The use of pioneer tree species in the restoration of forest openings after salvage felling in the Czech Republic

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ABSTRACT

Spruce, and in many places, pine forest stands in the Czech Republic are affected by dieback, which has accelerated since 2015. As a result, there is a need to restore forest openings caused by salvage felling, whose enormous size and total area in the Czech Republic require specific management approach methods. Previous, less frequent approaches to forest restoration, including multi-phase forest regeneration, were being explored. There is also an attempt to use pioneer tree species in forest regeneration. An example is silver birch (Betula pendula Roth.). This implies a change in how silver birch is viewed by Czechs—from a weed tree species to an economically attractive alternative. The economic viability of birch is enhanced by the use of natural regeneration. Therefore, it can be concluded that birch as a pioneer tree for climax species does not affect the economic efficacy of management of a forest property which, by its size, provides the owner with a sustainable yield. On the contrary, the results of the modelled economic calculations show a positive effect on the modelled average annual gross profit of forest production. The summary and comparison of the research results further underscore the importance of the price level of raw timber assortments. The results are useful for both large and small-scale forest owners, who achieve a sustained yield from the perspective of the forest property size.

KEYWORDS

economic efficiency, regeneration, declining spruce, forest management

1 INTRODUCTION

In recent years, Czech forestry has been addressing an issue of declining spruce stands at lower and middle altitudes, especially in northern Moravia. This causes an increase in the amount of salvage felling, resulting in an increase in the volume and cost of silvicultural operations. It is necessary to implement more costly measures to afforest forest openings which often merge into large areas due to the increasing share of salvage felling in threatened areas. Devitalized spruce stands, thinned by salvage felling, often fall victim to destructive winds. Such quickly spreading disaster areas are exposed to natural seeding of pioneer tree species, especially the silver birch (Betula pendula Roth.). The forest openings are not only more difficult and expensive to afforest with target production tree species, but the young forest stands also become more problematic to establish, often requiring multiple removals of weed tree species, including birch (Dudík et al., 2018). Changing the view of the birch from a "weed tree species" to a "worthy" alternative production species was analysed within a project of the Grant Service of the Forests of the Czech Republic, state enterprise, called "Ekonomika a pěstování březových porostů jako alternativa obnovy chřadnoucích smrkových porostů v České republice / The economics and silviculture of birch stands as an alternative to the regeneration of declining spruce stands in the Czech Republic" (Dudík et al., 2021a). Some of the methods and results of that project are presented in this article.

Efforts to change the species composition of forest stands are significantly related to the impacts of climate change. In the Czech Republic, the economic and production effects of tree species change as a result of adaptation to climate change have been addressed, for example, by Remeš (2020). Presently, after a change in Czech legislation (see Decree No. 298/2018 Coll.), birch is even considered a soil-improving tree species in most soil habitats. In terms of the legal framework, this provides a greater opportunity for birch to be used in forest regeneration.

Modelling and decision-making on the forest species composition from the viewpoint of economic efficiency have a long tradition in the Czech Republic. Recently, many papers were published on the topic, e.g., Pulkrab et al. (2014), Kupčák et al. (2016), Švéda et al. (2020a; 2020b), and Dudík et al. (2021b). Several factors enter into the economic modelling of forest production. Various risks affecting production processes and timber markets are of great practical significance in forestry (Mutenthaler and Sekot, 2016). In addition, the specific size or geographical location of forest properties and the possibility of obtaining accurate and complete economic information on these properties are also important; this issue was addressed, for example, by Toscani and Sekot (2017). The significance of the different forest functions on a given forest property also plays a role, and the production function may not be the most important one.

The paper aims to provide information to decide whether it is possible to use birch in the regeneration of declining spruce stands in the Czech Republic, and at the same time, show that changing the species composition utilizing birch can be an appealing (and also economically viable) alternative.

2 METHODS

Economic modelling utilizing birch as a pioneer species for forest opening restoration after salvage felling focuses on the mid altitudes in the Czech Republic, from 400 to 600 m ASL. Three representative groups of forest habitat sites (according to the Czech forest site typology system in Viewegh, 2003) are considered for these altitudes: acidic, nutrient-rich, and enriched by water (pseudogley). Two groups of models are considered in these habitats. In the first group of Birch Pioneer models (models BP1 to BP3), birch is considered a pioneer species for the climax tree species. The birch rotation period in the BP models is 20 years, the climax tree species rotation is expected to be 100 years, and the total regeneration of the model stand is 110 years (at ten years of age, the birch is underplanted with the climax species).

In the second group of Birch Final models (models BF1 to BF3), birch is again considered a pioneer species for the climax ones. In this case, however, birch is expected to stay in the stand until its felling age. The birch rotation in the BF models is 60 years, while a 100-year rotation period is expected for the climax tree species. The total rotation period of the model stand is 110 years (at ten years of age, birch is underplanted with the climax species).

