UNIVERSITATEA
BRAȘOV

IUFRO

ROMSILVA
REGIA NAȚIONALĂ A PĂDURILOR

PROCEEDINGS

International Conference
"Beech silviculture in Europe´s largest beech country"

IUFRO WP 1.01.07 *Ecology and silviculture of beech*

4-8 September 2006, Poiana Brașov, Romania

RIFR

SVERIGES LANTBRUKSUNIVERSITET
SLU

Forrest & Landscape Denmark

Hokkaido
Forestry
Research
Institute

Ädellövskog

PROCEEDINGS

International Conference
"Beech silviculture in Europe´s largest beech country"

IUFRO WP 1.01.07 Ecology and silviculture of beech

4-8 September 2006, Poiana Braşov, Romania

Co-Chairs:

Dr. Palle Madsen, Denmark
Dr. Kazuhiko Terazawa, Japan
Dr. Khosro Sagheb-Talebi, Iran
Prof.dr. Norocel-Valeriu Nicolescu, Romania

Scientific Committee:

Prof.dr. Norocel-Valeriu Nicolescu, Romania
Dr. Khosro Sagheb-Talebi, Iran
Dr. Kazuhiko Terazawa, Japan
Dr. Magnus Löf, Sweden
Dr. Catherine Collet, France
Dr. Palle Madsen, Denmark

CONTENTS

DROUGHT AND BEECH SILVICULTURE - WHAT WILL BE THE RELEVANT REGENERATION STRATEGIES AND TECHNIQUES?

Bolte Andreas*[1], Tomasz Czajkowski[2]

[1]Federal Research Centre for Forestry and Forest Products, Institute of Forest Ecology and Forest Inventory, A.-Moeller-Str. 1, D-16225 Eberswalde, Germany
Tel: + 33 34 – 65 345 - Fax: + 33 34 – 65 354 - E-mail: abolte@bfh-inst7.fh-eberswalde.de
[2]Goettingen University, Institute of Silviculture, Dept. I, Germany.

Introduction

European beech (*Fagus sylvatica* L.) is one of the main tree species in the ongoing conversions of coniferous plantations to deciduous forests, since beech dominates the potential natural vegetation (PNV) in large parts of Central Europe. However, the reputed drought sensitiveness of beech has led to discussions about the growth and regeneration of beech on dryer sites in southern Germany in the context of climate change predictions (Rennenberg et al. 2004, Ammer et al. 2005).
Summer 2003 was one of the warmest and driest periods in Central Europe for almost 100 years. The air temperature between June and August was anomalous, deviating from the 30 year average (1961-1990) by +2°C to +5°C (Schär et al. 2004). In northeastern Central Europe (north-eastern Germany and western Poland) a deficit in precipitation of 180 mm resulted from the 2003 drought. In this year the precipitation rate amounted to 440 mm p. a. only (Rudolf 2004).

In eight pure and mixed European beech forests in northeastern Central Europe the growth response of natural beech regeneration during the 2003 summer drought and the additional effects of shading was investigated. According to the results, adequate strategies for the natural regeneration of beech forest under conditions of frequent drought events are discussed.

Materials and Methods

The selected stands, comprising four to six year old natural beech regeneration situated on sites with similar sandy soils, spanned a 600 km geographic gradient from Northeast Germany to Northeast Poland (Masuria).
During the extended drought period from end of July to mid August 2003, the water status of beech regeneration was assessed by measuring the predawn potential (ψPD) of 17 to 22 randomly selected saplings with a Scholander pressure chamber (Scholander et al. 1965). All stands were then classified into class (1) without water stress ($\psi PD > -0.4$ MPa), class (2) with moderate water stress (ψPD - 0.4 MPa to -0.8 MPa) or class (3) with high water stress ($\psi PD < -0.8$ MPa, Czajkowski et al. 2005). Inventories of natural regeneration took place on permanently marked plots 0.12 ha to 0.25 ha in area. On six to eight subplots (20m² area), up to 20 beech saplings were labeled and total aerial shoot length, root collar diameter, and terminal shoot length were recorded. A second inventory in September 2004 enabled relative length and diameter increment in 2003 and 2004 to be calculated in relation to plant size at the beginning of the growth period.
Hemispherical photography was used to consider additional effects of below-canopy irradiance on plant performance by deriving the diffuse site factor (DIFFSF) of each subplot (Wagner 1994).

Results and discussion

Results showed that plant water status during July and August 2003 had a considerable effect on the relative increment of saplings during 2003 and 2004. Increased water stress, indicated by decreased predawn plant potential, correlated to lower relative length and diameter increment (Figure 1). A carry-over effect of the summer drought on beech sapling performance was evident as a decrease in relative growth was observed during the 2004 wet growing season compared to sapling growth during the 2003 drought year.

An analysis of covariance (ANCOVA) identified both water stress and diffuse site factor (DIFFSF) as parameters affecting relative growth increment of the saplings (Table 1). Water stress had a stronger effect on plant performance than shading. However influence of canopy was more evident when water stress was increased. For the relative length increment in 2004, climatic water shortage and diffuse site factor (DIFFSF) were found to have an interactive effect. The latter may reflect the impact of soil resource depletion in addition to the impact of shelterwood competition on regeneration performance by limiting light availability. In addition, the limited ability of shaded beech regeneration to adapt to water stress can also play a role. This may be due to the lower osmotic potential and lower root/shoot ratios of these plants (cf. Eschrich et al., 1989, Löf et al. 2005). The lower adaptation potential of shaded beech exacerbates the impact of competition from the overstorey (Aranda et al. 2001).

The predicted increase in summer drought events in Central Europe suggest that an optimization of soil water resource management in future silvicultural planning will be crucial for successful beech stand regeneration. In this context, a marked reduction in canopy after the successful establishment of young beech plants will reduce the risk of water stress, provided competition from ground vegetation is controlled. Irregular shelterwood systems creating gap openings with an initial area of up to 20 meters in diameter will provide those conditions, particularly in gap centers.

Figure 1: Relationships between plot means of predawn potentials und relative increment of the natural beech regeneration (RI_L: relative length increment, RI_D: relative increment of root collar diameter).

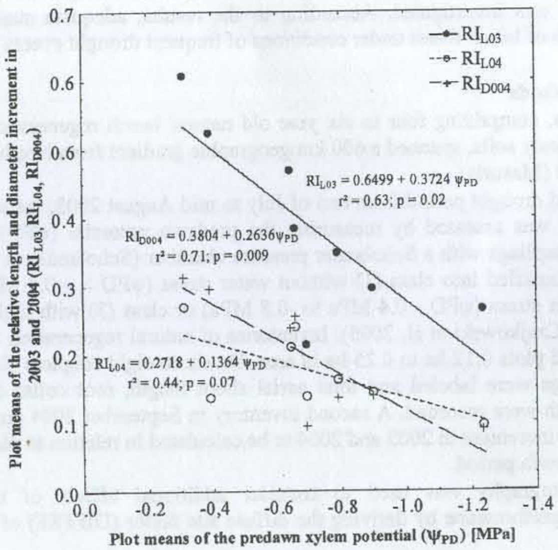


Table 1: Analysis of Covariance (ANCOVA), univariate tests using relative increment parameter (Type III decomposition, models with highest coefficients of determination); RI_{L03}: relative length increment 2003, RI_{L04}: relative length increment 2004, RI_{D004}: relative increment of root collar diameter 2004; SQ: sum of squares, MQ: mean of squares.

	FG	SQ	MQ	F	p
		RI_{L03} ($r^2 = 0.45$)			
Water stress class	2	0.674104	0.337052	18.2	<0.01
DIFFSF	1	0.120818	0.120818	6.5	<0.05
Error	55	1.020502	0.018555		
Total	58	1.840314			
		RI_{L04} ($r^2 = 0.41$)			
Water stress class	2	0.128944	0.064472	10.5	<0.01
DIFFSF*water stress class	3	0.126513	0.042171	6.8	<0.01
Error	53	0.326543	0.006161		
Total	58	0.555955			
		RI_{D004} ($r^2 = 0.46$)			
Water stress class	2	0.225830	0.112915	18.4	<0.01
DIFFSF	1	0.060702	0.060702	9.9	<0.01
Error	55	0.337438	0.006135		
Total	58	0.632050			

References

Ammer, Ch., Albrecht, L., Borchert, H., Brosinger, F., Dittmar, Ch., Elling, W., Ewald, J., Felbermeier, B., Gilsa, v. H., Huss, J., Kenk, J., Kölling, Ch., Kohnle, U., Meyer, P., Mosandl., R., Moosmayer, H.-U., Palmer, S., Reif, A., Rehfuess, K.-E., Stimm, B. 2005.. Allg. Forst- u. J.-Ztg. 176: 60-67.

Aranda, I., Gil, L., Pardos, J. A. 2001. Trees 15: 358-364.

Czajkowski, T., Kühling, M., Bolte, A. 2005. Allg. Forst- u. J.-Ztg. 176: 133-143.

Eschrich, W., Buchardt, R., Essiamah, S. 1989. Trees 3: 1-10.

Löf, M., Bolte, A., Welander, T. 2005. Scand. J For. Res. 20: 322-328.

Rennenberg, H., Seiler, W., Matyssek, R., Gessler, A., Kreuzwieser, J. 2004. Allg. Forst- u. J.-Ztg. 175: 210-224.

Rudolf, B. 2004. Deutscher Wetterdienst, Offenbach am Main.

Schär, Ch., Vidale, P.L., Lüthi, D., Frei, Ch., Häberli, Ch., Liniger, M. A., Appenzeller, Ch. 2004. Nature 427: 332-336.

Scholander, P.F., Hammel, H.T., Bradstreet, E.D., Hemmingsen, E.A. 1965. Science 148: 339-346.

Wagner, S. 1994. Ber. Forschungsz. Waldökosysteme Göttingen A 123

SHADE TOLERANCE OF SAPLINGS OF BEECH IN COMPARISON WITH MAPLE AND ASH

Any-Mary Petrițan*, Burghard von Lüpke

Institute for Silviculture, University of Göttingen, 37077 Göttingen, Büsgenweg 1, Germany
Phone: +551-393672, Fax: +551-393270, E-mail: apetrit@gwdg.de

Introduction

Since long German forestry is aiming at mixed species stands. This is reinforced by the change of the silvicultural paradigm to close-to-nature silviculture and at the same time impeded by the principles of continuous cover forestry involved with the former (Lüpke 2004). This is particularly true in beech (*Fagus sylvatica* L.) stands. Beech is well known as a very shade tolerant and heavy shade casting species. Both features contribute to high competitiveness resulting in pure beech stands on many sites. However, the need to mix in other species gained increasing importance the last decade. Besides the above mentioned more philosophical aspects additional reasons turned up: a) Climate change threatens the stability even of beech stands which are regarded as very stable ecosystems up to now. Mixed species of deviant ecological characteristics can enhance stand stability by distributing the risks of climate change (Petercord 1999). b) Many mixed species produce particularly valuable timber and grow naturally in early successional stages where beech is lacking or rare. In late successional beech stands they are competitively inferior. On nutrient rich sites, maple (*Acer pseudoplatanus* L.) and ash (*Fraxinus excelsior* L.) are the most important species of this category.

Pursuing the continuous cover concept, a forester typically has to grow a mixed regeneration of beech, maple and ash underneath a dense beech overstorey for many years. This is a new situation. In the past, the beech overstorey normally was removed within 10-15 years after having started the regeneration. This provided sufficient light to ensure an initial height lead of maple and ash over beech. In the new situation, the outcome is not foreseeable. In order to mitigate this uncertainty we carried out an investigation on shade tolerance of beech, maple and ash saplings under such conditions. We concentrate on height and diameter growth under low light because we regard these as decisive features for successful survival, or with other words, for shade tolerance.

Materials and Methods

The study area is located in the Göttingen Forest on two sites with rich nutrient supply, differing in water balance: 1) "Hünstollen" on shallow limestone plateau with rendzina and terra fusca soil, frequently with poor water supply during dry periods in summer. 2) "Hengstberg" on clayey downslope with deep terra fusca or cambisol/pelosol with constantly fairly good water supply. The altitude ranges from 301-400m, the mean annual rainfall is 680 mm (340 mm in the growing season) and the average annual temperature is 7,8°C. Shelterwoods of beech with few maple and ash trees, approximately 120 years old and with heterogeneous canopy densities cover both sites. 20-30 years ago natural regeneration started. Today it forms a dense thicket comprising maple, ash and beech as major species, underneath a fairly dense shelterwood.

Tree growth and light data were recorded within circular plots of 2,5 m^2, evenly distributed on both study stands and covering the whole range of canopy densities. From these plots saplings of the three species were stratified in three tree classes - dominant, codominant and suppressed - and equal numbers of each stratum were randomly selected as samples (in total 192 saplings at Hünstollen and 236 at Hengstberg). For every sapling, the following data were recorded: light intensity at the uppermost leaves by hemispherical fotos, total height, length of the last five annual terminal shoot increments and diameter at 10 cm above ground. After cutting the saplings, a stem disc was taken from 10 cm above ground for determining age and annual ring width for the last 10 years. As a measure of light intensity we used the indirect site factor (ISF, in % of above canopy light), and grouped the values in three light classes.

Results and Discussion

All the sample trees were about the same mean age (Tab. 1). Differences between sites and light classes were not significant. Beech was on the average with 16 years two years older than maple and three years older than ash. The minimal age ranged from 5 years for ash to 8 years for beech, the maximal age from 18 for ash and 25 for beech. From these values, a time window of 20 years for the natural regeneration on both sites can be derived. Regeneration started with beech, followed 2-8 years later by maple and ash. The last seedlings established were ashes. Züge (1986) found a comparable age lead of beech over maple and ash in a similar natural regeneration on the same site.

Table 1: Number, size and age of the sample saplings, grouped by study site, species and light class.

