Distribution of Scots Pine (*Pinus sylvestris*) Naturally Regenerating Seedlings on Abandoned Agricultural Land at Forest Edges

VYTAUTAS SUCHOCKAS
Lithuanian Forest Research Institute
Girionys, LT-4312 Kaunas distr. Lithuania

Suchockas V. 2001. Distribution of Scots Pine (*Pinus sylvestris*) Naturally Regenerating Seedlings on Abandoned Agricultural Land at Forest Edges *Baltic Forestry*, 7(1): 79–83.

Evaluation of natural regeneration of pine on abandoned agricultural land, and definition of the relationships between distance from seed source and stand structure in order to find the best methods to get good natural regeneration have been studied. The regeneration was evaluated by measuring the naturally regenerating seedlings of pine within the circle sample plot.

Due to the negative effect of the seed trees on the regenerating seedlings at the very edge of the forest, the abundant natural regeneration occurs in 5 to 15 m apart from the forest edge. In terms of capability to form a new productive stand, natural regeneration of pine basically ends in 130 m apart from the forest edge. Single groups of naturally regenerating pine seedlings were found up to 175 m apart from the forest edge.

The spatial distribution of naturally regenerating seedlings was not uniform. There were many empty spots, the occurrence of which did not depend on the distance from the forest edge. Empty spots were also found close to the forest edge, where the number of dispersed seeds was largest. To obtain uniform natural regeneration over whole site, soil scarification prior to seed dispersal is needed

Key words: natural regeneration, Scots pine, seedlings, soil scarification.

Introduction

Afforestation is one of the main means to utilize abandoned agricultural land in Central and Western Europe. To improve success of natural regeneration of abandoned agricultural land, it would be important to determine factors influencing regeneration. (Kohlstock, 1992; Gorzelak, 1999)

Wind direction and strength

The distance of seed dispersal mainly depends on the speed and the direction of wind, which are very important factors to consider when assessing possibilities for natural regeneration on abandoned agricultural land. In Lithuania, western and southern winds prevail (i.e. blowing from the west and from the south). During the warm period, western and south-western winds prevail (the probability is from 35 to 40 %). In April south-eastern winds prevail (Каушпла, 1983).

There are pronounced differences in the speed of wind at different time of the year. From May to September, western winds are strongest, while from October to April south-eastern winds are strongest. Northern and north-eastern winds are weak throughout all over the year. In Lithuania, the mean wind speed is 3.6 m/s. The minimum wind speed may be close to zero at any time of the year. The maximum wind speed in gusts is from 5 to 8 times greater than the mean wind speed. Namely, the very strong winds have the main effect on seed dispersal distance. In Lithuania, the winds often reach the speed of 15-17 m/s or, in gusts, may reach 22 to 24 or even 28 m/s (Каушпла, 1983). However, such extremely strong winds do not occur every year. More often, the stronger winds blow with speed of 10 m/s (defined as the monthly maximum wind speed: average of monthly maximum wind speed over a period of time, e.g. over a decade) or with speed of 15 m/s (defined as annual maximum wind speed) (Каушпла, 1983).

During each month, there is a 5 to 11-day-period during which wind speed is close to zero. In conifers, seed dispersal occurs in spring (March to May). During this period, there used to be 5 very calm days per month. The average wind speed during the period on awerage from March to May is 3.3 to 3.9 m/s. However, namely during this period, the strongest winds reaching 28 m/s were recorded. Mean maximum wind speed is 10 to 12 m/s, wind direction is not stable, though, southern and south-eastern winds blow more often (Каушпла, 1983). Therefore, dispersal of conif-

erous seeds occurs more or less evenly to all directions from the seed tree.

Seed yield and seed dispersal at the forest edge

The beginning of seed dispersal depends on climatic conditions. The seed dispersal starts after moisture of the cones drops down to 10 to 17 %. Most of the seeds are dispersed during April and the first half of May. Amount of the dispersed seed depends on the seed yield. In Scots pine, the reproductive circle extends for two growth periods, and trees used to flower almost every year. However, the seed yield varies between years. As seed maturation in Scots pine takes a relatively longer time, timing of different seed development stages may differ between the years. It is unlikely, that the climatic conditions will be favourable for seed development during all the stages of the reproductive circle. This may explain variation in seed yield in different years (Braun, 1992).

Seed yield may also depend on soil fertility. Under the same climatic conditions, trees grown on rich soils yield twice as much seed as trees grown on poor soils (Schmidt-Vogt, 1991).

Percentage of empty seeds differs between the years and is usually ranging from 10 % to 40 %.

