Availability of forest plots for reforestation activities

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Abstract. Over the past decades, as a result of the economic use of forests, the impact of fires and biotic factors, the forest cover has undergone significant anthropogenic transformation. In certain forest conditions, reforestation is delayed for a long period, which leads to the accumulation of non-producing forest lands. The aim of the work was to develop a methodology for determining the criteria for accessibility of forest areas for carrying out reforestation activities on the example of the territory of the Taezhinsky forestry of the Krasnoyarsk Territory. The area is dominated by deciduous plantations of average productivity. In the surveyed areas, natural regeneration is represented by soft-leaved species - birch and aspen of medium and large size categories from 1000 to 6000 pcs/ha. There is no natural regeneration of coniferous species. In these areas, it is necessary to create forest crops. The availability of forest areas for carrying out reforestation activities is limited by the transport, ecological and economic accessibility of forest crops. Within the boundaries of transport accessible quarters for carrying out reforestation activities, areas are identified that are suitable for soil and forest growing conditions for creating forest cultures with promising forest inventory characteristics not lower than grade III. The presented conditions correspond, first of all, to the green moss and forb groups of forest types. These plots constitute the second zone of silvicultural zoning, that is, an outstanding characteristic within the transport accessible quarters. The first stage of development includes forest areas of the II class of bonitet and higher, the second stage - III class of bonitet. Areas of quality class IV and below are reserved for natural reforestation.

1. Introduction
Over the past decades, as a result of the economic use of forests, the impact of fires and biotic factors, the forest cover has undergone significant anthropogenic transformation. Clear and non-clear cuttings of the forest are carried out annually. Forests are damaged or completely destroyed by fire, insect pests, industrial emissions and natural disasters. On clearings and burned-out areas, there is often a change of species and restoration of deciduous plantations [1]. In certain forest conditions, reforestation is delayed for a long period, which leads to the accumulation of non-producing forest lands.

The state of forests is largely controlled by anthropogenic influences. The criterion reflecting the dynamics of forest cover due to anthropogenic impact is the ratio between the main forest-forming species [2].
The method of clearcutting and the subsequent direction of the succession cycle are related only to the process of subsequent recovery. In this case, it does not matter what caused the afforestation or, for example, the shrubbery of felling areas. The disturbance of the forest cover due to forest fires and felling of forest stands is expressed in comparable values of the area.

The significantly more favorable climatic and soil conditions in the southern taiga are reflected in an increase in the productivity of forest stands, a decrease in the reforestation period, and the emergence of plantations with the most diverse combination of tree species. The geographical position of the southern taiga can be considered as optimal for the existence of taiga ecosystems.

2. Materials and methods
The aim of the work was to develop a methodology for determining the criteria for accessibility of forest areas for carrying out reforestation activities on the example of the territory of the Taezhinsky forestry of the Krasnoyarsk Territory.

Before conducting the research, the following tasks were set:

- zoning of the forestry territory, taking into account accessibility;
- development of criteria for the accessibility of forest areas for reforestation activities;
- drawing up a register of areas available for reforestation in the forestry area with an indication of the location (quarter, allotment).

It was revealed that the availability of forest areas for carrying out reforestation activities is limited by the following factors:

a) transport accessibility of forest areas during the period of silvicultural work (spring, autumn), as well as agrotechnical maintenance;

b) ecological and economic accessibility of forest areas, which depends on the suitability of growing conditions for the creation and cultivation of artificial stands with forest inventory parameters not lower than natural stands under the same conditions.

One of the most important problems of forest reproduction is to determine the ratio of types of reforestation: natural overgrowth, promoting natural renewal and the creation of forest cultures.