Species	Light classes	n	Indirect Site Factor (% full sun)	Diameter (mm)	Height (cm)	Age
Hünstollen n=192						
Beech	3-9,9%	26	7,7 (3,5-9,9)	8,8 (4,0-19,0)	142,2 (67,0-288,0)	15 (8-21)
	10-16,9%	25	13,8 (10,0-16,9)	17,3 (8,0-32,0)	278,9 (143,0-490,0)	18 (12-24)
	17-24%	18	18,6 (17,0-22,3)	26,4 (10,0-48,0)	381,9 (150,0-632,0)	18 (13-24)
		69	**12,7 (3,6-22,6)**	**16,5 (4,0-48,0)**	**254,3 (67,0-632,0)**	**17 (8-24)**
Maple	3-9,9%	23	7,4 (3,8-9,9)	9,8 (6,0-19,0)	152,6 (86,0-307,0)	12 (7-17)
	10-16,9%	26	13,4 (10-16,4)	15,4 (6,0-29,0)	253,2 (127,0-447,0)	16 (12-21)
	17-24%	24	18,9 (17,0-23,7)	28,3 (13,0-54,0)	420,4 (222,0-579,0)	16 (12-19)
		73	**13,3 (3,79-23,7)**	**17,9 (6,0-54,0)**	**276,5 (86,0-579,0)**	**15 (7-21)**
Ash	3-9,9%	23	7,4 (3,9-9,7)	8,3 (5,0-13,0)	131,3 (75,0-228,0)	13 (8-20)
	10-16,9%	21	12,9 (10-16,5)	12,0 (5,0-18,0)	233,9 (109,0-395,0)	14 (5-21)
	17-24%	6	19,3 (17,2-20,5)	17,3 (11,0-23,0)	331,7 (272,0-384,0)	16 (12-19)
		50	**11,1 (3,9-20,5)**	**10,9 (5,0-23,0)**	**198,4 (75,0-395,0)**	**14 (5-21)**
Hengstberg n=236						
Beech	3-9,9%	27	6 (3,2-9,9)	7,4 (4,5-14,0)	123,6 (76,0-290,0)	14 (9-25)
	10-16,9%	29	12,8 (10,3-16,5)	16,0 (9,0-41,5)	263,8 (142,0-513,0)	16 (11-24)
	17-33%	28	20,8 (17,2-30,9)	34,6 (10,0-56,0)	436,7 (200,0-738,0)	18 (12-23)
		84	**13,3 (3,2-30,9)**	**19,5 (4,5-56,0)**	**276,4 (76,0-738,0)**	**16 (9-25)**
Maple	3-9,9%	27	6,3 (3,9-9,4)	8,6 (5,0-11,0)	141,8 (90,0-446,0)	12 (6-20)
	10-16,9%	25	13,1 (10,0-16,5)	15,3 (10,0-28,0)	281,3 (186,0-493,0)	14 (5-20)
	17-33%	29	20,9 (17,1-30,8)	37,9 (17,0-61,0)	487,6 (206,0-707,0)	16 (8-21)
		81	**13,6 (3,9-30,8)**	**21,4 (5,0-61,0)**	**308,6 (90,0-707,0)**	**14 (5-21)**
Ash	3-9,9%	29	6,0 (3,3-8,7)	7,6 (4,0-12,5)	129,9 (50,0-320,0)	12 (5-19)
	10-16,9%	25	13,0 (10,0-16,1)	17,7 (8,0-43,0)	301,8 (128,0-622,0)	15 (8-23)
	17-33%	17	22,6 (17,3-31,2)	30,1 (16,8-42,0)	491,2 (312,0-700,0)	13 (9-18)
		71	**12,5 (3,3-31,2)**	**16,5 (4,0-43,0)**	**276,9 (50,0-700,0)**	**13 (5-23)**

For the following analysis, it is important that mean ages of the light classes did not differentiate significantly. However, there is a clear tendency of being more younger saplings in the low light class (3-9,9 % of above canopy light), most of them forming the understorey of the thicket. But differences between the medium and high light classes (10-16,9 % compared with 17-24 respectively 33 % of above canopy light) were negligible.

Annual terminal shoot growth, averaged over the last 5 years, of all three species rose with light (Fig. 1). Significant differences between beech and maple/ash occurred only in the high light class, with beech showing 35 (Hünstollen), respectively 43 cm (Hengstberg), and maple/ash about 37 % (Hünstollen), respectively 40 % (Hengstberg) more. Maple and ash showed no difference among themselves under the whole range of light conditions. All species reached larger height increments at the study site Hengstberg, presumably because of better water supply. But in deep shade (3-9,9 % of above canopy light) there was no significant difference, with all species growing about 10 cm annually. Light was the only limiting factor, without interacting with other growth factors like e.g. water supply.

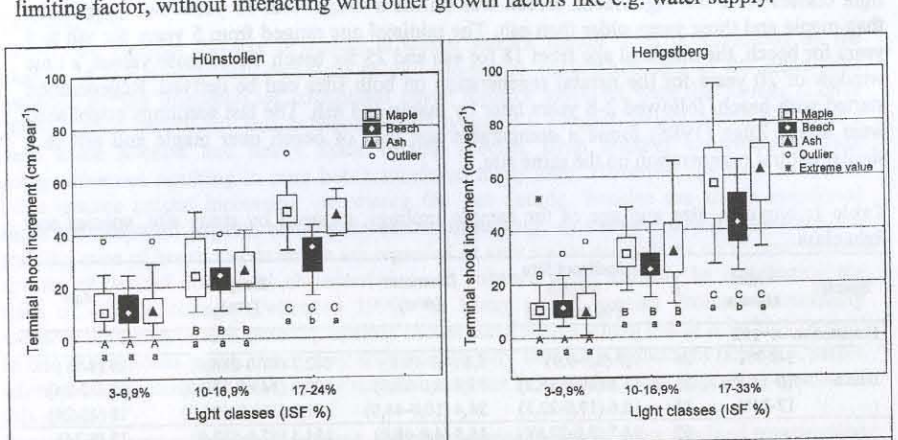


Figure 1: Annual terminal shoot increment as average over the last 5 years for light classes and tree species. The significant differences between species within light classes are marked by lower case letters and those between light classes within each species by capitals (Mann-Whitney-U-Test p<0,05).

Annual radial increment, also averaged over 5 years, showed more or less the same picture, with one exception: even in the high light class beech was not inferior to maple and ash. No significant species differences could be detected. The rise of annual increment with increasing light was more pronounced with radial than with height growth. Whereas radial increment gained 4,2 fold (Hünstollen), respectively 6,0 fold (Hengstberg) from low light to high light class (as a mean of all three species), the respective values for height growth (3,3 and 5,4) were smaller. As observed in previous studies (Pacala et al. 1994, Lin at al. 2002, Gratzer et al. 2004) the more shade-tolerant species (i.e., beech) have less height growth at high light levels than less shade-tolerant species (i.e., ash and maple). However, unlike to their findings, in our study beech did not exhibit higher growth in deep shade.

The course of the annual diameter increment over the last 10 years is exemplarily shown in figure 2 for beech at Hünstollen. The steep rise from 2000 to 2001 and the subsequent fall to 2002 are conspicuous, particularly pronounced in the high and medium light class, but still detectable in low light. The other two species and the second site Hengstberg showed more or less the same increase, but the subsequent fall was much weaker, or missing as in the case of maple. We assume the reason for the increase being a cutting and opening up of the shelterwood in winter 2000/2001, while the dry season in 2003 and a mass outbreak of the louse *Cryptococcus fagisuga* in summer 2004 might explain the fall with beech in Hünstollen. The reaction of maple and ash can be interpreted as less sensitivity to drought.

Contrary to diameter growth, height growth increased one year later after opening the canopy, what is similar to the results of Collet et al. (2001). With this lag, it showed the same pattern during the following years.

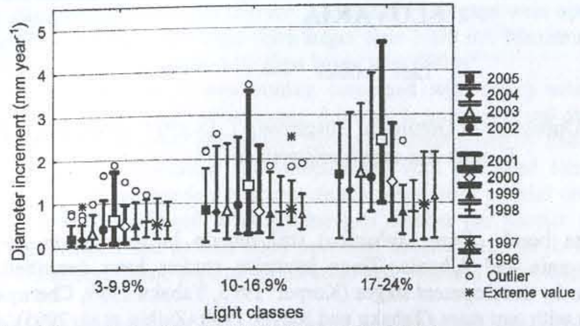


Figure 2: Annual diameter increment for the last 10 years for beech at Hünstollen.

References

Collet, C. et al. 2001. Ann. For. Sci. 58: 127–134.
Gratzer, G. et al. 2004. Can. J. For. Res. 34: 1093-1107.
Lin, J. et al. 2002. Oecologia 132: 428-435.
Lüpke, B. v. 2004. Forstarchiv 75: 43-50.
Pacala, S.W. et al. 1994. Can. J. For. Res. 24: 2172-2183.
Petercord 1999. Hainholz Forstwissenschaften, Dohrenbusch, A. (Eds.), Hainholz Verlag, Göttingen, Braunschweig, ISBN: 3-932622-43-X
Züge, J. 1986. Dissertation Forstwiss. Fachbereich Uni. Göttingen, 213 p.

STAND STRUCTURE AND GAPS OF VIRGIN BEECH FORESTS IN SLOVAKIA

Lars Drößler

Institute of Silviculture, University of Göttingen, Büsgenweg 1, D-37077 Göttingen, Germany
E-mail: lars.droessler@web.de

Introduction

Virgin forests with pure beech (*Fagus sylvatica*) still remain in reserves in Romania, Ukrainia, Slovakia, Slovenia and Albania. Three intensive studies have described stand structure in these reserves by development stages (Korpel' 1995, Tabaku 1999, Chernyavskyy 2005). Two studies dealt with gap sizes (Tabaku and Meyer 1999, Zeibig et al. 2005). Here a further study is presented, conducted in two forest reserves in eastern Slovakia.
The aim of the study is to describe the natural disturbance regime. It will be assessed by the proportion of gap area in the forest and gap size frequencies.
Gaps might be also considered as the first development stage in the forest. The second aim of this study is to describe the further stand development. The sizes of further stages are determined by the number of neighbouring trees belonging to a stage defining dbh class.

Materials and Methods

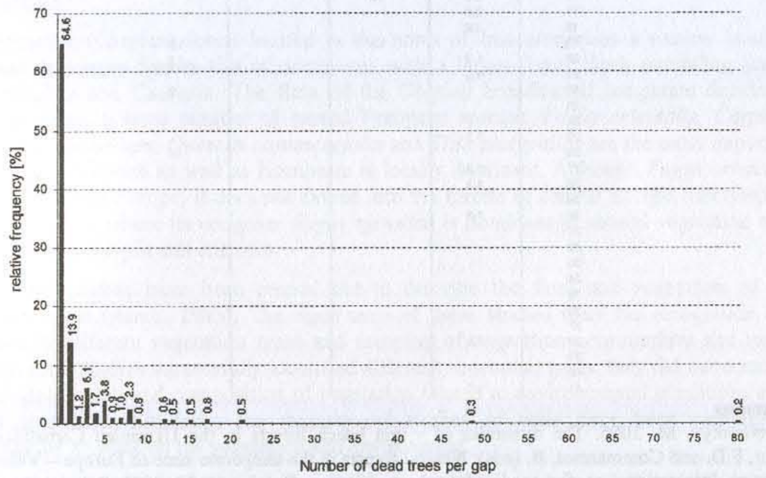
Both reserves are located in eastern Slovakia. The Havešová Reserve has very good growth conditions for beech: stand height is 45 m. The south slope is 10° on average. The Kyjov Reserve also has good growth conditions: stand height is 30 m. The northeast slope is 10°. Both sites are described in detail by Drößler and Lüpke (2006a).
A gap is defined as interruption of the canopy in the upper stand layer (Havešová: 30-45 m, Kyjov: 20-30 m). According to height curves, a tree growing into the upper stratum has a DBH of approximately 30 cm at Havešová and 20 cm at Kyjov. These DBH values were used to distinguish between gaps with regeneration and closed forest. In addition 7 cm DBH were also used as distinction, because stand structural analysis is based on trees with DBH ≥ 7 cm.
Gaps were recorded by line transect sampling according to Runkle (1992). In each gap the number of dead canopy trees (gap makers, visible up to ~40 years after tree fall) was determined. Gap frequencies were corrected according to selection probability of differently sized gaps. More detailed information given in Drößler and Lüpke (2005).
To describe stand structure on 20 plots, 0.4 ha each, live trees (minimum 7 cm DBH) were recorded and coordinates determined. Additionally tree height and crown radius were measured for 60 trees per reserve to determine correlations with DBH. Thus a tree distribution map with circular crowns could be drawn for each plot. The next step was a grouping of trees of similar size: All trees were assigned to diameter classes, which were trees between 7-20 cm (initial stage), 21-40 cm (early), 41-60 cm (medium) and 61-100 cm (late optimum). The number of trees in each DBH class with crown contact was determined. Thus the crown radius provided a boundary limit in defining neighbouring and non-neighbouring trees. The frequency of single trees and differently sized tree groups was then derived.

Results and Discussion

Gaps: Gaps comprised 15% of the forest area. Half the area of gaps was covered by trees with 7 cm or greater DBH. In both reserves the gap size distribution was very similar: 2/3 of gaps were formed by single tree fall. 25% of gaps were formed by 2-4 trees and 9% of gaps by 5-10 trees (Figure 1). Only 1/5 of dead trees formed a new gap, while 4/5 extended a gap.

The number of gaps decreased exponentially with increasing gap size. More than 85 % of the canopy gaps were smaller than 250 m². Around 10 % of gaps were openings between 250 and 1000 m², and 1-3 % of the gaps were larger than 1000 m². Maximum gap size was 0.4 ha. Half of gap area was comprised by gaps larger than 600 m².
The results suggest single tree cutting combined with group selection seems to be the appropriate harvesting method in managed forests to imitate natural disturbances very closely. Unfortunately, gap number per hectare can not be determined by line transect sampling. This number would be interesting for comparisons with managed forests (e.g. shelter wood cutting). Digital height models of forest stands, generated by aerial photographs and elevation height models, can be used to determine gap number per hectare (Nuske and Nieschulze 2004). This method and around 5000 ha virgin beech forests in Romania offer a promising opportunity to investigate gaps an larger scale and with less effort than terrestrial surveys.

Figure 1: Frequency of gaps in Kyjov in relation to the number of dead trees per gap.



