BioClimLand, 2013
No. 2, 56–66

UDK 582.29 : 581.5.

Translocation as the method of negative impact decrease on lichenobiota

Andrey N. Efremov[1], Natalya V. Plikina[2]

[1] Design Institute for Oil and Gas Projects Construction and Rehabilitation (Omsk, Russia)
[2] Omsk State Pedagogical University (Omsk, Russia)

The realization of industrial and infrastructure projects is accompanied by some negative consequences on lichenobiota, a low labile group that reacts vehemently to changes of habitat conditions. The priority strategy of lichenobiota conservation and minimization of environmental risks is conservancy of intact habitats. However, in certain cases transformation degree and planned influences are in such a state that translocation is a more effective alternative option. The conservation of cenopopulations in situ by translocation to similar biotopes obtains high importance for conservancy of rare and protected species of lichens. At realization of this strategy, there is no destruction of individuals although a habitat is collapsed. Besides, it is possible to avoid a negative impact during operational phase by means of recipient territories choice. Microhabitats conditions correspondence of recipient territories to the donor ones allows increasing process efficiency. Possible realization difficulties include small amount of information about experience realization, technology adaptation under conditions of certain habitats and possible death of some thallomes. Translocation technology development as alternative option of rare lichens species preservation is a qualitatively new approach, differing in high economic efficiency and low ecological risks from others.

Keywords: lichenobiota, translocation, ecological risks, industrial and infrastructure projects.

Introduction

Implementation of industrial and infrastructure projects is accompanied by negative impact on vegetation cover including lichenobiota, the least labile group that reacts to slightest changes of habitat conditions. The priority strategy of lichenobiota conservation and minimization of environmental risks is preservation of intact habitats. However, in certain cases the degree of transformation and planned influences is so high that translocation appears to be the only alternative option.

The preliminary environmental impact assessment for development projects is regulated by Article 47 of the Town-Planning Code of the Russian Federation # 190-FZ [1]. The main scope of assessment of the predictable impact on the environment (within environmental engineering surveys prior to implementation of development projects) is presented in construction regulations SP 47.13330.2012 Engineering Survey for Construction... [2] and SP 11-102-97 Environmental Engineering Survey for Construction [3].

The general strategies of biodiversity protection are determined in a number of international regulatory documents, such as Convention on Biological Diversity [4] and Global Strategy for Plant Conservation [5], which consider biological diversity as a key element providing sustainable functioning of ecosystems. A priority trend in rational nature management is the development of non-government initiatives, such as FSC Principles and Criteria of Forest Stewardship [6] and concept of Important Plants Areas [7]; the latter are designed in accordance with the international nature protection practice although they are not classified as legally protected territories.

The International Finance Corporation (IFC) has adopted a sustainable development concept as a risk management strategy [8]. In case of direct investments, IFC requires the application of standards in management of environmental and social risks and impacts to prevent the negative consequences. The IFC Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources [8] acknowledges that protection and conservation of biological diversity and careful use of ecosystems, taking into account future needs, form the basis of sustainable development. Special requirements are set for critical habitats (Clause 16, PS 6 IFC). In case critical habitats are negatively affected, an impact assessment should be provided to minimize the consequences for biological diversity and to integrate the monitoring of such habitats into the company's project management system [8].

In the Russian Federation, the main regulatory document in the area of biodiversity conservation is Federal Law # 7- FZ *On Environmental Protection* [9]. Legal relations in the area of vegetation protection are partially regulated by Forestry Code of the Russian Federation # 200- FZ [10]. *Strategy for the Preservation of Rare and Endangered Species of Animals, Plants and Fungi* (Addendum to Order # 323 of the Ministry of Natural Resources of Russia) [11] establishes the following priority measures aimed to preserve rare and endangered species: conservation of populations in their natural habitats; conservation and rehabilitation of natural habitats, reconstruction of biotopes; and recruitment of lost populations. Restrictions of business activities with regard to the listed items are determined in the IUCN Red List of Threatened Species [12] and CITES [13] at the international level; in Russia, by Government Decree # 158 *On the Red Book of the Russian Federation* [14] and the Order # 419-a of the RF State Committee for Environment Protection *On Approval of the Russian Federation Red Book Keeping Procedure* [15] at the federal level. Liability for illegal extermination of protected species is determined by the Criminal Code of the Russian Federation # 63- FZ [16] and Articles 84.3 and 84.4 of the Administrative Violations Code # 195- FZ [17]. Fixed charges for damage extent calculation are established by the Order # 658 of the Ministry of Natural resources of the Russian Federation *On the Endorsement of Charges for Calculation of Damage Incurred on the Plant Objects* ... [18].

