The Structure and Thinning Requirements for Broadleaved Stands of Natural Origin in Latvia

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Abstract

The structure of 2 to 9-year-old natural origin broadleaved stands is analyzed, using the method of component analysis. The stands under study represent natural regrowth of trees in fertile cutovers of dry mineral, wet mineral, wet peatland, drained mineral, and drained peatland forest growing conditions. For analyzing the internal structure of young stands the following traits are used: a) the forest stand before felling and the forest adjoining the cutover – 22 traits; b) the structure of ground cover vegetation in cutover – 31 traits; c) the structure of young stand and soil characteristics – 45 traits. The results of component analysis show that the 160 young stands of the age from 2 to 9 years ought to be treated as a single population that could be denoted by a common term – young stands in fertile forest types.

The initial density of natural origin broadleaved stands is notably high: in 89 % of the stands surveyed the number of stems exceeded 10,000 trees/ha while in individual cases it exceeded 120,000 trees/ha. The number tree stems shooting up naturally does not depend on the cutover width. As it follows from the analysis of stand structure (species composition and height), in a cutover the young stand may form a variety of biogroups. Because of significant differences in biogroup structure a unified thinning regime is not suitable for the whole site. In such cases the tending of young broadleaved stands ought to follow the biogroups of particular tree species.

Key words: young broadleaved stands of natural origin; forest stand structure

Introduction

Restocking by conifers the cutovers suitable as to growing conditions also for broadleaves may often be risky due to both abiotic (wind, frost) and biotic factors (broadleaved competition at the early age, wildlife damage, diseases) as well as high planting and protection costs. Many of the risks have no relevance for naturally regenerating broadleaves which, accordingly tended, will turn into commercially valuable crop stands. Besides, the commercial value of hardwoods (silver birch, aspen, *Alnus* sp., noble hardwoods) increases and is close to that of conifers or even higher.

Let us point to some problems that may in future affect the cultivation of broadleaves in Latvia:

1. Broadleaved forests, mostly resulting from self-afforestation of abandoned agricultural lands and unstocked cutovers, are established over large areas with no silvicultural treatment. Because of no pre-commercial thinning (cleanings), the stand structure is uneven with the tree species of lesser commercial value (grey alder, aspen) predominating.

2. Until recently the hardwood timber was considered of low value, and commercial forestry was oriented towards cultivating mainly conifers with Norway spruce excessively used in artificial forest regeneration. According to the data of the Latvia's forest information system, ten years ago there was an obvious shortage of young broadleaved stands with the broadleaved-dominated forests of the age from 1 to 20 years accounting for 1.4 % only (Jansons 2009). Therefore, starting this research, we were based on practical varities acquired in coniferous stands.

3. In recent years large areas of cutovers under fertile forest growing conditions are left for natural regeneration with broadleaves. It is mainly because the private forest owners have no financial resources for planting conifers while the state-owned and corporate enterprises are interested in increasing the area under broadleaved stands. Yet, without pre-commercial thinnings no high quality stands can be expected in the future. Natural regeneration by broadleaves occurs already during the first years after clear-felling with the coppice of fast-growing species outperforming the saplings of silver birch and noble hardwoods. Belated cleanings will be to no avail either.

The quality of the old stand next to the cutover appears to be the only criterion for evaluating the performance we may expect from naturally regenerating broadleaves. Normally, the young growth of natural origin comprises a mix of tree species and in rare cases the height of young shoots can be considered as an indicator of stand quality. It refers to aspen coppice first of all, while in many cases the quality of birch and noble hardwood saplings is not high either. Selecting the future crop species from a diversity of naturally sprouting young shoots following the tree species of highest quality in the adjoining old stand ought to be the guiding principle in making the future crop stand.

Regarding the dynamics of stand growth, the results of the given study, derived from recurrent measurements on long-term sample plots, show that keeping the initial density of young growth high is a significant silvicultural error which can be described by the following regularities:

1. The lower the initial stand density at young age the higher is the yield at maturity (Юодвалькис и Озолинчюс 1987, Карев и Скоморовский 1998, Zeide 2004, Zālītis 2006). Let us mention that in most cases these authors consider as **low density** the plantations with the initial density of 5,000 trees/ha, and as high density – 20,000 trees/ha. However, reducing the initial density to 5,000 trees/ha has no significant effect on the volume growth, and we cannot recommend it as the lowest density in practical forestry.

