Natural Regeneration on Narrow Strip Clear-cuts of Norway Spruce (*Picea abies* (L.) Karst) Stands

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The rate of natural regeneration of Norway spruce and birch on narrow strip clear-cuts in Norway spruce stands aged from 25 to 30 years of age in South Sweden, and the relationships between the rate of regeneration and environmental conditions have been studied in order to find the best methods of natural regeneration. The first year regeneration was evaluated by counting seedlings within circle sample plots located on scarified belts within strip clear-cuts.

About 14.5 % of total variation in the rate of spruce regeneration and 12.7 % in the rate of birch regeneration were due to peculiarities of stands and strip clear-cuts. The rest of variation was attributed to within strip clear-cut variation of micro-site ecological conditions.

In separate stands the correlation between the regeneration rate and some ecological factors studied varied due to differences between these stands. There was found very weak negative correlation between the regeneration of spruce and width of strip. The correlation between the amount of birch regeneration and width of strip was strong and positive (r=0.40). Regeneration of birch was better on wide strips, but that of spruce was better on narrow strips.

The most significant correlation was found between the width and depth of scarification and the amount of Norway spruce seedlings (r=0.35-0.68). However, the correlation between the birch regeneration and scarification quality was very weak. The rate of birch regeneration was positively correlated to soil moisture and negatively correlated to the amount of slash both at plot mean and stand mean levels. The rate of Norway spruce regeneration was not correlated with the rate of birch regeneration. This also indicates that these tree species differ in adaptability and ecological priorities and, therefore, the different means should be used to get successful natural regeneration of each species. Differences in regeneration success of these species on different sites could have a significant impact on the changes in species composition and quality of new stands.

Key words: Norway spruce, natural regeneration, seedlings, strip clear-cut, soil scarification.

Introduction

Due to the continuously rising cost of artificial reforestation, the use of natural regeneration becomes more important. Natural regeneration is considered the main method of regeneration of gene conservation populations and natural stands in various categories of protected territories. Natural stand regeneration is a comprehensive, practical and cheap alternative to forest planting in commercial forests as well. However, at least two requirements have to be fulfilled for natural stand regeneration to be successful:

1) suitable seed sources should be available; and

2) the rate of first year regeneration and survival should be sufficient to get a young stand with high initial density.

A satisfactory seed source of high technical quality seed and of suitable provenance is necessary for successful natural stand regeneration. Stands are naturally regenerated by using seed sources that are found on the area to be regenerated or in the neighbouring stands. A good seed yield is one that can guarantee successful stand regeneration after it has been harvested under moderate growth conditions. Seed yield is considered good, intermediate, or poor if it results in more than 200,000, between 75,000 and 200,000, or less than 75,000 sound seeds/ha being produced, respectively. The minimum yield necessary for stand regeneration should exceed 120,000 seeds/ha (Duryea and Dougherty 1991, Backer, Janas 1982). Natural regeneration also can be combined with planting seedlings of suitable provenance to increase the initial density.

Clear cuts, seed tree, and shelterwood harvests are the three major methods used to harvest natural even-aged stands. The selective breeding harvesting method is applied in uneven-aged stands (Smith 1986). Clear cuts might be used for natural stand regeneration when regenerating small areas if a satisfactory seed source is available in the neighbouring stands. Studies in Canada (Fraser et all. 1976, Pominville and Ruel 1995) show that strip cutting led to higher coniferous regeneration, stocking, and a lower percent of failures than clear-cutting. However, on unscarified areas, the gain attributable to strip cutting was not significant. Strip cutting is an interesting option on sites with good regeneration before cutting. Scarification improved natural regeneration of black spruce by seeding (Prevost 1996). Site preparation, if it is planned, should be more intensive on areas that are further from the seed source, thus, ensuring the homogeneity of the new stand (Parviainen 1994). The width of the wood lot should not exceed 50 metres (Finland), 90 metres (USA), and 122 metres (Australia) or should not be larger than 2.5 to 4.0 ha. The longitudinal axis of the clear-cut area should be perpendicular to the direction of the prevailing winds during the period of seed distribution.

Two periods of clear cutting are preferable in order to get good natural regeneration of forests:

1) Stand harvesting should be done during the period of seed distribution. It must be done in late autumn or winter (November to March) after the cones are ripe or the seed is distributed but before seed germination takes place. The optimal situation is after the cones are ripe but before the distribution of seed starts, thus ensuring that the fewest seeds possible are covered by slash.

