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Кіраўніцтва справамі Прэзідэнта Рэспублікі Беларусь

Міністэрства прыродных рэсурсаў і аховы навакольнага асяроддзя Рэспублікі Беларусь

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МАНІТОРЫНГ І АЦЭНКА СТАНУ РАСЛІННАГА СВЕТУ

МОНИТОРИНГ И ОЦЕНКА СОСТОЯНИЯ РАСТИТЕЛЬНОГО МИРА

VEGETATION MONITORING AND ASSESSMENT

Прысвячаецца 90-годдзю Нацыянальнай акадэміі навук Беларусі і 25-годдзю Нацыянальнай сістэмы маніторынгу навакольнага асяроддзя ў Рэспубліцы Беларусь

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В сборник включены материалы V Международной научной конференции «Мониторинг и оценка состояния растительного мира». Всего представлено 115 материалов 241 автора из 70 организаций и ведомств, научно-исследовательских учреждений, высших учебных заведений, заповедников и национальных парков Абхазии, Беларуси, Казахстана, Сербии, США, России, Турции, Украины и Швеции.

В материалах подводятся итоги работ по мониторингу и изучению состояния растительного мира, обсуждаются актуальные проблемы мониторинга лесной, луговой, водной и болотной растительности, ресурсообразующих, инвазивных и охраняемых видов, насаждений в условиях техногенной и рекреационной нагрузки и пути их решения. Значительная часть представленных работ посвящена проблемам охраны окружающей среды и использования ресурсов растительного мира.

У зборнік уключаны матэрыялы V Міжнароднай навуковай канферэнцыі «Маніторынг і ацэнка стану раслінага свету». Усяго пададзена 115 матэрыялаў 241 аўтара з 70 арганізацый і ведамстваў, навукова-даследчых і вышэйшых навучальных устаноў, запаведнікаў і нацыянальных паркаў Абхазіі, Беларусі, Казахстана, Сербіі, ЗША, Расіі, Турцыі, Украіны і Швецыі.

У матэрыялах падводзяцца вынікі працаў па маніторынгу і вывучэнні стану раслінага свету, абмяркоўваюцца актуальныя праблемы маніторынгу лясной, лугавой, воднай і балотнай раслінасці, рэсурсаўтваральных, інвазійных і ахоўных відаў, насадаў ва ўмовах тэхнагеннай і рэкрэацыйнай нагрузкі і шляхі іх вырашэння. Значная частка пададзеных працаў прысвечана праблемам аховы навакольнага асяроддзя і выкарыстання рэсурсаў раслінага свету.

Materials of V International scientific conference “Vegetation Monitoring and Assessment”. The book consists of 115 reports 241 authors from 70 scientific and educational organizations of Abkhazia, Belarus, Kazakhstan, Serbia, the USA, Russia, Turkey, Ukraine and Sweden, working in field of vegetation monitoring, nature conservation, forestry.

Results of vegetation monitoring and assessment and actual problems of monitoring of forest, meadow, water, mire vegetation and plantations under technogenic and recreational pressure are discussed in the book. Significant part of reports is concerned with problems of environmental protection and rational use of plants resources.

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Максимум видового разнообразия сыроежковых грибов наблюдается в сосняках мшистых, которые находятся на III стадии дигрессии. Отмечено 25 видов и 2 разновидности. Из рода *Russula* найдено 20 вида и 2 разновидности, а 5 – из рода *Lactarius*. С увеличением нагрузки происходят существенные изменения в фитоценозе, в результате чего руссуляльные грибы начинают успешно конкурировать с другими видами симбиотрофов и выполняют роль «скорой помощи» для древесной растительности. Размещение базидиом носит рассеяно-групповой характер. Основное количество плодовых тел отмечено в непосредственной близости от тропинок.

В лесах, которые находятся на IV и V стадиях дигрессии, происходит специализированный отбор видов сем. *Russulaceae*, способных выжить в экстремальных условиях. Зарегистрировано 12 видов из сем. *Russulaceae*, из них 10 относятся к роду *Russula* и 2 – к роду *Lactarius*. Размещение базидиом носило групповой характер и они встречались вблизи стволов деревьев.

Таким образом, обилие базидиом сыроежковых увеличивается с усилением рекреационной нагрузки. На I-II стадиях дигрессии обилие не превышало 3 баллов, на III – 4, на IV-V – 5 баллов.

Следует также отметить, что у некоторых видов наблюдается тенденция к более раннему образованию базидиом на ПП III стадии дигрессии и только спустя декаду на ПП I-II и IV-V.

