Translocation of rare plant species as a method of biodiversity preservation in specially protected natural areas

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Abstract.The article reflects the inventory checking results of the territory of the regional ranked "Uporovsky" nature reserve (Uporovsky district, Tyumen region). The growth of protected species of vascular plants, including *Calluna vulgaris* (L.) Hull, *Neottianthe cucullata* L. Schlechter, *Digitalis grandiflora* Mill. was revealed on the area allocated for extension of the right-of-way for 110 kV power transmission lines. A scientifically grounded transfer of individuals of protected plant species was carried out from the sites, allocated for clearing right-of-way of power transmission line, to new habitats similar in ecological conditions located within the nature reserve. The study was carried out at the time of year favorable for transfer, taking into account the ontogeny stage of the transferred plants. Methods and approaches of translocation of vascular plant species have been developed. The preparation of plants transferring (coordinate binding, labeling, etc.), removal of the translocated individuals from the original habitat and their transportation to new safe areas was performed. A system for monitoring the state of translocated plants was developed, and a high level of survival of plants after translocation to new habitats was noted.

1. Introduction

Biological diversity is the basis for maintaining the ecological balance and sustainable development of the region's biota. In this regard, the problem of preservation and reproduction of rare and endangered species of organisms in natural habitats is relevant. Specially protected natural areas are one of the most effective forms of nature protection activity, which allows preserving biological and landscape diversity [1-3].

In the center of Uporovsky district of Tyumen region on the land of the state forest fund, inter-farm forest farm and "Kolos" collective farm, in seven kilometers from Uporovo village, there is an "Uporovsky" nature reserve, which area is estimated as 6920 hectares (Uporovsky district, Tyumen region, Russia. Coordinates N 56.1839, E 66.1609). It exists since 1996, was reorganized on 20 April 2009, currently it is active. This is a complex zoological nature protection object of regional rank.

There is protection of natural forest complexes and growing here rare and endangered plant species is carried out in the "Uporovsky" nature reserve. Moreover the protection and counting of majority of plants species is held by employees of nature protection areas [4-6].

The vegetation cover of these places is represented by pine forests, birch forests with an admixture of aspen. All phytocenoses in this area belong to the formation of pine forests or birch, birch-pine and pine-birch forests derived from it.

The vegetation cover of these places is represented by pine forests, birch forests with an admixture of aspen. All phytocoenoses that are distinguished by a high density of protected (Red Book) species, refer to the formation of pine forests or derivatives of this formation by birch, birch-pine, pine-birch forests [7, 8].

The 110 kV power transmission line with a length of 8 kilometers and the width of the right-of-way of about 30 meters passes through the territory of the regional ranked "Uporovsky" nature reserve (Uporovsky district, Tyumen region). In 2017 it was planned to expand the guard zone of the power transmission lines by 10 meters from each side.

Before clearing the area for the power line, we examined the designated area for rare and protected plant species. As a result of the inventory, three protected species of vascular plants were identified: *Neottianthe cucullata* L. *Calluna vulgaris* (L.) Hull., *Digitalis grandiflora* Mill.

One of the ways to preserve the biodiversity of rare plant species is their transfer (translocation) to a protected area. Researchers from many countries are involved in the transplantation of rare plants, who agree that the search for optimal habitats is crucial for successful translocation. Plant survival mainly depends on favorable habitat conditions [9-11].

Before carrying out work on clearing the territory from forest vegetation, within the planned extension of the right-of-way for power transmission lines, a set of works was carried out to survey the designated territory in order to detect the growth of rare and protected plant species within its boundaries. As a result of the conducted inventory checking, the growth of protected species of vascular plants, including three species in the area allocated for economic activities (extension of the right-of-way for power transmission lines), was revealed on the territory of the nature reserve.

