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REVIEW ARTICLE

Afforestation and secondary succession

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Abstract. Secondary succession is a long and complicated natural process returning forests to post agricultural lands, whereas afforestation is an attempt to speed up this process by planting trees. Massive afforestation in the twentieth century brought an increase in forest area in Poland along with management problems in these areas due to disturbances caused by root diseases. Therefore it appears necessary to employ successional processes more fully in order to create sustainable forest ecosystems.

Key words: afforestation, natural disturbances, secondary succession

1. Introduction

Forests of the temperate zone have served as a habitat for early humans in Europe, Northeastern United States, and also in large parts of China. Most of those forests were cleared for the needs of agriculture, as their soil and climate conditions were suitable for intensive production of food with no additional watering required (Campbell 1995).

That process, however, did not occur evenly, and forest cover changes of the discussed territories were irregular. Growth of civilisation resulted in decrease of forest area, but after wars or disease epidemics, forests in some areas returned to the sites previously used by humans. Such phenomenon of the spontaneous forest return, also called the secondary forest succession, in large degree shaped the landscape of the temperate zone (Szwagrzyk 2004).

It was only in the 19th century, when the prospect of forest disappearance due to extensive harvesting became obvious, that people started to introduce more sustainable methods of forest resource management. Those activities determined the state of forests existing today and also the return of forests to the areas, which were previously used for agriculture (Bernadzki 1997).

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In France, afforestation activities were started already at the end of 18th century and by 1950, an area of about 3,400,000 ha was afforested (Strzelecki, Sobczak 1972).

The United Kingdom doubled its forest area by afforesting of more than 1,000,000 ha in the 20th century. During the last 100 years, afforestation in Spain was 2,500,000 ha, and in Italy – 2,000,000 ha. After the World War II, Bulgaria afforested about 1,000,000 ha, and Hungary – 500,000 ha of land. Relatively few afforestation activities were conducted in Ireland, Germany and Greece (Kwiecień 1996).

2. Short history of deforestation and afforestation in Poland

Szujecki (2003) notes three main stages of the most significant deforestation events touching Polish lands: '12–13th centuries, when farmers started to use ploughs shod with a metal point; 16–17th centuries, when wheat and potash exports became very profitable; 19th century, when the Industrial Revolution caused huge demand for construction, mine and fuel wood'.

The first half of the 20th century led to especially large changes in forest area of Poland. Even with all the afforestation activities conducted with varying intensity

from the 19th century, the forest area, only during the interwar period, decreased by about 900,000 ha (Sobczak 1996). As an outcome, the forest area of Poland constantly decreased from about 80% in the beginning of country's history to about 43% in the 18th century, reaching its lowest in Polish history value of 20.8% in 1945.

The turnaround of this process came only during the period 1947–1970, when after intensive afforestation practices as well as natural succession processes, the forest area of Poland increased to 27%. The average annual afforestation area during that time was 39,600 ha, and during its peak period of 1959–1965, it was more than 50,000 ha. In the record year of 1960, the area afforested was 61,800 ha. During the consecutive years, the rate of afforestation started to decrease from 16,200 ha annually during the years 1971–1980 to 6,500 ha annually during the years 1981–1990 (Smykała 1990).

The 1990s gave a new boost to the afforestation process and their area started to systematically increase from 7,600 ha in 1991 to 23,400 ha in 2000, with the annual average area being 14,900 ha. The high level of afforestation of above 20,000 ha lasted until 2003 and after that started to decrease to lower than 5000 ha in 2012 (KPZL 2003).

Altogether, during 1947–2012, a total of 1,477,000 ha of agricultural lands was afforested. The area of forests in Poland increased by 2,694,000 ha from 6,470,000 ha in 1945 to 9,164,000 ha in 2012, which corresponds to 29.3% forest cover (the report on the state of forests, 2012).

The aforementioned 8.5% growth in forest cover mostly comes from artificial afforestation implemented during that period, while the rest of the area resulted from natural succession. Birch and pine seedlings colonised large areas of unused agricultural lands, especially in years following the World War II. The data about such sites was not registered until the end of the 20th century, so their area could only be estimated to about 900,000 ha (Puchniarski 2000).

