss of steppe from "scientifically unjustified afforestation";

• Pollution of aquatic and coastal ecosystems with inadequately treated sewage, leading to nutrient loading and eutrophication;

• Hydropower dams altering natural flow regimes and changing aquatic vegetation and communities;

• "Poaching and unauthorized fellings";

• Draining and reduction in area of wetlands;

Loss of traditional varieties of crops and breeds of livestock, and replacement by modern varieties and hybrids;

• Introduction of fish species in reservoirs;

• Creation of forest monocultures;

• Introduction of invasive species; and

• Negative effects of climate change on forests, esp. drying and increase of insect pest outbreaks.

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Practical work. Sozological aspect of scientific research

Task 1. Determine the sozological aspect of the results of the proposed scientific research.

The vegetation of channels and floodplains of Słupia (Poland) and Strizhen (Ukraine) rivers in urbanized territories

Introduction

Vegetation is an important topic in the research and Practical work of managing ecosystems in zones of water level fluctuations, not only in reservoirs, as Jiang W. et al. (2021) demonstrated in their article, but also in other rivers, lakes, and adjacent territories.

The vegetation of water bodies and waterlogged areas, in particular riverine areas (to a greater extent) and river floodplains (to a lesser extent), differs from other types of vegetation in its intrazonality, as well as in specific features of structure and functioning. The main factor of changes in the development of communities of aquatic macrophytes in water bodies and floodplains is the fluctuation of water level, which determines the morphological variability of plant species and associated plant communities. It should be noted that the development of higher aquatic vegetation in waters is caused, along with other factors, by wave and waste water movements (Kirvel '2005). Also, the degree of anthropogenic pressure affects the state of the vegetation of the channel, coastal strips and floodplains of rivers.

For the purpose of studying the vegetation were chosen rivers Slupia and Strizen near the cities of Słupsk (Poland) and Chernihiv (Ukraine), located in a close latitudinal range (geographic coordinates 54°27′50″, 17°01′43″ and 51°30′19″, 31°17′05″) and moderate urbanization or the so-called residential load (urban population density 2,250 men/ km² and 3,632 men/ km²). The climate of Slupsk is maritime, Chernigov is moderately continental. In both rivers, water level fluctuations occur with a certain regularity in time and during the entire vegetation of plants.

Study areas

The Słupia River is one of Baltic coastal rivers and is located in the region of Central Pomerania (North of Poland). It originates in a peatland in the vicinity of locality Sierakowice and flows into the Baltic Sea in locality Ustka. It flows through several lakes, including Lake Tuchlińskie, Trzebocińskie and Węgorzyno. The river is 138.6 km long and its catchment consists mainly of farmlands and forests, and encompasses 1623 km^2. The channel is about 12 m wide in the upper course of the river and rises downstream to about 20 m. Mean depth ranges from 0.7-1.2 m to 1.6 m in the upper and lower course, respectively. Maximal depth reaches 6 m. Banks are generally well defined. Typical discharge, averaged for the year, ranges from 17 to 18 m^3. There are no anoxygenic episodes (Krzysztof 2009). The Słupia River within the urban zone is more fleeting than the Strizhen River along the entire interval of its current.

The Stryzhen River is located in the Chernihiv region (North of Ukraine). It belongs to the basin of the Desna river and is a right-bank tributary of the first order. Natural vegetation covers 42.7% of the total pool. The river flows through the territory of Chernihiv region. The length of the river is 32.4 km, the catchment area is 158 km^2; 8.0% of the river basin is covered with woods, 0.28% – with swamps and 57.3% – with arable lands. The source of the river, which is located 2.5 km to the west of the village Veliky Osniaky, Ripky district, Chernihiv region, is 150.00 m above sea level. Flow rate of the river is 14.0 million m^3, shallow stack year supply of 75 and 95% – respectively 9.39 million m3 and 5.53 million m^3. Rriver's flow is regulated poorly. The total number of ponds and reservoirs that regulate the local flow is 5, and their total volume is 1.531 million m^3. The river water belongs to the calcium bicarbonate class, its hardness is 4.2-4.9 mgEq/l, its total mineralization is 290 - 320 mg/l. By its regime the Stryzhen river refers to the East European type. The river is fed mostly by snow and rain. The Stryzhen' river basin is highly cultivated: 7 villages and the city of Chernihiv are within the basin. The state of some environmental factors and orientation of the occurring processes cause the overall ecological situation in the basin of the Stryzhen river, which at present in general is unsatisfactory (Lukash et al. 2016).

Matherial and methods

Studies of vegetation of channels and floodplains of small rivers in urbanized territories were held in Słupsk city (Słupia River) and Chernihiv city (Strizhen River). Materials (phytosociological relevés and herbarium) for the article were collected during 2017-2021. The field study of the vegetation was carried out by geobotanical methods (Korchagin, Lavrenko 1976). The 54 phytosociological relevés were carried out during the optimum of vegetation period in the areas of 4-50 m^2.

The syntaxa were identified according to Matuszkiewicz (2019), Dubyna (2006), and Mucina et al. (2016). The syntaxa names are ordered according to Mucina et al. (2016).

Results and their discussion

The classification scheme of vegetation of the Słupia and Strizhen rivers respectively in the Słupsk city and Chernihiv city was drawn up based on the results of field studies, after the identification of syntaxa. It is presented in the Table 1.

Table 1

Syntaxonomic composition of vegetation of channels and floodplains of small rivers in urbanized territories

Syntaxa	Słupia River (in Słupsk)	Stryzhen River (in Chernihiv)
Lemnetea O. de Bolos et Masclans 1955	+	+
Lemnetalia minoris O. de Bolos et Masclans 1955	+	+
Lemnion minoris O. de Bolos et Masclans 1955	+	+
Lemnetum minoris (Oberd. 1957) Th. Müller et Görs 1960	+	+
Lemno minoris-Spirodeletum polyrrhizae W.Koch 1954	+	+
Salvinio-Spirodeletum (polyrrhizae) Slavnic 1956	-	+
Potamogetonetalia Koch 1926	+	-
Nymphaeion albae Oberd. 1957	+	-
Nuphareto lutei-Nymphaeetum albae Nowinski 1930 et Tomaszewicz 1977	+	-
Isoëto-Nanojuncetea Br.-Bl. et Tx. in Br.-Bl. et al. 1952	-	+
Nanocyperetalia Klika 1935	-	+
Eleocharition soloniensis Philippi 1968	-	+
Transitive phytocoenosis between *Eleochario-Caricetum bohemicae* Klika 1935 em. Pietsch 1961 and *Dichostylidi-Helochloetum alopecuroidis* (Timar 1950) Pietsch 1973	-	+
Phragmito-Magnocaricetea Klika in Klika et Novák 1941	+	+
Phragmitetalia Koch 1926	+	+
Phragmition communis Koch 1926	+	+
Phragmitetum communis (Gams 1927) Schmale 1939	+	+
Scirpetum lacustris Schmale 1939		+
Typhetum angustifoliae (Allorge 1922) Soó 1927	+	+
Typhetum latifoliae Soó 1927	+	+
Oenanthetalia aquaticae Hejny ex Balatova- Tulackova et al. 1993	+	+
Carici-Rumicion hydrolapathi Passarge 1964	+	+
Butometum umbellati (Konczak 1963) Philippi 1973	+	+
Butomo-Sagittarietum sagittifoliae Losev in Losev et V. Golub 1988	-	+
Sagittario-Sparganietum emersi R.Tx. 1953	-	+
Molinio-Arrhenatheretea Tx. 1937	+	+
Potentillo-Polygonetalia avicularis Tx. 1947	+	+
Agropyro-Rumicion Nordhagen 1940	+	+
Ranunculo-Alopecuretum geniculati R.Tx. 1937	+	+
Alno glutinosae-Populetea albae P. Fukarek et Fabijanic 1968	+	-
Alno-Fraxinetalia excelsioris Passarge 1968	+	-
Alnion incanae Pawłowski et al. 1928	+	-
Alnetum incanae Lüdi 1921	+	-
Polygono-Poetea annuae Rivas-Mart. 1975	+	+
Polygono arenastri-Poetalia annuae Tx. in Gehu et al. 1972 corr. Rivas-Mart. et al. 1991	+	+
Polygono-Coronopodion Sissingh 1969	+	+
Prunello-Plantaginetum Faliński 1963	+	+
Bidentetea Tx. et al. ex von Rochow 1951	+	+
Bidentetalia Br.-Bl. et Tx. ex Klika et Hadac 1944	+	+
Bidention tripartitae Nordhagen ex Klika et Hadac 1944	+	+
Polygono-Bidentetum (Koch 1926) Poli et J. Tx. 1960	+	+
Chenopodion rubri (Tx. in Poli et J. Tx. 1960) Hilbig et Jage 1972	+	+
Chenopodietum glauco-rubri Lohm. 1950		+
Xanthio riparii-Chenopodietum Lohm. et Walther 1950		+

The coastal and aquatic vegetation of the Słupia and Strizen rivers develops in their coastal zone, forming discontinuous stripes, which are often parallel to the coast, are 1–10 m long and up to 2 m wide. Find and pinpoint boundaries communities of macrophytes is not always possible due to partial mixing.

The communities of the coastal aquatic plants, like other groups of organisms, undergo targeted changes – successions. Modern successions of coastal aquatic vegetation of the Slupia and Strizen rivers within the urban zones of Slupsk and Chernigov are predominantly allogeneic, occurs due to external factors. For example, the first stage of overgrowing of the watercourse of the Sterzen river is marked by the dominance of such free-swimming species as *Lemna trisulca*, *L. minor*, *Hydrocharis morsus-ranae*, *Ceratophyllum demersum*, *Elodea canadensis*, occasionally *Stratiotes aloides* whose participation in cenoses is 25–50%. Phytocenoses at the initial stage of overgrowing in the watercourse of the Slupia River were not found.

In the coastal water strips of both rivers, we observed phytocenoses with monodominance *Phragmites australis*, *Glyceria maxima*, *Typha latifolia* (in the river Sterzen – *Typha angustifolia*). Their projective cover in different communities is 60-80% (total grass cover 80-100%). These species form a grouping of perennial grasses *Glycerietum maximae*, *Phragmitetum communis*, *Scirpetum lacustris*, *Typhetum latifoliae*, *Typhetum angustifoliae*. These communities belong to the most widespread class of aquatic vegetation in Pomeranian and Polesie – *Phragmito-Magnocaricetea*. In stagnant water in these cenoses, the dominant species *Lemna minor* and *L. trisulca* are found with a cover of no more than 15%. In the floodplains of the Slupia and Strizen rivers, there are meadow communities of rich, sometimes slightly saline, soils of heavy texture, which are periodically flooded or submerged. They belong to the order *Potentilla-Polygonetalia* avicularis. These natural communities alternate with areas of phytocenoses of the *Polygono-Poetea annuae* (unlike the previous ones, they have a greater number of annuals), which are formed under the influence of trampling and in places where waterfowl are concentrated.

Our research (Lukash et al. 2016) shows that under the influence of meteorological factors (mainly rainfalls) edaphic and hydrological conditions in the riverside alluvial sediment near the Stryzhen estuary has been changed. Ecological and coenotic sequence of succession is the following: nitrophile community *Chenopodietum glauco-rubri* → community of therophytes, transitive from *Eleochario-Caricetum bohemicae* to *Dichostylidi-Helochloetum alopecuroidis* → halophilous community *Ranunculo-Alopecuretum geniculati* + ruderal community *Prunello-Plantaginetum* + water-terrestrial community *Sagittario-Sparganietum emersi*.

The coastal psammophyton communities (transitive between *Eleochario-Caricetum bohemicae* and *Dichostylidi-Helochloetum alopecuroidis* of the Strizhen River are of the greatest scientific interest. Its formation was influenced by weather conditions, which indirectly freed habitat and favorable edaphic factors (moderate salinity and high nitrate content) (Lukash et al. 2016). The vegetation of the floodplains of the Slupia and Strizen rivers has even more differences. The floodplain phytocenoses of the city of Sterzen in Chernigov are represented mainly by ruderal groups, in particular, phytocenoses from the class Bidentetea. Within the city of Slupsk (park of culture and recreation), in shallow water (1.0–1.5 m) in the floodplain reservoirs of the Slupia river, there are cenoses of attached vegetation with leaves floating on the water surface in particular communities belonging to the *Nuphareto lutei-Nymphaeum albae* association. These phytocenoses have 70–80% coverage, mainly due to dominant species (60–80%).

In the floodplain of the River Sterzen within the urban zone of Chernigov, floodplain forests have not survived. In the floodplain of the Slupia river within the city of Slupsk, we can find fragments of hygrophilic non-boggy forests belonging to the *Alnetum incanae* association. The secondary forest is formed by *Alnus incana* (L.) Moench., which has a crown density of 0.7–0.8 and a height of 12–16 m. The secondary forest includes *Ulmus laevis* and Fraxinus excelsior. *Humulus lupulus* L. occasionally winds along the tree trunks. The underbrush was not found, only single specimens are found *Rubus caesius*, *Salix cinerea* L., *Ribes nigrum* L., *Prunus padus*, *Sorbus aucuparia*. The layer of grasses has a projective cover of 50–70%. The herbaceous layer contains characteristic species *Alnion incanae* (*Carex remota*, *Chrysosplenium alternifolium*, *Circaea lutetiana*, *Festuca gigantea, Ficaria verna, Gagea lutea, Stellaria nemorum*, *Rubus caesius*, *Equisetum sylvaticum*, *Galium palustre, Iris pseudacorus, Lycopus europaeus*, *Lysimachia vulgaris, Solanum dulcamara*, *Athyrium filix-femina, Thelypteris palustris* Schott.). The *Alnetum incanae* association is diagnosed by species such as *Brachypodium sylvaticum*, *Chaerophyllum hirsutum*, *Deschampsia cespitosa*, *Equisetum hyemale*, *Filipendula ulmaria*, *Geum urbanum*, *Geum rivale*, *Impatiens noli-tangere*, *Ranunculus repens*, *Stachys sylvatica*, *Thalictrum aquilegiifolium*, *Urtica dioica*, *Valeriana excelsa*.

The distribution of these forests in Pomerania is natural, because the European range of *Alnus incana* covers this territory (Fig. 1).

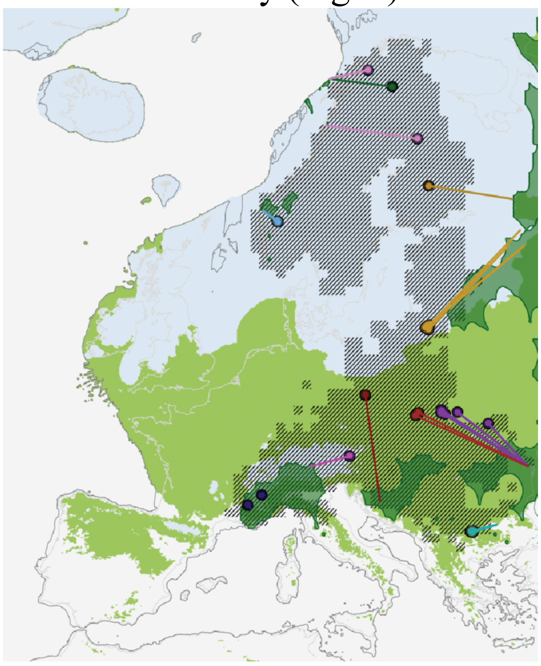

Fig. 1. Distribution of Alnus incana in Europe (based on Kurtto et al., 2018).

Alnus incana (L.) Moench is native to western Europe. Gray alder prefers moist to mesic sites throughout its distribution but occurs in a wide variety of plant communities within that moisture gradient. Speckled alder occurs in forest, shrub, and herbaceous communities. It also occurs in elm-ash-cottonwood (*Ulmus-Fraxinus-Populus* spp.) galleries and forests (Fryer 2011) and can be found on stream banks, lake shores and damp meadows and also in bogs and nutrient-rich swamp communities (Durrant et al 2016). Instead, Chernihiv Polesie, within which the floodplain of the Stryzhen River is located, is outside the continuous distribution of *Alnus incana*.

Conclusions

Both for the Słupia River within the city of Słupsk and for the Strizhen River within the Chernihiv city, the composition and dynamics of the plant quatic macrophytes communities are determined by changes in weather and hydrological conditions, as well as anthropogenic pressure. Due to the higher velocity of the Słupia River in its channel free-floating plants communities of the Lemnetea minoris class poorly represented.

At the same time, such communities, along with eu- and mesotrophic phytocenoses of the *Potametea* class, formed by plants completely submerged in water and with floating leaves, are found in floodplain water bodies. Communities of the *Phragmito-Magnocaricetea* class have formed in the coastal strips of both rivers, as well as in areas of the floodplain with wide fluctuations in water level, rich in mineral elements and silt deposits.

Temporarily flooded and highly zooanthropogenic nutrient-rich upland floodplains occupied by the *Agropyro-Rumicion* communities. On the hill with nitrificated sandy, dry, hardened substrate we found the ruderal Prunello-Plantaginetum communities. However, the vegetation cover of the Strizhen River floodplain is more ruderalized, as compared to the Słupia River floodplain. It has the greater syntaxonomic diversity of phytocenoses of summer annuals on soils rich in nitrates (class *Bidentetea*).

Fragments of hygrophilous wetlands belonging to the *Alnetum incanae* association are the phytocoenotic value of the Słupia floodplain within the city of Słupsk. The spread of these forests is due to the availability of optimal climatic conditions in Pomerania (unlike Polesie) for the growth of the dominant *Alnus incana*.

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Task 2. Determine the sozological aspect of your scientific research.

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Lecture. Species level of plant conservation

1. The Convention on Biological Diversity.
2. The Bern Convention.
3. The International Union for Conservation of Nature (IUCN) Red List of Threatened Plants.
4. National environmental documents of plant conservation.
5. Endangered algal species and how to protect them.

Species (the lowest) level is the conservation of individual species (autosozology) is provided by environmental documents.

1. **The Convention on Biological Diversity**

The Convention on Biological Diversity (CBD), known informally as the Biodiversity Convention. The Convention on Biological Diversity (CBD) entered into force on 29 December 1993. It has 3 main objectives:

- the conservation of biological diversity:
- the sustainable use of the components of biological diversity
- the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

The Convention on Biological Diversity is the international legal instrument for "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources" that has been ratified by 196 nations.

Its overall objective is to encourage actions, which will lead to a sustainable future.

The conservation of biodiversity is a common concern of humankind. The Convention on Biological Diversity covers biodiversity at all levels: ecosystems, species and genetic resources. It also covers biotechnology, including through the Cartagena Protocol on Biosafety. In fact, it covers all possible domains that are directly or indirectly related to biodiversity and its role in development, ranging from science, politics and education to agriculture, business, culture and much more.

The CBD’s governing body is the Conference of the Parties (COP). This ultimate authority of all governments (or Parties) that have ratified the treaty meets every two years to review progress, set priorities and commit to work plans.

The Secretariat of the Convention on Biological Diversity (SCBD) is based in Montreal, Canada. Its main function is to assist governments in the implementation of the CBD and its programmes of work, to organize meetings, draft documents, and coordinate with other international organizations and collect and spread information. The Executive Secretary is the head of the Secretariat.

The Convention on Biological Diversity, as an international treaty, identifies a common problem, sets overall goals and policies and general obligations, and organizes technical and financial cooperation. However, the responsibility for achieving its goals rests largely with the countries themselves.

Private companies, landowners, fishermen, and farmers take most of the actions that affect biodiversity. Governments need to provide the critical role of leadership, particularly by setting rules that guide the use of natural resources, and by protecting biodiversity where they have direct control over the land and water. Under the Convention, governments undertake to conserve and sustainably use biodiversity. They are required to develop national biodiversity strategies and action plans, and to integrate these into broader national plans for environment and development. This is particularly important for such sectors as forestry, agriculture, fisheries, energy, transportation and urban planning. Other treaty commitments include:

Identifying and monitoring the important components of biological diversity that need to be conserved and used sustainably.

Establishing protected areas to conserve biological diversity while promoting environmentally sound development around these areas.

Rehabilitating and restoring degraded ecosystems and promoting the recovery of threatened species in collaboration with local residents.

Respecting, preserving and maintaining traditional knowledge of the sustainable use of biological diversity with the involvement of indigenous peoples and local communities.

Preventing the introduction of, controlling, and eradicating alien species that could threaten ecosystems, habitats or species.

Controlling the risks posed by organisms modified by biotechnology.

Promoting public participation, particularly when it comes to assessing the environmental impacts of development projects that threaten biological diversity.

Educating people and raising awareness about the importance of biological diversity and the need to conserve it.

Reporting on how each country is meeting its biodiversity goals.

2. The Bern Convention

The Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention) was adopted in Bern, Switzerland in 1979, and came into force in 1982. The Bern Convention is a binding international legal instrument in the field of nature conservation, covering most of the natural heritage of the European continent and extending to some States of Africa.

It is the only regional Convention of its kind worldwide, and aims to conserve wild flora and fauna and their natural habitats, as well as to promote European co-operation in this field. The treaty also takes account of the impact that other policies may have on natural heritage and recognises the intrinsic value of wild flora and fauna, which needs to be preserved and passed to future generations.

Fifty countries and the European Union have already signed up to the Convention and committed to promoting national conservation policies, considering the impact of planning and development on the natural environment, promoting education and information on conservation, and coordinating research.

Key points:

The EU is a contracting party to the convention on the conservation of European wildlife and natural habitats.

