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Floristic diversity responses in young hybrid aspen plantations to land-use history and site preparation treatments

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ABSTRACT

Floristic diversity was studied in 7- to 8-year-old commercial hybrid aspen (*Populus tremula* L. × *Populus tremuloides* Michx.) plantations on abandoned agricultural sites with a different land use (grassland or crop field) and site preparation (whole-area ploughing or strip tillage) history. The aim of the study was to investigate how the understorey vegetation had developed in such repeatedly disturbed communities and which environmental variables had significantly affected this. A total of 204 vegetation plots (2 m × 2 m) were established within 51 experimental areas; vegetation descriptions were compiled, concentrations of total N, extractable P and K, and pH of the soil humus layer were determined, and canopy cover of the trees was estimated. Weighted average Ellenberg values for light, moisture, pH, and nitrogen, as well as several life-history characteristics, were calculated for the vegetation plots. Altogether 191 vascular plant species were described: on average 16.7 ± 0.4 species per plot and 28.6 ± 1.1 species per experimental area. Former land use and site preparation method had a significant impact on the position of vegetation plots in detrended correspondence analysis (DCA) ordination, confirmed also by the multiresponse permutation procedure (MRPP). Soil characteristics were significantly correlated with DCA axes. Former land use and site preparation method also affected the species composition. All sites were dominated by competitor species; ruderals were represented in a higher proportion in former fields and whole-area ploughed sites. Species richness and Simpson's diversity index were higher in plantations where strip tillage had been used for site preparation and lower on sites with higher nutrients concentrations in the humus layer. Generally, overstorey vegetation, characterized in the current study using canopy cover, had not started to affect understorey vegetation in young plantations. Application of less intensive site preparation methods is recommended in order to support higher species richness and lower share of ruderal species.

1. Introduction

As a result of the rising demand for timber, pulpwood, bioenergy and several other products from woody plants, the area under forest plantations is continuously increasing in the world (Evans, 2004; FAO, 2005). Further advantages of plantations include the reduction of timber harvested from natural forests and the accumulation of atmospheric carbon in order to slow down global warming. Meanwhile, more attention is paid to the biodiversity of forest plantations, including floral diversity (Moore and Allen, 1999; Hartley, 2002).

Hybrid aspen (*Populus tremula* L. × *Populus tremuloides* Michx.) has received attention in the Baltic Sea region due to its fast growth, cold-hardiness and suitability for the production of pulpwood and bioenergy. It has been recommended as an alternative species for the afforestation of abandoned agricultural lands (Liesebach et al., 1999; Karacic et al., 2003). Recent studies have mainly focused on biomass production, clonal tests, and site-growth relations of hybrid aspen (Yu and Pulkkinen, 2003; Karacic et al., 2003; Rytter and Stener, 2003; Rytter, 2006; Tullus et al., 2007). Studies of floristic diversity have been rare in commercial hybrid aspen plantations in the Baltic Sea region. The floristic diversity of hybrid aspen plantations has been briefly analysed together with other fast-growing poplar plantations on former arable land in Germany (Heilmann et al., 1995) and Sweden (Weih et al., 2003) and in exhausted oil shale quarries in Estonia (Tullus et al., 2008).

Typical secondary successional processes cause changes in the understorey vegetation of forest plantations with additional influences coming from the tree canopy and root-related factors

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(Brockerhoff et al., 2003; Newmaster et al., 2006). Thus, plantation age is associated with plant species composition, richness, and diversity. Young plantations have shown higher species diversity and richness compared to older plantations. This is due primarily to colonization by light-demanding ruderal species, which are suppressed as soon as light availability in the ground layer decreases (Nagaike et al., 2003). Forest species tend to increase in abundance during succession, depending on distance from colonization sources (Dzwonko, 2001; Verheyen et al., 2003). In the current study, we investigated whether the overstorey impact on the understorey vegetation characteristics is significant in young sparsely spaced hybrid aspen plantations on abandoned agricultural land.

Silvicultural treatments used for plantation management also play a significant role in vegetation development (Lindgren and Sullivan, 2001; Nagaike, 2002; Ito et al., 2006; Nagai and Yoshida, 2006), and may even set a plant community back to an earlier successional stage. Site preparation is common practice in the establishment of plantations. Depending on the nature and intensity of the site preparation method, some or the majority of the existing vegetation could be removed, consequently affecting the species richness and diversity of the plant cover (Haeussler et al., 2002; Newmaster et al., 2007). We compared the understorey responses to two site preparation methods with different intensities (strip tillage and whole-area ploughing) in young plantations.