It should be noted that most of the regulatory documents treat the lichens as a component of an ecosystem and range them in a wide category "Objects of the Vegetable World". The main focus is made on the conservation of the red-listed species rather than on their habitats. Conservation of lichen diversity at the regional level is achieved through the protection of typical and rare plant communities.

The objective of this study is to develop a project of translocation of protected lichens as a strategy of *in situ* protection on the territories affected by significant man-induced impacts.

Research methods

The principle of translocation was developed when the Design Institute for Oil and Gas Projects Construction and Rehabilitation carried out an assessment of potential impact on protected lichen species and their habitats in the course of the planned OPF Compression Project. On the levelled land plot allotted for the compression station, within the facility-affected zone, a compact habitat of three species of lichens listed in the Red Book of the Russian Federation [19] and the Red Book of Sakhalin Oblast [20] was found: *Bryocaulon pseudosatoanum* (Asahina) Kärnefelt., *Lobaria pulmonaria* (L.) Hoffm., and *Menegazzia terebrata* (Hoffm.) A. Massal. In accordance with the criteria I and II specified in Clause 16 of IFC PS 6: *Biodiversity Conservation and Sustainable Management of Living Natural Resources* [8], this territory is considered a critical habitat since it is a compact habitat of several rare species [8]; according to the Classification of High Conservation Value Forests (HCVF), the locality is to be related to HCVF type 1.2 [6].

The above restriction was taken into account when making a decision on the plot plan preparation and equipment and utilities configuration. The area with massive growth of protected species (being a fragment of natural forest with the area of 0.23 ha) is adjacent to the land plot allotted for the compression station construction (54 m to the north), a motor road (58 m to the south) and the main production site (234 m westward of flare zone). Lichens are extremely sensitive to ambient air pollutants, and the presence of pollutants in the period of the compression station operation will facilitate the degradation and deterioration of habitat conditions, and the gradual loss of lichens. The specified area should have an exclusion zone with a buffer 10 m wide, with the fireproof break being as small as practicable. This complicates the equipment arrangement. The existing buffer is situated in the impact zone with a severely transformed landscape. Therefore, it was vital to develop a brand new alternative, and translocation was selected as such.

The assessment of vegetation cover as a habitat of protected lichens was made within the identified locality and in the background habitats, using traditional research methods [21]. Collection and preparation of herbarium specimen of lichens were carried out in accordance with standard practice [22]. The assessment of habitats included such parameters as substrate and synusial preference, frequency, area occupied by thallomes, and projective cover. Five test sites were established in the compact habitat area, where the frequency, projective cover degree and area of thallomes were measured using a measuring grid, with further extrapolation to the entire locality [23].

The area occupied by the individual species of epiphyte lichens on the surface of trunks and branches was calculated using the formula:

$$A = S \times a \times PC \times b, \tag{1}$$

where A is the area occupied by epiphyte lichens; S is the area of a phorophyte's trunk surface; a is the number of trees; PC is the projective cover of lichens (in fractions); and b is the frequency of lichens.

Trunk surface area is assumed to be a cone surface and is calculated by the formula:

$$S = \pi \times r \times h, \tag{2}$$

where S is the area of a tree trunk surface; r is the average radius of a tree trunk base; and h is the average height of a tree.

For *Bryocaulon pseudosatoanum,* the corrective factor 1.5 has been applied to formula 2, since this species can grow on branches as well.

The frequency of lichens was calculated by the formula:

$$b = n / N, \tag{3}$$

where b is the frequency of lichens; n is the number of sites where a species was registered; and N is the total number of test sites.

