MANAGEMENT OF GREY ALDER (*ALNUS INCANA MOENCH.)* STANDS IN LATVIA

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Abstract. Grey alder stands currently take up 10.2 % or 329 700 ha of the total forest area, and the area of these stands is continuing to increase mainly in non-managed agricultural lands of private owners (Central Statistical Bureau, 2007). The reforestation of cutting areas harvested in the wintertime by grey alder root and stump coppices reaches 35-150 thousand per hectare in the first year. The amount of coppices decreases to 16-47 % in the following 3 years. The first thinning of young alder stands can be recommended at an age of 3-5 years by decreasing the number of trees to 4000-5000 per ha. The research showed that the resurgence with root and stump offspring in grey alder clearings was intense, and no expenses were required for forest restoration. By artificially making grey alder grow in agricultural lands, the planting and maintenance costs are similar to those of other species. The research shows the possibilities of increasing the amounts of wood obtained per unit of area when freely choosing the rotation age and the purpose of growing grey alder. It is shown that by cutting grey alder at an age of 15-20 years, 1.90-2.28 times more wood per ha can be obtained than by cutting aspen, birch and black alder at the age determined by the law. The results of this research allow recommending grey alder as a prospective tree species with rotation age of 15-20 years for production of energy wood and with rotation age of 25-30 years for production of energy wood and small timber.

Key words: grey alder, site index, basal area, rotation age, volume.

Introduction

With the growing demand for timber, mainly in the power sector, as well as with the development of timber processing technologies, more attention is paid to previously unconsidered, mainly fast-growing, tree species resources and usage possibilities, as well as to creation of plantations of fast-growing species. Grey alder is one of these as yet unconsidered tree species in Latvia.

Grey alder stands currently take up 10.2 % of the total forest area (Central Statistical Bureau, 2005-2008). The growing stock of grey alder, in accordance with State Forest Service (SFS, 2005-2008) data, is 9.7 % (Forest Sector in Latvia 2008, Latvia Forest Industry Federation, p. 32). The share of grey alder cut timber is 1 % in state forests and 15 % in other forests (Forest Sector in Latvia 2008, Latvia Forest Industry Federation, p. 32).

Analyses of grey alder stands show that in both state and private forests, the majority (approximately 60 %) is made up by 35-year-old (age class VII) and older trees, where annual increments decrease (Daugavietis, Daugaviete 2007, 2008; Pārskats, 2008)).

There are no recommendations for management of grey alder stands today, no age limitation has been set for cutting of grey alder. It means the forest owner is free to choose the growing purpose and felling site cycle duration (Forest Restoration Regulations, No. 398 of 11 September 2001).

The grey alder growth and yield tables in use in Latvia, which give basic information for stand management, were prepared in 1963 and are intended mainly for assessment of grey alder stands growing on forest soil, but are lacking in information about stands growing on abandoned agricultural lands (Mežsaimniecības tabulas, 1963).

Taking into account the interest of forest owners in obtaining the maximum yield in the least amount of time, the questions of reforestation and afforestation, thinning and grey alder growth progression are very important for forest owners, and have been investigated.

Materials and methods

Twelve harvested grey alder stands in the period from November to February (2005-2006) in different growing conditions (Aegopodiosa (Aeg.), Dryopteriosa (Dryop.), Oxalidosa (Ox.), Myrtilloso-polytrichosa (Myrt.-pol.), Hylocomiosa (Hyl.), Myrtilloso-sphagnosa (Myrt.-sph.) and Mercurialiosa mel. (Merc.) forest types) were selected for evolution of the natural regeneration process, growing of young stands and influence of the first thinning on stand development.

Three sample plots with an area of 500 m² were established in each clearing. Each sample plot was divided into four sectors, and the number of trees was reduced to 10 000, 5 000 and 2 500 trees (coppices) in the different sectors (Figure 1) by thinning one-year-old stands in October-November, while one sector was left untended.

The coppices were enumerated; height and root collar diameter (for one-year-old trees) or breast height diameter (DBH) of older trees (coppices) was measured after one, two and three year growth.

