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Silver fir sapling bank in seminatural stand: Individuals architecture and vitality

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Abstract

The relations between age, crown architecture, height and height increment of silver fir (*Abies alba* Mill.) saplings were analysed using a multivariate method. Individuals from the saplings bank in mixed, unevenly aged, seminatural stands in Western Poland were investigated. Examined features were analysed with respect to light availability, which varied between 5.9 and 25.8% of full sunlight. The age of firs in the saplings bank varied from 11 up to 101 years. Under shade, growth is suspended and saplings tend to form a flat crown. Reduction of growth of a sapling did not influence its mortality, and did not diminish its ability to vigorously grow for up to 90-year-old saplings. Results of the PCA showed that age was not connected with sapling size, growth or crown morphology. Height increment is related to the relative crown length (RCL) and to the size of the sapling. In looking for an objective and quantitative indicator of growth potential, results suggest the RCL as a feature not influenced by sapling size. It should be pointed out that the vitality defined in this way reflects only the current growth, but not the potential to survive or the ability for rapid growth along with a changing light environment. The apical dominance ratio (ADR) value seems to be an indicator of light conditions in the understorey, but this trait is influenced by the height of the sapling.
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Keywords: *Abies alba*; Natural regeneration; Age structure; Crown morphology; Understorey light; Vitality

1. Introduction

A major challenge for modern silviculture is to reconcile the timber production function with the recreational and ecological functions of forest ecosystems. Most of this challenge regards the development of close-to-nature silvicultural systems, based on natural ‘‘self-regeneration’’ (Bergeron and Harley, 1997; Hüttl et al., 2000; Schütz, 2001). An interesting silvicultural concept, selection forest treatment (often called ‘‘plentering’’), is able to connect both the ecological and the financial forest functions. This kind of management is possible in areas with suitable forest growth conditions, in the zone of natural silver fir (*Abies alba* Mill.) distribution (Schütz, 2001). Silver fir is a component of non-managed natural, mixed, multi-layer canopy and unevenly aged forests in Central and Western Europe (Faliński and Pawlaczyk, 1993). Fir is known

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to be one of the most shade-tolerant European tree species (Brzeziecki and Kienast, 1994). The strategy of coexistence of fir in a mixed forest is the production of a durable saplings bank (Faliński and Pawlaczyk, 1993). Fir saplings establish themselves mainly in the heterogeneous environment of the northern margin of canopy gaps (Diaci, 2002; Grassi et al., 2004), but they are less numerous in centers of large gaps than under the dense crown (Grassi et al., 2004). With the creation of canopy gaps, fir saplings waiting under the canopy, in the form of a sapling bank, are likely to respond with more vigorous growth (Grassi et al., 2004), usually after a period of acclimation to the changed light environment (Robakowski et al., 2003). Older saplings, which were established prior to the gap creation, mainly refill the gap, because they have a size advantage when compared to individuals established after the creation of the gap (Grassi et al., 2004).

Successful management of naturally renewing forests requires information not only about the number of saplings, but also about their potential for survival and continued growth, namely vitality or vigour. According to Givinish (1988), growth is an integrated measure of the whole-plant carbon balance, which ultimately determines mortality. Because sapling carbon balance is mostly light limited, mortality is often assessed as a function of light (Kobe et al., 1995). On the other hand, silver fir saplings are physiologically and morphologically suited to low PPFDs (Grassi and Bagnaresi, 2001; Robakowski et al., 2003, 2004). In low-light environments the saplings of shade-tolerant species are able to reduce their growth without dying (Kobe et al., 1995; Parent and Messier, 1996; Kobe and Coates, 1997). Additionally, it is known that growth changes with saplings size or age (e.g. Duchesneau et al., 2001; Claveau et al., 2002). Therefore, it is not clear what the relationship is between mortality, growth and vitality of silver fir saplings.

The aim of this study was to assess the relationships between age, crown architecture, size and height increment of fir saplings in semi-natural, mixed forests. These features were analysed with respect to light availability. Additionally, simplified traits for quantitative assessment of fir sapling vitality are discussed.

2. Study area

The study site is situated in Trzebnica foothills (Western Poland) with a mean elevation of 100–150 m a.s.l. The average annual temperature is 7.7 °C (January 1.7 °C, July 17.4 °C), the annual average precipitation is 550–560 mm, 60% of precipitation takes place during the growth season (Walczak, 1970). The average annual concentration of SO_2 in air is about 6 $\mu g/m^3$, the NO_2 concentration in air is about 16–18 $\mu g/m^3$.

The sampling plots were established in three natural reserves, which protect the silver fir on its northern distribution boundary (located in area from 51°17′N, 16°47′E to 51°25′N, 17°59′E). The reserves were established in the 1950s, silvicultural treatments were confined to sporadically removal of old, dead trees, and unsuccessful attempts at planting firs. The history of management of these stands before 1950 was unknown, due to historical and political changes of this area. The soil was mainly acid brown and haplic luvisols, often with gley process in deeper parts of the profile. The foliar and soil chemistry analysis indicated that nutrient availability did not limit sapling growth in those sites (Szymura, in preparation).

2.1. Stand structure

These stands were unevenly aged, mixture of coniferous and broad-leaved trees. Dominant species were *Picea abies* (35% of the basal area), *Pinus silvestris* (18%), *Abies alba* (16%), *Quercus petraea* and *Q. robur* (10%), *Fagus silvatica* (9%) and *Larix decidua* (8%). Other species like *Betula verrucosa*, *Tilia cordata*, *Carpinus betulus*, *Sorbus aucuparia* and *Ulmus scabra* occupy about 5% of the total basal area. The mean tree density was 463 stems/ha, with a mean basal area of 26 m^2/ha. These stands are a mosaic of patches in different developmental phases, thus differing in trees density, size, and light conditions. The vertical structure was multilayered. The highest, around 35–40 m, were spruces, larches, pines, beeches and firs. The middle layer was formed by the younger individuals of these species and birches. The hornbeams, limes and elms were present only in the lower layer. The total basal area consisted mainly (70%) of trees from upper stands layer (higher than 30 m). Canopy gaps of different sizes were present in the stands.

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