The regional authorities of Sakhalin Oblast have not established fixed charges for the calculation of damage caused by gathering or extermination of lichens listed in the Red Book of Sakhalin Oblast [20]; therefore, the calculation of damage was made based on the Order # 658 of the Ministry of Natural Resources of the Russian Federation *On the Endorsement of Charges for Calculation of Damage Incurred on the Objects of Flora* ... [18].

Risk assessment was performed in accordance with current internal standards of Sakhalin Energy Investment Company Ltd [24, 25, 26].

2. results and discussions

In accordance with phytogeographical zoning, the studied area relates to the North-Sakhalin area of the Amgun-Sakhalin floristic district of the Circumboreal floristic region and occupies the territory of the North-Sakhalin plain [27]. The background vegetation is represented by larch forests (*Larix cajanderi*) and larch open stands with dwarf pine (*Pinus pumila*) layer, which are associated with a variety of species adapted to moisture and soil nutrition deficit (*Arctostaphyllos uva-ursi, Carex vanheurckii, Cladonia arbuscula, C. rangijerina, Empetrum sibiricum, Vaccinium vitis-idae*a). In the terrain microdepressions, along the water bodies, there are some sphagnum bogs or grass and sphagnum bogs. Natural sedge meadows and sedge and reedgrass meadows are confined to the Sea of Okhotsk coast [28] (see Figure).

The studied species of lichens (*Bryocaulon pseudosatoanum, Menegazzia terebrata, Lobaria pulmonaria*) are confined to forest habitats only, which are represented by larch forests with green mosses and short grasses and by larch, spruce and silver fir shrub forests with green mosses. *Bryocaulon pseudosatoanum* typically forms synusia of fruticose *(Bryoria trichodes*, *Usnea longissima*), foliose (*Parmelia sulcata, P. squarrosa*, *Hypogymnia sachalinensis, H. subduplicata, H. sachalinensis, H. vittata)* and crustose lichens *(Mycoblastus sanguinarioides*, *Ochrolechia arborea, Bacidia laurocerasi)*. Beside epiphyte synusia, epigeic species *Alectoria ochroleuca* and *A. nigricans* are observed on branches and logging residues. On branches of *Larix cajanderi* synusia of *Bryocaulon pseudosatoanum* with *Japewia tornoënsis* can be found. *Menegazzia terebrata* forms synusia with *Bryoria trichodes*, *Usnea longissima*, *Hypogymnia spp., Ochrolechia pallescens,* and *Lecidella elaeochroma* on the trunks of *Abies sachalinensis. Lobaria pulmonaria* forms epiphyte lichenosynusia with *Hypogymnia spp.* and *Usnea longissima* on the trunks of *Picea ajanensis.*

In the course of locality and impact zone investigations, the total number of registered locations amounted to 35 including 20 locations of *Bryocaulon pseudosatoanum*, 12 locations of *Lobaria pulmonaria,* and three locations of *Menegazzia terebrata*. All registered species are epiphytes growing on the trunks and branches of live and dry trees (*Larix cajanderi, Picea ajanensis, Abies sachalinensis*) at different heights. The condition of the observed cenopopulations of lichens is stable; no visible signs of damage (changed colour, necroses, mechanical damages) have been detected.

Construction of a new process facility, the compression compressor station, will result in a considerable human-induced impact on the vegetation cover (both the protected species and their habitats). The most serious impact will consist in full removal of the vegetation cover during the construction and land planning works, as well as vegetation cover discontinuity and mechanical damages. Deforestation will lead to increasing insolation and reducing humidity in the habitats, which will trigger distortion of some physiological reactions and negatively affect the processes of growth and development. The territory adjacent to the site will almost entirely be subject to moderate transformation (topsoil compaction, mechanical damages). During the construction period, the main impact on the habitats of protected lichens will be caused by transient sources. Since the construction phase will be short, negative impact on the identified locality will be less significant than that at the operation phase. During the operation, the main impact will be associated with the emission of exhaust gases in the atmosphere from stationary sources (compressor units, flare zone of the process facility). Taking into account the fact that the identified locality is situated within the sanitary protection zone and lies in the main direction of pollutants spreading from the stationary and transient sources, destructive processes in lichenobiota should be expected to develop. Thus, the impact of the compression station construction phase is estimated as major and the impact of its operation phase as significant due to demutation process development.

