



RESEARCH ARTICLE

The Effects of Different Intensity of Thinning on the Development in Scots Pine (*Pinus sylvestris* L.) Stands in Kazakh Uplands

Andrei V. Ebel¹ • Yekaterina I. Ebel² • Sergei V. Zalesov³ • Sezgin Ayan^{4*}

¹S.Seifullin Kazakh Agro Technical University, Faculty of Agronomy, Nur-Sultan/Kazakhstan

²Kokshetau Forest Breeding Center (KFBC), Cordon "School Forestry", Nur-Sultan/Kazakhstan

³Ural State Forest Engineering University (USFEU), Yekaterinburg/Russian Federation

⁴Kastamonu University, Faculty of Forestry, Department of Silviculture, Kastamonu/Turkey

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ABSTRACT

The search for more accurate methods of predicting the growth and development of forest stands became the most urgent task set for foresters of Kazakhstan to determine the permissible interventions in the natural course of the life of plantings, provide high durability and resilience in forests. The aim of the study was to identify the effects of diameter and density of Scots pine stands of Kazakh Uplands on their growth and productivity and the related productivity of single plantation stands taking into account the conditions of growth and development of internal factors as well as further study of the methodology for assessing the forestry cost-effectiveness and improvement thinning. To achieve this aim, effects of varied felling intensities on Scots pine stands were studied. The most common two forest types in upland Scots pine forests were chosen as permanent sample plots; the dead pine-lichen and moss pine-grass. The results showed that improvement thinning of moderate and severe intensity which are more profitable should be done in Scots pine forests of Kazakh Upland as well as carrying out such thinning increases the yield of the larger logs and increases the value of the left stand.

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Introduction

To satisfy the growing demand for wood from local forests, keeping their best soil and water protection and shelterbelts functions, ensuring increased productivity of forests by at least 10-15% is the pioneer task of the Republic of Kazakhstan foresters. Zhukov (1976) points out: "The cardinal solution to enhance the productivity of forests is closely related to a deep identification of patterns of development, the establishment of the relationship between the individual components of forest ecosystems and the formation of the structural

features of plants in different environments" to emphasize the main directions of forest biology science. Lebkov (1965, 1967), Plotnikov (1979) and many other studies highlighted the structure of forest stands in their researches.

Prevailing soil and climatic conditions become particular importance in the Scots pine forests of Kazakh Upland. Furthermore, taking into account the great value and increase in demand for Scots pine wood the importance of the further cultivation of this species become more visible in local forests. Besides this recent forest inventory data indicates a significant

* Corresponding author

E-mail address: sezginayan@gmail.com

change of distribution of Scots pine plantations more than that of little value aspen and birch. The prevalence of different tree species depends on their biological and environmental sustainability in these conditions, as well as on the level of forest management.

The predominance of Scots pine in the stand composition can be provided with the forestry measures as well as it can be significantly improved the condition and growth of plants. The search of more accurate methods of predicting the growth and development of forest stands become more urgent in accordance with the new challenges of forest cultivation for determining the extent measure of permissible interference in the natural processes; adjust their course and provide high durability and resilience of forest ecosystems. One of these methods which can contribute to the direction of growth of the trees in the woods is forest felling. Timofeev and Georgievski (1957) denotes that for various purposes improvement thinning can be used as a main silvicultural method of cultivation of healthy and highly productive forests.

Decreasing in workload of forestry in terms of felling is observed currently. The state institutions for the protection of forests and fauna have difficulties on carrying out forestry works because of current economic conditions in Kazakhstan. There is no exception in the felling of forests, because timber obtained during felling operations is one of the sources of their own funds, so it is important not to turn the felling of forests in the "cutting income" for receiving the wood will not become

the main purpose, and in the process of care it will be not broken silvicultural principle of trees selection for felling. This is especially important during the felling, as it can lead not only to a decrease in growing stock in the age of final felling, but also to the loss of vegetation stability. At the same time, compliance with the requirements of silvicultural felling in general and migratory logging in particular can significantly increase the productivity of cultivated stands (Sennov 1977, 1984, 1999, 2005, Zalesov and Luganski 1989, Makarenko and Mukanov 2002). Thus, nowadays in economic environment it becomes more urgent to find ways of optimizing silvicultural and economic indicators of improvement felling. The aim of the research was to determine the effects of diameter and density of Scots pine (*Pinus sylvestris* L.) stands on growth and productivity at intermediate felling activities in Kazakh uplands.