Wild flora and fauna constitute a natural heritage of great value that needs to be preserved and handed on to future generations. In addition to national protection programmes, the parties to the Convention consider that cooperation should be established at a European level.

The parties undertake to:

- promote national policies for the conservation of wild flora, wild fauna and natural habitats;
- integrate the conservation of wild flora and fauna into national planning, development and environmental policies;
- promote education and disseminate information on the need to conserve species of wild flora and fauna and their habitats.

The parties agree to take appropriate legislative and administrative measures to protect the wild flora species specified in Appendix I (Strictly protected flora species). The convention prohibits the deliberate picking, collecting, cutting or uprooting of such plants.

Appropriate legislative and administrative measures must also be adopted to conserve the wild fauna species listed in Appendix II (Strictly protected fauna species).

Any exploitation of wild fauna specified in Appendix III (Protected fauna species) must be regulated in order to keep the populations out of danger (temporary or local prohibition of exploitation, regulation of transport or sale, etc.). The parties are prohibited from using indiscriminate means of capture and killing capable of causing the disappearance of, or serious disturbance to, the species.

The convention lists some exceptions to the above:

- for the protection of flora and fauna;
- to prevent serious damage to crops, livestock, forests, fisheries, water and other forms of property;
- in the interests of public health and safety, air safety or other overriding public interests;
- for the purposes of research and education, of repopulation, of reintroduction and for necessary breeding;
- to permit, under strictly supervised conditions, the taking, keeping or other judicious exploitation of certain wild animals and plants in small numbers.

The contracting parties undertake to coordinate their efforts for the protection of the migratory species specified in Appendices II and III whose range extends into their territories. A standing committee responsible for following the application of the convention is set up.

The principal aims of the Convention are to ensure conservation and protection of wild plant and animal species and their natural habitats (listed in Appendices I and II of the Convention), to increase cooperation between contracting parties, and to ensure the protection of certain fauna species (listed in Appendix 3) imposing regulations on any exploitation. To this end the Convention imposes legal obligations on contracting parties, protecting over 500 wild plant species.

Appendix 1 description – Special protection (`appropriate and necessary legislative and administrative measures`) for the plant taxa listed, including prohibition of deliberate picking, collecting, cutting, uprooting and, as appropriate, possession or sale.

3. The International Union for Conservation of Nature (IUCN) Red List of Threatened Plants

The international environmental documents are the IUCN Red List of Threatened Plants, Convention on the Conservation of European Wildlife and Natural Habitats.

IUCN RL – IUCN Red List of Threatened Plants, Established in 1964 and updated annually. The IUCN Red List is a critical indicator of the health of the world's biodiversity. Far more than a list of species and their status, it is a powerful tool to inform and catalyse action for biodiversity conservation and policy change, critical to protecting the natural resources we need to survive. It provides information about range, population size, habitat and ecology, use and/or trade, threats, and conservation actions that will help inform necessary conservation decisions.

The IUCN Red List is used by government agencies, wildlife departments, conservation-related non-governmental organisations (NGOs), natural resource planners, educational organisations, students, and the business community. The Red List process has become a massive enterprise involving the IUCN Global Species Program staff, partner organisations and experts in the IUCN Species Survival Commission and partner networks who compile the species information to make The IUCN Red List the indispensable product it is today.

To date, many species groups including mammals, amphibians, birds, reef building corals and conifers have been comprehensively assessed. As well as assessing newly recognized species, the IUCN Red List also re-assesses the status of some existing species, sometimes with positive stories to tell. For example, good news such as the downlisting (i.e. improvement) of a number of species on the IUCN Red List categories scale, due to conservation efforts. The bad news, however, is that biodiversity is declining. Currently, there are more than 142,500 species on The IUCN Red List, with more than 40,000 species threatened with extinction.

Despite the high proportions of threatened species, we are working to reverse, or at least halt, the decline in biodiversity. Increased assessments will help to build The IUCN Red List into a more complete 'Barometer of Life'. To do this, we need to increase the number of species assessed to at least 160,000. This will improve the global taxonomic coverage and thus provide a stronger base to enable better conservation and policy decisions. The IUCN Red List is crucial not only for helping to identify those species in need of targeted recovery efforts, but also for focusing the conservation agenda by identifying the key sites and habitats that need to be protected. Ultimately, The IUCN Red List helps to guide and inform future conservation and funding priorities.

The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. It divides species into nine categories: Not evaluated (NE), Data deficient (DD), Least concern (LC), Near threatened (NT), Vulnerable (VU), Endangered (EN), Critically endangered (CR), Extinct in the wild (EW) and Extinct (EX).

A taxon is Not Evaluated when it is has not yet been evaluated against the criteria.

A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and a threatened status. If the range of a taxon is suspected to be relatively circumscribed, and a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

A taxon is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category.

A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (see Section V), and it is therefore considered to be facing a high risk of extinction in the wild.

A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (see Section V), and it is therefore considered to be facing a very high risk of extinction in the wild.

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (see Section V), and it is therefore considered to be facing an extremely high risk of extinction in the wild.

A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

4. National environmental documents of plant conservation

The examples of national documents on the flora conservation are: Polska czerwena księga roślin, Rozporządzenie Ministra Środowiska z dnia 9 lipca 2004 r. w sprawie gatunków dziko występujących roślin objętych ochroną, Czerwona lista roślin i grzybów w Polsce, Чырвоная кніга Рэспублікі Беларусь, Червона книга України.

Red List of plants and fungi in Poland (Czerwona lista roślin i grzybów w Polsce).

The hazard categories used in the third edition of the Red List are not consistent with those established in 1994 by the IUCN. According to the authors, the reason is the lack of information on the current state of occurrence of many species. Compared to the previous edition, the categories of species previously included in the category of unspecified Threatened (T) have been clarified. The categories were also clarified with information on the isolated, extrazonal nature of Polish populations (square brackets around the category designation). As a result, the categories used in the red list of vascular plants are as follows: Extinct (EX), Extinct in the wild (EW), Endangered (E), [Endangered (E)], Vulnerable (V), [Vulnerable (V)], Rare (R). The characteristics are given in the original language.

Extinct – wymarłe i zaginione – gatunki, których występowanie w Polsce, mimo ponownych poszukiwań, nie zostało potwierdzone na stanowiskach gdzie je zbierano, ani na innych, nowych stanowiskach;

Extinct in the wild – i zagnione na stanowiskach naturalnych (extinct in the wild) – taksony, których występowanie w Polsce, mimo ponownych poszukiwań, nie zostało potwierdzone na stanowiskach gdzie je zbierano, ani nie znaleziono ich na nowych stanowiskach ale są uprawiane w ogrodach botanicznych lub na siedliskach zastępczych;

Endangered – wymierające – krytycznie zagrożone – taksony mocno zagrożone wymarciem, których przeżycie jest mało prawdopodobne, jeśli nadal będą działać czynniki zagrożenia; odpowiada to kategorii CR (krytycznie zagrożonych) w czerwonej księdze;

[Endangered] – wymierające – krytycznie zagrożone na izolowanych stanowiskach poza glownym obszarem swojego występowania – taksony zagrożone wymarciem, których przeżycie jest mało prawdopodobne, jeśli nadal będą działać czynniki zagrożenia, przy tym występują na izolowanych stanowiskach poza głównym obszarem swojego występowania, jest to uszczegółowiana kategoria E, odpowadająca bardziej ogólnej kategorii CR w czerwonej księdze;

Vulnerable – narażone – taksony zagrożone wymieraniem, które zapewne przesuną się w najbliższej przyszłości do kategorii wyższej (E – wymierające krytycznie zagrożone), jeśli będą nadal działać czynniki zagrożenia;

[Vulnerable] – narażone na izolowanych stanowiskach poza glownym obszarem swojego występowania – taksony, które zapewne przesuną się w najbliższej przyszłości do kategorii E – wymierających krytycznie zagrożonych, jeśli będą nadal działać czynniki zagrożenia, przy tym występują na izolowanych stanowiskach poza głównym obszarem swojego występowania, jest to uszczegółowiana kategoria V;

Rare – rzadkie – potencjalnie zagrożone wymarciem – taksony o ograniczonych zasięgach geograficznych, o małych obszarach siedliskowych lub też występujące na rozległym obszarze, ale w dużym rozproszeniu. Uwaga: gatunki rzadkie nie muszą być zagrożone – tak jest tylko w tym wypadku, gdy ich populacja maleje lub znajduje się na zagrożonych zmianami terenach. Kategoria ta odpowiada z grubsza LR w czerwonej księdze.

The Red Data Book of Ukraine (Червона книга України), is an official national red list of the threatened animals, plants and fungi that are protected by the law in Ukraine. State administration, conservation regulation and control of species is provided by the state institutions such as the Cabinet of Ukraine, Ministry of Ecology (Ministry of

Environmental Protection and Natural Resources), and other state institutions.

Scientific support for the Red Data Book is provided by the National Commission on the Red Data Book issues that prepares propositions about including and excluding species from the Red Data Book, provides control over materials preparation, determination of edition structure and coordination of related activities. The National Commission on the Red Data Book issues is formed by the National Academy of Sciences of Ukraine based on its I.I. Schmalhausen Institute of Zoology and M.G. Cholodny Institute of Botany that directly conduct registry of the red data.

The first edition of the Ukrainian Red Data Book was published in 1980, just couple of years after there was released the first edition of the Soviet Red Data Book. It was published by the National Academy of Sciences of Ukraine publishing house Naukova Dumka.

In 1994 and 1996 there was released the second edition of the Book by the Ukrainian Encyclopedia.

In 2009 the Third Edition of the Red Book of Ukraine was released by Global Consulting Ukraine. This edition includes 826 species (611 vascular plants, 46 bryophytes, 60 algae, 52 lichens, 57 mosses). The approaches to species selection and category comparing assessment, which are accepted by Ukraine and IUCN, are highlighted as well as species distribution according to phytoceonological and political regions.

As of 2019 the 1369 species are protected by the Red Book of Ukraine. In the Red Book of Ukraine the following information is specified on each of the species included in it:

- category,
- distribution,
- the main location,
- number in nature, including those outside of Ukraine and its changes,
- information about the propagation or captive breeding,
- measures taken and to be taken for their protection,
- sources of information.

The book also contains maps and photos (pictures) of plant species included in it.

Depending on the condition and extent of threats to populations of species listed in the Red Book of Ukraine, they are divided into the following categories: Extinct (0), Endangered (I), Vulnerable (II), Rare (III), Unspecified (IV), Unknown (V), Recovered (VI).

Extinct: species, about which after several searches conducted in typical areas or other known and probable locations of distribution, no information about their existence in the wild was found;

Endangered: species in danger of extinction, conservation of which is unlikely if unfavourable effect is continued.

Vulnerable: species that in the near future may be classified as “endangered” if the affecting action continues.

Rare: species, which populations are small, which are not currently classified as “endangered” or “vulnerable”, although they threatened;

Uncertain: species are known, they are classified as “endangered”, “vulnerable” or “rare”, but there is no reliable information that enables us to determine which of these categories they belong to;

Unknown: species that could be attributed to one of the above categories, but due to the lack of reliable information that remains to be determined;

Recovered: species, which populations do not cause concern due to conservation measures, however, they are not to be used, and require constant monitoring.

The examples of the plants that are listed in the Red Book of Ukraine.

Lycopodium annotinun L.

Status: II category.

Distribution: Ukrainian Carpathians Polissia, occasionally – Volyn Upland, Minor Polissia and northern part of the steppe zone. Species is common in the West and East Europe, the Mediterranean, the Caucasus, in the West and East Siberia and the Far East.

Designated Growth: Coniferous and mixed rainforest (forms curtain).

Number: multiple populations, their number decreases.

Reasons for change in the population: Deforestation, recreational load, picking plants as a decorative plant.

General Characteristics: Perennial herb 10-30 cm tall stem creeping, long, cylindrical, rooted at the nodes, sparsely covered with linear-lanceolate leaves upward. Strobili solitary, sessile, cylindrical. Spore production in July – September.

Measures of protection: the Red Book of the Ukrainian SSR (1980). Protected in Polesie natural and Carpathian Biosphere Reserve. The status of populations should be constantly monitored.

Salvinia natans All.

Status: II category.

Distribution: All territory of Ukraine (in the valleys of the Dnieper, the Desna, South Bug, Seversky Donets) – sporadically. Species is common in the Centeral Europe, the Mediterranean, the Caucasus, on Wednesday. Asia and the West Siberia, China, Japan, North America.

Habitat: freshwater shoal and standing water (depth 0.5-2.5 m) of silty sand and silty – peat sediments. In the lower reaches of the river is characterized by grouping species into other places creates only frahm.

Number: Populations are sharply reduced in polluted waters.

Measures of protection: the Red Book of the Ukrainian SSR (1980). Protected in reserves – Carpathian (biosphere) and the Roztochia (natural) and sanctuaries, particularly in Buschanskyi of state value (Ostrog district of Rivne region). All locations of species should be identified, especially in the forest-steppe zone, new protected areas should be created.

Reasons for change in the population: collecting plants as medicinal plants, deforestation, recreational activities.

General Characteristics: Perennial, yellowish or pale green plant. Stem 5-25 cm tall, dichotomous branching, densely covered with lanceolate or linear-lanceolate leaves solid. Spore production July – October.

5. Endangered algal species and how to protect them

On 19 August 2005 at the Eighth International Phycological Congress in Durban, South Africa, a special session of talks, each followed by an open discussion, brought together expertise to answer some major questions regarding the subject of endangered algae and their conservation and to discuss the possible methods and tactics necessary to achieve realistic protection. It was organized and chaired by Robert Andersen, and the topics and speakers of the talks were as follows:

1) Are there endangered microalgal species?

2) Are there endangered macroalgal species?

3) The use of culture collections in the conservation of algae.

4) Legislation and the conservation of algae.

It was these talks and ensuing discussions that form the basis of this commentary.

The concept for the microalgae that “everything is everywhere” is challenged. Evidence that some species have restricted ranges means that their biogeography has to be taken into account in their conservation. For the marine macroalgae, evidence of the impact of climate change, ocean acidification and introduced species on native floras is often anecdotal and points to the need for long-term monitoring and scientific study to determine changes in abundance and distribution. Most people, including many phycologists, do not immediately think of algae when discussing endangered or recently extinct species. The phytoplankton of the oceans and seaweeds in the photic zone along almost every coastline in the world generally give the impression of commonness in the oceans and thus protection in numbers. Similarly, the algae of lakes and rivers seem common and abundant. We now know that many algae, especially the macrophytes, are restricted in their distribution and thus are vulnerable to stochastic environmental and anthropogenic events; although, some species are now widely distributed, possibly through human intervention. Conservation initiatives exist for the algae, but they are at best patchy.

The first documented case of a historical extinction of an alga, *Vanvoorstia bennettiana* (Harvey) Papenfuss (*Delesseriaceae, Rhodophyta*), was reported by Millar and Kraft (1993) and Millar (2003). Lists of endangered algal species have been tabulated in several countries. Germany has probably made the most progress. In Japan, Watanabe et al. (2005) report that 24 charophycean taxa are classified as endangered, and some may now be extinct. In addition, several freshwater red algae are classified as endangered. The charophyte *Lamprothamnium papulosum* (Wallroth) J. Groves became the first nonvascular plant to be given legal protection in Britain. The charophyte *Lynchnothamnus barbatus* (Meyen) Leonhardi is a rare and endangered species in Australia. Four charophytes that were endemic to Japan: *Chara fibrosa* Agardh var. *brevibracteata* Kasaki, *Chara globularis* Thuillier var. *hakonensis* Kasaki, *Nitella flexilis* (L.) Agardh var. *bifurcata* Kasaki and *Nitella minispora* Imahori.

To conserve algae, it is necessary to consider whether we need to have different approaches in different parts of the world and/or for different types of habitats that support algae. For example, we need to consider whether algae in temperate regions require a different conservation approach to those in tropical regions. We need to consider whether individual species are to be conserved, in which case it is necessary to understand their biology, or whether we go for a site designation and whether that is sufficient to maintain populations of specific species or groups of species.

We also need to consider whether different species need different approaches if threatened. The answer is going to depend on the threats. So if the threat is global warming/climate change, it might be important (e.g. through modeling) to consider where species might move to and to maintain those environments in good condition. Given that premise, all habitats need to be looked after (including buffer zones), and this is the goal we should be aiming for. If a species is threatened because of development (e.g. marina building, bridge building), then another approach is needed (cf. section on legislation). A good knowledge of the biology of the alga or algae under consideration is also vital.

Endangered species lists heighten awareness, and there is recent phycological literature that draws attention to extinct or endangered species as well as literature cited elsewhere in this article). New species are being discovered each year. The common, morphologically distinct species have been described already, leaving the more rare (and cryptic) species as undescribed. These rarer, undescribed taxa may be at greatest risk of extinction.

Given that the algae are a heterogeneous group of organisms that include all photosynthetic species apart from higher plants, the conservation of the different algal groups and their habitats, including whether they are marine or freshwater, microscopic or macroscopic, will inevitably require different approaches.

Species conservation may be achieved in two general ways: (1) by protecting the habitat and (2) by protecting the organism. Many people prefer protecting the habitat, thereby allowing the species to respond to environmental change in an adaptive manner. However, when protecting habitats, it is sometimes necessary to look across political boundaries or even take a global approach. To conserve algae, it is necessary to consider whether we need to have different approaches in different parts of the world and/or for different types of habitats that support algae. For example, we need to consider whether algae in temperate regions require a different conservation approach to those in tropical regions. We need to consider whether individual species are to be conserved, in which case it is necessary to understand their biology, or whether we go for a site designation and whether that is sufficient to maintain populations of specific species or groups of species.

It is not always possible to protect a habitat, and therefore other means of protecting threatened and endangered species are necessary. One powerful means is *ex situ* cultivation, that is, maintaining the species outside its natural habitat. *Ex situ* algae conservation see in lection “*Ex situ* conservation of plant diversity”.

The reality is that while there may not be much we can do physically, there are methods of protection that can be effective if there are legal processes. It is not much use pointing out that a certain species of algae is threatened if there is nothing that can be done to stop the threat from continuing. The most effective way to protect a marine alga or, for that matter, any organism is to set laws that make the threat illegal and for the relevant authorities to be forced to ameliorate the threat. Politicians, councils, governments and property developers generally recognize only one process, and that is the legal process and hence laws. Therefore, biodiversity conservation should include not only the careful management of animal and plant species that are threatened with extinction by human activities but also the laws that require mitigation of the threat(s). Some countries (e.g. Australia, the United States, South Africa, the United Kingdom) now have 'threatened species legislation' that allows the 'listing' of species on bipartisan parliamentary schedules as vulnerable, endangered, critically endangered and extinct. Much of this legislation has been adopted and adapted from the IUCN, and within Australia, there is legislation at both the state and federal levels.

So, the use of species and site designations, including biodiversity action plans, important plant areas and key biodiversity areas are explored as ways forward for algal conservation and the raising of public awareness. Legislation is considered as the best method in which algae can be given protection.

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Practical work. Rare Polesie plant species in environmental documents

Task 1. Analyze the representation of the aquatic tertiary relict plant species of Eastern Polesie (*Aldrovanda vesiculosa* L., *Salvinia natans* (L.) All. and *Trapa natans* L.) in international and national environmental documents (IUCN Red List, Appendix 1 Bern Conventions, Ukrainian and Poland Red Data Books). Fill in Table 2 with the results.

Table 2

Aquatic tertiary relict plant species of Eastern Polesie

Plant species	*Aldrovanda vesiculosa*	*Salvinia natans*	*Trapa natans*
IUCN Red List			
Appendix 1 Bern Conventions			
Ukrainian Red Data Books			
Poland Red Data Books			

A very rare species (3 modern locations) is *Aldrovanda vesiculosa*. It is a relict of the Tertiary flora. Its range of occurrence is rather wide (Europe, Asia, Africa, Australia), although the number of its localities is relatively small. The majority of them have been in Europe, but are no longer confirmed. The distribution of *A. vesiculosa* in Eastern Polesie is limited by the climatic factors and the lack of seed propagation. The growth in a reservoir is temporary due to the fact that the species is very sensitive to the anthropogenic eutrophication and water pollution. Thus, 6 localities of this rare species, discovered in the XX century on the territory of Eastern Polesie, are lost due to the changes in the ecological regime of the biotopes of this species or their destruction. For comparison, exploration of the *Aldrovanda vesiculosa* localities in Poland proved that in 63% of cases the reason for Aldrovanda extinction was anthropopressure.

A moderately rare species (12 modern localities) – *Trapa natans*. This tertiary relict has a wide native range extending from Western Europe and Africa to Eastern and Southeastern Asia. The species has been introduced into North America and Australia. There are no threats to the spread of this relict species on the territory of Eastern Polesie. None of its known localities disappeared during the last century. In some localities there is only a decrease in the area of populations due to overgrowing of reservoirs. During the last 20 years, there has been a significant increase in the area of the *T. natans* communities in the shallow water of the Kyiv Reservoir. A weak anthropogenic eutrophication of habitats stimulates the development of *T. natans*.

A relatively rare species (over 25 modern localities) – *Salvinia natans*. It is a tertiary relict species with an extensive geographical range from Central and Eastern Europe to south-eastern Asia. The plant is associated with areas of sub-oceanic temperate, subtropical and tropical climates.The number of *S. natans* populations varies considerably from year to year; the species may disappear in some resevoirs and appear in others. The species is sensitive only to abrupt changes in the hydrological regime. The main threat factor is the drying up of reservoirs, which has been observed in Eastern Polesie during the recent years due to the climate changes and sinking of the groundwater levels. That is why about 10% of the habitats of the relict species in small reservoirs of Eastern Polesie have been lost during the recent decades.