Favourable environment during pollination and seed development results in production of a higher number of seeds per cone. Large cones (of dry weight over 6 g) contain 35 to 45 seeds per cone. Small cones (of dry weight less than 4 g) contain 10 to 15 seeds per cone. One cone on average, contains 20 seeds (Leibundgut, 1981).

A mature Scots pine stand occupying an area of 1 ha may produce from 400 thousand to 2 million seeds This amount of seed may also be dispersed at the forest edge (Dengler, Röhrig 1990).

Seed dispersal distance depends on wind speed and height of the seed trees. When following down, the seeds are flying in spiral. Seeds of Scots pine are falling dawn with the speed 0.83 m/s (measured in the diagonal) or 1.2 m/s (if measured straight dawn). Then, on a calm day, the seeds dispersed at the height of 30 m approximately should reach the ground in 36 seconds. During these 36 seconds, the seeds may easily be blown away from the parental tree. During a calm day, seed dispersal distance equals to half of the height of the seed tree. If a falling seed would be caught by wind gust at the speed of 1.7 m/s, it may be blown for 35 m away from the seed tree and, if the speed of the wind gust is 2.7 m/s, the seed may be blown for 51 m away from the seed parent (Kolerman, 1950; Schmidt-Vogt, 1991). Single seeds may fly over 200 m from the seed parent. However, only 10 % of the seeds may fly more than 50 m from the seed parent. Empty seeds are lighter and are falling dawn more slowly than filled seeds and, thus, may be blown away for a larger distance than filled seeds. Thus, when moving further from the seed stand, the number of empty and undeveloped seeds is increasing (Wiersum,1984; Mikšys, 1999). Owing to falling down of undeveloped cones, insufficient opening of cone scales and pest insect or fungal damage, only 40 % of the mature seeds are reaching the ground. Immature but sound seeds may also reach the ground. This affects germination capacity of the sound seeds dispersed, which is, usually, reaching 50 % (Schmidt-Vogt, 1991).

Material and methods

Based on the data of the forest inventory, it was found that during the last decade, the largest areas of self-regenerated Scots pine stands in the abandoned agricultural lands had formed five years ago. Therefore, the 5-year old Scots pine stands were studied.

For this study, 22 abandoned agricultural areas being under self-regeneration stage and neighbouring to the Scots pine stands were chosen in the forest enterprises of Jonava, Kazlų Rūda and Veisiejai. The study objects are situated on the same kind of Podzolic sandy soils. The soil moisture conditions and bulk density of the soil on all study objects are similar. Spacing and distribution of trees in the self-regenerated abandoned agricultural lands were evaluated in the circle-shaped study blocks (experimental plots) of 100 m² in size. The study blocks were situated in all directions perpendicularly to the edge of seed origin. Close to these stands, the study blocks were situated every 25 meters in the perpendicular direction from the edge of them. In perpendicular direction, 5 to 8 circle-shaped study blocks were established, depending on the size of the area to be studied. In each abandoned area, 5 series of the circle-shaped study blocks were established every 50 meters in a lengthwise direction from the forest edge. In each abandoned area, depending on size, 25 to 40 study blocks were established. The size of abandoned areas varied from 2 to 3.5 ha. The total size of all study blocks (experimental plots) per abandoned area varied from 0.25 to 0.4 ha.

Each tree was evaluated entirely in the study blocks. The taxation parameters for trees were evaluated following the accepted methods. Tree crown projection was measured in two directions as well.

The statistical analyses of data were conducted by the MS Excel program. According to the statistical analyses of data, the results are presented graphically.

Results and discussion

The study on patterns of natural regeneration on abandoned agricultural land has revealed, that the spatial distribution of naturally regenerating seedlings is not uniform. Seeds of coniferous species may be dispersed rather far from the seed source and even a single well-flowering tree may provide a sufficient number of seeds to cover a site of several hectares.

Our study on natural regeneration on abandoned land has shown, that abundant natural regeneration occurs ef the distance from 5 to 15 m from the forest edge. This may be explained by the negative effect of the seed trees on the regenerating seedlings at the very edge of the forest.

Variation in density of naturally regenerating seedlings of Scots pine when moving further from the forest edge

In spite of the fact that during the time of Scots pine seed dispersal in Lithuania (March and May), south-eastern and eastern winds prevail, winds may quite often blow towards other directions as well. Therefore, there was no significant difference in the direction of seed dispersal away from the forest edge.