In order to preserve the protected plant species, which were found on the right-of-way, it was decided to transplant them to a safe area. There was obtained permission by the Department of Subsoil Management and Ecology of the Tyumen region for carrying out works to identify and transfer protected flora species from the 110 kV power transmission line to the territory of the regional ranked “Uporovsky” nature reserve (Uporovsky district, Tyumen region, Russia). Coordinates N 56.1839, E 66.1609. Works on transplantation were carried out in July, August 2017.

The purpose of this work is the transfer (translocation) of protected plant species found on a site set aside for a high-voltage power line to a safe area.

2. Materials and methods

2.1. Boundaries of nature reserve

The northern boundary begins in the northwestern corner of the quarter 22 of the Bunkovsky district forestry of the Uporovo forest district (point 1, coordinates N 56.1452, E 66.0610) and goes north-east along the right side of the Bunkovo-Uporovo road. Not reaching 500m to Skorodum village, at the extreme northern point (point 2) with coordinates N 56.1450, E 66.0930 the border turns to the southeast and follows the forest road, crossing the blocks 17, 18, 19, 20, 21 of the Bunkovsky district forestry, to south-eastern corner of the quarter 21 of the Bunkovsky district forestry.

The eastern border starts in the southeast corner of the quarter 21 of the Bunkovsky district forestry (point 3, coordinates N 56.1310, E 66.1435) and goes to the south-west along the eastern border of the quarter 28 of the Bunkovsky district forestry to its southeast corner. Further south-east along the right side of the forest road in the direction of the Morevo village, to point 4 (coordinates N 56.1141, E 66.1537). Then the border turns to the south and goes to the right bank of the river Emurtla (point 5, coordinates N 56.1015, E 66.1537).

The southern boundary starts on the right bank of the river Emurtla (point 5), goes along the right bank of the river downstream to the west, ends at the point with coordinates N 56.0945, E 66.0820 (point 6).

The western border starts at point 6, goes north, 1.5 km to the bridge near Bunkovo village, the border turns north along a 1.5 km curve from the southeast, east and north sides around Bunkovo village and overlooks the right side of the road Bunkovo-Uporovo (point 7, coordinates N 56.1055, E

66.0705) then goes north along the right side of the road, coinciding with the western boundary of block 89 of the Uporovsky rural district forestry, to point 1 (Figure 1).

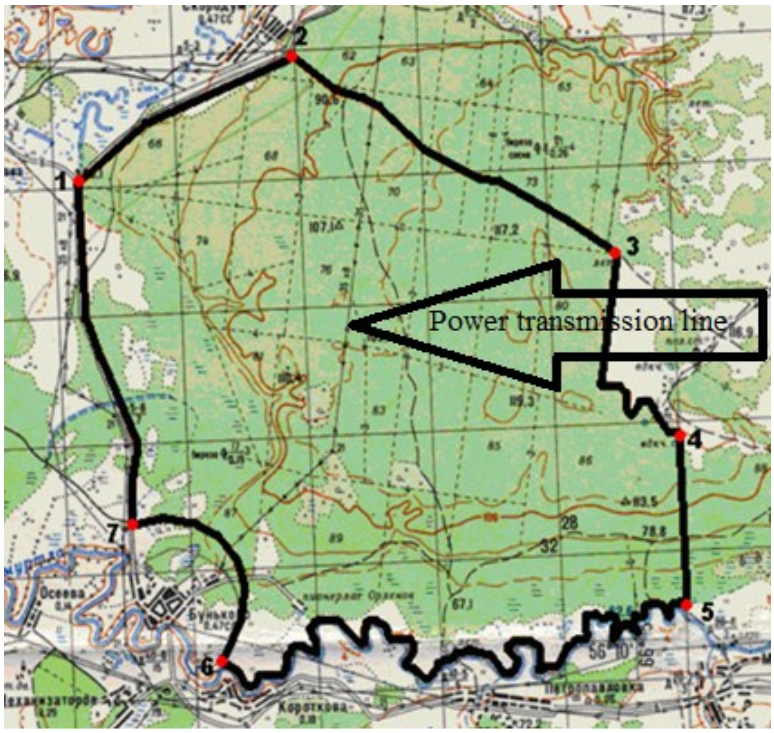

Figure 1. A schematic map of the regional ranked "Uporovsky" nature reserve (Uporovsky district, Tyumen region).