Task 2. Make the map-schemes of the present aquatic relict species (*Aldrovanda vesiculosa* L., *Salvinia natans* (L.) All. and *Trapa natans* L.) range in Ukraine and Eastern Polesie (Fig. 2, 3).

Figure 2. Map scheme of Ukraine.

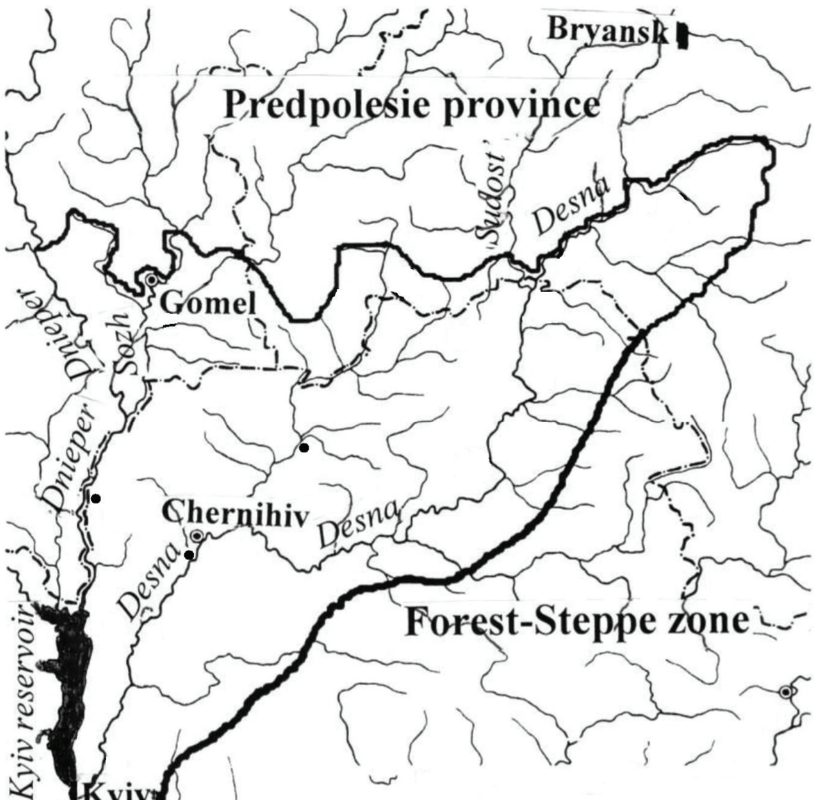

Figure 3. Map scheme of Eastern Polesie.

Task 3. Analyze the representation of the rare plant species of the regional conservation level in heath plant communities (Table 3).

Table 3

Floristic structure of the Ukrainian Polesie heath plant communities of the *Calluno-Ulicetea* class: the *Calluno-Genistetum pilosae* (relevés 1-3) and the *Scabioso canescentis-Genistetum* (relevés 4-8) associations

Region	**Right-bank Polesie**			**Left-bank Polesie**				
Relevé number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Shrub layer (b) cover [%]	60	40	5	1	5	< 1	0	15
Herb and dwarf shrub layer (c) cover [%]	80	50	90	40	35	45	50	25
Mosses layer (d) cover [%]	10	0	30	25	70	80	90	85
Lichens layer (e) cover [%]	0	0	0	0	10	5	0	5
Ch., D. Ass. Calluno-Genistetum pilosae and All. Calluno-Genistion pilosae								
Sarothamus scoparius	5	4	+	.	.	.	.	.
Genista germanica	+	+	+	.	.	.	.	.
Ch., D. Ass. Scabioso canescentis-Genistetum								
Genista tinctoria	.	.	.	+	+	1	+	+
Polygonatum odoratum	.	.	.	+	1	+	+	+
Scabiosa ochroleuca	.	.	.	+	+	+	+	+
Solidago virgaurea	.	.	.	+	+	+	+	+
Vincetoxicum hirundinaria	.	.	.	+	+	+	+	+
Ch. All. Calluno-Arctostaphylion								
Arctostaphylos uva-ursi	.	.	.	.	1	1	+	+
Carex praecox	.	.	.	+	+	+	.	.
Peucedanum oreoselinum	.	.	.	+	+	1	2	+
Scorzonera humilis	.	.	.	.	.	+	+	+
Ch. Cl. Calluno-Ulicetea and O. Vaccinio myrtilli-Genistetalia pilosae								
Calluna vulgaris	80	50	30	10	5	8	10	5
Carex ericetorum	+	+	+	+	1	1	+	.
Dicranum scoparium	.	.	.	.	+	2	1	+
Hieracium umbellatum	+	+	+	+	+	+	+	+
Vaccinium myrtillus	1	+	1	.	.	.	.	.
Accompanying species								
Cl. Vaccinio-Piceetea								
Ajuga reptans	.	.	+	.	.	.	.	.
Cladina rangiferina	.	.	.	.	1	1	.	.
Cladonia uncialis	.	.	.	.	1	+	.	1
Dicranum rugosum	.	.	.	.	.	.	.	4
Luzula pilosa	.	.	1	.	.	.	.	.
Melampyrum pretense	.	.	.	+	.	.	.	.
Pinus sylvestris (b)	1	1	1	1	1	+	+	3
Pinus sylvestris (c)	.	.	.	.	+	1	1	1
Pleurozium shreberi	2	.	4	3	5	5	5	4
Polytrichum juniperinum	.	.	.	1	2	2	2	3
Pulsatilla patens	.	.	.	.	.	.	.	+
Trientalis europaea	.	.	.	.	+	+	+	+
Vaccinium uliginosum	.	.	.	.	.	+	+	2
Vaccinium vitis-idaea	.	.	.	.	+	1	1	1
Cl. Molinio-Arrhenatheretea								
Achillea submillefolium	+	.	.	.	.	.	.	.

Agrostis stolonifera	.	.	.	.	.	.	.	+
Briza media	+	1	.	.	.	.	.	.
Carex hirta	.	+	.	.	.	.	.	.
Festuca rubra	.	.	1	2	.	.	.	.
Holcus lanatus	.	1	.	.	.	.	.	.
Ranunculus acris	.	+	.	.	.	.	.	.
Sieglingia decumbens	.	.	3	.	.	.	.	.
Cl. Nardetea strictae								
Genista germanica	.	.	.	.	.	.	.	+
Luzula campestris	.	.	.	.	.	+	+	+
Lycopodium clavatum	.	.	+	.	+	+	+	.
Nardus stricta	.	.	+	.	.	.	.	.
Pilosella officinarum	+	+	+	+	+	+	.	+
Potentilla erecta	.	+	.	.	+	.	.	+
Veronica officinalis	+	.	.	+	+	+	+	.
Cl. Koelerio-Corynephoretea canescentis								
Chamaecytisus ruthenicus	.	.	+	.	.	.	.	.
Festuca ovina	.	.	.	2	3	3	3	.
Jasione montana	+	+	.	.	.	.	.	.
Koeleria glauca	.	.	.	.	2	3	3	.
Potentilla argentea	+	1	.	.	.	.	.	.
Rumex acetosella	.	.	.	+	.	.	.	.
Solidago virgaurea	.	.	+	.	.	.	.	.
Cl. Crataego-Prunetea								
Crataegus monogyna	+	+	.	.	.	.	.	.
Galeopsis bifida	.	.	+	.	.	.	.	.
Prunus spinosa	.	+	.	.	.	.	.	.
Rosa canina	+	+	.	.	.	.	.	.
Cl. Epilobietea angustifolii								
Calamagrostis epigeios	+	1	.	+	.	.	.	.
Rubus idaeus	.	.	.	.	+	.	.	.
Sambucus racemosa	.	.	.	.	+	.	.	.
Cl. Festuco-Brometea								
Centaurea scabiosa	.	+	.	.	.	.	.	.
Euphorbia cyparisias	+	1	.	.	.	.	.	.
Cl. Trifolio-Geranietea sanguinei								
Anemone sylvestris	+	.	.	.	.	.	.	.
Galium verum	+	+	.	.	.	.	.	.
Cl. Erico-Pinetea								
Daphne cneorum	+	.	.	.	.	.	.	.
Cl. Papaveretea rhoeadis								
Viola arvensis	.	+	.	.	.	.	.	.
Other species								
Betula pendula (b)	+	+	.	+	.	.	.	.
*Betula pendula (*c)	.	+	.	.	.	.	.	.
Calamagrostis arundinacea	.	.	.	.	.	.	.	2
Cerasus mahaleb	+	.	.	.	.	.	.	.
Genista tinctoria	.	.	+	.	.	.	.	.
Holcus mollis	+	+	.	.	.	.	.	.
Hypericum perforatum	+	+	.	2	.	.	.	.
Populus tremula (b)	.	+	1	.	.	.	.	.
Populus tremula (c)	.	+	+	.	.	.	.	.
Pteridium aquilinum	.	.	.	+	.	.	.	.
Pyrus communis (b)	+	1	.	.	.	.	.	.
Quercus robur (b)	.	.	1	.	.	.	.	.
Veronica chamaedrys	.	.	+	.	.	.	.	.

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Lecture. Coenotic level of plant conservation

1. Ecological significance of plant communities and the importance of their conservation.
2. Principles and criteria of phytocenotic diversity conservation. Green Books.

There is a growing trend in ecological research to study the relationships between abiotic and biotic components of an ecosystem. Vegetation is the expression of environment in a specific habitat at a specific time and hence needs to be properly studied in relation to its surroundings at both species and community levels. Vegetation composition and structure are influenced by various natural and anthropogenic disturbances on both local and broader scales. It is thus imperative to understand the patterns of distribution of plant species and the influencing factors at these different scales. A plant community is an assemblage of plant species growing together in a particular habitat. An ecological community in which populations of plants or animals remain stable and exist in balance with each other and their environment. Climax community is a climax community is the final stage of succession, remaining relatively unchanged until destroyed by an event such as fire or human interference (Fig.4).

Coenotic (the middle) level of plant conservation is the conservation of plant communities (synphytosozology).

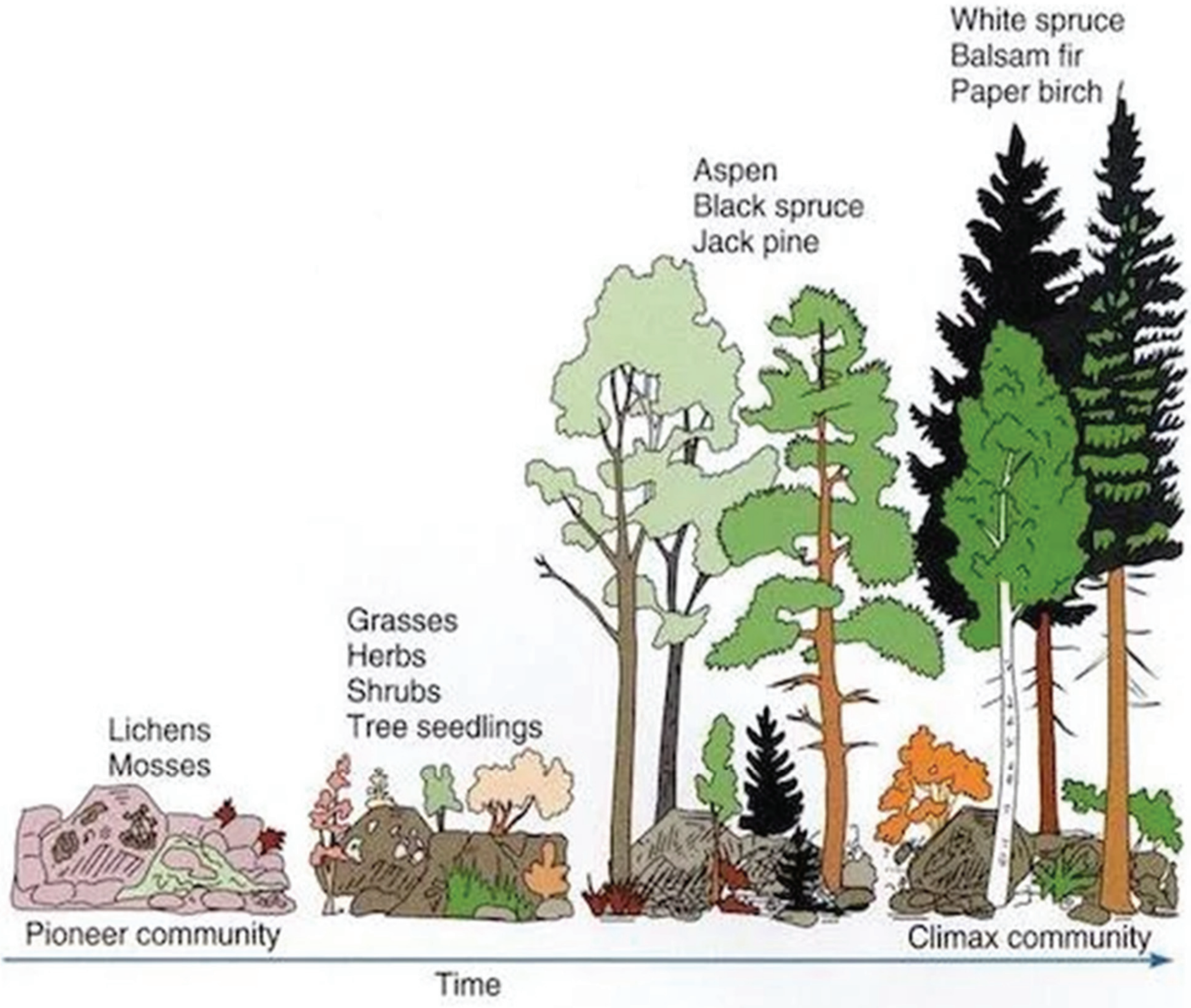

Figure 4. Plant community. (Climax community (n.d.). In *Dictionary.com, LLC*. Retrieved January 4, 2022, from https://www.dictionary.com/browse/climax-community)

1. Ecological significance of plant communities and the importance of their conservation

A plant community is an assemblage of plant species growing together in a particular habitat. It is recognizable by its assemblage of plant species that interact with each other as well as with the elements of their environment and is distinct from adjacent assemblages. Plant communities can vary in size from a small ephemeral wetland to a forest. In short, a plant community is the floral component of an ecosystem.

Plant communities are not static entities: rather they may vary in appearance and species composition from location to location and also over time. What makes each of these communities distinguishable is its general physiognomy or physical structure. This overall appearance is created by the particular species present, as well as their size, abundance, and distribution relative to one another.

Dominant species, those whose presence most influences the community environment and composition, are often the largest or the most abundant and may be a single species or several co-dominant species. Dominance may also be sociologic, expressed in the form of allelopathogens, chemical compounds manufactured by some plants that inhibit the growth and development of other species and/or seedlings of the same species within a certain distance. Community structure and distribution are dictated by the balance of environmental factors: soils, climate, topography, geography, fire, time, and humans and other living beings.

A plant community is simply the native plants that tend to grow together in any given habitat. So, for example, different plant communities are found on a steep dry slope, or in the floodplain near a stream, or in an open area. Often the assemblage of plants present is governed by topography.

Conserving and restoring plant communities allows us to protect plants and wildlife in ways that mirror natural environments. Restoring common, dominant native plants that are the ecosystem drivers can create ecological uplift – the drivers will create the conditions that bring along rarer, passenger species that need those conditions to thrive and reproduce.

Plant communities can also help guide choices not only about what to plant, but how much. For example, a floodplain forest often has a dense herbaceous layer, while a mesic to dry forest understory is often sparse, with large areas of leaf litter. The density that occurs in nature may not match gardening conventions. Planting for succession will create a multilayered understory, with varying age classes of mature canopy trees and young saplings.

Plant communities can provide far greater benefit over the complete life cycle of wildlife species than focusing narrowly on a single species. For example, many people have learned that milkweeds are essential for Monarch caterpillars. While they are necessary, Milkweeds are not sufficient. They are actually relatively poor insect hosts: Goldenrods are much more important late-season nectar sources for migrating Monarch butterflies, and as hosts for specialist bees. A diversity of species within a plant community supports a greater diversity of wildlife.

Particular attention should be paid to forest phytocenoses. Plant species in forest ecosystems have faced various environmental changes over their long ecological and evolutionary histories. Some of these changes have been slow, but others have occurred quite rapidly in the recent past.

The tremendous increase in research on environment-related subjects in recent decades explains the impacts of rapid changes in the environment in general and vegetation in particular. The most important factors influencing the future of plant species are the degree and rate of changes in the surrounding environment. Such changes may have serious consequences for the ability of plant species, especially those with less genetic diversity and narrow ecological amplitude, to adjust to changing conditions. Moreover, the rate of environmental change is so rapid that plant species with long generation times may be unable to adapt rapidly enough to keep pace.

Some species adapt to changing conditions by changing their growth forms, development, and life cycles. Changes in species life cycle ultimately bring changes in the formation of plant communities and hence ease the way for invasive species. In such scenarios, it becomes imperative for plant researchers to study environmental variations in terms of how these affect species composition and community structure. Abiotic, biotic, historical, and human factors contribute diversity and variation in the distribution of plant species and communities. The nature of these variations in temperate forests of developing countries is still insufficiently documented and analyzed.

2. Principles and criteria of phytocenotic diversity conservation. Green Books

The conservation of the biodiversity of our planet, including the diversity of plant communities, is becoming increasingly important every decade. This is reasoned by the ongoing transformation of vegetation due to the increasing anthropogenic impact and climate change on a global scale. Protection of plant communities is one of the principal issues of plant conservation.

Recently, European countries have been actively developing the “Red book of plant communities”, which are aimed at the identification of communities in need of protection, which are the habitat of rare and endangered plant and animal species. The evolution of the species takes place within the community, and it can be preserved only there. The founder of the theoretical developments of this direction is E.M. Lavrenko, who believed that the presence of rare species, especially in the status of dominants and codominants, is one of the criteria for the protection of communities. In addition, it is necessary to preserve zonal (typical) communities and phytocenoses located on the border of their ranges.

The conservation of existing plant communities ensures the functioning of the biosphere as a whole. This is one of the principles of the ecosystem approach.

Great work has been done in European countries on the conservation of phytocenotic diversity over the past half century. Back in the 70s of the 20th century, the first approaches were published in the scientific literature of Germany, which later became widely developed. Initially, rare and vulnerable plant communities were considered on the territory of individual federal lands. The Index and the Red List of Plant Communities summarized material throughout Germany and presented information on 807 rare associations and communities in need of protection. In the 1980s, books about plant communities in need of protection appeared in the Czech Republic and Ukraine. The 90s of the 20th century were marked by a wide coverage of the problem of phytocenotic diversity conservation in the scientific literature of Estonia, Austria, Switzerland and Russia. At the beginning of the 21st century, the monographs on rare plant communities in Eastern Europe began to be developed.

Let us consider the development of views on the principles and criteria for the identification of rare plant communities in need of protection and the creation of relevant Green Books.

On the basis of the use of floristic, botanical-geographical, phytocenotic and other criteria of conservation value, S.M. Stoyko identified 7 categories of communities in need of protection.

Later, this division of phytocenoses was taken into account in order to develop principles for the identification of rare, endangered and typical plant communities when creating the Green Book of the Ukrainian SSR.

The 1st category includes phytocenoses, the edifiers and co-edifiers of which are high-grade taxons listed in the Red Books. They are characterized by instability during the succession and a tendency to reduce the area.

The 2nd category combines indigenous phytocenoses, formed by the same species, but distinguished by their stability during succession and the stability of the range.

Indigenous communities belong to the 3rd category, in which various phytocenotic positions are occupied by common species, but with reduced ecological and biological potential at the boundary of the range or altitude distribution, as well as intrazonal phytocenoses deserving protection by botanical-geographical or chorological characteristics.

The 4th category combines phytocenoses ecologically associated with endangered representatives of animal world.

The 5th category includes indigenous phytocenoses with rare combinations of phytocenotypes, but presenting phytocenotic or economic interest, as well as phytocenoses of scientific research or economic reference value.

The 6th category includes the culture-phytocenoses from promising introduced or aboriginal species that have experimental or reference value.

The 7th category combines phytocenoses, previously widespread, but which became rare as a result, not so much due to natural historical causes, but to industrial or natural fires.

In 2009, the second issue of the Green Book of Ukraine was published, which is an official government document, containing information on the current state of rare, endangered, and typical natural plant communities in need of protection. The “Regulation on the Green Book of Ukraine” was approved by a resolution of the Ministry of Ukraine in August 29, 2002, and the methodology for establishing the environmental status of communities was approved by order of the Ministry of Conservation and Environmental Management of Ukraine in May 27, 2009.

The Green Data Books are necessary tools for the conservation organization. In accordance with this approach, the Green Data Books have been produced for many regions of Eastern Europe. With respect to current Ukrainian legislation, a status of the Green Data Book is defined by many Laws of Ukraine. The Green Book of Ukraine is the basis for the development of conservation measures, reproduction and use of plant communities recorded in it.

On the basis of the analysis and generalization of the experience of international a set of essential characteristics was proposed and scales to assess the conservation value of plant communities were developed. The system implies that communities receive expert evaluation based on 6 criteria: 1) floristic-phytocenotic significance; 2) rarity; 3) naturalness; 4) reduction of occupied area; 5) recoverability; 6) protection provision.