Such information contradicts the widespread opinion that secondary succession in Poland is of minor importance. Secondary succession is a widespread phenomenon, which appears on a large scale in all (besides Antarctica) continents. By ignoring or underestimating it, forecasting of forest cover changes in the near or far future would be inaccurate (Szwagrzyk 2004).

3. Afforestation strategy

The main goal of afforestation is to change the use of a given site by directing the reestablishment of forest ecosystem. Such task is, however, difficult and time consuming, and tree planting itself is only the beginning of the long and complex process.

In order to reach in the future rather stable and effective development of forest ecosystem, one should model silvicultural activities on the process of natural succession with special attention given to secondary forest succession. Ecosystems that originated without human interference present the optimal structures from the point of view of their species and spatial characteristics within given environmental conditions. Such processes could last several decades or even several hundred years and having two important features: large inertness or ability to resist changes and maintain relative balance, as well as large elasticity or the speed with which those ecosystems return to their balanced state after the withdrawal of a stress factor (Gorzelak 1999).

Processes that take place in nature do not always agree with economic goals. Therefore, it is highly important to formulate a goal of afforestation process at each site and plan further activities according to this goal. After all, artificially planted sites aimed at timber production require different silvicultural activities from those needed for plant communities managed in order to create stable forest ecosystems (Gorzelak 1999).

An attempt to combine those two goals directed towards timber as well as habitat production is one of the primary reasons of faults emerging in timber stands created on agricultural lands. The reality proves that an assumption that the result of afforestation would come out as a stand that in given conditions provides maximum timber production as well as the most positive impact on natural environment is wrong (Rykowski 1990).

The studies of timber quality also support the need to implement different silvicultural activities in timber stands created on agricultural lands. First of all, it appears that timber harvesting age should be decreased on such sites due to lesser time needed for trees to reach technical maturity (Jelonek 2013).

Awareness of this problem has existed for quite a long time. Stanisław Sokołowski in his 'Hodowla lasu' ('Silviculture') (1921) wrote: 'When afforesting unused lands, it would be first of all important to improve site conditions and mainly soil to such level that would allow next generation of trees to develop into tree stand with certain economic value. Initial afforestation activities rarely produce stands, which have significant value, which occurs due to their uneven growth, frequent corrective plantings and first of all due to poor site conditions. It is only when soil under closed stand will obtain

better qualities, that young stands with better future possibilities will emerge'.

On the other hand, Walerian Dakowski (1929) turned the attention to wrongful tree species selection: 'Large sites, which are important objects of forest economy, should mainly be afforested by Scots pine. However, afforestation with pine should be conducted very carefully. Unused lands for a long time stopped being forest soil and due to this, they lost physical and chemical soil characteristics, and also they lack mycorrhizal fungi. Without proper mycorrhizal associations, pine stands will not be able to develop normally and to bring good forecast in the future. On the contrary, the birch and black locust stands, regarded as pioneer species, will provide first harvest of timber so that later give way to pine'.

Władysław Płoński (1930) also acknowledged the importance of the transitional stands structured from birch, alder, aspen and even shrubs, depending on local conditions that, during one or two generations, are able to create soil conditions suitable for major tree species. He also believes that 'success of forest plantations on agricultural lands would not be hindered by any setbacks if our management practices are based on rules dictated by nature itself, if we would restore the shifted balance of forest-forming elements following the road of evolution'.

Every forest in every place and time implements several functions simultaneously while doing it in a natural way (Principles of Silviculture, 2012). The expectations of humans from forests through the centuries were, first of all, related to the forest's productive function. Therefore, accepted models of afforestation of agricultural lands attempted to fulfil those expectations in the best possible way. And actually economic views most often dictated the necessity to interfere into natural course of forest restoration (Gorzelak 2006).

In Poland, during the period of the most intensive afforestation, the most simple model of planting was used, which is based on planting trees into furrows on agricultural lands. Due to poor understanding of site conditions, easiness and low prices of pine seedling production, afforestations conducted during that time resulted in pine monocultures. During 1970s, afforestation practices were placed under higher requirements related to protection and design of landscape, nature protection and enhancement of soil and water protective forest functions (Gorzelak 2006).