2) Stand harvesting after the seed germination starts. It should be done at the end of the summer of a year with high seed yield (mast year).

A good yield of sound seeds is vital for both cases. This method is risky because it makes the period of stand regeneration shorter.

The seed tree method may be successfully applied for the Scots pine regeneration. A minimum of between 10 and 15 evenly distributed trees of high quality, which have high seed yield, should be selected on an area of 1 ha to ensure success. The basal area of selected trees should be between 1.4 and 2.8 m^2/ha. The number of trees that remains on the harvested area should depend on site conditions and tree size. For black spruce, in order to improve regeneration on strip clear-cuts it is recommended to leave the seed trees for 8 years before they are felled (Tenhagen and Jeglum 1997). However, application of seed tree method for improving regeneration of Norway spruce is very limited due to windfalls.

Before the reproductive stand harvesting takes place, it is recommended to prepare the area by using chemical measures (e.g., spraying herbal vegetation and sprouts of the undesired species) or by using fire (Brown and Davis 1973). To ensure a satisfactory amount of seeds, 3 to 5 vegetation seasons before the reproductive harvesting the seed trees might be released by removing all trees in a distance of 5 to 10 metres, or by thinning the stand to a basal area of 14 to 16 m^2/ha. Such a stand thinning increases the seed yield already during the first year after the reproductive harvesting. This measure is particularly necessary if the crowns of the seed trees are small. The seed trees should be removed from the area as soon as possible (usually after 3 to 5 years) when there are no less than 2,500 evenly distributed seedlings/ha.

The shelterwood method is similar to the seed tree method except 75 to 125 trees/ha are left (basal area of 5 to 7 m^2/ha.). This method is applied when harvesting even-aged stands that consist of no clearly evident trees of class A. Similar to the seed tree method the number of selected trees also depends on tree size as well as site and local conditions. Seed trees are usually removed from the stand after 3 to 6 years. If after 5 years the number of seedlings/ha exceeds 12,000, the stand should be thinned (Leibundgut 1981, Schubert, Adams 1971). The shelterwood method is costly silvicultural method and requires expertise, care and continuity (Westerberg, Hannerz 1994). It is possible to obtain a higher return than in traditional stand harvesting only when suitable sites are chosen and appropriate treatment programmes used.

In South Sweden, many stands of Norway spruce between 25 and 30 years old are of bad quality. This is due to the low density of stands (because of low number of seedlings planted and/or survived), and because the origin of planting material used (Byelorussian continental provenances) was not suitable for eco-climatic conditions in South Sweden. Pominville P. and Ruel J.C. (1995) concluded that strip cutting could be a good option on sites with insufficient advanced growth. Natural regeneration of these stands is one of the main methods because artificial reforestation is too costly. However, in order to have sufficient advanced growth and good quality stems in the new stands a high initial density of seedlings and young stands should be guaranteed. Therefore, it is very important to get good first year regeneration and good survival of seedlings.

Our studies aimed to evaluate the possibilities of natural regeneration of spruce and birch on narrow strip clear-cuts in Norway spruce stands of poor quality, and to define the relationships between the rate of regeneration and environmental conditions in order to find out the best methods of natural regeneration. Eco-climatic conditions in South Sweden are rather similar to those in Lithuania and, therefore, these studies might be of the same importance for improving regeneration of Lithuanian forests.

Methods and materials

The studies were conducted in August 1994 on narrow strip clear-cuts in Norway spruce forests of the forest company "Gustafsborgs Säteri AB" in South Sweden. Strips were clear-cut in 1992-1993 in bad quality stands between 25 and 30 years of age in order to evaluate the possibility of stands' reconstruction by natural regeneration. The width of strip clear-cuts varied from 16 to 60 m (Fig. 1). Belts of the remaining stands were 20 to 50 m wide. Timber and slash were removed from the strips before soil scarification. The scarification was done to support natural regeneration of spruce and birch. The removing of the grass layer and soil scarification are done using site preparation machines with slow spinning disk (disc trenching machines). The width of scarified belts varied from 0.1 to 0.7 m, the mean distance the between belts was 2.5 m. Seed was wind-sown from the remaining belts of premature stands and neighbouring mature stands. Seed yield was above average both in 1993 and 1994.

