



Estimation of natural regeneration of spruce in areas under threat to forest stability at high altitudes of the Beskid Śląski Mts.

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Abstract: Barszcz J., Małek S., 2008. Estimation of natural regeneration of spruce in areas under threat to forest stability at high altitudes of the Beskid Śląski Mts. – *Beskydy*, 1 (1): 9–18

The aim of this paper is to determine the perspectives of the growth of spruce in the threatened forest areas located at high altitudes (above 800 m) of the Beskid Śląski Mts., in the light of the results of estimation of its natural renewal. In the areas under serious threat to forest stability at higher altitudes of the Beskid Śląski Mts., the natural regeneration of spruce and its accompanying species – a phenomenon which occurs frequently but with small coverage of an area – does not keep up with the increasing dying out of trees and the degradation of stands. That is why it does not guarantee the permanence of forest development. For this reason most of the area of spruce stands, especially the ones which are relatively or seriously threatened with disintegration, has to be artificially rebuilt in a relatively short time.

The number of occurrences of this regeneration as well as the quality, vitality and survival chances of samplings decreases with increasing altitude and increasing degree of stand degradation threat. This decrease is caused by small intensity of fructification of spruce and by difficult site conditions. It should be improved by means of appropriate steps concerning forest management.

Due to special conditions in which young spruce trees grow, even scarce regeneration of this species, especially in the stands with considerable stability, must not be disregarded despite their low general estimation. Even they may turn out useful due to the exceeding of the best period of fructification and the damage of tree crowns, which increases with their age.

For the above reasons, the period of spruce renewal at these altitudes should be prolonged using seed-bearing years of middle classes of age. The juveniles and samplings thus acquired ought to be protected and tended. They should be supplemented early enough, especially in gaps, by means of seedlings of spruce and other species of good origin, both genetic and altitudinal, using the stand as a kind of protection to accelerate the process of regeneration.

Keywords: natural regeneration, Norway spruce, forest decay, Beskid Śląski Mts.

Introduction

Norway spruce (*Picea abies* /L./ Karst.) is the second (after pine) important forest-creating species in Poland. Apart from the Sudety Mts, it has a crucial role in the western part of the Beskydy Mts. In the Beskid Śląski Mts the current share of homogenous and mixed spruce stands amounts to about 80%, even exceeding this value locally, as in the Wisła Forest District and at altitudes above 900 m. Additionally, there are fewer mixed spruce stands and multi-species stands at these

locations than elsewhere (Barszcz and Mach 1984). The share of spruce was increased here in the past and homogenous spruce stands were introduced. They were often of foreign origin and replaced mixed forests, better adapted to more fertile sites (Broda 1965). In time, due to increasing anthropogenic pressure, soil degradation by spruce monocultures and harmful effects of abiotic and biotic factors, especially of industrial air pollution, which particularly threatens the forests of the Beskid Śląski Mts. (Barszcz 1990a, 1990b, Barszcz et al. 1994, Staszewski et

al. 1996, Bytnerowicz et al. 1999, Małek 2002a, 2002b, 2004, Małek et al. 2005, Zwoliński 2003), local phenomena of disease, which affected these stands in the past, have extended their harmful effects to large areas of dying forests (Sierota 1995). It is the most visible at the highest and most exposed locations (Capecki 1994, 1997). In the considerably weakened stands, damaged spruce crowns produce a largely limited number of cones (Grodzki 1994). What is also noted is excessive appearance and growth of the plants of undergrowth as well as considerable damage caused by deer and rodents, which hinders forest renewal and rebuilding. Forest rebuilding is the crucial forest management aim in spruce monocultures of the Beskidy Mts. (Jaworski 2003). The aim of this paper is to determine the perspectives of the growth of spruce in the threatened forest areas located at high altitudes (above 800 m) of the Beskid Śląski Mts. in the light of the results of estimation of its natural renewal.

Research area

According to the nature and forest regionalization of Poland (Trampler et al. 1990), the area of the present research is located in the VIII Carpathian Region, Province 1 of the Beskid Śląski Mts. and Beskid Mały Mts. and partly in Province 4 of the Beskid Żywiecki Mts., within Forest Promotion Complex „Beskid Śląski Mts. Forests“.