2. The number of trees as the height function is true only for the stands with a fairly high initial density where there is a tough competition between trees (Кайрюкштис и Юодвалькис 1976, Abetz 1981, Рябоконь 1991, Zālītis and Lībiete 2008). In 18 years at the initial density below 3,000 trees/ha all spruces of the height 8 m had survived and at the age of 30 years 72% of them belonged to the main stand. On the other hand, at the initial density of 20,000 trees/ha, at the age of 30 only 31% of the trees met the characteristics for inclusion in the main stand.

3. In low density stands, the trees are more resistant against root rot as they grow taller, show higher diameter increment, and have more vigorous crowns. In sparse stands the lowest branches die back and come off much in the same way as in dense stands (Brünig and Heuveldop 1976, Vyskot 1978, Рябоконь 1991, T. Zālītis and P. Zālītis 2007). In spruce plantations of low initial density, the underbrush and vascular plants in the space between rows survive for the wildlife to feed on, while a dense plantation would turn into a thicket devoid of life. Some authors recommend thinning out thicker branches in late pre-commercial thinnings (Varmola and Salminen 2004).

Before starting the given research work two major tasks were formulated:

1. In what kind of stands in fertile forest ecosystems the natural regeneration of broadleaves would culminate, and is the initial number of stems in the young broadleaved growth sufficient to expect a high-yield crop stand?

2. What is the species structure of naturally regenerating young stands, and what methods of pre-commercial thinnings should be applied?

Material and methods

According to the Latvian forest typology all forest ecosystems fall into five types of growing conditions: forests on dry mineral soils (49% of all Latvia's forests according to the NFI data), forests on wet mineral soils (9.6%) and wet peatlands (8.4%). Because of a considerable part of woodlands drained two types of man-made forest growing conditions are singled out: forests on drained mineral soils (19.3%) and forests on drained peatlands (13.5%). Within each type of growing conditions there is a number of forest ecosystem types (from 4 to 6), which characterize mainly the differences in soil fertility and the potential effect of forest cultivation. For example, **Sl** *Callunoso cladinosa* is the most oligotrophic forest type within the dry mineral soil forest growing conditions, and **Gr** *Aegopodiosa* – the most fertile one. The traits for classing tree stands with one or another forest type are methodically collected and described for mature forest stands. After the stand is final-felled the forest type for cutover and the young growth is usually estimated from the previous forest inventory records. In Latvia's forest regulations, different forest types have specific demands regarding the terms of forest regeneration and tree species used. The fertile forests, for which natural regeneration is analyzed in the given study, account for 36% of the total forest area.

For the needs of research work 160 fertile forest type cutovers were randomly chosen in eight administrative districts of Latvia (Bauska, Daugavpils, Gulbene, Jēkabpils, Jelgava, Liepāja, Limbaži, and Ogre) (Fig. 1), totally 20 cutovers in each district.

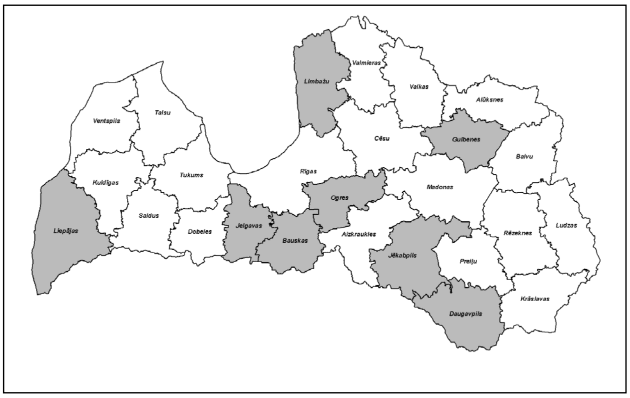

Figure 1. Location of sample plots on the territory of Latvia

In choosing the research material, the following restrictions were observed: a) the site of cutover is ecologically and economically suitable for cultivating broadleaves; as a result the reference sample comprised forest sites which according to the Latvian forest typology before felling belonged to the following forest types: **Vr** *Oxalidosa,* **Gr** *Aegopodiosa,* **Vrs** *Myrtilloso-polytrichosa,* **Grs** *Dryopteriosa,* **Lk** *Filipendulosa,* **As** *Myrtillosa mel.,* **Ap** *Mercurialiosa mel.,* **Kp** *Oxalidosa turf. mel.* (Bušs 1989, Zalitis 2006); b) the age of young growth on the cutovers was from 2 to 9 years (time after felling, not counting the year of felling); c) no trees planted on the cutovers and no precommercial thinnings done to the young growth.

