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THE SECOND COUNTRY REPORT ON FOREST GENETIC RESOURCES

POLAND

POLAND The State Forests

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Cover photo:
The Czaplinek Forest District of Czaplinek, photo by Dr Czesław Kozioł

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Abbreviations and acronyms

ARMA	Agency for Restructuring and Modernisation of Agriculture
Bśw	Fresh coniferous forest
BMśw	Fresh mixed coniferous forest
CILP	State Forests Information Centre
CORINE	Co–Ordination of Information on the Environment
CO_2	Carbon dioxide
SP	Statistics Poland (SP)
DGSF	Directorate General of State Forests
EUFGIS	European Information System on Forest Genetic Resources
EUFORGEN	*European Forest Genetic Resources Programme*
FAO	Food and Agriculture Organization of the United Nations
FMGO	Forest Management and Geodesy Office
FRA	Forest Resources Assessment
FRI	Forest Research Institute
FSC	Forest Stewardship Council
GDEP	General Directorate for Environmental Protection
IUFRO	International Union of Forest Research Organizations
LMśw	Fresh mixed broadleaved forest
Lśw	Fresh broadleaved forest
NO_2	Nitrogen oxide
PEFC	Programme for Endorsement of Forest Certification
RAPD	Random Amplification of Polymorphic DNA
SNP	Single Nucleotide Polymorphism
SO_2	Sulphur dioxide
SoEF2015	State of Europe's Forests 2015
SSR	Simple Sequence Repeats
SFNFH	State Forests National Forest Holding
WISL	Large-Scale Forest Inventory
a	are
m	metre
m^3	cubic metre
km	kilometre
km^2	square kilometre
ha	hectare

Preface and acknowledgments

Occupying about 30% of the land area in Poland, the forests play an enormous role in the lives of all human beings, providing them with many key and diverse ecosystem services. They are the living space of many species of plants, fungi and animals, and thereby support the maintenance and conservation of biodiversity. Forests absorb and store carbon dioxide from the atmosphere, contributing to regulating the global carbon cycle and mitigating climate change. Forests also enhance water retention, protect the soil against erosion by preventing its degradation and reduce the risk of natural disasters, such as droughts, floods and landslides. They are a natural place of recreation and rest for the public and also contribute to poverty eradication and economic growth by supplying wood, food and other non-wood forest products to meet the livelihood needs of the human communities and to generate their incomes.

The management of forests or the management of the population of forest trees should be identified with the management of forest genetic resources.

In recent years, European decision-makers discussed different options for the adaptation to climate change and its mitigation and developed different policies aimed at enhancing the role of forests and the forest sector in the mitigation of the impact of climate change. Most countries incorporated the aspects of climate change into their national forest programmes and the national biodiversity action plans. Several countries, including Poland, also prepared their inter-sectoral national adaptation strategies. Unfortunately, for the most part these actions failed to consider the significance of forest genetic resources. Moreover, although climate change is also deemed to pose a threat to biodiversity conservation, the majority of conservation measures focused on the diversity of species and habitats, while little attention was paid to genetic diversity which is the basis of biodiversity as a whole.

The conservation and proper use of forest genetic resources, i.e. the genetic material of forest trees, are the main elements of the sustainable forest management implemented in Poland. Genetic diversity ensures that forest trees can survive, adapt and evolve in the changing environmental conditions and is indispensable for maintaining the vitality of forests and their ability to cope with pests and diseases of trees.

A huge challenge for forest managers is to convince the public that through proper, sustainable forest management conservation of forest genetic diversity is realized, ensuring the durability of the genetic processes within the managed tree populations and thereby the durability of the forests and forest ecosystems and thus habitats and species. The above issue takes on special significance in the present period of dynamic changes unfolding in forest ecosystems under the impact of the selection pressure exerted by a large number of environmental factors related to climate change. The active stimulation of the genetic processes unfolding in woody plant populations by using forest management methods, consisting in the maintenance or enhancement of their genetic diversity, is an element of the pan-European strategy for genetic conservation of forest trees developed by EUFORGEN, which is implemented in Poland. Its main goal is to maintain the adaptive and neutral genetic diversity of forest trees.

I have the pleasure to present the Second Country Report on Forest Genetic Resources in Poland concerned with the above issues, which describes, among others, the current state of Polish forests and wooded areas, their resources and area, the functions they play, the status of species and genetic diversification of woody plant populations, as well as the threats related to the pressure exerted on forests and wooded areas by the environmental factors.

At the same time, I would like to express my gratitude for the huge contribution to the preparation of the Report. I would like to extend my words of gratitude to dr Czesław Kozioł, the Director of the Kostrzyca Forest Gene Bank, for his excellent coordination of the work on the Report, and to his Collaborators, for the efforts which they have taken in preparing this study. I would like to thank all the persons associated with forestry in Poland who have agreed to participate in creating this important document.

