Compensatory transplantation (Rhododendron aureum Georgi) as an element of conservation (restoration) of ecosystems of the north

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Abstract. The article describes the results of the research on transplantation of Rhododendron aureum. This species is listed in the red book of the Transbaikal territory, it is wide-spread at the construction site of Udokan Mining and Processing Complex. Since 2018, Baikal Mining company has been constructing the largest complex for mining and production of copper ore in Russia. Rhododendron aureum an evergreen shrub – was found at the construction site. As the result of the mining and processing complex construction and operation, some communities including Rhododendron aureum Georgi will be disturbed. This species is difficult to introduce into the culture, grows slowly. It starts blooming and fruiting only on 12th year. As compensatory measures for the protection of the species, researchers proposed transplanting this species. As a result of research, the possibilities and limitations of carrying out activities for transplanting and rehabilitation of this species were established, sites for extraction and planting were proposed, and a technology for preparing sites was developed. Sites for mining and transplanting were chosen as similar as possible in terms of conditions: the nature of the terrain, exposure and steepness of the slopes, and moisture conditions were taken into account. In August 2019, 320 specimens of the Rhododendron aureum were transplanted to a specially prepared site. The first results showed good acclimation at compliance with the requirements for transplantation and preparation of the area. This experience can be used for rehabilitation works mountain subalpine ecosystem.

1. Introduction
The scale of human-induced changes in natural complexes on the planet makes practical work related to ecosystem restoration an important part of strategies for ensuring the future of humanity. Such studies are aimed at developing specific effective recommendations and tools for restoring landscapes damaged by various types of anthropogenic impact [1].

The relevancy of restoration of ecosystems gained the global importance; therefore, at the 73rd Meeting on 6th of March, 2019 the UN General Assembly has proclaimed 2021-2030 as the Decade on Ecosystem Restoration.

A not unimportant contribution to the degradation processes makes the implementation of large industrial projects in the mining industry, which is accompanied by, including, loss of natural systems, reducing biodiversity, loss of rare species, reduction of ecosystem functions of the landscapes. Rare species are particularly sensitive to transformations and changes [2].
The large project in the Trans-Baikal Territory and the Russian Federation is the construction of Udokan complex for mining and processing of Udokan copper deposit ore. The development of the Udokan copper deposit has been carried out by «Baikal mining company» since 2018. The project implementation is associated with significant transformation of territory of the mountain alpine and subalpine landscapes.

In the result of the engineering and environmental survey the areas of protected species growth (Rhododendron aureum) were discovered in the areas of future location of Udokan mining and processing complex facilities.

The aim of the research was the estimation of compensatory transplantation possibility to be used as a method for restoration of habitats and preservation of rare species population in mountain landscapes of Siberia.

2. Models and methods

Rhododendron aureum Georgi evergreen shrub included in the Red Book of the Trans-Baikal Territory was the transplantation object. It was referred to Category and Status 3 as a rare species growing in restricted areas which is associated with specific growth conditions [3, 4]. It ornamental and medicinal plants [5].

A survey of 12 sites of Rh. aureum habitat was conducted on the land allotment for the construction of Udokan Mining and Processing Complex facilities. Areas, limiting factors of shrub distribution, and conditions for preserving populations of this species are specified. In August 2019, 320 specimens of the shrub were transplanted to a specially prepared site. The planting material was taken from the territory where the Udokan tailing dump will be located. The shrub was removed with a layer of mosses. The areas for acquisition and transplantation were selected by the closest conditions (to the extent possible): the terrain structure, the direction and the steepness of slopes, the moisture conditions were taken into account.

3. Results and discussion

The necessity of the transplanting measures is dictated by the fact that as a result of engineering and environmental surveys, areas of growth of Rhododendron aureum, an evergreen shrub listed in the Red book of the Transbaikal territory, were identified on the territory of the deposit.

In compliance with the RF laws, if growth areas of rare and endangered species are found within the land allotment, then their transplantation in adjacent habitats with similar growth conditions, ecological and biological peculiarities of the specific species shall be provided. The experience of other regions shows that the creation of artificial populations in natural biotopes is the most complicated option of compensatory measures. Information is published only about a small number of successful works, negative experience, as a rule, does not receive coverage in the scientific literature [6, 7].

Rh. aureum is an evergreen shrub 0.2-0.6 m tall. This type of protected plants is widely distributed within the Kodar-Udokan mountain area, and participates in the shrub layer in most forest formations. The plant is successfully restored and adapts to subtle changes in the environmental situation. The specificity of its habitat and its proximity to the upper mountain belts are the limiting factors of its distribution. North Asian mountain General belt species. In Russia, it is found in the far East, Chukotka, Sakhalin, Kamchatka, the Kuril Islands and Primorye. In Siberia grows in subalpine open woodlands in the mountainous regions of Western and Eastern Siberia.