24 sample plots with an area of 100 m² were established for evolution of the natural afforestation process of abandoned agricultural lands. Sample plot series 0-11.28 m; 11.28-22.56 m; 22.56-33.84 m; 33.84-45.12 m; 45.28-56.40 m; 67.68-78.96 m in two repetitions were established in areas adjacent to grey alder stands (abandoned agricultural lands) on north (N), west (W), south (S) and east (E) sides.

More than 200 sample plots of grey alder stands of different age (5-44 years), density and site index were established in different regions of Latvia on forest and abandoned agricultural lands.

The area of the sample plot was 100 m² if the breast height diameter (*DBH*) of all trees was ≤12.0 cm and 500 m² if the *DBH* was ≥ 12.0 cm. The *DBH* and polar coordinates of each were measured; the height of tree, the first live branches and first dry branches were measured for 20 trees around the average *DBH* (± 4 cm).

One or two model trees in the sample plot were felled for height and diameter increment analyses.

The stem volume of each tree was calculated by the following formula (Liepa, 1996):

$$V_j = \Psi \cdot H^{\alpha} \cdot d^{\beta \cdot \lg h + \varphi}, \quad (1)$$

$$\text{where } V_j = 0.7450 \cdot 10^{-4} \cdot H^{0.81295} \cdot d^{0.06935 \lg h + 1.85346}, \quad (2)$$

where V – volume of stem, m³
H – height of stem, m
d – stem diameter at breast height (*DBH*), cm.

The obtained data of age, *DBH*, tree height, density, basal area and quality class were used for elaboration of the growth models of grey alder stands and tree characteristics by using methods of multiple regression analyses.

Results and discussion

The natural reforestation of cutting areas harvested in winter time in grey alder and other broad-leave tree root and stump coppices is very intense and reaches 35-150 thousand per hectares in the first year. The number of coppices decreases to 16-47 % in the following two years (Table 1).

Table 1

The amount and characteristics of grey alder coppices in the natural regenerated areas

Forest type	**Number of coppices, thous.copp·ha^{-1}**		**Average**					
			2006		2007		2008	
	2006	2008	Root collar diameter, cm	Height of coppice, m	*DBH* of coppice, cm	Height of coppice, m	*DBH* of coppice, cm	Height of coppice, m
Ox.	35.9	26.6	1.3±0.2	1.1±0.2	1.3±0.3	1.5±0.4	1.3±0.5	1.6±0.7
Myrt. Pol.	32.6	24.4	1.2±0.2	0.9±0.2	1.3±0.4	2.4±0.4	1.6±0.6	3.2±0.6
Hyl.	36.8	27.2	1.2±0.2	1.1±0.2	1.2±0.4	2.5±0.6	1.6±0.8	3.1±0.9
Myrt.-sph.	39.0	29.2	1.2±0.3	1.2±0.2	1.3±0.4	2.4±0.5	1.4±0.7	2.9±1.1
Aeg.	36.7	30.9	1.4±0.2	1.0±0.3	0.9±0.3	2.2±0.4	1.6±0.6	3.4±0.4
Dryop.	41.9	33.5	1.3±0.1	1.0±0.2	1.1±0.2	2.1±0.3	1.3±0.8	2.4±0.8
Merc.	120.7	63.9	1.4±0.1	0.9±0.1	0.8±0.3	2.0±0.4	1.1±0.5	2.4±0.6

On the basis of this research, the dynamics of grey alder biomass are calculated for various forest types, which allow selecting the best type of grey alder stand management for the respective growing conditions.

In abandoned agricultural land adjacent to grey alder stands, stands of uneven age, various density and composition are formed. If these stands have not been managed by the age of 5, they practically cannot be turned into high-quality forest stands due to the great variety of species, tree age differences, uneven density and therefore – the yield obtained. These grey alder stands intermixed with more than 2 tree species are not prospective and can potentially be used only for obtaining biomass.

The analyses of height increments of different stands on the basis of sample trees show that the height of trees can be calculated by the following formula:

$$H = \frac{H_{20}}{0.847}(\mathrm{Ln}(A+15)-2.708) \qquad (3)$$

where H_{20} – the average height of the stand at the 20-year-age or site index;
A – the age of the stand.

The new scale of stand quality that covered stands on forest and abandoned agricultural lands was elaborated and recommended (Figure 1).