Stand structure: Projected on 10 ha 269 single trees and 93 groups with 2 trees occurred in the first DBH class in Kyjov (Table 1). In both reserves the frequency of tree groups was very similar. In each DBH class single trees dominated with exponentially decreasing number of groups with increasing group size. The largest tree group in the late optimum stage consisted of 22 trees with an area of ~0.2 ha. But maximum size is limited by the edge of 0.4 ha sample plots. Nevertheless the clear relationship between group size and group frequency was also observed for other DBH class divisions done by Drößler and Lüpke (2006b). They determined similar tree group frequencies on a 13 ha plot in Kyjov. Differences with managed forests were shown and the method recommended to assess close-to-nature structure silviculturally.

Table 1: Number of tree groups with trees of similar size in Kyjov (projected on 10 ha).

Number of trees per group	DBH class/development stage: 7-20 cm (initial stage)	21-40 cm (early optimum stage)	41-60 cm (medium optimum stage)	61-100 cm (late optimum stage)
1	268.8	158.7	99.8	57.6
2	93.4	65.3	25.6	24.3
3	53.8	24.3	12.8	10.2
4	34.6	11.5	15.4	3.8
5	16.6	9.0	7.7	2.6
6	9.0	3.8		2.6
7	7.7	2.6	5.1	1.3
8	7.7	2.6		3.8
9	11.5	1.3		2.6
10	6.4	1.3	2.6	1.3
11	5.1	1.3	1.3	1.3
12	3.8			
13	2.6			1.3
14	1.3	1.3		1.3
15	1.3	1.3		1.3
16	2.6	1.3		
17	2.6			
18	2.6			
19		1.3		1.3
20	1.3			1.3
21	1.3			
22				1.3
23				
24				
25	1.3			
26				
27	1.3			
28	1.3			
29				
30	1.3			
31				
32				
33				
34				
35				
36				
37				
38	1.3			
39				
40				
41	1.3			

References

Chernyavskyy, M. 2005. The dynamics of virgin beech forests in the Ukrainian Carpathians. In: Hamor, F.D. and Commarmot, B. (eds): Natural forests in the temperate zone of Europe – Values and utilisation. International conference in Mukachevo, Ukraine. October 13-17, 2003. Rakhiv, Carpathian biosphere Reserve; Birmensdorf, Swiss Federal Research Institute WSL.

Drößler, L., Lüpke, B. v. 2005. Canopy gaps in two virgin beech forest reserves in Slovakia. Journal of Forest Science 51: 446-457.

Drößler, L., Lüpke, B.v. 2006a. Verjüngung, Wachstumsfaktoren und Holzvorrat in zwei slowakischen Buchenurwald-Reservaten. AFJZ in press. German.

Drößler, L., Lüpke, B.v. 2006b. Stand structure in virgin and managed beech forests. European Journal of Forest Research. In press.

Korpel', Š. 1995. Die Urwälder der Westkarpaten. Gustav Fischer. Stuttgart, Jena, New York. German.

Tabaku, V. 1999. Struktur von Buchen-Urwäldern in Albanien im Vergleich mit deutschen Buchen-Naturwaldreservaten und –Wirtschaftswäldern. PhD. thesis Univ. Göttingen. Cuvillier. German.

Tabaku, V., Meyer, P. 1999. Lückenmuster albanischer und mitteleuropäischer Buchenwälder unterschiedlicher Nutzungsintensität. Forstarchiv 70, 87-97. German.

Zeibig, A.; Diaci, J.; Wagner, S., (in press): Gap disturbance patterns of a beech virgin forest remnant in the mountain vegetation belt of Slovenia. In: Hamor, F.D. and Commarmot, B. (eds): Natural forests in the temperate zone of Europe – Values and utilisation. International conference in Mukachevo, Ukraine. October 13-17, 2003. Rakhiv, Carpathian biosphere Reserve; Birmensdorf, Swiss Federal Research Institute WSL.

RELATIONSHIPS BETWEEN BEECH TREE TYPES AND SOIL PROPERTIES IN THE FORESTS OF NORTH OF IRAN

Ali Salehi *[1], Ghavamudin Zahedi Amiri[2]

[1] Department of Forestry, Natural Resources Faculty, University of Guilan, P.O. Box 1144, Somesara, Iran

Tel: +98 182 3223599 – Fax: +98 182 3222102 – E-mail: asalehi@guilan.ac.ir

[2] Department of Forestry, Natural Resources Faculty, University of Tehran, P.O. Box 31585-4314, Karadj, Iran.

Introduction

The Hyrcanian (Caspian) forest located in the north of Iran comprises a narrow band of temperate deciduous forests that is contiguous with a larger forest block extending across eastern Turkey and Caucasia. The flora of the Caspian broadleaved temperate deciduous forest comprises a large number of central European species. *Fagus orientalis, Carpinus betulus, Acer velutinum, Quercus castaneaefolia* and *Tilia platyphilos* are the most important tree species and Beech as well as Hornbeam is locally dominant. Although *Fagus orientalis* occurs in southern Europe, it does not extend into the forests of central Europe described by Ellenberg (1988), where its congener *Fagus sylvatica* is dominant in natural vegetation on a wide range of soil types and climates.

Many recent studies have been carried out to describe the flora and vegetation of the Hyrcanian forest (Asadi, 1985). The main aims of these studies were the recognition and definition of different vegetation types and mapping of vegetation communities and types. Although these studies successfully identified different vegetation types, they did not consider how the distribution and composition of vegetation related to environmental conditions such as soil properties. Similarly, the majority of studies of soils have been carried out independently of work on the vegetation and environment.

The main aim of this research was to investigate the relationships between the distribution and composition of tree species, especially Beech trees in relation to soil properties in one district of the Hyrcanian forest.

Material and methods

The study site is the Kheirood-Kenar forest (51° 32' N, 36° 27' W) of the Caspian in northern Iran and classified as mountain forest with an altitudinal range from about 650 to 1400m a.s.l. The highest mean monthly temperatures of 29° C occur in June and July and the lowest of 7.1° C in February and the mean annual rainfall of 1354.5 mm.

325 rectangular square plots of 50 * 50m-(2500 m^2) were chosen in the forest. On each plot, the diameter of all trees more than 7. 5-cm diameter at breast height were measured and identified. Slope, elevation and aspect were recorded for each plot. In order to select sites for soil sampling the forest was stratified into about 300 landform units based on differences in altitude, slope and aspect. In each landform unit, each tree plot was compared with its two nearest neighbour plots on the base of their species compositions using the Sorenson index. In this way, 85 sample plots were selected for soil profile from the original 325 tree plots.

Inside each selected plot, soil profile was dug, soil horizons were identified and characteristics of each horizon recorded A soil sample was collected from each horizon of the profile and for all of the soil samples, the soil texture, soil pH, soil bulk density, total nitrogen, organic carbon and available phosphorus were identified.

Numerical and statistical analyses

Basal area for each tree species in all of the plots and the total basal area for all of the trees species within each plot were calculated. Two-way indicator species analyses (TWINSPAN) (Hill, 1976) method for classification and one-way ANOVA (Analysis Of Variance) method was also used to test differences amongst tree groups identified by TWINSPAN.

Soil variables and topographic factors comprising altitude, aspect and slope for all 85 soil samples, as well as total basal area were prepared in the form of matrices for the other multivariate analysis. Relationships between tree composition and measured environmental variables were examined in the output of DCA. For testing differences amongst soil properties and topographic variables in four tree groups, one-way ANOVA was also used. Correlation coefficients between environmental variables and relationships between these variables and tree groups resulted from ANOVA were calculated by Minitab program, version 13/1. For all of the above mentioned multivariate analysing "PC–ORD"program version 3.17 was also used.

Results and discussion

The results of TWINSPAN classification for the 325-tree sample plots identified four tree groups or tree types at the second level of division. At the first level of TWINSPAN high basal areas of Fagus orientalis and Carpinus betulus are the key features for the division. Tree groups A and B were dominated by Carpinus betulus and tree groups C and D by Fagus orientalis. Acer cappadocicum and Quercus castaneaefolia were the other abundant tree species inside group A. The main tree species distinguishes group B from the other groups was Alnus subcordata. Inside group C, although there were several tree species, Fagus orientalis was the dominant species within this tree group. The abundance of Fagus orientalis is also high inside group D, but Tilia platyphilos was the tree species, which distinguished this group from the other groups.

Distribution of tree samples on the DCA axes in the places, where soil sample were collected, showed distribution of Fagus orientalis and Carpinus betulus is in contrast to each other. The value of basal area of Fagus orientalis for the plots distributed on the left side of DCA diagram is significantly more than the plots which have been located on the right side of DCA diagram covered by distribution of Carpinus betelus.

Correlation coefficient between the environmental variables and two axes of DCA showed that percentage of organic carbon in A horizon ($r = -0.310$), C/N ratio in A horizon ($r = -0.319$), content of silt in B1 horizon ($r = -0.239$) and altitude ($r = -0.396$) had a significant relationship to the first axis of DCA. Content of clay ($r = -.309$) and silt ($r = 0.320$) in B1 horizon had a significant relationship to the second axis of DCA. The direction of the arrows of C%, C/N ratio and altitude and correlation coefficient between these variables and the first axes of DCA show that these variables trend toward the left side of the first axis of DCA, where Fagus orientalis is dominant, and in contrast of the place where Carpinus betulus is dominant. These results identified that the content of C%, C/N ratio and altitude increase as basal area for Fagus orientalis increases amongst tree plots located on the left side of DCA diagram.

Fagus orientalis/Carpinus betulus gradient is the most important vegetation gradient in the site study. The distribution form of Fagus orientalis and Carpinus betulus along the forest stands is in contrary to each other, with Carpinus betulus being dominant in the forest stands located at low altitude and gradually replaced by Fagus orientalis at high altitude.
The results of different analyses in this study define except the altitude, percentage of organic carbon (C %) and carbon to nitrogen ratio (C/N) in A horizon was significantly correlated with the forest composition compared to other soil variables and they referred to organic materials and the rate of their decompositions. The results of the study demonstrated that by increasing of altitude, and increasing of domination of beech in the forest, content of these soil variable increases. The percentage of organic carbon and C/N ratio in the soil depends on decomposition of organic materials, then it is clear that the variations of these factors in the soil, which is affected by the altitude-induced climatic differences. Bonito et el. (2003) in their research in broad leaved forest in United State described mineralization of nitrogen significantly affected by altitude. On the other hand although many environmental factors affect the rate of litter decomposition, the rate of litter fall is remarkably uniform among tree species growing under similar soil and climatic conditions (Fisher & Binkley, 2000). In the comparison of leaf decomposition rates among different plant species identified that litter of Carpinus betulus was decomposed faster than Fagus orientalis (Cornelissen, 1996), so that the presence of beech in this study may augment the content of nitrogen and carbon in higher altitude. Overall there are complex relationships between tree compositions, altitude and soil organic matter in the study area, but it is clear that C/N ratio was directly related to altitude and C%.

Although the variations of altitude, C/N ratio and C% can explain the main gradient of tree composition (Fagus/Carpinus gradient), the results of ANOVA and DCA showed that the amount of silt is higher compared to clay content in the area covered by Fagus orientalis. In fact the results confirmed beech tree type placed in area by lighter soil texture classes compare to hornbeam tree type covered the areas by heavier soil texture classes.

References

Assadi, M., 1985. The study of plant communities in Patom district of Kheyrood-Kenar forest (MSc thesis). University of Tehran.
Bonito, G.M., Coleman, D.C., Haines, B.L & Cabera, M.L, (2003). Can nitrogen budgets explain differences in soil nitrogen mineralization rates of forest stands along an elevation gradient?, Forest Ecology & Management, 176, 563-574.
Cornelissen, J.H.C., 1996. An experimental comparison of leaf decomposition rates in a wide range of temperate plant species and types. Jor. Eco. 4, 573-582.
Ellenberg, H., 1998. Vegetation ecology of central Europe. Cambridge University.
Fisher, R., Binkley, D., 2000. Ecology & Management of forest soils, John Wiley & sons Inc.
Hill, M.O., Bunce, R.G.H., Shaw, M.W., 1976. Indicator species analysis, a divisive polythetic method of classification and its application to a survey of native pine woods in Scotland. Jou. Eco. 63, 597-613.

THE STRUCTURE AND DYNAMICS OF VIRGIN BEECH FOREST ECOSYSTEMS FROM "IZVOARELE NEREI" RESERVE – INITIAL RESULTS

Daniel-Ond Turcu*[1], Ioan Alexandru Stetca[2]

[1]Forest Research and Management Institute (ICAS) Bucharest, Timisoara Branch, 300 310, Timisoara, Romania; Tel/Fax: + 40.256.220085 - E-mail: turcu_dani@yahoo.com

[2]Forest Research and Management Institute (ICAS) Bucharest, 077 190, Bucharest, Romania; Tel: + 40.21.3503245 - E-mail: istetca@yahoo.co.uk

Introduction

The natural forest is the most complete and rich information source regarding the organization and functioning of the forest ecosystems. The forest ecosystems with a high degree of naturalness are an important reference point for forest management (Peterken, 1996).

Beech (*Fagus sylvatica L.*) natural forest ecosystems are of strategic importance for both European and Romanian forestry, due to the importance of beech forests in Europe (roughly 12 million ha), representing a large resource for both timber production, biodiversity conservation and environmental protection. The highest degree of naturalness is encountered in virgin beech forests (von Oheimb et al., 2005). These forests are situated in Central and South-eastern Europe, covering surfaces from a few hectares to a few hundred hectares (Leibundgut, 1993; Korpel, 1995; Bândiu, 1995; Tabaku, 2000). According to the 2001-2004 inventory, Romania has over 200000 ha of virgin forests, 40% of which are represented by pure and mixed beech mountain forests.

In the "Izvoarele Nerei" Scientific Reserve one of the largest European remnant virgin forests was preserved. It covers a surface of approximately 5000 ha of pure beech virgin forest in different developmental stages. This paper aims to give a general presentation of the characteristics of this unique forest: a highly diversified structure and its variation along 700 m altitudinal gradient, a nearly monospecific composition – dominated by beech with very few exemplars of fir and elm and sycamore, impressive trees dimensions (the largest trees having diameters over 1 m and heights over 50 m) and large standing volume (frequently over 1200 m^3/ha).

Materials and Methods

The structure of the forest was investigated in ten permanent circular experimental plots of 1 ha each, randomly established at 4 altitudinal levels (800, 1000, 1200 and 1350 m). The vegetation layer was divided in the following study layers: standing trees, regeneration, herbaceous flora, and deadwood.