As the result, the quality of afforestation during several decades at the end of 20th – beginning of 21st centuries is definitely higher. Larger species diversity of planted trees, which takes into account site conditions; diverse methods of soil preparation, which are adapted to specifics of agricultural lands; or inclusion of already existing tree groups into planned plantations provide an opportunity for developing sustainable, in comparison to prior practices, plant community (Sobczak, Jakubowski 1998).

4. How to manage forests on agricultural lands?

Taking into account the fact that 25–30% of forest in Poland grows on sites that were deforested and further used for agriculture or remained fallow, demonstrates the scale of the problem (Szujecki 2003).

Currently, the 'National program for expanding of forest cover' (KPZL) serves as an instrument that guides the level and spatial structure of afforestation practices. It was adopted by the Council of Ministers on 28 June 1995. The main goal of this program is to create conditions for increasing forest cover of Poland to 30% in 2020 and to 33% in 2050 (KPZL 2003).

Previous experience of afforesting agricultural land by major forest species, among which pine holds the first place, shows that reaching mature and healthy tree stand has been possible only in a limited number of cases (Bernadzki 1990).

The main characteristics of forest stands emerging on afforested sites result from simplified species and age composition as well as specific soil and site conditions of farmlands. From the ecological point of view, such stands are closer to 'agrocenosis' than to forest ecosystems, where trophic chain presents more or less continuous biological stability. In that sense, first generation of forest trees on agricultural lands could not be considered to be a forest, it rather constitutes a certain phase of artificially initiated forest establishment process. From the point of view of natural ecological succession, afforestation often imposes growth of the species distinct to the current conditions of that biological community. Adaptation of such community is always accompanied by diseases, which is part of natural ecological processes (Rykowski 1990).

One of such examples is a root rot caused by *Heterobasidion annosum* (Fr.) Bref. fungi. This disease commonly occurs in tree stands planted on agricultural lands. It causes various pathologic changes within the stand leading to tree mortality, decrease in crown cover and often to biological degradation of the stand (Sierota 1996).

That is why the role of transitional plant communities in silvicultural management could not be underestimated at any stage of stand development in order to create stable semi-natural ecosystems. Good survival of forest communities that spontaneously occupy vacant sites confirms such approach. Some such examples include vast areas of birch stands, former grasslands or wet pastures covered by black alder, as well as grey alder stands, which could be found mainly in the Low Beskid and Bieszczady Mountains (Bernadzki 1990). Similarly, pine stands originating from wild seeding are healthier, less susceptible to root rot and produce stands with more diverse age structure (Falińska, Faliński 1990).

In such a context, the inclusion of the natural succession on the area of 80,000 ha during 2001–2020 into the KPZL programme should be positively evaluated (KPZL 2003).

5. Summary

Forests created on former agricultural land present one of the important problems for the contemporary silviculture (Bernadzki 1990).

The specifics of timber production in such areas are based, first of all, on soil characteristics described as 'syndrome of agricultural soil' (Sierota, Małecka 2003).

This type of agricultural habitat indicates the need to change management approach used for stands grown in such conditions (Rykowski 1990). Similarly, different technical qualities of timber obtained from such stands suggest the need for modification of timber use (Jelonek 2013).

The development of sustainable forest ecosystems on agricultural lands requires full employment of natural processes occurring there, such as establishment of pioneer or transitional stands. It is justified not only from ecological point of view, but also supports basics of sustainable forest management. Such approach decreases management risks that constantly accompany silvicultural decisions and result from unpredictability of natural processes affecting growth of forest as a whole and each stand individually (Bernadzki 2006).

Forest growth is tied to cycle of disturbances that initiates processes of adaptation and growth of structures better adapted to changing environmental conditions (Dobrowolska 2010).

The forecasts related to increase in forest cover of Poland insufficiently consider the process of secondary succession (Szwagrzyk 2004). Therefore, study of spontaneous return of forests to lands not devoted to agriculture has both large educational value and practical usefulness (Falińska, Faliński 1990).

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