Materials and Methods

The area of research is characterized by a sharply continental climate conditions on the background of a lack of moisture in the summer when evaporation is almost twice the amount of precipitation. In difficult soil and climatic conditions, Scots pine forests of Kazakh Upland have great soil and water protection, field and climate-regulating value because it has that geographical position. The amount of Scots pine forest is about 33.8 % of the total forest land area (Table 1).

Table 1. Distribution of forested land by dominant species and age groups for growth class III (by Taxation Description Government National Nature Park "Burabay")

Predominance species	Covered with forest area		Distribution of forest area by age groups, th. ha					
	th. ha	%	Young stand		Middle aged	Maturing	Ripe and overripe	
			I class	II class			total	including maturing
Pine	100,3	33,8	24,4	13,1	50,9	9,4	2,5	-
Larch	0,4	0,2	0,3	0,1	-	-	-	-
Maple	0,3	0,1	0,2	0,1	-	-	-	-
Elm	2,7	0,9	1,7	1,0	-	-	-	-
Birch	160,9	53,9	16,0	11,0	74,1	36,3	23,5	-
Aspen	29,4	9,9	3,5	4,9	7,9	7,1	6,0	-
Poplar	1,1	0,4	0,5	0,6	-	-	-	-
Willow	1,5	0,5	-	-	-	-	1,5	1,4
Bushes	0,8	0,3	-	-	-	-	0,8	0,5
Total	297,4	100	46,6	30,8	132,9	52,8	34,3	1,9

To measure effects of diameter and density of Scots pine stands of Kazakh Uplands on their growth and productivity, the study area was chosen from two forest types in most common pine forests of Kazakh uplands as called dead pine-lichen forest and moss pine-grass forest. The number of trees on each permanent sample plot with an area of 0.005 to 5 hectares were decreased at least 150-200 trees after felling where the initial number of trees were among 400 to 2000. Each sample area was divided into several sections, one section remained as a control plot and thinning of stands with varied intensity carried out on the rest. Ranking of felling changes among weak, moderate, strong and very strong where the selected

stocks are 15, 16-25, 26-35 and > 35 %, respectively of the growing stock (Danchenko and Danchenko 2004).

Processing and description of sample plots were carried out according to the procedure adopted in forest management with the account of instructions (1995) to meet the requirements of OST 56-60-83 and methodological developments of Georgievski (1953), Molchanov (1967), Anuchina (1977, 1982), Verhunova (1979), Atrohina and Yeviy (1985). Primary enumeration on sample plots allocated for felling was used for the study of growth patterns of thickened pine.

Sections on sample plots were laid a square or rectangular shape (Operating rules, 1995). In the corners of all the sections of permanent sample plots it was established posts, in accordance with the requirements of OST 56-44-80. Measuring the diameter was done with a caliper with an accuracy of up to 1 mm in two directions: N-S and E- W. When enumeration, trees are divided into categories of technical validity and by Craft's classes. Forest growth site was established by Orlov's scale (Orlov 1927), the fullness of the table of growth progress of pine layer continuum of Kazakh Upland was established by Makarenko's scale et al. (1980). Accounting of deadwood was done separately.

Identification of the impact on the completeness of the stands to the taxation rates was conducted by comparing a number of plots of the same age but with different fulfillment in different forest types. Stand density was determined by dividing the amount of space in the test section of the stand on the proper amount of space in the normal section of the stand for a certain "local tables total basal area and stocks of trees and shrubs in the fullness of 1.0" (Makarenko et al. 1980).