It should be considered that the identified locality is situated in the impact zone and sustains cumulative impact (gas emissions, mechanical damages), which may enhance the degradation of habitats of lichens even if protective measures are taken (buffer zone retention, roads watering to remove dust etc.). In this regard, conservation of lichens *in situ* and the habitat conservation seem to be inefficient in the presence of a 10-meter buffer zone and sources of emission.

An alternative option of the project implementation is the translocation of protected species to the biotopes that have a number of parameters essential for normal development. Some experience of re-introduction and translocation of rare and endangered plants has been described in Russian and foreign literature [29, 30, 31, 32, 33]. Unlike animals and plants, an important specific feature of lichens protection is impossibility of their introduction and conservation *ex situ*.

One of the existing strategies for *Lobaria pulmonaria* re-introduction is the ***transplantation*** of thallomes; this type of works aimed to increase the population was carried out in Switzerland [34]. In the works of O. Gilbert [35], transplantation of thallomes of *Lobaria amplissima* together with the pieces of bark, 3–5 cm in diameter, was performed. A long-term monitoring of transplants growth showed that the transplantability rate was 70 %; the highest damage and mortality of thallomes due to the transplantation were observed in the first year. An interesting option is to disperse lichens using propagules [36]**.** In Russia, works on *L. pulmonaria* thallomes transplantation were carried out in the Republic of Komi [37]. Although this experience was successful, translocation has not become a widespread practice, as the thallomes transplantability required long-term observations [34]. During the monitoring, the most frequent controlled parameters are the size of thallomes and the degree of their dying-off; biomass annual buildup is a less frequent parameter, the determination methodology for which was suggested by B. McCune et al. [38].

Translocation is an intentional or induced transfer of wild-growing individuals or populations from one part of a species' area to another [29, 39]. Translocation has a number of advantages. Firstly, this technique implies the transfer of phorophyte fragments (including dead grass and trees subject to removal during the works implementation) together with the lichen thallomes, which is supposed to provide a higher survival rate. Secondly, this technique is less labour-consuming due to the easy preparation and fixation of transplants. The main requirement at all stages of work is a detailed documenting of the process and the direct participation of a professional lichenologist. The procedure includes the following basic phases:

1. Selection, registration, and marking of phorophytes and donor segments.
2. Identification of biotopes for the translocation (recipient habitats) based on the field surveys data.
3. Selective cutting of trees not being the habitats of the rare species of lichens (for the scenarios where full deforestation is required). Transportation of the tree-length material from the work site.
4. Mechanical cutting of marked trees using a harvester. In order to prevent the damage of lichen thallomes during the phorophytes cutting and trees transportation, the works should be performed in highly humid conditions; otherwise, the thallomes should be moistened artificially.
5. Transportation of marked donor fragments which are the natural habitats of *Menegazzia terebrata*, *Lobaria pulmonaria,* and *Bryocaulon pseudosatoanum* (with branches) to similar biotopes.
6. On the recipient site, the phorophyte trunks can be positioned either horizontally on the substrate (part of *Lobaria pulmonaria* thallomes, and *Bryocaulon pseudosatoanum* on the branches of phorophytes) or at an angle of 45–60° to the supporting tree (*Menegazzia terebrata*, remaining part of *Lobaria pulmonaria* thallomes, and *Bryocaulon pseudosatoanum*). Next, it is necessary to grid the phorophyte trunks, make up sketches of the sites and determine the diameters of lichen thallomes, their reproduction methods, and substrates.
7. Monitoring of the populations of translocated lichens. The main controlled parameters should include annual sketching, measurement of thallome diameters, projective cover, the degree of thallomes dying-off, the determination of reproduction methods, the composition of developing synusia, and the occurrence of these species of lichens in adjacent areas.

