Silvicultural and ecological assessment of renewal cuttings

E A Surina[1*], and *N S* Minin[1]

[1]FBU "Northern Research Institute of forestry", Research Department, 13, Nikitova, Arkhangelsk, 163062, Russian Federation

Abstract. The objects of research were forest plantations, passed through renovation rubles in the Arkhangelsk forestry of the Arkhangelsk region. Trial plots were established in spruce plantations (bilberry spruce forest and sphagnum spruce forest), on fresh haulage, in apiary, and on old haulage after felling more than 30 years ago. Based on the results of the research, a model was built, with the help of which it is consistently assessed during the course of the research what happens to the forest stand after cutting (on a fresh trail, 4-5 years after cutting) and after more than 30 years on an old trail. In the blueberry spruce forest, 4-5 years after felling, the amount of undergrowth increased slightly (by 1500 pieces/ha) compared to the forest stand and mainly due to self-sowing, the species composition was preserved - spruce, birch, aspen. After more than 30 years, there was a massive increase in undergrowth by 8 times. In the sphagnum spruce forest in the apiary, birch prevailed; immediately after felling, due to littering and the impact of machinery, undergrowth settlement was not observed. After more than 30 years, the number of undergrowth increased due to birch (69%). Thus, by evaluating the undergrowth and undergrowth in the blueberry type of forest, the felling strategy is updated. In the sphagnum type, reforestation processes continue and reforestation processes are still observed.

1 Introduction

The main normative act regulating the sphere of forest relations in the Russian Federation is the Forest Code adopted in 2006 [1]. The development of forestry is one of the priority areas of activity of the Ministry of Natural Resources of Russia, it is carried out comprehensively, in accordance with the instructions of the President and the Government of the Russian Federation, the Fundamentals of State Policy in the field of use, protection, protection and reproduction of forests for the period up to 2030, the Strategy for the development of the forest complex of the Russian Federation until 2030 [2-3]. The organization of the relevant work is aimed at solving the problem of forest conservation, set in the Decree of the President of the Russian Federation of 07.05.2018 No. 204 "On national goals and strategic objectives for the development of the Russian Federation for the period up to forests" of the national project "Ecology" [4-5]. The goal of the project is

* Corresponding author: surina_ea@sevniilh-arh.ru

to ensure a balance between the disposal and reproduction of forests in the ratio of 100% by 2024. The priority is the conservation of forests, including on the basis of their reproduction in all areas, cut down and dead forest plantations. Decree of the Government of the Russian Federation dated February 11, 2021 No. 312-r "On Approval of the Strategy for the Development of the Forest Complex of the Russian Federation until 2030" approved the Strategy for the Development of the Forest Complex of the Russian Federation until 2030. The strategy is aimed at achieving sustainable forest management, innovative and efficient development of the use, protection, protection and reproduction of forests, ensuring the rapid growth of the forest sector of the economy, social and environmental security of the country, unconditional fulfillment of the international obligations of the Russian Federation in terms of forests. On January 1, 2021, new Rules for Forest Care came into force, approved by Order of the Ministry of Natural Resources and Ecology of the Russian Federation dated July 30, 2020 No. 534, which made further changes to the Rules for Forest Care [6]. On January 1, 2021, the Order of the Ministry of Natural Resources of Russia dated December 1, 2020 No. 993 "On Approval of the Rules for Timber Harvesting and Features of Timber Harvesting in Forest Areas, Forest Parks, Specified in Article 23 of the Forest Code of the Russian Federation" came into force [7]. The state policy in the field of forest relations is defined by a special document - the Fundamentals of State Policy in the field of use, protection, protection and reproduction of forests in the Russian Federation for the period up to 2030, approved by the order of the Government of the Russian Federation of September 26, 2013 No. 1724-r [2]. Among the mechanisms and tasks for the implementation of state policy in the field of use, protection, protection and reproduction of forests, the increase in the efficiency of forest sector management is also indicated. At the regional level, in some constituent entities of the Russian Federation, within the framework of planning, such strategic planning documents as state programs in the field of forest relations and the forest complex are developed and approved. Thus, the state program of the Arkhangelsk region "Development of the forest complex of the Arkhangelsk region", approved by the Decree of the Government of the Arkhangelsk region of October 8, 2013 No. 459-p (as amended on August 18, 2022) [8], includes the subprograms "Ensuring the use of forests", "Reproduction of forests" and "Protection and protection of forests". Decree of the Government of the Russian Federation of April 15, 2014 No. 318 (as amended on March 31, 2021) approved the State Program of the Russian Federation "Forestry Development", the goals of which are to increase the efficiency of the use, protection, protection and reproduction of forests, to ensure stable satisfaction public needs for resources and useful properties of the forest with guaranteed preservation of the resource and ecological potential and global functions of forests [9]. Mandatory conditions for the implementation of the Strategy for the Development of the Forest Complex of the Russian Federation until 2030 are, among other things, the promotion of rational forest management and intensive use, reforestation. Cuttings for the renewal of forest plantations are carried out in accordance with the standards specified in the Order of the Ministry of Natural Resources of Russia dated July 30, 2020 No. 534 "On Approval of the Rules for Forest Care". Felling of forest plantations renewal carried out in overmature forest stands, mature forest stands and in mature forest stands losing their intended functions in order to create favorable conditions for the growth of young promising trees present in the plantation, appearing in connection with the promotion of forest regeneration and felling of forest plantations carried out for the purpose of care behind forest plantations (Article 10). Renewal cuttings are not carried out in walnut commercial zones and in forest plantations with a predominance of Korean pine (Article 14). Renewal felling of forest plantations located in specially protected natural areas is allowed only if their implementation is established by the regulations on this specially protected natural area (Article 15). The age periods for various types of cuttings carried out for the purpose of caring for forest

