Reforestation in Poland: History, Current Practice and Future Perspectives

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Abstract

In the past, the entire region of Poland was overgrown by forests. Due to economic changes, the forest cover was reduced to 40% in the 18th century and 21% after the Second World War. After the war, Polish foresters undertook considerable efforts to increase the forest cover to 30.8% by 2015. Polish forests are characterized by the dominance of oligo- and mesotrophic coniferous species (68.7%). This include the pioneer species, Scots pine. It covers approximately 60% of the area. The species composition of Polish forests determined the dominance of artificial regenerations. However, the currently prevailing direction of forest culture is natural regeneration. This tendency is related to "greening" of the forest management, the priority of durability over productivity and culture of multifunctional forests. A natural or seminatural direction of forest culture is being promoted. Renewal of the species such as fir, beech, oak, or spruce from the last stages of succession have always taken place in a natural manner, whereas the statistics are generated by the dominant species preferring open areas during renewal. Currently, the scale of natural regenerations of the pine is increasing. It is increasingly common to value the favorable economic aspect of natural renewal of the species, and the experience of practitioners supported by scientific research increase the likelihood for success. In Poland, the majority of methods of regeneration proceedings (forest cutting) and the law are directed at obtaining and promoting natural renewal. Independent of the concept of natural renewal promotion, the location of Poland in the intermediate climate zone, between the influence of oceanic and continental climates, resulted in the formation of valuable tree stands with high flexibility and tolerance to growth conditions. They are divided into seed stands, excluded stands, and timberlands. Thus, Poland is in possession of a great base for seed collection. At the beginning of 1990s, a rapid need for container seedlings occurred due to numerous disasters (wind-broken trees, gradations). Currently, in Poland, 17 field nurseries are in operation producing 1–10 million seedlings. In 1992, Poland received a loan from the World Bank to conduct afforestations and the "National Program for Increasing the Forest Cover" was started. The main objective of the plan is to increase the forest cover to 30% in 2020 and 33% in 2050. Within the program, it is planned to include vegetation of the natural succession in the area of approximately 80,000 ha.

Keywords

Poland; Afforestation; Forest Nursery; Seed Base; Natural Regeneration; Secondary Succession

Contents

1 Introduction

In the past, forests were found almost throughout the region of Poland. Due to economic changes, forests were subjected to major transformations. At the end of the 18th century, the forest cover in Poland was approximately 40%, yet it was reduced to 20.8% in 1945. From 1945 to 1970, afforestation process (933,500 ha) was initiated; thus, the forest cover increased to 27.0%. The forest cover in late 2015 was 9,420,000 ha and was close to the forest area of Ukraine and Italy. The forest cover in Poland in 2015 was 30.8% and it was only slightly less than the EU average of 32.8%, which, however, includes the forest cover of the Russian Federation (44.7%). The forest cover per capita in Poland is 0.24 ha and it is one of the lowest levels in the European region (Poland - The State Forest in Figures – 2016).

2 Forests in Poland

The forest ownership structure in Poland is dominated by public forests—80.8%, primarily including forests managed by the State Forest Enterprise entities (PGL LP)—77.0% and national parks—2.0% (Fig. 1). For approximately 40 years, the ownership structure of forests had changed to a minor degree, only during the period 1990–2015 the share of private forests increased by 2.2% to the current 19.2%.

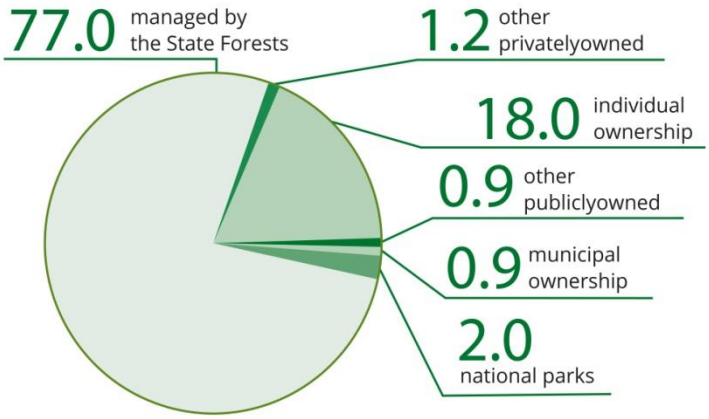

Figure 1. Forest ownership structure in Poland, in terms of percentages (Poland - The State Forest in Figures—2016).