The use of these criteria leads to two integral indicators that determine the conservation status of plant communities: 1) danger of extinction; 2) category of protection.

The assessment of the risk of extinction is carried out taking into account the type of rarity, reduction of occupied area, ability to recover, protection provision, and presence of threatening factors. To assess the status of rare species, the IUCN scale is used: Ex - extinct, EW - extinct in the wild, Cr - critically endangered, En - endangered, Vu -vulnerable, LR - lower risk, DD - data deficient - species for which there is insufficient data. The category of protection reflects the value of the plant community and is defined as an integral indicator of the following parameters: 1) floristic-phytocenotic significance; 2) the nature of the distribution; 3) naturalness; 4) reduction of occupied area. A 4-grade rating scale was used: highest, high, medium, low. After determining the category of plant community protection, it is proposed to assess the status of the protected area as a derivative of the protection categories of all communities in a certain territory.

Nowadays a unified concept of the creation of “Red” or “Green” books of rare plant communities that are in need of protection is not formed. In European countries, existing inventories of phytocenosis needing protection have a legislative basis. The results of studies of rare plant communities presented in Green Books can be used in the design and creation of ecological networks, individual protected areas, zoning in national and natural parks.

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Practical work. Rare plant communities in Polesie

Task 1. According to the Green Book of Ukraine, identify plant communities that occur in Polesie. Describe the diversity of three plant communities according to the scheme: synphytosociological index, class, category, status, distribution in Ukraine, physical and geographical conditions, biotope, phytocoenotic, autphytosozological and botanical-geographical significance, potency structure, coenotic and reproducibility, type of storage regime, biotechnical and sozotechnical recommendations.

Task 2. Make a scheme of syntaxonomic affiliation of the rare plant communities based on the table date.

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Table 4. Floristic composition of the aquatic plant communities with the participation of the relict species in Eastern Polesie

Relevé number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Cover [%]	85	70	95	70	60	85	85	70	50	35	65	80	35	40	75	55	30	100	95	55	100	100	60
Ch. *Lemnetea minoris*, *Lemnetalia minoris*																							
Lemna minor	4	2	3	4	1	4	2	1	.	3	2	2	.	3	.	.	.	.	.	.	.	.	+
Spirodela polyrrhiza	2	2	2	2	2	2	+	+	.	2	4		4	1	.	.	+	.	.	.	.	2	.
Hydrocharis morsus-ranae	.	.	.	2	.	.	.	.	2	.	.	2		+	.	2	+	+	.	.	.	+	.
Lemna trisulca	2	+	2	.	.	.	2	.	3	.	1	2			.	.	.	.	.	.	.	.	.
Lemna gibba	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	.	.	.	.
Ch. *Lemnion minoris*																							
Wolfia arrhiza	.	4	5	.	1	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
D. *Salvinio-Spirodeletum (polyrrhizae)*																							
Salvinia natans	4	2	+	+	5	1	4	5	4	+	1	2	.	.	+	+	+	.	.	1	+	.	1
D. *Utricularion vulgaris*																							
Utricularia vulgaris	.	.	.	.	.	.	.	.	.	.	.	4	+	+	.	.	.	.	.	.	.	.	.
D. *Lemno-Utricularietum vulgaris,Spirodelo-Aldrovandetum vesiculosae*																							
Aldrovanda vesiculosa	.	.	.	.	.	.	.	.	.	.	.	1	2	1	.	.	.	.	.	.	.	.	.
Ch. *Potametea, Potametalia*																							
Potamogeton perfoliatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	1	+
Myriophyllum verticillatum	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	+	.	.	+	.	+	.
Elodea Canadensis	.	.	.	.	.	.	.	.	.	.	.	1	.	.	+	.	.	.	.	.	.	+	+
Ch. *Nymphaeion albae*																							
******Ch. *Nupharo lutei-Nymphaeetum albae***																							
*****Ch. *Nymphaeetum candidae***																							
****Ch. *Trapetum natantis***																							
Ch *Trapo-Nymphoidetum peltatae																							
******Nuphar lutea*	.	.	.	.	.	.	.	.	.	.	.	1	.	.	5	.	.	.	.	.	.	.	1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
****Nymphaea alba	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	.	2
****Nymphaea candida*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	+	.	1	.	.	.
**Nymphoides peltata*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	4
,Trapa natans*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	5	2	3	5	3	2
Other species																							
Ceratophyllum submersum												1											
Sagittaria sagittifolia	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	2	.
Stratiotes aloides	.	.	.	.	.	.	.	.	+	.	.	2	.	.	+	2	.	.	.	.	.	.	.

Note: D. – differential species, Ch. – characteristic species.

Dates and locality of the relevés: 1 – 11/07/2019, reclamation canal "Mlynok" (the Borzna district, Chernihiv region, Ukraine); 2 – 04/08/2019 – the floodplain of the Desna river (the city of Chernihiv, Ukraine); 3 – 17/08/2018, the riverbed of the Bilous river (the city of Chernihiv, Ukraine); 4 – 18/08/2019, the riverbed of the Stryzhen river (the city of Chernihiv, Ukraine); 5 – 18/08/2019, the floodplain of the Desna river (the city of Chernihiv, Ukraine); 6 – 23/08/2015, lake "Vorona" (the Borzna district, Chernihiv region, Ukraine); 7 – 19/07/2016, the left bank floodplain of the Desna river in the surroundings of the Spaske village (the Sosnytsia district, Chernihiv region, Ukraine); 8 – 20/08/2016 – the left bank floodplain of the Sozh river (the Ripky district, Chernihiv region, Ukraine); 9 – 12/07/2020, lake Bolhach, the floodplain of the Dnieper river (the Ripky district, Chernihiv region, Ukraine); 10 – 21/07/2017, the Rudnia village, the Mesha river near the bridge, near the dam created by beavers within (the Kozelets district, Chernihiv region, Ukraine); 11 – 25/07/2016 – an old riverbed of the Desna river in the surroundings of the Yevmynka village (the Kozelets district, Chernihiv region, Ukraine); 12 – 25/08/2019, lake Bolhach, the floodplain of the Dnieper river (the Ripky district, Chernihiv region, Ukraine); 13 – 07/06/2019, the pond in the hydropark, the floodplain of the town of Snovsk (the Chernihiv region, Ukraine); 14 – 25/07/2020, lake Perekop, the floodplain of the Desna river, the surroundings of the Shestovytsia village (the Chernihiv district, Chernihiv region, Ukraine), 15 – 21/07/2014, the lake in the floodplain of the Desna river, the Domnytsia village (the Mena district, Chernihiv region, Ukraine); 16 – 11/09/2007, the pond in the Pokrovske village (the Klymov (Klymovo) district, Briansk region, Russia); 17 – 29/08/2007 – the left bank floodplain of the Dnieper river, lake Vyr (on the border of the Homel and Buda-Kosheliv districts, Homel region, Belarus); 18 – 10/09/2007, the floodplain of the Desna river, the surroundings of the Krasnoie village (the Trubchevskyi district, Briansk region, Russia); 19 – 29/07/2019, lake Kozerohy (the Chernihiv district, Chernihiv region, Ukraine); 20 – 25/07/2016, lake Adrianove (the Ripky district, Chernihiv region, Ukraine); 21 – 15/06/2017, Kyiv Reservoir within the Mizhrichynskyi Regional Landscape Park, 1.5 km to the west from the Kosachivka village (the Kozelets district, Chernihiv region, Ukraine); 22 – 12/09/2007, the riverbed of the Sudost river, the surroundings of the Lukin village (the Poharskyi district, Briansk region, Russia); 23 – 18/07/2016, the right bank floodplain of the Desna river (the Novhorod-Siverskyi district, Chernihiv region, Ukraine).

Syntax: 1-11 – Salvinio-Spirodeletum (polyrrhizae) Slavnić 1956; 12 – Lemno-Utricularietum vulgaris Soó (1928) 1938; 13, 14 – Spirodelo-Aldrovandetum vesiculosae Borhidi et Komlódi 1959; 15 – Nupharo lutei-Nymphaeetum albae Nowiński 1930; 16 – Nymphaeetum candidae Miljan 1956; 17-21 – Trapetum natantis Th.Müller et Görs 1960; 22,23 – Trapo-Nymphoidetum peltatae Oberdorfer 1957.

Projective coverage scale in points: + - 0% (single individuals), 1 – 1-4%, 2 – 5-15%, 3 – 16-25%, 4 – 26-50%, 5 - >50%.

Syntax: 1-11 – Salvinio-Spirodeletum (polyrrhizae) Slavnić 1956; 12 – Lemno-Utricularietum vulgaris Soó (1928) 1938; 13, 14 – Spirodelo-Aldrovandetum vesiculosae Borhidi et Komlódi 1959; 15 – Nupharo lutei-Nymphaeetum albae Nowiński 1930; 16 – Nymphaeetum candidae Miljan 1956; 17-21 – Trapetum natantis Th.Müller et Görs 1960; 22,23 – Trapo-Nymphoidetum peltatae Oberdorfer 1957.

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SCIENTIFIC PRINCIPLES OF ECOSYSTEM PROTECTION OF PHYTODIVERSITY AND EXPERIENCE OF *EX SITU* PRESERVATION IN THE WORLD AND UKRAINE

Lecture. Ecosystem level of plant conservation

1. The understanding of habitat conservation of rare plants.
2. The EU's biodiversity strategy for 2030 & Natura 2000.
3. Biosphere reserves.
4. The national system of protected areas for plant conservation.
5. Important Plant Areas of Ukraine.

Ecosystem or territorial (the highest) level of plant conservation is the habitat conservation (reserved sozology).

1. The understanding of habitat conservation of rare plants

Habitat conservation is a management Practical work that seeks to conserve, protect and restore habitats and prevent species extinction, fragmentation or reduction in range. It is a priority of many groups that cannot be easily characterized in terms of any one ideology.

The natural environment is a source for a wide range of resources that can be exploited for economic profit, for example timber is harvested from forests and clean water is obtained from natural streams. However, land development from anthropogenic economic growth often causes a decline in the ecological integrity of nearby natural habitat. For instance, this was an issue in the northern Rocky Mountains of the US.

However, there is also the economic value in conserving natural habitats. Financial profit can be made from tourist revenue, for example in the tropics where species diversity is high, or in recreational sports which take place in natural environments such as hiking and mountain biking. The cost of repairing damaged ecosystems is considered to be much higher than the cost of conserving natural ecosystems.

Measuring the worth of conserving different habitat areas is often criticized as being too utilitarian from a philosophical point of view.

A great many of the rare plants that occur on the national forests and grasslands are best conserved by keeping their native habitats healthy. Sometimes the only action necessary is to conserve and protect existing rare plant habitat and to conduct periodic monitoring to ensure that rare plant populations are still thriving. Periodic monitoring of healthy rare plant populations can protect their long term existence, by detecting downward trends or alteration of their habitat which would otherwise go unnoticed.

In some cases, conserving and protecting the existing habitat of rare species, such as meadows, prairies or savannas, may include conducting prescribed burns because these areas depend on fire to maintain their openness. This is especially important because habitat may disappear or change due to fire suppression Practical works.

Some species and populations of rare plants, however, need more than habitat conservation. These plants need active management to reverse downward population trends. Periodic monitoring is essential to detecting the first signs of decline in rare plant populations and their habitats. Once we determine a particular set of corrective actions needed to reverse the decline of a rare plant population, we implement those necessary actions.

Sometimes habitat restoration is possible by removing weeds, or by simply allowing natural disturbance by fire, water, or wind to return to the ecosystem. In many of our savannas, woodlands, and prairie ecosystems, the exclusion of fire has led to such serious decline of disturbance-dependent plants that their continued existence is compromised. Removing encroaching woody plants and reintroducing fire have proven to help restore these fire-dependent communities and the plants, both common and rare, that rely on disturbance-dependent ecosystems.

Often, though, rare plants are restricted to special soil types, which are nearly impossible to recreate once the soil layers are churned up. Conservation of good quality habitat and maintenance of natural ecological processes in these habitats are our best hope for these substrate-specific rare plants.

Too often, the introduction of invasive species into rare plant habitats has had substantial adverse effects on rare plants, their populations, and habitats. The use of integrated pest management actions to eliminate and control invasive species will allow for the recovery of the community and its rare plants.

2. The EU’s biodiversity strategy for 2030 & Natura 2000

The EU’s biodiversity strategy for 2030 is a comprehensive, ambitious and long-term plan to protect nature and reverse the degradation of ecosystems. The strategy aims to put Europe's biodiversity on a path to recovery by 2030, and contains specific actions and commitments. The biodiversity strategy aims to put Europe's biodiversity on the path to recovery by 2030 for the benefit of people, climate and the planet. The strategy contains specific commitments and actions to be delivered by 2030. Establishing a larger EU-wide network of protected areas on land and at sea.

Through concrete commitments and actions, the plan is for EU countries to put in place effective restoration measures to restore degraded ecosystems, in particular those with the most potential to capture and store carbon and to prevent and reduce the impact of natural disasters.

As part of this plan, the Commission proposed the EU's first ever Nature Restoration LawSearch for available translations of the preceding which includes an overarching restoration objective for the long-term recovery of nature in the EU's land and sea areas, with binding restoration targets for specific habitats and species.

The strategy highlights unlocking funding for biodiversity, and setting in motion a new, strengthened governance framework to ensure better implementation and track progress improve knowledge, financing and investments better respecting nature in public and business decision-making.

The EU will enlarge existing Natura 2000 areas. Search for available translations of the preceding, with strict protection for areas of very high biodiversity and climate value.

In the European Union countries, NATURA 2000 project has been implemented. It is a network of territories where protection of certain species of animals and plants and their habitats is required. Stretching over 18% of the EU's land area and more than 8% of its marine territory, Natura 2000 is the largest coordinated network of protected areas in the world. It offers a haven to Europe's most valuable and threatened species and habitats.

Natura 2000 is a network of core breeding and resting sites for rare and threatened species, and some rare natural habitat types which are protected in their own right. It stretches across all 27 EU countries, both on land and at sea. The aim of the network is to ensure the long-term survival of Europe's most valuable and threatened species and habitats, listed under both the Birds Directive and the Habitats Directive.

The Natura 2000 Viewer is an online tool that presents all Natura 2000 sites. It provides key information on designated species and habitats, data on population sizes and information on conservation status. The viewer can be used for general purposes of for more specific searches.

Natura 2000 is not a system of strict nature reserves from which all human activities would be excluded. While it includes strictly protected nature reserves, most of the land remains privately owned. The approach to conservation and sustainable use of the Natura 2000 areas is much wider, largely centered on people working with nature rather than against it. However, Member States must ensure that the sites are managed in a sustainable manner, both ecologically and economically.

The legal basis for the NATURA 2000 project is the Directive 79/409 / of Council of the European Union, of April 2, 1979 on the protection of wild birds, as well as Directive 92/43 / of May 21, 1992 on the protection of natural habitats and wild birds, fauna and flora. The legal regulations of the project list the species of animals and plants that, due to their rarity and requirementsfor habitat conditions, especially need to be protected. This, first of all, refers to species and their ranges that are under threat of extinction. According to the proposal of the States Parties, specific areas are identified for the protection of these species and their ranges.

The regions are divided into 7 biogeographic regions of the European Union – Alpine, Atlantic, Polar, Continental, Macaroesian, Mediterranean and Pannonian. The NATURA 2000 network includes protected areas where conservation of more than 180 species and subspecies of birds should be ensured, as well as special reserves in which more than 250 different habitats, more than 200 species of animals and more than 430 plant species are to be preserved. Nowadays NATURA 2000 includes more than 20% of the territory of the European Union. The States Parties are responsible for protected areas and must ensure the safety of species and their ranges defined by legal regulations.

Within these territories, economic activity, such as agricultural, are still allowed, but it should comply with the purpose of the conservation of the species and their habitats.

In addition, in European countries, a project of the organization of Key Botanical Territories in order to protect the most valuable botanically protected sites is being developed. Most recently, the European Union completed a major project “Red List of Habitats of Europe”, which led to the publication of the results in two parts: the first part includes lists of marine habitats, the second part – terrestrial and freshwater habitats.

3. Biosphere reserves

Biosphere reserves are "learning places for sustainable development". They are sites for testing interdisciplinary approaches to understanding and managing changes and interactions between social and ecological systems, including conflict prevention and management of biodiversity. They are places that provide local solutions to global challenges. Biosphere reserves include terrestrial, marine and coastal ecosystems. Each site promotes solutions reconciling the conservation of biodiversity with its sustainable use.

Biosphere reserves are nominated by national governments and remain under the sovereign jurisdiction of the states where they are located. Biosphere Reserves are designated under the intergovernmental MAB Programme by the Director-General of UNESCO following the decisions of the MAB International Coordinating Council (MAB ICC). Their status is internationally recognized. Member States can submit sites through the designation process.

Biosphere Reserves involve local communities and all interested stakeholders in planning and management. They integrate three main "functions":

- conservation of biodiversity and cultural diversity;
- economic development that is socio-culturally and environmentally sustainable;
- logistic support, underpinning development through research, monitoring, education and training.

These three functions are pursued through the Biosphere Reserves' three main zones (Fig. 5).

Core Areas. It comprises a strictly protected zone that contributes to the conservation of landscapes, ecosystems, species and genetic variation

Buffer Zones. It surrounds or adjoins the core area(s), and is used for activities compatible with sound ecological Practical works that can reinforce scientific research, monitoring, training and education.

Transition Area. The transition area is where communities foster socio-culturally and ecologically sustainable economic and human activities.

The World Network (Fig. 6) of Biosphere Reserves covers all major representative natural and semi-natural ecosystems. It spans over a surface of 6,812,000 km^2 in 129 countries. It's almost the size of Australia. There are about 257 million people living in Biosphere Reserves worldwide.

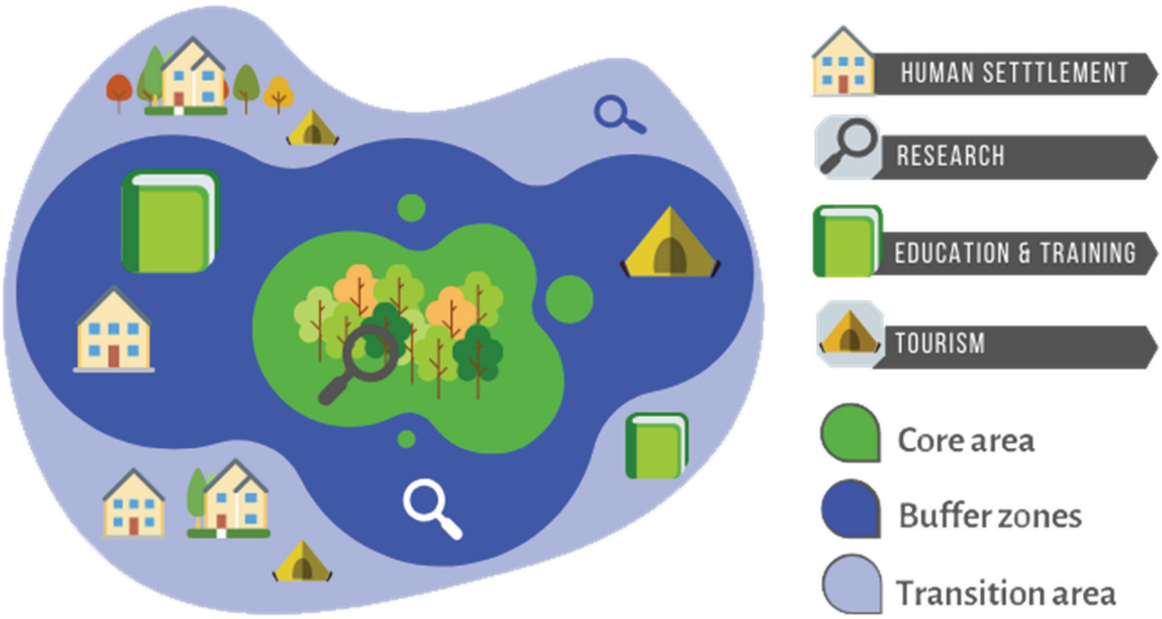

Figure 5. Functions zones of Biosphere Reserves.

Figure 6. The World Network of Biosphere Reserves

4. The national system of protected areas for plant conservation

The national system of protected areas is currently composed of more than 8,200 protected areas covering around 4.3 million ha, or 6-7 percent of the national territory. The protected area system was established in 1992 by the “Law on the Ukraine Nature Reserve Fund,” which defined a national system of protected areas for an independent Ukraine. It was, however, based on the perspective of nature conservation and the system of protected area categories that was developed throughout the former Soviet Union. This has led to some difficulty in comparing it with current global concepts and categories of protected areas. A key to understanding this are the Russian or Ukrainian names of the protected areas: zapovednik, zakaznik, and “park.” Zapovednik (Russian: заповедник, plural заповедники, from the Russian заповедный), meaning "sacred,” or “protected from disturbance,” is an established term throughout the territory of the former Soviet Union for a protected area which is kept "forever wild." It suggests strict nature protection, with human entry and use limited mainly to scientists. The closest English translation would therefore be “nature preserve” or “nature sanctuary”. Zakaznik (Ukrainian: singular: заказни́к; plural: заказники́, transliterated: zakaznyk, zakaznyky;) is a type of protected area in Russia and other former Soviet republics such as Ukraine where temporary or permanent limitations are placed upon certain on-site economic activities, such as logging, mining, grazing, or hunting. The Law on the Ukraine Nature Reserve Fund defined eleven categories of protected areas, only five of which form the core of the protected area system.