2.2. Translocation

The description of vegetation was carried out during the growing seasons according to the methodological approaches and methods, which were accepted in phytocoenology and widely used in geobotanical studies [12, 13].

In the used method of (transfer) translocation, primary attention was paid to preserving the integrity of the root system of the transplanted plants species, both from the point of preventing its mechanical damage, and from the point of preserving it in the initial period, in the original optimal neighborhood with the habitual environment, as well as the roots of the nearest representatives of the flora. This allows to save for a long time all the consortium connections in the part of pedobiology, and also to exclude possible mechanical damage to the root system. Any shaking, resulting in the vibration of the root system, which is detrimental for intergrown root hairs with the soil microparticles, was minimized while removing.

A special feature of the biology of *Calluna vulgaris* (L.) Hull. is the presence of rhizomes. Dug and loosened the soil around each bush, determining the direction of growth of rhizomes. Long, intertwined rhizomes were removed from the ground, with minimal damage. Cenopopulations of this species sometimes dominate in the grass-shrub cover on dry soils in pine forests of cowberry-heather-green moss. Less developed on dry oligotrophic sands in lichen pine forests and more humid and humus soils of blueberry-green moss pine forests with a developed grass layer. The new locality was located within the pine forests with mixed grass and reed grass cover, with optimal for it lighting and humidity.

Specific site for protected plants transplantation were chosen on the new location. When choosing a site for transplantation (translocation), the opacity, configuration, size and depth of places for new

locations were taken into account. All the biological characteristics of the transferred species of flora and their ecological requirements were taken into account during the work (phytocoenotic environment, illumination of forest areas, soil moisture, topography). After the transplantation, the plants were irrigated, labeled, photographic fixation was held, geographic coordinates were recorded on the GPS-navigator ("Garmin"). Maps of rare and protected species locations in the contour of the right-of-way of power transmission line were developed based on the satellite photographs of Google Earth, on which locations of species, marked with GPS-navigator "Garmin", were plotted.

3. Results and discussion

The flora of the studied area within the nature reserve territory is made up of 125 species of vascular plants, united in 102 genera and 44 families, 11 of them belong to spore plants (*Lycopodiophyta*, *Equisetophyta Polypodiophyta*), 3 species – to *Pinophyta*, the remaining 110 species – to *Magnoliophyta* including class of bipartite (96 species) and class of monocotyledons (14 species). The analysis of the revealed floral composition shows the belonging of the plant communities of the investigated territory to the forest formations of the taiga natural zone. In general, there are forests of southern taiga prevail in the area of research, with dominance of coniferous tree species: *Picea obovata* Ledeb., *Abies sibirica* Ledeb., *Pinus sylvestris* L. Such indigenous forests grow on the plots of the investigated area, or along the steep or steeper slopes on well drained soils of the podzolic series (sod-podzolic), forming primary communities, in which the above-mentioned tree species act as edifiers.

An example of this forest type is the pine Lycopodiaceae. The formula of the forest stand is 10C, the density of the tree canopy is 0.6. The community is four-tiered. The first tier is about 37 meters high, formed by *Pinus sylvestris* L., the average trunk diameter is 0.5 meters, the maximum diameter is 0.6 meters. The average age is 120-130 years. The second tier, formed by *Pinus sylvestris* L., is about 12-15 meters height, the average trunk diameter is 0.3 meters (maximum 0.4 meters). *Pinus sibirica* Du Tour at the age of 14-18 years is marked as the undergrowth in the community. In the grassy tier *Diphasiastrum complanatum* (L.) Holub, *Fragaria vesca* L. are dominant. In the first substage of the grassy tier *Antennária dióica* (L.) Gaertn., *Trifolium lupinaster* L., *Lathyrus pratensis* L., *Polygonatum odoratum* (Miller) Druce are marked. In the second substage, a height of 0.5-0.6 meters, *Luzula pilosa* (L.) Willd., *Pulmonaria mollis* Wulfen ex Hornem, etc. grow. The third substage of a grassy tier, with a height of 0.4 meters and below, is formed by *Pyrola rotundifólia* L., *Viola hirta* L.