The main costs for this option implementation are the compensation charges for the destruction of habitats of rare lichens in accordance with the Order # 658 of the Russian Federation Ministry of Natural Resources [18], and the expenses for the translocation procedure. The expenses for lichens translocation can be calculated according to the recommendations on resettled plants rehabilitation [31], using the formula (4) with complements:

$$Q = 2 \times N \times T \times R + 2 \times N \times R \times T_{м} + A \times N + M_1 + M_2, \qquad (4)$$

where Q is the cost of relocation; N is the number of phorophyte trunks; T is man-hours; R is the cost of one man-hour; $T_{м}$ is the time spent on transportation; A is the cost of using motor vehicles; M_1 is the cost of lichenologist's participation in the translocation process; and M_2 is the cost of annual monitoring.

The preliminary number of phorophyte trunks to be transferred with lichens *Bryocaulon pseudosatoanum, Lobaria pulmonaria, Menegazzia terebrata* is 28 pieces, taking into account the frequency of individual species and the possibility of their cohabitation on one phorophyte trunk. Estimation of costs and the amounts of cost-based payments are shown in Tabl. 1 and 2.

Table 1. Preliminary assessment of damage to the habitat of the protected lichen species

Type of impact	Charge, RUR/m^2	Area of habitat, m^2	Damage amount, RUR
Destruction of habitats (Bryocaulon pseudosatoanum, Lobaria pulmonaria, Menegazzia terebrata) [18]	22,500	21.4	481,500.0
Corrective factor 1.5 for damage caused using appliances (Clause 8 of Comments to Order # 658 of the RF Ministry of Natural Resources [18])			722,250.0
TOTAL			722,250.0

Table 2. Preliminary estimation of costs for lichens translocation

Indicator	Value
N – number of phorophyte trunks, pcs	28
T – man-hours	1.0
R – cost of one man-hour, RUR	400.0
$T_м$ – time spent for transportation, hours	1.0
A – transportation costs, RUR/trunk	200.0
M_1 – costs for lichenologist's participation in translocation, RUR	20,000.0
M_2 – costs for annual monitoring, RUR	10,000.0
TOTAL	80,400.0

The proposed translocation technique can be combined with transplantation activities. For transplantation purposes, it is reasonable to select the thallomes that can, for technological reasons, be destructed during gathering, or single thallomes found on a trunk. The thallomes should be cut out together with substrate (bark fragment) the diameter of which should be 2–3 times larger than the diameter of lichen. The thallomes should be fixed on recipient phorophytes, taking into account the appropriate conditions of microhabitats (substrate preference, consortium links, height of affixion, exposition etc.). The transplants are fixed with epoxy adhesive or polymer-insulated metal brackets.

In case of transplantation of maximum 10 % of all thallomes taken for the translocation, the cost of works will possibly increase by approximately 15–20 % (primarily, due to the labour input in transplants preparation and fixation). The transplantation of all thallomes is ineffective because transplantation is a more destructive technique.

In the course of translocation project development (*option 3*), other methods of negative impact mitigation were studied to assess possible alternatives. One of them is the conservation of populations *in situ* in the area of compact habitat of rare lichen species with the 10 m buffer zone for the period of operation (*option 1*). However, since lichen thallomes are sensitive to changes in microclimate and have specific reproduction, the buffer zone must be at least 50–150 m to provide an efficient protection [34, 40], which is impossible taking into account the necessity to establish a fireproof break during project implementation. The habitat of lichens is surrounded by the potential sources of emission, such as a flare zone, a motor road, and the projected compression station site. Considering the proximity of industrial areas, in the period of operation the protective zone will be insufficient for the habitats conservation, and it will facilitate degradation and deterioration of habitat conditions, and the delayed loss of lichens.

Another option is a complete destruction of protected species *in situ* and their habitats, and equivalent compensation payments (*option 2*). This option results in the most negative consequences for the biota. Although the protected species are spread widely enough in the vicinity of the Onshore Production Facility, and the destruction of identified locality will not lead to the extinction of protected species populations, their structure will be affected significantly.

The summary assessment of impacts for the three alternative options is shown in Table 3. Options 1 and 3 are not inconsistent with the IFC Standard 6 [8], since they imply lower environmental risks for rare species and provide the long-term monitoring of dynamic parameters.