Polish forests are dominated by coniferous species (68.7%). Scots pine covers 58.1% of the forests of all ownership categories. The share is higher in the stands managed by the State Forests—60.3% (Fig. 2).

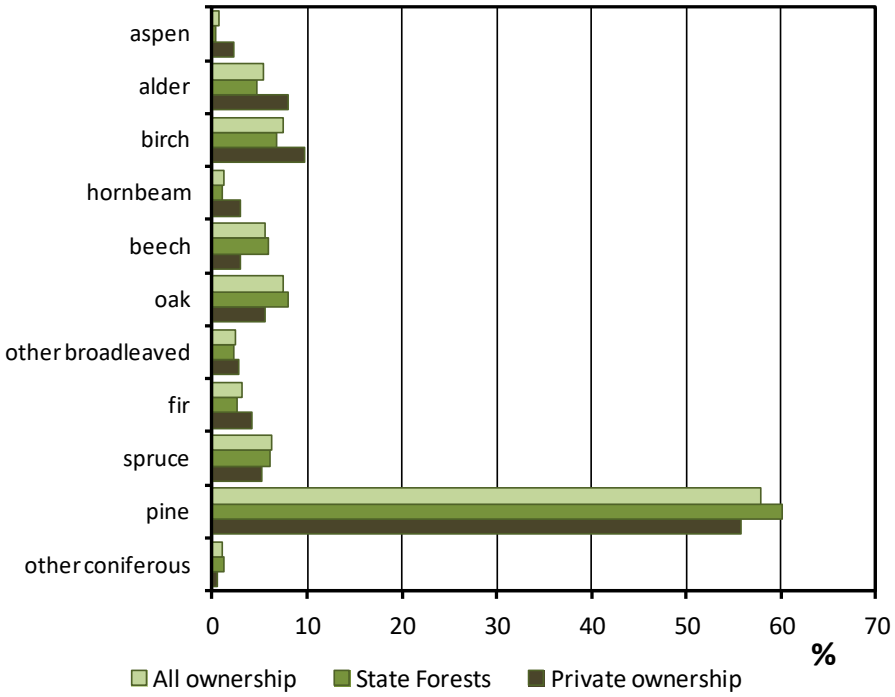

Figure 2. Area share of dominant species in all ownership categories, in the State Forests and in private forests according to the National Forest Inventory 2011–2015 (Poland - The State Forest in Figures—2016).

From 1945 to 2015, the share of deciduous species increased within species compositions. In this period, the area of deciduous stands in the State Forests increased from 13.0% to 23.5% (Poland - The State Forest in Figures – 2016). The share of mixed-species stands increased as well.

In terms of volume, Polish forests are among the best in Europe. The Polish average according the State of Europe's Forests is 269 $m^3 \cdot ha^{-1}$, which is considerably higher than the average for Europe (163 $m^3 \cdot ha^{-1}$). Moreover, as evaluated by the State of Europe's Forests (SoEF), Poland possesses significant wood resources—more than 2.5 billion m^3 (Forest Europe 2015).

3 Seed Base

The location of Poland in the transitional climatic zone, between the influence of oceanic and continental climate resulted in the creation of valuable stands with high flexibility and tolerance to growth conditions. They are divided into seed stands, excluded stands, and timberlands. Thus, the State Forests are in possession of a perfect base for the collection of seeds intended for the culture of seedlings for artificial regeneration, which remains the main method of forest renewal in Poland.

According to the state as of 2014, the National Register of Forest Primary Materials (the most valuable seed base used for renewals and afforestations) contained 2,629 registered seed sources, 20,065 commercial seed stands (290,314 ha), 1,085 selected seed stands (17,712 ha), 269 seed plantations (1,979 ha), and 8,559 plus trees.

Despite the rich seed base, good seed yield constitutes an irregular occurrence. In order to alleviate the influence of periodicity of yielding, a system for seed storage

had to be developed. Currently, 20 warehouses are in operation in the area of Poland, containing primarily oak and beech, pine, spruce, and fir and larch. From 1950 to 2000, the amount of seeds obtained was highly variable due to the different intensity of yielding and differing demand for seed (Table 1).

