Journal of Engineering and Applied Sciences 13 (Special Issue 8): 6494-6499, 2018
ISSN: 1816-949X

Reproduction of Stable Pine Forests in the Southern Urals

Kamil M. Gabdrakhimov, Alfat F. Khayretdinov, Rida R. Sultanova, Svetlana I. Konashova, Vladimir F. Konovalov, Ildar G. Sabirzyanov, Aydar K. Gabdelkhakov, Regina R. Isyanyulova, Maria V. Martynova and Lyubov' N. Blonskaya
Federal State Budget Educational Institution of Higher Education,
"Bashkir State Agrarian University", 50th Anniversary of October Street 34., Ufa, Russia

Abstract: Multipurpose target use of forest resources in modern times of society development requires the reproduction of stable pine forests. Natural reproduction of stable forest ecosystems often suffers under the influence of natural and economic factors which leads at the first turn to the disappearance of ripening and mature stand undergrowth. The aim of the research is to find appropriate ways of pine forests reproduction in the Southern Urals. The objects of the research are pine stands growing in different forests and differ from each other in normality, stand composition, age and growth class. Conservation of biodiversity and increase in tolerance of pine forests are possible with the stimulation of the natural forest reproduction by contributing to the natural forest restocking taking into account forest types. Presence of undergrowth and of natural seeding under the canopy is a mark of pine stand tolerance. On the basis of the research made on sample plots and according to the data of forest management over an area of 775.3 thousand of hectare there have been made a classification arrangement of forest reproduction, a division of forest types into eight groups in accordance to the reforestation effect and there have been elaborated recommendations for the natural and combined reproduction of stable pine forests in the Southern Urals.

Key words: Forest reproduction, pine, contribution to the natural reproduction, combined forest reproduction, forest crops, combined reproduction

INTRODUCTION

Forest resources belong to the most important natural renewable resources. Continuous forest growth and development is assured by natural, combined and artificial forest-making processes which are influenced by different natural and economic factors.

As Kirkman notes pine forests reproduction is a long-term prospects both for timber harvesting and for other ways of forest land use. In addition to this, time is the main variable in the process of creating sound forest stands, managing the forest structure and biodiversity reproduction (Kirkman and Jack, 2017).

Insufficient amount of natural seeding and undergrowth under the pine forest canopy, change to soft-wooded broadleaved species after clear felling without helping natural reproduction and other reasons result in the necessity to create artificial forests which in its turn results in the decrease in biodiversity and in the climax forest tolerance as well.

Brockway and Outcalt (2017) notes that free and gradual felling of pine forests have favorable effect on the natural pine reproduction by decreasing the amount of overstorey trees and by increasing at the same time the amount of available light and soil resources.

Intensive economic activity results in profound changes of plants after timber harvesting and after other use of forest lands. It can be seen, especially in the silvicultural and valuation marks of the young generation. Owens thinks that the Scotch pine reproduction potential is determined first of all by the amount of conelets and conelet seeds which later can form sound undergrowth under the forest canopy.

As Smolonogov notes, reproduction and forming technologies of pine forests require deep knowledge in the field of forestry but possible ecological problems should be also taken into account during forest reproduction without regard to the forest site.

When reproducting forests in modern times they fall back more often on creation of forest crops but also including natural and combined reproduction process of primary forests which is controlled and regulated by forestry specialists. Complete forest reproduction is meant

Corresponding Author: Kamil M. Gabdrakhimov, Federal State Budget Educational Institution of Higher Education, "Bashkir State Agrarian University", 50th Anniversary of October Street 34., Ufa, Russia

only when speaking about protected forests. In specific forests and in economically used forests where natural reproduction is actively supported it is possible to get high yields of highly productive plants (Kutiavin and Torlopova, 2016).

Creation of forest crops is recommended when there is no undergrowth under the forest canopy or when forest reproduction is carried out by the use of general-purpose species.