Table 3. Summary Assessment Matrix of Options Implementation

Impact	Recipient	Period of impact	Impact on the environment	Impact on the social sphere (social publicity)	Impact on the health of people
		Option 1			
Indirect impact on natural habitats of protected species	Habitats of the protected species of lichens	Construction, operation (growing impact)	Major impact (4 points)	Slight impact (1 point)	No impact (0 points)
Indirect impact on protected species	Protected species of lichens	Construction, operation (growing impact)	Major impact (4 points)	Slight impact (1 point)	No impact (0 points)
		Option 2			
Loss of habitats of protected species	Habitats of the protected species of lichens	Construction	Massive impact (5 points)	Massive impact (5 points)	No impact (0 points)
Destruction of protected species	Protected species of lichens	Construction	Massive impact (5 points)	Massive impact (5 points)	No impact (0 points)
		Option 3			
Loss of habitats of protected species	Habitats of the protected species of lichens	Construction	Massive impact (5 points)	Massive impact (5 points)	No impact (0 points)
Impact on protected species	Protected species of lichens	Operation (no direct impact)	Slight impact (1 point)	No impact (0 points)	No impact (0 points)

Based on the analysis of possible alternative options, conservation of species *in situ* by translocation appears to be the optimal method in case of habitat loss. If this option is implemented, individual lichens will not be destructed even though their habitat is collapsed. There are some environmental risks in this option; the scarce experience of such projects implementation makes it difficult to assess the productivity and efficiency of translocation. If the results prove to be positive, this technique can be used during construction and reconstruction of industrial and infrastructure facilities. Similar conditions of microhabitats (substrate, microclimate and consortium links) in the donor and recipient sites will improve the translocation efficiency.

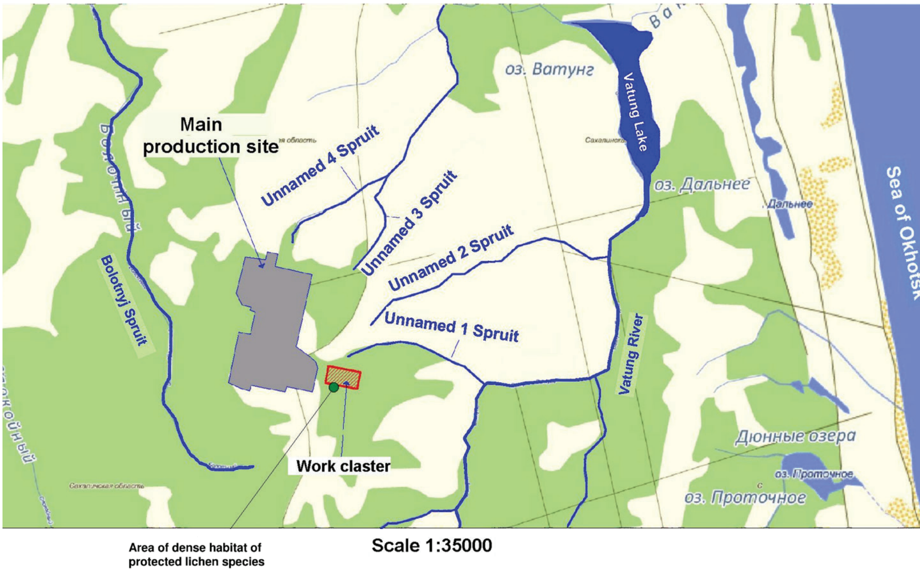

Fig. 1. Review scheme

Conclusion

The developed technology of lichen translocation allows conserving the protected lichen species in natural habitat. The translocation procedure is not inconsistent with the IFC Standard 6 [8] and current regulations of the Russian Federation regarding the protection of biological diversity, since it implies lower environmental risks for rare species and provides a long-term monitoring of dynamic parameters. This technology will conserve the individual rare lichens transferred to similar biotopes, while the factor of the negative impact can be mitigated. This makes translocation a promising technology that may be used for negative impact mitigation in the areas of human-induced transformation of habitats.

References

[1] Federal Law from 29.12.2004 # 190FZ «Urban Development Code of the Russian Federation» (on 23.07.2013) (In Russian).