Studies of regeneration were conducted in 2 to 7 strips in each of 17 stands. The length of strips varied from 70 to 800 m. Measurements of natural regeneration and site conditions were made on permanent and temporal circle sample plots of 0.8 m^2. They were located on scarified belts every 15 meters in the middle of strip clear-cuts (Fig. 1). Every 15 plots there were located 1 permanent sample plot in the middle of the strip and additional 2 permanent sample plots close to the sides of strips in order to evaluate the influence of distance to stand on regeneration. In stands No.182, No.185, and No.201 the groups of 3 permanent sample plots were located every 15 metres. Permanent sample plots were marked with plastic sticks and labelled. These plots will be used to study the survival of seedlings and additional regeneration in coming years. A total of 305 sample plots were set. In order to evaluate the impact of clear-cut on the growth of the remaining stands aside the strip clear-cuts, the diameters at breast height of 5 to 25 trees, and the height of one average tree, were measured to the left and right of every group of permanent sample plots in the belt of 2 metres wide.

The regeneration was evaluated by separately counting spruce, pine, larch, and birch seedlings within the circle sample plot. The scarification width was evaluated in dm. The scarification depth was evaluated in points (1 pt. =1 to 5 cm, 2 pt.=5 to 10 cm, 3 pt.=10 to 15 cm and so on). The area of sample plot covered by grass and slash was assessed in per cent. Soil moisture was evaluated in points (dry soil - 1 pt., normal - 2 pt., moist - 3 pt., and wet - 4 pt.). The strip clear-cut width was measured at location of every sample plot.

Variance components for the rate of first year regeneration were evaluated by variance analysis according to the following model:

$$y_{ik} = \mu + s_i + e_{k(i)},$$

where: y_{ik} = observed value on *ik*th sample plot from the *i*th strip clear-cut/stand, μ = overall mean, s_i = effect of *i*th strip clear-cut/stand, $e_{k(i)}$ = random residual of the *ik*th observation (sample plot), assumed normal distribution. The ANOVA and VARCOMP procedures were used to perform the analysis of variance.

The correlation was evaluated at two levels: sample plots means and means of stands. The effects of

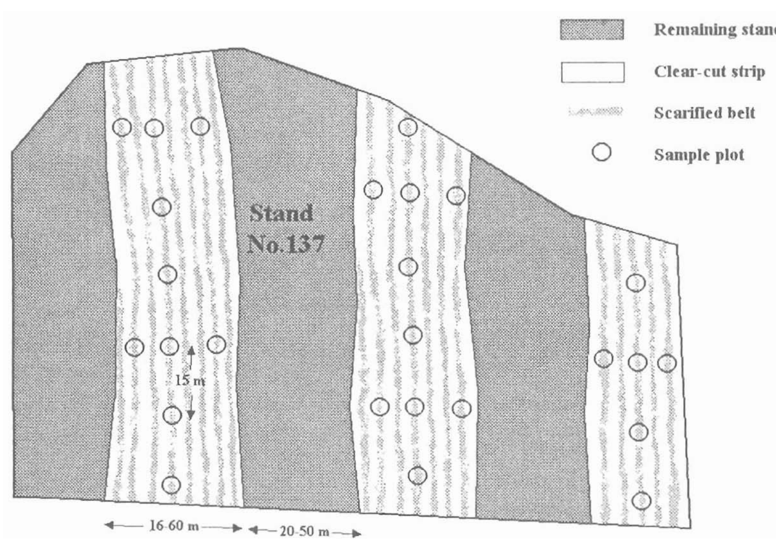

Figure 1. Scheme of strip clear-cuts in Norway spruce stand No.137 and location of sample plots

the separate ecological components studied (scarification depth, width, soil moisture, strip width, etc.) on regeneration were evaluated by using square regression analysis (RSQUARE and REG procedures). Regression analysis was conducted on sample plots means. The combined effects of some ecological components on the rate of regeneration were estimated using multivariant stepwise regression analysis (STEPWISE procedure).