Combined reproduction representing combination of artificial and natural forest reproduction can become the most efficient way now a days. In addition to this method both natural reproduction of forest crops and stimulating of natural reproduction of main trees (Gabdrakhimov and Khatmullin, 2001).

In the view of Avrov (2000) and Belov *et al.* (2016) as far as of other scientists biological balance in the forest is assured by the combination of both natural and artificial forest reproduction.

Natural and artificial forest reproduction are sometimes considered as antipodes. Different ways of reproduction should be considered according to each particular case. Reproduction of forest plants is necessary for getting good timber for producing seeds for carbon combining and for co-producing of numerous forest products. Many research foresters suppose that it is necessary to apply modern combined methods of forest reproduction to obtain full reforestation of the forest site which is more productive in the context of raw materials and ecology (Luganskii *et al*, 2010; Siren, 1974).

The goal of the research is to justify optimization parameters of forming and reproduction of stable pine forests. The tasks of the research are to make a comparative evaluation of different ways of forest reproduction in different soil and typological conditions and to develop a recommendation on how to increase the pine forests tolerance of the Southern Urals Region.

MATERIALS AND METHODS

The objects of the research are pine trees of the Southern Urals regin of the Republic of Bashkortostan (RB) growng in different forest growth conditions. Evaluation of the forest reproductive potential has been made on permanent study areas of district forestries with the use of the materials of forest management. The state of the undergrowth has been estimated based on the standard taxation methods depending its on size categories and state.

Researches made in the forests of the Southern Urals allowed to estimate reforestation potential of pine plantations, their first and further reproduction. There has been revealed the dependence of the amount of undergrowth and natural seeding under the forest canopy on the forest types. Research materials represent theoretical and practical recommendations for optimization of forming and reproduction of stable pine forests in the Sothern Urals.

RESULTS AND DISCUSSION

The problems of reproduction and the formation of stable pine plantations in the Southern Urals must be addressed by the introduction of modern technologies to promote natural regeneration and the creation of forest cultures, taking into account the diversity of natural and climatic and economic conditions.

Reproduction of stable pine plantations, taking into account forest types ID closely interrelated with the optimization of the timber harvesting system. For today, only 20% of cuttings can be provided with natural restoration of pine forests. The use of partial cuttings in uneven-aged and mixed plantations will allow to increase the areas of natural continuously producing stands.

Reproduction of stable pine forests can be achieved by facilitating the natural renewal and expansion of combined reproduction. Natural regenerative processes lead to biological equilibrium in the forest and allow the constant forest use (Muller, 1981). In the classification of forest reproduction that we have developed, they are divided into methods, practices, methods and types, focusing attention on the importance of forest reproduction (Fig. 1).

Kirkman pay attention to local reproduction of forests and did not always pay attention to the importance of forest reproduction. Currently, the purpose of future forests is of great importance and therefore, when reproducing forests, it is necessary to know the type of use of each specific forest area and to take it into account when forming the composition and structure of future plantations (Kirkman and Jack, 2017; Jin *et al*., 2017).

When choosing methods and ways of forest reproduction, it is necessary to focus on the future significance and use of this forest area, taking into account the natural and economic conditions of the region.

In the forest reproduction of the South Urals in recent years, the prevalence of forest crops is driven by the lack or insufficient amount of natural pre and subsequent renewal. With combined reproduction of forests,

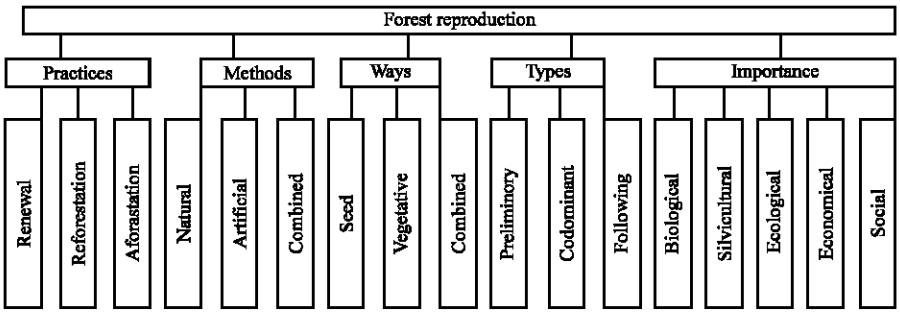

Fig. 1: Forest reproduction classification

deciduous species predominate in the stands. Pine in the composition of naturally renewed stands on felling makes no more than 30%.

