GREY ALDER *ALNUS INCANA* (L.) MOENCH ADDITIONAL GROWTH CHANGES AFTER THINNING IN *AEGOPODIOSA* SITE TYPE

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Abstract
Grey alder stands *Alnus incana* (L.) Moench have a number of distinctive features. In fertile soils it successfully forms productive forest stands without any human intervention. Therefore, relatively few publications can be found on the thinning effects on stand reaction after thinning. It is possible that due to the highly intensive circulation of substances in the ecosystems of grey alder (high photosynthesis and canopy thinning, withering and breaking off of the lower branches, litter decomposition within a few years, thereby ensuring a continuous and stable plant mineral nutrition substance complementarity in the soil) response reaction of the remaining trees and management of grey alder forest stands could be different comparing to other tree species. The study analyses stock volume additional increment dynamics during 10-year period after the thinning in 24-year-old grey alder pure stands in *Aegopodiosa* site type. Thinning of grey alder forest stands have caused a moderate positive reference reaction – during 10 years, in addition to the total increase, 3.17 m^3 ha^{-1} have been added. During the valuation interval response reaction differs among the years. In the first four years it is relatively small as accumulation of the growing potential is taking place. From the fifth to seventh year after felling an intensive growing takes place, which results in repeatedly additional annual increment. Starting from the eighth year, the trees show tendency to return to a steady state as it was before the thinning.
Key words: grey alder, effect of thinning, additional volume increment, *Aegopodiosa* site type.

Introduction

Thinning is always such a radical intervention in any forest stand that its effect persists for years after the thinning (Liepa and Zaļkalns, 2014). The nature and intensity of the impact depends on a wide variety of conditions. So during the long stand thinning history numerous studies have been done to find an environmentally substantiated and economically advantageous way of thinning (Zviedris et al., 1961). The criterion for comparing of different study results is the state of health and productivity changes of thinned stands (Eberts, 1996; Zālītis, 2010). There is no doubt that the thinning should not become a risk factor of explosion of tree diseases, such as root rot or enhanced proliferation of pests, for example a massive invasion of needles consumers. No less important is to increase or at least keep the pre-thinning timber productivity. This is being substantially dependent on the tending intensity (Антанайтис и др., 1986). Experience has shown that the selection of inappropriate thinning efficiency criteria, such as the annual tree ring width change after the thinning can lead to, although scientifically based, over-rarefying of the stands. In this case, the width of tree ring annual increase cannot compensate for the increase of the thinned trees, thereby resulting in the decrease of the productivity of the remaining forest stand. For the most tree species this problem has been identified and partially solved by the development of thinning regulations (Donis et al., 2012).

The situation is different with the grey alder *Alnus incana* (L.) Moench stands management research. As a reason two considerations can be mentioned – wood of grey alder is with relatively low assessment comparing to other tree species, as well as grey alder biological characteristics. The use of wood depends on the physical and mechanical properties, chemical composition, dimensions of the derived wood products, wood defects and other factors. According to these conditions, grey alder wood is mainly used in containers, wood fibre and board industry, lathing, charcoal, firewood, meat and fish smoking (Daugavietis, 2006). New opportunities for the use of grey alder can be given for renewable energy production. This tree species is quite suitable for use in heat energy industry because of its outstanding fast growth, high biomass productivity, easy afforestation and foster regeneration as well as wide occurrence. Latvia has a considerable amount of grey alder resources. This refers to both the forest and in particular abandoned agricultural lands occupied area as well as to the stock volume and the amount of the biomass (Miezīte, 2008; Daugavietis et al., 2009; Miezīte et al., 2011). According to the State Forest Service data (Meža statistikas..., 2014), the total area of grey alder stands in Latvia is 210,704.5 hectares with a total volume stock of 30,305,201 m^3, which is an important alternative for energy production. Especially important is the fact that grey alder mostly regenerates naturally in fertile forest site types and in uncultivated agricultural land forms healthy young stands. Reasonable use of these properties of grey alder allows the forest owner to avoid the expenditure for the planting and reproductive material, focusing more on further forest pre-commercial thinning. In dry and sandy soils feasible is planting of the grey alder too (Rokjānis, 1957). Economic significance of the grey alder is not yet sufficiently identified. Over time, the treatment of this tree species has changed in a very wide range from hopeful suggestions on wood plasticizing (Kärki, 1999; Zīverts, 2008; Morozovs, 2008) and ending with the calling the grey alder a forest weed, whose admixture impacts negatively the target species such as Scots pine and Norway spruce, reducing their productivity and quality. Because of this, even the regulatory guidance materials recommended to exclude the grey alder from conifer stands (Norādījumi par..., 1993).