The spatial position (x, y, z), diameter (dbh), height (h), crown projection and crown length for all standing trees (dbh ≥ 8 cm, h ≥ 3 m) was measured. Additionally some qualitative characteristics were recorded: presence of forked or broken trees vitality (healthy, damaged or dead), bark characteristics, and presence of T fiber and frost damages.

All saplings (h<2 m) and trees higher than 2 m, with the dbh <8 cm where counted and considered "regeneration points". Areas covered with seedlings of approximately same age and height (3 height classes, 0 - 0.5 m, 0.5 - 1.3 m, >1.3 m), dbh<8 cm where measured as "regeneration polygons" (surface and description of seedlings – height, age and vitality).

The deadwood was measured and mapped. The height and dbh for standing deadwood (dbh ≥15 cm, h≥1,3 m), the length and diameter at ends for fallen deadwood (logs and fallen parts of the trunk and branches with a diameter≥15 cm and a length≥3 m) where registered. Stumps

higher than 1,3 m where recorded when at a height of 20cm the diameter was ≥15 cm. The decomposition status was described (solid wood, partially rotten or rotten).

For each of the ten experimental plots specific regression equations where calculated in order to observe the correlation between dbh and height of the trees. The volume was calculated using the following regression equation:

$$\log v = a_0 + a_1 \log d + a_2 \log^2 d + a_3 \log h + a_4 \log^2$$

for beech the coeficients are:

a_0	a_1	a_2	a_3	a_4
-4,11122	1,30216	0,23636	1,26562	-0,07966.

Results and Discussion

The mean density of living trees ≥8 cm dbh amounted to 387 ha^{-1}, from which more than half where healthy trees (244 ha^{-1}). The mean basal area amounted to 50,7 m^2ha^{-1}, with a maximum of 57,8 m^2ha^{-1}, with the following mean and maximum values for the healthy trees: 39,5 m^2ha^{-1} and respectively of 46,5 m^2ha^{-1}. The average and maximum values for the standing volume where 831,0 m^3ha^{-1} and of 1139,8 m^3ha^{-1} respectively, with 697,6 m^3ha^{-1} and 986,8 m^3ha^{-1} values for the healthy trees. The diameters distribution curve has a typical reversed "J" shape, while the heights distribution curve has a bimodal form with a peak in the 5-10 m height class and a second larger one in the 25-30 m class. A strong correlation between diameters and heights was observed in all plots (a *p*-value between 0,85 and 0,95). Some of these important structural characteristics are present shortly in Table 1.

Table 1: Structural characteristics of trees (≥8 cm dbh) in the10 permanent plots

Characteristic	Average
Healthy trees percentage	62,98
Average diameter (cm)	33,31
Maximum diameter (cm)	126,40
Average basal area – all trees (m^2ha^{-1})	50,70
Average basal area – healthy trees (m^2ha^{-1})	39,50
Average height (m)	21,58
Maximum height (m)	51,68
Average crown length (m)	12,39
Average crown projection (m^2)	33,38
Broken trees percentage	15,57
Average volume – all trees (m^3ha^{-1})	831,0
Average volume – healthy trees (m^3ha^{-1})	697,60

In the case of deadwood, a large variation between plots was observed, whit a visible decrease of the volume at higher altitudes (Table 2).

As expected the regeneration layer was present in all plots, but only in those whit extended gaps, larger areas where covered by continuous regeneration polygons.

The observed structural characteristics of the Nera forest are comparable with those observed by Tabaku (2000) in the Albanian beech forests and Leibundgut (1993) in Serbia. The monospecific composition, higher structural diversity and higher volumes and tree dimensions reflect the optimum growing conditions found by the beech in the Nera reservation (Peters, 1992).

Table 2: The volume of standing and fallen deadwood

Plot number	Total deadwood volume (cu.m)	Percent from the total volume (%)	Standing deadwood (cu.m)	Fallen deadwood		
				Solid wood (cu.m)	Partially rotten wood (cu.m)	Rotten wood (cu.m)
102	62,7	6,9	18,9	6,2	12,4	25,2
103	46,4	5,8	14,0	0,2	23,2	9,0
104	79,4	9,0	17,4	24,5	17,4	20,1
110	79,2	7,2	16,2	5,1	14,3	43,6
112	104,5	8,6	29,2	0,0	0,0	75,3
114	108,7	11,7	31,3	0,0	0,0	77,4
116	105,6	10,5	30,3	0,0	0,0	75,3
118	50,4	7,8	17,6	0,0	0,0	32,8
119	52,9	7,2	9,9	6,7	3,7	32,6
120	53,6	8,6	21,6	3,5	2,1	26,3

At this stage of the research, a variation of the structure and dynamic of beech along altitudinal gradient forest can be observed. These patterns and the mechanisms behind the altitudinal variation will need further research.

REFERENCES

Bândiu, C., Smejkal, G. M., Vişoiu-Smejkal, D. (1995). "Pădurea seculară. Cercetări ecologice în Banat", Timişoara, Mirton.
Bengtsson J., Franc A., Menozzi P. (2000). "Biodiversity, disturbances, ecosystem function and management of European forests", Forest Ecology and Management 132: 39-50.
Doniţă, N., et al. (2001). « Les forets vierges de Roumanie », Louvain-la-Neuve, Foret Wallonne.
Giurgiu, V. (1984). "Biometrie forestieră", Bucureşti, Ceres.
Korpel, S. (1995). „Die Urwälder der Westkarpaten" Stuttgart, Gustav Fischer Verlag.
Leibundgut, H. (1993). „Europäische Urwälder: Wegweiser zur naturnahen Waldwirtschaft" Bern.
Peterken, G. (1996). "Natural Woodland—Ecology and Conservation in Northern Temperate Regions", Cambridge, Cambridge University Press.
Peters, R. (1992). "Ecology of beech forests in the northern hemisphere" Wageningen.
Pontailler J., Faille A., Lemke G. (1997). "Storms drive successional dynamics in natural forests: a case study in Fontainebleau forest (France)", Forest Ecology and Management 98: 1-15.
Tabaku, V. (2000). „Struktur von Buchen-Urwäldern in Albanien im Vergleich mit deutschen Buchen-Naturwaldreservaten und Wirtschaftswäldern" Göttingen, Cuvillier Verlag.
von Oheimb, G. C. W., Tempel H., Härdtle, W. (2005). "Structural pattern of a near-natural beech forest (*Fagus sylvatica*) (Serrahn, North-east Germany)." Forest Ecology and Management 212: 253-263.

DIRECT SEEDING ON FORESTLAND AND THE INFLUENCE OF RODENT PREDATION ON BEECH NUTS

Maria Birkedal[1], Matts Karlsson[1], Magnus Löf[1] and Palle Madsen[2]

[1]Southern Swedish Forest Research Centre, SLU, 230 53 Alnarp, Sweden
Tel: + 46 40 41 51 20 - Fax: + 46 40 46 23 25 - E-mail: maria.birkedal@ess.slu.se
[2]Forest & Landscape Denmark

Introduction

During artificial regeneration of beech (*Fagus sylvatica* L.) on forest land, the common practice is to plant 2–3-year-old bare-rooted seedlings at a stock density of about 2,500–5,000 per ha (Madsen and Löf 2005). Regeneration costs are high, and in southern Scandinavia, the costs may reach 7, 000 Euro per ha even when the fencing is excluded. Therefore, the development of alternatives is needed. Direct seeding is an old method that has attracted renewed attention (Küssner and Wickel, 1998; Willoughby et al., 2003). The costs are lower compared to planting and may range between 750–2,000 Euro per ha all included except fencing. Something that means fifty per cent or less compared with the costs of conventional planting. However, predation by rodents on beech nuts is a major problem for regeneration (Armour 1963, Ashby 1959, Löf et al. 2004).

Little is known concerning silvicultural measures for improved direct seeding. The specific objectives of this study were to: (1) evaluate the effects of various timing of direct seeding, (2) evaluate the effects of the size of granivorous rodent populations on predation, and (3) with the assistance of camera surveillance try to find out exactly what species of animals that remove the seeds from the site.

Materials and Methods

The experiments were set up with four blocks (6×4,5 m^2) at each of three sites (Söderåsen 1, Söderåsen 2 and Krageholm) in southernmost Sweden during May 2005. A randomized block design with two treatments in each block was used. The treatments were direct seeding of beech nuts in May and in June. Soil scarification was carried out manually in May using a planting spade. In the treatments there were two rows of seeds, with 30 seeding points in the rows. The beech nuts were sown two at each seeding point together with a piece of white paper, to make it easier to locate the seeds at the end of the season. The distance between the seeds in the row was 15 cm. All sites were fenced against larger herbivores.

The population sizes of rodents were determined before the direct seeding in May and in June. Rodent live traps (type Ugglan, 10 x 9 x 25 cm) were set out in grids of forty or forty-two traps at all sites. The distance between the traps was 15 m, and the traps were baited with oats, apple and hay. On both occasions the traps were out for two nights and the rodents caught the first night were marked and counted. The following night the marked animals caught were counted separately from the animals caught for the first time.

A digital camera (SB – 282CWH, Loke) with a motion detector and infrared light was set up in one block and site following the seeding in June.

Results and Discussion

Four to five months after the direct seeding of beech nuts there were very few seeds remaining at the sites unharmed. Neither the percent of seeds remaining, nor the percent of seedlings established differed much between May and June on either site (Table 1). Rodent populations were generally larger later during the summer than in the spring (Pucek et al. 1993), why seeds could be expected to disappear at a higher rate in June than in May. On the other hand the availability of other food sources than sown seeds is greater in June than in May, which may explain the small difference between the two times of direct seeding. The difference between the percent of seeds remaining and the percent of seedlings established was mostly the result of nonviable seeds.

Table 1: Percent seeds remaining and seedlings established in October following seeding in May and June at three sites in southern Sweden. Mean ± SE

	Södersåsen 1		Söderåsen 2		Krageholm	
	May	June	May	June	May	June
Remaining seeds, %	9,6 ± 2,8	14,2 ± 9,3	6,7 ± 2,7	7,1 ± 3,9	3,3 ± 1,2	3,3 ± 1,2
Established seedlings, %	3,8 ± 1,6	2,1 ± 2,1	0,4 ± 0,5	1,3 ± 1,5	1,3 ± 0,4	0

Another important factor for the disappearance of seeds was the size of the experiment. The blocks were not very large and there were not that many seeds sown in each treatment, which means that a few rodents easily could eat all the seeds. That was likely the reason why it was hard to see a relation between the number of rodents caught (Table 2) and the disappearance of seeds (Table 1).

To make a good estimate of rodent population size with the mark-recapture method a rather large number of individuals need to be recaptured during the second trapping night. Since that was not the case in this study, the occurrence of rodents is presented as total number of individuals caught on each trapping occasion instead of as individuals per hectare (Table 2).

The most common rodent species on all three sites and on both trapping occasions was the bank vole (*Clethrionomys glareolus* Schreber) (Table 2). Other species caught were yellow-necked mouse (*Apodemus flavicollis* Melchior) and wood mouse (*Apodemus sylvaticus* L.). The total number of rodents caught was largest at Söderåsen 2 on both trapping occasions (Table 2), but the percent of seeds remaining was not the lowest at this location (Table 1). As discussed above that might be due to the small size of the experiment.

Table 2: Number of trapped individuals of mice and voles at three sites and two times divided by species.

	Söderåsen 1		Söderåsen 2		Krageholm	
Species	May	June	May	June	May	June
Clethrionomys glareolus	2	13	14	19	6	10
Apodemus flavicollis	1	7	1	4	0	0
Apodemus sylvaticus	2	5	8	4	0	2
Total	5	25	23	27	6	12

Another explanation for the nonexistent correlation between the number of rodents caught and the disappearance of seeds would be that the seeds were removed by some other animal than mice and voles. Birds are for example known to eat a lot of beech nuts (Watt 1919). To get an idea if that could be the case the camera was set up to monitor the rows of seeded beech nuts.

Since the infrared light unfortunately was not strong enough the pictures taken during the night were all black, and during the day no animal was seen eating from the beech nuts.

Two things that could be determined due to the camera were that the seeds disappeared during the dark hours, and that they, to a large extent, disappeared almost immediately after the seeding. The white paper that was buried together with the seeds made it possible to see on the photographs if the holes where the seeds were put had been dug up. The last picture taken in daylight on the day of sowing showed no pieces of paper on the ground, but the first picture taken the morning after revealed that practically all seeds had been removed from their initial position since a lot of white paper pieces were laying on the soil surface.

Birds for example mostly seek for food with their eyes, while rodents use their olfaction (Vander Wall 1998). This enhances the belief that the seeds were taken by rodents since animals looking for food with their eyes would not find the buried beech nuts. Rodents are also known to be active during night, while seed-eating birds are often foraging during the day.

References

Armour, C.J. 1963. Forestry Abstracts 24(24):27-38.
Ashby, K.R. 1959. Quart. J. For. 53: 228-236.
Küssner and Wickel. 1998. Forstarchiv 69: 191-198.
Löf et al. 2004. For. Ecol. Manage. 188: 113-123.
Madsen and Löf. 2005. Forestry. 78: 55-64.
Pucek, Z. et al. 1993. Acta Theriol. 38(2): 199-232.
Vander Wall, S.B. 1998. Ecology 79(1):233-241.
Watt, A.S. 1919. J Ecol. 7:173-203.
Willoughby et al. 2003. Forestry 76: 83-94.

COMPARISON OF PLANT SPECIES DIVERSITY OF DIFFERENT PLANT COMMUNITIES IN CASPIAN FORESTS, IRAN

Javad Eshagh Nimvari [*1], Asadollah Mataji [2]
Ghavomoddin Zahedi Amiri[3], Mohammad Reza Marvi Mohajer[4]

[*1]PhD student, Faculty Of Natural Resources, University Of Tehran, Karaj , Iran
P.O. Box 31585-4314,Fax: +98 0261.2227765,Email: Javad_Eshagh@yahoo.com
[2]Assistant Professor, Research and Science Campus, Islamic Azad University
[3]Associate Professor, Faculty Of Natural Resources, University Of Tehran, Karaj , Iran
[4] Professor, Faculty Of Natural Resources, University Of Tehran, Karaj , Iran

Introduction

Biodiversity is defined as the kinds and numbers of organism and their patterns of distribution (Barnes 1998). The focus of biodiversity measurement is typically the species and species diversity is one of the most important indices which is used for evaluating of ecosystems in different scales (Ardakani 2004).

