Folia Forestalia Polonica, series A, 2010, Vol. 52 (2), 76–82

ORIGINAL ARTICLE

Annual dynamics of natural regeneration of silver birch (*Betula pendula* Roth) on a research plot located in the area of forest decline in the Silesian Beskid Mountains

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Abstract

The study shows a high dynamics approximately five-year-old natural regeneration of silver birch (*Betula pendula* Roth) growing on the research plot located in the fertile mountain habitat in the middle of the lower montane forest zone in the Silesian Beskid Mountains (Beskid Śląski) compared to its co-occurring species. The dynamics is expressed as a significant annual increment in height and diameter of birch trees, leading in consequence to the appearance of an older sapling phase for most regenerations of this species. This creates the possibility of early undercanopy planting of tree species adjusted to the site conditions, mainly silver fir (*Abies alba* Mill.) and European beech (*Fagus sylvatica* L.).

Keywords

decline forest area, conversion, regeneration development, Silesian Beskid Mountains, *Betula pendula*

Introduction

Silver birch (*Betula pendula* Roth) has a wide territorial range, extending mainly on the temperate and boreal zones in Europe and Asia, also encroaching into the lower montane areas (Browicz 1979; Ceitel 1994; Ceitel and Iszkuło 2000; Zhukovskaya and Ulanova 2006; Hynynen et al. 2010). Because of its extensive area of occurrence and pioneering character, silver birch can colonize sites with different soil fertility and moisture, as well as with a wide amplitude of climatic conditions (Zarzycki 1979; Falińska 1996). The diversity of environmental conditions results in different birch growth rates. However, this growth is usually much higher, particularly at a young age, than the rate of diameter and height increment in most of the species which came to coexist with birches (Braathe 1988; Karlsson et al. 1997; Ceitel 1994; Ceitel and Iszkuło 2000; Zhukovskaya and Ulanova 2006).

The large-scale decline of Norway spruce [*Picea abies* (L.) H. Karst.] forests over the past two decades of the 20th century occurred mainly in the Sudetes on both sides of the Polish-Czech border, as well as in the Ore Mountains near the German-Czech border (Boratyński et al. 1987; Fabiszewski and Wojtuń 1994; Vacek and Balcar 2000; Vacek et al. 2000). In the Carpathians, this process intensified during the first decade of the 21st century, mainly in the Silesian and Żywiec Beskid

Received 30 July 2010 / Accepted 3 November 2010

Mountains (Grodzki 2004; Szabla 2004). The degradation of spruce stands has led to the appearance of large open areas encouraging the succession of pioneer species, including birch, into the mountain areas devoid of tree cover (Ceitel 1994; Gorzelak 1995; Ceitel and Iszkuło 2000).

The usefulness of transitional birch communities for forest management under the forest decline conditions in Western Sudetes has been noticed and described (Ceitel 1994; Ceitel and Iszkuło 2000). The authors pointed to birch as the species that might delay the introduction of target species. However, the minimum age of birch regeneration at which planting of species adequate to the conditions of mountain sites could take place was not clearly defined. The early introduction of these species allows shortening of the period of stand development to become more stable and adjusted to site conditions. This age is closely related to the high dynamics of young birch trees in an open space.

Currently, colonization by birch communities of some areas affected by the disasters that occurred in the Silesian and Żywiec Beskid Mountains gives a chance for the quick transformation of their species compositions adequate to site requirements. To initiate efforts in this direction, it is necessary to know the dynamics of birch natural regeneration under the conditions of forest decline in the Carpathians. The measurements taken in the framework of the pilot study and the preliminary results obtained are an attempt at drawing attention to this problem and to the need to continue and develop the research.

Materials and methods

The research was conducted in 2008–2009 in the area of a large-scale *Picea abies* forest decline in the Babia Góra Massif of the Silesian Beskid Mountains, in the Carpathians (Southern Poland). The object of the study was natural regeneration of *Betula pendula* which had colonized the area exposed after the removal of damaged and dead spruce stands (Fig. 1). This regeneration developed on the south-east-facing slope, in the middle of the lower montane forest zone, on the fertile mountain site with *Dentario glandulosae-Fagetum* as a potential plant association.