Table 1. Total amount of seeds (in Mg) of all species obtained in the State Forests from 1950 to 2000 (Bernadzki 2004).

Year	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000
Seeds obtained per tree stand	5	848	3624	1499	1233	3461	282	395	2180	1546	2226
Seeds from seed extraction plant	–	65	102	122	34	13	33	17	29	23	15

After 2000, the amount of seeds collected has remained at a stable level. In 2016, 1,098 Mg of seeds of deciduous species and 551 Mg of cones for coniferous species was collected.

4 Seedling Production

The nursery production is the element of basic economic activity of the State Forests and it is conducted within the framework of its organizational structures. The objective of nursery production is obtaining of good quality planting stock of appropriate origin, ensuring obtaining of good culture effect with the economic calculation considered. The following technologies for planting stock production are used in the nursery production (ZHL 2012):

- field production of bareroot seedlings,
- bareroot seedling production on substrates,
- container seedling production.

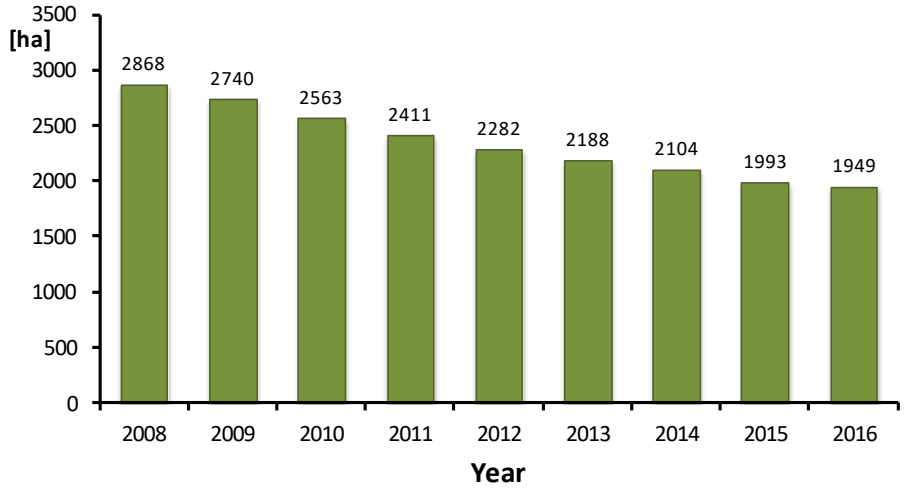

Figure 3. Change of the forest nurseries production area in the period 2008–2016 (Rostek and Biernat 2017).

In 1940s, the planting stock was produced in small, temporary nurseries. In the 1950s, larger nurseries were established (1–3 ha) and the so-called regional nurseries (up to 25 ha), related to the then used administrative division of the State Forests (Szymański and Urbański 1997). Since 1950, the total production area of the nurseries was constantly increasing from the level of 1.9–4.4 thousand ha in 1965. Later, the

total area of nurseries was gradually decreasing, to reach the level of approx. 3.4 thousand ha in the period 1985–2000. Since the beginning of the 21st century, the production area of nurseries has been gradually decreasing, attaining the level of less than 2,000 ha in 2015, due to the lower demand for seedlings and the development of container nurseries (Fig. 3).

The quantity of seedlings cultured in the 70-year period was variable. The highest numbers of seedlings were cultured in the period after World War 2 (more than 2 m per annum), which was linked to the high demand for afforestation material, primarily of coniferous species (pine, larch, and spruce). Currently, approximately 700–800 m seedlings are produced annually, and the share of coniferous and deciduous species is similar (Fig. 4).