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INTEGRATIVE ECOLOGICAL AND GENETIC MONITORING OF CLOUDBERRY (*RUBUS CHAMAEMORUS* L.) POPULATIONS ON THE SOUTHERN BORDER OF THE EUROPEAN AND NORTH AMERICAN AREA (IN BELARUS AND MINNESOTA)

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Объектом исследования являются популяции Rubus chamaemorus L. в Беларуси и Миннесоте (США), где этот циркумполярный бореальный вид находиться на южной границе ареала распространения и охраняется законодательством штата (Миннесота) и Республики Беларусь. Такие «краевые» популяции являются наиболее уязвимыми к изменениям климата. Сравнительная оценка параметров эколого-ботанических особенностей среды их произрастания позволяет идентифицировать экологические предпочтения и лимитирующие факторы. Интегральный сравнительный анализ развития популяций, эколого-ботанических параметров среды, а также вариабельности генетического разнообразия позволит ответить на вопрос о происхождении популяций, оценить их подразделенность, адаптивный потенциал вида в исследуемых регионах, выявить аллели, расширяющие способность популяций противостоять и выдерживать резкие изменения качества среды. Проект направлен на получение новых данных по идентификации областей по сохранению вида, оптимизацию практических мер охраны его местообитаний и отдельных популяций.

The subjects of the study are the populations of *Rubus chamaemorus* L. (cloudberry) in Belarus and the state of Minnesota (USA), where this circumpolar boreal species reaches the southern boundary of the distribution area and is protected by state (Minnesota) and national (Belarus) governments. There are 17 known places of growth of *R. chamaemorus* in 14 administrative districts in Belarus and only 7 locations in Minnesota. In the context of global climate change, the study of such low-latitude edge

populations, which are extremely important for the long-term survival and maintenance of the genetic diversity of the species, is particularly relevant as it helps to clarify the history and phylogeography of its distribution on the local landscape, and generally to assess the evolutionary potential of the species across its whole range [1]. The purpose and objectives of this study were to conduct integrated ecological and genetic studies: 1). to obtain quantitative and qualitative characteristics of the ecological parameters of habitat and the state of cloudberry populations in Belarus and Minnesota; 2). to develop an effective system for detecting variability of genomic DNA at the intra- and interpopulation levels using AFLP and SRAP markers aimed at identification of the genetic diversity (GD) parameters of populations.

Field examination. To address the objectives and obtain comparable results, a unified protocol for monitoring and comparative studies of the ecological and population parameters of the species under the conditions of their natural growth and collection of plant material for genetic analyzes based on [2] has been developed. The assessment of the diversity of the plant community of the target habitats is based on geobotanical descriptions. As a result of field studies during the growing seasons in 2017–2018 an inventory was made and permanent points of observation (PPO) were established for 7 natural populations of Belarus (2 PPOs are located on the territory of Grodno, 1 – Minsk and 3 – Vitebsk regions) and Minnesota (1 PPO). Comparative analyses of the development of the populations and plant community survey on the PPO network made it possible to identify patterns of habitat preferences, either for certain landscape types or for associated plant species, and limiting factors (risk factors) for the development of populations (the data are summarized in Table). Based on the results of the inventory, it is established that at the borders of the Belarusian and Minnesotan range the species grows on raised wetlands and is confined mainly to the plant communities of cottongrass-shrub-sphagnum pine forests. Locations with highest viability of cloudberry plants were characterized mainly with the moist habitat and soil cover corresponding to A4–A5 of growth condition types, density of standing timber in the range 0.4–0.5, and stable state of subcanopy (see Table). The shrub layer in all communities is represented by heather, wild rosemary and blueberry; hare's-tail cottongrass (*E. vaginatum*) was also found at all sites. Ecological parameters of populations at the southern range of the species distribution have been established. It is shown that in the eastern, central and western part of the Belarusian area, as well as in Minnesota, populations are mainly characterized by critical or low indicators of viability and are unstable due to geographic disruption and restriction, unfavorable gender distributions (predominance of males over females or absence of either) and plant community changes caused by succession due to prior fires or logging on, or nearby, the cloudberry landscapes. Only “Lonno” location, which is one of the most productive from all estimated, possess relatively equilibrated (balanced) number of age periods of ontogenesis: 54% pre-generative over 46% of generative individuals.

