Regeneration under a shelterwood system of spruce-dominated forest stands at middle altitudes

J. Souček

Forestry and Game Management Research Institute, Opočno Research Station, Opočno, Czech Republic

ABSTRACT: An experiment with regeneration under the shelterwood of spruce-dominated mature stand was established at middle altitudes of the Žďárské vrchy Hills in 1971. The paper brings a comparison of the development of basic forest stand characteristics for the plot under shelterwood and for the control plot. Analyses of annual rings demonstrated a higher diameter increment of sample trees on the plot under shelterwood, a more pronounced increase in the increment being however observed only 12 years after release. A subsequent forest from the combined regeneration occurs on 88% of the plot under shelterwood and on 67% of the control plot. The required proportion of beech and fir is established on both plots with spruce as the main commercial species having been retained. The subsequent forest stand is differentiated in terms of height and diameter and the two plots exhibit a rather varied structure.

Keywords: transformation; shelterwood system; spruce; fir; beech; diameter increment; combined regeneration

Spruce accounts for a dominant proportion in Czech forests and even-aged spruce monocultures take up a considerable area. High timber production in these forests is endangered by biotic and abiotic factors (Mráček, Pařez 1986; Thomasius 1988; Tesař, Klimo 2004). Central Europe has recently recorded an increasing interest in the ecological use of the forest and in an ecosystem approach to it. Forest management has to strive for an optimum synthesis of ecological, technical and economic requirements. Enhanced ecological stability, gene pool preservation and improved wood producing and non-wood-producing functions of the forest are feasible only with a broader transition to nature-friendly forest management (Spiecker et al. 2004). In our conditions this would particularly imply the area size reduction of coniferous monocultures growing on sites with the natural occurrence of broadleaved or mixed stands and the enhanced stand structuring. In a shelterwood system the gradual felling of mature trees creates favourable growth conditions for regeneration and its subsequent development with the retained forest stand components still fulfilling the commercial and non-commercial forest functions. The variability of regeneration progress and rate makes it possible to gradually regenerate tree species of different growth requirements and to use the increment potential of high-quality individuals retained in the stand at the same time (Korpeľ et al. 1991). The shelterwood system of management in spruce stands in upland was studied by many authors (Poleno 1967; Čížek 1969; Zakopal 1976). After the reduction of shelterwood management in the 70s and 80s its renewal started in the 90s (Poleno 1997).

The origination of homogeneous and even-aged forests dominated by spruce and pine is bound to management procedures taken over from agriculture whose application dates back to the 18th century in our conditions. The impact of opinions advocating restrictions on growing spruce monocultures in the following period fluctuated in dependence on the occurrence of disasters, economic situation and increasing awareness of the forest health and development. Efforts focused on a reduction in the representation of coniferous monocultures have a long tradition in the Czech Republic (Čížek et al. 1959). In some localities the clear-felling system was gradually replaced with refined management procedures.

Supported by the Czech Science Foundation, Project No. 526/04/P180.

Large-scale works on the conversion of non-autochthonous spruce monocultures started already in the period between the wars and continued until the 1970s. Thanks to the long-term application of management procedures some localities did not show their discontinuation even after a diversion from the refined procedures. A number of localities have been preserved from that period mainly in the Bohemian-Moravian Upland with spruce forests worked out by different procedures at different intensities and management duration. Doc. Ing. Jaroslav Švarc was a person with a considerable influence on forest management in the region of Žďár nad Sázavou, who commenced a system of management focused on the modification of tree species composition and enhanced forest stand structuring already in the period after the war (Švarc 1987b). The majority of Švarc followers continued in the adopted procedure.

The paper presents a comparison of the development of forest stand characteristics in a mature stand dominated by spruce in the locality Štěnice regenerated under a shelterwood system. The experiment was established in 1971 where a considerable part of older stands was expeditiously felled. The experiment was to demonstrate increment capabilities of similar stands and a possibility of combined regeneration. Development of undergrowth with proceeding regeneration under a shelter is compared with the control plot on which only incidental felling was carried out during the research period of 30 years.

MATERIAL AND METHODS

The forest stand under study is situated in the Žďárské vrchy Hills on the estate owned by Dr. Radoslav Kinsky, near the village of Sázava on a mild northern slope (8–10%) at an altitude of 570–590 m above sea level (49°33´46´´eastern longitude, 15°52´56´´northern latitude). The bedrock is orthogneiss poor in nutrients, Cambisol is sporadically passing into boulder scree with humic filling. The present forest type is stony fir-beech stand with tufted hair grass (5N8). Mean annual precipitation amounts to 786 mm, mean air temperature is 5.9°C (CHMI station Hlinsko 580 m a.s.l., 1951–2005). The tree species composition considered for primary management group 531 is as follows: spruce 7, beech 2, larch (linden, fir, pine) 1; rotation period 110 years, regeneration period 40 years and regeneration start at an age of 91 years. The studied forest stand is likely to have originated by natural or combined regeneration on a clear-cut area. Age variability of sample trees (107–130 years at the time of plot establishment) suggests development through natural regeneration with most sample trees exhibiting however growth in the open space.