Larin in his study of the strategy for the reproduction of forest resources of the European North came to the conclusion that the effectiveness of natural seed renewal of pine stands depends on the conditions of the site and of presence of quality seed material. The research foresters from Scandinavia and Central Europe Leibundgut (1981), Muller (1981) and Olberg (1951) also proved the possibility of successful natural regeneration of the main rocks only under certain favorable conditions and with intensive assistance of foresters.

In our studies, the structure of stands and the biological features of tree species are also the determining parameters of the natural renewal of stands. In the Southern Urals the forest growing conditions and the composition of the stands where pine predominates are far from unambiguous. Anthropogenic impact on forest land has led to a change in the silvicultural properties of soils and forest types.

Kovaleva and Smolonogov (2015), EP came to the same conclusions and they noted that the forest typology is the determining parameter in the formation and development of pine plantations.

Our research has shown that the breed composition and the number of undergrowth and natural seeding in each forest type vary depending on the terrain and the intensity of economic activity. However, the reforestation process remains one of the main attributes of forest types.

The living ground cover and the undergrowth are the determining ecological factors in relation to the process of reforestation. With a small amount of undergrowth, they can contribute to reforestation but with abundant development, light and mineral nutrition can interfere with competing for moisture (Scotter, 1972).

Surveys of the prevailing types of forests on the reforestation effect and the further progress of the growth

Table 1: Provision of pine forest stands by groups of forest types

Groups of forest types	Area coved by forest: Thousand hectares	Area coved by forest: Percentage	Area of ripe and overmature stands with coniferous growth: Mid-range	Area of ripe and overmature stands with coniferous growth (%)
Dumetosous	25.2	3.2	4.1	4.5
Gramineous	262.1	33.8	2.3	17.9
Goutweed	303.8	39.2	2.0	13.3
Mixed herbs	82.5	10.6	2.0	8.4
Green moss	50.2	6.5	3.2	35.4
Sorrel-myrtillus	41.8	5.4	2.1	23.6
Nettle-spireae	6.9	0.9	3.3	6.3
Sedge-sphagnum	2.8	0.4	4.3	9.4
Total	775.3	100.0	2.3	16.0

of stands in the Southern Urals have made it possible to unite all types of forests into eight groups (Table 1).

Groups of forest types are characterized by certain patterns. Shrub and sedge-sphagnum types of forests are characterized by low productivity of stands 4-5 class of forest site quality. Under-pine renewal is noted to 4.5% of mature and over-mature stands. The amount of pine undergrowth does not exceed 2.0 thousand pieces/ha.

Gramineous forests are relatively productive (2-3 class), they are resistant to unfavorable factors and by 17.9% provided with undergrowth. For natural reproduction of pine forests in poaceous forest types, intensive measures should be taken to promote natural regeneration.

Mixed herbs pine stands are the most productive in comparison with other groups of forest types. In a mixed-type group of forests, stands with 1a to 2 class of bonitet dominate and forest cultures can reach the Ib class of bonitet. Under the canopy of ripe and overmature stands of a mixed herbs group of forests, a relatively small amount of young growth is observed.

The nettle-spiraea forests have an average productivity but have high soil and water protection properties.

Species-Sphagnum group of forests have the lowest productivity. Basically, these forests belong to the category of protective, unexploited forests. Under-pine renewal is rare in the nettle-spiraea and sedge-sphagnum groups of forests.