Population genetic study. The developed protocol using SRAP (15 primers tested, 7 selected), and AFLP (3 primers, according to the method [3]) marker systems reliably tests the variability of genome regions of *R. chamaemorus* at inter- and intrapopulation levels. a preliminary assessment of the intra- and interpopulation genetic variability of individuals from the studied localities was carried out (for at least 11 individual cloudberry plants from 4 populations of Belarus and Minnesota) was performed based on the GD parameters of populations: genetic distances between populations, number of polymorphic loci and their percentage, indicators of total and effective number of alleles (Na and Ne), genetic population subdivision (Gst), φPT (the FST analogue), the gene flow (Nm), the general and particular genetic diversity (H), the number of rare alleles, the expected heterozygosity (He, uHe). Assessing the balance of which together with genetic latent potential index (GLP) allow us to assess the genetic stability of each studied population. Moreover, initial sequencing of the chloroplast intergenic spacer psbA-trnH of *R. chamaemorus* individuals showed slight variability (in total 3%; 1 bp substitution in ~300 bp length fragment was detected at 50% of analysed individuals from Minnesota) between individuals from the Minnesota population, but did not reveal any among or between the Belarusian populations, which is in general consistent with the literature data that this region is highly conservative, though it does seem suitable for phylogenetic studies [4].

Table 1 – Comparative characteristics of phytocoenotic and vital indicators of R. chamaemorus populations of in the surveyed locations

Characteristics of habitat and state indices of populationи состояния популяции	Permanent points of observation (PPO)							
	Grodno district, reserve «Chertovo Boloto» (Western border of Belarus distribution area)	Grogno district, Lida reg, reserve «Dokudovsky» (Southern border of Belarus distribution area)	Minks district, Miadel region, NP «Narochansky» (Southern border of Belarus distribution area)	Vitsebsk district, reserve «Korytensky Mokh » (Eastern border of Belarus distribution area)	Vitsebsk district, Polotsk region, reserve «Lonno» (Central part of Belarus distribution area)	Vitsebsk district, Miory region, reserve «Boloto Mokh» (Northern-Western part of Belarus distribution area)	Minnesota, Cook county (Central part of Minnesota distribution area)	
Plant community characteristics								
Habitat	raised peat wetland, Southern-Eastern shore of the distrophic lake	up raised per peat wetland, 0.6 km to the North-East from the distrophic lake	raised peat wetland, Western shore of the distrophic lake	raised peat wetland, Nothern shore of the distrophic lake	raised peat wetland, around the distrophic lake	raised peat wetland, Northern shore of the distrophic lake	open raised peat wetland	forested raised peat wetland
Type of forest, association	tussock cottongrass- common heather- sphagnum moss	bog Labrador tea - European blueberry – sphagnum moss- pine forest	bog Labrador tea -sphagnum moss- - pine forest	bog Labrador tea - European blueberry - moss- pine forest	bog Labrador tea -sphagnum moss- - pine forest	tussock cottongrass- bog Labrador tea - sphagnum moss- - open bog	grey alder- Northern Labrador tea- Three leaf Solomon's-seal- sphagnum moss- open bog	grey alder- Northern Labrador tea- sphagnum moss – Canada mayflower - leather leaf-black spruce forest
Type of habitat conditions	A5	A4	A4-5	B3	A5	A5	B4	A5
Standing timber	-	10Ps, single Bp	9Ps1Bp	10Ps+Bp	10Ps	10Ps	-	9Pm1Ll
origin	post-pyrogenic	natural	natural	natural	natural	natural	7 years after logging	natural
age, years	-	80	60	90	110	70	-	80
density	-	0,6	0,7	0.6	0.5	0.4	-	0.6
Subcanopy	5Pb5Ps	7Bp3Ps	8Ps2Bp	7Ps2Ppd1Bp	8Pp1Bpd1Ps	10Ps, Bp singly	6Ai2Pm2Ab+ Av+Ba+Ss+ Pt	10Pm+Ll+Ab
average height, m	0.5	1.6	1.2	2	1.5	0.8		2.5
density, individuals(ind)/ha	300	500	500	1500	1500	500	600 (40 - logged)	
state	unstable	unstable	unstable	stable	stable	stable	unstable	stable
Species composition of the ground vegetation (abundance after O. Drude's scale)*								
Alnus incana, Ai	-	-	-	-	-	-	cop2	-
Betula pubescens, Bp	sol	cop1	sp	sp	cop1	rr	-	-
Betula pendula, Bpd	-	-	-	sp	rr	-	-	-
*Pinus sylvestris, Ps (Picea mariana**, Pm)*	sol	sol	cop1	cop3	cop2	cop3	sp	cop3