Plant communities are defined as an assemblage of functionally similar species populations that occur together in time and space. Plant communities are separated from each other based on indicator species and each community has distinctive species composition. Therefore, plant species diversity would be different among the communities. The more diverse community, the more stable environment (Ardakani 2004).

The smallest share of wooden species and species diversity could be found both in spruce (Picea abies) and beech (Fagus sylvatica) forests. Oak (Quercus robur) forests show the richest species diversity (Hauk 2005).

Hyrcanian vegetation zone is a green belt stretching over the northern slopes of Alborz mountain ranges and covers the southern coasts of Caspian Sea. The specific environmental conditions in this forests have been led to occurrence of different forest communities (Sagheb-Talebi 2004).

In order to practice silvicultural methods in different communities, we must learn about plant species diversity in them. This knowledge helps the forest manager to evaluate performed silvicultural treatments.

The aim of this study was firstly to recognize the forest communities in the study area, then identify and compare the plant species diversity in that forest communities.

Materials and Methods

This study was being carried out in the experimental forests of university of Tehran (located in northern Iran, total area ca. 7000 ha). These forests are natural deciduous hardwood forests which have been under low intensity management.

The study area was sampled by randomized-systematic method. Sample sites were located by overlaying a 200 x200-dot grid on a l/10,000-scale topographic map of the study area. Potential sample sites occurred on the map at the intersection of a row and column selected from a table of random numbers.

Floristic sampling was made on a floristically homogeneous surface area of 400 m^2 sample which was identified according to the minimal area procedure. At each sample, floristic list and an estimate of percent cover abundance of each vascular plant (in the tree, shrub and ground layers separately) were being recorded with using of Braun-Blanquet scale (Mueller – Dombois 1974).

The vegetation data was analyzed using TWINSPAN classification and complementary DCA analysis resulted in the recognition of different communities.

Species richness was calculated as the average number of species per sample. Shannon and Simpson indices were applied to quantify diversity and equitability of samples of different recognized communities.

A Tukey test was used to test whether there were significant differences in the species richness, diversity and evenness indices among the different communities.

Results and Discussion

152 samples were established and104 species were recorded in the study area in different layers including12 trees, 9 shrubs and 83 herbs.

Four communities including Querceto-Carpinetum betulii, Carpineto-Fagetum Orientalis, Rusco-Fagetum Orientalis and Fagetum Orientalis were recognized in the study area.

Table 1: Descriptive statistics of different diversity indices in the different communities

Indices	Community type	Number of Samples	Mean	Std. Deviation	Std. Error	Minimum	Maximum
Species Richness	Fagetum Orientalis	21	18.95^{a*}	4.20	0.92	9.00	28.00
	Querco-Carpinetum	30	27.97^{b}	6.80	1.24	16.00	39.00
	Carpineto-Fagetum	59	27.00^{b}	5.42	0.71	16.00	38.00
	Rusco-Fagetum	37	22.19^{a}	6.92	1.14	10.00	36.00
Evenness	Fagetum Orientalis	21	0.64^{a}	0.12	0.03	0.30	0.84
	Querco-Carpinetum	30	0.76^{b}	0.09	0.02	0.56	0.91
	Carpineto-Fagetum	59	0.71^{b}	0.07	0.01	0.48	0.83
	Rusco-Fagetum	37	0.65^{a}	0.10	0.02	0.36	0.80
Shannon	Fagetum Orientalis	21	1.86^{a}	0.41	0.09	0.86	2.62
	Querco-Carpinetum	30	2.49^{b}	0.27	0.05	1.89	3.15
	Carpineto-Fagetum	59	2.32^{b}	0.24	0.03	1.63	2.74
	Rusco-Fagetum	37	1.96^{a}	0.44	0.07	0.94	2.74
Simpson	Fagetum Orientalis	21	0.70^{a}	0.14	0.03	0.32	0.89
	Querco-Carpinetum	30	0.84^{b}	0.07	0.01	0.67	0.94
	Carpineto-Fagetum	59	0.84^{b}	0.06	0.01	0.57	0.91
	Rusco-Fagetum	37	0.74^{a}	0.13	0.02	0.37	0.91

* (a,b) Means followed by a different superscript (a, b) are significantly different at the 0.05 level.

According to Table 1, the highest level of all diversity indices belonged to Querceto-Carpinetum and the least level could be found in Fagetum oriental. Diversity indices of Carpineto-Fagetum were close to those of Querceto-Carpinetum while all Rusco-Fagetum indices were as less as Fagetum Orientalis communities.The mean differences between (Carpineto-Fagetum, Querco-Carpinetum) and (Fagetum Oriental, Rusco-Fagetum) were significant in all diversity indices at the 0.05 level but there were no significant differences in the different indices between themselves.

The results illustrated that Querceto-Carpinetum betulii, Carpineto-Fagetum communities were significantly more diverse than Rusco-Fagetum and Fagetum Orientalis communities. Therefore, it is concluded that the plant diversity in mixed forest communities would be more than that of pure ones.

References

Ardakani, M.R, 2004. Ecology, Tehran University Press,340pp
Barnes, B.V., 1998. Forest ecology, John Wiley and Sons, INC., 773 pp.
Hauk, E., 2005.Austrian Forest Inventory.Waldwissen.net
Mueller-Dombois, D., 1974. Aims and methods of vegetation ecology, John Wiley, New York, 547 pp.
Sagheb-Talebi, K. 2004. Forests of Iran, Research Institute of Forests and Rangelands.

A SURVEY ON CHANGES OF GROWING STOCK OF BEECH (*FAGUS ORIENTALIS*) NATURAL FOREST STAND AT ASALEM IN GUILAN PROVINCE

Iraj Hassanzad Navroodi*[1], Manochehr Namiranian[2], Mohammadreza M. Mohajer[3]

[1]Faculty of Natural Resources, Guilan University, P.O.Box 1144, Someasara, Iran
Tel: (0182)3223023 - Fax: (0182) 3222102 - E-mail: lrzad2002@yahoo.com
[2] Faculty of Natural Resources, Tehran University, Iran
[3] Faculty of Natural Resources, Tehran University, Iran

Introduction

Stock volume of tree species in different sites is subjected to change. The level of changes depends on sites factors. Knowing the level of changes in different sites are very important to plan forest management and any other forestry plans (Asli & Etter, 1963). Knuchel(1950) divided the Swiserland beech forest sites into three groups of bad, medium and good sites. The combination of tree species in this area is different from the northren Iran. Growing stock in Switzerland beech forest sites was 500 sylve/ha in good sites, 350 and 250 sylve/ha in medium and bad sites respectively. Considering the changes of the stock volume in various sites, it is necessary to study the stock volume in different conditions and sites.

The objective of the present study is determination of ideal growing stock of beech (*Fagus orientalis*) in different sites. It seems that growing stock in natural forest stand does not vary significantly from ideal growing stock. In this study the untouched or slightly exploited natural forests were considered. The study area is Asalem which is situated in west of the Guilan province. In this area 10 sites were selected and studied.

Material and Method

The study area was beech (*Fagus orientalis*) natural forest stand at Asalem in the Guilan province, northren Iran. These sites were situated in 700-1700 meters above sea level. The mean annual rainfall and temprature in the Piceason climatology station (situated at 1244 meter above sea level) are 1286.5 mm and 8.5 $°_C$ (Sheikholeslami, 1998). On the base of Ambreget formula(Q2), climate of northren Iran at beech forest stand is very cold and wet. The mean temperature in the coldest month of the year is 8.1 $°_C$ and hotest month is 21 $°_C$ with very rainy summer. The climate of the studied area is Eurasiatique type (Assadollahi, 1987). Soil of the Asalem area are lying on the alkaline & acidic Igneous bedrock(Habibi kaseb, 1984.). The pH of these soils are 4.5 through 5.5 and sometimes accedes to 6. The textures of the soils are sandy-loam, silty-loam, clay-loam and sandy-clay-loam. These soil types are well drained. The forest stands in the studied sites include: pure fagus type(over 90% of fagus and other species including *Carpinus betulus, Acer velutinum, Acer cappadocicum & Sorbus torminalis*) and mixed fagus type including about 75% fagus together with *Carpinus betulus, Acer velutinum, Acer cappadocicum, Alnus sp., Tilia begonifolia, Ceracus avium, Fraxinus excelsior & Sorbus torminalis* (Hassanzad Navroodi, 2000).

In this study the untoched or slightly exploited natural forests of the Asalem area were surveyed. The method of study was selective sampling(Zobeiry, 1994). In this area 10 sites and 3 plots in each site with area of one hectare(Korpel, 1982) located at different conditions were selected and the following parameters were studied: tree species, diameter at breast height(DBH), trees height and stem quality analysis. The altitude from sea level, slop in percent and aspect were also determined.

Local Tarif Table of Chooka are used to calculate growing stock per hectare. In order to study the growing stock changes, stock volume per hectare were calculated for all species in each site separately. Stock volume per hectare in each site were also evaluated on the base of volume distribution at three diameter classes that are 15-30, 35-50 & >50 cm (Prodan, 1965). The sites with growing stock less than 300 sylve/ha, 300-400 sylve/ha, 400-500 sylve/ha & over 500 sylve/ha, were defined as poor, medium, good & very good growing stock, respectively. Significant differences between mean growing stock in studied sites were evaluated by ANOVA and multiple rang test.

Results and Discussion

Studies show that forest stands in this area are uneven aged high forest. Minimum altitude was 700 meter and maximum altitude was 1700 meter above sea level. In these sites, slop was 30-70% and aspect were western, north-western, northern, north-eastern and eastern. Soil depth was low through very deep. The mean number of trees, basal area and stock volume were 369 per ha, 37.7 m^2/ha and 479 sylve/ha respectively. Minimum stock volume was 302 and maximum stock volume was 607.5 sylve per hectare. In order to display the growing stock statement, stock volume distribution per hectare in this area are shown in table 1 and stock volume mean in table 2. As shown in these tables, sites with high growing stock over 50% volume are concerned as high diameter classes. Similar pattern were observed in Switzerland sites (Knuchel,1950). This shows that trees in productive sites have higher increment and reached higher sizes, but in poor sites, increment of trees were very low and trees did not reach higher diameter and height(Asli & Etter, 1963). However, differences of growing stock between poor and productive sites were very significant. Results of ANOVA and multiple rang test showed a significant difference between mean stock volume of 10 studied sites and those having north direction proved to be a very good growing stock (>500 sylve/ha). The sites with western, eastern and north-eastern aspect had a good growing stock (400-500 sylve/ha) and the north-eastern aspect had a moderate growing stock(300-400 sylve/ha). Soil depth exerted great impact on the growing stock. The influence of altitude from sea level had a significant influence on the growing stock in this area.

Table 1: Distribution of growing stock per hectare at different diameter breast height classes in studied sites

No.	Diameter classes(cm)			Total
Sites	Class 10 – 30 (sylve/ha)	Class 35 – 50 (sylve/ha)	Class > 50 (sylve/ha)	sylve/ha
1	45.6(10%)	100.6(22.1%)	308.3(67.9%)	**454.5**
2	99.4(25.2%)	192.9(49%)	101.7(25.8%)	**394**
3	32.8(5.9%)	75.3(13.5%)	448.4(80.6%)	**556.5**
4	35.2(6.6%)	61.5(11.5%)	438(81.9%)	**534.7**
5	73.5(16%)	107.9(23.4%)	279.1(60.6%)	**460.5**
6	54.8(12.1%)	80.1(17.8%)	316.1(70.1%)	**451**
7	74.3(24.6%)	118.7(39.3%)	109(36.1%)	**302**
8	67.7(15.5%)	123.3(28.1%)	247.4(56.4%)	**438.4**
9	33.9(5.6%)	108.3(17.8%)	465.3(76.6%)	**607.5**
10	20.3(3.4%)	50.5(8.6%)	520.1(88%)	**590.9**
Mean	**53.8(11.2%)**	**101.9(21.3%)**	**323.3(67.5%)**	**479**

Table 2: Mean of growing stock of species per hectare in studied sites

Fagus orientalis	Carpinus betulus	Acer velutinum	Acer capadocicum	Alnus sp.	Tilia begonifolia	Ulmus glabra	Cerasus avium	Fraxinus excelsior	Sorbus torminalis	**Total**
394.8 (82.4%)	25.68 (5.4%)	27.34 (5.7%)	7.16 (1.5%)	12.06 (2.5%)	6.87 (1.4%)	1.54 (0.3%)	0.962 (0.2%)	1.72 (0.4%)	1.04 (0.22%)	**479 (100%)**

References

Asadollahi, F. 1987. Geographical study of plant communities of the north-west forests of Hircanian (Asalem) and its use in natural resources, Journal of forest and rang management, 2nd year, vol 5 : 4-7.

Asli, A., Etter, H. 1963. Forest management plan of educational forest of the Faculty of Forestry(Noshahr), Tehran University, No. 16: 1-74.

Asli, A., Etter, H. 1963. Measurement of forest increment., Faculty of Forestry Publicatrion, Tehran University, No. 13: 1-74.

Habibi kaseb, H. 1984. Study on soil in beech forest stands of northren Iran and its role in extention of various types of beech forest stands., Iranian Journal of Natural Resources, Tehran University, No. 38: 1-15.

Hassanzad Navroodi, I. 2000. A survey on quantity and quality of growing stock changes of natural forest stand of Asalem beech., PhD thesis, Natural Resources of Tehran Universiey: 227 .

Knuchel, H. 1950. Planung und kontrolle im forestbetrieb. Verlag H. R. sauerlaender & Co. Aarau.

Korpel, S. 1982. Degree of equilibrium and dynamical changes of the forest on example of natural forests of Slovakia.: 23.

Prodan, M. 1965. Holzmesslehre, Frankfort/M. : 644.

Sheikholeslami, H. 1998. Study of the effects of changes in elevation, slope and vegetation cover in soil transformation of the Asalem region., MSc thesis, Faculty of Agriculture, Tehran University: 175.