plantations are given in Appendix No. 1 to the Rules (Article 16). Measures for the renewal of plantations (renewal felling and activities supplementing it) are carried out with the assistance of natural reforestation or with the planting of target tree species in mature and overmature forest stands that are losing their useful functions, or in weakened, losing stability, viability of maturing forest plantations. Activities for the renewal of forest plantations should not be carried out in forest plantations growing on slopes with a steepness of more than 20 degrees, as well as in forests located in forest-tundra zones, in spawning forest belts (Article 44).

2 Materials and methods

The objects of research were forest plantations, passed through renewal felling in the Arkhangelsk forestry in the Arkhangelsk region. Cuttings were carried out by the strip method. The entire forest stand and undergrowth were removed in the strips. Overmature, diseased, dry, unpromising and dry undergrowth trees were cut down. Selection of sites for detailed study, laying of test plots and route passages for instrumental-eye survey in the most common types of forest.

All trial plots were planted in different types of forest (bilberry spruce forest and sphagnum spruce forest) in compliance with OST 56-69-83 “Forest management trial plots. bookmark methods. The type of forest is determined according to the classification of V.N. Sukachev, a geobotanical description is also carried out on it. Detailed accounting of trees on samples by thickness steps, with their division into generations (if the plantation is of different ages), condition categories [10].

Trial area No. 1. Trial area - 0.25 ha. Type of forest - fresh blueberry spruce forest. The terrain is flat, the microrelief is represented by overgrown stumps and fallen trees. Stand age class − VI. The average stand height is 17.6 m, the average diameter is 18.3 cm.

Trial plot 2, area 0.05 ha. Forest type - sphagnum spruce forest. The terrain is a hilly plain, the microrelief is represented by hummocks. Age class - VI. Quality class - IV. The average height of the stand is 15.2 m, the average diameter is -16.4 cm. The intensity of felling in apiaries is 25%.

3 Results

When cutting renewal, the main indicators are qualitative and quantitative changes in the undergrowth. On the old portage under the conditions of the blueberry type of forest vegetation conditions, an increase in undergrowth occurred due to an increase in the undergrowth of spruce and birch. More than 30 years after the felling, there was no aspen left on the old portage, and more than half of the area is occupied by spruce. Due to the mineralization of the soil during felling and the accumulation of seeds from the apiary, pine appeared, birch was 2 times more. On the portage, on which felling was carried out 4-5 years ago, aspen and birch were found almost everywhere. Spruce undergrowth occupied no more than 10%.

Mostly, the participation of reliable undergrowth was spruce in the apiary and on portages, and in the apiary and on the old portage, the occurrence of reliable undergrowth was 84-87%, and in fresh 67%, probably the undergrowth was damaged during felling. In the apiary, more than half of the birch is dubious undergrowth, on the old trail, after more than 30 years, the number of trustworthy undergrowth has increased due to improved lighting and heat supply. Aspen undergrowth in all three plots is a trustworthy undergrowth. The pine that appeared on the old portage is almost all trustworthy. In the apiary, spruce recovery is poor, the amount of viable undergrowth is less than 1290 pieces/ha. After more

than 30 years on the old trail for spruce and pine undergrowth, the restoration is satisfactory, since spruce - more than 2500 pieces/ha, and pine - more than 1290 pieces/ha. On a fresh portage, as well as in an apiary, recovery is worse, they did not eat enough. In the apiary and on the old portage, there is more undergrowth of different species (coniferous and deciduous) of medium size, and small and large - an equal amount. In the apiary, almost the entire undergrowth of the preliminary generation is found, on the old trail there is an undergrowth of the subsequent generation of medium size. Two-thirds of the new trail is represented by undergrowth of medium size coniferous and deciduous, 4390 pieces/ha, and the remaining third was occupied by small, large undergrowth was encountered singly. In general, undergrowth of medium size prevails in the blueberry type in all three plots.