The research plot was located in a place where natural regeneration of birch assessed on the basis of a survey of the whole study area showed an average growth in number and height. The plot was a 20 × 20 m (0.04 ha) square, situated at an elevation of 800 metres above sea level, compartment 151a in the territory of the Węgierska Górka Forest District. The oldest birch trees were five years old.

The measurement methods applied on the research plot included:

- counts of all trees by development phase and species:
  - seedlings of 0 to 50 cm in height,
  - younger saplings of 51 to 130 cm in height,
  - older saplings of 130 cm in height and dbh up to 7 cm;
- measurements of dbh by tree species (older saplings only),

Fig. 1. Area of *Picea abies* forest dieback in the first year after deadwood removal (left picture) and five years later (right picture)

- measurements of tree height in all developmental phases of regeneration occurring on the research plot.

In order to determine the dynamics of birch regeneration on the research plot, the measurements were repeated after a year.

Results

The first measurement showed that the number of trees per hectare was 16,250. The share of seedlings was 48 per cent, of younger saplings – 50 per cent, and of older saplings – only 2 per cent. Species composition of the regeneration was as follows: the share of spruce and birch was similar, 44 per cent and 43 per cent, respectively, of European rowan (*Sorbus aucuparia* L.) – 9 per cent, of goat willow (*Salix caprea* L.) – 2 per cent, and the remaining 1 per cent comprised sycamore maple (*Acer pseudoplatanus* L.), European beech (*Fagus sylvatica* L.), common aspen (*Populus tremula* L.) and silver fir (*Abies alba* Mill.). The area covered by regeneration was approximately 50 per cent. The regeneration featured a cluster distribution (Fig. 1 – right picture). Spruce dominated in numbers in the seedling development phase, while birch – in the younger sapling development phase and was the only one of all the species that reached an older sapling phase (Fig. 2). Therefore, in spite of a slightly lower number of birch trees compared to spruce trees, the position of birch in the regeneration structure may be considered dominant.

A year after the first inventory, the number of species such as spruce, birch, rowan, willow and aspen was found to slightly increase (Fig. 3). This shows that the natural regeneration of the examined tree species continues. Single larch seedlings appeared. The number of beech and fir trees did not change, while no sycamore seedlings were found. This illustrates a low survival of seedlings of this species. The regeneration area increased to about 80 per cent.

Due to a fast height growth of birch regeneration, the percentage of seedlings and younger saplings phases changed over a year in favour of the older sapling phase (Fig. 4). Such changes were minor in respect of both spruce and other species, causing a much lower growth dynamics for these species.

Also the breast height diameter distribution in the older saplings that occurred over a year testifies to the significant development of birch regeneration (Fig. 5). While the first measurement showed the presence of only a few birches representing this phase of development in the lowest dbh classes measured (less than 1.0 cm and from 1.1 to 2.0 cm), the second measure-

