INFLUENCE OF TREE SPECIES MIXTURE TO REDUCE WIND DAMAGES IN BIRCH STANDS

Baiba Jansone [1]
Edgars Dubrovskis [2]
Linards Sisenis [3]
[1, 2, 3] Latvia University of Life Sciences and Technologies, Latvia
[1] Latvian State Forest Research Institute Silava, Latvia

ABSTRACT

Climate change is linked to increase in frequency and/or severity of different damages in forest stands. Birch (Betula spp.) stands can be significantly affected by wind and snow (freezing rain). Aim of our study was to assess, if admixture of other tree species reduces the proportion of damaged trees in birch stands.

Data from total of 836 sample plots (size 500m^2) in birch stands at the age of up to 81 year were analysed. Among the mixed sands (MS) and pure stands (PS >80% of single tree species), the mean proportion (± confidence interval) of damage was assessed from the total number (TN) and basal area (BA) of overstory (first layer) trees. MS were further assessed in two groups – one or more species in admixture (MS+1 and MS+2).

The proportion of mixed birch stands was increasing with age: from average of 21% at the age of up to 20 years to 64% at the age of 61-70 years, most likely do to difference in historical management. In period between the 1950th and 1990th, birch was considered as undesirable species and the older stands formed mainly due to low survival of coniferous trees and natural ingrowth of birch, whereas starting from the 1990th birch was more widely recognized and used as target species.

Proportion of undamaged birch trees (both, when assessed as TN or BA) was not significantly different between MS and PS. Also presence of second layer trees did not affect the proportion of damaged overstory trees significantly. There were significant differences among the groups of mixed stands: more wind or snow damaged trees were found in certain age groups in stands with more than one admixture species present.

Creating a mixed birch stands in comparison to pure stands of the same tree species may not result in lower frequency of damaged trees, thus this approach cannot be automatically recommended as a tool for adaptation to climate change.

Keywords: *storm damage, stem breakage, uprooting, mixed stands*

INTRODUCTION

Mixed species stands are formed as deliberate management decision or as reaction to circumstances – mostly – low survival of the target species. Most common mixture in hemiboreal conditions is between birch (silver birch or downy birch, often not separated in practical forest management) and Norway spruce.

These species are also the main used in afforestation in Latvia both for planting of mixed stands (mostly spruce with birch admixture) or pure stands. Afforestation had led to increase of forest by c.a. 1% over last two decades in Latvia [1] and is important also in other countries in our region. In natural regeneration Norway spruce ingrowth in broadleaved tree stands can be observed, also creating tree species mixture, but over much longer period of time [11]. Higher productivity of the newly formed stands can also be achieved, while using the tree breeding – regeneration with plants grown from seed orchard seeds [3, 4]. In better the soils the volume gain is higher, thus also the premium for planting greater, even so the genetic gain as proportion in comparison to unimproved material is similar as in poorer soils [7]. Breeding of silver birch is profitable in Latvia [5]; its results are used to produce material for forest regeneration of c.a. 15% from the total birch final harvest areas – indicating still a notable potential for increase. Genetic diversity of such material is comparable to that found in natural regeneration. Both silver birch and Norway spruce and be propagated vegetatively, thought for practical purposes with different methods., and clonal plantations created. Such plantations have lower genetic diversity at a single stand scale. Therefore testing for the growth and branch traits as well as for vitality (resistance to different risks) is required. Some of the damages can be assessed relative late in the young stands of particular tree species. For example, occurrence of stem cracks for Norway spruce: the heritability of stem cracking is low, ca., two times lower than for the diameter at breast height [14, 15], still the selection of a single clone with this fault (at a conditions of severe drought events), can result in notable damages and thus loss for the forest owners. For the birch such birch there are less vulnerabilities that cannot be assessed at relative young age.