To determine the average height, it was measured the height of the altimeter BH-1 with an accuracy of 10 cm, followed by the construction of curves heights. To determine the total basal area of the stand it was held caliper measurement of the diameter up to 1 mm in two directions: NS and EW. Then, according to the enumeration of trees of diameter classes it was calculated cross-sectional area in each diameter and using the "assortment tables of pine stands of Kazakh upland" (Makarenko et al. 1987) and it was determined the amount of space per section and per 1 hectare. The average diameter was defined as the diameter of a circle, the

area of which is equal to the estimated average cross-sectional area of one tree.

All digital material of fieldwork was processed by the traditional methods of mathematical statistics (Zdvorik, 1952, Svalov 1977, Gromyko 1981, Zaicev 1984). In carrying out the research work the generally accepted techniques used in forest inventory, forestry, soil science and biocenology were used. The experimental data was obtained by re-enumeration on the permanent sample plots. Taxation stands was performed instrumentally.

Results and Discussion

During the work it was revealed that Scots pine forests of Kazakh Upland is characterized with its considerable heterogeneity of relative completeness in both dead-lichen and moss-grass forest types. The dead pine-moss forest type is characterized with an increase in the completeness with increasing age tree stands. Pine stands of moss-grassy type of forest with the age of older than 60 years are characterized by the opposite behavior. High rates of relative density of stands of all ages recorded in the number of permanent sample plots indicate the need to clarify the standard tables for Scots pine of Kazakh Upland.

After analyzing the data of Table 2 it can be concluded that by the age 105 year dependent of natural mortality of the initial density of stand becomes more apparent. The higher the initial density of the stand, the higher the proportion of mortality among the trees. On the experimental plot №3 at the age of 93 the density makes up by the following sections: K-1 - 5500; K-2 - 6860; K-3 - 7000; K-4 - 6900 / ha, and the share of apostasy: K-1 - 88.5; K-2 - 85.1 K-3 - 74.8; K-4 - 88.0%.

Table 2. Changes in density of Scots pine stands of Kazakh Upland with age

Experimental plot №2							
Section	Density, pieces (ps)/ha			Mortality			
	in the age of 47	in the age of 58	in the age of 105	during 12 years		during 58 years	
				ps/ha	%	ps/ha	%
K-1	11710	9384	3660	2326	19,9	8050	68,7
K-2	19150	13990	4880	5160	26,9	14270	74,5
K-3	19680	14652	5380	5028	25,5	14300	72,7
K-4	18540	16024	3920	2516	13,5	14620	78,9
Average	17270	13512	4460	3758	21,7	12810	74,2

Experimental plot №3							
Section	Density, pieces (ps)/ha			Mortality			
	in the age of 35	in the age of 47	in the age of 93	during 12 years		during 58 years	
				ps/ha	%	ps/ha	%
K-1	47900	23974	5500	23926	49,9	42400	88,5
K-2	46000	29333	6860	16667	36,2	39140	85,1
K-3	27800	19504	7000	9296	32,2	20800	74,8
K-4	57700	30547	6900	27153	47,0	50800	88,0
Average	45100	25839	6565	19261	42,7	38535	85,4

The values of the original density in stands older than 35 years in the range of 0.6 - 1.5 does not have a significant impact on the average height of the stands at maturity. Thus optimum relative density in the 47 - year old pine stands of the dead-lichen forest type, in terms of the average height of the stand makes up 0.9-1.0, in the 35 years old pine stands of the same forest type it is - 0.71-0.8 and in the age of 60 - year old pine tree stand of moss-grass forest type, it is - 0.8, average difference values of 93-105-years-old pure Scots pine stands with different initial relative completeness usually does not exceed the accuracy of the determination of the taxation measure.

In the result of this research; it was revealed that in this type of forest, Scots pine forest is dead cover lichen to the age of 47, stands are with medium density and dense and almost equalize by the number of trees, and rare have lower density. By the age of 93-105 years, the density indicators in all forest stands are almost equal. It must be concluded that the higher the initial density, the more intense the natural felling of the stand and by the age of 93-105 years, regardless of the initial density in the stands is approximately equal to the number of trees.