Zobeiry, M. 1994. Forest Inventory, Tehran University Publicatrion, No. 2238, ISBN 964-03-3506-1: 401.

PATTERNS AND PROCESSES OF NATURAL REGENERATION IN UNMANAGED FORESTS

Peter Meyer *[1]

[1]Nordwestdeutsche Forstliche Versuchsanstalt, Göttingen, Germany
Tel: + 551/69401-180 - Fax: + 551/69401-160 - E-mail: Peter.Meyer@nw-fva.de

Introduction

Roughly two main types of unmanaged forest can be distinguished in Europe: so called primeval or virgin forests which have (almost) never been managed and strict forest reserves (SFR), which are left to develop freely - in most cases after intensive human impact. In the nemoral zone of Europe true virgin forests amount to less than 0,1 % of the forested area (Bücking et al. 2000). Research in these remnants of Europe's original forests has increased in the last decades resulting in several compilations of the existing knowledge (e. g. Faliński 1986, Korpel 1995, Peterken 1996, Vrška et al. 2002).

In contrast to primeval forests dynamics in SFRs are still governed by past management for a considerable time span (Meyer 2005). Therefore they can not be regarded as an "instant" substitute for missing virgin forests. Nevertheless they can show how nature works in absence of direct human impact.

In order to reduce input near to nature forestry aims at integrating natural processes into management concepts. Thus, the scientific interest in unmanaged forests is closely linked to its application in forest management.

Regenerating forests is one of the most cost-intensive measures in forestry. Therefore monitoring and analyzing patterns and processes of regeneration in unmanaged forests is of major interest for forestry research.

The presented paper deals with regeneration in unmanaged beech (*Fagus sylvatica* L.) forests in Europe. On the basis of results from SFRs in Lower Saxony, Germany and Albanian virgin beech forests the following hypothesis are addressed:

Typically, regeneration of unmanaged beech forests

1. is restricted to canopy gaps
2. is impeded significantly by several negative factors, e. g. disadvantageous soil conditions, competition of herbs and/or grasses or browsing
3. shows a broad-scaled spatial pattern.

Conclusions for forest management are drawn.

Materials and Methods

In order to analyze regeneration two indicators are applied. The sum of shoot lengths (= SSL; m m^{-2}) serves as indicator of regeneration biomass production. The probability of regeneration above 2 m height at a certain plot (= PADR) serves as indicator of regeneration success.

SSL was applied in a comparative analysis of regeneration in two beech SFRs and Albanian beech virgin forests. The SFRs represent oligotrophic beech forests situated in the Solling mountains, Lower Saxony, Germany. They were set aside from management in 1972. Both SFRs are covered with almost pure beech stands. Underneath the even-aged overstory (age: 155 and 167 years) regeneration has developed after gap-formation caused by windfalls and stem breakages. On two monitoring plots in each SFR (sized 1.0 and 1.5 ha) dbh and tree positions of the stand ≥ 7 cm diameter were measured on three successive occasions from 1972 to 1999. Regeneration (trees < 7cm dbh, without seedlings < 1 year) was recorded per height-class on systematically distributed subplots at the last inventory.

For the Albanian virgin forests data on sample areas of 3.6 to 5.0 ha with a full survey of dbh and positions of trees ≥ 7 cm dbh carried out in 1997 are available (s. Tabaku 1999).

Regeneration (trees < 7cm dbh, without seedlings < 1 year) was sampled on a systematic grid network. The Albanian sample areas represent mesotrophic beech forests. They are assumed to be roughly comparable to Mid-European beech forests (Tabaku & Meyer 1999).

PADR was applied in 9 SFRs in Lower Saxony and the Albanian virgin forests. The true probability of regeneration > 2 m height in three basal area classes (low, medium and high basal area) was compared to the expected probability in case of a random distribution.

Additionally a literature review was conducted in order to address the hypothesis in a generalized way.

Results and discussion

If regeneration is confined to gaps there should be a pronounced decrease of SSL with increasing basal area of the living stand. Thus basal area per ha was computed in circles with a radius of 10 m surrounding the regeneration sample plots. Subsequently values derived were classed into 4 ranks and the mean values of the 4 groups were related to mean SSL (Fig. 1).

Whereas the range of SSL is comparable between SFRs and Albanian virgin forests, the relationship to overstory density differs considerably. Mean SSL shows a distinct decrease with increasing basal area in the SFRs. In the virgin forests either no clear relationship is detectable (Munella) or an optimum at fairly high densities is followed by a decreasing phase. Even at very high densities > 60 m^2 ha^{-1} high levels of SSL are maintained in the virgin forest.

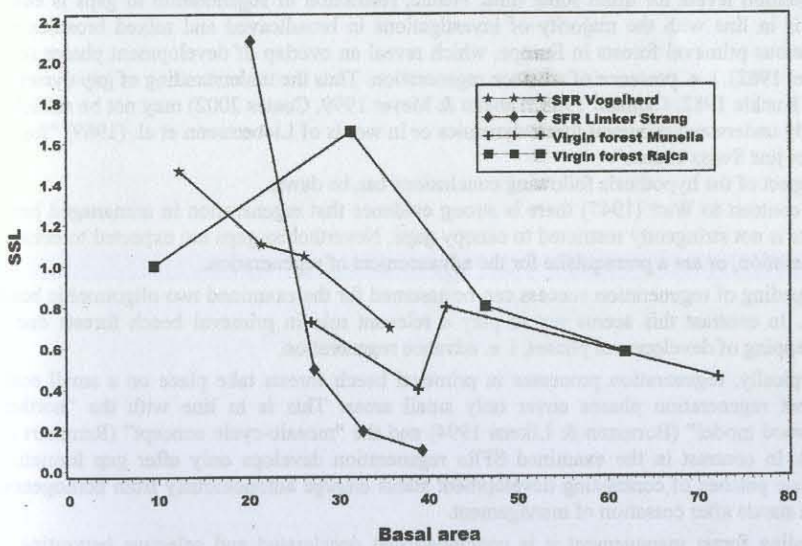


Figure 1: Mean sum of shoot lengths (SSL; m m^{-2}) in relation to small scale basal area (m^2 ha^{-1}) in strict forest reserves (SFR) of Lower Saxony and Albanian beech virgin forests.

In the virgin forests regeneration (without seedlings < 1 year, mainly beech s. Tabaku 1999) was found at each sample point. Regeneration > 2 m height was recorded with a frequency of 67 % (Munella) to 79 % (Rajca). Hence, advance regeneration seems to be a typical feature of the examined beech virgin forests.

At much lower levels of basal area in the examined SFRs frequency of regeneration was found to be 61 % to 89 % and of regeneration > 2 m height 20 % to 59 %. Regeneration developed after a wind storm in 1972 and was favored by ongoing disturbances thereafter (Meyer 2005). Maximum age indicates a lack phase of 5-10 years until regeneration started to develop (age determined by traces of bud scares).

30 years of free development of SFRs have led to regeneration processes clearly restricted to gaps. The probability of regeneration > 1,5 m height in gaps was recorded in the SFR "Limker Strang" in 2004. The investigation of 60 canopy gaps revealed a probability of 77 %.

Applying the indicator PADR to 9 SFRs in Lower Saxony yields results comparable with SSL. Regeneration success is significantly higher where stand density is low (Chi Square test statistic; results not shown here). However, this applies only to beech basal area. Admixed species like oak (*Quercus petraea* Matt., *Quercus robur* L.), maple (*Acer pseudoplatanus* L., *Acer platanoides* L.) or ash (*Fraxinus excelsior* L.) enhance regeneration success. In the Albanian virgin forests PADR shows a non-significant decrease with increasing basal area.

There is no doubt that basic ecological principles apply equally to all kinds of ecosystems, including primeval forests. Therefore regeneration should generally be affected by competition of overstory trees (e. g. Angestam et al. 2003).

In virgin forests this relationship may be masked by maturity- and age-effects. On the one hand competitive strength of overstory trees decreases with age. On the other hand a full development cycle with many seed years offers numerous opportunities for regeneration, especially in small-scaled textures with edge-effects between development phases. Furthermore regeneration of shade-tolerant beech can stand low radiation and high competition levels for quite some time. Hence, restriction of regeneration to gaps is eased. This is in line with the majority of investigations in broadleaved and mixed broadleaved-coniferous primeval forests in Europe, which reveal an overlap of development phases (e. g. Korpel 1982), i. e. presence of advance regeneration. Thus the understanding of gap dynamics (e. g. Runkle 1982, Canham 1988, Tabaku & Meyer 1999, Coates 2002) may not be sufficient to fully understand primeval forest dynamics or in words of Liebermann et al. (1989) "forests are not just Swiss cheese".

In respect of the hypothesis following conclusions can be dawn:

1. In contrast to Watt (1947) there is strong evidence that regeneration in unmanaged beech forests is not stringently restricted to canopy gaps. Nevertheless gaps are expected to enhance regeneration, or are a prerequisite for the advancement of regeneration.

2. Impeding of regeneration success can be assumed for the examined two oligotrophic beech SFRs. In contrast this seems not to play a relevant role in primeval beech forests due to overlapping of development phases, i. e. advance regeneration.

3. Typically, regeneration processes in primeval beech forests take place on a small scale. Distinct regeneration phases cover only small areas. This is in line with the "northern hardwood model" (Bormann & Likens 1994) and the "mosaic-cycle concept" (Remmert ed. 1991). In contrast in the examined SFRs regeneration develops only after gap formation. Separate patches of contrasting development status emerge autonomously from homogenous beech stands after cessation of management.

Regarding forest management it is concluded that decelerated and selective harvesting of canopy trees over as long periods of time as possible provides the highest probability for successful natural regeneration.

References

Angestam, E. et al. 2003. For. Ecol. Management, 176, 61-73.
Bormann, F. H. & Likens, G. E. 1994. Springer Verlag.
Bücking, W. et al. 2000. *in* European Commission, 39-133.
Canham, C. D. 1988. Ecology, 69, 786-795.
Coates, K. D. 2002. For. Ecol. Management, 155, 387-398.

Faliński, J. B. 1986. Geobotany, 8.
Korpel, Š. 1982. Acta facultatis forestalis, 24, 9-31.
Korpel, Š. 1995. Gustav Fischer Verlag.
Liebermann, M. et al. 1989. Ecology, 70, 550-552.
Meyer, P. 2005. For. Snow Landsc. Res, 79, 33-44.
Peterken, G. F. 1996. Cambridge University Press.
Remmert, H. (ed.) 1991. Ecol. Studies, 85.
Runkle, J. R. 1982. Ecology, 63, 1533-1546.
Tabaku, V. 1999. Ph. D. thesis, University of Göttingen, Germany.
Tabaku, V. & Meyer, P. 1999. Forstarchiv, 70, 87-97.
Vrška, T. et al. 2002. Academia.
Watt, A. S. 1947. J. Ecol., 35, 1-22.

THE EFFECT OF STAND DENSITY AND SOIL PREPARATION ON SEEDLING EMERGENCE AND EARLY GROWTH OF NATURAL REGENERATION OF BEECH

Witold Kopryk, Wojciech Gil*
Forest Research Institute, Silviculture Department,
Bitwy Warszawskiej 1920 r. 3, 00-973 Warsaw, Poland
*Phone: +48 22 822 32 012 ext. 162, email: gilw@ibles.waw.pl

Introduction

European beech (*Fagus silvatica* L.) is one of the most important forest-forming species in Poland. It covers over 4% of total forest area, building valuable stands, particularly in the north, and in the mountain areas in the south of the country (Leśnictwo 2004).

The main factors determining the silvicultural quality of beech regeneration include: stand preparation for seed production and seeding, proper soil conditions allowing initiation of self-seeding and its development, light felling and, in the older age, improvement felling.

In the years 1976-1995, the Silviculture Department of the IBL carried out research aimed at the improvement of the adequate silvicultural methods to create optimum conditions for fruit bearing, seeding and germination, as well as growth and development of natural regeneration of beech stands.

The research included:

- determination of the impact of stand density on seed crop and on the emergence and growth of beech seedlings in the first years of life
- impact of soil preparation on the emergence and growth of natural regeneration

Material and methods

The research started in the year 1976. Four pure beech stands were selected, growing in similar habitat conditions (fresh forest) but differing in density (Table 1). The age of stands ranged from 95 to 130 years, and the experimental sites measured 0,75 hectare. Every site was divided into three 0.25 ha plots.

Table 1. Characteristics of experimental sites

Site No.	Trees per ha	Age	Density
1. (Gryfino)	304	123	1.08
2. (Gryfice)	136	120	0.80
3. (Sławno)	95	130	0.72
4. (Golub Dobrzyń)	234	95	0.95

Tree location was determined on all plots. Every tree was measured for DBH, total height and length of crown and crown horizontal projection in eight directions, on the basis of which crown projection area was calculated. The insolated area of the crown was calculated according to the formula proposed by Assman (1968).

Soil was prepared prior to seeding, using the following tools:

1. LPz-75 Double-Furrow Plough
2. PTL-2 Disc Plough
3. PR-W Spreading Plough
4. Part of every experimental site was left with soil unprepared, as control.

The main plots were divided into 10m-wide strips on which, randomly selected, individual tools were applied.

Seed crop evaluation was carried out in every stand on the basis of 15 model trees selected from 3 plots. Seeds were collected from three ($3m^2$) points under every tree and subjected to health and germination capacity evaluation.

The inventory of young natural regeneration was carried out in summer 1977 at measurement stations ($1m^2$ in size) in the number of 25 per plot. For the next 5 years, measurements were taken every year. They included: determination of the quantities and measurement of the height of self-seedlings. Data were collected for every soil preparation method to determine its impact on the growth and development of self-seedlings. The ($p=0.05$) variance analysis was used to analyze the measurement results.

Results

The research showed that the crown formation parameters had a positive effect on seed crop which oscillated between 1,475 kg of seeds per ha on Site No.3 with the lowest stand density and 709 kg/ha on Site No.4.

Soil preparation with tools prior to seeding produces several-hold regeneration effects in terms of seed germination and young natural regeneration, and assures competitive advantage for them over herbaceous plants in the first years of growth. The best regeneration results are obtained on the soil being ploughed and harrowed.

The research also showed the negative impact of stand density on the survival and growth of beech seedlings in the first five years of life.

The research results were the basis for formulating the principles of natural regeneration of beech in Poland.