Results and discussion

There are different sources of variation in regeneration rates. One part of the variation was induced by micro-ecological differences of sites within a stand, and the other one was caused by differences between stands. These different sources of variation were evaluated by using both the variance and covariance analysis. About 14.5 % of the total variation in the rate of spruce regeneration were caused by the peculiarities of stands and strip clear-cuts. The rest of the variation was due to within strip clear-cut variation in micro-site ecological conditions. For birch, about 12.7 % of total variation can be attributed to the peculiarities of stands and strip clear-cuts.

Within separate stands the correlation between the regeneration rate and some ecological factors studied were of different strength due differences between these stands. However, the main trends can be clearly identified. Some results are presented in Tables 1 and 2. There was very weak negative correlation (based on stands means) between the amount of spruce regeneration and width of strip clear-cuts. However, the correlation between the amount of birch regeneration and width of strip clear-cuts is strong and positive (r=0.40). So, birch regeneration is better on wide strips, but spruce regeneration is slightly better on narrow strips. In black spruce regeneration studies, Tenhagen and Jeglum (1997) found that decreased strip width resulted in increased stocking and density in 18-year-old strip clear-cuts. On the strip clear-cuts, the balsam fir stocking was constant, while black spruce stocking increased (Pominville, Ruel 1995). The microclimate and site characteristics are different on strip clear-cuts of different width/

plots) and on the basis of stand means

* - the most significant correlation coefficients are underlined

area. The microclimate is harsher on large clear-cut areas than in shelterwood or narrow strip clear-cuts and that increases selection pressure. It could reduce genetic diversity of new generation. The genetic composition of generation on large clear-cut areas could differ from new generation in shelterwood or on narrow clear-cuts and that could have negative implications on adaptation of stand in the future. It was concluded (Groot, Carlson 1996), that moderation of air temperature at clear nights would be best achieved with a maximum strip width of 0.6 tree heights which would reduce damage to white spruce seedlings after spring frost and have a positive effect on natural regeneration. Microclimatic conditions in narrow strip clear-cuts are close to that in shelterwood and could be more favourable both for improving regeneration, type of adaptation, and for increasing genetic diversity of new stands.

The differences in regeneration of different species show differences in the ecological optimum and in dispersal ability of seed. This could have an impact on the changes in composition of the new stands, which in most cases needs to be avoided.

In our experiment, we found significant correlation between the quality of scarification (width and depth of scarification) and amount of spruce seedlings (r=0.35-0.68). The shape of that relationship is shown in Figures 2 and 3. The correlation between the birch regeneration and scarification quality is very weak. The rate of birch regeneration is related to soil moisture: higher moisture leads to better regeneration of birch (Fig. 4). However, this relationship is not strong. The rate of birch regeneration was positively correlated with soil moisture both at plot mean and stand mean levels. The rate of spruce and birch regeneration was negatively correlated with the amount of slash at both levels as well.

The curves and equations of regression of regeneration on the separate ecological components studied (scarification depth, width, soil humidity, strip width and so on) and coefficients of determination (R^2) are presented in Figures 2 to 5.

The combined effects of the main ecological components on the rate of first year regeneration were estimated according to the equations:

$$Y_{spruce}=1.36 + 3.33*WSCA - 2.17*DSCA + 0.29*DSCA^2 \qquad R^2 = 0.29$$

$$Y_{birch} = 2.89 + 6.56*WSTR + 0.10*WSTR^2 + 3.37*SLA + 62.9*HUM \qquad R^2 = 0.09$$

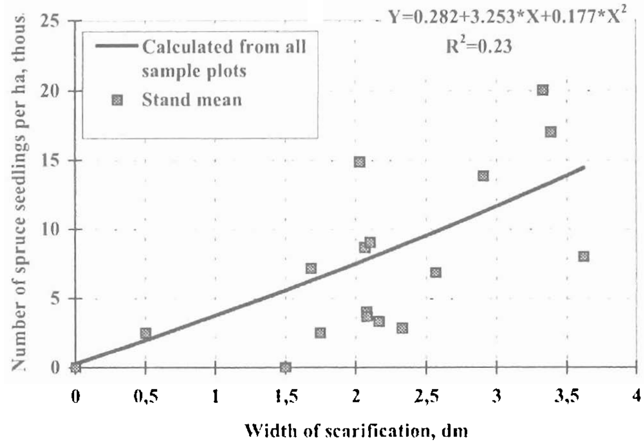

Figure 2. The effect of scarification width on the first year Norway spruce regeneration on strip clear-cuts