According to Romer's division (1949), the area of the present research lies in the zone of mountainous climate in the region of the Beskid Śląski Mts. and Beskid Zachodni Mts. According to Hess (1965), it is situated in the moderately cold with yearly average temperature 4 °C–6 °C and precipitation 1020–1150 mm and cold climatic zones with average temperature 2 °C–4 °C and precipitation 1150 mm – 1350 mm (Wilczek 1995). The dominant winds are south-western and western; in summer also north-western. These winds gain the highest speed between November and March and can cause great damage to stands. The spatial distribution of rain and snowfall in the Beskid Śląski Mts. and in the western part of the Beskid Żywiecki Mts. depends on the location of the extended part of this region with relation to rain-bearing winds from NW and SW, which is the cause of higher amount of rain and snowfall than in the other parts of the Beskidy Mts. at the same altitudes (Hess 1965, Kozłowska-Szczęśna et al. 1983). Abundant snowfall may cause damage due to deposition of snow and ice on tree branches, while rainfall brings in considerable amounts of industrial pollution (Małek 2002b). The research area also witnesses periodical lack of rainfall, which may weaken the vitality of spruce and hinder its regeneration (Modrzyński 1976).

The Beskid Śląski Mts. are formed out of the godula nappe (Ziętara 1988). Its constituent types of rock (cf. Bednarek and Prusinkiewicz 1980) are quartz-silicate and carbonate-silicate. At high altitudes, the most important base of soil is the quartz-silicate series, consisting of conglomerates and coarse-grain types of sandstones (mainly the magura and istebna ones), which produce sandy or sand-clay, acid rock mantle – the base of podzolic soils. This series is typical of coniferous sites. The rock mantle of these deposits is more stony. At high altitudes, especially on mountain tops and ridges, the rock mantle is coarse-stony. The water conditions created here – especially on tops and ridges and on steep southern slopes – are worse for demanding spruce and its saplings (Jaworski 1995, Modrzyński 1998) than the conditions found on the mantle rock of the marl-silicate deposits. The latter create more water conditions for plants, especially in areas with small slope reduction; and they form substrate for various types of brown soils. Under homogenous spruce forests, they have been variously degraded or have become podzolic (Maciaszek et al. 2000).

Material and methods

Preliminary, large-area estimation of natural renewal of spruce in stands growing at altitudes of above 800 m (upto 1000 m a.s.l. with dominance of *Luzulo nemorosae-Fagetum* and *Abieti-Piceetum montanum*, above 1000 m a.s.l. *Abieti-Piceetum montanum* (up to 1100 m a.s.l.) and *Plagiothecio-Piceetum tatricum* (Wilczek 1995) based on an analysis of 199 phytosociological surveys made in 4 forest districts (of Bielsko, Węgierska Górka, Wisła and Ustroń) by BULiGL in Cracow and made available by RDLP Katowice (Regional Directorate of State Forests in Katowice, cf. Aneksy 1998). Those data were used to determine the average coverage and frequency of occurrence of natural regeneration of trees in layer B (shrubs) and C (herb), according to Braun-Blaunquet (Tab. 1).

Detailed estimation of spruce regeneration was carried out on the basis of the authors' own permanent sample plots, set up in homogenous spruce stands with the taper of 0.6–0.7 and with different degrees of the threat of disintegration as well as in monocultures, where the disintegration was already complete. According to the degree of threat of degradation, the following groups of sample plots were distinguished:

RS – relatively stable stands (plots no. II, XIV and XVII, with the degree of crown damage within 0.69–0.89), consisting of mixed spruce stands or mixed stands, probably of native origin,

RTH – stands relatively threatened with degradation (plots no. I, III and XVIII, with the degree

of crown damage within 1.18–1.38), spruce monocultures in the first generation;

STH – stands seriously threatened with degradation (plots no. VIII, IX and XV, with the degree of crown damage within 1.71–1.93), consisting of spruce monocultures in the second generation, with occasional occurrence of beech, mountain ash and sycamore. Degree of crown damage was established on each plot on tree cut average tree according to: the changes in length, the shape and needles color, the number of needles on shoot and the number of needles years and defoliation, the changes in tree vitality, the height increment and the canopy shape (Regulation no. 143 of the Ministry of Forestry and Timber Industry of 19.09.1970, item 111.). The administrative divisions and the characteristics of site and stand conditions of these sample plots are presented in Tab. 2.