Assmann E. 1968: Nauka o produkcyjności lasu [Forest Growth and Yield]. PWRiL, Warszawa, 1-628.
Leśnictwo 2004 [Forestry 2004]: Główny Urząd Statystyczny. Warszawa, 1-324.

NATURAL REGENERATION OF BEECH (*Fagus silvatica*, L.) IN THE VIRGIN FOREST LOM IN THE WEST PART OF THE REPUBLIC OF SRPSKA

Zoran Govedar[1] and Milun Krstic[2]

[1] Forestry Faculty of Banjaluka University, Banjaluka, Bosnia and Hecegovina
[2] Forestry Faculty of Belgrade University, Belgrade, Serbia and Montenegro

Introduction

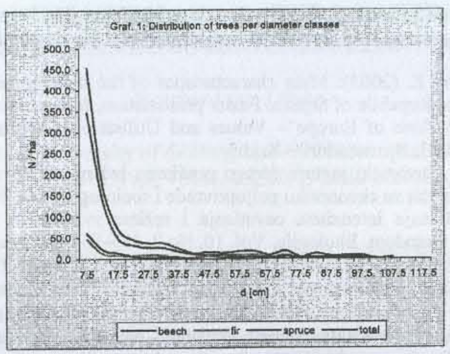
Virgin forest Lom (297.80 ha) is located in western part of Republic of Srpska. Beside well known virgin forest Perucica (1388 ha), and virgin forest Janj (295.00 ha), it is one of rear untouched natural forests in Republic of Srpska. Abundant of species and preservation of stands in virgin forest Lom are significant basis for research of natural regeneration of Beach tree (*Fagus silvatica)* in mixed stands of Beach, Fir, and Spruce.

Materials and Methods

Virgin forest is located at 44°27′ - 44°28′N, and 16°27′ - 16°30′ E, on mountain Klekovaca, and its ridge Lom. According to Thornthwait – Matter (1955) hydro bilans in researched area dominant climate is per humid – A (Ik = 287), and in vegetation period moderate – humid climate – B2 (Ik = 105.22). Average annual air temperature is 4.7°C, and in vegetation period 9.6°C. Annual participation is 1597 mm, and in vegetation period 746 mm. Data collection has been done on permanent research plot (P = 1.0 ha). Research plot is located on flat terrain, 1320 m above the se level. Geology in researched stand is tear limestone, and shallow soils are dominant (kalkomelanosol, kalkokambisol) and combinations – mosaics with other soil series. Stand belong association group *Vaccinio – Piceion* Br. / Br.- Bl. (1938) 1939 and association *Piceo – Abieti – Fagetum* (Treg.1941) Čolić 1965. Emend. Gajić et al.
Research plot is based on centre virgin forest in stand prest and woodland. On researsh plot one all trees measured diameter (taxation limits 5.0 cm) and thain higst. In all researsh plot that one taken two researsh plots (20x20 m). One is taken in density crown (0.8 and 0.9). On sistematicaly based on elementary plots 1 m^2 wich one based characterise of yaung growth (species trees, hight, number of trees). Analise site quality (Drinić, et al., 1980) and hight which one caustmited used Prodans function. Regime light is fortify stacionary izohel systems analysis(Kolić, 1975). Treatment influence regime light and characteristic seedlings assessed is analysis varijanse 3x2x3 - factorial experiment (Hadživuković, 1991).

Results and Discussion

Total number of trees in stand is 996/ha (live trees 965/ha, and dead trees 31/ha). By the number of trees, Beach is dominant with 69.0 %. In lower dbh classes (up to 30 cm), Beach tree is 60.0 % of total number. This domination has been caused by socialization (Mlinšek, 1968) of Beach tree in stand down floor. This phenomena could not be understand as final process (Šafar, 1953, 1955; Fukarek, 1965), but as natural process of species succession in stand natural regeneration. Distribution line of tree number per dbh classes is very similar to distribution line characteristically for uneven age stands. It is possible to make conclusion that stand is in optimal faze, uneven age faze. The highest frequency of tree number is in high class of 7,5 m, where Beach is dominant, but is also obvious one secondary maximum in high class of 28,5 m. In first five high classes contains 74 % of trees. That shows process of Beech tree growth in stand down floor.



Tariffs for Beach are II/III, while for Fir and Spruce is I/II (Matić, et al., 1980). Total volume in OP1 stand is 1216.0 m3/ha, from which volume of dead tress is 113.2 m3/ha (the most dead tree is Fir, about 50%) or 9.3% from total volume. Mix volume species ratio Fir : Spruce : Beach tree = 42 % : 29% : 29%. Stand annual yield (live trees) is 10,12 m3/ha and yield ratio among species Fir : Spruce : Beach tree = 37.8% : 20.5% : 41.7%. Percentage of volume growth is very low with value of 0.92%.
Stand has 674 juvenal plants of Fir, Spruce, and Beach tree which height is over 130 cm, and dbh under inventory minimum (5.0 cm). Mix of species juvenal plants Fir : Spruce : Beach = 18.1% : 13.8% : 68.1%. In this juvenal plants category Beach is most frequent in Height class 4.3 – 5.3 m (109/ha or 23.75%), and its quality is generally bad (54.0%), while with excellent quality only 14.2% and good quality 31.8%. Juvenal plants are spread in small groups or individually.
Light regime, that has been measured by stationary isohels method (Kolić, 1975), shows that light intensity in high crown density (0.9 – 1.0) is 895 Lx/m2, and permeability coefficient is Kp = 2.7%. In condition of total crown closure (0.8) light intensity is 1500 Lx/m2, and permeability coefficient Kp = 3.8%. The highest frequency of juvenile Beach tree is an area where is light intensity between 1000 and 2000 Lx, and light permeability, compare to open space between 3% and 4%.
Based on the result of analyses of variance, it has been concluded that is statistically significant impact of both studied factors on size of Somer Beach tree hight growth on level of significance 0.05. Impact of light permeability on size of Somer Beach tree hight growth in dens and closed crown canopy has mostly linear effect.

References

Diaci, J., Rozenbergar, D., Boncina, A. (2005): Interaction of light and regeneration in Slovenian Dinaric Alps: Patterns in virgin and managed forests. International Conference »Natural Forests in the Temperate Zone of Europe – Values and Utilisation«, Mukachevo, Transcarpathia, Ukraine, october 13-17; 2003, Birmensdorf – Rakhiv
Drinić, P. (1956): Taksacioni elementi sastojina jele, smrče i bukve prašumskog tipa u Bosni. Zavod za uređivanje šuma Poljoprivredno – šumarskog fakulteta, Sarajevo
Drinić, P. (1957): Taksacioni elementi bukovih sastojina prašumskog tipa u Donjoj Drinjači . Radovi Poljoprivredno – šumarskog fakulteta, god. II, br. 2, Sarajevo
Drinić, P., Matić, V., Vukmirović, V., Stojanović, O., Pavlič, J., Prolić, N. (1980): Tablice taksacionih elemenata visokih i izdanačkih šuma u BiH. Šumarski fakultet, Sarajevo
Fukarek, P. (1965): Prašuma Perućica nekad i danas. Posebni otisak – separatum, Narodni šumar, časopis za šumarstvo i drvnu industriju, god. XIX, sv. 1-2, Sarajevo
Govedar, Z. (2002): Elementi strukture i prirodno podmlađivanje mješovite sastojine bukve, jele i smrče u prašumi Janj. Šumarstvo, br. 4-6, LV, Beograd

Govedar, Z. (2005): Načini prirodnog obnavljanja mešovitih šuma jele i smrče (*Abieti – Piceetum illyricum*) na području zapadnog dela Republike Srpske. Disertacija, Šumarski fakultet u Beogradu, Beograd
Govedar, Z., Stanivuković, Z. (2003): Main characteristics of the development stages of the virgin forests Janj and Lom in the Republic of Srpska. Poster presentation, International Conference »Natural Forests in the Temperate Zone of Europe – Values and Utilisation«, Mukachevo, Transcarpathia, Ukraine, october 13-17; 2003, Birmensdorf – Rakhiv
Hadživuković, S. (1991): Statistički metodi (drugo prošireno izdanje). Univerzitet u Novom Sadu, Poljoprivredni fakultet, Institut za ekonomiku poljoprivrede i sociologiju sela, Novi Sad
Kolić, B. (1975): Određivanje intenziteta osvetlenja i režima svetlosti u šumskim zajednicama stacionarnom izohelskom metodom. Ekologija, Vol. 10, No 2, 155-164, Beograd
Leibundgut, H. (1982): Europäischer Urwälder der Bergstrufe. Bern Stuttgart, Haupt.
Leibundgut, H. (1986): Ziele und Wege der naturnahen Waldwirtschaft. Schweiz. Z. Forstwes. 137: 245-250
Leibundgut, H. (1989): Naturnahe Waldwirtschaft. Wilhelm – Münker – Striftung, 23 Siegen.
Manuševa, L., Fukarek, P., Panov, A. (1967): Proučavanje sastojina prašumskog tipa. Institut za šumarstvo u Sarajevu, Sarajevo
Mlinšek, D. (1968): Slobodna tehnika gajenja šuma na osnovu njege. Jugoslovenski poljoprivredno šumarski centar, služba šumarskje proizvodnje
Mlinšek, D., Zupančič, M. (1974): Enoletna rast vršnih mladik v bukovi gošči jelovo – bukovega pragozda. Zbornik gozdarstva i lesarstva, L. 12, št. 1, s. 67-86, Ljubljana
Prpić, B., Matić, S., Vukelić, J., Seletković, Z. (2001): Bukovo – jelove prašume hrvatskih dinarida. Monografija, Obična jela u Hrvatskoj, Akademija šumarskih znanosti, Zagreb
Schütz, J.P. (1999): Close-to-nature silviculture: is this concept compatible with species diversity? Forestry 1999 72(4):359-366; doi:10.1093/forestry/72.4.359 © 1999
Stojanović, Lj., Krstić, M., Bobinac, M. (1999): Stanje i razvoj prašume „Felješana". Zaštita prirode br.51, str.155-164, Beograd
Šafar, J. (1953): Proces pomlađivanja jele i bukve u hrvatskim prašumama. Institut za šumarska istraživanja NRH, sv. 16, Zagreb
Šafar, J. (1955): Problem nadiranja i širenja bukve u arealu jele. Poseban otisak iz knjige »Anali Instituta za eksperimentalno šumarstvoJugoslavenske akademije«, Vol. I, Zagreb
Thornthwaite, C.W., Mather, J.R. (1955): The Water Balance. Centerton, N.J. Publ. In Climatology, v.8, n.1, 104p
Tregubov (1941): Le fôret viegres montagnardes des Alpes Dinariques, Massive de Klekovatcha et Grmetch, Montpellier

NATURAL REGENERATION AND NATURE-BASED SILVICULTURE - DOES THE SPONTANEOUS REGENERATION WORK WELL?

Burghard von Lüpke

Institute for Silviculture, University of Göttingen, 37077 Göttingen, Büsgenweg 1, Germany
Phone: +551-393672, Fax: +551-393270, E-mail: bluepke@gwdg.de

Introduction

The title contains three terms which need definitions. I propose the following:

- Natural regeneration: it mimics regeneration in unmanaged, primeval forests with some important differences. Time of regeneration and ecological conditions, particularly light intensity and seedbed features, are controlled by the forester in order to achieve certain management goals. As an example, the forester will synchronize tree harvest and mast bearing whereas naturally a tree dies and gives space for regeneration without caring for seed production. Or a forester will use soil preparation, vegetation control and fertilization to improve conditions for germination and growth of tree seedlings.
- Spontaneous regeneration: after some human impact like cutting and timber harvest, regeneration follows spontaneously without any technical support like seeding, soil preparation or vegetation control. Contrary to natural regeneration, spontaneous regeneration is not planned. Particularly there is no temporal harmonization of seed production and cutting.
- Nature-based silviculture: this concept is the core of the main certification rules and widely accepted in germany, especially by public forest owners. The following characterization is based on certification requirements of the German PEFC group (Programme for the Endorsement of Forest Certification Schemes, PEFC 2006). From a silvicultural point of view, the following aspects are important: in principle forest owners have to refrain from clearcutting. Small-scale cutting types have to be preferred; particularly single-tree selection, target diameter cutting and group selection are regarded as ideally suitable. Thereby, regeneration is bound to small areas and more or less uneven-aged, which are important prerequisites for an essential goal, namely the structural enrichment of the forest. Another essential goal is the promotion and maintenance of mixed-species forests. By these means, forest stability shall be improved substantially.

In practise, target diameter cutting is by far the most widespread cutting type in germany to achieve the above mentioned goals. As far as we know from recent investigations in slovakian and albanian old growth beech forests (Tabaku and Meyer 1999, Tabaku 2000, Meyer et al. 2003, Drößler and Lüpke 2005), it emulates well the disturbance regime and regeneration conditions in primeval beech forests. As an example, drößler and lüpke found in two slovakian beech forest reserves that more than 85 % of all gaps were smaller than 250 m^2, and most of them were created by death of single overstorey trees. Despite the very shady conditions on the forest floor (mean diffuse site factors of 2.5 and 9.4 respectively), beech regeneration could be found all over, but grew substantially in height only in gaps. Mixed-species were scarce because of higher light demands.

Materials and Methods

The data source for this compilation is based on different studies carried out at the institute for silviculture of the University of Göttingen. Besides the above cited work of Tabaku (2000) and Drößler and Lüpke (2005) on the structure and dynamic of Albanian and Slovakian primeval beech forests, partly compared with managed forests (e.g. Single tree selection forest, Tabaku 2000), they comprise unpublished analyses of regeneration development under target diameter cutting regimes in beech stands near göttingen on acid and limestone soils.

Results and Discussion

Three examples of spontaneous regeneration in managed forests illustrate the widespread practical experience that small-scale cutting types like target diameter cutting produce satisfactorily dense beech regeneration.

1. Natural regeneration following target diameter cutting: Tab.1 contains a typical example of a 145 years old beech stand near Göttingen. The light intensity above the regeneration layer after the second target diameter entry is given in Tab. 2.

Table 1: Density and species composition of natural regeneration, triggered by target diameter cutting 7 years ago, in a 145 years old beech stand on acid soil.