Long-term studies [3] made it possible to determine this ratio for the forest vegetation zones and subzones of the Krasnoyarsk Territory (table 1).

| Subzones                  | Natural overgrowth,% | Promotion of natural renewal,% | Forest crops,% |
|---------------------------|----------------------|--------------------------------|---------------|
| North taiga               | 100                  | –                              | –             |
| Middle-taiga              | 85                   | 15                             | –             |
| South taiga               | 25                   | 37                             | 38            |
| Subtaezhno-forest-steppe  | 36                   | 36                             | 28            |
| Mountain taiga and mountain black | 37               | 27                             | 36            |

Forest crops are produced when natural regeneration is less efficient than them. Therefore, when designing forest crops in areas where natural regeneration is possible, it is necessary to prove that the production of crops is more efficient than the latter [4].

For the conditions of the Taezhinsky forestry, this ratio is determined as follows: natural overgrowing - 25%, assistance to natural renewal - 37%, forest crops - 38%.

According to I.I. Bashkeev [5], the economic efficiency of reforestation can be determined by a formula that takes into account the cost indicators of forest reproduction.

Identically, they propose to determine the economic efficiency of forest reproduction [6,7]. However, the time factor must be taken into account. With long reproduction cycles (50–100 years), the effect of future forest crops is reduced to an insignificant value. This is primarily due to the standard for
determining the multi-temporal costs of the EPP. This standard must meet long forest reproduction cycles.

To compare the costs of carrying out forest reproduction measures for different systems of reforestation measures, which depend on the silvicultural classification of unforested lands, the proposed formulas are not very suitable.

Earlier, we proposed a simpler version of the methodology for calculating the economic efficiency of reforestation activities, which is based on an expert assessment of the costs corresponding to each of the compared forest reproduction systems [2].

The Tayozhinskoе forestry is located on the territory of the West Siberian southern taiga plain and Central Siberian subtaiga forest-steppe regions. The total area of 1,079,853 hectares is administratively subdivided into six district forestries: Meletskoyе, Birilyusskoyе, Malо-Ketskoyе, Kytatskoyе, Birilyusskoyе rural, Novobirilyusskoyе rural. Protective forests occupy 16.7% of the forestry area, the remaining 83.3% are commercial forests.

The forested area is dominated by birch stands at 48.2% and fir stands –21.5%. Spruce stands occupy 10.5%, pine –6.0%, cedar –7.0%, aspen –6.8%.

The average bonitet class is III.4 for conifers, II.7 for deciduous ones. The share of plantations with higher bonitet classes (II and higher) is 22.6%. The share of low-density forest stands (0.3–0.5) is 42.0%.

As of 01.01.2019, the forestry had 15659 hectares of forest crops, 857 hectares of unclosed forest cultures and 20670 hectares of land intended for reforestation (reforestation fund). Of this fund, 305 hectares are attributed to dry forests, 6755 hectares - to dead stands, 11957 hectares - to felling and 1653 hectares - to clearings and wastelands.

The reforestation fund is distributed according to renewal methods as follows:

- natural reforestation - 1286 ha,
- assistance to natural regeneration - 17891 hectares,
- lands on which reforestation can be ensured only through the creation of forest plantations - 1493 hectares, including those available for economic impact (forestry fund) - 278 hectares.

It should be noted that the safety of forest crops largely depends on the technology of creation and technical equipment of the process of planting artificial plantations [8,9,10]. The species composition of forest crops created in 2018 is represented by spruce - 30 hectares, care of forest crops in translation into a single one was 210 hectares, forest crops were transferred to wooded lands - 251.5 hectares.

There are no permanent seed plots and seed plantations.

3. Results and discussion

The survey covered forest areas that are part of the reforestation fund of the territory of the KGBU "Taezhinskoe lesnichestvo" (table 2).

The results of field surveys of part of the forest areas described in Table 2 are presented below. The characteristics of natural renewal are shown in table 3.

Plot number 1. Located in Birilyussky uchastkovoyе lesnichestvo in the 80th quarter of the 6th division, the area is 10 hectares. Coordinates: latitude north - 57°09'11''; east longitude - 90°84'37''. It is a clearing. The soil is gray forest medium loamy fresh. In the clearing, there are biogroups of Scots pine, aspen, birch, and a single Siberian cedar. Composition - 5 Birches, 4 Pines, 1 Aspen. The age of birch is 88 years old, pine trees are 160 years old, and aspen trees are 87 years old.

