



Jul 1st, 12:00 AM

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Sidorencov, Victor and Zhafyarov, A., "On the models of primary forest restoration in the Russian North-West" (2010). *International Congress on Environmental Modelling and Software*. 4.
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On the models of primary forest restoration in the Russian North-West

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Abstract: Commercial loggings in 1940-1990 drastically changed most of the primary coniferous forests in Russian northern regions, especially, those which are close to populated localities and roads. Clearcuts significantly reduced silvicultural, economic and esthetic values of the forests due to failings in primary forest restoration. The forests emerged after clearcuts are formed mainly by birch and aspen, the share of spruce is very modest there. This paper attributes failures of spruce forest restoration to lack of viable spruce undergrowth and presents a database summarizing the results of field studies that provide an empirical ground for development of process-based models of spruce forest restoration.

Keywords: forest restoration, undergrowth preservation, database, modelling.

1. INTRODUCTION

Due to intensive exploitation of the vast forest area located in the region of research, undeveloped road network and economic costs, artificial forest restoration on the most clearcut areas is impossible. Forest restoration in such areas usually occurs through species change. According to the data of forest inventory (Forest plan of Vologda region, 2007), the area of coniferous forest in Vologda region decreased by 153 000 hectares or by 3%, from 2003 to 2004, in consequence of increasing impact of forest harvesting, and due to inefficient forest restoration. Moreover, from 1961 to 2006, the area of spruce stands decreased by 19.5% because of intensive harvest and natural regeneration of birch and aspen on clearcut areas. Due to the species change, the tree species composition of vast territories had changed, that adversely influenced both the ecological situation in the region of research and the economic and silvicultural value of emerging forests. The research presented in this paper is to determine the factors that influence the species composition and the structure of emerging forests.

2. METHODS

The methods, usually applied for forest inventory, were used in this study. At the first stage of research, it was carried out the analysis of forests that underwent clearcutting from 2 to 55 years ago. At the second stage of the research, it was carried out the brief inspection of forests naturally emerged after clearcut and forests created in the course of silvicultural restoration of spruce. The inspection included visual inventory, establishing temporal Bitterlich sample plots, and establishing permanent sample plots. All plots are located relatively far from waterways, on the gentle, almost flat slopes. The conditions of growth can be characterized as good or relatively good in sense of water and nutrients supply.

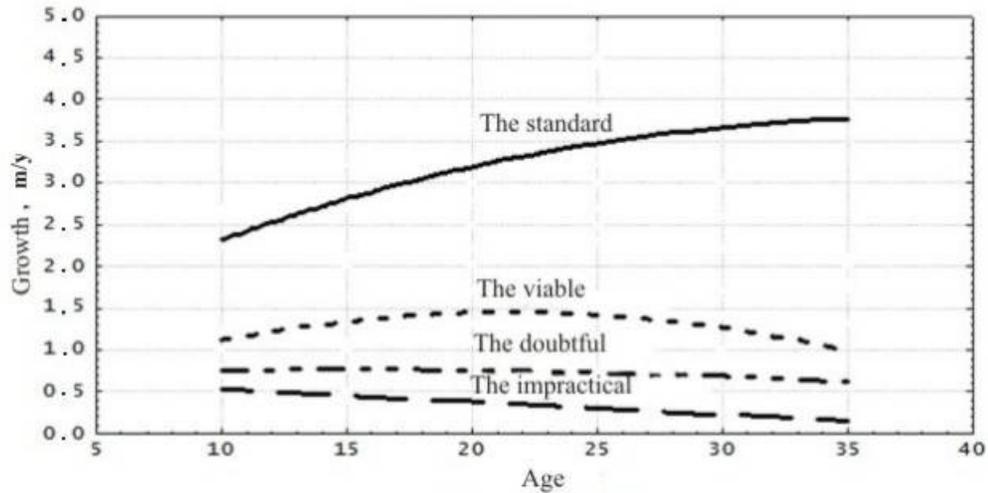


Figure 1. Empirical models of height growth for standard ($y=0.9714+0.1605x - 0.0027x^2+0.000011364x^3$; $R^2=0.84$), viable ($y=0.2893+0.1077x-0.0025x^2$; $R^2=0.76$), doubtful ($y=0.6747+0.0123x-0.0004x^2$; $R^2=0.81$) and impractical ($y=0.679-0.0015x$; $R=0.69$) undergrowth.