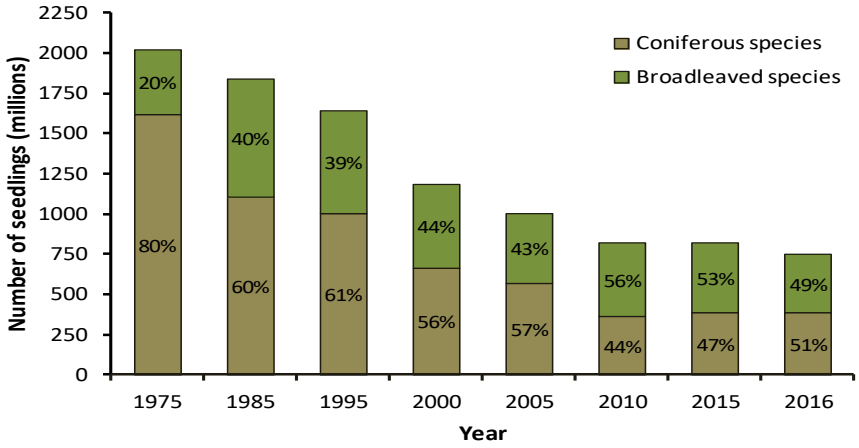

Figure 4. Share of coniferous and deciduous seedling and seedling production capacity in forest nurseries in the period 1975–2016 (Rostek and Biernat 2017).

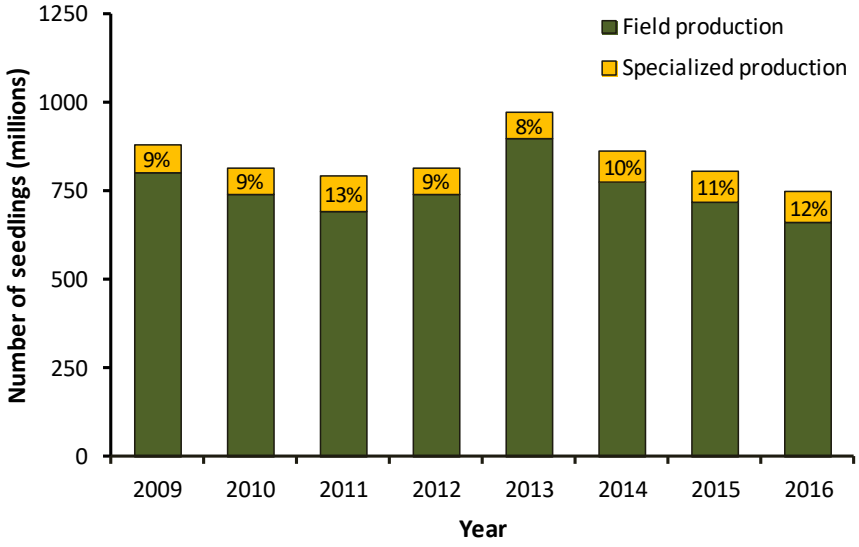

Figure 5. Nursery production in the State Forests in the period 2009–2016 with the division into field and specialized production (container seedlings + controlled conditions) (Rostek and Biernat 2017).

Due to the numerous disasters (fires, tree stand dieback, wind-broken trees, and gradations), the beginning of the 1990s brought rapid increase in the demand for container seedlings. Nowadays, 17 container nurseries are in operation in the State Forests, producing from 1 m (Ustroń Forest District) to 10 m seedlings (Rudy Raciborskie and Gidle Forest Districts). About 44.3 million seedlings were produced in these nurseries in 2016. Moreover, 21 nurseries culture part of the material in the form of container seedlings, of which 8.9 million was produced in 2016 (Rostek and Biernat 2017). However, the share of specialized production remains low and depending on the year it ranges from 8% to 13% of the total number of seedlings (Fig. 5).

A new program for the development of nurseries in Poland does not include the development of new container nurseries. Their number, distribution in the country, and production capacity fully covers the demand for seedlings with covered root system.

5 Reforestation

Throughout the last 40 years of the past century, the surface area of reforestations was gradually decreasing. Since the beginning of the 21st century, a slight reversal of the trend can be observed. Worthy of further attention is the increase in the share of natural renewal in the total reforestation area observed since the second half of the 1970s. In the period 1976–1980, the share of natural reforestations was 3.4%, in 1981–2000 it was 4.2%, in 2001–2010—10.4%, and in the last 5 years—13.7% (Fig. 6).