The experiment consists of two plots 0.75 ha in size located above each other vertically in a line perpendicular to the contour. The plots are mutually isolated by means of a protective belt to eliminate management effects from the neighbouring forest stands. Stand development on the shelterwood plot under gradual regeneration was compared with stand development on the control plot with only incidental felling done during the experiment. At the time of establishing the experiment the initial forest stand was 117 years and the tree species composition was dominated by spruce (76) with other represented species being fir (15), pine (8), birch and larch (1). Salvage felling prior to the establishment of the experiment was used for a large-scale opening of the forest (stocking 0.6) and the spruce and fir groups of natural regeneration were complemented with planted beech and fir. In establishing the experiment the trees with dbh above 7 cm were numbered, their height was measured along with crown setting

Table 1. Tree numbers of the parent stand on plots according to tree species (trees/ha). The percentage representation of tree species according to tree numbers and the standing volume in 1971 and 2001 and its change

Year	Shelterwood plot					Control plot				
	spruce	fir	pine	larch	total	spruce	fir	pine	birch	total
1971	329	81	19	1	431	321	97	28	1	448
1981	301	64	15	1	381	296	57	24		377
1992	192	20	11	1	224					
2001	187	19	10	1	217	264	44	21		329
2001 (after felling)	123	15	4	1	143	196	41	20		257
Tree number percentage 1971	76.5	18.9	4.3	0.3	100	71.7	21.7	6.3	0.3	100
Tree number percentage 2001	86.0	10.5	2.8	0.7	100	76.3	15.9	7.8		100
Volume species percentage 1971	74.4	17.6	7.6	0.5	100	69.3	19.7	10.9	0.1	100
Volume species percentage 2001	82.6	13.3	2.7	1.4	100	77.8	12.5	9.7	0	100

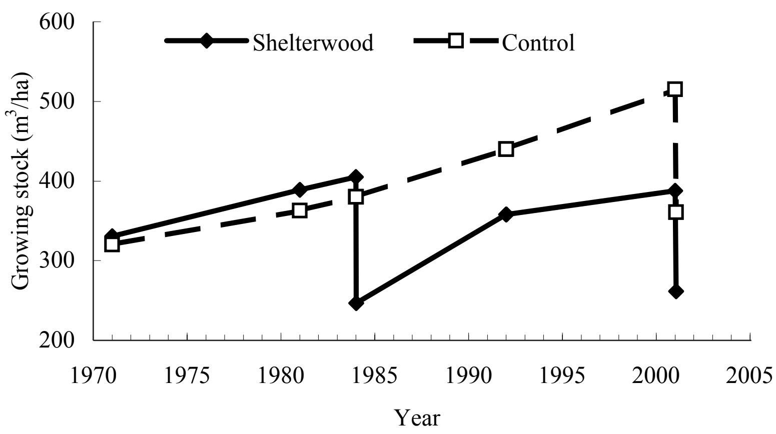

Fig. 1. Growing stock development

height, crown projection and tree classification (Vyskot et al. 1971). Repeated measurements of the original forest stand on the two plots were carried out in 1981 and 2001 with additional surveying of the shelterwood plot in 1992 (Stránská 1994). The measured values were used for the calculation of mean values according to the tree species per 1 ha area. The whole-area inventory of the subsequent stand was done in 1971, 1981 and 2001 according to height classes and tree species with the plot under shelterwood being subjected to the inventory of 100 m^2 and transects in 1992. As the original records from the measurements in 1971 and 1981 were not preserved, data used in assessing the development of fundamental stand characteristics were those presented in Švarc (1987a).

In order to assess an increment response to the management method discs from felled trees and increment cores from standing trees were sampled on both plots in winter 2001/2002 with the survey being focused on spruce as a dominant tree species. Intact trees of medium size sampled at random were analyzed. Five samples for full stem analyses and 20 trees for increment cores were analyzed on each plot. Diameter increment on the discs was measured in 4 directions according to the cardinal points, the increment cores were sampled at all times by 2 perpendicularly to each other. Each tree-ring series was visually cross-dated, checked, corrected for missing and false rings. For each tree-ring series, basic statistical characteristics were calculated. Differences between plots were tested by *t*-test in the program NCSS 2004.

RESULTS AND DISCUSSION

Initial stand characteristics were comparable on the two plots with differences not exceeding 5% (Table 1, Fig. 1). The stand characteristics corresponded to the tabular values for spruce stand of the given age and for stocking usual on the sites (Černý et al. 1996). The representation of spruce was dominant on the two plots both in terms of frequency and in terms of growing stock. The proportion of fir in the standing volume was 18% on the plot under shelterwood and 20% on the control plot. Other species were pine, individually larch and birch (Table 1).