The complex site and stand estimation performed on sample plots in the stands aged between about 80 and 150 years included:

the number of younger juveniles (up to 2 years) and older ones (over 2 years) on 20 plots of 1 m²; the number of saplings (in the following height classes:

I: 0.5–1.5 m;

II: 1.5–2.5 m;

III: over 2.5 m);

the quality in three classes:

1 – good (straight stem, side shoots and top shoot undamaged, top bud well developed);

2 – average (slight, unilateral stem deviation, scarce damage of side shoots, top shoot undamaged, top bud underdeveloped);

3 – bad (stem with damage and considerable deviation, considerable damage of side shoots, damaged top shoot, top bud undeveloped or inexistent) and

the vitality of saplings in three classes:

1 – good (needles long, dark green, without discoloration; in the youngest vertical the top shoot longer than average side shoot length, long crown – longer than ½ of whole tree height);

2 – average (needles of average length, green with scarce discoloration; in the youngest vertical the top shoot length equal to average side shoot length, crown average – between ½ and ¾ of whole tree height);

3 – bad (needles short, yellow-green with numerous discolorations; in the youngest vertical the top shoot shorter than average side shoot length, crown short – shorter than ¼ of whole tree height);

the survival share according to criteria used in the state forest farm in Poland (ZHL 2003) on five 100 m² plots.

The criteria for survival share include the following two factors: SPU (first number in Tab. 3) – a degree of coverage of an area by a culture (in %, in relation to the required number of seedlings per ha according to the adopted planting distances) in the following scale: 1 – over 90%; 2 – 71–90%; 3 – 51–70%; 4 – up to 50% of area coverage as well as PHU (second number in Tab. 3) – a degree of decrease in the cultivation utility of a culture (in %, related to symptoms of disease, damage caused by biotic and abiotic factors, wrong species composition, wrong forms of species mixture, wrong origin and other causes) i.e. the so-called cultivation utility index in the following scale: 1 – healthy cultures consistent with their site, established correctly, with only single defects up to 10%; 2 – cultures with defects up to 20%; 3 – cultures with defects up to 30%; 4 – cultures with defects over 30%.

For stands, additionally, was determined the percentage of spruce trees producing cones in 2000–2003 and the degree of damage to their crowns (Tab. 2).

The results obtained underwent analysis in the STATISTICA 6.0 program (Łomnicki 2002, Rutkowska, Socha 2003). Comparing the average values of selected features in three groups of sample plots, i.e. RS, RTH and STH and between plots, the following tools were used: for estimates features (quality and vitality) – multipartite tables and for quantitative features with the normal distribution – the t-Student test, and in the case of a lack of normal distribution – U-Mann-Whitney test with statistically significant reaction of an analysed feature at the significance level $\alpha = 0.05$.

The area of spruce stands with different degrees of threat of disintegration has been established by the employees of the State Forest Administration supervised by the authors of this study according to the following criteria:

STH – stands of probably native origin: with crown thinning and needle discoloration up to 10%, corresponding to the site, scarcely damaged by biotic and abiotic factors, frequently of good technical quality, of varying ages and often of many layers, with no need of rebuilding; **RTH** – stands of foreign origin: weakened, with crown thinning and needle discoloration between 10 and 60%, not corresponding to the site, with average damage by biotic and abiotic factors, with single, dying tops and increment inhibited at a young age, thinned, of low technical quality, mostly even-aged and consisting of a single layer, with the need of rebuilding within the period of several years (maximally up to about 25–30 years);

RS – stands of foreign origin: considerably weakened and dying, with crown thinning and needle

Tab. 1: Mean coverage (Cov) and frequency of occurrence (Occ) of natura renewal in forest stands above 800 m a.s.l. in the Beskid Śląski Mts.