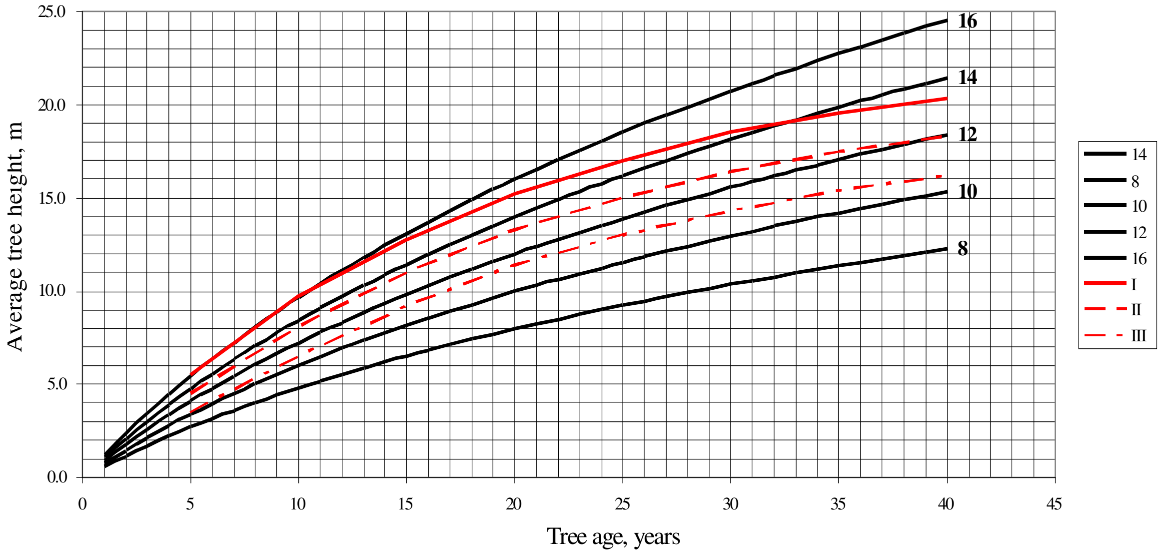

Fig. 1. **The regularities of stand quality class (H_{20}) compared to the currently used curves of Mūrnieks (I,II,III)**

The characteristics of the sample plots used for the growth development models are given in Table 2.

Table 2

Characteristics of sample plots

Age, years	Number of sample plots	Quality class (H_{20})	Basal area, $m^2 \cdot ha^{-1}$	Amount of trees per ha
5	7	6.6-14.0	0.8-6.0	2920-11900
6-10	25	8.1-19.7	2.3-22.5	2640-12000
11-15	32	4.9-7.1	2.1-27.9	1220-15700
16-20	30	8.8-21.8	9.9-39.8	720-16300
21-25	17	10.7-18.5	12.4-38.4	920-5140
26-30	18	10.7-18.1	19.5-50.0	1100-4660
31-35	9	10.9-16.2	20.2-43.2	1220-3640
36-40	9	10.4-17.2	19.4-42.1	840-1860
>40	3	10.9-13.2	18.6-42.6	880-2200
Total	150			

The following formulas for calculation of average breast height diameter (*DBH*, cm), volume (V, m³·ha^{-1}), basal area (G, m²·ha^{-1}) and number of trees per ha (N) were elaborated for grey alder stands of different quality classes:

- for modeling of the *DBH* progression of a stand

$$DBH = 0.9898 A^{0.6586} N^{-0.1883} H_{20}^{0.742} \tag{4}$$

The characteristic parameters of the regression equation: *DBH*=1.0 cm; R=0.978; D=0.960.

- for modeling of the volume progression of a stand

$$V = 0.1625 A^{0.548} G^{1.011} H_{20}^{0.7855}. \tag{5}$$

The characteristic parameters of the regression equation: $S_{v.}$ = 3.2 m^3 ha^{-1}; R= 1.000; D = 0.999.

- For modeling of the progression of the basal area of a stand

$$G = 0.0000451\, A^{1.3278} N^{0.6582} H_{20}^{1.546} \tag{6}$$

The characteristic parameters of the regression equation: S_G=3.5 m^2 ha^{-1}; R=0.946; D=0.894.