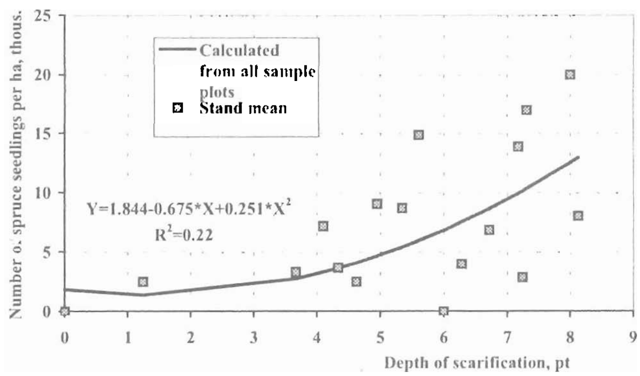

Figure 3. The effect of scarification depth on the first year Norway spruce regeneration on strip clear-cuts

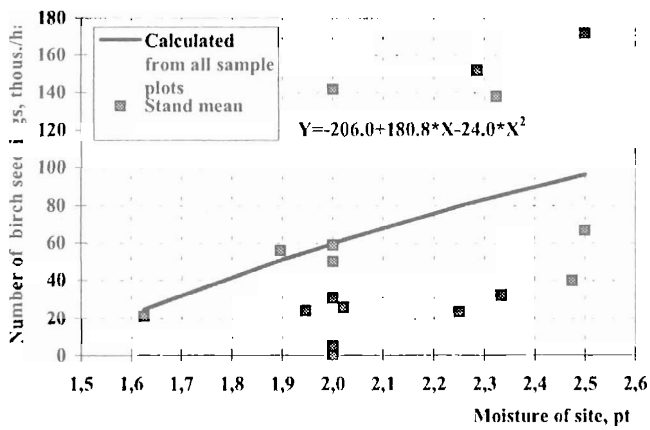

Figure 4. The influence of site moisture on the first year birch regeneration on strip clear-cuts

Emphasis is placed on the fact (Boerset 1976) that favourable conditions for regeneration are in places which have a good combination of heat and moisture.

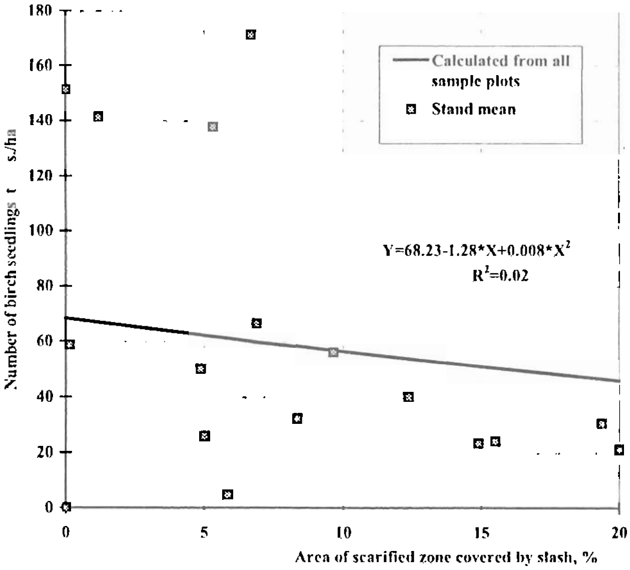

Figure 5. The influence of the amount of slash on the first year birch regeneration on strip clear-cuts

These site conditions in the middle of strip clear-cuts studied are slightly different from those on the sides (close to the remaining stand). However, the rate of Norway spruce regeneration was not influenced by distance to the remaining stand. The average number of spruce seedlings per plot on the sides or in the middle of the strips was almost the same. Meanwhile, the regeneration of birch was 2 to 3 times better in the middle of the strips than that on the sides of the strips. It could be attributed to differences in soil moisture: due to transpiration and evaporation from the remaining stand, soil moisture close to the edges of strips was too low for germination of birch seed.

The average characteristics of the environment in strip clear-cuts and regeneration rate in different stands are presented in Table 3 and Figures 6, 7 and 8.