Forest district	Cov/ Occ	Saplings (shrubs layer – B)						Juvenile (herb layer – C)				
		%	Spruce	Beech	Fir	Sycamore	others	bushes	Spruce	Beech	Fir	Sycamore
Ustroń	Cov	1.9	2.4	0.3	2.2	0.0	0.0	2.0	1.4	0.0	0.7	0.9
	Occ	32.5	55.0	15.0	25.0	0.0	0.0	47.5	60.0	10.0	37.5	37.5
Bielsko	Cov	0.9	0.8	0.2	0.0	0.0	0.0	0.7	3.3	0.0	0.3	0.7
	Occ	37.0	30.7	18.4	0.0	0.0	13.7	76.9	79.9	16.7	15.6	24.6
Wisła	Cov	2.4	3.7	1.2	0.0	0.0	3.5	3.2	0.1	0.1	0.0	1.4
	Occ	50.0	75.0	36.7	0.0	0.0	38.4	81.7	56.7	36.7	0.0	53.4
Węgierska Górką	Cov	4.5	1.0	0.7	0.0	0.0	0.8	2.0	0.5	0.0	0.1	1.1
	Occ	37.1	48.0	13.5	1.6	1.0	15.9	83.6	49.4	21.2	15.9	44.6
Beskid Śląski Mts. Mts	Cov	2.4	2.0	0.6	0.6	0.0	1.1	2.0	1.3	0.0	0.3	1.0
	Occ	39.1	52.2	20.9	6.7	0.3	17.0	72.4	61.5	21.1	17.2	40.0

Tab. 2: Characteristics of sample plots in the Beskid Śląski Mts.

Plot number	Forest district	Compartment	Division	Altitude m a.s.l.	Slope in degrees	Type and sub- type of soil	Species composition	Age	Degree of damage of spruce crown	cones production 2000–2003 (%)
In stable stands (RS)										
II	Ustroń	Brenna	111f	900	45	BRk	6NS 3EB 1SF	130	0.87	5
XIV	Bielsko	Szczyrk	148k	1200	5	BRk s.l.b.	NS	110	0.69	9
XVII	Węgierska Górką	Lipowa	117f	1020	20	BRk	8EB 2NS	150	0.89	5
In stands under relative threat (RTH) *										
I	Ustroń	Brenna	111a	900	35	BRk	NS	130	1.38*	7
III	Ustroń	Brenna	112g	900	10	BRk s.l.b.	NS	130	1.35*	9
XVIII	Węgierska Górką	Lipowa	118b	1020	5	BRk	NS	110	1.18*	10
In stands under serious threat (STH) **										
VIII	Wisła	Wisła	142c	1075	10	BRk sil.b.	NS	100	1.93**	5
IX	Bielsko	Szczyrk	149i	1125	5	BRk sil.b.	NS	100	1.71**	9
XV	Węgierska Górką	Lipowa	117b	1200	10	BRk sil.b.	NS	80	1.84**	9

Legend: BRk – brown soil, k – acid, s.l.b – light podzolization, sil. b – high podzolization

NS, EB, SF, ie. Norway spruce, European Beech and Silver Fir

* – statistically significant reaction of an analysed feature at the significance level $\alpha = 0.05$ according to stable stands (RS)

** – statistically significant reaction of an analysed feature at the significance level $\alpha = 0.05$ according to stable stands (RS) and stands under relative threat (RTH)

Tab. 3: Characteristics of natural regeneration of spruce on sample plots in the Beskid Śląski Mts.

Plot number	Juveniles				Saplings				Estimation of		
	Younger		Older		Number per hectare		Number per hectare		Quality	Vitality	Survival share
	%	%	Number per hectare	Number per hectare	I	II	III	III	Scale 1-3	Scale 1-3	Acc. to ZHL
	In height classes										
II	0	100	2500	38	37	25	1460	1.8	1.4	3-2	
XIV	100	0	2500	100	0	0	40	1.9	1.5	4-2	
XVII	50	50	1000	60	40	0	300	2.3	1.9	4-3	
	In stands under relative threat (RTH) *										
I	9	91	16500	92	6	2	2500	2.0	1.8*	3-2	
III	21	79	9500	29	29	42	340	2.0	2.0*	4-2	
XVIII	82	18	30000	100	0	0	20	2.4	1.9	4-3	
	In stands under serious threat (STH) **										
VIII	100	0	500	100	0	0	80	2.6**	2.3**	4-4	
IX	100	0	2000	100	0	0	40	2.5**	2.2**	4-4	
XV	100	0	2500	100	0	0	60	2.4	2.0	4-3	

* - statistically significant reaction of an analysed feature at the significance level $\alpha = 0.05$ according to stable stands (RS)

** - statistically significant reaction of an analysed feature at the significance level $\alpha = 0.05$ according to stable stands (RS) and stands under relative threat (RTH)

Tab. 4: Areas (in ha) of damaged forest and of necessary rebuild in treat of degradation with the natural and artificial regeneration occurred in forest at 2005 year.