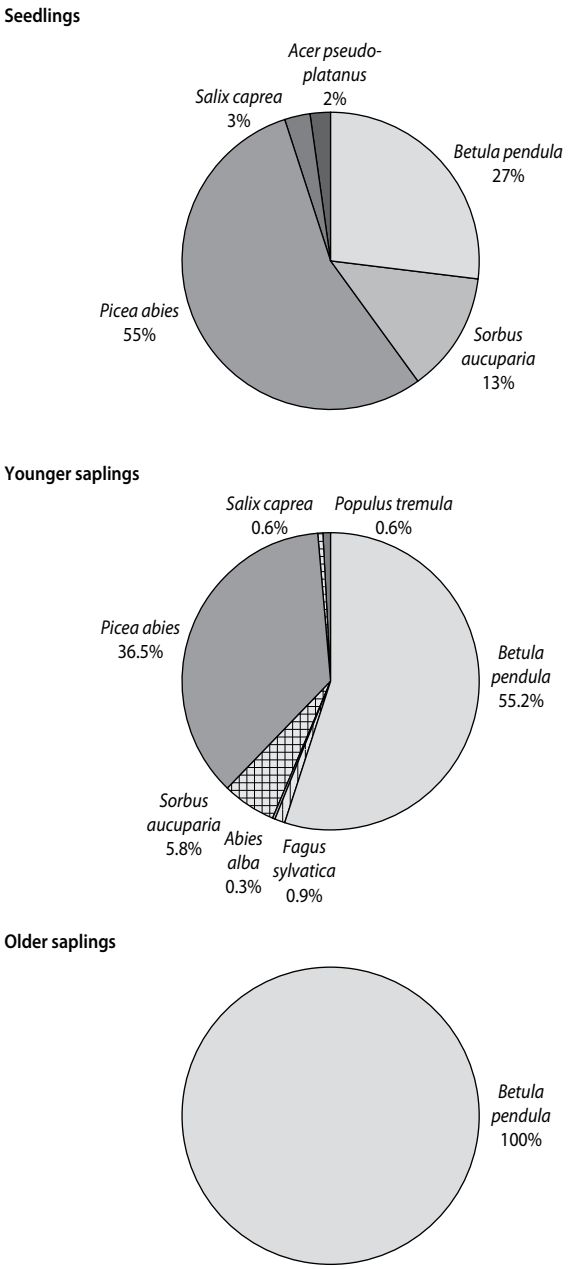

Fig. 2. Species composition of development phases of approximately five-year-old natural regeneration of *Betula pendula*, with a percentage share of ongoing spruce natural regeneration in the area of forest decline in the middle of the lower montane forest zone

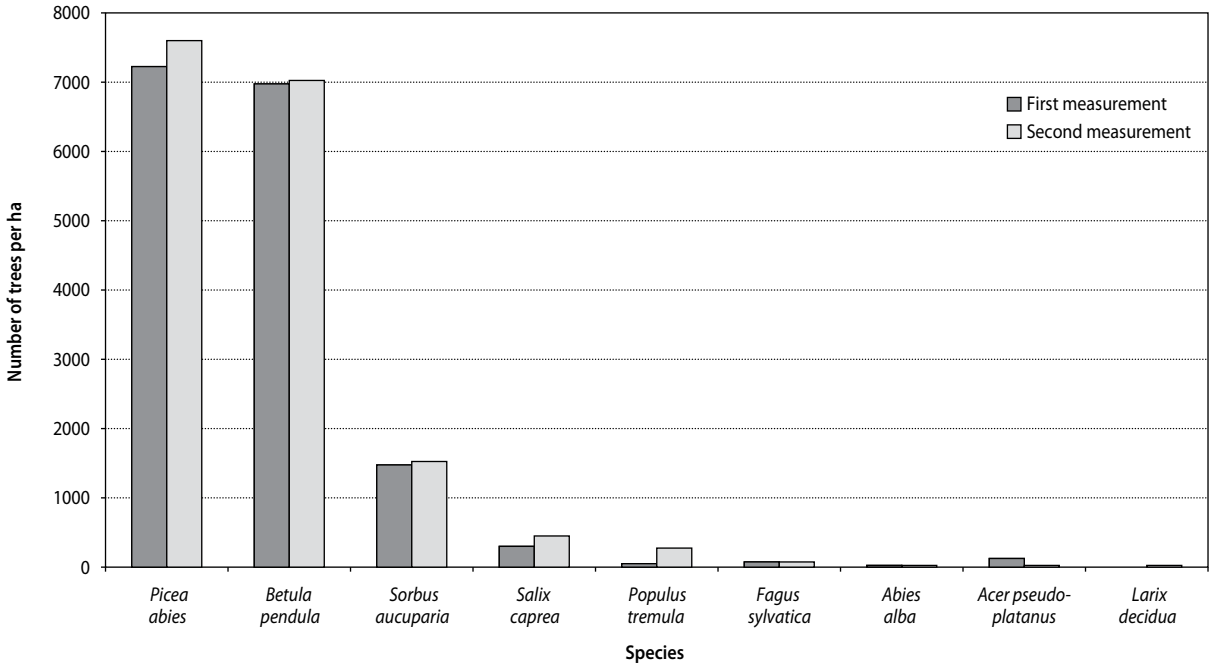

Fig. 3. Changes in the number of trees by species in regeneration on the research plot, determined on the basis of two consecutive measurements taken in one year interval