Natural regeneration of pine occurred from 5 to 15 m from the forest edge with the density of 5 to 9 thousands of seedlings per ha. When moving further from the forest edge, the number of naturally regenerating pine seedlings was continuously increasing and reached the maximum number at the distance from 30 to 60 m apart from the forest edge, followed by a gradual decrease down to 4-5 thousands of seedlings per ha at the distance of 100 m from the forest edge. Namely, 4 to 5 thousands of pine seedlings per ha would be the lower limit for the number of pine seedlings needed to form a new stand of appropriate quality and productivity. At the distance of 130 m from the forest edge, the number of naturally regenerating pine seedlings was somewhat larger than 1000 seedlings per ha. However, this number is insufficient to form a new productive stand. Thus, in terms of capability to form a new productive stand, natural regeneration of pine basically ends at the distance of 130 m from the forest edge. Single groups of naturally regenerating pine seedlings were found up to 175 m from the forest edge.

The dependence of the number of naturally regenerating pine seedlings on the distance from the forest edge by fitting a fourth order polynomial model is shown in Figure 1 (R^2 for model was 0.83).

When moving further from the forest edge, crown cover of naturally regenerating pine seedlings (vertical projection of crown perimeters) was changing similarly as the number of naturally regenerating seedlings. At

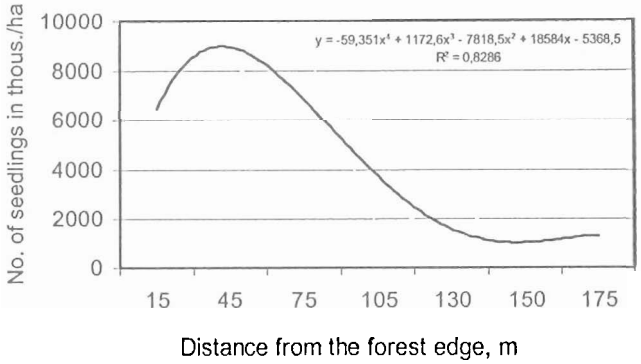

Figure 1. Dependence of number of naturally regenerating 5-years-old seedlings of pine on the distance from the forest edge.

the forest edge, crowns of 5-year-old naturally regenerating pine seedlings covered about 50 % of the area. When moving further from the forest edge, crown cover of the naturally regenerating seedlings was increasing and the seedling crowns were closed at the distance from 30 to 70 m from the forest edge (crown cover was greater than 80 %). At the distance of 100 m from the forest edge, crown cover still exceeded 50 %. Afterwards, crown cover was steadily decreased to 10 % of the area at the distance of 140 m from the forest edge. The dependence of the crown cover percentage on the distance from the forest edge by fitting a third order polynomial model is shown in Figure 2.

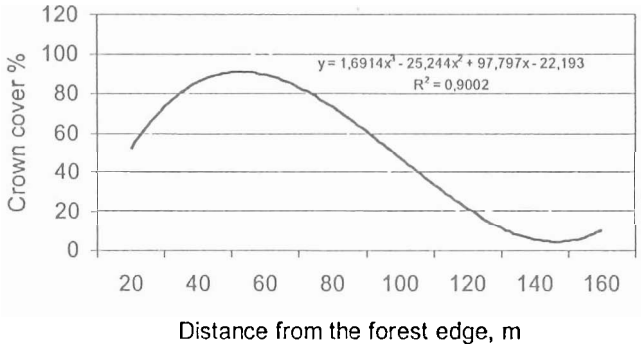

Figure 2. Dependence of the crown cover percentage of 5-year-old pine seedlings on the distance from the forest edge.

The height of naturally regenerating seedlings partially depends on the spacing between the seedlings. At the forest edge, crowns of naturally regenerating pine seedlings were not closed and the seedlings were 15 cm shorter than the seedlings grown further from the forest edge. This may result from shading by the trees at the forest edge. When moving further from the forest edge (40 to 70 m from the forest edge), crowns of the pine seedlings were closed and competition among the seedlings occurred, which

resulted in more intensive height growth. Further from the forest edge, spacing between the naturally regenerating pine seedlings became wide and the height of the seedlings was almost the same as the height of the seedlings at the forest edge. The dependence of the seedling height on the distance from the forest edge by fitting a fourth order polynomial model is shown in Figure 3 (note, R^2 was 0.44 only).