Table 2: Influence of forest types on the composition of the undergrowth under the canopy of mature and overmature pine stands

	Undergrowth composition (%)				
Forest type	Pine	Larch	Spruce	Birch	Aspen
Gramoneous	38±4.2	1±0.3	2±0.6	48±3.3	11±1.3
Goutweed and stone bramble	52±5.3	1±0.1	3±0.8	41±4.8	3±0.7
Myrtillus and cowberry	58±7.3	1±0.2	-	40±4.7	1±0.5
Green moss	80±4.2	1±0.4	7±1.3	12±4.5	-
Broad-leaved grassed	40±5.4	-	20±4.2	32±3.3	8±1.3

Table 3: Forestry and forest inventory characteristics of young forest on the cut over lands of the pine stands

		Young forest characteristics			
Forest type before felling	Felling type	Age of transferring of forest plantations into the forest lands into (years)	Composition	Amount of trees, (thous.pieces/ha)	Average hight/m
Goutweed and stone bramble	willowherb	10	6S4B+EedOs, Lp	2.5±0.40	1.6±0.2
Myrtillas and cowberry	Reedgrass	10	6C4BedL, Ax	2.2±0.37	1.5±0.2
Green moss	Reedgrass	10	8S1B1EyedL	2.6±0.42	1.4±0.2
Broad leaved grassed	Gramoneous	15	1S3E4B2Os+P	1,8±0,18	1.4±0.3

The composition of the undergrowth under the forest canopy basically depends on the forest type and the low forest normality. Studies carried out on study plots according to the mensurational descriptions of divisions and based on the latest forest management show that the most favorable conditions for pine undergrowth are created in green moss forests (Table 2).

Thus, in green moss forests, the number of pine undergrowth tend to change, depending on the normality of the mother stand which can be described in an equation of second order with a high determination coefficient:

$$Y = -10.903 \times 2 + 13.6 \times -2.5522,\ R^2 = 0.75$$

Pine undergrowth of predominates under the canopy of stands with a normality of 0.7 and lower in the main forest types. In broad-leaved and gramineous forests, pine undergrowth is less than half of the total composition. At the same time soft-wooded broadleaved species score the advantage.

In green moss forests, the growth of the natural seeding and undergrowth, depending on age in open areas id characterized by the equation: H = 0.11-0.025A+0.01A2 and the growth under the mother trees canopy by the equation as follows: H = 0.09 1-0.010A+0.007A2 with the coefficients of determination 0.98 ± 0.06 and 0.97±0.05, respectively.

On relatively dry and humus-poor sandy soils and at medium abundances, the herb layer does not prevent the emergence of pine seedlings. A powerful herb layer leads to a decrease in emergence of pine seedlings and natural seeding in places where the plantings are thinned out by fires or by gradual and selective felling. Some also proves that, after continuous forest fires, pine forests are the first to reproduct (Siren, 1974).

On cut over lands, the following pine reproduction is most evident in green-moss, goutweed-cowberry and bilberry-red bilberry forests (Table 3). To provide full felling by natural pine seedings it is necessary to promote the natural renewal by the soil mineralization by the use of the seed tree cutting method and by undergrowth conservation under the forest canopy.

Table 4: Sowing qualities of pine seeds of natural origin and of forest crops of different age

	Natural plantations (years)		Forest crops (years)		
Marks	28	140	30	86	90
Average amount of seeds ina conelet, (pcs).	23.2±4.1	10.0±1.3	13.0±1.2	11.0±1.4	6.7±1.7
Weight of 1.000 pcs. of seeds, (g)	6.5±0.65	7.8±0.66	7.0±0.66	3.8±0.22	5.6±0.34
Germination energy (%)	88.9±3.2	47.9±2.8	82.0±2.9	53.0±2.1	62.0±3.0
Germination ability (%)	91.0±2.4	57.3±1.9	82.0±2.1	61.0±1.8	62.0±2.2
Field germination on the planting area	67.7±3.4	42.5±2.1	53.4±3.6	46.1±2.7	46.2±2.5

The specific purpose of the planned stands is an important point in the forest reproduction. Depending on the forest growing conditions where pine plantations are planned, they are able either to produce the greatest amount of quality wood or are most suitable for soil and climatic conditions and are the strongest in the cenotic sense. Maier notes the high dependence of the growth of pine forest crops in California on soil conditions (Maier, 2001).