The number of trees was reduced by incidental felling by 11% and 16% on the plot under shelterwood and control plot, respectively, the reduction

Table 2. Mean stem dimensions

Year	Shelterwood plot					Control plot			
	spruce	fir	pine	larch	Ø	spruce	fir	pine	Ø
Mean diameter (cm)									
1971	26.2	26.0	37.1	38.9	26.7	25.5	25.3	36.7	26.2
1981	29.5	28.8	38.7	41.8	30.1	29.6	26.6	39.2	29.8
1992	35.4	34.8	44.6	46.1	35.8				
2001	38.8	39.9	45.8	46.8	39.3	37.1	30.7	40.6	36.4
Mean height (m)									
1971	23.8	26.0	26.6	26.0	23.5	22.1	19.7	25.0	21.7
1981	25.3	28.8	29.1	28.5	25.2	24.2	22.0	27.4	24.0
1992	30.0	28.9	31.0	33.5	29.9				
2001	29.2	28.2	31.1	34.0	29.3	28.7	25.2	30.4	28.3

of standing volume by incidental felling reaching 5% on the shelterwood plot and 9% on the control plot. Incidental fellings were used to remove mainly small-diameter trees but the standing volume increased on both plots in spite of the felling. The increasing air pollution load in this period was unfavourably reflected especially in the health condition and vitality of fir with the species representation in the standing volume falling to a third. In 1984, the growing stock on the plot under shelterwood was reduced by 41% of the planned cutting (159 m^3/ha). The stand opening after this measure was sufficient for the growth of the subsequent stand and the two plots were subjected only to incidental felling in the following period. In 2001, the standing volumes of the plot under shelterwood and of the control plot were reduced by felling at 40% (128 m^3/ha) and 34% (148 m^3/ha), respectively. The growing subsequent stand on the two plots was released by felling which further initiated natural regeneration on the control plot. In 1971–2001, the number of trees on the plot under shelterwood and on the control plot decreased by 67% and 43% (of which 16% felling in 2001), respectively. During the survey, the proportion of spruce increased on both plots to the detriment of fir, more markedly on the plot under shelterwood. The felling of large-diameter pine trees in 2001 dramatically reduced the proportion of the species volume on the control plot. Due to their low representation, the other tree species did not show a proportion higher than 1% (Table 1). Mean volume increment of the stand on the control plot and on the plot under shelterwood in the studied period (1971–2001) reached 9.6 m^3/ha and 9.7 m^3/ha, respectively. In spite of increased felling, the stand on the plot under shelterwood achieved the volume increment comparable with the control plot. The mean volume increment slightly exceeded the tabular values (Černý et al. 1996) but still well corresponded to findings from comparable plots (e.g. Schmitt 1994; Spathelf 1998).

No initial data on the size of individual trees exist but a similar pattern of tree diameter and height frequencies can be expected to exist on both plots with respect to comparable forest characteristics. Besides the increment, mean stem dimensions are also influenced by logging measures, with the change in dimensions not fully predicating of the increment capabilities of individual trees or species without knowing more about former fellings. Larch and pine constituted a dominant level throughout the whole research period with the markedly lower initial tree heights of spruce and fir being affected by a higher proportion of subdominant individuals. The mean size of individual tree species was gradually increasing in the course of the study (Table 2) with a minimum mean diameter increment in pine and larch in the recent period likely being affected on both plots by bark slipping in the lower part of the stem. Thanks to their position in the upper stand layers these tree species cannot be expected to exhibit a sudden increment decrease as may follow out from Table 2. In 2001, the range of diameters of the original stand was identical on the two plots (10–70 cm). A higher number of small- and medium-diameter trees on the control plot affects the smaller mean stem diameter (Table 2) while the numbers of large-diameter trees are comparable on the two plots (Fig. 2).

The change in mean stem was favourably reflected also in the slenderness ratio (h/d) characterizing static stability. A higher initial value on the plot under shelterwood (88, control plot 83) was influenced by the occurrence of fir and spruce trees of the less favourable h/d ratio. A gradual decrease in slenderness ratio values in the subsequent years resulted partly from fellings and partly from the increased stability of individual trees due to different deposi-