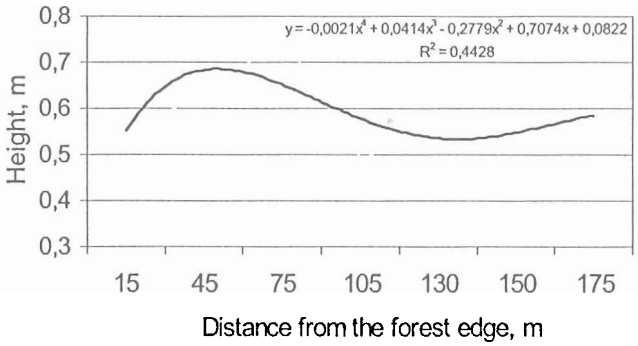

Figure 3. Dependence of height of 5-year-old pine seedlings on the distance from the forest edge.

Conclusion

Average values over several experimental plots were shown in the figures. However, the spatial distribution of naturally regenerating seedlings was not uniform. There were many empty spots, occurrence of which did not depend on the distance from the forest edge. Empty spots were also found close to the forest edge, where the number of dispersed seeds was highest. To obtain uniform natural regeneration over the whole site, soil scarification prior to seed dispersal is needed. When moving further from the forest edge, the number of the seeds dispersed decreases. Therefore, when moving further from the forest edge, the soil shall be scarified to a higher degree. Natural regeneration of pine seedlings occurred in sufficient density to form a new stand over 100 m from the forest edge. If soil scarification is used, we may expect the natural regeneration to form a new stand at the distance of 130 m from the forest edge. This means, that soil scarification prior to seed dispersal may improve the success of natural regeneration of pine for 30 %.

References

Braun H. 1992. Forstgenetik heute. Die Rolle von Forstgenetik und Forstpflanzenzuchtung in einem ökologisch orientierten Waldbau.-Der Wald, 42, 6:208-210.

Dengler A., Röhrig E. 1990. Waldbau auf ökologischer Grundlage. Verlag Paul Parey. Hamburg und Berlin, s.: 56-66.

Gorzelak A. 1999. Zalesianie terenow porolnych. Warszawa – s:-173.

Kohlstock N. 1992. Ackeraufforstung.- Der Wald 42 (11): 406-407.

Kohlermann L. 1950. Untersuchungen ueber die Verbreitung der Samen und Fruechte mitteleuropaeischer Baeume durch den Wind. Frankfurt/Main 75 s.

Leibundgut H. 1981. Die natürliche Waldverjungung. Verlag Paul Haupt Berlin und Stuttgart. 108s.

Mikšys V. 1999. Produktyvių ir tvarių medynų rūšinės sudėties ir struktūros formavimo girių augimvietėse ūkiniai ekologiniai pagrindai. Mokslinė ataskaita, p. 52.

Schmidt-Vogt H. 1991. Die Fichte. Band 11/3. Verlag Paul Parey, Hamburg und Berlin. 784s.

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

Каушила К. А. 1983. Климат Вильнюса и Каунаса. Ленинград. 225с.

Received 22 February 2001

РАЗМЕЩЕНИЕ СЕЯНЦЕВ СОСНЫ ОБЫКНОВЕННОЙ (*PINUS SYLVESTRIS*) НА БЫВШЫХ ПОЧВАХ СЕЛЬСКОХОЗЯЙСТВЕННОГО НАЗНАЧЕНИЯ ПРИ ЕСТЕСТВЕННОМ ОБЛЕСЕНИИ ОПУШЕК ЛЕСА

В. Сухоцкас

Резюме

Работа посвящена исследованию естественного облесения бывших почв сельскохозяйственного назначения сосной, а также установлению связей между расстоянием от семенного источника и структуры сформировавшегося древостоя. Естественное облесение бывших почв сельскохозяйственного назначения сосной исследовалось путем обмера сеянцев на выделенных круглых пробных площадях.

В связи с негативным влиянием материнского древостоя, сеянцы сосны на бывших пахотных почвах появляются на расстоянии 5-15м от материнского древостоя. Достаточное количество сеянцев для сформирования нового древостоя появляется на расстоянии 130м от материнского древостоя. Но отдельные группы сосен были расположены на растоянии 175м от края материнского древостоя.

Размещение сеянцев сосны на площади является неравномерным. На естественно облесенных бывших почвах сельскохозяйственного назначения часто встречаются пустые места, распределение которых на площади мало зависит от расстояния от материнского древостоя. Пустые места встречаются и в непосредственной близости к материнскому древостою, не смотря на то, что в этих местах выпадает наибольшее количество семян сосны. Чтобы получить более равномерное размещение сеянцев на площади, перед выпадом семян необходима подготовка почвы.

Ключевые слова: естественное облесение, сосна, сеянцы, обработка почвы.