Silver birch management is more profitable than that of other deciduous tree species in Latvia [13], partly due to well established wood processing and thus high prices of top-grade logs. Therefore is important to reduce any risks that might affect survival of trees and outcome of such logs. Use of the best genotypes for regeneration or afforestation is one of the ways to minimize different cumulative risks over the rotation period. For example, repeated damages by cervids to the top-shoot have a negative impact to increment of young trees, when exceeding the capacity of tree compensatory growth [12]. Fast growth – combining the genetics and physiology, i.e. use of high quality plant material, often with improved root system – reduces the time period, when the tree is prone to the damage. In some cases total amount (frequency) of browsing damages can also be reduced in mixed stands, but rarely for the single target species, if that's the most affected one by a particular species of cervids. Reduction of this biotic damage becomes increasingly more important due to rise of cervid population density [12]. Most important negative abiotic factors are drought and wind. Cumulative risks to those can also be reduced using faster growing trees. The direct influence of altered precipitation regime on shoot and root biomass of silver birch plants on fertile mineral soils had been observed [10]. It can be minimized using larger, more drought tolerant plants. Also drought, often in combination of presence of dry undergrowth and/or ground vegetation, increases the fire risk, caused by people's negligence or intentional burning [9]. As faster the tree growth and increases the dimensions and bark thickness, as higher the chances for survival in the fire event. Growth in plantation can additionally be improved with fertilization: even the single (initial) fertilization can have a positive effect for up to 15 years [6]. It can also be improved with tending and maintenance of suitable moisture regime, leading to more resources available for target tree and even to formation of additional height increment in the same season [8]. Birch is rather resistant to wind damages [2], however, it is still affected. Selected management regime can minimize the risk – stands are most vulnerable (less stable) in period up to five years after the commercial thinning, thus reduced amount of commercial thinnings over the life-span of the stand decreases the cumulative probability of damages. Similarly, faster growing (selected) trees, reaching the target diameter of the stand faster, also would decrease the probability of wind damages. Admixture of Norway spruce in the stands of other tree species (e.g. birch) has been shown to increase the wind damage risk [2]. However, these results are based on assessment of a single (even so large-scale) storm. For the decision on establishment of mixed or mono-species (pure) stands, broader information is needed. Therefore aim of our study was to assess, if admixture of other tree species reduces the proportion of damaged trees in birch stands.

MATERIAL AND METHODS

Study area was Latvia, located in hemiboreal forests (57˚N, 22˚E) of Latvia (Fig. 1); it it characterized by generally mild climate with annual sum of precipitation 700-800 mm and mean air temperature in the warmest and coldest month (July and January, respectively) 18°C and -6°C, based on data of Latvian Environment, Geology and Meteorology Centre. Region is located in central part of Silver birch distribution range – this tree species has good growth and no strong limiting factors in Baltic States.

Data from total of 836 sample plots (size 500m^2), located systematically across the territory of Latvia, in birch stands (birch is a dominant tree species) at the age of up to 81 year were analysed. Sample plots were divided in two groups – pure stands (PS), where birch constitutes more than 80% of the standing volume, and mixed stands (MS). MS were further assessed in two groups – one or more species in admixture (MS+1 and MS+2, respectively). The mean proportion (± confidence interval) of damage was assessed from the total number (TN) and basal area (BA) of overstory (first layer) trees. Wind damages were specifically noted.

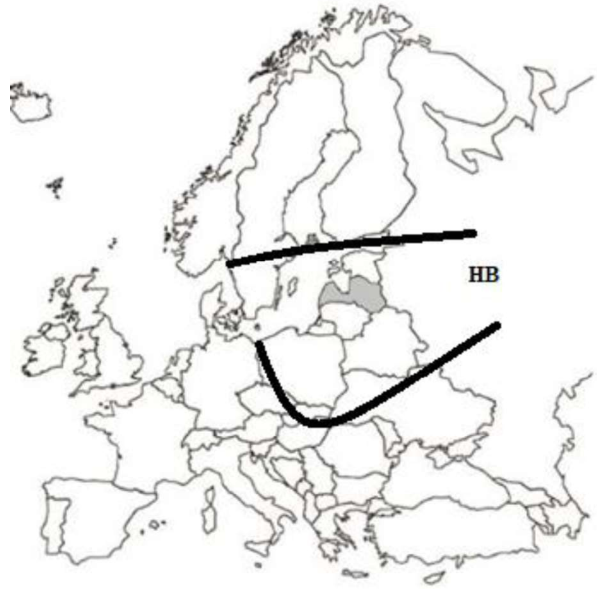

Figure 1. Location of study area and approximate borders of hemiboreal vegetation zone (HB) in accordance to FAO, 2007

RESULTS AND DISCUSSION

The proportion of mixed birch stands was increasing with age: from average of 21% at the age of up to 20 years to 64% at the age of 61-70 years, most likely do to difference in historical management (Fig. 2). In period between the 1950th and 1990th, birch was considered as undesirable species and the older stands formed mainly due to low survival of coniferous trees and natural ingrowth of birch, whereas starting from the 1990th birch was more widely recognized and used as target species. It is caused by increasing economic importance of veneer production as well as production of sawn material from broadleaved trees to a larger scale, leading to higher profitability of birch (in comparison to other broadleaved tree species) from the perspective of forest owner [13]. Also birch is less affected by browsing damages and thus preferred in regeneration as population density of cervids is increasing [12]. Natural regeneration of this tree species is abundant, thus most of the young stands had been formed in this low-cost way.