It should be emphasized that considerably more than the practical use of grey alder wood, ecological role of grey alder in forest ecosystem is especially high. This is a tree species that improves the growth conditions for the more commercially valuable tree species (Indriksons, 2006). It is convincingly proved that the grey alder increases soil fertility, reducing the acidity of the soil and improving its structure, aeration, plant nutrient substance attraction (nitrogen), soft humus and mycorrhiza formation, as well as increasing the tree resistance to root rot infection (Gaitnieks et al., 2000; Rytter, 1996). However, despite the many irreplaceable grey alder characteristics, in forestry practice this tree species remained outside the forest managers' attention. In general, it can be said that so far grey alder stands have been left to grow wild, paying attention just to cutting in clear felling. It is evidenced by the forest statistics (Meža statistikas..., 2014), describing the activities in forest and their intensity in different tree species stands. Grey alder even does not have a defined final cutting age, leaving all the rights of the cutting decision to the forest owner (Meža likums, 2000). Regeneration of these stands with the same tree species – grey alder - last year reached just 5,309 ha or 13.1%. In addition, in the majority of cases (99.9%) regeneration occurs naturally and does not require any effort and expense from forest owner or legal manager.

A similar attitude has been observed in thinning of grey alder stands. For example, in year 2013 in the whole 1,641.9 ha of grey alder stands thinned were 33,710 m^3 or 20.53 m^3 ha^{-1}. Perhaps this is due to the indifferent attitude observed in practice – in the fertile soils grey alder appears naturally and forms productive stands without any human intervention. At least according to the thinning of stands, the following considerations should be evaluated and empirically verifiable. Grey alder usually forms sparse stands where individual tree crowns relatively undisturb one another to receive the necessary amount of light for photosynthesis. Where illumination decreases below the critical level, the thinnest branches, particularly the lower part of the crown, quickly die and break off together with leaves supplementing the litter layer. This process is continuous from year to year. Comparing to other species more important for forestry is the fact that grey alder litter decomposes in a year or two, constantly adding nutrients to the soil. Such substances and energy cycle ensure sustainable and balanced tree supply with the existence resources. Therefore, the annual increment in the unthinned grey alder stands is high and stable. The situation can be changed radically after the first thinning. Canopy thinning gives an opportunity to increase the capability of light influx, which leads to the loss of some small branches. Therefore, the annual amount of litter in the coming years after thinning substantially reduces. On the other hand, litter in the grey alder stands decomposes so quickly that it is often most drained by surface runoff or filter in deeper soil horizons. Consequently, it partly suspends the previous steady nutrient flow to the roots of the trees, which is a reason for the stand productivity decline. How long and strong is the influence? Is the long-term stand additional volume increase able to compensate the loss of the increment connected with the cutting of the part of the trees during the thinning? These and other issues are explained in this study evaluating the results of thinning in grey alder 24-year-old pure stands in the site type *Aegopodiosa*. The aim of the research is to analyse grey alder additional growth changes after thinning in *Aegopodiosa* site type. This work is a continuation of the authors' previous study of the productivity and rational management of grey alder stands in the site type *Aegopodiosa* (Miezīte et al., 2011).

Materials and Methods

Collection of empirical materials was carried out in two pure stands of grey alder in *Aegopodiosa* site type arranging 0.12 ha plot in each stand. In one of these stands in the year 2002 the thinning was done, in the other one – control stand was left undisturbed. Edaphic and phytocenotic situation in both stands was similar. Characteristics of the thinned stand: location coordinates X:466335 Y:6293276 (private farm Spulles); stand area 1.0 ha; species composition – 100% grey alder; age - 34 years; site index class I; stand density 0.8; stand average tree diameter was 18.0 cm; average height - 17.0 m; basal area 23.0 m^2 ha^{-1}; stock volume 189 m^3 ha^{-1}. The control stand characteristics: location coordinates X:467685 Y:6290835 (private farm Medņi); stand area 1.7 ha; species composition – 100% grey alder; age - 38 years; site index class I; stand density 0.8; stand average tree diameter was 16.0 cm; average height - 17.0 m; basal area 22.0 m^2 ha^{-1}; stock volume 185 m^3 ha^{-1}. In both stands soil characteristics is typical to *Aegopodiosa* site type - sod calcareous soil with a neutral reaction. In both stands the undergrowth *Picea abies* (L.) H. Karst, *Betula pendula* Roth, *Quercus robur* L., *Fraxinus excelsior* L. and *Acer platanoides* L. are represented, but *Padus*