[2] Set of Rules 47.13330.2012. Engineering Surveys for Construction. Main Provisions. Revised Edition. Construction Standards and Regulations 110296. Approved by Federal Agency for Construction, Housing and Utilities, Order # 83/GS, from 10.12.2012 (In Russian).

[3] Set of Rules 1110297 Engineering and Ecological Surveys for Construction, 1997. M. : Gosstroy Rossii (In Russian).

[4] Convention on Biological Diversity, Rio de Janeiro, 05.07.1992. Signed by Russian on 13.06.1992, ratified Federal law # 16FZ from 17.02.1995.

[5] *Global Strategy for Plant Conservation*, 19.04.2002. URL: http:// www.cbd.int/gspc/default.shtml (date: December 2013).

[6] *FSC Principles and Criteria of Forest Stewardship* FSCSTD01001 V50 D49. URL: http://igi.fsc.org/download.fscpcv5withexplanatorynotes.15.pdf.

[7] Anderson Sh., 2003, *Identification of main botanical territories: A guide for choosing sites in Europe and base for developing these rules worldwide*. M., 39 p.

[8] *Performance Standards on Environmental and Social Sustainability*. International Finance Corporation, World Bank Group. Ver. January 1, 2012.

[9] Federal Law from 10.01.2002 # 7FZ «On the Protection of the Environment» (on 22.07.2013) (In Russian).
[10] Federal Law from 04.12.2006 # 200FZ «Russian Forestry Code» (on 28.07.2012) (In Russian).
[11] Order of Ministry of Natural Resources and Environment of the Russian Federation # 323 «On Approval of Strategy for Preservation of Rare and Endangered Animal, Plant and Fungus Species», from 06.04.2004 (In Russian).
[12] *IUCN 2013. IUCN Red List of Threatened Species*. Version 2013.1. URL: http://www.iucnredlist.org.
[13] Convention on Conservation of Wild Fauna and Flora and Natural Habitats in Europe, Berne, 19.09.1979.
[14] Decree of the Russian Federation Government # 158 «About the Red Book of the Russian Federation», from 19.02.1996 (In Russian).
[15] Order of State Committee for Environmental Protection of the Russian Federation # 419a «On Ratification of Russian Federation Red Book Rules of Order», from 03.10.1997 (In Russian).
[16] Federal Law from 13.06.1996 # 63FZ «Criminal Code of the Russian Federation on Administrative Violations» (on 01.09.2013) (In Russian).
[17] Federal Law from 30.12.2001 # 195FZ «Administrative Violations Code of the Russian Federation» (on 30.09.2013) (In Russian).
[18] Order of Ministry of Natural Resources and Environment of the Russian Federation # 658 «On the Approval of Scales for Calculation of Damage Extent Caused to Russian Red Book Plant World and its Habitat Caused by Breach of Environment and Natural Resource Management Legislation», from 01.08.2011 (In Russian).
[19] Russian Red Book: *Plants and Fungus*, Ministry of Natural Resources and Environment of the Russian Federation; Federal Service for Supervision over Natural Resource Management; Russian Academy of Sciences; Russian Botanic Society; Moscow State University; Main editorial board: Yu.P. Trutnev et al.; Content by R.V. Kamelin et al. M. : Partnership of Scientific Publication KMK. 2008. 855 p. (In Russian).
[20] Sakhalin Region Red Book. Plants, Editorinchief V.M. Eremin (YuzhnoSakhalinsk: Sakhalinskoe Knizhnoe Izdatelstvo). 2005. 348 p. (In Russian).
[21] *Field Geobotany*, Editorship E. M. Lavrenko, A.A. Korchagina. M.; L. : Izd. AS USSR. Vol. 1–5. 19591976. 2291 p. (In Russian).
[22] *USSR Lichen Field Guide*. L. : Nauka. 1974. № 2. 283 p. (In Russian).
[23] Kravchenko M.V., Bogolyubov A.S. *Lichen community description methodology*. M. : Ecosystema, 1996, 24 p. (In Russian).
[24] Corporate Standard: Impact Assessment Procedure, 0000S9004P712700E, edited 01. 2013, Sakhalin Energy Investment Company, Ltd. (In Russian).
[25] Corporate Standard: Risk Management Procedure / эффектами и оценка экологических аспектов и воздействий, 0000S9004O000900R, edited 01. 2013, Sakhalin Energy Investment Company, Ltd. (In Russian).
[26] Corporate Standard: Biological Diversity, 0000S9004O025900, 2013, Sakhalin Energy Investment Company, Ltd. (In Russian).
[27] Krestov P.V., Barkalov V.Yu., Taran A.A. *Botanical and geographical zoning of Sakhalin. Sakhalin flora and fauna*. Materials of International Sakhalin Project. Vladivostok, 2004, p. 67–90.
[28] Bakalin V.A., Pisarenko O.Yu., Chernyadieva V.Ya. Brioflora of Sakhalin. Vladivostok : Izd. dom of Maritime State University, 2012. 310 p.
[29] Gorbunov Yu.N., Dzybov V.S., Kuzmin Z.E., Smirnov I.A. *Guidance notes for rare and endangered epecies reintroduction*. Tula : Grif and K, 2008, 56 p. (In Russian).
[30] Valee L. et al. *Guidelines for the translocation of threatened plants in Australia*. Second edition. Australian network for Plant Conservation (Australia, Canberra). M., 2004, 80 p.
[31] Methodology of Rehabilitation of Transited Plants and Animals in Danger Due to Direct Negative *Impact in Mountainous and Plain Territory on Site of XXII Olympic Winter Games and XI Paralympic Winter Games 2014 in Sochi*. Approved by Direction #10p of Ministry of Natural Resources and Environment of the Russian Federation, from 28.04.2010 (In Russian).
[32] Korovin S.E., Kuzmin Z.E., Trulevich N.V., Shvetsov A.N. *Plant transition: technical approach*. M. :MSKhA, 2001. 75 p. (In Russian).
[33] Akeroyd J.R. and Jackson P.W. *A Handbook for Botanic Gardens on the Reintroduction of plants to the wild*. UK : BGCI, 1995. 29 p.