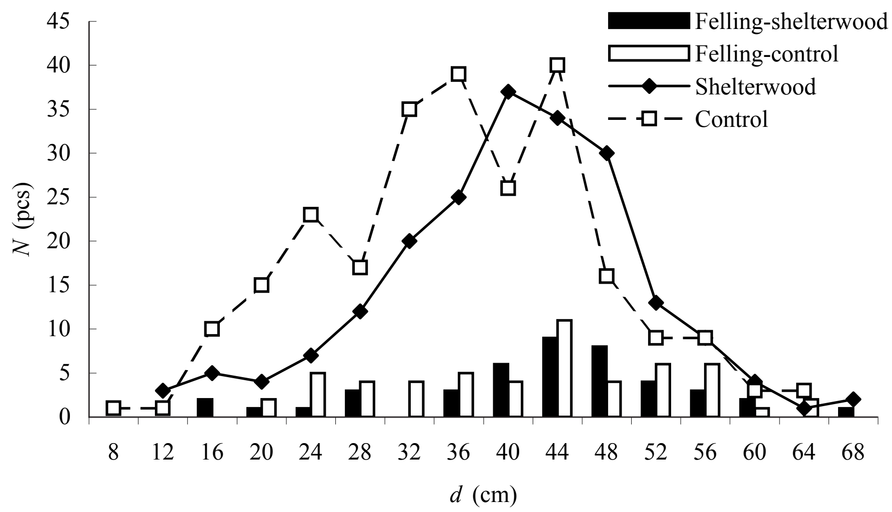

Fig. 2. Tree frequency distribution according to diameters after felling in 2001

tion of diameter increment. The final values of mean stem slenderness quotient were 75 on the plot under shelterwood and 78 on the control plot. The higher diameter increment in the lower part of the stem will favourably show in the decreased slenderness ratio with the pronounced diameter increment variances at different stem heights representing a danger of stem malformation (Holgén et al. 2003; Weihe 1977). Static stability of the two forest stands was satisfactory during the whole period of study.

The initial mean crown length (13 m) was comparable on the two plots. The stand opening (sanitary felling, soil environment treatment for underplanting) had a favourable effect on the crown length with crowns on both plots exhibiting an identical extension by 1.5 m during the first decade. The continual height increment and the limited drying out of shaded lower branches affected the crown length on the plot under shelterwood with the mean length in 2001 (18.5 m) representing crown extension against the initial condition. Long crowns were shown mainly by spruce and fir, markedly shorter crowns of pine and larch having been influenced by the shading of lower branches by the growing up surrounding stand. Gradual stand enclosure on the control plot was influenced by the drying out of lower shaded branches with the mean crown length in 2001 reaching only 9.4 m.

The missing initial data make it impossible to valuate the increment response of trees to the carried out measures. During the felling in 2001, spruce sample trees and increment cores were taken from the two plots for the assessment of diameter growth. Dimensions of sample trees corresponded to mean tree dimensions, sample trees on the plot under shelterwood had the crown on average by 22% longer. Mean diameter increment of sample trees in the period before the establishment of the experiment was comparable on the two plots, with the mean value of 2.9 mm indicating a high increment potential of the trees with respect to their age. Significant factors affecting increment were climatic conditions, air-pollution load and occurrence of other negative factors (Eckstein et al 1989; Riemer et al. 1997). A decrease in increments is mostly connected with the incidence of dry warm period in the previous term (e.g. in 1976). The influence of these periods is often long-lasting (Brázdil, Chromá 2003). The minimum variances between the plots in the mean increment of sample trees were observed to occur until 1977. In the following period the increments were gradually increasing with sample trees on the plot under shelterwood exhibiting a permanently higher increment against the control. The considerable stand opening by planned cutting in 1984 (with 41% of standing volume removed) did not markedly affect the diameter increment of the studied trees. A higher increment of trees on the shelterwood plot occurred as late as after 1996 with the mean annual diameter increment during the culmination in 1999 reaching 5.5 mm.

Literary data on the increment of released trees vary in the values of the intensity and duration of increased increment; an important role is played by the position of trees within the stand, the measure and method of release, site and climatic conditions. Spiecker (1986) demonstrated that the increment response of trees released suddenly at a great intensity depends more on the course of climatic effects than on the release itself. Spathelf (1998) and Epp (2003) corroborated the significant effect of crown size and quality on the tree increment. The necessity of crown reconstruction may considerably delay the increment reaction. With the exception of years 1998 and 1999 the differences in the diameter increment of trees on the plot under shelterwood and on the