Average heights: Birch - 24 m, Pine - 28 m, Aspen - 23 m; diameters: Birch - 26 cm, Aspen - 24 cm, Pine - 28 cm.

The distribution over the area of natural regeneration is uneven, single or in clumps directly near birch or aspen trees. There is a single spirea average. There is no coniferous undergrowth. A strong sodding of the soil was established by blunt reed grass. The living ground cover contains a large number of herb species. The average height of the living ground cover is 1.2 m.

Forest crops created on this site have died. The cause of their death was a forest grassland fire.
Table 2. List of sites surveyed in the field according to the latest forest inventory.

| №  | District forestry       | Quarter | Highlighted | Area, ha | Plot characteristics                                                                 |
|----|------------------------|---------|-------------|---------|--------------------------------------------------------------------------------------|
| 1  | Birilyusskoe           | 80      | 6           | 10      | Clearing, III bonitet, forest type - RT, units. 6 Birch 4 Pines (70), gray forest soil, strong turf, spirea, rose hips, medium density; household’s activities: forest. culture |
| 2  | Birilyusskoe           | 88      | 11          | 7       | Clearing, III bonitet, forest type - RT, units. 10 Birch (65), gray forest bee, strong turf; household’s activities: forest. culture |
| 6  | Malo-Ketskoe           | 145     | 4           | 77      | Clearing, III bonitet, type of forest - OCP, unit. 8 B2 Asp (15), medium podzol soil., Fresh, strong turf, pdl dog-rose, spirea, willow bush. thick; household’s activities: forest. culture |
| 11 | Novobirilyusskoe       | 7       | 3           | 10      | 4 As 2 As 4 B 16 m, 55 years old, grade III, large-grass, density 0.5, 110 m³/ha |

Total 224

Plot number 2. Located in Birilyusskoy uchastkovoye lesnichestvo in the 88th quarter of the 11th section, the area is 7 hectares. Coordinates: north latitude - 57°05'97''; east longitude - 90°81'57'' (figure 1).

It is a clearing. The soil is gray forest medium loamy fresh.

Figure 1. Severe turfing of plot №2.
Biogroups of birch trees are found in the clearing. Composition - 10B. The birch is 84 years old. Average height - 23 m; diameter - 24 cm. Distribution over the area of natural regeneration is uneven. Scots pine undergrowth is absent. A strong sodding of the soil was established by blunt reed grass. The living ground cover contains a large number of herb species. The average height of the living ground cover is 1.1 m.

Plot number 6. Located in the Malo-Ketsky uchastkovey lesnichestvo in the 145th quarter of the 4th section, the area is 77 hectares. Coordinates: north latitude - 57°35’32”; east longitude - 90°79’92”. It is a forb birch forest renewed in a clearing. The soil is soddy, medium-podzolized, medium loamy, fresh. In the clearing, single trees of aspen, birch and Siberian fir are found. Composition: 7B3Asp singly Siberian fir. The age of the birch is 30 years, average: height - 20 m, diameter - 16 cm. The distribution over the area of natural regeneration is uneven, by biogroups. There is no renewal of conifers. There are thickets of spirea with an average height of 1.0 m to 1.5 m, wild rose with a height of 0.5 m to 1.2 m. The undergrowth is represented by goat willow. Sodding of the soil with large-tailed sedge has been established. The living ground cover contains a large number of herb species. The average height of the living ground cover is 1.4 m. Forest cultures created in the clearing are dead.

Plot number 11. Located on the territory of the Novobirilyussky collective farm “Bolshevik” in the 7th quarter of the 3rd section, area of 10 hectares. Coordinates: latitude north - 57°06’95”; east longitude - 90°73’30”. It is a clearing. The soil is gray forest, medium loamy, moist. There are aspen and birch trees in the clearing. Composition - 6Asp4B. The age of the aspen is 60 years. Medium: height - 24 m; diameter - 26 cm. The distribution over the area of natural regeneration is uneven, in biogroups and, mainly, around aspen trees (the size of biogroups is 30 × 60 m). There is a single spirea average.