On acidic and nutrient-rich sites (models BP1, BP2, BF1, BF2), European beech is the projected climax species. On water-enriched sites (models BP3, BF3), it is silver fir. The structure of the models regarding the habitat and birch silviculture is shown in Table 1.

Given the nature of birch, we assume that the pioneer stand will be established naturally, i.e., by birch self-seeding. The climax species is then introduced under the birch as part of artificial regeneration. The economic modelling applies to the timber production function of the forest stand in the six models presented. The area of the model forest stand is always 1 ha.

Table 1. General structure and classification of the silvicultural framework

Mid-altitude sites	Method and purpose of birch cultivation	
	Mixed stands	
	Pioneer species for the climax species	Production species of value in mixture with the climax species
Acidic (edaphic category K)	BP1 (birch and beech)	BF1 (birch and beech)
Nutrient-rich (edaphic category B)	BP2 (birch and beech)	BF2 (birch and beech)
Water-enriched (edaphic category O)	BP3 (birch and fir)	BF3 (birch and fir)

The findings on the silvicultural and production potential of birch stands serve as the basis for differentiated modelling of the economic efficiency of the stands' management. The management represents a whole production cycle comprising planting, stand establishment, tending, felling, and the sale of raw timber assortments. The birch timber sorting is based on assortment tables for average-quality stands. We also model silvicultural and harvesting operations in birch stands, considering the range of operations in technical units. Unit costs represent average levels in the Czech Republic in 2020; for the calculations,

the share of overheads is 35% of direct costs. Unit yields (raw timber assortment prices) represent average levels in the Forests of the Czech Republic, state enterprise, in 2020. The calculation is used to quantify costs and yields in particular economic models.

The economic efficiency evaluation of birch management follows the concept of the "Forest Rent Theory." An economically balanced forest is the basic model for sustainable production in forestry, meaning it generates similar annual yield/income (at a usual level of timber sales) and similar costs/expenses, with an average profit rate in the frame of regular management (and technologies used) based on a forest management plan. The only evaluation criterion for this approach is profit, which is generally defined as an annual average difference in yields and total costs. For the model calculation, it is the average annual gross profit of forest production (GPFP).

3 RESULTS

The initial economic modelling results in CZK are recalculated and presented in EUR (rounded to the nearest euro, 1 EUR = 26.444 CZK; source: CNB, 2023).

Figure 1 shows the average annual gross profit (EUR per ha) of forest production results for the six economic models (GPFP), where birch was used as the pioneer species. Models BF1 to BF3 expect cultivation of birch until its felling age.

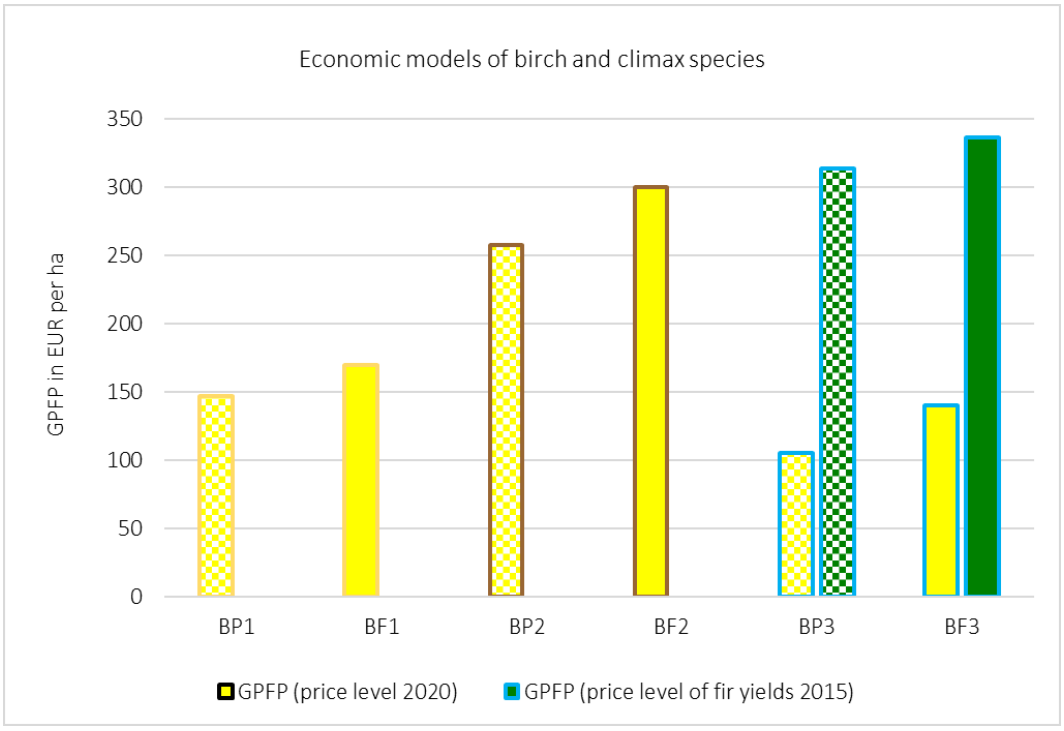

Figure 1. The average annual gross profit (EUR per ha) of forest production models using birch in forest stands.