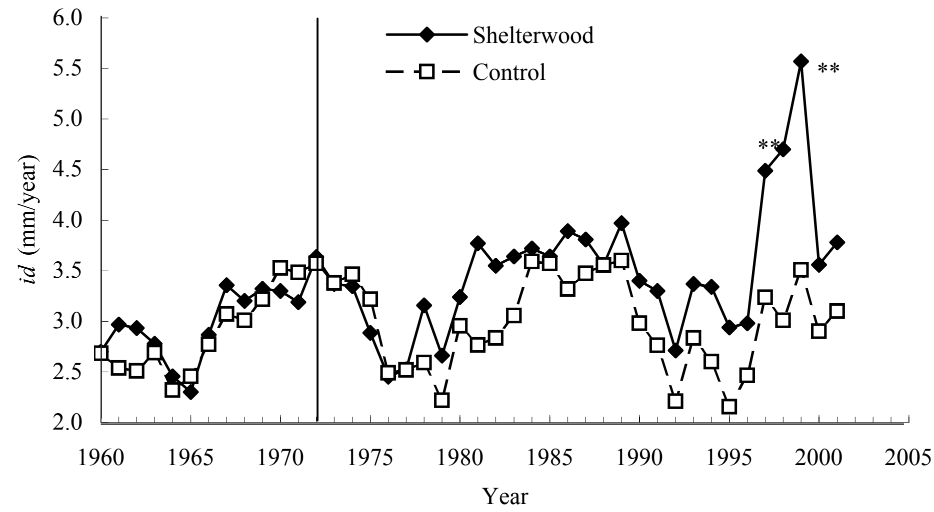

Fig. 3. Mean diameter increment in spruce sample trees (** indicate statistically significant differences in annual diameter increments on the level $\alpha = 0.01$)

Table 3. The percentage of regeneration area and the species composition

	Regeneration area (%)	Spruce	Fir	Beech	Other species
Shelterwood plot					
1971	18.1	79.8	16.7	0.8	2.7
1981	80.9	80.5	13.4	5.9	0.2
2001	88.4	72.8	19.0	8.2	0.0
Control plot					
1971	25.4	73.2	15.4	10.2	1.2
1981	56.2	59.8	28.8	11.0	0.4
2001	67.3	81.9	14.5	3.6	0.0

control plot were insignificant ($p < 0.01$). The increment exhibited a considerable variability that was lower on the plot under shelterwood for the whole time.

The subsequent forest stand

At the time of trial establishment on the two plots there occurred isolated spruce and fir groups of natural regeneration whose height did not usually exceed 100 cm. In 1968 and 1972, the whole-area underplanting with beech and fir was carried out on the two plots in order to ensure the corresponding representation of these species in a subsequent forest stand. The fencing of underplantings was functional only in the initial period, later the undergrowth served conversely as a wildlife lodge in winter. The initial condition of the subsequent stand was better on the control plot than on the plot under shelterwood. In 1971, a subsequent stand on the shelterwood plot took up 18% of the area with 41% of the undergrowth area reaching a height smaller than 50 cm and other 30% of height up to 1 m. The species composition was dominated by spruce and fir with the proportion of broadleaves being minimal (Table 3). In the same year, the control plot exhibited a subsequent stand on 25% of the area with 52% of the undergrowth area reaching a height up to 50 cm