Forest zone in m a.s.l.	Area of damaged forest	Natural regeneration	Artificial regeneration	Area of necessary		degree of threat of degradation		
				rebuilding	rebuilding	STH	RTH	RS
Ustroń Forest District								
800-1000	257	33	43	178	46	65		67
>1000	1	1	0	1	0	0		1
Bielsko Forest District								
800-1000	1055	143	93	819	119	310		390
>1000	221	15	41	165	34	58		74
Wisła Forest District								
800-1000	668	177	54	437	196	161		80
>1000	134	20	18	96	73	15		8
Węgierska Górk Forest District – only areas located in the Beskid Śląski Mts.								
800-1000	1530	220	191	1104	242	549		314
>1000	61	5	12	43	13	17		13
the Beskid Śląski Mts.								
800-1000	3510	573	380	2539	603	1085		850
>1000	416	40	70	304	120	90		94
Total	3926	614	450	2843	723	1175		945

discoloration over 60%, with numerous, dying tops, even-aged and consisting of a single layer with considerable thinning, requiring intensive sanitary cutting; as well as younger stands, e.g. cultures which require much correction, improvement and urgent rebuilding within the period of a few years.

Results

The results of estimation of natural and artificial renewal of spruce on permanent sample plots indicate the fact that the number of spruce juveniles per 1 ha ranged from about 500 to about 30000 items.ha⁻¹ (the average for all plots was 7500 individuals, per hectare (Tab. 3). Relatively the greatest number of juveniles were found in the group of stands under relative threat of degradation (on average about 18670) while their smallest number was in the group of stands under serious threat (on average about 1670). Their number in the latter group was slightly smaller than in the group of stable stands. Generally, the number of spruce juveniles on all plots is too low. Even on the plot with the highest number of them (plot no. XVIII), there were only 30% as compared to the required minimum (Regulation no. 47 DGLP, 1999). The small number of younger juveniles is due to very weak fructification of spruce in the last three years and degree of damaged spruce crown (statistically significant between group: RS – RTH, RS – STH and RTH – STH) (Tab. 2). Their fructification was probably bad also before this recent period, which can be deduced from the percentage of older juveniles and of saplings. As regards the altitude of the plots, the number of juveniles and saplings was higher at lower altitudes, which – considering the similar percentage of trees with fructification at all examined altitudes – indicates the influence of site factors and of the degree of threat to forest stability on the regeneration of this species. At lower altitudes and in the stands less threatened with degradation, the number of older and higher saplings was greater.

Generally, the quality and vitality of these saplings was average and low rather than good; it was related with the degree of threat to forest stability. The quality of the stems of saplings growing in the stable stands and in the stands relatively threatened with degradation was similar; it was better by about 0.5 unit of this feature than the saplings in the group seriously threatened with degradation and statistically significant between group: RS – RTH, RS – STH and RTH – STH. The vitality of seedlings was on average slightly better than their quality, estimated according to the same scale. The differentiation between groups of stands relative to the degree of degradation

threat in a stand was more considerable, on average between about 0.3 and 0.6 of a unit of vitality and statistically significant between group: RS – RTH, RS – STH and RTH – STH. The estimation of the quality and vitality of spruce saplings shows its dependence on altitude (statistically significant between plots), which, in turn, affects the degree of stand degradation. In the stands which were located lower and in more stable stands, the features of saplings discussed above had relatively the best values. The approximate percentage of survival of these saplings reveals similar tendencies. Generally, it is very low; however, given the special conditions in which the analysed stands grow, even such signs of regeneration should be regarded as promising despite small coverage and low stem quality, as in these conditions each occurrence of natural regeneration may turn out useful. Accordingly, steps should be taken to improve the conditions of their growth (Tab. 3).

A detailed analysis of forest areas located above the altitude of 800 m in the forest districts of the Beskid Śląski Mts., conducted in 2005, showed that 3510 ha of spruce stands located at the altitude of 800–1000 m were threatened with disintegration; regeneration was noted in only about 23% of this area. In areas above 1000 m above sea level, there were 416 ha of spruce stands, only 13% of which showed signs of regeneration. The remaining majority of these areas has to be regenerated artificially, especially the stands which are relatively (RTH) or seriously (RS) threatened with disintegration, and require very urgent rebuilding in a relatively short time (Tab. 4).