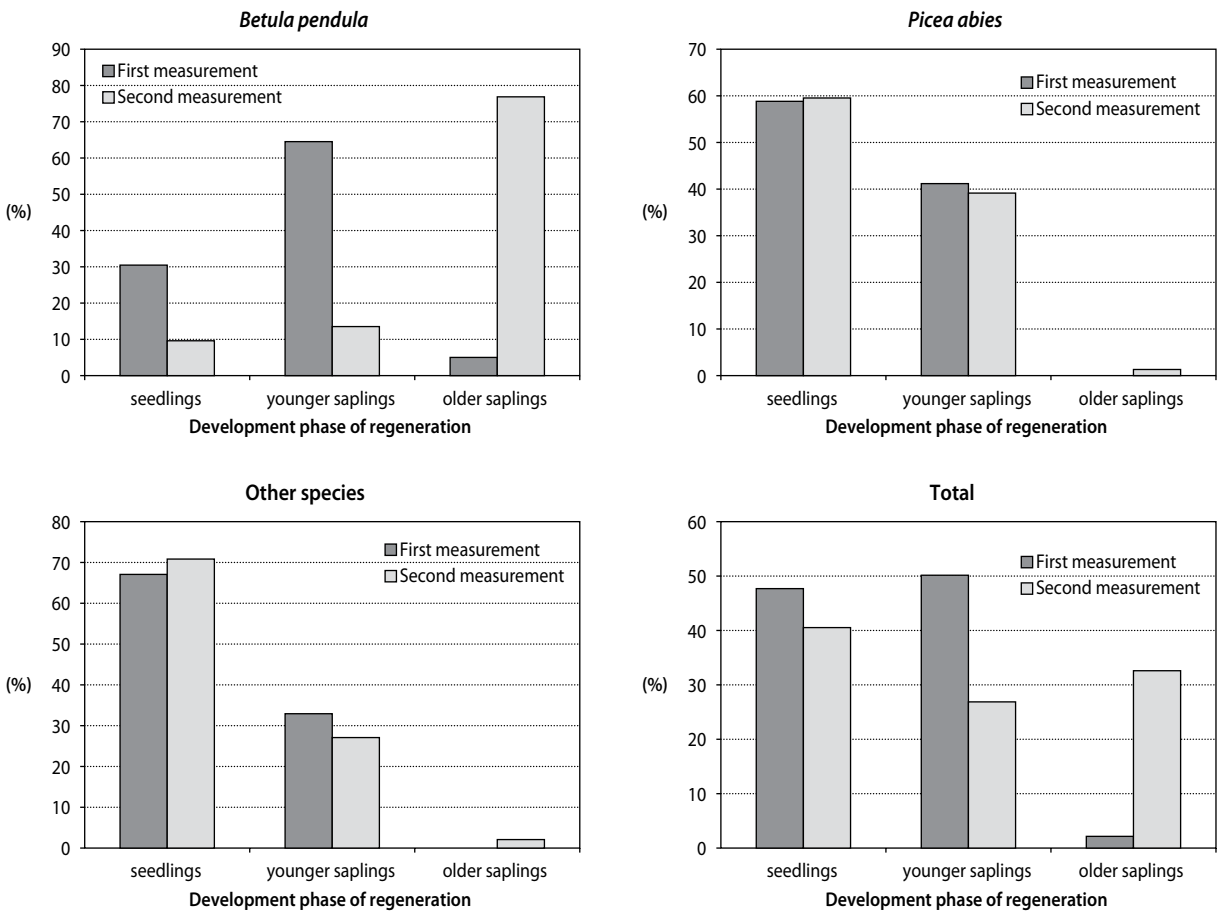

Fig. 4. Percentage share of development phases on the research plot, determined on the basis of two consecutive measurements taken in one year interval

ment showed a fifteen-fold increase in the total number of older birch saplings, and their thickness expressed by diameter at breast height exceeded 4 cm.