Thus, in the investigated territory, the primary (indigenous) communities include spruce, fir and pine forests and a typical set of southern taiga grasses, bushes and shrubs.

In many areas of the investigated territory, the indigenous forests due to logging and fires are replaced by derivatives (secondary) forests formed by small-leaved species – *Betula pendula* Roth and *Populus tremula* L. Such forests are at different stages of the succession series and are gradually replaced by indigenous communities, which are facilitated by the absence of development-inhibiting factors, including anthropogenic ones. The undergrowth of coniferous tree species is well developed, which favors the natural course of the indigenous vegetation restoration.

In small areas of more open territories forming forest glades, the grass and shrub communities are developing, they are formed by the species of the meadow-frontal complex *Solidágo virgáurea* L., *Campanula cervicaria* L., *Hypericum perforatum* L., *Dianthus versicolor* Fischer ex Link, *Carlina biebersteinii Bernh*. ex Hornem., *Astragalus danicus* Retz. with the participation of the species *Calluna vulgaris* (L.) Cull, *Trifolium lupinaster* L., *Leucanthemum vulgare L.*, *Achilléa millefólium* L., etc.

As a result of the conducted studies, the growth of the Red Book species was recorded in the territory allocated for clearing the right-of-way of 110 kV power transmission line: *Calluna vulgaris* (L.) Hull (194 bush), *Neottianthe cucullata* (L.) Schlechter (6 individuals) and *Digitalis grandiflora* Mill. (48 individuals), which could be destroyed during the implementation of economic activities.

The Red Book species are distributed roughly in the surveyed territory, successfully developing in optimal for species phytocenoses: *Neottianthe cucullata* L. in green-moss pine forests, *Calluna vulgaris* (L.) Hull in low pine forests with elements of heath, *Digitalis grandiflora* Mill. in poorly stepped medium-moistened pine forests (Table 1).

Table 1. Rare species of vascular plants detected on the right-of-way of power transmission line of "Uporovsky" nature reserve.

No.	Species	Category of rarity	Number of individuals (i)
1.	*Calluna vulgaris* (L.)	III- rare species	194 bush
2.	*Neottianthe cucullata* (L.) Schlechter	III- rare species	6 individuals
3.	*Digitalis grandiflora* Mill.	III- rare species	48 individuals

The preparation of plants transferring (coordinate binding, labeling, etc.), removal of the translocated individuals from the original habitat and their transportation to new safe areas was performed.

It is noted that not many researchers studied the environmental conditions to select the places of transplantation, while the number of studied factors is usually limited. It is proposed to compare plant communities between the donor population and potential sites. This transplantation stage should be performed at an early stage of the site selection process [14, 15].

Calluna vulgaris (L.) Hull. Heather Family. Rare species. Evergreen shrub, stems lignified, raised, branched, 15-50 cm high. Leaves are opposite, sessile, pressed, boat-shaped, small, 1.7-2.3 mm long, at the base arrow-shaped. Flowers rejected or drooping, form almost one-sided brushes, ending with leafy tops. The calyx is lilac-pink, shiny, with oblong-elliptical obtuse lobes, completely covering the corolla. The corolla is a quarter of the calyx length, lilac-pink, incised into oblong-ovate lobes, fruit – a box. Coordinates of new locations: N 56.2136, E 66.1746 ; N 56.2116, E 66.1738; N 56.2115, E 66.1738; N 56.2110, E 66.1737; N 56.2098, E 66.1735; N 56.2090; E 66.1734; N 56.2085, E 66.1733; N 56.2084, E 66,1733; N 56.2015; E 66.1718.