A strong turfing of the soil was established by big-tailed sedge. The living ground cover contains a large number of herb species. The average height of the living ground cover is 1.4 m.

Inspection of forest areas made it possible to state the following:

• the previous forest inventory adequately assessed the state of unforested lands (mainly clearings of forb and large-herb groups of forest types of grade III quality class) and outlined the creation of forest plantations on them;
• forest plantations were created by the forestry on plots 1, 4, 6, 7. They died as a result of ground fires;
• in the surveyed areas, natural regeneration is represented by soft-leaved species - birch and aspen of medium and large size categories from 1000 to 6000 pcs / ha. There is no natural regeneration of coniferous species. On these sites, it is necessary to create forest plantations (table 3).

| Plot No. | Breeds      | Forest type group | Number of undergrowth, thousand pcs. per 1 ha, depending on the size category |
|----------|-------------|-------------------|--------------------------------------------------------------------------------|
|          |             |                   | Shallow 0.1–0.5 m | Medium 0.6–1.5 m | Large - more than 1.5 m |
| 1        | Birch tree  | herb              | absent            | 750               | 500                     |
|          | Aspen       |                   | absent            | 2750              | 3750                    |
| 2        | Birch tree  | herb              | absent            | 600               | 350                     |
|          | Aspen       |                   | absent            |                    | absent                  |
|          |             |                   |                   |                    |                         |
| 6        | Birch tree  | herb green        | absent            | 3000              | 400                     |
|          | Aspen       | moss              | absent            | 1000              | 200                     |
|          |             |                   |                   |                    |                         |
|          |             |                   |                   |                    |                         |
| 11       | Aspen       | herb              | absent            | 1667              | 3611                    |
|          | Birch tree  |                   | absent            |                    | absent                  |

Table 3. Characteristics of natural regeneration in the surveyed areas.
The transport accessibility of forest areas for the purpose of artificial reforestation has been determined and agreed with the Tayozhinsky forestry. Further, within the boundaries of transport accessible quarters for carrying out reforestation activities, areas are identified that are suitable for soil and forest growing conditions for creating forest cultures with promising forest inventory characteristics.

4. Conclusion
As a result of the studies performed, the following can be stated:

- The territory is dominated by deciduous plantations of average productivity. The area of created forest plantations is 1.5% of the total area of the forestry.
- The reforestation fund according to the forestry data is 20670 hectares, including the forestry fund available for economic impact - 278 hectares.
- Forest crops are produced when natural regeneration is less efficient than them. Therefore, when designing forest crops in areas where natural regeneration is possible, it is necessary to prove that the production of crops is more efficient than the latter.
- In the surveyed areas, natural regeneration is represented by soft-leaved species - birch and aspen of medium and large size categories from 1000 to 6000 pcs/ha. There is no natural regeneration of coniferous species. In these areas, it is necessary to create forest crops.
- The availability of forest areas for carrying out reforestation activities is limited by the transport, ecological and economic accessibility of forest crops.
- Within the boundaries of transport accessible quarters for carrying out reforestation activities, areas are identified that are suitable for soil and forest growing conditions for creating forest cultures with promising forest inventory characteristics not lower than grade III. These conditions correspond, first of all, to the green moss and forb groups of forest types. These areas constitute the second zone of the zoning of cultures, that is, an eminent characteristic within the limits of transport accessible quarters. The first stage of development covers forest areas of the II class of bonitet and higher, the second stage - areas of the III class of bonitet. Plots of quality class IV and below are reserved for natural reforestation. Thus, the first stage of forestry development is 188.2 hectares, the second - 1663.8 hectares, the third - 147 hectares (the third stage of development includes areas of a large-herb group of forest types of the III quality class).
- A zoning scheme was drawn up for the forestry area according to its accessibility for reforestation.

Thus, a methodology for assessing the availability of forest areas for the creation of forest plantations is presented. The forest fund of the territory of the Tayozhinsky forestry by its structure is modal for the southern taiga plantations.

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