The nationally-managed categories of protected areas (national nature preserves, national nature parks, and biosphere preserves) make up 46 percent of the area of Ukraine’s protected area system; Nature Reserves (zakazniks) account for 32 percent of the area of Ukraine’s protected area system, and regional landscape parks another 18 percent. A large marine zakaznik of more than 4,000 km² was created in 2008 in the Black Sea to protect declining beds of the red alga Phyllophora. These statistics suggest the important role in biodiversity conservation of the regional landscape parks, managed at the oblast level with input from local councils, and zakazniks, administered through regional offices of the MENR and managed by local councils and land users.

National nature preserves have the strictest restrictions on use, and there is no zoning of uses within the preserve – the entire area is managed for the same and limited objectives. Rangers responsible for ensuring these restrictions are generally full-time staff of the preserve with limited qualifications and low salaries. The protected areas of this category are financed from the government national budget. If the budget of the preserve is low, the number of rangers is often not sufficient for controlling the whole area, and illegal hunting, fishing, and gathering of mushrooms, berries, and medical herbs by local people may occur.

Biosphere Preserves are also under strict protection, and financed from the national budget. Their territories are zoned into areas of strict protection, buffer zones, and zones of "anthropogenic landscapes," and this allows more opportunities for creating additional revenue for their protection through tourism and collection of wild products in the zones with fewer restrictions. This additional income can, in turn, lead to more money to hire rangers and better protection.

For National Parks and regional landscape parks that allow tourism and recreation, budgets can often support more rangers than in other types of protected areas, which improves resource protection. These four main types of protected areas have administrations with appropriate staff, including rangers. Some other categories of protected areas, such as nature reserves (zakazniks) have no administration, no budget, and no rangers. Protection is supposed to be provided by land users and local authorities. Most of these "protected areas" have practically no protection.

Site visits to six protected areas of different types and in different ecological regions, and nearby communities:

- the Prypiat-Stokhid National Nature Park, the Volyn Region;
- the Polyskyy Nature Reserve, the Zytomyr Region;
- the Askaniia Nova Biosphere Reserve, the Kherson Region;
- the Nyzhnodniprovski Pravni National Nature Park, the Kherson Region;
- the Oleshkivski Pisky National Park, the Kherson Region;
- the Chornomorskyy Biosphere Reserve, the Kherson Region.

Example, the Prypiat-Stokhid NNP is located on the Pripyat and Stokhid Rivers, part of the upper watershed of the Dnieper Basin. The park has an area of 3,932 km², 43% of is wetlands. Three Ramsar Sites are located in the park, and it supports 40 plants in the Red Book of

Ukraine. Drainage of the area started as early as 1775 during construction of the Dnieper-Bug Canal. Today about two-thirds of the flow from the Pripyat is diverted into the canal, and the diversion is controlled by Belarus. According to experts from the Institute of Hydrology, the reduced flow of the Pripyat results in increased siltation and changes in riparian and wetland habitats and threatening the relict Ice Age biota of the area.

During the last half of the 20th century extensive draining of Polesie's wetlands occurred, with a total drained area of about 60,000 km2. Parts of this drainage system continue to function all around the park, reducing the ground water level 1-1.5 meters, reducing wetland area within the park. Much of the drained land that was used for agriculture is no longer used, but the pumps and canals continue to work. During our site visit we have observed the Korostyns'ka drainage system that covers 35.3 km^2. The drained bogs, that used to be agricultural land are not in use anymore for agriculture production, however the drainage system continues to work. Wetland restoration has been discussed as part of the program to develop Ukraine's ecological network.

5. Important Plant Areas of Ukraine

The aim of the Important Plant Areas (IPAs) programme is to identify and protect a network of the best sites for plant conservation throughout Europe and the rest of the world, using consistent criteria. The identification of IPAs is based on three criteria.

Criterion A – Presence of threatened plant species: the site holds significant populations of one or more species that are of global or regional conservation concern.

Criterion B – Presence of botanical richness: the site has an exceptionally rich flora in a regional context in relation to its biogeographic zone.

Criterion C – Presence of threatened habitats: the site is an outstanding example of a habitat or vegetation type of global or regional plant conservation and botanical importance. "IPA" is not an official designation.

IPAs are selected scientifically using criteria supported by expert scientific judgement. IPA criteria were published in 2001. Since then IPA were selected in many countries. In Ukraine, first six IPAs were identified in 2008. In 2012 16 new areas were selected in the Sea of

Azov region. There are 173 IPAs identified within the territory of Ukraine. These data are available also in the IPA database online. IPAs were identified in Ukraine mainly using criteria A and C.

Criterion A includes subcriteria A(i) (species with categories EX, CR, En and VU in the IUCN database version 2015–4), A(ii) (species listed in Appendix I of the Bern Convention, Resolution 6 of the Steering Committee of the Bern Convention, or the Red Data Book of European bryophytes), A(iii) (species with categories "endangered" and "vulnerable" in the Red Data Book of Ukraine (2009) that are considered national endemics of Ukraine), A(iv) (limited range species with categories "endangered" and "vulnerable" in the Red Data Book of Ukraine (2009) that are not national endemics). Totally the Criterion A list for Ukraine has 185 species: subcriterion A(i) – 23 species, A(ii) – 96, A(iii) – 33, and A(iv) – 65 species. 145 species were used as criteria.

Criterion C in our analysis was the presence of habitats from Reslution 4 of theSteering Committee of the Bern Convention, 2014 version. In addition, one priority habiatat from the Habitats Directive was used: 4070 Bushes with Pinus mugo and *Rhododendron hirsutum* (*Mugo-Rhododendretum hirsuti*). The Ukrainian subtype of this habitat (F2.46) is not present in Resolution 4. For most habitat types we selected maximum five areas. Main exceptions are some habitats correspoding to the priority habitats of the Habiatats Directive: E1.2 Perennial calcareous grassland and basic steppes (includes 62C0 Ponto-Sarmatic steppes and 6240 Sub-Pannonic steppic grasslands), F3.247 Ponto-Sarmatic deciduous thickets (includes priority habitat type 40C0 Ponto-Sarmatic deciduous thickets), G1.6 Fagus woodland (includes priority habitat type 9150 Medio-European limestone beech forests of the Cephalanthero-Fagion), G1.7 Thermophilous deciduous woodland (includes priority habitat types 91H0 Pannonian woods with Quercus pubescens and 91I0 Euro-Siberian steppic woods with Quercus spp.). The largest number of IPAs are selected for habitat E1.2. Former (and potential) area of habitat E1.2 in Ukraine is a few tens of times larger than its current area. At present, the habitat is highly fragmented so five best sites include only 10% of its area in Ukraine. Besides, five sites cannot represent the geographical and ecological diversity patterns of steppes.

Example of IPA – Zaplava Desny.

Administrative regions. Chernihiv region: Borzna raion, Chernihiv city, Chernihiv raion, Kozelets raion, Korop raion, Kulykivka raion, Mena raion, Novhorod-Siverskyi city, Novhorod-Siverskyi raion, Sosnytsia raion; Kyiv region: Brovary raion, Vyshhorod raion; Sumy region: Krolevets raion, Shostka raion, Seredyna-Buda raion.

Ownership: state, private.

Biogeographic regions: continental.

Habitats. Level 1. C – 5%; D – 15%; E – 68%; F – 1%; G – 9%; H – 1%; I – 1%.

Habitats. Level 2. C1 Surface standing waters – 2%; C2 Surface running waters – 3%; C3 Littoral zone of inland surface waterbodies – 1%; D5 Sedge and reedbeds, normally without free-standing water – 15%; E2 Mesic grasslands – 33%; E3 Seasonally wet and wet grasslands – 35%; E5 Woodland fringes and clearings and tall forb stands – 5.3%; F9 Riverine and fen scrubs – 1%; G1 Broadleaved deciduous woodland – 6%; G3 Coniferous woodland – 3%; H5 Miscellaneous inland habitats with very sparse or no vegetation – 0.5%; I1 Arable land and market gardens – 1%.

Futher habitat description. C1.2 Permanent mesotrophic lakes, ponds and pools; C1.6 Temporary lakes, ponds and pools; C2.3 Permanent non-tidal, smooth-flowing watercourses; C3.2 Water-fringing reedbeds and tall helophytes other than canes; C3.4 Species-poor beds of low-growing water-fringing or amphibious vegetation; C3.5 Periodically inundated shores with pioneer and ephemeral vegetation; C3.6 Unvegetated or sparsely vegetated shores with soft or mobile sediments; D5.1 Reedbeds normally without free-standing water; D5.2 Beds of large sedges normally without free-standing water; E2.1 Permanent mesotrophic pastures and aftermath-grazed meadows; E2.2 Low and medium altitude hay meadows; E3.4 Moist or wet eutrophic and mesotrophic grassland; E5.4 Moist or wet tall-herb and fern fringes and meadows; F9.1 Riverine scrub; F9.2 Salix carr and fen scrub; G1.1 Riparian and gallery woodland, with dominant Alnus, Betula, Populus or Salix; G1.2 Mixed riparian floodplain and gallery woodland; G1.4 Broadleaved swamp woodland not on acid peat; G3.4 Pinus sylvestris woodland south of the taiga.

Land use: agriculture (animals) – 15%; agriculture (arable) – 1%; forestry – 9%; mowing/hay making – 45%; nature conservation and research – 5%; urban/industrial/transport – minor.

Protected areas: overlaps (3743 ha) with Desniansko-Starohutskyy National Nature Park, overlaps (14038 ha) with Desnianskyy Biosphere Reserve, overlaps (about 5007 ha) with Mezynskyy National Nature

Park, overlaps with Mizhrichynskyy regional Landscape Park (about 11200 ha), includes the Desna River Floodplains Ramsar Site (4270 ha), includes the Kamoretskyy State Zoological Reserve (515 ha), the Obolonskyy State Botanical Reserve (400 ha), the Putyvskyy State Botanical Reserve (150 ha), the Muravyivska State Hydrological Nature Monument (40 ha), the Ozero Trubyn State Hydrological Nature Monument (40 ha), the Vaden State Hydrological Nature Monument (20 ha), includes the Babakove Regional Hydrological Reserve (12 ha), the Boloto Kolodlyve Regional Hydrological Reserve (13.3 ha), the Blystovskyy Regional Landscape Reserve (400 ha), the Deminka Regional Landscape Reserve (1431 ha), the Fedorove Regional Hydrological Reserve (14 ha), the Horytskyy Landscape Hydrological Reserve (796 ha), the Kovchynskyy Regional Landscape Reserve (311 ha), the Kyslyche Regional Hydrological Reserve (178 ha), the Lebedynske Regional Hydrological Reserve (184 ha), the Makoshynskyy Regional Landscape Reserve (1533 ha), the Mialyne Regional Hydrological Reserve (102 ha), the Oryvtsove Regional Hydrological Reserve (12 ha), the PaikaKryvcha Regional Hydrological Reserve (216 ha), the Popovychove Regional Hydrological Reserve (11 ha), the Smolianske Regional Hydrological Reserve (15 ha), the Spaskyy Regional Landscape Reserve (543 ha), the Spaskyy-1 Regional Hydrological Reserve (214 ha), the Synychne Regional Hydrological Reserve (10 ha), the Urochyshche Kuty Regional Botanical Reserve (122 ha), the Vuzke Regional Hydrological Reserve (11 ha), the Zadesnianskyy Regional Landscape Reserve (940 ha), the Zolotynka Regional Landscape Reserve (527 ha), includes the Ramsar Site "Desna river floodplains" (4270 ha), includes the proposed Ramsar Site "Floodplains between the town of Oster and the village of Smolyn", overlaps (82511 ha) with the Emerald Site "Chernihivske Podesennia", overlaps (3743 ha) with the Emerald Site "Desniansko-Starohutskyy National Nature Park", overlaps (14038 ha) with the Emerald Site "Desnianskyy Biosphere Reserve", overlaps (5340 ha) with the Emerald Site "Kyivske Podesennia", overlaps (13660 ha) with the Emerald Site "Verhnie Podesennia", overlaps (5007 ha) with the Emerald Site "Mezynskyy National Nature Park", overlaps (1824 ha) with the Emerald Site "Dolyna Seimu", overlaps (50750 ha) with the Emerald Site "Nyzhnie Podesennia", overlaps (7058 ha) with the Emerald Site "Mizhrichynskyy Regional Landscape Park", overlaps with the proposed National Nature Parks "Prydesnianskyy" and "Shostkynskyy".

Threats: abandonment/reduction of land management – low, agricultural intensification/ expansion (general) – low; burning of vegetation – low, development (urbanization) – low, water (drainage) – low.

General description. 338 km section of the floodplain of the Desna river. This is the largest floodplain with natural water regime in Ukraine. Its average width is about 5 km. Floods are regular. The riverbed has natural meanders. There are many oxbows and lakes. Major vegetation types are mesic meadows dominated by Alopecurus pratensis, Poa pratensis, Festuca pratensis, Festuca rubra, Agrostis gigantea; drier sandy meadows dominated by Poa angustifolia, Agrostis vinealis, Calamagrostis epigeios; moist medadows dominated *by Deschampsia cespitosa, Phalaroides arundinacea, Filipendula ulmaria, Geranium palustre; mires and littoral vegetation dominated by Phragmites auistralis, Glyceria maxima, Carex acuta, Carex acutiformis, Carex appropinquata, Carex juncella, Carex elata, Carex rostrata, Carex vesicaria, Carex vulpina. There are forests (Salix alba, Quercus robur, Alnus glutinosa, Populus nigra, Populus alba, Pinus sylvestris) and shrubs (Salix cinerea, Salix triandra, Salix acutifolia). Aquatic vegetation is very diverse. Main dominants are Ceratophyllum demersum, Lemna minor, Lemna trisulca, Hydrocharis morsus-ranae, Nuphar lutea, Nymphaea alba, Nymphaea candida, Potamogeton natans, Sagittaria sagittifolia, Sparganium emersum, Stratiotes aloides, Utricualaria vulgaris*.

Botanical significance. This area is most important for conservation of floodplain complexes in Ukraine.

Criterion C

- C1.223 Floating Stratiotes aloides rafts; area: 30 ha; trend: stable; area data quality: poor; trend data quality: medium.
- C1.224 Floating Utricularia australis and Utricularia vulgaris colonies; area: 20 ha; trend: stable; area data quality: poor; trend data quality: medium.
- C1.3411 Ranunculus communities in shallow water; area: 1 ha; trend: stable; area data quality: poor; trend data quality: medium.
- C2.33 Mesotrophic vegetation of slow-flowing rivers; area: 200 ha; trend: stable; area data quality: poor; trend data quality: medium.
- C3.4 Species-poor beds of low-growing water-fringing or amphibious vegetation; area: 30 ha; trend: stable; area data quality: poor; trend data quality: medium.

- C3.51 Euro-Siberian dwarf annual amphibious swards; area: 30 ha; trend: stable; area data quality: poor; trend data quality: medium.
- D5.2 Beds of large sedges normally without free-standing water; area: 25000 ha; trend: stable; area data quality: poor; trend data quality: medium.
- E2.2 Low and medium altitude hay meadows; area: 30000 ha; trend: stable; area data quality: medium; trend data quality: medium.
- E3.4 Moist or wet eutropic and mesotrophic grassland; area: 65000 ha; trend: stable; area data quality: medium; trend data quality: medium.
- E3.5 Moist or wet oligotrophic grassland; area: 1000 ha; trend: stable; area data quality: poor; trend data quality: poor.
- E5.4 Moist or wet tall-herb and fern fringes and meadows; area: 300 ha; trend: stable; area data quality: poor; trend data quality: poor.
- F9.1 Riverine scrub; area: 5000 ha; trend: stable; area data quality: poor; trend data quality: poor.
- G1.11 Riverine Salix woodland; area: 2000 ha; trend: stable; area data quality: poor; trend data quality: poor.
- G1.21 Riverine Fraxinus – Alnus woodland, wet at high but not at low water; area: 200 ha; trend: stable; area data quality: poor; trend data quality: poor.
- G1.22 Mixed Quercus – Ulmus – Fraxinus woodland of great rivers; area: 1000 ha; trend: stable; area data quality: medium; trend data quality: poor.

Conservation proposals. Create the Emerald Sites including the entire IPA.

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Practical work. Heathland habitats and their conservation

Calluna vulgaris (L.) Hill., European Boreo-temperate element of flora, has a large geographic distribution and is dominating in many heath ecosystems. Such a type of vegetation prevails in many heathlands of northern and western Europe. In Ukrainian Polesie *Calluna vulgaris* is at the southern border of its distribution. That is what causes the affect on the species distribution in the region. The purpose of our study was to investigate the cenotic features of the *Calluna vulgaris* habitats and its population structure in Ukrainian Polesie.

Heathlands are highly dynamic habitats, with strong biotic and abiotic interactions affected by external drivers, despite their appearance as a homogeneous, stable ecosystem. All of the factors studied influence diversity patterns, community structure and general quality of the habitat. As experience of European (in particular, Polish) scientists shows, study of main heath formations and accompanying plant communities is very important for management, treatment and also conservation of the *Calluna vulgaris* ecological systems.

Task 1. Find out the information about current threats facing heathland habitats.

Question 1. Use the web resources listed below to produce a summary table of the activities that you think are currently threatening heathland habitats. In each case make a note of what the threat is and how it threatens the heathland habitat (i.e., what are its impacts on heathland extent, and heathland ecology – flora and fauna).

- Websites summarising some current threats to heathland habitats:

- http://www.southdowns.gov.uk/learning/themes-to-study/habitats/heathland/threats-to-heathland
- http://jncc.defra.gov.uk/page-5942

• Report on the impacts of acid and nitrogen deposition on the Lowland Heath:

- http://ukreate.defra.gov.uk/PDFs/Leaflets/Lowland%20heath.pdf

• Video footage discussing damage to heathland sites:

- http://www.bbc.co.uk/news/uk-england-13721441
- http://www.bbc.co.uk/news/science-environment-13836059

Question 2. Look at the graph "Heathland Status – The condition of lowland heathland sites designated as SSSI or SAC" and answer the following questions:

a. Use the internet to find out what 'SSSI' and 'SAC' stand for. Which of these designations can be given to sites for their international wildlife importance?

b. What percentage of heathland SSSI and SAC sites are classified as 'unfavourable not recovering' or 'destroyed or partly destroyed'?

Task 2. Lowland heathlands have a very distinctive plant community. In this activity you will be using the internet to find out about the types of plants that grow in heathlands and how they are different to plants in other habitats.

Question 1. Look at the photographs below of a typical heathland plant community (Fig. 7, 8).

a. How would you describe this habitat?

b. What can you say about the relative cover of trees, shrubs and grasses?

Question 2. Name three shrubs that characterise lowland heathland.

Question 3. What characteristics of heathlands and features of heathland soils make habitats particularly challenging environments for plant species to survive in?

Question 4. Because of the unique abiotic conditions found on heathlands, the plants that grow there have to be highly specialised to survive. Use the internet to research the following three plants. What adaptations do they have to the heathland environment?

The plants you need to research are: common heather (*Calluna vulgaris*), dwarf gorse (*Ulex minor*) and sundew (*Drosera rotundifolia*). Tip: Try to find out how they increase their nutrient uptake and how they may reduce water loss.

Figure 7. Heathland in Grenspark de Zoom-Kalmthoutse Heide (Belgium). https://media-cdn.tripadvisor.com/media/photo-s/18/9c/03/67/heathland-in-grenspark.jpg

Figure 8. Heathland in Polesie Nature Reserve (Ukraine). https://wownature.in.ua/parky-i-zapovidnyky/poliskyy-pryrodnyy-zapovidnyk/

Question 5. Mosses and lichens are commonly found in heathland habitats.

a. How are mosses and lichens different to vascular plants?

b. Find the name of one moss and two lichen species that may be found on heathlands.

Question 6. Bracken can become a dominant plant in heathland communities, out-competing other heathland plant species and reducing plant diversity. Whilst some bracken is important in heathland habitats, too much can reduce the biodiversity and quality of the heathland.

Find out two reasons why bracken is so effective at out-competing other plant species.

Question 7. Heathlands can typically be either dry heaths or wet heaths and mire.

a. List some plants that are associated with each of these different heathland habitats.

b. Which of these types of heathland typically has a greater plant species richness?

Question 8. Most heathlands have been created by humans and all heathlands have a rich cultural history. Find out some ways that humans used to use the heather plants that they harvested from heathlands.

Task 3. Read the article "Phytocenotic features of *Calluna vulgaris* (L.) Hill.in Ukrainian Polesie" and make a syntaxonomic scheme of heathlands plant communities in the Polesie Nature Reserve.

Task 4. Determine the floristic features of the *Calluno-Nardetum strictae* and *Ledo-Sphagnetum magellanici* associations in the Polessky nature reserve in comparison with the heather communities of the Right-bank and Left-bank Polesie. Use tables 6 and 7 to complete this task.