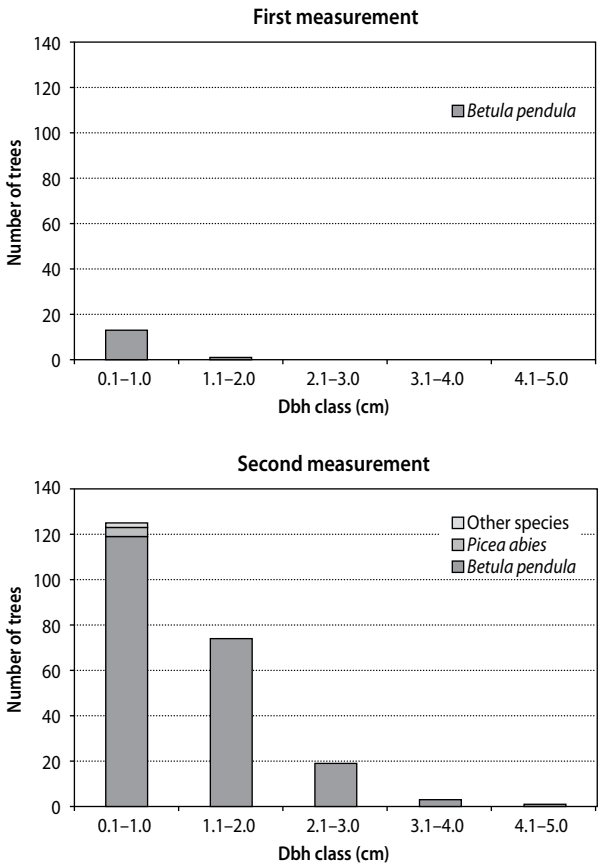

Fig. 5. Dbh distribution of older saplings on the research plot, determined on the basis of two consecutive measurements taken in one year interval

Changes which occurred over a year also relate to the average height of birch regeneration in its development phases. In the younger phases, where shift of individual trees from one height classes to another occurred, these height averages show only slight fluctuations. A substantial increase in average height occurred in the oldest phase of development, which was in this case the older sapling phase. The average height increment is the result of a fast growth of birches, a large number of which reached the dimensions far exceeding the minimum height limit for older saplings. Although during the same period few spruce trees reached the dimensions allowing their classification into the older sapling phase, their average height in this phase is almost twice lower than in the case of birch (Fig. 6).