In each of the eight administrative regions chosen were 20 cutovers of different age (i. e. the number of years after felling) and having the traits as specified above. The cutovers were chosen randomly, using the database of standwise forest inventory. In each cutover, the survey was done on nine identical circular sample plots (SPs) of the total area 60 m^2. The SPs were arranged in three rows – two along the sides and one in the centre with three SPs in each. Along the cutover's longer sides the SPs are 20m off the edge; the distance rows from the cutover ends is ¼, ½, and ¾ of the cutover length, respectively. In each SP, the following measurements were made:

• number of trees following the tree species and height groups (<10cm; 11-20cm; 21-50cm; 51-100cm; 101-200cm; >200cm);

• soil disturbance (visual evaluation: 1 – slight, 3 – heavy);

• peat layer depth, cm;

• mean height of the ground vegetation, cm.

The following data are supplied for each cutover surveyed:

• cutover age (number of years after timber harvest, including the year of final felling);

• cutover length, width, and area;

• composition of the tree stand cut down;

• description of the adjacent forest stand (on side 1 and 2);

• forest type before final felling.

In each cutover, the ground vegetation is surveyed at 200 points, distributed along SP rows perpendicular to the cutover sides. The survey is done by sticking into the ground an iron rod, 1.5m long and 0.3cm in diameter, and recording all the plants whose above-ground parts (leaves, stems, or blossoms) are in contact with the rod (point-square method).

The data are entered into unified field sheets and fed into a matrix developed for data processing in the *MS Excel* environment. For analyzing the typological structure of natural origin broadleaved stands in fertile forest types used is the method of component analysis, which was successfully applied when developing the Latvian forest typology (Буш и др. 1975).

The method of component analysis was used to solve the problem of grouping (In how many groups? Following what traits the given object falls into one or another group?) the research objects. The tree stands appearing in cutovers were correlated with the numerical values for the following parameters: a) stand age; b) projective cover of ground cover vegetation ecological groups (Буш и Аболинь 1968); c) forest type before felling, numerically described by the value of forest land (in grades); d) depth of peat layer; e) degree of soil disturbance; f) structure of felled stand; g) structure of the old forest next to the young stand; h) number of stems in the young stand of the height below 1m; i) number of stems in the young stand of the height above 1m; j) width of the young stand (cutover).

Results and discussion

In all research objects, the initial density of naturally regenerating stand was notably high: in 99 % of the objects surveyed in fieldwork the number of trees exceeded 2,000 trees/ha, and in 89 % of objects – 10,000 trees/ha (Table 1), which testifies a successful re-establishment of forest ecosystem after felling. At the same time a significantly high diversity of tree species coming up was observed, with aspen, usually as a coppice growth, predominating. The dominance of aspen (also grey alder) in regenerating stands makes one seek the ways how to control the initial species composition. Under the coppice growth quite a high number of saplings of commercially more valuable species (silver birch, noble hardwoods) were often found. The high initial density of naturally regenerating stands is indicative of an intolerable loss of energy of growth in the fight of competition between the tree stems sprouting up on the cutover.

Table 1. Maximum, minimum, and average number of trees (N) in SPs of analyzed districts

District	$N_{aver.}$	N_{min}	N_{max}	The number of cutovers with N N < 2000	The number of cutovers with N N < 10000
Bauska	23300	5300	44500	-	1
Gulbene	11500	1500	28200	2	7
Limbaži	19100	2700	51500	-	3
Liepāja	24000	6700	56000	-	1
Daugavpils	40800	8000	119700	-	1
Jelgava	32000	9300	63000	-	1
Ogre	24900	4700	89000	-	2
Jēkabpils	30700	3700	64300	-	1

Both exceedingly high number of young shoots on the cutover under natural regeneration and a disproportionate species composition count in favour of early pre-commercial thinnings (cleanings). For establishing high-value crop stand from the initial stock of natural origin (high number of young stems) an additional inflow of energy is needed, i.e. silvicultural intervention, which is most urgent just in the first years of stand development.

When analyzing 160 stands with a highly differing number of young stems and species composition, a question arises whether all the objects selected for research can be treated as a single population. An answer to this question will determine the methods of analysis, prognoses of the future performance of young stands, and the most suitable silvicultural activities to be taken. As already mentioned, the research objects belonged to a variety of forest types. It is quite possible that the traits used for classing a mature stand with one or another forest type hold no more after the stand is final-felled and as such cannot be included in the regulations for forest regeneration.