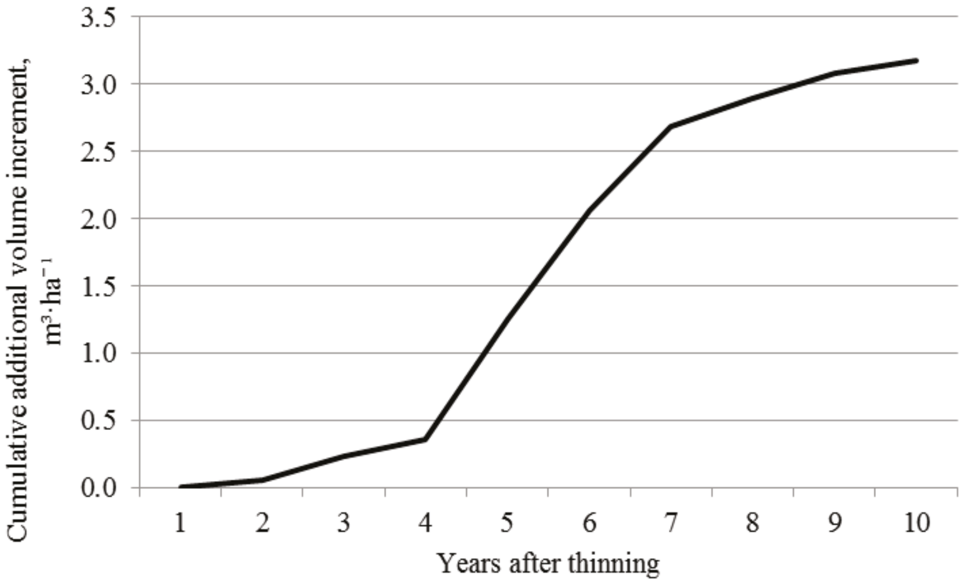

Figure 1. Dynamics of the cumulative additional tree volume increment during 10 years after the thinning in grey alder stands in *Aegopodiosa* site type.

avium Mill., *Corylus avellana* L., *Sorbus aucuparia* L. are presented in understory, and ground vegetation consists of *Oxalis acetosella* L., *Paris quadrifolia* L., *Aegopodium podagraria* L., *Urtica dioica* L. and *Anemone nemorosa* L.

Field works were implemented in October 2012. In each sample plot the diameters of all trees were measured at 1.3 m above the root collar; using ordinary dial calliper (accuracy 0.1 cm) and hypsometer SUUNTO the height of 25 trees (reading accuracy of each measurement - 0.5 m) was measured. In thinned stand using M. Pressler's auger 21 wood samples were collected. In turn, in the control stand 50 wood samples were collected. Drilling was conducted at a breast height, selection of sampled trees - random. Drilling depth was up to core, drilling direction - perpendicular to the growth axis of the trunk. Each core was put in separate straw thus preventing from breakage and drying before reaching the laboratory.

The last 20 tree ring widths of each core were measured in the laboratory with accuracy 0.01 mm using measuring table with Lin TAB system microscope and T-Tools Pro software. Before the measuring all cores were abraded and stained using dilute iodine solution for better differentiation of ring borders.

The dendrometric parameters of both stands are calculated using forest inventory methods (Liepa, 1996). To avoid misunderstanding, it should be added that the forest stand average diameter was calculated as geometric mean using all tree diameter measurements and the mean height - as a function of the average diameter trend line. Response reaction after thinning was evaluated assessing the additional tree volume increment (Liepa and Zaļkalns, 2014). Both the cumulative and the current (average periodical) additional tree volume increment are calculated. Dynamics of both kinds of additional increment are tracked for 10-year long period after thinning –starting from the year 2003 up to year 2012. Descriptive statistics is used for the data analysis (α=0.05).

Results and Discussion

Timber volume additional increment is that part of the tree or tree cluster (e.g. forest stand) increment which can be explained by the researched factor. This indicator is free from that part of increment which in a given time period should be formed without this effect. This is very important because it avoids a distorted reflection of the impact of the annually fluctuating environmental impact. Additional impact is perceived being positive if the researched influence improves the wood formation conditions and negative - if it worsens it.

It should be underlined that additional cumulative increment expresses the yield accumulation during the whole researched interval. Therefore, the figure of this parameter (Fig. 1.) represents the equalized dynamics of the investigated factor.

By contrast, the annual additional increment characterises the factor's impact annual fluctuations (Fig. 2), because of that this indicator is perfect for the meteorological analysis of the stand productivity changes (Liepa, 1996).