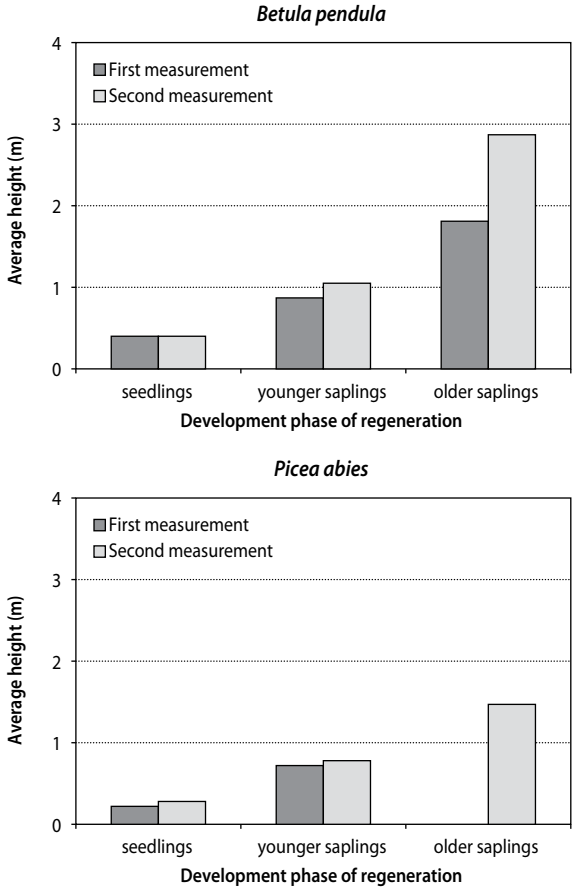

Fig. 6. The average height of *Betula pendula* and *Picea abies* regeneration in individual development phases, determined on the basis of two consecutive measurements taken in one year interval

Discussion

The fast growing ability of birch in young age classes (Ceitel 1994; Karlsson et al. 1997; Ceitel. and Iszkuło 2000; Huth and Wagner 2006; Hynynen et al. 2010), as well as the possibility of using birch nurse crop to shape species compositions adequate to site conditions, including areas of forest decline (Ceitel 1994; Ceitel and Iszkuło 2000; Vacek and Balcar 2000; Vacek et al. 2000) is widely known. However, the disparities in growth rates between the regeneration of birch and other co-occurring species, including target species, make us consider another aspect of birch stand

conversion not discussed earlier. This aspect refers to the possibility of an early start with the introduction of target species (mainly beech and fir). The above mentioned authors considered the opportunity to focus on other activities relating to the large-scale decline of spruce stands and delaying stand conversion (for several years or decades?), as the main advantage of the presence of birch regeneration on decline forest areas in the mountains. Meanwhile, those involved in current forest management practices, taking into account also economic reasons, are reluctant to decide on retaining for a longer period of time pioneering birch communities, believing, that the profitability of birch production in relation to other species is lower. Counting on higher economic benefits in the future, decisions are often made about removing birch and exposing the natural regeneration of spruce that occurs under its canopy, in spite of the fact that stands with spruce as a dominant species are not adjusted to the local site requirements.

An alternative solution, which offers many more benefits, would be the introduction of target species already when birch regeneration is aged 5–6 years. Its aim is that the birch at this age reach an older sapling phase followed by a very dynamic height growth. In such a case, the average height of older birch saplings aged 6 years, reaching nearly three meters, makes it possible to provide cover for the introduced fir and beech. The advantages of the proposed solution include: maximum shortening of the period with a transitional birch community and reaching, in a short time, the species composition adequate to site requirements.

To make this possible, it seems necessary to fulfil also the following requirements:

– introduction of target species to the plots where, at the beginning of the older saplings phase, pioneer species cover a minimum of 50–60 per cent of the area,
– control and regulation of the quantity of the ongoing spruce natural regeneration, as not to threaten the growth of introduced species,
– regulation of the competition for space and light between the expansively developing birch trees and target species,
– effective protection of introduced species against damage caused by deer.

Because of the pilot character of the undertaken research providing just modest evidence, some questions still remain open:

– the possibility of applying the described method to other mountain sites (mainly of medium site quality) with different birch growth dynamics,
– maximum altitudinal range in the Carpathians where the percentage cover of birch regeneration is large enough to use it for species composition conversion.

Conclusions

– The research proved high growth dynamics of approximately five-year-old natural regeneration of birch in the conditions prevailing on the research plot located on the fertile mountain site, in the middle of the lower montane forest zone in the Silesian Beskid Mountains, compared to its co-occurring species.
– This dynamics is expressed by a significant annual diameter and height increment in birch, leading in consequence to the older sapling phase for most regenerations of this species.
– The high growth dynamics of natural birch regeneration creates the possibility of early planting under the canopy of stands with site-adjusted-species, mainly silver fir and European beech.

Acknowledgements

I wish to express my cordial thanks to Dr. Mieczysław Kosibowicz for inspiring me to take up this topic and for his valuable assistance in the fieldwork.

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