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Table 6

Floristic structure of the forest bogs plant communities (*Ledo-Sphagnetum magellanici* association) with *Calluna vulgaris*

Relevé number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Tree layer (a) cover [%]	0	5	0	0	0	50	0	0	40	40	0	0	70	0	40	0	0
Shrub layer (b) cover [%]	50	50	50	60	30	10	40	40	20	75	70	40	20	40	< 1	20	50
Herb and dwarf shrub layer (c) cover [%]	60	75	80	80	65	60	80	60	60	75	70	70	80	60	65	80	90
Mosses layer (d) cover [%]	70	20	20	40	80	60	95	98	90	80	40	70	40	95	98	30	0
D. Ass. Ledo-Sphagnetum magellanici																	
Ledum palustre	1	+	+	+	+	4	1	+	3	1	+	+	4	1	1	1	1
Oxycoccus microcarpus	.	.	.	.	.	.	.	+	.	+	.	.	.	+	.	.	.
D. Ass. Gr. of the forest bogs (Ch. Cl. Vaccinio-Piceetea)																	
Pinus sylvestris (a)	.	1	.	.	.	4	.	.	4	1	.	.	5	.	4	.	.
Pinus sylvestris (b)	3	2	1	1	3	1	4	4	3	4	5	4	+	4	+	+	+
Pinus sylvestris (c)	+	.	.	.	.	.	.	.	.	.	.	+	+	1	.	.	.
Pleurozium shreberi	+	.	.	.	.	.	+	.	.	.	3	.	4	.	.	.	1
Trientalis europaea	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	+	.
Vaccinium myrtillus	.	+	.	.	.	+	+	.	.	.	.	.	.	.	.	.	+
Vaccinium uliginosum	+	1	+	.	.	+	+	.	.	+	+	.	+	.	.	.	2
Vaccinium vitis-idaea	1	+	.	.	.	.	.	.	.	.	+	.	1	.	.	+	.
Ch. All. Sphagnion medii and O. Sphagnetalia medii																	
Andromeda polifolia	.	.	+	+	1	+	+	+	1	+	+	.	+	1	2	+	.
Eriophorum vaginatum	.	.	.	+	4	1	4	4	3	1	1	+	1	4	4	4	+
Oxycoccus palustris	.	.	1	.	1	+	3	+	2	3	.	.	+	1	1	1	.
Sphagnum acutifolium	4	.	.	.	.	3	3	.	.	.	3	.	.	.	.	.	.
Sphagnum centrale	.	.	.	.	.	.	.	.	.	.	.	.	+	.	5	+	.
Sphagnum compactum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
Sphagnum cuspidatum	.	.	1	4	2	.	.	5	5	.	.	4	.	.	.	.	.
Sphagnum fallax	.	.	.	.	4	.	5	.	.	.	.	.	.	.	.	.	.
Sphagnum fuscum	.	3	.	.	.	.	.	.	.	.	.	.	+	.	1	.	.
Sphagnum magellanicum	+	+	+	.	3	.	.	3	2	.	+	.	.	+	.	4	+
Sphagnum rubellum	.	.	.	.	.	.	.	.	.	5	.	+	.	5	1	+	.
Ch. Cl. Oxycocco-Sphagnetea																	
Aulacomnium palustre	.	.	+	.	.	3	+	+	.	.	.	2	.	.	.	.	+
Drosera rotundifolia	+	+	+	+	+	.	.	+	+	+	+	.	+	+	+	+	.
Salix aurita	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Accompanying species																	
Cl. Alnetea glutinosae																	
Alnus glutinosa (b)	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Betula pubescens (a)	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.
Betula pubescens (b)	.	.	4	5	.	2	.	.	.	2	1	2	.	.	.	3	4
Betula pubescens (c)	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Salix cinerea	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cl. Vaccinio-Piceetea																	
Dicranum rugosum	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Melampyrum pratense	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polytrichum commune	+	.	.	1	.	.	.	.	.	.	.	4	.	.	.	.	.
Polytrichum gracile	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cl. Scheuchzerio palustris-Caricetea fuscae																	

Carex lasiocarpa	.	.	.	2	1	.	.	.	.	+	.	.	.	+	.	.	.
Carex nigra	+	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Rhynchospora alba	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	+	.
Cl. Molinio-Arrhenatheretea																	
Molinia caerulea	2	2	.	.	.	.	+	.	.	+	2	4	3	.	.	.	.
Juncus effusus	1	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Cl. Nardetea strictae																	
Nardus stricta	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Potentilla erecta	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Cl. Calluno-Ulicetea																	
Arctostaphylos uva-ursi	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Calluna vulgaris	40	60	65	60	1	5	2	1	10	50	60	25	1	5	10	30	80
Cl. Koelerio-Corynephoretea canescentis																	
Astragalus arenarius	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Other species																	
Betula pendula (a)	.	.	.	.	.	.	+	.	.	.	.	.	.	.	3	.	.
Betula pendula (b)	4	4	.	.	5	.	.	.	.	.	.	.	3	2	+	.	.
Betula pendula (c)	.	2	.	.	.	.	.	.	.	.	.	.	2	+	+	.	.
Populus tremula (b)	.	1	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.
Populus tremula (c)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Pteridium aquilinum	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polytrichum alpestre	.	.	3	.	.	4	+	1	2	.	.	.	.	.	.	.	.

Notes.

Dates and localities of relevés:

1 – 16.08.1980, the Sarny forestry (sq. 9), Sarny district, Rivne region.

2 – 13.08.1980, the post-pyrogenic succession stage, the Berezne district, Rivne region.

3 – 10.08.1980, the post-pyrogenic succession stage, the Pochaiv Reserve (sq. 76), Berezne district, Rivne region.

4 – 10.08.1980, the post-pyrogenic succession stage, the Pochaiv Reserve (sq. 76), Berezne district, Rivne region.

5 – 12.07.1982, the Plotnytsia tract, Chervona Volia forestry (sq. 7), Novohrad-Volynskyi district, Zhytomyr region.

6 – 10.07.1982, the Chervona Volia forestry (sq. 1), Novohrad-Volynskyi district, Zhytomyr region.

7 – 22.10.1974, the Perebrody forestry (sq. 81), Dubrovytsia district, Rivne region.

8 – 27.07.1976, the Rostan forestry (sq. 21), Shatsk district, Volyn region.

9 – 16.07.1973, the Babii Mokh swamp, Zolote forestry (sq. 39), Dubrovytsia district, Rivne region.

10 – 25.06.1981, the Polesie Nature Reserve, the Klitne tract, Kopyshche forestry (sq. 47), Zhytomyr region.

11 – 25.06.1981, the post-pyrogenic succession stage, the Polesie Nature Reserve, the Klitne tract, Kopyshche forestry (sq. 38), Zhytomyr region.

12 – 25.06.1981, the Polesie Nature Reserve, Kopyshche forestry (sq. 26), Zhytomyr region.

13 – 13.06.1982, the swamp forest, the Polesie Nature Reserve (sq. 51), Zhytomyr region.

14 – 12.06.1982, the oligotrophic swamp, the Polesie Nature Reserve (sq. 40), Zhytomyr region.

15 – 12.06.1982, the oligotrophic swamp, the Polesie Nature Reserve (sq. 41), Zhytomyr region.

16 – 11.06.1982, the post-pyrogenic succession stage, the Polesie Nature Reserve (sq. 41), Zhytomyr region.

17 – 07.06.1978, the Vysotsk forestry (sq. 75), near the Verbivka village, Dubrovytsia district, Rivne region.

Author of relevés: T. Andrienko.

Table 7

Floristic structure of the Ukrainian Polesie heath plant communities of the *Nardetea strictae* class: the *Calluno-Nardetum strictae* association

Region	**Right-bank Polesie**																	**Left-bank Polesie**			
Relevé number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Shrub layer (b) cover [%]	60	30	0	1	0	80	50	5	15	60	70	50	70	40	50	70	40	15	0	0	2
Herb and dwarf shrub layer (c) cover [%]	70	75	55	40	60	70	70	75	80	40	15	45	40	55	45	80	80	80	95	90	90
Mosses layer (d) cover [%]	10	50	50	30	70	2	10	50	10	60	80	35	60	50	30	< 1	30	0	0	0	10
D. Ass Calluno-Nardetum strictae																					
Calluna vulgaris	15	15	15	15	15	35	30	40	40	35	10	20	25	20	15	60	40	60	5	30	40
Viola canina	+	.	+	.	.	+	.	.	.	.	+	.	+	.	.	+	.	1	+	2	+
Ch. All. Violion caninae																					
Hypochaeris uniflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Juncus squarrosus	+	+	+	2	+	+	1	+	+	+	+	+	+	+	+	+	+	.	.	.	.
Pimpinella saxifraga	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+
Ch. O. Nardetalia strictae																					
Hypericum maculatum	.	.	.	.	+	+	.	+	.	+	+	.	.	.	.	.	.	+	+	+	+
Nardus stricta	2	4	+	1	+	+	1	+	4	+	+	+	+	+	4	2	+	3	5	4	4
Ch.Cl. Nardetea strictae																					
Antennaria dioica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+
Carex pilulifera	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+
Luzula campestris	.	+	+	+	+	.	+	+	.	.	.	.	+	.	.	1	+	+	+	.	+
Lycopodium clavatum	+	.	.	.	.	+	.	.	.	+	+	.	.	.	+	.	.	+	.	+	+
Pilosella officinarum	.	+	+	.	+	.	.	+	+	+	+	+	+	.	+	.	+	.	+	.	.
Potentilla erecta	+	1	+	+	.	+	+	+	1	+	+	+	.	+	+	+	+	+	+	.	+
Veronica officinalis	+	.	+	.	.	+	.	.	+	.	.	+	+	+	.	+	.	+	+	2	+
Accompanying species																					
Cl. Molinio-Arrhenatheretea																					
Achillea submillefolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	+
Agrostis stolonifera	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	+	+
Alchemilla micans	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.

Anthoxanthum odoratum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	+	2
Carex echinata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Carex leporina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Carex panicea	.	2	.	2	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Centaurea jacea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+
Cnidium dubium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Coccyganthe flos-cuculi	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Deschampsia caespitosa	.	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	2	+
Festuca rubra	.	.	.	.	.	.	.	+	.	1	+	.	.	3	1	+	.	1	+	+	+
Galeopsis pubescens	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Galium uliginosum	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gentiana pneumonanthe	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	+
Juncus effusus	.	+	1	1	+	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Juncus tenuis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Leontodon autumnalis	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Luzula pallidula	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.
Lysimachia vulgaris	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Lythrum salicaria	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Mentha arvensis	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Molinia caerulea	5	+	.	.	+	4	4	.	.	.	.	.	+	.	.	1	4	.	.	.	.
Phleum pratense	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Poa nemoralis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Prunella vulgaris	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus acris	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ranunculus repens	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sieglingia decumbens	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.	+	.	.
Succisa pratensis	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Trifolium repens	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Viola uliginosa	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cl. Vaccinio-Piceetea																					
Arctostaphylos uva-ursi	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Chamaecytisus ruthenicus	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.
Dianthus pseudosquarrosus	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dicranum rugosum	.	.	.	.	.	2	.	.	.	4	3	3	.	.	.	.	.	.	.	.	.

Dryopteris carthusiana	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Frangula alnus (b)	4	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.
Luzula pilosa	.	.	+	.	.	.	+	+	.	1	.	.	.	.	.	.	+	.	.	.	.
Melampyrum pratense	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	.	.	.
Pinus sylvestris (b)	.	.	.	.	.	5	3	1	1	5	5	4	5	1	.	.	4	.	.	.	.
Pinus sylvestris (c)	.	.	.	.	.	.	+	.	.	.	1	5	+	.	.	.	+	.	.	.	.
Pleurozium shreberi	2	.	.	.	.	.	.	4	.	4	5	2	5	4	4	.	.	.	.	.	.
Polytrichum commune	.	.	.	.	5	.	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.
Polytrichum gracile	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polytrichum juniperinum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	2
Rhododendron luteum	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Trientalis europaea	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Vaccinium uliginosum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Vaccinium vitis-idaea	+	.	.	.	.	.	.	+	+	+	.	2	1	2	.	+	.	.	.	.	.
Cl. Scheuchzerio palustris-Caricetea fuscae																					
Agrostis canina	.	.	.	.	2	.	1	.	.	.	.	.	.	.	2	.	.	.	.	.	.
Carex echinata	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex nigra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Juncus articulatus	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lycopodiella inundata	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sphagnum cuspidatum	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Viola palustris	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cl. Koelerio-Corynephoretea canescentis																					
Corynephorus canescens	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Cytisus zingeri	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.
Jasione montana	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Koeleria glauca	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	2
Polytrichum piliferum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Rumex acetosella	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Cl. Epilobietea angustifolii																					
Calamagrostis epigeios	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Chamaerion angustifolium	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.

Gnaphalium sylvaticum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Oberna bechen	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Rubus idaeus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Cl. Oxycocco-Sphagnetea																					
Andromeda polifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Drosera rotundifolia	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Polytrichum strictum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.	.	.	.
Sphagnum compactum	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sphagnum fallax	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Cl. Alnetea glutinosae																					
Betula pubescens (b)	1	.	.	1	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.
Lycopus europaeus	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Salix aurita	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Salix cinerea	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cl. Isoëeto-Nanojuncetea																					
Gnaphalium luteoalbum	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gypsophila muralis	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hypericum humifusum	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sagina nodosa	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cl. Carpino-Fagetea sylvaticae																					
Hypericum montanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Oxalis acetosella	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Ranunculus auricomus	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cl. Phragmito-Magnocaricetea																					
Carex vesicaria	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.				
Carex vulpina	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Thyselium palustre	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cl. Festuco-Brometea																					
Carex praecox	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Other species																					
Agrostis capillaris	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Betula pendula (b)	.	.	.	.	.	1	4	4	.	2	.	.	4	4	5	5	2	.	.	.	.
Betula pendula (c)	.	.	.	.	.	1	+	.	.	.	.	.	.	+	.	+	.	.	.	.	.
Genista tinctoria	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Holcus mollis	.	.	.	.	+	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Hypericum perforatum	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.
Phalacroloma annuum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Populus tremula (b)	1	.	.	.	.	.	.	.	.	.	2	2	.	.	.	+	+	.	.	.	.
Populus tremula (c)		.	.	.	.	.	.	.	.	.	+	+	.	.	.	+	+	.	.	.	.
Pteridium aquilinum	.	.	.	.	.	.	.	1	2	+	.	.	.	.	.	.	.	.	.	.	.
Quercus robur (b)	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Sorbus aucuparia (b)	+		.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Veronica chamaedrys	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.

Notes. Dates, localities and authors of relevés:

1 – 11.08.1985, the floodplain of the Prypiat river, near the Nobel lake, the Zarichansk district, Rivne region; T. Andrienko. 2 – 11.08.1985, the floodplain of the Prypiat river, the Zarichansk district, Rivne region; T. Andrienko. 3 – 03.08.1980, the Polesie Nature Reserve, the floodplain of the Kamenka river, the Kopyshche forestry, Zhytomyr region; T. Andrienko. 4 – 23.06.1981, the Polesie Nature Reserve, the Perha forestry, Zhytomyr region; T. Andrienko. 5 – 13.08.1980, the sands, the Berezne district, Rivne region; T. Andrienko. 6 – 14.06.1982, the Polesie Nature Reserve, (sq. 50), the Zhytomyr region; T. Andrienko. 7 – 11.06.1982, the post-pyrogenic succesion stage, the Polesie Nature Reserve, (sq.42), the Zhytomyr region; T. Andrienko. 8 – 03.08.1980, the Polesie Nature Reserve, the floodplain of the Kamenka river, the Kopyshche forestry, Zhytomyr region; T. Andrienko. 9 – 12.08.1980, the wasteland, near the Verbivka village, Berezne district, Rivne region; T. Andrienko. 10 – 27.08.1972, the Kurchytsia forestry (sq. 57), Novohrad-Volynskyi district, Zhytomyr region; T. Andrienko. 11 – 25.08.1972, the forest area at the Malynsk village, Berezne district, Rivne region; T. Andrienko. 12 – 23.08.1972, the Sarny forestry (sq. 147), Sarny district, Rivne region; T. Andrienko. 13 – 23.08.1972, the Sarny forestry (sq. 147), Sarny district, Rivne region; T. Andrienko. 14 – 25.07.1981, the Polesie Nature Reserve, the Selezivka forestry (sq. 31), Ovruch district, Zhytomyr region; T. Andrienko. 15 – 23.07.1981, the Polesie Nature Reserve, the Selezivka forestry (sq. 19), Ovruch district, Zhytomyr region; T. Andrienko. 16 – 07.06.1978, the dunes, the Vysotsk forestry, 6 km from the Verbivka village, Dubrovytsia district, Rivne region; T. Andrienko.

17 – 11.06.1982, the post-pyrogenic succesion stage, the Polesie Nature Reserve (sq.41), Zhytomyr region; T. Andrienko.

18 – 15.07.2013, the heathland (2 ha), Mokrets tract near the Uhlova Rudnia village, Ripky district, Chernihiv region; O. Lukash, V. Popruha.

19– 19.07.1995, the meadow between the Berestovets and Sidorivka villages, Borzna district, Chernihiv region; O. Lukash.

20 – 18.08.2006, between the peaty meadow and pine forest, to the east of the Buda Vorobyivska village, Novhorod-Siverskyi district, Chernihiv region, N 52°22'43,2"; EO 32°31'51,0"; O. Lukash. 21 – 27.07.1996, the meadow between the swamp and the pine forest, outskirts of the Smolianka village, Kulykivka district, Chernihiv region; O. Lukash.

Practical work. Important Plant Areas in Ukraine

Task 1. Draw a map of the territory of the centres of Important Plant Areas in Ukraine, marking the centers of different areas: >100000 ha, >10000 ha and ≤100000 ha, >1000 ha and ≤10000 ha, >100 ha and ≤1000 ha, ≤100 ha.

Task 2. Fill in Table 8 for such species: *Adenophora lilifolia* (L.) Ledeb., *Aldrovanda vesiculosa* L., *Angelica palustris* (Besser) Hoffm., *Botrychium multifidum* (S.G.Gmel.) Rupr., *Cypripedium calceolus* L., *Jurinea cyanoides* (L.) Rchb., *Narcissus angustifolius* Curt., *Pulsatilla patens* (L.) Mill. (*P. latifolia* Rupr.), *Salvinia natans* (L.) All., *Trapa natans* L.

Table 8

"Criterion A species and corresponding selected IPA".

Taxon	A(i)	A(ii)	A(iii)	A(iv)	IUCN	db 2015-4	BC	Res 6	RBEB	RDBUIP	As where the taxon is a criterion of selection

Task 3. Determine for criterion C the habitats of selection (Code, Name in Resolution 4) for the IPA "Zaplava Desny"

Task 4. Choose the plants species that are found on the territory of IPA "Zaplava Desny":

Checklist of species for assessment of the botanical richness of habitats type G1: Broadleaved deciduous woodland

Taxaceae

1. Taxus baccata L.

Ranunculaceae

2. Aconitum besserianum Andrz. ex Trautv.

3. Aconitum degenii Gayer

4. Aconitum gracile (Rchb.) Gayer

5. Aconitum lasiostomum Rchb.

6. Aconitum nemorosum M.Bieb. ex Rchb.

7. Aconitum variegatum L.

8. Aquilegia vulgaris L.

9. Cimicifuga europaea Schipcz. *(Actaea europaea* (Schipcz.) J.Compton*)*

10. Delphinium pallasii Nevski
11. Helleborus purpurascens Waldst. et Kit.
Urticaceae
12. Urtica kioviensis Rogov.
Caryophyllaceae
13. Cerastium sylvaticum Waldst. et Kit.
Brassicaceae
14. Cardamine tenera S.G. Gmel. ex C.A. Mey.
15. Hesperis candida Kit. ex Müggenb., Kanitz et Knapp
16. Hesperis matronalis L.
17. Hesperis steveniana DC.
18. Hesperis sibirica L.
19. Hesperis voronovii N.Busch
Primulaceae
20. Cyclamen kuznetzovii Kotov et Czernowa *s.str.*
21. Lysimachia verticillaris Spreng.
Thymeleaceae
22. Daphne sophia Kalen.
23. Daphne taurica Kotov
Tiliaceae
24. Tilia dasystyla Stev.
Fabaceae
*25. Lathyrus laevigatus (*Waldst. et Kit.) Fritsch
26. Lathyrus transsilvanicus (Spreng.) Rchb.
27. Lathyrus venetus (Mill.) Wohlf.
Rutaceae
28. Dictamnus gymnostylis Stev.
Aceraceae
29. Acer stevenii Pojark.
Apiaceae
30. Laserpitium latifolium L.
Celastraceae
31. Euonymus nanus M.Bieb.
Rhamnaceae
32. Rhamnus tinctoria Waldst. et Kit.
Santalaceae
33. Thesium ebracteatum Hayne
Oleaceae
34. Syringa josikaea Jacq. fil.

Rubiaceae
35. Asperula propinqua Pobed.
Boraginaceae
36. Solenanthus biebersteinii DC.
Solanaceae
37. Scopolia carniolica Jacq.
Scrophulariaceae
38. Scrophularia vernalis L.
Campanulaceae
39. Adenophora liliifolia (L.) A. DC.
Liliaceae
40. Colchicum umbrosum Steven
41. Erythronium dens-canis L.
42. Fritillaria ruthenica Wikstr.
43. Nectaroscordum meliophilum (Juz.) Zahar. *(Allium siculum Ucria subsp.*
dioscoridis (Sm.) K.Richt.*)*
44. Ruscus hypoglossum L.
45. Veratrum nigrum L.
Amaryllidaceae
46. Galanthus elwesii Hook. fil
47. Leucojum vernum L.
Iridaceae
48. Crocus banaticus J. Gay
49. Iris graminea L.
50. Iris hungarica Waldst. et Kit.
51. Iris variegata L.
Orchidaceae
52. Anacamptis pyramidalis (L.) Rich.
53. Comperia comperiana (Steven) Asch. et Graebn.
54. Corallorhiza trifida Châtel.
55. Cypripedium calceolus L.
56. Dactylorhiza romana (Seb. et Mauri) Soó
57. Epipactis atrorubens (Hoffm ex Bernh.) Schult.
58. Epipactis microphylla (Ehrh.) Sw.
59. Epipactis purpurata Smith
60. Epipogium aphyllum (F.W.Schmidt) Sw.
61. Himantoglossum caprinum (M.Bieb.) K.Koch
62. Limodorum abortivum (L.) Sw.