The amount of birch seedlings in each sample plot has more variation than that of spruce seedlings. This indicates the existence of more significant fluctuation of the amount of birch seed being spread by the wind within the strip clear-cut and higher sensitivity of birch seeds to environmental conditions needed for germination and first year survival of seedlings. The rate of spruce regeneration was not correlated with the rate of birch regeneration. This also indicates that these species differ in adaptability and ecological priorities. So, the different means should be used to get successful natural regeneration of each species.

Ecological conditions in South Sweden are very similar to those in Lithuania Therefore, all these regularities found could be valid for Lithuanian forests. However, these regularities can be attributed to preliminary because the experiment was set on clear-cut areas not specially assigned for the scientific experiment and the design was not suitable enough to define clear relationships between the rate of regeneration and environmental conditions. It enabled us to evaluate the success of regeneration in narrow strip clear-cuts and get general understanding on species peculiarities and on the general relations between the ecological conditions and regeneration. However, controlled experiments and more sophisticated study methods are necessary in order to determine complicated biological regularities of the species in interaction with the sites.

Table 3. The correlation between the ecological factors and rate of regeneration in separate Norway spruce stands

Ecological factors	Correlation coefficients in stands No.1502/ No.193/ No201		
	Number of seedlings		
	all species	spruce	birch
West-East position of strips	-0.35 -0.05 -0.35	-0.21 0.09 0.13	-0.33* -0.07 -0.36
Width of strip	-0.32 -0.14 0.14	-0.40 -0.14 0.12	-0.26 -0.12 0.13
Width of scarification	0.53 0.30 0.38	0.51 0.35 0.63	0.45 0.24 0.34
Depth of scarification	0.33 0.41 0.17	0.48 0.40 0.36	0.24 0.35 0.15
Area covered by grass	-0.08 -0.21 -0.17	-0.06 -0.25 -0.35	-0.08 -0.17 -0.14
Area covered by slash	-0.22 0.31 -0.18	-0.34 0.14 -0.27	-0.16 0.31 -0.16
Moisture of site	0.12	-0.03	0.15
Number of spruce seedlings	0.58 0.53 0.25	1.00 1.00 1.00	0.37 0.34 0.18
Number of birch seedlings	0.99 0.98 0.99	0.37 0.34 0.18	1.00 1.00 1.00

* - the most significant correlation coefficients are underlined

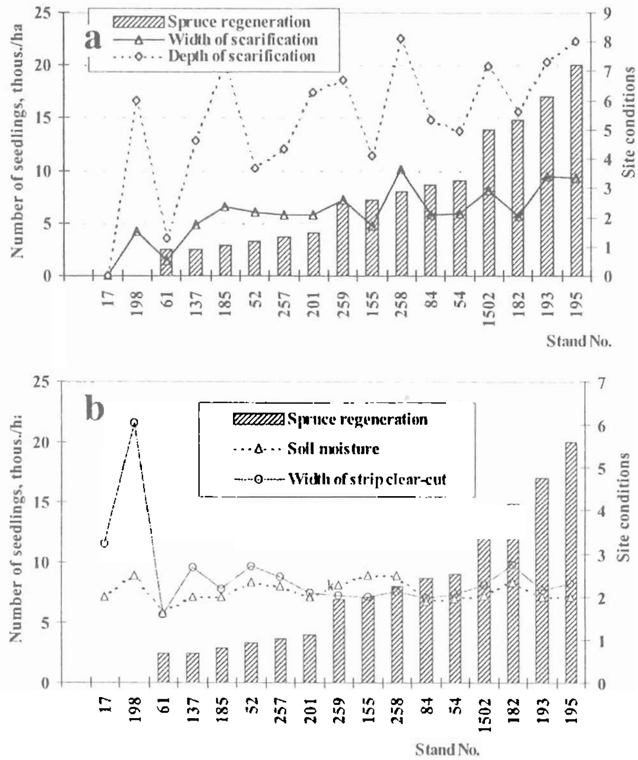

Figure 6. The first year Norway spruce regeneration on strip clear-cuts in different stands