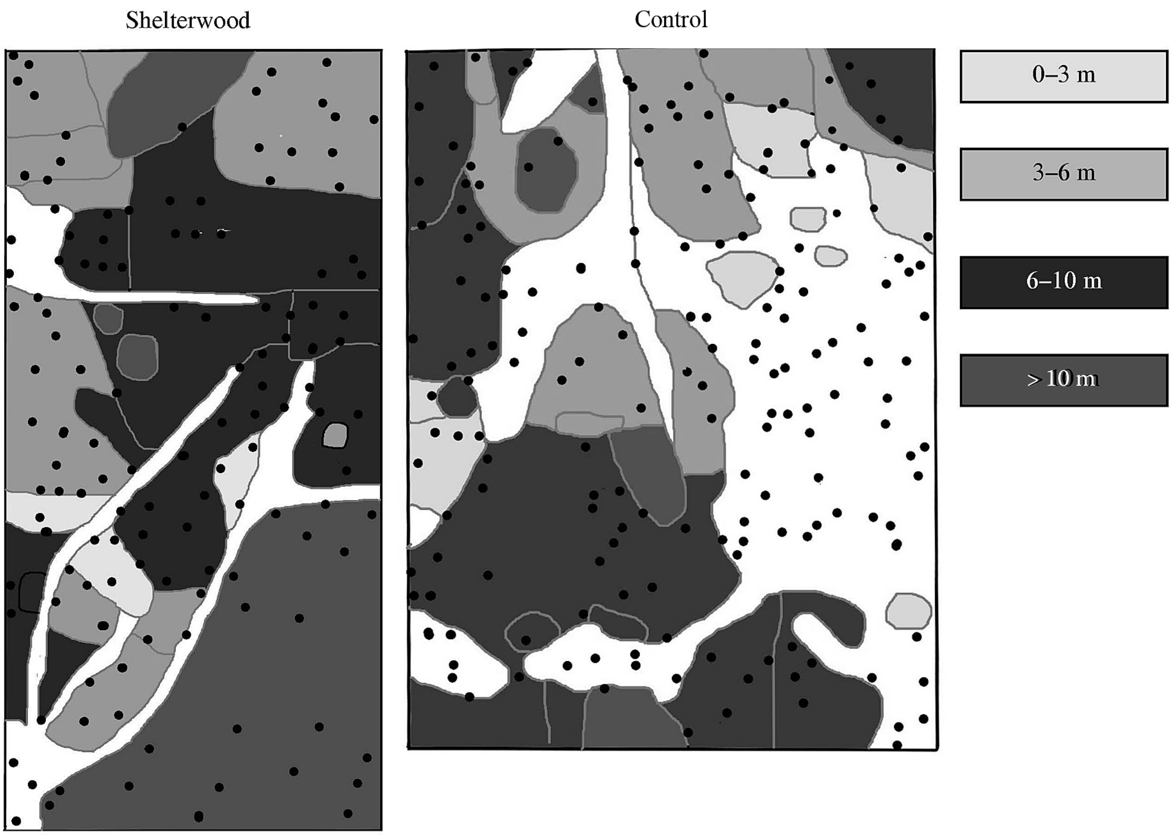

Fig. 4. Distribution of height classes in the subsequent stand; the points represent the layout of trees in the initial stand (situation 2001)

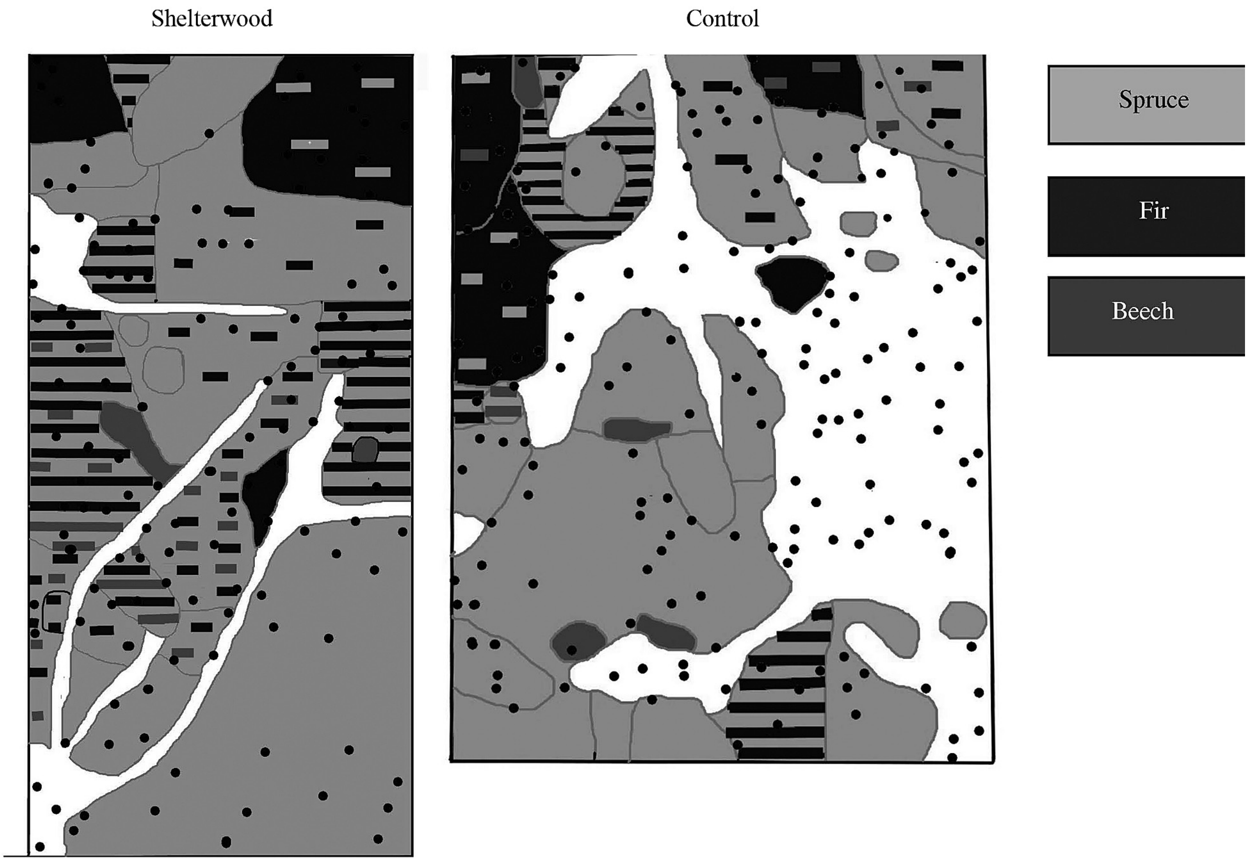

Fig. 5. The subsequent forest stand layout according to tree species; the points represent the layout of trees in the initial stand (situation 2001)

and other 23% of height up to 1 m. Dominated by spruce and fir similarly like the plot under shelterwood, the control plot had a proportion of beech affected by underplanting. Until 1981, the area of the subsequent stand increased to 81% on the plot under shelterwood and to 56% on the control plot. The dominance of spruce remained preserved on both plots while the proportion of fir increased on the control plot (Table 3). Spruce and fir were represented in all height classes (from seedlings up to advance growths over 2 m), beech from underplanting occurred in lower height classes (Švarc 1987a). In 1992, the subsequent stand on the plot under shelterwood covered nearly the whole area, exceptions were only denudated stones and skidding lines (Stránská 1994). The undergrowth height considerably fluctuated according to the age and intensity of the preceding release with the tallest spruce individuals reaching heights up to 12 m. The tree species composition was continually dominated by spruce with the proportions of fir and beech depending on the release intensity and on the height increment of individual tree species in mixtures. Beech occurred mainly at lower altitudinal zones and repeated game damage affected adversely its frequency and height growth (Stránská 1994).