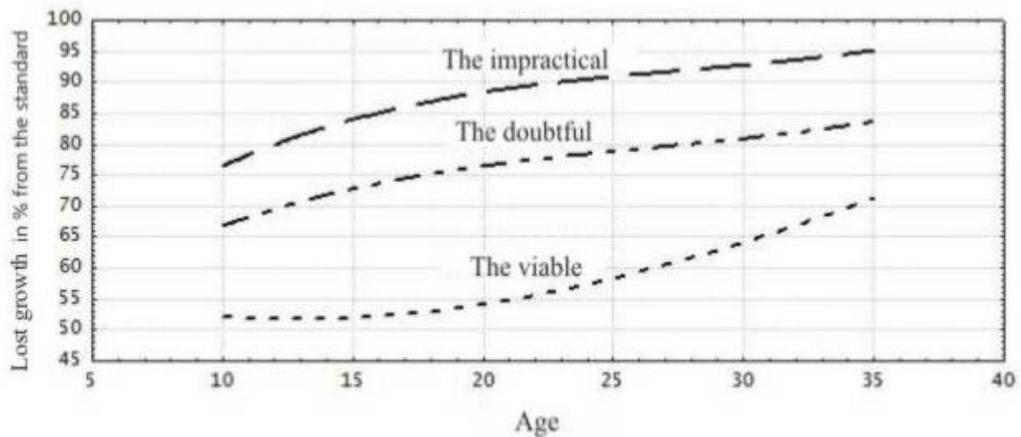


Figure 2. Empirical models of deviation from the standard rate of height growth for viable ($y=61.1069-1.5498x+0.0701x^2-0.0005x^3$; $R^2=0.84$), doubtful ($y=44.2734+3.1643x-0.1038x^2+0.0013x^3$; $R^2=0.80$) and impractical ($y=47.7347+4.0524x-0.1331x^2+0.0016x^3$; $R^2=0.70$) undergrowth.

3. RESULTS

The results of the field study (46 plots) were compiled into a database that contains information on species composition by stand layer, on average diameter, height, viability, and the number of trees by diameter class, on the biomass of undergrowth with respect to its viability and growth conditions, on the height of undergrowth by viability classes.

Based on the data of field study, the following types of clearcut were identified:

- 1) clearcut without undergrowth preservation,
- 2) clearcut with retention of birch patches, but without undergrowth preservation,
- 3) clearcut with retention of aspen patches, but without undergrowth preservation,
- 4) clearcut with undergrowth preservation.

Clearcut without undergrowth preservation was often used more than 40 – 50 years ago in spruce forests with minor admixture of birch. Planless hauling of timber eliminated undergrowth almost completely. The few spruce patches that remained were associated to gaps in forest cover. Natural restoration led here to a dense birch forest with a minor fraction of spruce in the upper layer (20% or less). The second layer is formed by spruce regenerated during the first 10 years after clearcut. The third layer is formed by spruce trees of the same generation grown in unfavorable conditions.

The second type of clearcut was characterized by retention of 150-350 birch trees per hectare. The age of these trees did not exceed 20–30 years at the time of clearcut. Natural restoration led here to a forest the first layer of which is formed by birch patches retained during the clear-cut. The trees in these patches are higher than trees of the second layer by 14-15 meters. The second layer is formed mainly by birch regenerated after clearcut, and the third layer is formed mainly by the spruce.

The third type of clearcut resulted in formation of mixed aspen-birch forests. The number of trees in retained aspen patches did not exceed 200 trees per hectare, and their age was about 25-35 years at the time of clear cut. Natural restoration led here to a forest the first layer of which is formed by aspen, and the second layer is formed by birch with minor admixture of aspen (less than 30%) regenerated either from stump sprouts or seeds during 3–7 years after clearcut. It takes 20 years for spruce to form third layer in such forest.

A clearcut with undergrowth preservation resulted generally in natural restoration of spruce forest. The fraction of birch and aspen depended on amount of viable spruce undergrowth, and some other factors. It was minor when the density of spruce undergrowth was higher than 2500 trees per hectare, the height was higher than 3 meters, the age was less than 40 years, and the fraction of viable undergrowth was higher than 76%.

The quality of a forest formed in result of natural restoration depended not only on the quantity but also on the quality of viable spruce undergrowth. The adverse influence of the upper layer manifests itself in reduced growth rate and viability of undergrowth. Differentiation by viability occurs at the age of 10 years. The rate of height growth peaks at the age of 25 years in the case of viable undergrowth, at the age of 20 years in the case of doubtful undergrowth, and at the age of 10 years in the case of impractical undergrowth (Fig 1). As it can be seen from the Figure 2, the reduction in the rate of height growth (as compared to standard stands) is significant even in the case of viable undergrowth (50-70 % depending on age), and is severe in the case of impractical undergrowth (more than 75%).

4. DISCUSSION

The share of coniferous forests in the southern taiga regions of the European part of Russia decreased by 36% from 1927 to 2003 [Korotkov and Storozhenko, 2008]. According to the previous studies [Obydennikov, 1980; Tikhonov, 2000; Dekatov, 2001], birch and aspen dominate in the regions where species change occur. The results of the study presented in this article confirm that natural restoration of disturbed spruce forests leads to species change and results in increased share of birch and aspen.

Many researchers [Alekseeva, 1978; Kairyukshtis, 1974; Tikhonov and Zhizhkun, 2000; Korotkova and Storozhenko, 2008] mentioned about the relation between species composition of a naturally restored forest and the amount of undergrowth preserved at the time of clearcut. The earlier empirical models, however, were not taking into account ecological conditions of its growth before clearcut. The results of the study presented here fill this gap and suggest that growth rate before clearcut is the characteristics of undergrowth which is essential for forecasting the perspectives of natural restoration of spruce forests.

5. CONCLUSION

This article reports the necessary conditions for natural restoration of spruce forests. It also shows that the share of spruce in a naturally restored forest depends on quantity, viability and the age of undergrowth preserved at the time of clearcut. For making a reliable forecast of the spruce share one needs better understanding of ecological processes that determines growth and differentiation of spruce undergrowth. Database, compiled in the course of research, provides the ground for development, identification and verification of process-based ecological models, suitable for this purpose.

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