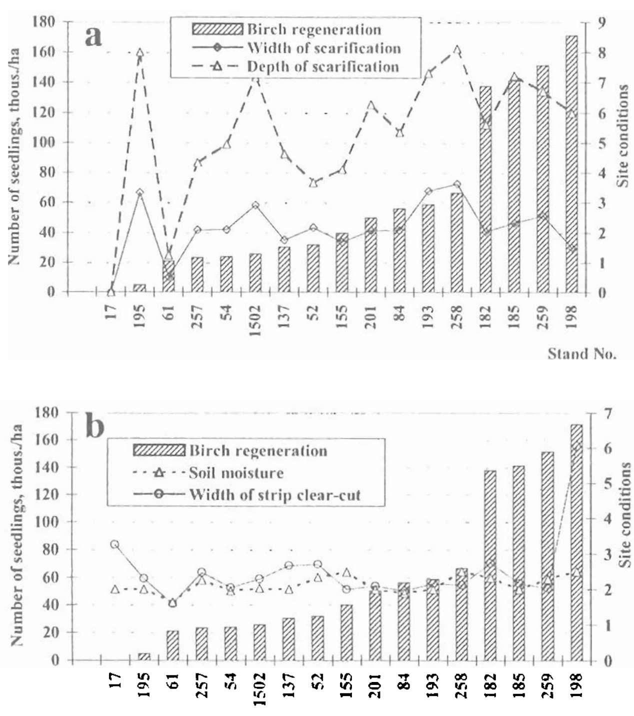

Figure 7. The first year silver birch regeneration on strip clear-cuts in different stands

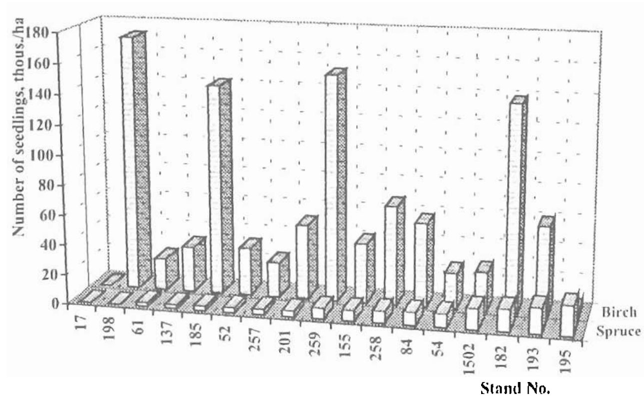

Figure 8. The first year regeneration of Norway spruce and birch on strip clear-cuts

Conclusions

About 14.5 % of total variation in the rate of spruce regeneration were due to the peculiarities of stands and strip clear-cuts. The rest of the variation was due to within strip clear-cut variation of micro-site ecological conditions. For birch, about 12.7 % of total variation can be attributed to the peculiarities of stands and ecological conditions in strip clear-cuts.

In separate stands the correlation between the regeneration rate and some ecological factors studied varied due to differences between these stands. There was a very weak negative correlation between the regeneration of spruce and width of strip. The correlation between the amount of birch and width of strip was strong and positive (r=0.40). Regeneration of birch was better on wide strips, whilst that of spruce was better on narrow strips. This could be influenced by differences between the species in the ecological optimum and seed dispersal ability.

The amount of birch seedlings in each sample plot has more variation than the number of spruce seedlings. This indicates the existence of more significant fluctuation in the amount of birch seed being spread by the wind within the strip clear-cut and higher sensitivity of birch seeds to environmental conditions needed for germination and first year survival of seedlings.

The most significant correlation was between the scarification quality and amount of spruce seedlings (r=0.35-0.68). However, the correlation between the birch regeneration and scarification quality was very weak. The rate of birch regeneration was positively correlated to soil moisture and negatively correlated to the amount of slash both at plot mean and stand mean levels. The rate of spruce regeneration was not correlated with the rate of birch regeneration. It also indicates that these tree species differ in adaptability and ecological priorities and, therefore, the different means should be used to get successful natural regeneration of each species. Differences in regeneration success of these species on different sites could have a significant impact on the changes in species composition and quality of new stands.

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References

Boerset O. 1976. Problems of natural regeneration in Scandinavian forests. Schweizerische-Zeitschrift fur Forstwesen, 127: 165-181.

Brown A. A. and Davis K. P. 1973. Forest fire control and use. Mc graw-Hill Book Co., New York. 686 p.

Clarke G. C. 1992. The natural regeneration of spruce. Scottish Forestry, 46: 107-129.

Duryea M. L. and Dougherty P. M. 1991. Forest Regeneration Manual. Kluwer Academic Publishers. Dordrecht-Boston-London.433p.