Both images show that the response reaction of grey alder to the stands thinning started immediately after the thinning and trend is to continue throughout

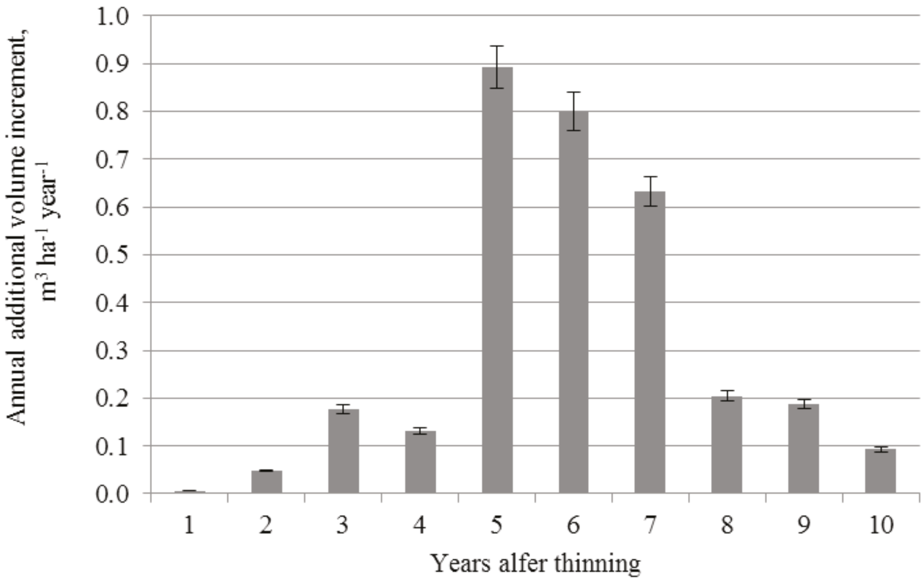

Figure 2. Dynamics of the annual additional tree volume increment during 10 years after the thinning in grey alder stands in *Aegopodiosa* site type.

all the evaluation interval (Fig. 1.). However, over the years there are distinct differences. Especially well it can be seen in the graph that shows annual additional increase (Fig. 2.). During the first four years, after thinning it is minimal and detectable only by scrupulous measurements and calculations. However, unlike a similar situation in coniferous stands where after-thinning stress in the first two or three years results in the stand productivity decline (Лиепа, 1980), in the researched grey alder stands negative additional increment is not observed. Apparently, in *Aegopodiosa* site type grey alder forest the stand adaptation to dramatically different growing conditions, which occur after thinning, is less tense, because of great amount of nutrients accumulated in the soil before. Impetuous increase of additional increment growth begins in the fifth year after the thinning and continues for the next three years, and then gradually decreases. The authors assume that the base of such tree reaction course is decomposition of felling residuals.

It is possible that grey alder stand requires at least the first four years to thinning residues get mineralized and released nutrients get involved in biomass synthesis. In addition, intensive photosynthesis regeneration happens during this period, when the canopy of left trees grows and occupies the canopy openings of felled trees. This gradually lifts up the tree growth potential. It can be seen in the fifth year after felling in our example. The potential runs out in three years and in the eighth year the yield additional annual increase indicates the trend to return to the steady state of stand as it was prior the thinning. The question remains - how many years it would take to reach balance and what will be the total effect of thinning (additional cumulative stand volume increment)?

The analysis of other tree species stands thinning effect shows that the reaction of the trees after thinning is significantly dependent on the felling intensity (Zālītis and Dubrovskis, 2002; Prindulis et al., 2013). Unfortunately, this study cannot be ascertained for two reasons. First, in the year 2002, during the thinning, the measurements of felled trees height and diameter were not performed, which excludes the possibility to calculate the amount of stand volume. Second, the dead organic matter decomposition was so intense that in autumn of 2012 there were no stumps left of the felled trees.

However, it is likely that thinning intensity was moderate. This is suggested by fact that the previous 10 years, the researched stands have successfully renewed the stand density what was before the thinning. Using P. Mūrniek's yield tables for grey alder stands (Sacenieks, Matuzānis, 1964), it is found that in October 2012 stand density was 0.73. Supporting that argument must be the fact that the overall thinning effect of the researched stand considered to be small – in 10 years the cumulative additional increment affected by thinning is only 3.17 m^3 ha^{-1} stem yield, which significantly lags behind the thinning effectiveness of other tree species stands. It is possible that it is based on a number of causes, such as grey alder stand specifics in the forest ecosystem movement of substance or delayed thinning. The optimal age for thinning of this peculiar tree species stands to raise the productivity of the forest land could be up to 10 - 15 years. This conclusion, which is quite topical for the private forest owners (around 95% grey alder stands in Latvia are owned by private forest owners (Meža statistikas CD, 2014), should be empirically approved continuing initiated series of studies of grey alder ecosystems.

Conclusions

1. The thinning of grey alder forest stand in *Aegopodiosa* site type has caused a positive reference reaction which generally can be assessed as moderate. Thinning effect over 10 years in addition to the total increase have given only 3.17 m^3 ha^{-1}, - comparing to other tree species it is considered to be negligible.
2. During the valuation interval response reaction differs among the years. In the first four years it is small, completing the canopy openings. From the fifth to the seventh year after felling an intensive growing takes place, which results in repeatedly additional annual increment. Starting from the eighth year, the trees show the tendency to return to a steady state as it was before the thinning.

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