[34] Nemchinova A.V., Ivanova N.V. Ways to manage population of Lobaria pulmonaria during forest use. Regions in Unstable Development: Materials of International Research Conference *«Regions in Unstable Development»,* KostromaSharya, April 2830, 2010. Kostroma : KSU, 2010, № 2, p. 203–205 (In Russian).
[35] Gilbert O.L. *A successful transplant operation involving Lobaria amplissima* // Lichenologist. 1991. Vol. 23, № 01, p. 73–76.
[36] Scheidegger C. and Goward T. Monitoring lichens for conservation. *Red Lists and conservation action plans.* Monitoring with lichens – monitoring lichens / eds. L. Nimis, C. Scheidegger, Wolseley P. Dordrecht (Netherlands: Kluwer Academic Publishers), 2002, p. 163–182.
[37] Pystina T.N. *Something about Lichens and Not Only*. 2013. URL: http://ib.komisc.ru/add/old/t/ru/ir/vt/0148/10.html (In Russian).
[38] McCune B., Derr C.C., Muir P.S., Shirazi A., Sillett S.C. and Daly W.J. *Lichen pedants for transplant and growth experiments*. Lichenologist. 1996. Vol. 28, № 01, p. 161–169.
[39] *IUCN Guidelines for Reintroductions*. Prepared by the IUCN/SSC Reintroduction Specialist Group. IUCN, Garland, Switzerland and Cambridge, UK, 1998.
[40] Rare Species of Plants, Animals and Fungus of Forest Ecosystems on the Territory of Arkhangelsk Region and Recommendation for Their Conservation / editorinchief E.A. Rai, E.V. Shavrin. Arkhangelsk : PTU, 2005, p. 45.

About

Andrey N. Efremov – Design Institute for Oil and Gas Projects Construction and Rehabilitation, Omsk, Russia. E-mail: stratiotes@yandex.ru

Natalya V. Plikina – PhD, Assistant professor, Omsk State Pedagogical University, Omsk, Russia. E-mail: tele-text@yandex.ru