For the successful renewal of any breed a high quality seed material is necessary. The analysis of the quality of seed material collected from pine trees of natural origin and from forest crops of different age, growing on dark gray forest middle loamy soils, shows that the weight of 1,000 pcs. seeds collected in natural plantings are quite high but the germination energy and germination of seeds collected from overmature pine forests are quite low (Table 4).

Table 5: The influence of the composition of pine stands on the natural renewal in goutweed and stone bramble forest

			Undergrowth characteristics				
Part of pine in the stand composition (%)	Amount of the examined plots (pcs)	Square of the examined plots (ha)	Composition	Amount (thous. pcs./ha) Total	Including coniferous	Average height (m)	Average age, years
1-10	38	397.0	44S55B1Os	1.22±0.2	0.54±0.04	2.2±0.2	14
11-40	63	721.0	35S3P59B3Os	1.69±0.2	0.64±0.03	2.2±0.1	15
41-70	111	1095.4	56S1L41B2Os	1.91±0.3	1.09±0.04	3.4±0.1	18
71-100	91	1037.4	77S2L19B2Os	2.69±0.3	2.13±0.05	3.2±0.2	18
Total	303	3250.8					

Comparison of the sowing qualities of seeds harvested from natural plantations and from young forest crops proves a better quality of seeds harvested from natural plantations. The yield of seeds from natural plantations collected from one conelet is much higher than from forest crops, so to provide nurseries with good seeds it is necessary to organize collection of conelets from natural plantations of a younger age. Pine plantations of the local population provide felling areas with the seed material of a better quality.

The renewal potential of pine stands depends on the composition of the mother stand. Single samples of pine undergrowth under the forest canopy appear only when the pine trees in the stand composition makes from 1-10%. If the pine does not predominate in the stand, then pine should not be expected to prevail in the growth (Table 5). The undergrowth composition changes depending on the species composition of the mother stand. Pure pine stands are provided with the maximum amount of pine undergrowth (2.13 thous. pieces/ha).

Under the canopy of forest crops, there is a small amount of undergrowth which is explained by the high and even stand density of forest crops. Certain gaps appear in natural pine plantations of different age which leads to an increase in the undergrowth under the canopy of the forest and to the creation of favorable conditions for a steady generation change after the natural fall of trees or after selective felling.

CONCLUSION

Thus, the sustainable development of the forest is provided by a continuous reforestation process which depends on many factors. To ensure biological balance in the pine forests of the Southern Urals, it is necessary first of all to focus on the natural reproduction of pine forests. The use of various ways, methods of reproduction of sustainable pine forests should lead to the reproduction of the entire complex of natural communities common for this particular forest formation.

Forest typology is the basis for different ways and methods of forest reproduction. One of the most promising ways to provide natural renewal of primary trees, taking into account forest types, natural soil fertility and its reforestation effect id early help in natural renewal of parent trees.

The study and comparative assessment of plantations of different composition, age and renewal potential indicate the presence of high-productivity, sustainable and low-productivity, less stable plantations. Maximum productivity and reproductive ability of plantations do not always coincide. Highly productive plantations do not always have a reliable undergrowth under their canopy. Self-renewal of plantations is an indicator of the persistency of these plantations.

There is a new direction in increasing the stability and productivity of pine plantations through combined reproduction, contributing to the natural renewal and creation of pine forest crops. There are such areas on cut over lands of Uchaly and Beloretsk forestries where during the period when felling in the Republic of Bashkortostan was prohibited, all larch was left on the felling areas.