The inventory of the shelterwood plot in 2001 recorded the subsequent stand on 88% of the area with 12% of area without regeneration being represented by skidding lines (Figs. 4 and 5). The existing pattern of roads and lines still enables the environment-friendly primary extraction of felled trees. The subsequent stand on the control plot was recorded on 67% of the area with its occurrence being bound to small plots with the permanently open canopy. A considerable part of the control plot is covered by litterfall or sparse herbaceous vegetation which do not hamper the subsequent natural regeneration. The species composition of both plots is dominated by spruce and beech occurring as individual and group admixtures. Fir groups are bound to less open plots in which fir was capable to compete with spruce in height growth. Spruce occurs in all height classes, its dominant representation being observed in height classes over 6 m (Table 4). This height class

Table 4. The percentage representation of a subsequent stand according to height classes

Plot	0–3 m	3–6 m	6–10 m	10+ m
Shelterwood	4.3	23.8	29.3	42.6
Control	9.9	28.4	48.1	13.6

has the greatest representation on the control plot; the plot under shelterwood is dominated by trees higher than 10 m. The upper height of long-released spruce trees in the subsequent stand on the plot under shelterwood is reaching up to 18 m while the greatest tree height achieved on the control plot is 13 m.

CONCLUSION

The paper presents a summary of results from the production of a forest stand regenerated under shelterwood as compared with the control plot and from the growth of a subsequent stand at middle altitudes as exampled on the locality Štěnice in the Žďárské vrchy Hills. The surveyed forest stand was chosen in 1971 as an exhibit of high-quality spruce-dominated coniferous stand of middle altitudes. During 30 years of the experiment, only incidental felling was carried out on the control plot while thinnings on the plot under shelterwood were focused on the growth promotion of the subsequent stand.

The development of basic stand characteristics differed due to different management methods with annual volume increment being comparable on the two plots. Mean tree dimensions were similar on both plots for the whole period of study, only the crown lengths of trees on the shelterwood plot were greater. Despite its age the surveyed forest stand demonstrated a high increment potential. Annual-ring analyses corroborated a higher diameter increment of sample trees on the plot under shelterwood, a more pronounced increase in diameter increment was however observed only in the 1990s. The delayed increment response to heavy felling is likely to have been affected by the unfavourable climatic and air pollution situation in the 1980s. The combination of natural regeneration of spruce with the planting of beech and fir resulted in regenerating nearly the whole shelterwood plot with only skidding lines remaining without regeneration. The proportion of regeneration on the control plot is lower with dominating groups of lower tree height. The subsequent stand occurs only at long open places and the remainder of the plot has conditions favourable for further regeneration. The required representation of beech and fir was ensured on both plots with spruce retained in the subsequent forest stand as the main commercial species. The current tree species composition can be partly modified by tending measures in the following years, the area representation of mixed groups is considerably high. Both plots exhibit a variety of tree heights with the subsequent stand gradually reaching the crown space of the initial stand at long open places and creating a more complex stand structure. No significant damage due to biotic and abiotic factors was recorded in the stands.

References

BRÁZDIL R., CHROMÁ K., 2003. Kolísání extrémně vlhkých a extrémně suchých měsíců v České republice. Meteorologické zprávy, *56*: 73–79.

ČERNÝ M., PAŘEZ J., MALÍK Z., 1996. Růstové a taxační tabulky hlavních dřevin České republiky. (Smrk, borovice, buk, dub.) Jílové u Prahy, IFER: 245.

ČÍŽEK J., 1969. Pěstební výběr při obnově smrkových porostů v podrostním hospodářství (část 1). Sborník VLÚ VŠZ v Praze, *12*: 87–109.

ČÍŽEK J., KRATOCHVÍL F., PEŘINA V., 1959. Přeměny monokultur. Praha, SZN: 190.

ECKSTEIN D., KRAUSE C., BAUCH J., 1989. Dendroecological investigation of spruce trees (*Picea abies* [L.] Karst.) of different damage and canopy classes. Holzforschung, *43*: 411–417.

EPP P., 2003. Zur Abschätzung des Zuwachspotentials von Fichten und Tannen nach starken Freistellung in Plenterüberführungbeständen. Schriftenreihe Freiburger Forstliche Forschung, Band 24: 135.