Species	Mean density ($n\ ha^{-1}$)	Coefficient of variation (%)	Minimum - Maximum ($n\ ha^{-1}$)	Proportion of species (%)
Beech seedlings	28,040	121.6	0 - 305,730	87.1
Non-beech seedlings	4,170			12.9
Sum	32,210			100.0

Note: Mean height of beech seedlings: 105 cm. Non-beech seedlings: 9 species, mainly *Salix caprea* and *Acer pseudoplatanus*. Statistic parameters refer to 120 sample plots of 3.14 m^2.

A density of 28,000 seedlings can be regarded as sufficient given the mean seedling height of 105 cm. The proportion of mixed-species clearly is not acceptable, particularly because they are on the average smaller than the competing beeches and will be exterminated with increasing height growth. The reason is the not sufficient light supply (Tab. 2).

Table 2: Light intensity above the regeneration layer of tab. 1, after the second entry of target diameter cutting.

Parameter	PAR (% of above canopy PAR)
Mean	15.1
Minimum	1.6
Maximum	31.7
Coefficient of variation (%)	50.6

2. Natural regeneration underneath a beech single tree selection forest on a limestone soil in northern Thuringia ("Bleicherode"): the stand originated 150 years ago from coppice with standards and is uneven-aged. More than any other type of forest, a single tree selection forest relies on spontaneous regeneration. Regeneration has to proceed permanently everywhere in the stand, thus making any of the above mentioned silvicultural measures impossible. Fig. 1 shows the seedling density and the species composition. As in the foregoing example, seedling density and spatially distribution are fully sufficient, but with increasing height the proportion of mixed species like maple and ash is approaching zero. Light intensity on the forest floor reached on the average only 7.2 % of above canopy light, but heterogeneity was higher than in the first example (Tab. 2), indicated by a range of 0.1 to 41.7 % and a coefficient of variation of 104 %.

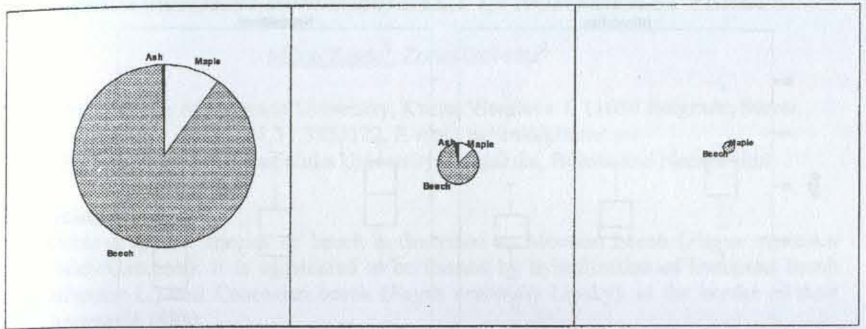


Figure 1: Density and species composition of regeneration in beech single tree selection forest "Bleicherode". From left to right: height < 0.2 m, $n\ ha^{-1}$ = 101,700; height 0.2-1.0 m, $n\ ha^{-1}$ = 21,100; height > 1.0 m, $n\ ha^{-1}$ = 1,240. The size of the circles corresponds approximately to the absolute seedling densities in the different height classes (after Tabaku 2000).

3. Mixed beech-maple-ash spontaneous regeneration on a limestone site near göttingen, triggered by target diameter cutting and, for the last entry, group selection cutting (data from the investigation of A.M. Petrițan): figure 2 shows the relative frequency of the germination years of the beech seedlings on two sites. The sample trees represent an area of approximately 2-3 hectares, thus the data describe fairly large stands. Leaving outliers apart (at "Hünstollen" ages of 8 and 29 years, at "Hengstberg" none), the regeneration is between 11 and 24 and 9 and 25 years old, respectively. Thus the time window of 14 and 17 years respectively for beech regeneration was rather narrow. It becomes even narrower if one looks at the dominant trees, i. E. The trees with favourable future prospects (Tree class 1 in Figure 3). Their age range amounts to 9 and 13 years respectively. The codominant and suppressed saplings are younger on average. After start of the regeneration, progenies of later seed years have clearly smaller chances to reach a later overstorey position. Besides it is remarkable that there was seed production almost every year within the total time period. This corresponds well to observations of Züge (1986) and Schmidt (2006) in the same region.

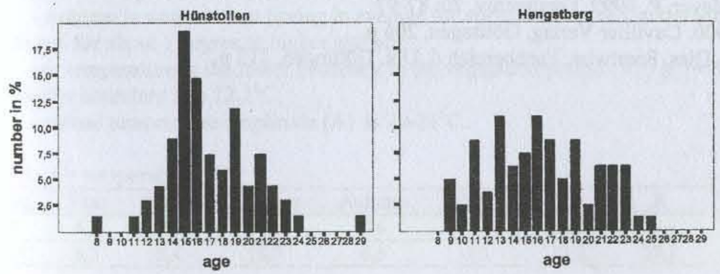


Figure 2: Age distribution of beech saplings in two thickets (data of A.M. Petrițan)

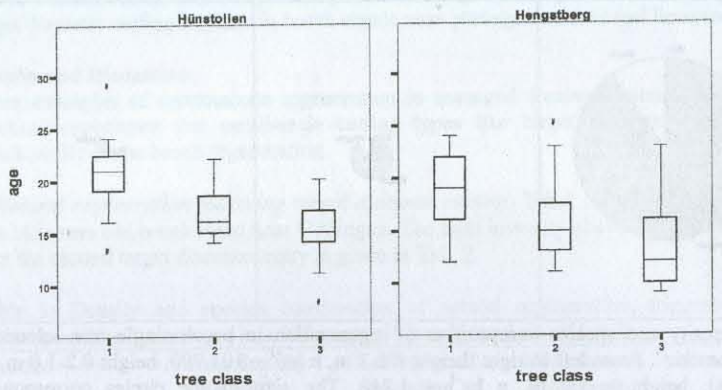


Figure 3: Age distribution of beech saplings in different tree classes. Class 1 = dominants; class 2 = codominants; class 3 = suppressed trees. Data are the same as in fig. 2.

Conclusions: there are many practical experiences and some scientific observations which demonstrate that spontaneous beech regeneration works well under a nature-based silvicultural regime. The reason might be a general suitability of small-scale cutting and regeneration methods for beech, as they mimic well the situation in natural beech forests. In addition the frequency of seed years has increased the last decades (Schmidt 2006), and the impact of game has gone down considerably. On the other hand, regeneration of mixed-species is greatly impeded by the superior competitiveness of beeches under these shady conditions. Thus, one important goal of nature-based silviculture is going to be missed as another one is to be perfectly reached.

REFERENCES

Drössler, L.; Lüpke, B. v. 2005. J. Forest Science, 51: 446-457
Meyer, P.; Tabaku, V.; Lüpke, B. v. 2003. Forstwiss. Cbl., 122: 47-58
PEFC. 2006. http://www.pefc.de
Schmidt, W. 2006. Allg. Forst- und Jagdztg., 177: 9-19
Tabaku, V.; Meyer, P. 1999. Forstarchiv, 70: 87-97
Tabaku, V. 2000. Cuvillier Verlag, Göttingen, 206 p.
Züge, J. 1986. Diss. Forstwiss. Fachbereich d. Uni. Göttingen, 213 p.

CLIMATIC CHARACTERISTICS OF THE BEECH FOREST (*Fagetum moesiacae montanum*) BELT IN NORTHEAST SERBIA

Milun Krstic[1], Zoran Govedar[2]

[1]Forestry Faculty of Belgrade University, Kneza Viseslava 1, 11030 Belgrade, Serbia
Tel: +381.11.3553122, E-mail: milunk@Eunet.yu
[2] Forestry Faculty of Banjaluka University, Banjaluka, Bosnia and Hecegovina

Introduction

In the Serbia a special species of beech is described as Moesian beech (*Fagus moesiaca* Domin, Maly/Czeczott): It is considered to be formed by hybridization of European beech (*Fagus silvatica* L.) and Caucasian beech (*Fagus orientalis* Lipsky), at the border of their ranges (Jovanović 1985).

Forests of beech in Northeast Serbia occur as a special altitudinal belt. Based on the altitudinal classification of the Deli Jovan mountain vegetation (Kalinić et al. 1984), the lower boundary is about 600 m, and the upper boundary of the belt is about 1100.

This paper shows the climatic characteristics of the altitudinal belt of beech forests in this region in the zone between 600 and 1100 m a.s.l.

Materials and Methods

The climate of this altitudinal belt was described by the method of altitudinal gradients of basic data of meteorological elements, based on the data of multi-annual measurements (1961-2000) of a great number of lowland and upland weather stations in the study region. On this basis, the values of meteorological elements were calculated for a definite altitude (lower and upper limits of beech forest altitudinal zone). Annual and seasonal values were presented – for spring, summer autumn and winter and vegetation period of the most important climatic elements: air temperature and rainfall. Finally, the climatic type was assessed by Lang's and Thornthwaite's method.

Results and Discussion

Air temperature

The basic characteristics of the temperature regime for the mentioned heights above sea level in analyzed altitude belt, as per Table 2, are the following:

- in the lower boundary of analyzed belt (600 m), the mean annual air temperature is 8.3°C and in the upper boundary (1100 m) is 6.2°C;
- Autumn is warmer than Spring in average for about 0.5 degree Centigrade at lower altitude and for about 1 degree at higher altitude;
- air temperature at the lower boundary in the vegetation period (VP) is 14.8°C, while at the higher boundary it is 12.2°C;
- annual temperature amplitude (A) is 20-21°C.

Table 1: Air temperature (°C)

H (m)	Year	Spring	Summer	Autumn	Winter	VP	A
600	8,3	8,2	17,7	8,6	-1,4	14,8	20,7
1100	6,2	5,4	15,7	6,5	-3,1	12,2	20,1

Pluviometric regime

It is known that continental type of pluviometric regime occur in Serbia, having two maximum and two minimum precipitation amounts during a year. The primary maximum occurs most frequently at the beginning of summer period (in June) and somewhere at the end of springtime (in May), while the secondary maximum can most frequently found in some regions in November. Primary minimum is at the end of winter (in February) or at the beginning of March, while the secondary one most frequently occurs at the beginning of autumn – in September.

The average annual precipitation amount ranges from 654 mm at the lower boundary to 701 mm at the upper boundary of the analyzed forest belts (Table 2).

The most frequent rains occur in summer with 29-31% of the annual precipitation amounts, while the driest season is in winter (about 20%).

The annual precipitation amounts increase with altitude for about 10 mm over 100 meters.

During the vegetation period, 58-60% of the annual amount of precipitation occurs.

Table 2: Average annual precipitation (mm)

H (m)	Year	Spring	Summer	Autumn	Winter	VP	VP/Y (%)
600	654	175	203	149	128	389	59,4
1100	701	192	204	167	138	408	58,1

Climate and geographic characteristics of the region

Climate and geographic characteristics of the region represent the influence of geographic position of a certain region to the climate features and vice versa (Kolic 1988).

The degree of continentality of the region was determined by Kerner's thermodromic coefficient (DC) and shows that moderate continental climate occurs at the lower boundary of analyzed belt, mild continental (mountainous) climate up to 1100 m.

Table 3: Climate and geographic characteristics

H (m)	Continentality of the region		Drought index after De Martonne		Pluvial risk hazard	
	DC %	Type of climate	**DI**	Runoff	**C**	Type
600	2,1	Moderate continental	35.8	Permanent	9.9	Mild
1100	5,8	Mild continental	43,3	Abundant	8.9	Mild

The runoff type and irrigation demand determined by drought index (DI) after De Marton, is characterized by expressive exoreism, i.e. runoff is permanent and abundant, meaning that according to this parameter, we deal with wet regions namely, this is a typical forest region.

Pluvial erosion hazard – risk of soil erosion caused by raindrop bombardment is expressed in accordance to the risk coefficient (C) after Fournier, indicating there is only a mild risk of pluvial erosion.

Climate classification

Climate classification after Lang and Thornthwaite is of utmost importance for the needs of forestry and especially for the choice of the methods for the forest growing (Kolic 1988).

Climate classification after Thornthwaite is performed based on values of calculated water balance. In the analyzed altitude forest belt, the climate varies from Subhumid moist to Mild humid ($C_2 - B_1$).

Table 4: Climate classification after Lang and Thornthwaite

H (m)	After Lang		After Thornthwaite		
	RF	Type of climate	Im		Type of climate
600	79	Climate of thin forests – not in optimum	11.8	C_2	Sub humid moist
1100	113	Climate of high forests – they are in optimum	31.5	B_1	Mild humid

Based on the climate classification after Lang, which is defined by the rain factor (RF), it can be seen that the humid climate occurs in the forest belt up to 700 m above sea level where the forests are not in their climate, physiological and biological optimum, and above mentioned height, they are.

References

Jovanović, B., Kolić, B. 1985 Klimatsko-vegetacijska (oroklimatogena) reonizacija Suve planine. Glasnik Šumarskog fakulteta 54, Beograd: 19-63

Kalinić, M., Mišić, V., Dinić, A. 1984 Edafsko-vegetacijske osobenosti planine Deli Jovan i krajine u severoistočnoj Srbiji. Beograd, Zemljište i biljka, Vol. 33, br. 3

Kolić, B. 1988 Šumarska ekoklimatologija. Naučna knjiga, Beograd: 397 str.

Krstić, M. 1998 Climatic characteristics of the sessile forest belt (Quercetum montanum serbicum Čer et Jov.) on Stara planina. Jubilee Scientific Conference: 70 Anniversary of the Forest Research Institute of the Bulgarian Academy of Sciences. 6-7 October, Sofia. Proceedings: 76-79.

Krstić, M., Smailagić, J., Nikolić, J. 2001 Climatic characteristics of the Sessile oak forests (Quercetum montanum serbicum Čer. et Jov.) belt in Serbia. 3rd Balkan Scientific Conference "Study, conservation and utilization of the forest resources". 2-4. October, Sofia. Proceedings, Vol. I: 200-209

Samilagić, J., Krstić, M., Cvjetićanin, R. 2002 Climate and vegetation characteristics of the mountain Deli Jovan in East Serbia. 18th International Conference on Carpation Mmeteorology. Belgrade, 7-11 October

*** (2001) Klimatološki podaci Srbije. Arhiva RHMZ Srbije, Beograd.