Later, despite of the planting of pure pine crops, forest crops with $7C_{fc}3P+B$ composition were formed in green moss forests and with $9C_{fc}1P+B$ composition in 15-20 years old gramoneous forests. Increasing the sustainability and continuity of forest management in pine forest cultures implies a transition to natural regeneration and ensuring the sustainability of forest management in forest cultures.

Increasing the persistence and continuity of forest management in forest pine crops means to go on natural reproduction and ensuring the persistence of forest management in forest crops.

In order to increase the stability of pine plantations in the Southern Urals, depending on particular forest growth conditions when using forests, it is necessary to apply felling methods, aimed not only to pine conservation but also to self-seed crops appearing.

Modern forest management in developed countries involves the development and implementation of new approaches in the reproduction of sustainable forests in the economic practice. In many cases, they focus on the artificial reproduction of forests with economically important species not taking into account the need to

preserve biodiversity. This can lead to impoverishment of the species composition of forests and a sharp decrease in the sustainability of forest ecosystems. Considering the reproduction of stable pine forests in the Southern Urals.

RECOMMENDATIONS

In the future, it is necessary to proceed from the need of their reproduction both artificially and naturally, paying special attention to combined reproduction.

REFERENCES

Avrov, F.D., 2000. Reproduction of stable forest plants. For., 2: 33-35.

Belov, L.A., S.V. Zalesov, P.I. Rubtsov, A.I. Tolstikov and M.V. Usov *et al*., 2016. Supply of pine plantations with pre-generated undergrowth in a berry forest. For. Russ. Forestries, 3: 4-12.

Brockway, D.G. and K.W. Outcalt, 2017. Influence of reproduction cutting methods on structure, growth and regeneration of longleaf pine forests in flatwoods and uplands. For. Ecol. Manage., 389: 249-259.

Gabdrakhimov, K.M. and R.Z. Khatmullin, 2001. Ecology of Pine Forests Reproduction. Bashkir State Agrarian University, Ufa, Russia, Pages: 131.

Jean-Phillippe, S., 1990. [Natumaher silviculture in Switzerland (In German)]. Allg. For., 45: 731-732.

Jin, X., T. Pukkala, F. Li and L. Dong, 2017. Erratum to: Optimal management of Korean pine plantations in multifunctional forestry. J. For. Res., 28: 1105-1105.

Kirkman, L.K. and S.B. Jack, 2017. Ecological Restoration and Management of Longleaf Pine Forests. CRC Press, Boca Raton, Florida, USA., ISBN:9781351648189, Pages: 427.

Kovaleva, N.M. and R.S. Sobachkin, 2015. Ground cover and pine renewal after selective cutting in pine forests of Krasnoyarsk forest steppe. For. Sci., 2: 105-112.

Kutiavin, I.N. and N.V. Torlopova, 2016. State of growing stock and of undergrowth of pine formations in the Pechora river basin. For. Sci., 4: 254-264.

Leibundgut, H., 1981. [The Natural Forest Rejuvenation]. Haupt Verlag AG - Publisher and Bookstore, Bern-Stuttgart-Wien, Switzerland, Pages: 107.

Luganskii, N.A., N.A. Zalesov and V.N. Luganskii, 2010. Forest Science. Ural State Forest Engineering University, Yekaterinburg, Russia, Pages: 432.

Maier, C.A., 2001. Stem growth and respiration in loblolly pine plantations differing in soil resource availability. Tree Physiol., 21: 1183-1193.

Muller, F., 1981. [From practice to practice: The best and most successful intervention (In German)]. Tiroles Forstwirt, 31: 20-51.

Scotter, G.W., 1972. Fire as an Ecological Factor in Boreal Forest Ecosystems of Canada. In: Fire in the Environment Symposium Proceedings, Scotter, G.W. (Ed.). United States Forest Service, Washington, D.C., USA., pp: 15-24.

Siren, G., 1973. Some remarks on fire ecology in Finnish forestry. Tall Timbers Fire Ecol. Conf., 13: 191-209.