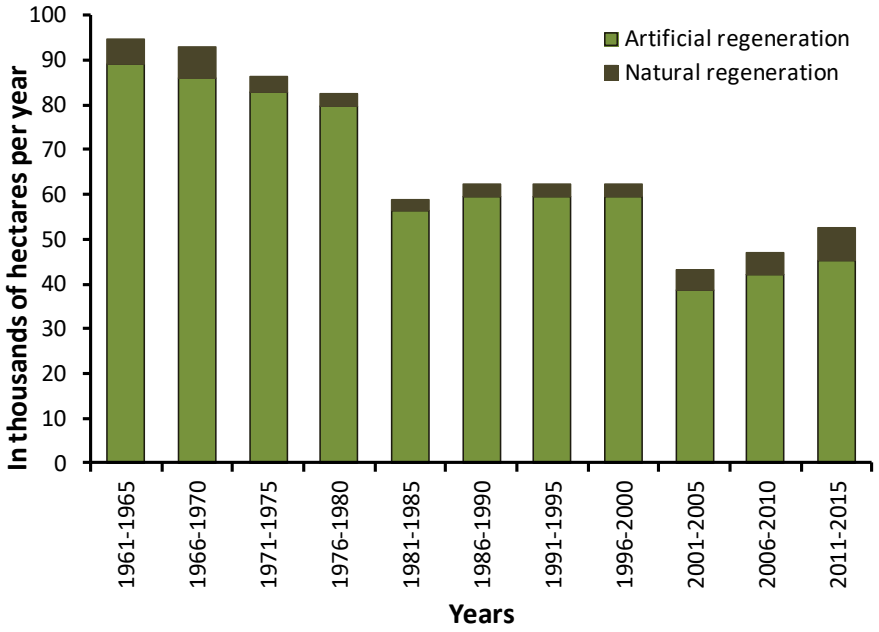

Figure 6. Size of the natural and artificial regeneration in the period 1961–2015 (Central Statistical Office).

6 Natural Regeneration

The high percentage of artificial regenerations (Fig. 6) results from the dominant surface area of oligo- and mesotrophic habitats (approximately 50%) naturally inhabited by pine stands with low percentage of other species (Fig. 1). Scots pine is a pioneer species and artificial reforestations on large areas (up to 6 ha) correspond to ecological requirements of the species. The currently prevailing direction of forest culture is natural regeneration. This tendency is related to the "greening" of the forest management, the priority of durability over productivity and culture of multifunctional forests. A natural or seminatural direction for forest culture has been promoted (Bernadzki 2011; Zajączkowski 2011; Jaworski 2011). The positive experience and increasing scale of natural regeneration of pine is also equally important. It is increasingly common that the favorable economic aspect of natural renewals of this species is valued and the experience of practitioners supported by scientific research (Andrzejczyk et al. 2009; Dobrowolska 2010) increase the likelihood for success. The majority of procedures (forest cutting) in use in Poland are directed at obtaining and promoting natural regeneration (ZHL 2012).

Clear cutting System

Wide strip (large-area) system—dedicated primarily to artificial regeneration of pine. However, within this procedure, fragments of mature stand with lower stratum, understory, and undergrowth are left on approximately 5% of the cutting to maintain the ecological niches and the resulting biodiversity. The additional aim is refilling of species leading to a greater genetic diversity of the culture and increase of the density and supplementing the admixtures.

Strip cutting system—used for artificial regeneration on habitats exposed to erosion or with excessive moisture levels. On unexposed habitats, this method allows for the use of side sowing of pine spruce or mixed stands consisting of the mentioned species.

Narrow strip system—ensures side sowing of spruce stands. In the step and wing form, it is used in pine and spruce stands with admixtures of other production species.

Shelterwood System

Uniform shelterwood system—utilizes upper sowing. Used primarily in beech and oak stands, and sometimes in pine and spruce stands. As a result of uneven cuts, it may evolve into gradual group cutting.

Strip shelterwood system—used in more difficult conditions in spruce or pine stands and in beech and oak stands.

Narrow strip shelterwood system—used in spruce stands on areas exposed to erosion.

Shelterwood group system—used for obtaining natural regenerations in beech and pine, oak and pine, fir and pine stands, and combinations of 2 shade-tolerant and large-seed species (beech, oak, and fir). In single-species beech or oak stands, it is used to obtain tree stands with variable age in the scale of several tens of acres.