In the apiary there is common wild rose (Rosa eanina L.), common juniper (*Juniperus communis L.*), single mountain ash (*Sorbus aucuparia*). In the area where felling was carried out 4-5 years ago, there are 1200 less common rose hips per hectare. Common juniper (*Juniperus communis L.*) was practically absent, common mountain ash (*Sorbus aucuparia*) – 3500 pieces/ha. After more than 30 years, alder (2300 pcs/ha) and willow (1200 pcs/ha) appeared on the old portage. The density of wild rose (*Rosa eanina L.*) and common juniper (*Juniperus communis L.*) is the same as on the new trail.

According to the data obtained, the undergrowth on the trail was consistently ahead of the undergrowth of the same size category under the canopy of the forest stand. These differences have already persisted for 10 years. In the undergrowth on the trail, the growth in height has increased in recent years, this is especially noticeable in the undergrowth of medium size. There is a clear trend in the intensity of growth of large undergrowth on the run, namely: 1 - the undergrowth of the preliminary generation successfully adapted to new conditions on the run, 2 - this category included undergrowth, which was small, and after felling quickly adapted and had intensive growth. Undergrowth grows well on the drag, due to the fact that the best conditions for growth have been created. Large undergrowth could experience unstable growth in the first years as a result of harsh lighting, which led to a decrease in growth. In the future, as it adapted, it was ahead of the undergrowth in growth, which was previously under the canopy of the forest stand.

Blueberry (*Vaccínium myrtíllus*) (70%) prevails in the forest stand among the grass-shrub layer, 12 species of plants are found under the canopy. At the same time, 4-5 years after felling, the diversity of species is richer on the portage, 23 species were found. In the moss cover under the canopy of the forest stand, *Hylocomium splendens* (30%) and *Pleurozium schreberi* (20%) dominate. Large dicranums (*Dicranum majus Turne*), broom-shaped (*Dicranum scoparium Hedw*) were abundant. Rarely you can find sphagnums - cuckoo flax (*Polýtrichum commúne*), triangular rhytiadelphus (*Rhytidiadelphus triquetrus (Hedw.) Warnst*.). The area occupied by mosses decreased after felling. On the portage, each of the above mosses occupies less than 10%, rarely there are broom-shaped dicranum (*Dicranum scoparium Hedw*), triangular rhytiadelphus (*Rhytidiadelphus triquetrus (Hedw.*) *Warnst.*), mniums appear. At the same time, immediately after 4-5 years after felling, there were significant changes: the number of species increased, dominant blueberries (*Vaccínium myrtíllus*) disappeared, up to 50% of the ground cover was missing.

During felling, the forest litter on the new trail almost disappeared. Due to the passage of machinery on the new portage, the upper horizons of the soil were significantly compacted on the portage. At a depth of 20-30 cm, the untouched soil in the stand is denser than the disturbed soil on the trail. More than 30 years after felling, the influence of technology on the upper horizon was observed on the old portage. The forest litter was formed, a thick organogenic horizon was formed, divided into 2 parts: the forest litter and the mixed horizon. A mixed horizon with a large amount of organic matter formed under the forest floor. Due to the large presence of organic matter, the content of field moisture in

the upper horizon increased markedly. This horizon did not look like a sod, not a coarse humus one. At a depth of 20 cm of soil, the influence of technology is due to the mixing of soil horizons, since the bulk density of the soil is lower than in the forest stand. At a depth of 30 cm of soil, the differences are already less noticeable and the horizons are typical. The upper soil horizons warmed up most intensively on the new trail, devoid of vegetation and forest litter. After felling, no significant changes in soil temperature were revealed; only the soil surface warmed up more strongly. Perhaps, excess moisture prevented warming up (water stands in ruts even in summer). At the same time, due to successful growth, restoration of undergrowth and undergrowth, the soil temperature is much lower on the old trail. Probably, the thick organogenic mixed peaty horizon, which played the role of a buffer and did not transmit heat, contributed to the temperature decrease.