The following equations have been obtained for the correlation of the amount of trees and age by site index:

$$N = 45801A^{-0.9455},\ H_{20}=8 \text{ m} \tag{7}$$

$$N = 34736A^{-0.9123},\ H_{20}=12 \text{ m} \tag{8}$$

$$N = 24012A^{-0.8617},\ H_{20}=16 \text{ m} \tag{9}$$

$$N = 13901A^{-0.774},\ H_{20}=20 \text{ m}, \tag{10}$$

where N – number of trees per ha;
A – stand's age, years;
S – declination of regression;
R – coefficient of correlation;
D – coefficient of determination.

By using the correlations found, tables of grey alder growth and yield or, more accurately, volume, have been developed for one variant for four site index, which describe the valuation characteristics of the main stand depending on the age (Table 3).

Table 3

The characteristics of grey alder stands of site index (I) H_{20}=20 m

Age, year	**Height, m**	***DBH*, cm**	**Number of tree, stem**	**Basal area, m^2**	**Volume, m^3**
Site index H_{20}=20					
5	6.8	5.8	4000	9.2	39
10	12.1	10.0	2339	16.3	102
15	16.4	13.8	1709	22.6	178
20	20.0	17.3	1368	28.7	264
25	23.2	20.6	1151	34.4	359
30	25.9	23.8	999	39.9	461
35	28.4	26.9	887	45.3	569
40	30.7	29.9	800	50.5	684

The grey alder growth and yield of stands have been compared with the results of other deciduous tree stands in accordance with the growth and yield tables currently in use.

The data on the wood amount obtained in grey alder stands, cut at a freely-chosen age, compared to the amount obtained in stands of other tree species, cut at the age established by the legislation, are given in Table 4.

Table 4

Volume obtained from grey alder stands compared to that obtained from stands of other soft deciduous tree species in full-density stands of site index *I*

Tree sp.	**Rotation age**	**Volume at the rotation age, $m^3 \cdot ha^{-1}$**	**Number of rotation cycles compared to**			**Volume obtained from grey alder stands compared to**					
			aspen	birch	black alder	aspen		birch		black alder	
						m³	%	m³	%	m³	%
Aspen	41*	249	1			249	100				
Birch	71*	378		1				378	100		
Black alder	71*	419			1					419	100
Grey alder	15	188	2.7	4.6	4.6	507	204	864	228	864	206
	20	248	2	3.5	3.5	496	199	868	229	868	207
	25	297	1.6	2.8	2.8	475	191	831	219	831	198
	30	338	1.3	2.3	2.3	439	176	777	206	777	185

Considering that no age limitations have been set for cutting of grey alder, the forest owner is free to choose the growing purpose and rotation cycle duration. At age below 40 years, the volume and the breast height diameter exceed that of the comparative species – birch, aspen and black alder. After 35 years, the volume increase in grey alder stands rapidly slows down, and preserving them is not effective. It means that, when growing grey alder, the forest owner must select the optimum rotation age depending on the growing purpose.

If the owner chooses to grow grey alder for energy wood purposes, it is more beneficial to select a shorter cycle – 10-20 years, obtaining more energy wood in 2-3 cycles than in a single cycle by cutting a stand at an age of 30-35 years.

If there is a market demand for thin timber, the recommended rotation age is 25-30 years, when the timber yield reaches 190-330 $m^3 \cdot ha^{-1}$.

Compared to other soft deciduous tree species, growing of grey alder for production of wood mass is beneficial due to its fast growth. For example, if comparing cutting of aspen, whose rotation age is 41 years, to cutting of grey alder at an age of 20 years, with two cycles, 199 % more biomass can be obtained from grey alder in the same area (Table 4).

The research shows that the resurgence with root and stump coppices in grey alder clearings is intense, and no expenses are required for forest restoration. By artificially making grey alder grow in agricultural lands, the planting and maintenance costs are similar to those of other species.

Conclusions

1. The research results allow confidently recommending growing of grey alder for production of energy wood with a rotation cycle of 15-20 years, and for production of thin timber and energy wood with a rotation cycle of 25-30 years.
2. The first thinning of grey alder stands may be recommended at the age of 4-5 years by decrease the number of trees to 4000-5000 per ha.
3. By properly managing grey alder stands, 180-230 % more volume can be obtained per unit of area, when compared to birch, aspen and black alder.
4. To promote management of grey alder stands in accordance with the owners' business plans, rotation age limitations in grey alder stands should not be set.

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