These results show that the BF2 model (birch grown to its felling age in a mixture with beech in nutrient-rich habitats) appears to be the most profitable model from an economic perspective, where its average annual gross profit of forest production reaches 300 EUR per ha.

The least economically beneficial model is BP3 (birch grown only as a pioneer species up to 20 years of age in a mixture with fir on water-enriched sites). The average annual gross profit of forest production reaches 105 EUR. The reasons for the low gross profit are described in the following chapter.

4 DISCUSSION AND CONCLUSION

The economic calculations of the six "birch models" attempt to show the average situation and conditions where the respective stands will be managed on a given site. In reality, the GPFP of a particular stand will be influenced, for example, by different proportions of successful natural regeneration of birch and thus different proportions of artificial regeneration, and possibly dissimilar numbers of weed and game control interventions.

Based on the information on prices of raw timber assortments published by the Czech Statistical Office (CZSO, 2023), a noticeable decrease in the prices of spruce assortments was observed between 2016 and 2020. In 2020, prices of spruce assortments were the lowest from 2010 to 2020. The Czech Statistical Office does not monitor prices of fir timber assortments. Based on market information, the trending prices of fir and spruce wood assortments are essentially the same. However, for fir, the prices of timber assortments tended to be about 20% lower. The economic models for birch with fir (BP3 and BF3) are marked by the lowest prices of fir timber in the period 2010 to 2020. If we consider the costs in 2020 for BP3 and BF3 and, alternatively, the price level of timber assortments in 2015 (i.e., before the calamity) for yields, we get significantly different GPFP results for these two models. For the BP3 model, the GPFP reaches 314 EUR, and for BF3, 337 EUR. The GPFP values at the 2020 cost and yield price level and, for comparison, the alternative birch-fir models at the 2020 cost and 2015 yield price level are shown in Table 2.

Table 2. GPFP values with the alternative fir price in 2015

	Economic models of birch and climax species—GPFP in EUR per ha					
	BP1	BP2	BP3	BF1	BF2	BF3
GPFP (price level 2020)	147	258	105	170	300	140
GPFP (price level of fir yields 2015)	NA	NA	314	NA	NA	337

NA—not applicable (birch and beech models)

For the sake of comprehensiveness, it should be noted that the price level of fir timber assortments in 2022 was higher than in 2015. On the other hand, it should be mentioned that the cost in the Czech Republic was also increasing compared to 2015 and 2020. The inflation rate between 2020 and 2022 was unprecedentedly high. Although the economic modelling results may signify a low GPFP for the birch and fir mixture, this should not be viewed as typical. The economic modelling was performed in 2021, so the price level of costs and yields in 2020 was taken into account. If we look at the price development of fir timber from 2010 to 2022, the year 2020 shows the lowest prices of that period. The year 2022 shows higher fir timber prices than in 2015. Therefore, we can conclude that a mixture of birch and fir on water-enriched sites is an economically viable alternative to a birch and beech mixture on nutrient-rich sites.

The results of the six birch models with standard spruce or beech models shows that spruce or beech are both the first and the target/climax species used to restore the opening. The comparison shows better results for the birch and climax mixture models, ranging from 10 to 30%, with broadly similar conditions entering the models (e.g., artificial regeneration technology, the extent of and technology needed for young forest stand tending, and harvesting and transport technologies used).

The potential of production and economics of birch stands has been observed for a long time, especially in Scandinavia. Current surveys indicate a high production potential of birch stands and associated economic effects in Central Europe as well (Lockow, 1997; Unseld and Bauhus, 2012). A significant regeneration potential of most sites, an ability to produce pure stands and to grow in mixtures with other tree species, along with the pioneer growth strategy, underpin the potential for early economic yield (Hynynen et al., 2010).

Based on the results, it can be concluded that, in the long run, the relative differences between the economic models are more significant than the absolute gross profit of forest production in EUR per year. At the same time, it is necessary to choose an appropriate and convincing price level for unit cost and yield inputs. In particular, this highlights the comparative results of the alternative models of one tree species with the economic modelling results of the other. If either of these tree species is in a highly favourable situation in the timber market or, conversely, in a highly unfavourable situation, this will significantly affect the results of the economic model comparisons.

Overall, it can be stated that the use and promotion of birch in forest stand regeneration and silviculture is becoming a competitive alternative to traditional timber production tree species—spruce and pine, in the Czech Republic. Economically, the advantage of birch silviculture is strengthened by the use of natural regeneration. Furthermore, it can be stated that the use of birch as a pioneer tree species does not necessarily lead to a deterioration in the economic result of a forest property sizeable enough to provide the owner with a sustainable yield.

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