Within the Udokan range, it grows at altitudes from 1300 to 2500 m above sea level in various biotopes: rare-coniferous spruce larch forests, larch forests with cedar elfin undergrowth, cedar-elfin thickets, and moss-lichen tundras of the highlands Rh. aureum plays a landscape role – it forms a tier in the upper band of the cedar taiga. In subalpine open woodlands it forms a shrub tundra in the high mountain zone successfully growing among the sphagnum mosses on peat (figure 1).
It grows quite slowly, and fruiting begins on average at 12 years of life. The plant is difficult to introduce into culture. Being high-altitude, cold-loving plants suffer from high summer temperatures. Analysis of the literature data suggests that it is impractical to collect and store seeds (after collection, they retain germination for the first three years); to create a nursery (seedlings obtained in greenhouses and nurseries can be planted for 8-10 years, they are susceptible to fungal and viral diseases) [7-9].

At the sites allotted for Udokan mining and processing complex facilities 27 model areas were prepared within the researched plant communities ($S = 0.25 \text{ m}^2$). At these areas structure of vegetation was studied, as well as the terrain structure, direction and steepness of slopes, moisture conditions, soil types, i.e. the whole complex of Golden rhododendron growth peculiarities. As a result of research, the possibilities and limitations of carrying out activities for transplanting and rehabilitation of this species were established, and sites for removal and planting were proposed. The survey revealed a significant number of environmental and mechanical restrictions for obtaining and transplanting plants. Trial excavations have shown that not all the natural conditions in which the species grows are suitable for transferring shrubs. Based on the features of the structure of the root system and shoots, it can be argued that the excavation of plants from stony areas and areas with a high projective cover of lichens will lead to damage to the root system.

For extraction we selected a plot of larch with dwarf birch rare coniferous with a predominance of moss cover. The territory of 2500 m$^2$ occupies a section of the Northern slope in the intermountain depression at an altitude of 1465 m. the general slope of the terrain is 3-6°, the territory with signs of waterlogging. At this site, a continuous count of the number of specimens was recorded 320 specimens of rhododendron, which is sufficient for the first stage of translocation. Trial production at this site showed that it is possible to remove the clump of rhododendron individuals without damaging the shoots and roots, while preserving the root layer. The thickness of the moss layer allows you to retain moisture during transport and transportation and protect the roots from mechanical damage. Also, in the course of the research, areas for transplantation were examined. Priority was given to areas partially or completely disrupted by survey or planning work within the land allotment of «Udokan» Mining Complex. Among these territories, we selected a site that was disturbed as a result of partial excavation, in an intermountain depression in the upper streams of Neizvestny Spring. According to the design solutions provided by the company, this section will not be used in the construction and operation of the metallurgical plant facilities. The site is located within an intermountain depression at an altitude of 1502 m., the slope is north-north-east, the general slope of the terrain is 2-6°. The site was specially prepared for the transplantation of rhododendron. Based on the ecology of the species, it is necessary to provide conditions for the absence of stagnation of water.
and compliance with the soil features of the growth of this plant. The process of technological preparation of the site included leveling the site taking into account the natural slope of the terrain (no more than 10°) with rock soil, measuring from 10 to 60 cm. At the same time, rocky soil is needed for natural drainage. Then the leveled area was covered with a soil-peat mixture at least 10 cm thick.

In August of 2019 all acquired specimens were transplanted. In September express estimation of transplanted material survivability was carried out. The performed estimate has shown high survivability of _Rh. aureum_ amounting to 98%. It is recommended to continue the work on transplantation of rhododendron and conduct it in a staged manner throughout the entire period of Udokan mining and processing complex construction. Depending on the speed of construction at different work sites, work on species rehabilitation can be planned for two years. The final recommendations on volumes of species planting and methods of reconstruction of habitats will be received on the basis of multiannual data received at model areas. This requires at least two sites to compare the success of the restoration of the natural complex [10]

4. Conclusion
Compliance with all translocation rules starting from the selection of areas for transplantation, acquisition of plants, their transportation and planting are the determining factors providing the successful survivability of plants at new sites. Thus, it is important to use the recommendations of this article for recultivation after the deposit development. Transplantation of bunches of _Rh. aureum_ shrubs shows good results and is recommended as a restoration measure for rehabilitation of natural ecosystems and population of this species.

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