Discussion

As far as juvenile coverage is concerned, the results received are considerably more negative than the percentage of spruce stands with a higher share of spruce juvenile from the whole area of Poland, and particularly from the Carpathian Province (Głaz, Zajączkowski 2002). This may point to difficult, specific conditions of renewal of this species at high altitudes of the Beskid Śląski Mts.

In much weakened stands, crown damage significantly reduces cone production in spruce (Grodzki 1994). A large crop of cones does not itself mean a large number of seeds which will cause forest regeneration. Schmidt-Vogt (1991) maintains that only half of the seeds reach the ground while the rest remains in cones or is eaten by birds and insects. Some of the seeds which reach the ground are barren or undeveloped and that only 30–50% of them is capable of germination. These factors may cause real reduction in the number of seedlings, which is small

anyway at high altitudes. Seedling development depends in turn on abiotic factors in the organic layer of soil and in the near-ground layer of air (Modrzyński 1976), which are unfavourable for their further development in the conditions of industrial pollution and considerable thinning of these stands. It also frequently turns out that, in the conditions of small stand density, intensive development of plants of the undergrowth, especially grasses of *Calamagrostis* and *Deschampsia*, make the natural regeneration of this species almost completely impossible.

The above data shows that in the stands in question (Barszcz and Małek 2001, 2002), mostly one-layer ones, the regeneration of the main forest-creating species, such as spruce, occurs quite frequently. However, generally, due to a small degree of regeneration area coverage, it does not guarantee the continuity of forest development at the altitudes in question (i.e. 800 m above sea level and higher) should this way of regeneration be the only one to rely on (Barszcz and Małek 2003). That is why it is advisable to intensify forest management measures in order to improve this situation and, in the case of no prospects for natural regeneration, to begin planting seedlings (of spruce and other species) of good genetic and altitudinal origin, and to perform it early enough, under the canopy (Barszcz and Małek 2006).

The dying out of spruce stands, especially ones at high altitudes, still proceeds at great speed. According to the assessment by the State Forest Administration this year, after the dry and hot summer 2006, it is necessary to remove about 0.5 million m³ of wood in order to prevent further development of spruce bark beetle. It is predicted that, if weather conditions are similar in 2007, the mass of dying trees may increase to 1.5 million m³. Hence, the Minister for the Environment is strongly in favour of taking any steps necessary to improve the condition of forests in this part of the Beskidy Mts (an official statement by the Minister for the Environment at the conference on 4th October 2006) – (<http://www.mos.gov.pl/>). The conclusion is that the process of rebuilding of these spruce stands, which should be the main forest management objective in the Beskidy spruce monocultures (Barszcz and Małek 2003, Jaworski 2003), ought to be acceler-

ated. This indispensable process will, according to the General Director of State Forests – be very expensive as the rebuilding will have to include private forests. These actions may be based on the rules of transformation and rebuilding of these threatened stands, as elaborated by the authors (Barszcz and Małek 2005).

Summing up and conclusion

In the areas under serious threat to forest stability at higher altitudes of the Beskid Śląski Mts., the natural regeneration of spruce and its accompanying species – a phenomenon which occurs frequently but with small coverage of an area – does not keep up with the increasing dying out of trees and the degradation of stands. That is why it does not guarantee the permanence of forest development. For this reason most of the area of spruce stands, especially the ones which are relatively or seriously threatened with disintegration, has to be artificially rebuilt in a relatively short time.

The number of occurrences of this regeneration as well as the quality, vitality and survival chances of saplings decreases with increasing altitude and increasing degree of stand degradation threat. This decrease is caused by small intensity of fructification of spruce and by difficult site conditions. It should be improved by means of appropriate steps concerning forest management.

Due to special conditions in which young spruce trees grow, even scarce regeneration of this species, especially in the stands with considerable stability, must not be disregarded despite their low general estimation. Even they may turn out useful due to the exceeding of the best period of fructification and the damage of tree crowns, which increases with their age.

For the above reasons, the period of spruce renewal at these altitudes should be prolonged using seed-bearing years of middle classes of age. The juveniles and saplings thus acquired ought to be protected and tended. They should be supplemented early enough, especially in gaps, by means of seedlings of spruce and other species of good origin, both genetic and altitudinal, using the stand as a kind of protection to accelerate the process of regeneration.

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