Digitalis grandiflora Mill. Scrophulariaceae Family. Perennial herbaceous plant. Rhizome is horizontal, multi-headed. Stem is straight, unbranched, pubescent at the bottom, glandular at the top, 40-120 cm high. Leaves are regular, large, light green, lanceolate, upper ones – are sessile, lower ones – are gradually narrowed into petiole. Flowers in a one-sided brush, large, drooping. Calyx lobes, as well as pedicels, are glandular, lanceolate. Corolla is yellow, inside with brown veins, irregularly bell-bilabiate. The capsule is glandular-pubescent. Coordinates of new locations: N 56.20940, E 66.17360; N 56.20850, E 66.17330; N 56.20840, E 66,17330; N 56.20150, E 66.17180.

Neottianthe cucullata (L.) Schlechter. Orchid Family. Perennial herbaceous plant. Tubers are spherical or kidney-shaped. Stems are 10-25 cm high, thin, ribbed, at the base with two closely approximated, almost opposite leaves, of which the lower ones are elliptic, the upper ones are narrower, lanceolate. Upper leaves are small, linear-lanceolate. The inflorescence is loose, one-sided, from 6-20 violet-pink sessile flowers. The perianth leaves are linear-lanceolate, stick together, forming a helmet. Lip is deeply three-lobed; lateral lobes are narrow, linear, medium – longer and wider than lateral ones. The spur on the end is slightly widened, almost equal to the ovary. Fruit – a box. Coordinates of new locations: N 56.21460, E 66.17460.

The flora objects transferred by the method of translocation are located on nine monitoring sites of the regional ranked "Uporovsky" nature reserve. Mapping of the territory with the GPS coordinates of all transplanted individuals was carried out. Many researchers claim that after transferring the plants need time to adapt them. After this it is necessary to monitor survival [16, 17]. The survival of the transferred flora species was monitored during 2017-2018. Its results showed that the adaptation of

almost all the translocated individuals was successful. As a result of monitoring in 2018, it was noted that the flowering phenophase of *Calluna vulgaris* (L.) shifted to a later date from the beginning of July (2017) to the middle of July (2018). Phenospectra of *Neottianthe cucullata* (L.) Schlechter and *Digitalis grandiflora* Mill. in translocated individuals in 2017–2018 actually matched.

In this project, the transfer of protected (Red Book) flora species from the right-of-way of power transmission line is only one of many compensatory measures that allow preserving and restoring the natural complex, to enhance its recreational and decorative-aesthetic qualities.

4. Conclusion

Thus, a scientifically grounded transfer of individuals of protected plant species was carried out from the sites, allocated for clearing right-of-way of 110 kV power transmission line, to new habitats similar in ecological conditions located within the regional ranked "Uporovsky" nature reserve (Uporovsky district, Tyumen region, Russia). The works were carried out at the time of year favorable for transfer, taking into account the ontogeny stage of the transferred plants. Methods and approaches of translocation of vascular plant species have been developed. The preparation of plants transferring (coordinate binding, labeling, etc.), removal of the translocated individuals from the original habitat and their transportation to new safe areas was performed. The implemented project showed the effectiveness of the used methods and approaches for the translocation of vascular plants for the preservation of rare and protected flora species at the territories allocated for economic activities. Under the conditions of intensive economic development of the territory, the method of translocation of rare and protected species can become an effective mechanism for maintaining biodiversity and sustainable development of the regions. Replicating the positive experience of translocation will make it possible to use this technique for other specially protected natural areas. In the established order and, if necessary, in specially protected natural areas, measures should be taken to restore the disturbed balance in ecosystems.

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