Thus, the ecological consequences of logging in the blueberry type of forest had an impact on the soil for more than 30 years, the soil became more loose, porous due to the mixing of forest litter and mineral layers, warmed up worse and a powerful mixed horizon was formed.

4 Discussion

An almost threefold increase in the number of undergrowth was found on the portage after recent felling compared to the apiary, probably due to birch. In general, the increase in the number of undergrowth occurred three times. Two-thirds of the undergrowth in the apiary is birch, one-fourth was occupied by spruce, and the rest by aspen. In the old portage, compared to the apiary, there were 3.3 times more spruce, and 2.8 times more birch. More than half of the undergrowth is viable and trustworthy, except for aspen.

The number of viable undergrowth is 800-1700 pieces/ha. On the old portage, the renewal of spruce was satisfactory, as they ate more than 1700 pieces/ha, pines - less than 400 pieces/ha. In the apiary, all three groups in terms of undergrowth size met more or less evenly, although there was slightly less small undergrowth. And on the old trail there was large and medium undergrowth, small undergrowth less often. In the apiary, almost the entire undergrowth of the preliminary generation, on the old trail, the undergrowth is mainly of the subsequent generation.

There was practically nothing left of the undergrowth on the fresh trail, more than half of the space was occupied by ruts from the passage of equipment. The apiary was dominated by common wild rose (*Rosa eanina L.*) and common juniper (*Juniperus communis L.*), rare mountain ash (*Sorbus aucuparia*) and willow. And on the old trail, due to excessive moisture, water began to accumulate, among the undergrowth there remained a more resistant to waterlogging breed of willow, 9300 pcs./ha. Single wild rose (*Rosa eanina L.*), mountain ash (*Sorbus aucuparia*), alder. Models of spruce undergrowth of different sizes were taken in the apiary and on the old portage. The average heights of medium and large undergrowth spruce in the apiary are less than in the portage; in small undergrowth, the heights are the same.

In recent years, in small undergrowth, average growth in height over the years was observed higher in the apiary. It is possible that after the cuttings, the tracks remaining after the passage of equipment served as a drainage system, removing moisture. The undergrowth settled on the rises between the formed ruts, where favorable conditions were created for the growth and development of undergrowth. Over time, the tracks became overgrown, in the first 20 years they still retained drainage functions, and in recent years, moisture removal has stopped. Water began to stagnate, taking into account the type of forest conditions, waterlogging occurred, which negatively affected the growth of spruce undergrowth. In the apiary, meanwhile, the growing conditions have not changed and growth could only increase. The undergrowth of the medium size category in the apiary has

average growths from 3 to 4 cm, on the run from 2 to 3 cm. Spruce on the run differed in the best growth. Large undergrowth in the forest stand and on the trail was equal in height, after a while the average growth in height on the old trail became larger, and the growth became better and in 2022 the average height of spruce in open areas became greater than under the canopy.

Under the canopy of forest stands in the grass-shrub layer, 18 plant species were identified. Their mosses are dominated by sphagnum mosses (covered by 80%), common polytrichum (*Polýtrichum commúne*) is abundant. At the same time, the variety of plant species is richer on the fresh trail. In the grass-shrub layer, 28 plant species were identified. Species such as field horsetail (*Equisetum arvense*) and marsh horsetail (*Equisétum palústre*) have disappeared. The coverage of each of the moss species is less than 10%, but sphagnums and common polytrichum (*Polýtrichum commúne*), rarely broom-shaped dicranum (*Dicranum scoparium Hedw*.), compressed polytrichum (*Polytrichum strictum Brid*) still dominated.

Thus, in the sphagnum forest type, the living ground cover was restored 30 years after felling. Some time later, immediately after felling, significant changes occurred: the number of species increased, some moisture-loving species disappeared (marsh horsetail (*Equisétum palústre*), field horsetail (*Equisétum arvénse*)); due to the drying of the haul from the passage of machinery, meadow plant species appeared (drooping barley grass (*Mélica nútans*), meadow grass (*Lathyrus pratensis L.*), thin bentgrass (*Agrostis tenuis Sibth*), soddy meadow grass (*Deschampsia caespitosa (L.) beauv*.) , there was no ground cover on more than 50% of the area, sphagnum was found on less than 40% of the area.

In the sphagnum type of forest, the influence of technology affected the depth of more than 30 cm. On the old trail, after 30 years, a decrease in temperature was revealed compared to the forest stand due to stronger shading. After felling the forest stand, when a layer of mixed horizons formed on the trail, the soil warmed up worse, this may be due to increased soil moisture (water was constantly in the ruts). On the old trail, the temperature on the soil surface is somewhat lower due to undergrowth and undergrowth, which also led to a slight decrease in temperature in the lower horizons compared to the forest stand.