HOLGÉN P. et al., 2003. Diameter increment in *Picea abies* shelterwood stands in Northern Sweden. Scandinavian Journal of Forest Research, *18*: 163–167.

KORPEĽ Š. et al., 1991. Pestovanie lesa. Bratislava, Príroda: 472.

MRÁČEK Z., PAŘEZ J., 1986. Pěstování smrku. Praha, SZN: 203.

POLENO Z., 1967. Podrostní hospodářství jako jedna z cest zvyšování produkce lesa. [Kandidátská dizertační práce.] Praha, VŠZ: 236.

POLENO Z., 1997. Trvale udržitelné obhospodařování lesů. Praha, MZe ČR: 105.

RIEMER T., SLOBODA B., ĎURSKÝ J., ŠMELKO Š., 1997. Testovanie stálosti dlhodobého trendu hrúbkového prírastku smreka v oblasti severného Slovenska. Lesnictví, *43*: 389–397.

SCHMITT M., 1994. Waldwachstumskundliche Untersuchungen zur Überführung fichtenreichen Baumhölzer in naturnahe Mischbestände mit Dauerwaldcharakter. Forstliche Forschungsberichte München, Nr. 144: 223.

SPATHELF P., 1998. Orientierungshilfe zur Prognose und Steuerung des Wachstums von Fichten (*Picea abies* (L.) Karst.) und Tannen (*Abies alba* Mill.) in Überführungswäldern mit Hilfe der relativen Kronenlänge. Schriftenreihe Freiburger Forstliche Forschung, Band 4: 192.

SPIECKER H., 1986. Das Wachstum der tannen und Fichten auf Plenterwald-versuchsflächen des Schwarzwaldes in der Zeit von 1950–1984. AFJZ, *157*: 152–164.

SPIECKER H. et al., 2004. Norway spruce conversion – options and consequences. European Forest Institute Research Report 18, Brioll, Leiden, Boston: 269.

STRÁNSKÁ M., 1994. Obnova lesa maloplošným pasečným postupem ve Žďárských vrších. [Diplomová práce.] Brno, VŠZ, LDF: 58.

ŠVARC J., 1987a. Studium vývoje a obnovy jedlo-smrkového porostu ve Žďárských horách. Lesnictví, *33*: 371–380.

ŠVARC J., 1987b. Použitelnost některých principů podrostního hospodářství v současné praxi. Lesnická práce, *2*: 62–65.

TESAŘ V., KLIMO E., 2004. Pěstování smrku u nás a v Evropě. In: Sborník příspěvků ze semináře Smrk – dřevina budoucnosti. Svoboda nad Úpou, 23.–24. dubna 2004. Hradec Králové, Lesy České republiky: 7–18.

THOMASIUS H., 1988. Stabilität natürlichen und künstlicher Waldökosysteme sowie deren Beeinflussbarkeit durch forstwissenschaftliche Massnahmen. Allgemeine Forstzeitschrift, *43*: 1037–1043, 1064–1068.

VYSKOT M. et al., 1971. Základy růstu a produkce lesů. Praha, SZN: 446.

WEIHE J., 1977. Die Wechselbeziehung zwischen Grundbreite (d:h), echter Formzahl und Kronenanteil in Fichtenbestanden. Forstarchiv, *48*: 200–203.

ZAKOPAL V., 1976. Dynamika přírůstu a obnovy při podrostním hospodářství ve smrko-bukovém stupni Orlických hor. Lesnictví, *22*: 523–544.

Received for publication March 19, 2007
Accepted after corrections June 14, 2007

Podrostní způsob obnovy porostu s dominancí smrku ve středních polohách

ABSTRAKT: Experiment s podrostní obnovou mýtního porostu s dominancí smrku byl založen v roce 1971 ve středních polohách Žďárských vrchů. Článek porovnává vývoj základních porostních charakteristik na podrostní ploše a kontrole. Letokruhové analýzy potvrdily vyšší tloušťkový přírůst vzorníků na podrostní ploše, výraznější zvýšení přírůstu však nastalo až 12 let po uvolnění. Následný porost z kombinované obnovy se vyskytuje na 88 % podrostní plochy, 67 % kontroly. Požadovaný podíl buku a jedle je zajištěn na obou plochách, smrk jako hlavní hospodářská dřevina zůstal na ploše zachován. Následný porost je výškově i tloušťkově diferencován, obě plochy vykazují značnou strukturovanost.

Klíčová slova: transformace; podrostní hospodářství; smrk; jedle; buk; tloušťkový přírůst; kombinovaná obnova

Corresponding author:

Ing. Jiří Souček, Ph.D., Výzkumný ústav lesního hospodářství a myslivosti, v.v.i., Výzkumná stanice Opočno,
Na Olivě 550, 517 73 Opočno, Česká republika
tel.: + 420 494 668 391, fax: + 420 494 668 393, e-mail: soucek@vulhmop.cz