One of the two types of Scots pine forests, moss pine-grass forest stand density is much lower than similar stands of the dead pine-lichen forest. Last pattern clearly shows that in the area of research, intensive felling in Scots pine stands of moss-grass forest type has significantly higher density than the dead pine-lichen.

Throughout the period of maximum forest growing, stock of stem wood is characterized by dense stands. At the same time in a pine forest of the dead-lichen differences in stock 35 years old and rare dense stands is 3.9 m³/ha (5.9%), and 93 years - 101.3 m³/ha (33.4%). The stock of mature pine stands of moss-grass exceeds that in rare and medium density, but inferior to that of the dense mature stands of the dead pine-lichen.

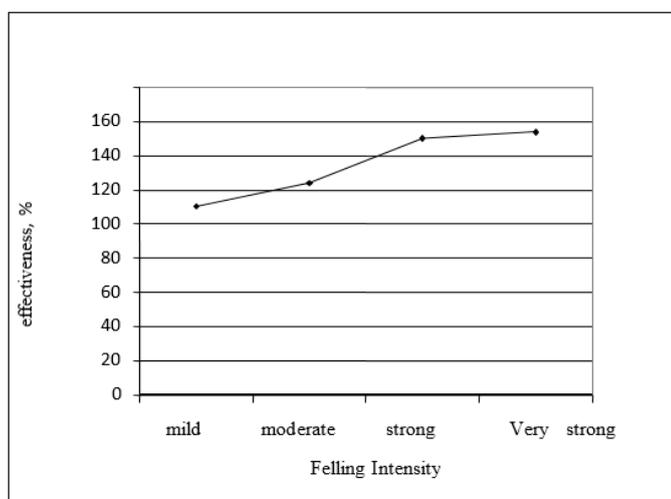


Figure 1. Distribution of overall economic efficiency, depending on the intensity of logging (Experimental plot № 3)

Figure 1 shows the analysis of the impact of logging on the value of the wood over time that there is accumulation of a

larger timber on a more space areas and therefore its value increases. Demand for wood from improvement felling in the conditions of Northern Kazakhstan is quite high, especially since felling in coniferous of the Republic prohibited for 10 years on the basis of the Resolution of the Government of the Republic of Kazakhstan from 23.04.2004 № 460 "On the prohibition of felling in coniferous and sexual plantations on the lands of the state forest fund and measures for their conservation." At the same time, in spite of the high demand, some of the wood is related to illiquid as small firewood has no sales. The proportion of illiquid wood averages about 8% of the total blank.

Calculation of economic efficiency shows that in thickened Kazakh Upland Scots pine forests, felling should be of moderate to severe intensity which are more profitable, as well as holding such felling increases the yield of the larger logs and increases the value left on the vine growing.

There are some opposite conclusions on the effect of fullness and density of plantings on the average height of the stand. According to some studies changing the fullness and density of planting does not increase growth in the average height of the stand (Malenko 1980) but on the other site some scientists say that changing of the fullness and density of planting may increase the growth in height (Smirnov 1970) and some authors consider that greatest increase in height is inherent in forest stands with the optimum density (Pamfilov 1951), Makarenko and Mukanov (2002) states that the change in the fullness and density of plantation in Scots pine forests of older age do not have a significant impact on the value of growth of the average tree height, in the thickened stands these indicators have a positive impact on the increase in growth in height, though not in all cases.

Current study shows that 47 age of the average maximum height of the pilot area, characterized by 2 sampling areas with the relative completeness of 0.9-1.0. With increasing age, this trend does not change, that is, the imposition of the original fullness of below and above 0.9-1.0 are characterized by the absence of forest management activities, the worst performance of medium height. At the same time, it should be noted that differences in the average height of the plots with different initial relative completeness does not exceed 105 - age of 0.5 m (3.9%), i.e. the accuracy of their determination. In other words, the relative completeness of the stands in the range of 0.6-1.3 does not have a significant effect on the average height in stands older than 47 years.