63. Ophrys apifera Huds.
64. Ophrys oestrifera M.Bieb.
65. Ophrys taurica (Aggeenko) Nevski
66. Orchis mascula (L.) L.
67. Orchis picta Loisel.
68. Orchis provincialis Balb.
69. Orchis punctulata Stev. ex. Lindl.
70. Orchis purpurea Huds.
71. Orchis simia Lam.
72. Steveniella satyrioides (Steven) Schltr.
Cyperaceae
73. Carex depauperata Curt. ex With.
74. Carex strigosa Huds.
Poaceae
75. Festuca drymeia Mert. et Koch
Araceae
76. Arum albispathum Steven ex Ledeb.
77. Arum orientale M.Bieb.

Reference

Onyshchenko, V. A. (ed.). (2017). *Important Plant Areas of Ukraine*. Kyiv, Alterpress.
http://www.botany.kiev.ua/doc/onysh_2017.pdf

Lecture. *Ex situ* conservation of plant diversity

1. Botanic Gardens Conservation Strategy.
2. Quantifying the extent and content of botanic gardens.
3. Potential role of botanic gardens in conservation. A strategy of threatened plant management in living collections.
4. Identifying and targeting under-represented lineages.
5. Evaluating progress towards Global Strategy for Plant Conservation Target 8.
6. Measuring response to species extinction risk.
7. *Ex situ* algae conservation.

1. Botanic Gardens Conservation Strategy

Plants are essential for life, capturing solar energy, and creating the biomass that underpins the biosphere. Plants underpin ecological processes such as climate regulation, carbon dioxide absorption, soil fertility and the purification of water and air, and provide the food, medicines, building materials and fuel that sustain human life. Yet an estimated 20% of plant diversity is threatened with extinction. The extinction threat is largely anthropogenic, including habitat degradation, invasive species, resource over-exploitation and climate change. It is estimated that 75% of the planet's land surface is experiencing human pressures such as expansion of built environments, with approximately 40% given to agriculture. Even in wilderness areas, plant populations are vulnerable to invasive species, pests, diseases and a changing climate. For plants with natural distributions within transformed environments, ex situ conservation may be the only way they can survive in the short, medium and even long term. Crucially, threatened plant diversity may also hold the key to solving our major challenges in areas of food security, energy availability, water scarcity, climate change and habitat degradation.

Botanic gardens are managed for many purposes, but offer the opportunity to conserve plant diversity ex situ, and have a major role in preventing species extinctions through integrated conservation action. Recognizing the unique position of botanic gardens for plant conservation, the first Botanic Gardens Conservation Strategy was published in 1989, developing the role of botanic gardens in conservation throughout the 1990. Then, in 1998, Botanic Gardens Conservation International (BGCI), a consortium of 800 botanic gardens in>100 countries, launched an international consultation process to update the Strategy, taking into account the Convention on Biological Diversity. The consultation culminated in the adoption of the Global Strategy for Plant Conservation (GSPC), which seeks to halt the loss of plant diversity and to secure a sustainable future where human activities support plant diversity, and where the diversity of plants supports human livelihoods and well-being. The strategy outlines 16 targets encompassing knowledge, conservation, sustainable use, awareness and capacity-building activities. They are:

Objective I: Plant diversity is well understood, documented and recognized

Target 1. An online flora of all known plants.

Target 2. An assessment of the conservation status of all known plant species, as far as possible, to guide conservation action.

Target 3. Information, research and associated outputs, and methods necessary to implement the Strategy developed and shared.

Objective II: Plant diversity is urgently and effectively conserved

Target 4. At least 15 per cent of each ecological region or vegetation type secured through effective management and/or restoration.

Target 5. At least 75 per cent of the most important areas for plant diversity of each ecological region protected with effective management in place for conserving plants and their genetic diversity.

Target 6. At least 75 per cent of production lands in each sector managed sustainably, consistent with the conservation of plant diversity.

Target 7. At least 75 per cent of known threatened plant species conserved in situ.

Target 8. At least 75 per cent of threatened plant species in ex situ collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes.

Target 9. 70 per cent of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species conserved, while respecting, preserving and maintaining associated indigenous and local knowledge.

Target 10. Effective management plans in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded.

Objective III: Plant diversity is used in a sustainable and equitable manner

Target 11. No species of wild flora endangered by international trade.

Target 12. All wild harvested plant-based products sourced sustainably.

Target 13. Indigenous and local knowledge innovations and Practical works associated with plant resources, maintained or increased, as appropriate, to support customary use, sustainable livelihoods, local food security and health care.

Objective IV: Education and awareness about plant diversity, its role in sustainable livelihoods and importance to all life on earth is promoted

Target 14. The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programmes.

Objective V: The capacities and public engagement necessary to implement the Strategy have been developed

Target 15. The number of trained people working with appropriate facilities sufficient according to national needs, to achieve the targets of this Strategy.

Target 16. Institutions, networks and partnerships for plant conservation established or strengthened at national, regional and international levels to achieve the targets of this Strategy.

Botanic gardens contribute to meeting all targets, but as the main institutions for ex situ plant conservation, they are key to achieving GSPC Target 8, which calls for ‘at least 75% of threatened plant species in ex situ collections, preferably in the country of origin, and at least 20% available for recovery and restoration programmes by 2020’. BGCI recently published its vision for a botanic garden-centred, cost-effective, rational global system for the conservation and management of all plant diversity. Two assertions lie at the core of the central role of botanic gardens in the conservation and management of plant diversity. First, that there is no technical reason why plant species should become extinct, given the array of *ex situ* and in situ conservation techniques such as seed banking, cultivation, tissue culture, assisted migration, species recovery and ecological restoration. And second, that as a professional community, botanic gardens possess a unique skill set that encompasses finding, identifying, collecting, conserving and growing plant diversity across the taxonomic spectrum. While it is difficult to prove a plant species cannot be conserved vegetatively or as seed, it is possible to evaluate the potential for ex situ conservation by assessing the extent of the plant diversity, including threatened species, that botanic gardens are already conserving and managing *ex situ*.

The global network of botanic gardens conserves an astonishing array of plant diversity, holding 105,634 species, equating to 30% of species diversity, 59% of plant genera, 75% of land plant families, and 93% of all vascular plant families. These numbers are all the more remarkable as they represent a minimum estimate, based on data derived from just one-third of botanic gardens worldwide. Such numbers emphasize that botanic gardens possess unique skills for conserving plant diversity across the taxonomic spectrum. Furthermore, botanic gardens are discernibly responding to the threat of species extinctions, housing at least 13,218 species at risk of extinction, equating to just over 41% of the world's known threatened flora.

The network is poorly positioned to protect tropical species, and substantial capacity-building is needed here. For example, an accessible cyber-infrastructure will be vital to collectively manage *ex situ* conservation of the world's plant diversity. Importantly, the current global cyber-infrastructure in the form of PlantSearch is limited to taxon-level data; however, effective *ex situ* conservation depends on high intra-specific diversity, and for this, individual accession-level data are needed. Only 10% of collections are dedicated to threatened species, and, to limit species extinction, it is essential that our full capacity is directed towards our most threatened plant species.

Botanic gardens must engage with these organizations and industries with responsibility for plant diversity in the natural landscape. Finally, it is important that coordinated international conservation of threatened species continues in the face of legislation that seeks to enforce the intellectual property rights of individual nations. Without deep sustained public support, the plant conservation movement will struggle. Fortunately, public-facing botanic gardens are typically near urban areas, and, according to data within the GardenSearch database, collectively host 500 million visitors annually. Consequently, botanic gardens can deliver the necessary education, citizen science and information to facilitate plant conservation action across the broader society. Given the quality of the collections, and their critical importance for conservation, it is vital that we speak to the strengths of the network, and promote its unique skills and resources to policymakers and funders. Despite impressive efforts by the world's botanic gardens, substantial investment will be required to build a fully functioning, cost-effective, rational global system for the conservation of threatened plant diversity that can prevent species extinctions in perpetuity.

At least one of three main factors should be taken into account to evaluate a collection: the status of a species in the wild (species risk assessments), the genetic representation of the collection in the context of wild variation or among the collection itself, and the operational cost of maintaining collections. A conservation value (C-value) of a species can be shared via online databases (e.g. BGCI ' s PlantSearch database), leading towards a unified effort of ex situ conservation in Botanic Gardens (Fig. 9).

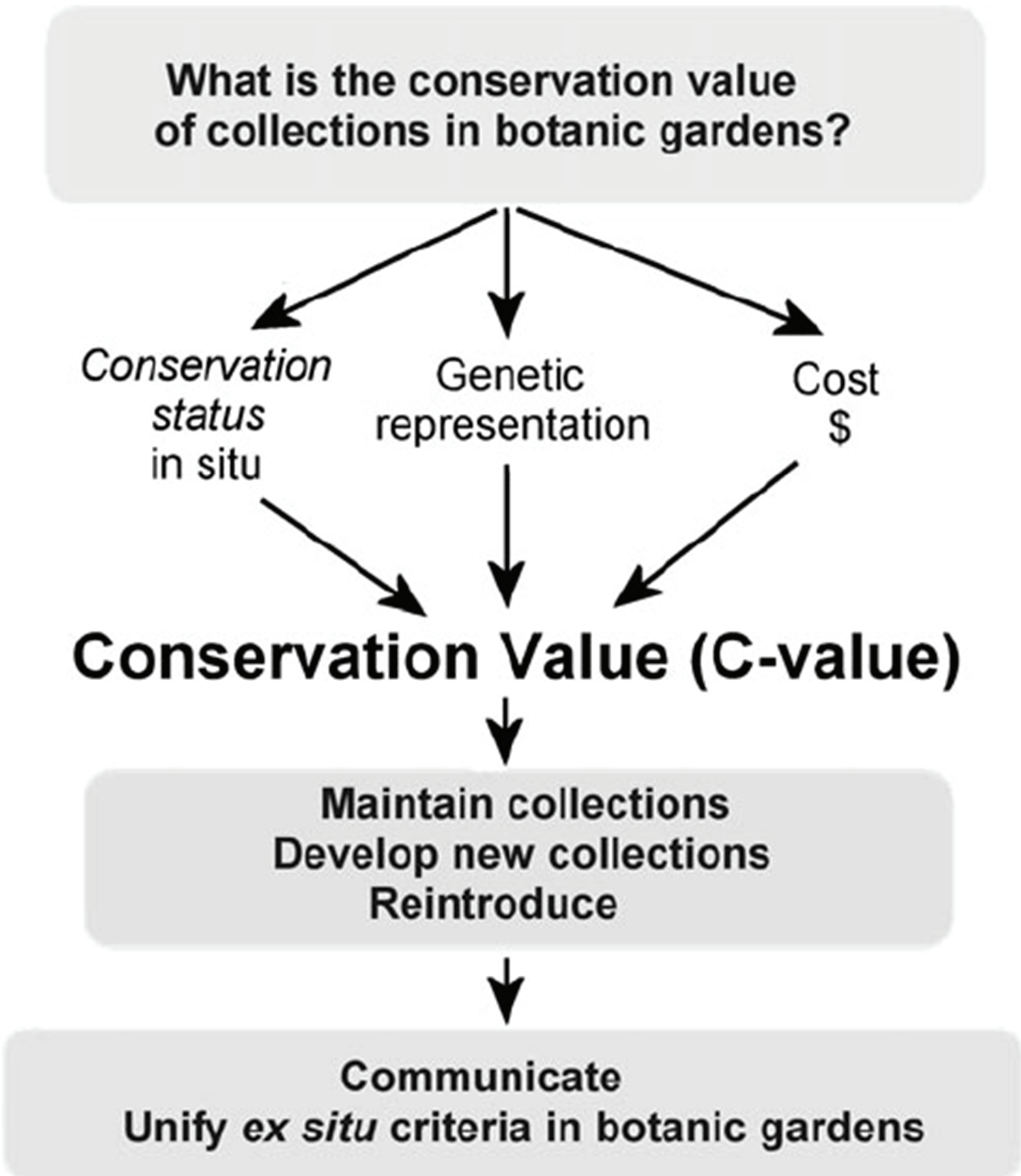

Figure 9. Strategy towards evaluating the conservation value of living collections in botanical gardens.

2. Quantifying the extent and content of botanic gardens.

To evaluate the geographic extent of the botanic garden network, and the degree to which digital collection data are available, we applied the most widely accepted definition of a botanic garden, as an institution holding documented collections of living plants for the purposes of scientific research, conservation, display and education. BGCI have accumulated data on botanical institutions and have assembled a digital directory of the world's botanic gardens within a database called GardenSearch (https://www.bgci.org/garden_search.php). Applying this definition to the GardenSearch database, we estimated that there are over 3,269 botanical collections in 180 countries around the world. Of these 3,269 institutions, BGCI has amassed collection data from 34% or 1,116 institutions, in the PlantSearch database (https://www.bgci.org/plant_search.php), the most comprehensive list of botanic garden accession names, containing 1,330,829 records of 481,696 taxon names. We analysed the PlantSearch database set against the most comprehensive list of plant taxa, The Plant List, and applied rigorous cleaning to these 481,696 PlantSearch taxa, removing invalid taxon names, deceased accessions, and horticultural cultivars. We can present only a minimum estimate of the diversity held in botanic gardens and associated seed banks, as our digitized data are derived from one-third of documented botanic gardens within the GardenSearch database. But we show that, of the 350,699 accepted plant species, 105,634 or 30% are held within the living collections of the global botanic garden network. These numbers equate to 59% of all plant genera, 75% of all embryophyte plant families and 93% of tracheophyte plant families, indicating a remarkable degree of taxonomic coverage within *ex situ* collections.

The absence of digital data does not necessarily equate to species absence, but in evaluating global targets and defining species conservation priorities, absence of a species and absence of data can be an equivalent problem, and here they are treated in the same way. The most dominant worldwide bias in the distribution of botanic gardens, and availability of associated digitized collection data, is a phenomenon termed positive latitudinal bias. Several countries in the Southern Hemisphere, such as South Africa, Australia and New Zealand, are major contributors of digital collection data. Still, 91% of recorded accessions, and 93% of recorded species are documented from *ex situ* collections in the Northern Hemisphere. This bias is due to the primary determinants of the geographical distribution of botanic gardens and species richness in botanic gardens, including socioeconomic factors such as GDP (gross domestic product) and metropolitan population size. But although explicable, it remains essential that biogeographic gaps in digital collection data are filled, to provide the robust cyber-infrastructure needed for coordinated *ex situ* plant conservation.

A positive latitudinal gradient, where botanic garden species diversity increases in temperate latitudes, runs counter to natural latitudinal gradients, where tropical ecosystems harbour the bulk of plant species diversity. The consequences of this skewed latitudinal distribution of botanic gardens for plant conservation has not been quantified on a global scale.

R. Mounce, P. Smith and S. Brockington retrieved species occurrence data for 236,904 accepted plant species, calculated the median of the latitudinal range for each species, cross-referenced these data with recorded presence or absence within the botanic garden network. They then refined the data set to species with at least five georeferenced occurrences, whose latitudinal range is either temperate or tropical. Analysis of these tropical and temperate splits showed that a temperate species has a 60% probability of *ex situ* cultivation in the botanic garden network, but just 25% for a tropical species. Indeed, from this data set, 66,905 or 76% of species absent from the botanic garden network are tropical species. On the one hand, to harbour 60% of all the temperate species in data set reveals the extraordinary capacity of the world's botanic gardens. But, on the other hand, *ex situ* conservation of tropical taxa in temperate climates is unfeasible on a scale that is meaningful for conservation, in part due to limited space and high energy costs of glasshouses. Given the shortage of data from tropical regions, the tropical–temperate disjunction may not be as severe, but it is clearly vital that the temperate network, with its associated conservation skills and resources, is extended to tropical latitudes, where many of the world's conservation priorities lie.

3. Potential role of botanic gardens in conservation. A strategy of threatened plant management in living collections

A traditional botanic garden (including an arboretum) is a place with an orderly, documented, labeled, collection of living plants, that is open to the general public, with collections used principally for research and education. With time, this initial scope has been broadened and started to include conservation issues, such as preservation of threatened plant species, although investment in creating and maintaining *ex situ* collections of wild species has been neglected by many countries apart from some material of crop wild relatives in crop genebanks. While for wild plants, *ex situ* conservation has long been regarded as subsidiary to in situ conservation, in the agricultural sector *ex situ* (seed banks or on farm) was the primary conservation strategy and *in situ* was not recognized formally until 1996. Not surprisingly, most of the ex situ protocols about sampling, gene bank standards and storage techniques were prepared by the agricultural sector and then adapted by the wild plant sector, notably by botanic gardens.

Nowadays, the Convention on Biological Diversity, although not referring to botanic gardens explicitly, recognizes the value of *ex situ* conservation, undertaken "preferably in the country of origin" and as a support to the "recovery and rehabilitation of threatened species and for their reintroduction into their natural habitats" (https://www.cbd.int/convention/text/default.shtml). The IUCN Species Survival Commission policy on *ex situ* conservation recognized the primary goal of ex situ activities as "to help support the conservation of a threatened taxon, its genetic diversity, and its habitat", and later stated that "for a growing number of taxa *ex situ* management may play a critical role in preventing extinction as habitats continue to decline or alter and become increasingly unsuitable". The Global Strategy for Plant Conservation highlighted that role by setting a goal of a minimum of 75% of threatened plant species being preserved within *ex situ* collections, with at least 20% available for recovery and restoration.

Nowadays, conservation of threatened plant species is explicitly included in the mission statements of many major botanic gardens yet few maintain *ex situ* collections with significant *in situ* conservation value. There are several reasons for the poor conservation utility of *ex situ* collections as discussed below.

The value of the existing and future species living collections for conservation will be a function of the species conservation status and how well the collection represents its natural genetic variation. The strategy includes the following components: 1) regional focus, 2) prioritization, 3) genetic diversity, 4) redundancy, 5) integration with *in situ* conservation.

Botanical gardens have their own suite of particular environmental (first of all climatic) conditions. Formally, every botanic garden can be assigned to a particular ecoregion, i.e. a regional conservation unit. If conservation planning and implementation has a regional base, creation of botanic garden living collections must also have a regional basis, and be an integral part of the latter (Fig. 10).

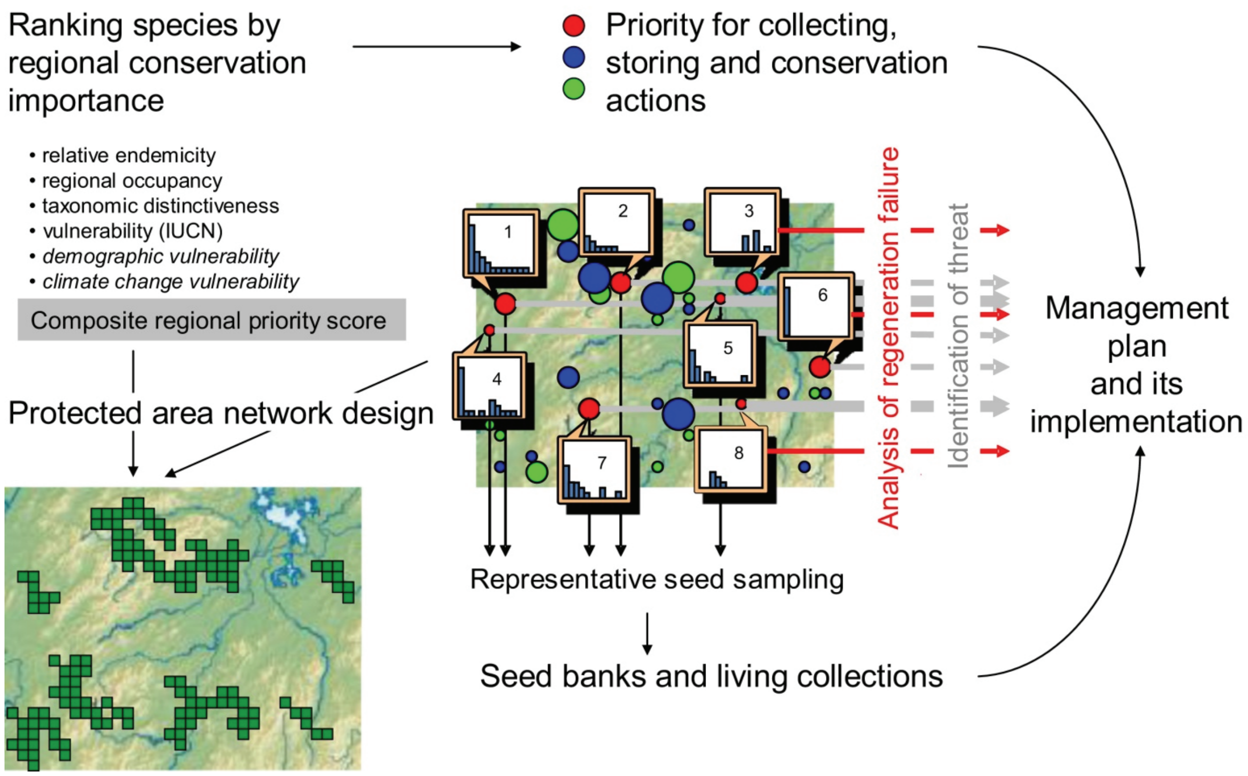

Figure 10. A scheme of regional conservation planning. Each colored circle denotes a population of one of three species with the circle size and color corresponding to a population size and species identity, respectively. All populations of one species (in red) are provided with size class distributions. In size class distribution histograms the x and y axes are size classes and plant density per unit area, respectively. The populations 3, 6 and 8 have easily identifiable regeneration problems. (Volis, 2017).