The chronosequence approach is used in our study, not a set of stands followed through a long period of time. Therefore it may as well be, that part of the current MS birch stands initially had been coniferous stands, that, and the due to higher mortality related to different causes (e.g. bark beetle infestation) may have changed to birch-dominated stands.

Overall limited amount of birch trees with damages were observed – the proportion of undamaged trees ranging from 94.0% to 99.2% and decreasing gradually with stand age (Fig. 2). It might be an effect of birch being rather little affected by different damaging agents [2], [12], [13]. Also the data collection method may have influence the result – if the storm or massive snow, ice amount affects the stand, causing most of the trees to be damaged, salvage logging operation usually is carried out promptly, thus there is limited probability, that the sample plats would be assessed between the time of damage occurring and the time of removal of damaged trees. Therefore our results presumably would represent the overall level of smaller-scale disturbance better than the catastrophic ones.

Proportion of un-damaged birch trees (both, when assessed as TN or BA) was not significantly different between MS and PS. Thus the deliberate admixture of other tree species would not automatically lead to reduced amount of damages. Also presence of second layer trees did not affect the proportion of damaged overstory trees significantly. This finding may be used in the practical management, where second-layer of Norway spruce if formed under birch trees [11], adding the financial value for the stand and creating a mixture in the vertical structure.

There were significant differences among the groups of mixed stands. The proportion of undamaged trees in age class of 41-60 years in MS+2 (0.993±0.014) was significantly, but not notably, higher than in MS+1 (0.925±0.045). Also there were no trees damaged by wind or snow in this age group in MS+, but a notable share (both from TN and BA) in MS+2. In age group of 61-70 years in MS+2 the proportion of damaged trees by wind and/or snow was 0.018±0.016 from the BA.

Small (in absolute values) proportion of damaged trees is still of practical importance, since the damages can accumulate in the stands over time. Typically, damaged trees are removed in commercial thinnings, however, with consideration of changing wind climate, management with less (or no) commercial thinning is recommended. Also initial planting density has been gradually decreasing due to rising planting costs and this trend might continue, with mechanised planting becoming more common. Thus survival and good quality (no damages) of every single tree will become increasingly more important.

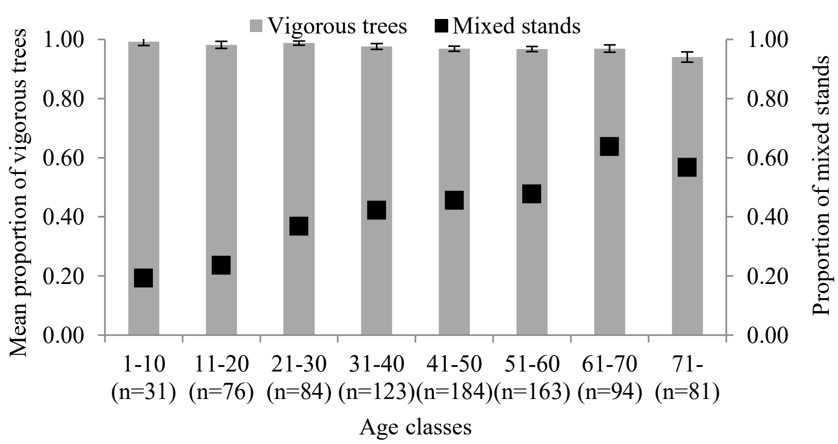

Figure 2. The proportion of vigorous (no any damages) tress (±confidence interval) in silver birch stands.

CONCLUSION

Establishment of mixed stands is often included in the recommendations and normative regulations as a measure to reduce the damages in the forest. However, the proportion (from the total number as well as from basal area) of overstory (dominant) birch trees without any damages was not significantly different between mixed and pure (mono-species) stands. Also presence of second layer trees did not affect the proportion of damaged overstory trees significantly. There were significant differences among the groups of mixed stands: more wind or snow damaged trees were found in certain age groups in stands with more than one admixture species present. Creating a mixed birch stands in comparison to pure stands of the same tree species may not automatically lead to reduced proportion of damaged trees (thus economic loses for the owner and society at large). More nuanced approach is needed in recommendations and consequently forest policy documents (normative regulations) to improve resilience and adaptation to climate change linked increase of disturbances. Such approach requires empirical information on the frequency of particular damaging agent (e.g. wind), potential amount of damages as well as the degree (how) and underlining mechanism (how much) the damages can be reduced with (particular) tree species mixture at the stand scale.

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