Land use history is another important factor affecting the vegetation of forest plantations (e.g. Ito et al., 2004; Wulf, 2004; Gachet et al., 2007). Former land use impacts soil structure and chemistry, consequently influencing the succession of the understorey, and this effect may remain visible for long periods of time, varying from decades to centuries (Honnay et al., 1999; Graae et al., 2003; De Keersmaker et al., 2004; Falkengren-Grerup et al., 2006). The significant relations between physicochemical soil properties (e.g. moisture conditions, pH, concentrations of the major mineral nutrients) and vegetation traits in plantations have been described in several studies (Ferris et al., 2000; Lu et al., 2006; Prach and Řehounková, 2006). We included the physicochemical soil properties and former land use (crop field or grassland) as potential site factors when explaining the variation in the understorey vegetation characteristics.

The aim of the current study was to investigate how understorey vegetation characteristics in young commercial hybrid aspen plantations are related to previous agricultural land use, site preparation method used for the establishment of these plantations, physicochemical soil properties and overstorey canopy cover. The following hypotheses were formulated:

(i) a less intensive mechanical site preparation method (strip tillage) will support higher vascular plant species richness (S) and diversity (D') compared to full-area ploughing;
(ii) differences in the concentrations of the major mineral nutrients, the acidity of the humus horizon and the moisture condition of the previous field soils will affect vegetation patterns;
(iii) former agricultural land use (crop field or grassland) and site preparation method will affect the species composition;
(iv) the overstorey will influence the understorey vegetation characteristics.

2. Materials and methods

2.1. Study area

The study uses 7- to 8-year-old commercial hybrid aspen plantations established in 1999 and 2000 on former agricultural land mostly in the southeastern and central part of continental Estonia (Fig. 1, Table 1). The land had previously been used as crop fields (number of experimental plots $n = 28$) or grassland ($n = 23$). Before planting 1-year-old micro-propagated hybrid aspens belonging to 27 clones (Tullus et al., 2007), site preparation was carried out. The plantation areas were either ploughed completely ($n = 18$, referred

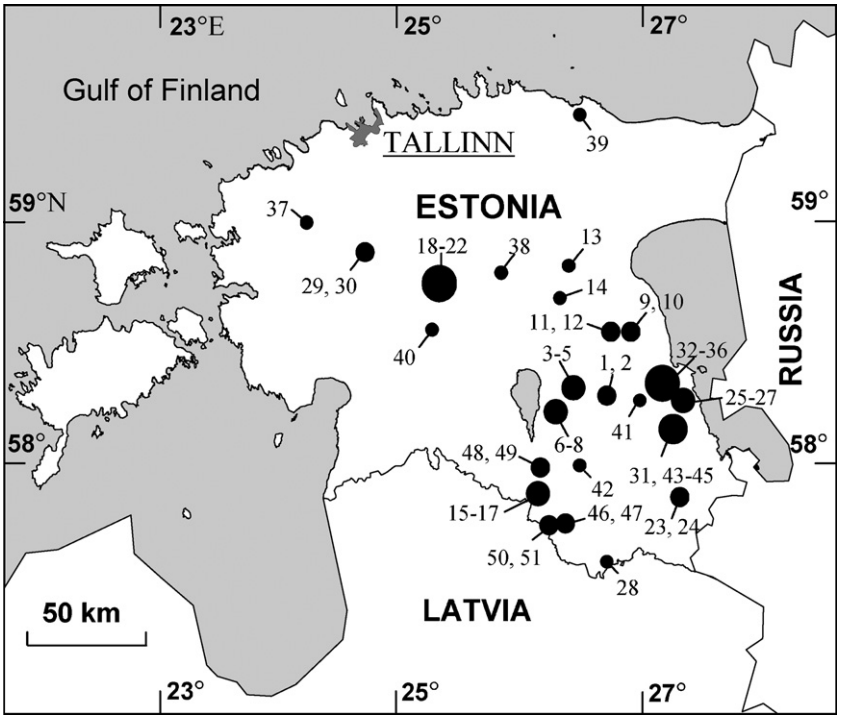

Fig. 1. Locations of the studied hybrid aspen plantations (marked with black dots) and experimental areas (size of the dots is related to the number of experimental areas within the plantations). Numbers of the experimental areas are explained in Table 1.