For analyzing the internal structure of the reference sample of young stands the following traits were used:

1) the forest stand before felling and the forest stand next to the cutover – 22 traits;

2) the structure of the ground vegetation - 31 traits;

3) the structure of the young stand and soil characteristics – 45 traits.

In component analysis each sample plot is treated as a vector in n-dimension space (in the given case comprising 98 traits), and when analyzing the structure of co-variate matix, indentified are two major eigenvectors (PRIN). The said eigenvectors generate a plane in which the objects, i. e. the sample plot descriptions, are projected. This approach gives such a placement of planes that best of all reveals the difference between the sample plots and as clearly as possible indicates their grouping.

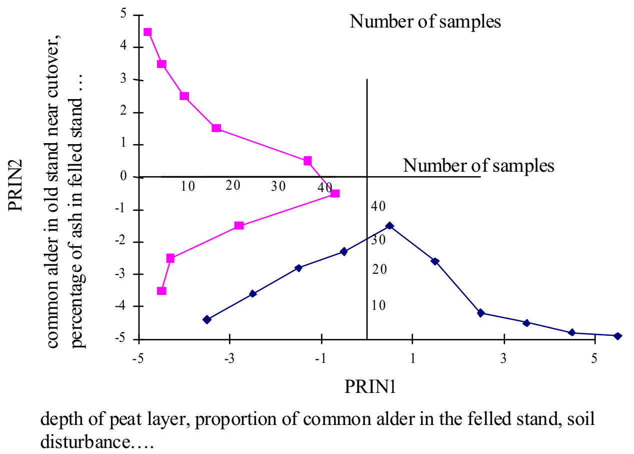

Figure 2. Trait distribution of the reference sample in multidimensional space following the parameters of the regenerating stand, the species structure in the stand felled and in the stand next to the cutover

Projecting the descriptions of young stands on the plane according to their coordinates in a system, where the most suitable vectors form the coordinate axes, resulted in a highly compact set of points. In each sector of the set of coordinates the stands of different age were found. The density of points in the centre is higher than in the periphery. Such a structure is typical of a sample made up from a single population.

This is confirmed by distribution frequency curves, which are obtained by projecting the points on the PRIN1 un PRIN2 coordinate axes (Fig. 2). For all the variants we obtain single-peak distribution curves, which are fairly close to normal distribution.

As it follows from the above analysis, there is no reason for grouping the young stands (cutovers) to single out specific diagnostic traits or create a special typology for them. Provided the age of the young stand is below 10 years, the forest type of the stand cut down is of no importance either. Clear-felling as an action destructive to the forest ecosystem obliterates for the time being the typological distinctions that existed between the forest ecosystems comprising mature stands. The restrictions introduced for choosing the objects to be studied were sufficient to count the young stands (cutovers) as belonging to a single population that can be denoted by a common term – fertile forest types.

During the growth and development of young natural origin stands the traits typical of different forest types will show up anyway. At the given stage of stand growth we have enough possibilities to follow up the development of young stands as a single population and analyze the differences in stand parameters.

Although the sample stands studied belong to a single population, in the course of growth a differentiation inside individual forest sites takes place. The traits that may vary are the species composition and the number of trees and height groups (up to 1 m, above 1 m). Such a differentiation results in a peculiar stand structure in separate parts of the site which must be taken into account when prescribing silvicultural treatment. As an example we refer to the sample plot of the Subate Forest District (Fig. 3).

To investigate the structure of young stands, natural regeneration in large (up to 10 ha) continuous cutovers was analyzed. In this study we have included the data collected in a continuous cutover (22.4ha; length 1,400m; width 160m) in the Subate Forest District (Daugavpils). The cutover area was arbitrarily divided into ten parcels of about 2ha in size. For greater clarity the parcels are numbered (Fig. 3). Chi-square method is used for juxtaposing the structure of young broadleaved stands between different parcels (Liepa 1974). By this method compared are individual parcels, singled out in the cutover. The comparison is done following the number of broadleaved trees distributed by the tree species and height groups (<1m and >1m).