Combined system: patch clear cutting and shelterwood cutting

Complete group clear cutting—used for the transformation of single species pine stands into beech and pine, oak and pine, or fir and pine stands. Within this procedure, natural lower layer of the dominant species (beech, oak, and fir) can be used to be incorporated in the future species composition (Skrzyszewski and Pach 2015).

Shelterwood and partial group clear cutting—used for the transformation of single beech and oak stands into mixed stands containing the above species and supplemented with fir or spruce.

Irregular Shelterwood System

Irregular group shelterwood system—used for the renewal of single species fir stands with admixtures of beech and spruce. Natural regeneration is obtained in groups extended in the long-term renewal period.

Irregular group and strip shelterwood system—used for the renewal of fir and spruce, beech and spruce stands, and transformations of single species spruce stands in the long-term regeneration period.

Swiss irregular group shelterwood system—used for simultaneous regeneration and tending of fir stands in a very long regeneration period; transformations of single-story fir stands into selection cutting stands; renewal of mixed-species stands (3 or more major species with different ecological requirements). The priority in this system consists in both regeneration as well as increase in the value—an increment and tending system. It allows for dispersion of the culture risk into multiple developmental phases and species. It allows for a full utilization of the value increment and optimization of the crop size structure (high percentage of large sizes). In its advanced form, the system becomes similar to the free silviculture system (Mlinšek 1966).

Selection System

Used primarily in fir stands, but does not exclude selection system entities in beech or spruce stands, particularly in the upper wooded sections.

7 Afforestation

Afforestation is one of the most important environmental and economic projects, aiming at the initiation of the forest forming process and reconstruction of the forest ecosystem in the area, where it has been altered to other forms of land use for various reasons and at different times.

From 1945 to 2002, the forest cover in Poland was increased by more than 7% as a result of large-scale afforestations, primarily on abandoned agricultural lands. Creation of such a large area of uncultivated land occurred mainly due to the political situation after the Second World War, which is migrations and resettlements in the south-east areas of Poland (Gorzelak 2004).

In 1992, Poland received a loan from the World Bank to perform afforestations, and the “National Program for Increasing the Forest Cover,” assumed in 1995 was started. The main objective of the program is to increase the forest cover to 30% by 2020 and 33% by 2050. Portion of lands with the lowest suitability for agriculture (approximately 1.5 million ha), where agricultural production is

unprofitable, was planned to be used for the afforestations. The area of Poland was divided into macro-regions including the occurrence of land characterized by contamination, degradation, or exposed to strong erosion, differing in terms of forest formation (Fig. 7).

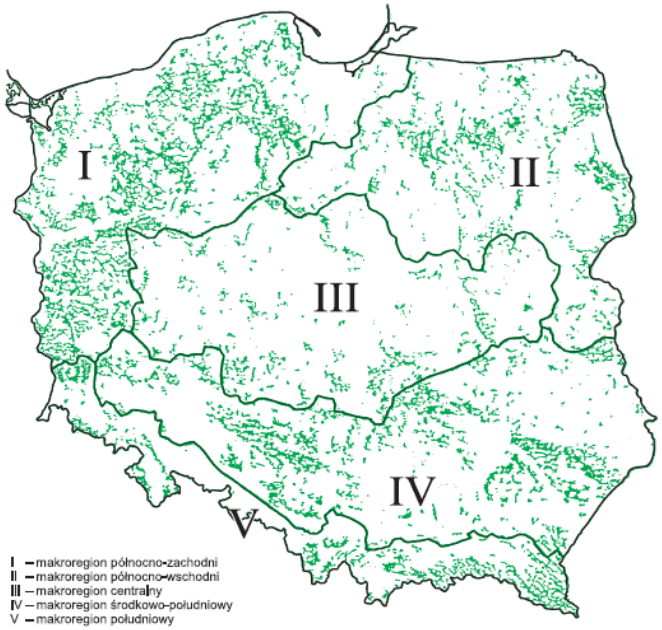

Figure 7. Macro-regions for the differentiation of the rules for shaping forest areas through afforestation and stocking (MOŚZNiL 1995), macro-regions I – north-west, II – north-east, III – central, IV – central-south, and V – south.