Fraser J. W., Haavisto V. F., Jeglum J. K., Dai T. S.. Smith D. W. 1976. Black Spruce regeneration on strip cuts and clearcuts in the Nipigon and Cochrane areas of Ontario. Great Lakes Forest Research Centre, Canada., Report No. OX 246, 33 p.

Groot A., Carlson D. W. 1996. Influence of shelter on night temperatures, frost damage, and bud break of white spruce seedlings. Canadian Journal of Forest Research, 26: 1531-1538.

Leibundgut H. 1981. Die naturliche Waldverjungung. Verlag Paul Haupt Bern und Stuttgart. 108s.

Parviainen J. 1994. Finish silviculture: managing for timber production and conservation. Journal of Forestry, September 1994 :33-36.

Prevost M. 1996. Effects of scarification on soil properties and seed regeneration in a black spruce stand in the boreal forest of Quebec. Canadian Journal of Forest Research, 26: 72-86.

Pominville P., Ruel J. C. 1995. Effects of clear-cutting and strip cutting on black spruce regeneration after 5 years in Quebec. Canadian Journal of Forest Research, 25: 329-342.

Schubert G. H., and Adams R. S. 1971. Reforestation practices for conifers in California California Dep. of Conservation, Division of Forestry, Sacramento. 359p.

Symposium stand establishment. 1974. IUFRO joint meeting. Wageningen - the Netherlands, 440p.

Tenhagen M .D. Jeglum J. K. 1997. Decreased strip width and increased seeding period result in increased black spruce stocking and density in 18-year-old strip clear-cuts. Frontline, Technical note, Great Lakes ForestryCentre, Canadian Forest Service, No. 89, 4 p.

Westerberg D., Hannerz M. 1994. Natural regeneration of spruce *(Picea abies)* under shelterwood. Resultat, Skog-Forsk (Forestry Research Institute of Sweden), Uppsala; Sweden. No. 17, 4 p.

Wiersum K. F. (Editor) 1984. Strategies and design for afforestation, reforestation and tree planting. Pudoc, Wageningen, 432p.

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ЕСТЕСТВЕННОЕ ЛЕСОВОЗОБНОВЛЕНИЕ НА УЗКИХ КОРИДОРНЫХ ВЫРУБКАХ В ДРЕВОСТОЯХ ЕЛИ ОБЫКНОВЕННОЙ (*PICEA ABIES* (*L.*) KARST)

А. Плюра, В. Кундротас, В. Сухоцкас

Резюме

Исследовалось естественное лесовосстановление ели и березы на сплошных узких коридорных вырубках в 25-30-летних реконстрируемых ельниках Южной Швеции и взаимоотношения между лесовосстановлением и условиями окружающей среды. Лесовосстановление оценивалось подсчитывая количество однолетних сеянцев на пробных площадках заложенных на минерализированных полосах внутри вырубленных коридоров.

Установленно, что вариация интенсивности естественного возобновления ели в 14,5% зависит от особенностей древестоя и вырубки. Остальная величина вариации зависит от микроэкологических условий на самой вырубке. Вариация интенсивности лесовозобновления березы в 12,7% зависит от особенностей древостоя и вырубки.

Корреляция между интенсивностью лесовозобновления и отдельных экологических факторов в различных местах исследования неодинаковое из-за разницы условий окружающей среды в исследуемых вырубках. Было установлено, что естественное лесовозобновление березы интенсивнее на широких вырубках, а ели на оборот – на узких вырубках.

Наиболее тесная достоверная кореляция установлена между показателями минерализации поверхности почвы и количеством сеянцев ели (r=0.35-0.68), тогда как корреляция между показателями минерализации почвы и возобновлением березы очень слабая. Уровень возобновления березы был в прямой зависимости от влажности почвы и в обратной зависимости от количества порубочных остатков. Уровни возобновления ели и березы некоррелировали. Это указывает на различие между этими видами по адаптации и экологическим приоритетам, что предопределяет применение различающихся технологий естественного возобновления. Различия в возобновлении этих видов в разных экологических условиях может значительно отразится на формировании видового состава и качества новых древостоев.

Ключевые слова: естественное лесовозобновление, сеянцы, ель, береза, коридорные вырубки, минерализация поверхности почвы.