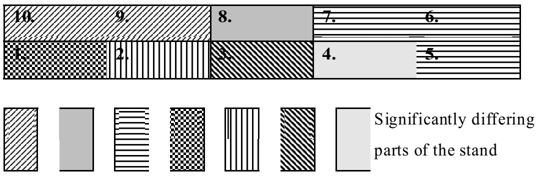

Figure 3. Lay-out of the analyzed stand at the Subate Forest District

There were no significant differences only between parcels 5-7 and 9-10. For example, in parcels 9-10 the future crop stand can be made by similar methods as the structure and the number of trees per ha is similar (Table 2). On the other hand, in parcel 10 located next to parcel 1 the number of birches is twice less, that of noble hardwoods – twice higher with the number of aspens three times less. The number of individual tree species in different biogroups within one and the same stand may vary from 0 to 11,700 (for example, common alder in parcels 6 and 19). Normally, the cleanings are planned and carried out, choosing one main species for the whole site. This method is right for the stands regenerated artificially with conifers, for example. The structuring of stand in biogroups, which is typical for naturally regenerating broadleaves, requires a different approach. A simplified recommendation, for example, to thin out all aspens in the whole site is acceptable, providing the quality of aspen in the adjoining old forest is critically low or the number of other species trees evenly distributed all over the site is sufficient for a future crop stand.

Table 2. The differences in stand species composition within a single cutover in the Subate Forest District

Parcel number	Number of trees/ha				
	Birch	Aspen	Common alder	Grey alder	Noble hardwoods
1.	6500	18800	0	0	5000
2.	45500	12500	0	0	13000
3.	52000	17500	0	0	1800
4.	52800	2900	200	0	7700
5.	57000	7200	800	0	7800
6.	24800	4400	11700	0	9600
7.	19700	3100	200	300	5700
8.	23900	7500	0	0	900
9.	4300	7000	0	2200	10200
10.	3100	5800	0	0	11500

Conclusions

1. The initial density of natural origin young broadleaved stands is notably high: in 89 % of the stands surveyed the number of stems exceeded 10,000 trees/ha, and in individual cases it was higher than 120,000 trees/ha.

2. Typological analysis by the method of component analysis of naturaly regenerating broadleaved stands of the age up to ten years shows that the stand removal as an action destructive to the forest ecosystem obliterates for the time being the typological distinctions that existed between the forest ecosystems of mature stands. That is why there is no reason either for grouping the young stands (cutovers) or placing emphasis on one or another diagnostic trait typical of them, including no need for typological distinction between them.

3. As it follows from the analysis of stand structure (species composition and height), in one and the same cutover the young growth may form different tree biogroups. Because of significant differences in the structure of these biogroups no unified thinning regime can be applied for the whole cutover. In such cases the tending of young broadleaved stands is done following the biogroups of particular tree species.

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СТРУКТУРА МОЛОДНЯКОВ ЛИСТВЕННЫХ ПОРОД В ЛАТВИИ И ВОЗМОЖНОСТЬ УХОДА ЗА НИМИ

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Резюме

Изучено 160 молодняков лиственных пород естественного восстановления в возрасте 2-9 лет. Заложенные пробные площади характеризуют плодородные леса на суходоле, на мокрых минеральных почвах, на мокрых торфяных почвах, на осушенных минеральных почвах, на осушенных торфяных почвах. Выполнен компонентный анализ внутренних параметров лесной экосистемы по 98 признакам, в том числе: 1) возраст молодняка; 2) проективное покрытие характерных групп травянистого покрова; 3) тип леса до выработки древостоя; 4) толщина торфяного слоя; 5) деформация почвы при выработке леса; 6) породный состав вырубленного древостоя; 7) породный состав к лесосеке прилегающего древостоя; 8) породный состав деревцев в молодняке ниже 1 м; 9) породный состав деревцев в молодняке выше 1 м; 10) ширина лесосеки. В результате выявлено, что структура молодняков лиственных пород не зависит от типа леса и все описания пробных площадей относятся к одной генеральной совокупности – плодородные типы леса.

Число деревцев в молодняках очень большое: на 89% вырубок оно превышает 10000 шт. га$^{-1}$, но на отдельных вырубках оно достигает 120000 шт. га$^{-1}$. Рекомендуется число деревцев высотой 3-5 м сократить одной рубкой прочистки до 2000 шт. га$^{-1}$.

Из целенаправленно сформированных молодняков в возрасте приспевающего насаждения число деревьев в среднем на 300 шт. га$^{-1}$ больше и запас древостоя на 160 м^{3} га$^{-1}$ больше, чем в насаждениях произраствших из перегущенного березового молодняка.

Ключевые слова: молодняк лиственных пород, структура насаждения, повышение продуктивности