The areas of afforestations were established considering the current experience in the implementation of the program, the possibility for afforestation financing, process of gradual transformation of agricultural land into forest land, as well as the Polish accession to the European Union (farming subsidies). Afforestation of the area of 780,000 ha has been planned for the period 1995–2020, including state land—180,000 ha and non-state land—600,000 ha (Table 2).

Table 2. Planned afforestation size without natural succession (in terms of thousands of ha) in subsequent periods (according to Gorzelak 2004, supplemented).

Land ownership category	1995–2000	2001–2005	2006–2010	2011–2020	Total 1995–2020
State	50	50	40	40	180
Non-state	50	70	120	360	600
Total	100	120	160	400	780
Execution (%)	111	81	32	9.4*	38.1*

*Up to 2014.

After year 2006, the areas of afforestations rapidly declined, which was the result of amended criteria for the allocation of private agricultural land for afforestation and the competition from the farming subsidies. Equally large decrease in afforestations was observed for the State Forests, which was caused by the decrease of area of former farmlands and uncultivated land allocated for afforestations by the Agricultural Property Agency (Fig. 8).

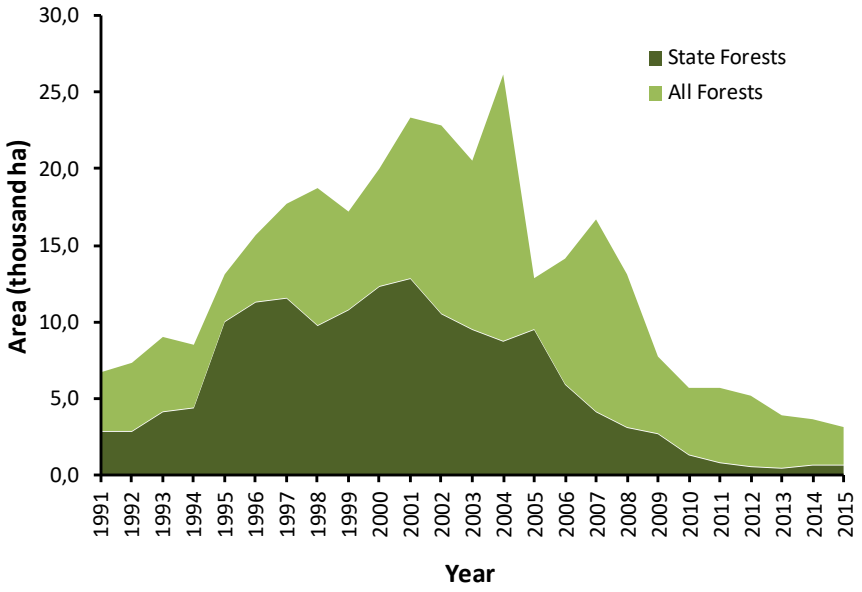

Figure 8. Size of artificial afforestation in Poland in the period 1991–2015 (Central Statistical Office).

8 Natural (Secondary) Succession

Afforestation of the former farmland can be implemented in different ways, and the most commonly used method consisted in artificial planting with seedlings cultured in nurseries, or seed sowing. Currently, natural (secondary) succession, consisting in spontaneous appearance of natural seedlings is becoming an increasingly common method. About 95.3 thousand ha of land were artificially afforested in the period 2001–2005, and the area of natural succession was 1.7 thousand ha (1.75%). According to the National Program for Increasing the Forest Cover, natural succession is planned for the area of approximately 80 thousand ha in the period 2001–2020 (Krawczyk 2014). Buraczyk (2013), who tested 188 sample areas, demonstrated 33 species in the species composition of the natural seedlings. Common birch and Scots pine play a significant role in the natural succession of former farmlands. The succession of tree species is most intensive during the first 4 years from the exclusion of lands from agricultural production. According to this author, the niches formed in the regeneration can be artificially supplied within the guided succession, which should be best carried out in the period of 5–8 years from the conclusion of agricultural use. Natural succession is supported by procedures in the field of ecological engineering, including the following:

- active restitution (grub removal, elimination of the plow soil, pH lowering, supplementation of organic matter);
- habitat and ecosystem restoration (supplementation of the absent trophic levels through colonization of *Formica polyctena* ants and multipedes); and
- creation of ecotone zones and biocenotic foci (forest edge and introduction of biocenotic admixtures).

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