5 Conclusion

One of the felling indicators is the amount of undergrowth and undergrowth, which depends on forest conditions. In the blueberry spruce forest, a few years after felling, the amount of undergrowth increased slightly (by 1500 pieces/ha) compared to the forest stand due to self-sowing, the species composition was preserved - spruce, birch, aspen. After more than 30 years, there was an expected increase in the number of undergrowth by almost 8 times, mainly due to spruce (58%), the diversity of species only increased (pine appeared). In the sphagnum spruce forest in the apiary, birch prevailed; immediately after felling, due to littering and the passage of machinery, undergrowth settlement was not observed. After more than 30 years, the number of undergrowth increased, mainly due to birch (69%). There was no change in the dominant species, although the number of spruce did increase. All aspen, which turned out to be less resistant to waterlogging than birch, disappeared from the portage, but pine appeared sporadically. The clutter of the trail after felling is important. The more littering, the higher the fire hazard, the worse the conditions for natural restoration and the worse the sanitary condition of the forest. In the forest stand, the littering of the area is less than 1%, while the portage is littered by almost half of the area. Clutter on the portage was 416 m3/ha.

Thus, evaluating the undergrowth and undergrowth in the blueberry type, the renewal felling turned out to be appropriate. After it, for more than 30 years, undergrowth was formed for the subsequent formation of a forest stand: 1st tier - from spruce, pine, birch and

aspen; 2nd tier - from mountain ash (*Sorbus aucuparia*), wild rose (*Rosa eanina L.*), alder, willow, common juniper (*Juniperus communis L.*). In the sphagnum type of forest on the portage, in which the forest stand was formed, there were only 4 species - spruce, birch, willow, and singly pine. Changes in the living ground cover are also significant. In the sphagnum spruce forest, also with increased illumination, the species diversity of the ground cover became richer. The trail was less than 50% covered with plants, a large percentage of the area was occupied by ruts filled with water and logging residues. During the felling, the forest litter was pulled off on the portage. The mixing of heavy mineral horizons with organic horizons had a great influence on the openness and density of the soil on the trails. In the sphagnum forest type, soil changes after felling were significant due to higher soil moisture and the thickness of the organogenic peat horizon. The logging action continues even now, because the soil has been significantly damaged due to the mixing of horizons, and restoration processes are still taking place in it.

Undergrowth species are diverse in types. In the sphagnum spruce forest, more than 30 years after felling, there was a large amount of birch, spruce, and singly pine. Of the undergrowth, only willow of coppice origin, which had a negative effect (coppice trees earlier and more often than others are susceptible to rot and diseases).

The negative point was that almost all blueberries (*Vaccinium myrtíllus*) and lingonberries (*Vaccinium vitis-idaea*) disappeared from the fresh trail in the blueberry forest type and high littering.

References

1. Forest Code of the Russian Federation, Federal Law of December 4, 2006 No. 200-FZ (2006)
2. Decree of the Government of the Russian Federation dated September 26, 2013 No. 1724-r “On approval of the Fundamentals of State Policy in the field of use, protection, protection and reproduction of forests in the Russian Federation for the period up to 2030” (2013)
3. Decree of the Government of the Russian Federation of February 11, 2021 "On approval of the Strategy for the development of the forest complex of the Russian Federation until 2030" (2021)
4. Decree of the President of the Russian Federation of 07.05.2018 No. 204 "On the national goals and strategic objectives of the development of the Russian Federation for the period up to 2024" (2018)
5. Federal project "Preservation of forests" within the framework of the national project "Ecology (2019)
6. Order of the Ministry of Natural Resources of Russia dated July 30, 2020 No. 534 “On approval of the Rules for the care of forests” (2020)
7. Order of the Ministry of Natural Resources of Russia dated 01.12.2020 No. 993 “On approval of the Rules for logging and features of logging in forest areas, forest parks specified in Article 23 of the Forest Code of the Russian Federation” (2020)
8. The state program of the Arkhangelsk region "Development of the forest complex of the Arkhangelsk region", approved by the Decree of the Government of the Arkhangelsk region of October 8, 2013 No. 459-p (2013)
9. The State Program of the Russian Federation "Forestry Development", approved by the Decree of the Government of the Russian Federation of April 15, 2014 No. 318 (2014)
10. OST 56-69-83 “Trial forest management plots. bookmark methods (1983)