This will allow botanic gardens to focus predominantly on the local (i.e. having natural populations in the region) species, and by virtue of this, to use more efficiently their limited land and financial resources (Fig. 11).

The common Practical work of botanic gardens of growing limited samples of species for public display and research must be revised. A new strategic focus for botanic gardens should be on 1) collecting and maintaining species genetic diversity, and 2) better coordination and cooperation with other botanic gardens and *in situ* conservation practitioners for 3) ultimate utilization of the preserved material in situ. To achieve this, and efficiently use limited resources available for botanic gardens, the following steps are necessary:

- planning of the living collections is done as a part of regional biodiversity conservation planning;

- species to be preserved in living collections are chosen using a unified and agreed procedure for ranking species by their conservation priority;
- living collections properly represent the species genetic diversity;
- creation of living collections takes into account such concerns as redundancy and climate change;
- each living collection, wherever possible, is an integral part of a programmes explicitly oriented towards species conservation, recovery and reintroduction.

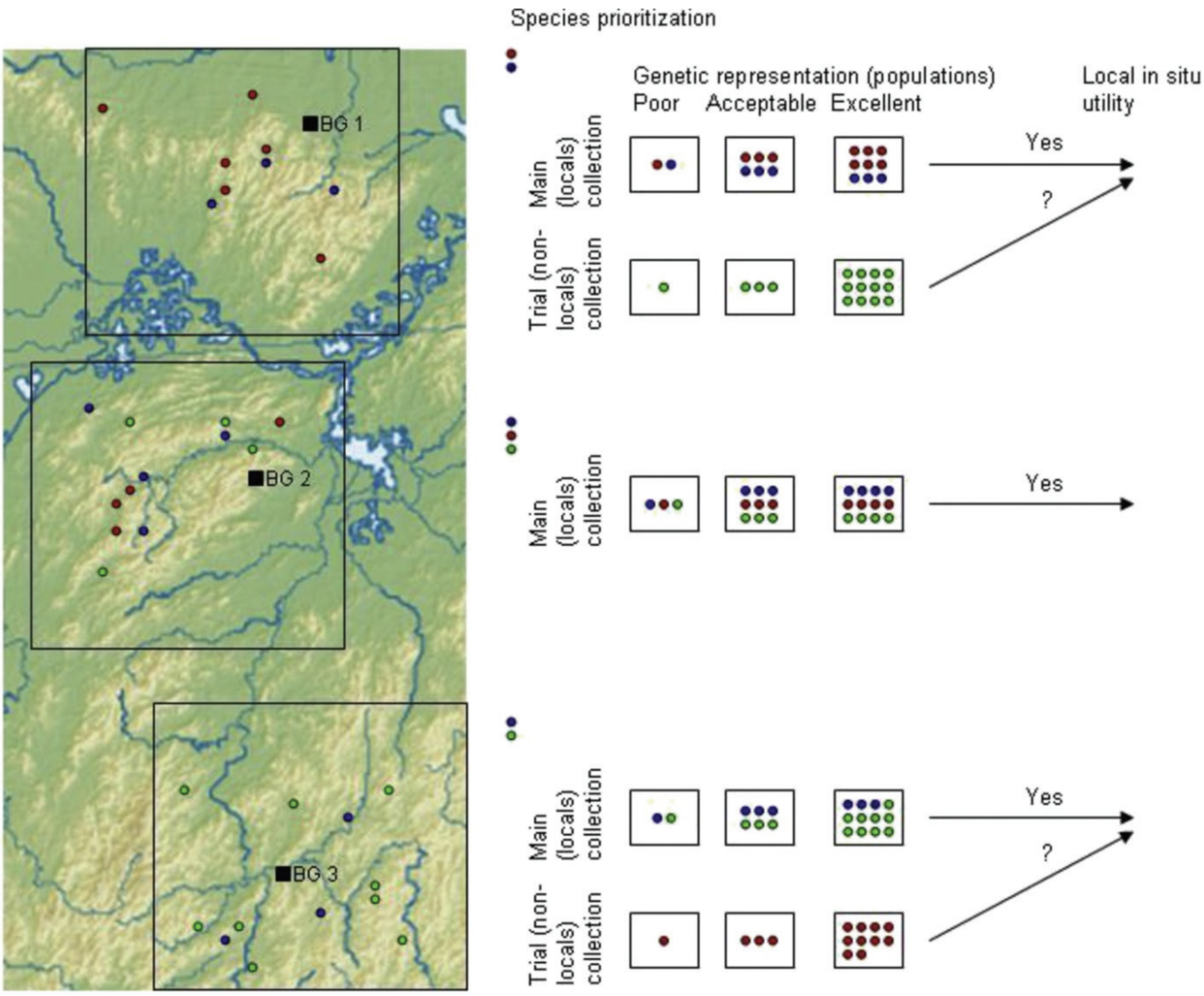

Figure 11. Living collections in three botanic gardens (BG1–3). Colored circles denote populations of three different species in three ecoregions denoted by rectangles. Species in each ecoregion are prioritized based on a set of criteria. For the species having the highest regional priority, representative collections are created. Only collections representing all known in the region populations (excellent representation) or at least three populations (acceptable representation) can be used for in situ actions. In addition to the main collections of regional locals, trial collections of non-local threatened species can be used for regional in situ actions based on plants' performance and SDM predictions. (Volis, 2017).

4. Identifying and targeting under-represented lineages

Angiosperms, gymnosperms and ferns enjoy 62.8, 96.6 and 54.0% generic coverage respectively, the non-vascular early-diverging land plant lineages – *Bryophyta, Marchantiophyta* and *Anthocerotophyta* – are almost completely undocumented with less than 5% generic coverage across the global botanic garden network. A weakness in the delivery of *ex situ* conservation goals for the plant kingdom as a whole. The lack of coverage for *Bryophyta* taxa denies their importance, as they represent key stages in land plant evolution, occur in endangered habitats such as peatland, host diverse microbiota and play a central role in nutrient cycling. Given the vascular plant emphasis of botanic gardens, this finding is unsurprising; however, the magnitude of the deficit calls for action. Many living collections host incidental collections of Bryophytes, and an increase in Bryophyte representation could be achieved by documenting existing taxa, as well as through specific acquisition strategies and horticultural innovation.

Of the 34 missing vascular plants families, 12 are monotypic and 13 are monogeneric, with the majority being restricted endemics, tropical trees or parasites, indicating how species paucity, endemism and life history can limit ex situ conservation. The cultivation of certain plants can pose a challenge, and this may be especially true for the estimated 4,000 species of parasitic angiosperms. However, below the rank of family, phylogenetic mapping provides a framework to target acquisitions to fill collection gaps.

Ther are two approaches. First, for all missing genera, scientists calculated the amount of evolutionary distinctiveness represented by each genus. Scientists then ranked all genera according to the amount of evolutionary distinctiveness that would be captured if each genus was accessioned into *ex situ* collections. Here, it is notable that many of the most important genera are also from early diverging land plant lineages, emphasizing the importance of conserving these taxa.

In a second approach, scientists computationally searched for clusters of closely related but absent genera below the taxonomic rank of family, to identify phylogenetic islands of evolutionary history not captured within *ex situ* collections. Scientists list the top ten clusters in terms of numbers of absent genera, for example, the *Grammitidoideae*, a subfamily of the fern family *Polypodiaceae*, of tropical distribution, with 13 out of 16 (81%) genera missing, and the *Helieae* tribe, within *Gentianaceae*, which occupy highly restricted ranges in the New World, with 10 out of 12 (83%) genera missing. Most absent clusters are tropical, emphasizing that latitudinal bias impacts on phylogenetic representation.

Through these gap analyses, scientists have generated resources that enable targeted acquisition, including a list of genera missing from gardens, and a list of all families ranked by their percentage of genera represented. Targeted acquisition strategies have the potential to enhance the value of *ex situ* collections, not just for conservation, but for research and education more generally. For example, comparative genomics depend on ready access to living material to sequence phylogenetically pertinent taxa, and cultivation of key phylogenetic lineages can provide essential material to teach evolutionary transitions.

However, phylogenetically targeted strategies are just one approach to enhance the value of living collections, and future studies should also explore under-representation of environmental niches, life histories, and medicinal, ethnobotanical or crop plants.

5. Evaluating progress towards GSPC Target 8.

The BGCI ThreatSearch database is the most comprehensive list of threatened plants, incorporating global, regional and national threat assessments (https://www.bgci.org/threat_search.php). Here, "Threatened" is defined as species that fall into the categories of "Vulnerable", "Endangered" and "Critically Endangered", as per International Union for Conservation of Nature (IUCN) criteria, or their equivalent designations in the case of non-IUCN methodologies. By cross-referencing two data sources, an early release version of the ThreatSearch database and BGCI PlantSearch, scientists assessed progress towards achieving GSPC Target 8, which calls for 'at least 75% of threatened plant species in *ex situ* collections, preferably in the country of origin'. First, we asked how many threatened species are present in the global network of botanic gardens and show that, currently, the global network is over half way towards achieving GSPC Target 8, with about 13,218 threatened species held in at least one *ex situ* collection, equating to 41.6% of all plant species assessed as threatened. As with the total diversity estimates, our figures are probably an underestimate of threatened plant diversity held in botanic gardens, as only a third of gardens are analysed here. Unsurprisingly, the extent to which *ex situ* collections contribute to these overall numbers varies considerably, from as little as one threatened species, to over five thousand, with a median number of threatened species per garden of 38. Nonetheless, these figures are impressive, as threatened species are often range-restricted, harder to find, and more difficult to cultivate and manage in *ex situ* collections. Although over 41% of all threatened species are currently held in ex situ collections, there is scope to improve these global efforts. Of the 1,330,829 records in PlantSearch, 134,771 or about 10% are threatened species, with 90% of *ex situ* collections devoted to species not yet identified to be at risk of extinction. If the network can hold over 41% of threatened species, with just 10% of current network capacity, there is potential to hold a greater proportion of threatened species. Furthermore, if *ex situ* collections of threatened species are to be of value for in situ restoration programmes, it is imperative that large populations are maintained *ex situ* to provide the necessary intra-specific genetic diversity for viable populations and species recovery. Such a goal will require the network to devote more collection capacity to conservation priorities.

Evaluation of GSPC Target 8 is problematic as it calls only for a percentage of threatened plants to be represented in *ex situ* collections, and yet the focus of the threat assessments varies considerably across the plant phylogeny. For example, of the 89,810 assessed species in BGCI ThreatSearch data set, 80,990 species of angiosperms (26%) have been assessed for extinction risk, compared with 3,611 pteridophyte species (34.4%), 4,303 bryophyte species (12.2%) and 986 gymnosperm species (89.3%). In the context of a variable number of assessments and hence threatened species across major lineages, conserving a percentage varies in its significance. But with respect to GSPC Target 8, only gymnosperms meet the target threshold, with 89% of threatened species held *ex situ*. Gymnosperms are a successful *ex situ* conservation story as: they are the least speciose of the major plant lineages, rendering the percentage-based GSPC Target 8 more feasible; they have an international conifer conservation programme; like most botanic gardens, they are broadly temperate; and they have horticultural value as evergreen collections. In stark contrast, the bryophytes, which have the poorest overall assessment rate of 12.2%, are similarly impoverished with respect to *ex situ* conservation, such that only 2.6% of threatened bryophytes are documented in the botanic garden network. Evidently, poor performance of *ex situ* collections with respect to non-vascular plants will further undermine *ex situ* conservation goals for these important but under-represented plant groups.

A relatively small number of nations are holding an exceptional number of threatened species, consistent with the skewed distribution of botanic gardens. Furthermore, using a set of IUCN-assessed threatened endemic species, scientists found that 2,780 country-endemic, threatened species are present in the botanic garden network with 1,231 or 44% held in ex situ collections within their country of origin, and 56% or 1,549 species held only in *ex situ* collections outside their country of origin. While dispersed collections provide some security against extinction, if endemic species are held solely outside their natural range, it seems less likely that they will be available for species recovery, and again, large *ex situ* populations are needed to provide genetic diversity for viable populations.

6. Measuring response to species extinction risk

Threatened species lists are established tools that provide a scaled assessment of extinction risk, which can guide conservation actions. While scale of threat is not sufficient to define priorities, if botanic gardens are actively responding to perceived extinction risk, one might find a signal of this response within collections themselves. Here, scientists looked for evidence of that response using a data set of IUCN globally assessed species. Ideally this question would be answered by a time series analysis; however, the present study is the first global assessment of *ex situ* conservation for threatened plant species, and, as such, there are no historic data against which to compare.

Consequently, to address this question here, scientists first asked whether threatened species at a higher risk of extinction were more likely to be found in at least one *ex situ* living collection. Scientists found that 39% of Critically Endangered species were held in *ex situ* collections compared with 35% of Endangered species, and 27% of Vulnerable species, indicating that a greater proportion of higher-risk species are held within the botanic garden network. Here, the relative proportion of each Red List category held by botanical gardens differs significantly from the proportions held on the Red List ($X^2_2=76.67, p<0.01$), suggesting an active response to increasing threat status for threatened species, as a whole. Scientists then assessed whether threatened species at a higher extinction risk were more likely to be accessioned multiple times across the botanic garden network. Here, scientists found that 11% of IUCN red-listed species were documented in just one institution, with a median representation of three. But scientists found that there was no relationship between elevated extinction risk and the number of institutions that hold any given threatened species ($X^2_{20}=28.63,\ p>0.05$), a result that suggests no coordinated shared global response to the extinction risk posed to individual species.

A signal of a global response to extinction risk is confounded by the fact that only a small fraction of capacity, 10%, is currently devoted specifically to conservation. Furthermore, most IUCN globally assessed species are centred in the tropics, and as global collections are deficient in tropical species, a tropical – temperate disjunction could underestimate any response signal. Scientists therefore explored whether threatened species were more likely to be included in the botanic garden network if they were temperate in origin, rather than tropical. Here scientists used a data set of globally assessed threatened species with at least five georeferenced occurrences, which had a latitudinal range that is either temperate or tropical. We find that the probability of *ex situ* conservation for a globally threatened temperate species is 77% (a 17% increase relative to temperate species as a whole), but the probability of *ex situ* conservation for a tropical species fell to 24% (a 1% drop relative to tropical species as a whole).

These findings suggest a differential response to threatened plants in temperate versus tropical environments. Scientists further found that the odds of conservation of temperate threatened species is 1.8 times that of a near-threatened temperate species ($p<0.01$), but the odds of conservation of threatened tropical species is 0.35 times that of a near-threatened tropical species ($p<0.001$). Together these analyses indicate that botanic gardens are discernibly responding to threatened temperate species, but less so for threatened tropical species.

7. *Ex situ* algae conservation

Ex situ conservation has been used mostly for the preservation of macroalgae. Nearly 15 years ago, Prof. M.M. Watanabe started to establish and maintain cultures of endangered freshwater charophytes in Japan. Recently, Dr Kasai and colleagues have conserved charophytes as well as some freshwater red algae. Through this effort, the Microbial Culture Collection at the National Institute for Environmental Studies (MCC-NIES), based in Onogawa, Tsukuba, Japan, maintains eight genera and 19 species of threatened or endangered charophytes and red algae.

A number of other efforts of *ex situ* conservation of algae are known. Maggs established a culture (male only) of *Anotrichium barbatum* (C. Agardh) Na¨geli from Wales, United Kingdom, that is maintained by the Culture Collection for Algae and Protozoa (CCAP), based in Oban, Scotland. Prior to collection by Maggs, the alga was believed to be extinct in UK waters. Although the alga is now very rare, in the mid-1850s, *A. barbatum* was reported from along the English Channel, from northern France to northern Spain, around the Canary Islands and along the coasts of western Africa and the Mediterranean Sea. F. Kupper and A. Peters established gametophyte cultures of the very rare brown seaweed *Desmarestia dresnayi* Lamouroux from material collected at the type locality in Brittany, France.

Cultures of actively growing algae are not the only way to establish ex situ preservation. For example, *ex situ* conservation may include preservation of spores, cysts, excised tissues, DNA and other biological materials. To date, there have been no efforts to preserve endangered algal species using spores, cysts or tissues.

It would be valuable to have numerous ex situ strains of endangered algae, but culture collections cannot maintain large numbers of actively growing algae because of costs. Cryopreservation offers an alternative. Endangered algae can be frozen in large numbers and kept viable indefinitely in liquid nitrogen storage tanks. More strains from an endangered population should ensure greater genetic diversity, and this diversity may be an important factor if the endangered species is released back into the environment.

The cryopreservation of algae is a well-established technique for many species of both micro- and macroalgae. The standard technique is a two-step cooling process where the cells are cooled at approximately -1^0C per minute until the sample is colder than the eutectic point. The eutectic point is approximately -40^0C, and at that temperature, all liquid water has been converted to ice regardless of the concentration of salts. The second step is to rapidly cool the sample to a temperature that is colder than the glass transformation temperature. The glass transformation temperature is approximately -135^0C, and at that temperature, ice crystals no longer increase or decrease. The samples are therefore stored in liquid nitrogen (>-195^0C), in liquid nitrogen vapors (typically between -160^0C and -195^0C) or in electrical ultrafreezers (approximately -155^0C). Once live cells are properly frozen and carefully stored, they should remain viable indefinitely. For successful cryopreservation, damage to living cells must be avoided during the freezing and the thawing stages. Organisms, whether single cells or multicellular thalli, are generally successfully cryopreserved when their cells are small, and conversely failed cryopreservation often occurs when cells are large or when cells have large vacuoles inside their cells.

Reintroduction of culture strains back into nature. As far as is known, no *ex situ* conserved species has been reintroduced, but, nevertheless, the debate is interesting. One side argues that the species should be allowed to grow in its native habitat if at all possible. It has been saved from extinction by ex situ conservation as a culture, and it is only logical that it be allowed to live in nature once again. The other side argues that cultured organisms have reduced diversity. Artificial environments, such as culture conditions, may accelerate genetic mutation or induce physiological change. If any undetected but remaining wild organisms exist (overlooked by humans), then a reintroduction of a culture strain may negatively affect those remaining wild organisms. The controversy is not biological in nature; rather, it touches on philosophical, cultural, political and even personal views of humans. Biologically, all species expand their geographic ranges (as well as see their ranges collapse) and colonize new regions when possible. Therefore, the question may be restated, when a species is not able to expand its range by itself, should humans intervene and aid its distribution? while that question cannot be answered here, it is easy to predict that reintroductions will be discussed and probably attempted in the future. Success will depend on various factors, but a limited genetic diversity from one or two cultures may prove to be insufficient for purposes of reintroduction to nature. Thus, the number of culture strains established for an endangered species is directly related to the purposes for establishing and maintaining the cultures

Ex situ conservation in the form of actively growing culture collections or in suspended animation cryogenically is a means of conserving algae at least for a restricted number of species and as a last resort; although, the success of reintroductions is unknown.

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Practical work (Excursion). The role of the M.M. Hryshko National Botanical Garden in plant scientific research and conservation

The M.M. Hryshko National Botanical Garden is a botanical garden of the National Academy of Sciences of Ukraine. Founded in 1936, the garden covers 1.3 km² (120 hectares) and contains 13,000 types of trees, shrubs, flowers and other plants from all over the world. It has many coniferous trees and honey locusts, and flowers such as peonies, roses, magnolias, and bushes including lilacs. The garden has hothouses, conservatories, greenhouses and rosaries. It is the most popular amongst the residents, where one can see exotic plants, and attend flower exhibitions. The blooming lilacs at the end of spring are popular in the central garden.

The territory of the garden is divided into floristic complexes, such as Ukrainian Carpathians, Plains of Ukraine, Crimea, Caucasus, Central Asia, Altai and Western Siberia, Far East. In every zone plants typical for a particular region can be found. The geography and landscape of each territory were recreated as well. Also, the garden has a large collection of unique and rare tropical and subtropical plants that are represented in the greenhouse. The Botanical garden can impress with more than 350 species of orchids.

Task 1. Decipher the notation in Fig. 12.

Figure 12. Map of the M.M. Hryshko National Botanical Garden.

Task 2. Find out the main directions of the scientific research of the M.M. Hryshko National Botanical Garden.

Task 3. On the example of the Plain of the Ukrainian section, set the value to effectively conserve and manage the *ex situ* population of endangered species. Give the examples of cultivated and introduced plants of the natural flora of the plain part of Ukraine

Task 4. Based on the sourses, compare the natural and introduced populations of *Galanthus nivalis*.

Task 5. Based on the sourses, compare the natural and introduced populations. The data about the state and structure of the introduced populations of *Scopolia carniolica* of the Carpathian, Podolskyy and Caucasian origin on the botanical and geographical areas.

Task 6. Set the role of a botanical garden *in situ* ecosystem management and *in situ* conservation for the conservation of certain plant species in their native Polesie and Forest-steppe zone habitats.

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