As noted earlier stand density is one of the most important factors determining the productivity of forest stands. Eytingen's (1962) considers that the variability of tree height depends on the degree of interaction between them, which, other things being equal, is determined by the density of the stand. With increasing stand age, it is decreased the number of trees per unit area, i.e., planting is self-thinned. Eytingen (1962) says self-thinning stands affects the initial density of the stand, and the self-thinning dense stands is more intense than in the middle and especially in the rare ones. Morozov (1970) notes that the intensity of the process of self-thinning occurs in a variety of stands not equal and depend on the soil

and climatic conditions. In the best conditions and on the best soils self-drop thinning plantations is faster than the plants on poor soils. Great importance to the process of self-thinning also influence on the ratio of tree species to light. Tretyakov (1937) notes that dying out processes of light-loving tree species occur more rapidly than that of shade-tolerant species. Nesterov (1961) finds the better conditions of life, the more the plant survives, and woodland in favorable conditions is denser. These examples show that to the process of self-thinning in the forest is paid much attention by various scientists in their works because of all sorts of factors and environmental conditions.

Our data show that at the age of 90-100 years, there is a direct dependence of the mortality of trees and the percentage of thinning stands. It should be noted that the sample in the range 20% have the highest percentage dropping out when the sample from 30 to 40% percentage of dropping out is reduced to 0%, and high sampling rate greater than 40% leads to an increase in percent dropping out from 1 to 8%. It should be noted that both low and large thinning leads to an increase in natural mortality in the thickened Scots pine plantations, and in areas with a strong inrush observed thinning out trees from the wind.

A large number of scientific papers are devoted to the analysis of economic efficiency and silvicultural thinning (Timofeev and Georgievski 1957, Sennov 1977, 1984, 1999, Zalesov and Luganski 1989, Smirnov 1970, Izuyminski 1970, Davydov 1971, Zalesov 1986, 1988, Chibisov 1992). All researchers have noted a positive change does not affect only quality but also quantity indicators stand after thinning. Changing the density and structure of the stand after thinning, its structure, improving commodity structure, increases the stability of the stand against the adverse effects of wind and snow. Thinning contribute to an increase in radial growth of trees. It is reduced number of timber passing in mortality (Sennov 1977, 1999, Zalesov and Luganski 1989, Smirnov 1970, Izuyminski 1970, Davydov 1971).

Conclusion

In the course of our research, significant qualitative improvement of the species composition of the forest fund did not happen because the thinning was carried out in pure composition of Scots pine plantations. At the same time, cutting maintenance had a positive impact on improving the health condition of forests. When thinning, in the result of removal of part of the stand of trees, their average inventory indices changes as well. Assessing the impact of improvement felling on basic inventory indices stands makes it possible to determine silvicultural effectiveness of their implementation. The conclusions derived from the results obtained allow us to establish the optimal intensity of thinning stands for each forest type, and frequency of improvement felling.

The results of our research in the thickened Scots pine forests aged of 93-105 years show that there is no clear dependence on the weight gain of the intensity of the thinning of forest stands which confirms the results obtained on these same sites at the age of 47-59 years (Makarenko 1967). This

suggests that the dynamics of inventory change with age remains stable. Calculation of economic efficiency shows that it should be thinning of moderate to severe intensity in thickened Kazakh Upland which are more profitable, as well as holding such thinning increases the yield of the larger logs and increases the value left on the vine growing.

From all the above data it can be concluded that, in accordance with the new objectives of forest growing it is urgent the search for more accurate methods of predicting the growth and development of forest stands to determine the permissible extent of interference with the natural processes that regulate their process, to ensure high durability and resilience of forest ecosystems. The practical significance of the results of this study can be used to estimate the growth and productivity of Scots pine forest stands at similar site conditions as well as to assess the economic efficiency of forestry and felling. It also can be applied in the development of programs of thinning and other economic activities in the Scots pine forests of Kazakh Uplands.

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