Andromeda polifolia	-	-	-	-	sp	cop1	-	-
Calluna vulgaris	sp	sp	sp	-	rr	cop2	-	-
Carex trisperma	-	-	-	-	-	-	sp	-
Chamaedaphne calyculata	sp	-	-	cop2	cop1	cop2	sol	cop1
Drosera rotundifolia	-	-	-	sol	-	sol	-	-
Empetrum nigrum	sp	-	sol	cop1	cop3	cop3	-	-
Eriophorum vaginatum	sp	sp	sp	sol	sp	cop3	rr	-
*Ledum palustre (L. groenlandicum**)*	cop1	cop1	cop2	cop3	cop3	cop3	cop1**	cop1**
Melampýrum pretense	sol	-	-	sol	sp	-	-	-
Oxyccocus microcarpus	-	-	-	-	-	rr	-	-
Oxycoccus palustris (V. oxycoccos)	sol	sp	-	-	sp	cop3	rr	-
Rubus chamaemorus	sol	cop2	sol	cop2	cop2	cop2	sol	cop1
Vaccinium myrtillus	rr	cop3	-	cop2	sp	-	-	-
Vaccinium uliginosum	sp	sp	sp	-	cop1	rr	-	-
Vaccínium vítis-idaéa	cop1	sp	cop2	cop2	cop3	sol	-	-
Smilacina trifolium (M)	-	-	-	-	-	-	-	cop1
Sphagnum mosses	cop2	cop3	cop1	sp	cop3	soc	soc	soc
Green mosses	cop1	sp	cop2	cop2	sp	cop1	sp	sp
In Minnesota on the PPO1 rarely (sp) or singly (sol) are also stated: *Abies balsamea (Ab), Alnus viridis (Av), Andromeda glaucophylla, Betula alleghaniensis (Ba), Larix laricina (Ll), Chamaedafnae caliculata, Carex canescence, C. chordorrhiza, C. pauciflora C. paupercula, C. tenuiflora, Gaultheria hispidula, Eriophorum augustifolium, Epilobium angustifolium, Epilobium adenocaulon, Rubus idaeus, Equisetum palustre, Sarracinia purpurea, Scirpus cyperinum, Populus tremuloides (Pt), Salix* sp. *(Ss)*								
Population characteristics								
Area, ha	0,03	1	0,06	0,14	120	1,1	0.63	2.05
population size, ind	10637	558182	2154	65240	51,9 млн	611600	415400	
medium density, ind/m^2	34,5	55,8	3,6	42,6	43,3	55,6	15.5	
projective cover, %	23,9	17,8	10	15,6	25,9	16,0	5	28
Age periods of ontogenesis, % (pregenera-tive/generative)	100/0	97/3	90/10	98/2	54/46	90/10	Na	Na
sex structure (% of female (F) versus male (M) individuals from the total number of generative (– - not presented)	–F/M***	–F/M (100%)***	–F/M (100%)***	(25%) F/ M (75%)	(24%) F/ M (76%)	(23%) F /M (77%)	–F/M***	
damage of the plants	up to 25% of leaves	-	up to 10% of leaves	single plants	-	-	> 25% of leaves	
type of damage	phytophags (rust)	-	phytophags (rust)	phytophags (rust)	-	-	phytophags (rust)	
Viability, level	critical	low	critical	low	high	medium	low to medium	

Notes and abbreviations: *Estimation of abundance of plant species (modified scale of O. Drude): Rr (rari) – occurs singly; Sol (solitariae) – occurs rarely; Sp (sparsae) – occurs in a minimal amount, sparsely; Cop1 (copiosae) – rather abundant; Cop 2 (copiosae) – abundant; Cop 3 (copiosae) – very abundant; Soc (socialis) – plants lock in their upper part, generate a cover. ** - species of the same genera, possessing similar ecological functions, presented in Minnesota. *** - estimation was done during not flowering period; Na – data not available; B – species native only to Belarus; M - species native only to Minnesota region.

The next step is to estimate a larger number of populations both in the study regions and also within the center of distribution of the species (well-balanced "reference" populations) and assess their GD, which will eventually allow assessing the phylogenetic relationships among all studied populations and their adaptive potential for predicting trends over time and developing action plans for their conservation, restoration and reproduction. For example, the data of the integral evaluation of the population development and its GD could help answer the question whether a population with a small number is genetically restricted due to a founder event or due to a bottlenecking well after the population was established - in many respects will help to answer. Promising are studies on *ex situ* crossings and plant propagation for repatriation purposes into populations with incomplete gender representation (i.e. presented only with male individuals) to increase their numbers and sustainability. Continued monitoring of populations of *R. chamaemorus* on the territory of Belarus and Minnesota is recommended (perhaps every 5 years) as is the application of biotechnological methods to conserve or restore genetic diversity at the most vulnerable locations.

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