Edward Siarka

Secretary of State at the Ministry of Climate and Environment
Government Plenipotentiary for Forestry and Hunting

Summary

Forests are the most natural formation in Poland's climatic and geographical zone. They are a crucial factor maintaining the ecological balance, continuity of life and landscape diversity, as well as reducing pollution. The preservation of forests is a prerequisite for the limitation of soil erosion processes, the regulation of the water regime and the shaping of the climatic conditions. Forests are a common public good which shapes the quality of human life and, at the same time, a form of land use ensuring biological production, which has a market value.

The climate change now observed, with its direction and intensity difficult to determine, contributes to a gradual change in the composition and structure of forest communities. In turn, the pollution of the environment causes the dieback of particular species or entire forest complexes. The economic growth and the growing human population exert an increasingly large social pressure on forests and generate rising expectations with regard to their functions, in terms of both the harvesting of increasingly large quantities of timber and the conservation of the natural values of forests (Haze, 2012; Zajączkowski G. et al., 2020).

The larger than average volume of timber resources in Poland as compared with other countries in Europe and a steady increase in the rate at which these resources are harvested result, on the one hand, from the climatic conditions, and, on the other hand, from the implementation of sustainable forest management.

Forests in Poland provide employment for more than 55,000 persons who are directly involved in economic and protective activities. Forests also stimulate the industrial production and the maintenance of many jobs in the forest-based sector, including e.g. in the wood industry, pulp and paper production and furniture making where more than 450,000 persons are employed (Zajączkowski G. et al., 2020).

In Poland, forest ecosystems are the most valuable and most numerously represented component of all the forms of nature conservation. They occupy 38.4% of the areas covered by legal protection. Forests in Poland are protected using many diverse spatial forms of nature conservation. They include: national parks, landscape parks, nature reserves, protected landscape areas, Natura 2000 sites ecological sites and landscape and nature complexes. Each of the forms listed above plays a different role in the Polish nature conservation system and is used for different purposes; therefore, it is characterised by a different conservation regime and range of restrictions on its use (Zajączkowski G. et al., 2020).

In 2019, in Poland 42,366,000m^3 of raw timber was harvested, including 40,638,000m^3 of net merchantable timber (less by 3,294,000m^3 than in 2018) and 1,728,000m^3 of small wood. In private forests, 1.307,000m^3 of net merchantable timber was harvested (less by 523,000m^{3}than in 2018) and so was 166,000m^3 in national parks. In 2019, in the State Forests a total of 40,626,000m^3 of raw timber was harvested.

On forest land alone, 38,892,000m^3 of net merchantable timber was harvested, including 20,502,000m^{3}as part of final fellings and 18,390,000m^3 as part of intermediate fellings. About 1,717,000m^3 of small wood was harvested (Zajączkowski G. et al., 2020).

The sustainable forest management carried out by the Polish State, including the State Forests National Forest Holding, has for many years now contributed to the implementation of many objectives laid down in Agenda 2030 and those assigned to the particular Sustainable Development Goals.

In Poland, forests primarily occur in areas with the poorest soils and this is reflected in the distribution of forest habitat types. According to the most recent data, both coniferous and broadleaved habitats occur in 50% of the forest area. In addition, in both groups, upland habitats, occupying a total of 6.7% of the forest area, and mountain habitats, occurring in 8.5% of the forest area, are distinguished. In the State Forests National Forest Holding, the share of coniferous habitats is 49.6%, while in private forests it is 55.4%. According to the data from the Large-Scale Forest Inventory, the dominant forest habitat types are those of mixed coniferous habitats with their share of 29.4%(WISL, 2020; Zajączkowski G. et al., 2020).

At present, the forest area in Poland is 9259000ha (according to the Statistics Poland as of 31.12.2019 r.), representing forest cover of 29.6% (Zajączkowski G. et al.,2020).

In 2019, Poland's forest cover as calculated in accordance with the international standard was 30.9% and was lower than the 2015 European average of 32.8% (Zajączkowski G. et al., 2020).

Still different information can be found in the database of the Forest Information System for Europe (www.forest.eea.europa.eu).On the basis of the CORINEL and Cover data of 2018, supplied by the European Environment Agency, and the data collected as part of the Copernicus Land Monitoring Service, Poland's forest cover was determined at the level of 33.53% (as of 10.09.2020).

In the ownership structure of the forests in Poland, the public forests dominate –80.7%, including 76.9% administered by the State Forests National Forest Holding. In the period from 1990 to 2019, the share of private forests grew by 2.3% to the present 19.3%. The share of the publicly-owned forests fell accordingly (from 83% to 80.7%). The increase in the share of the area of national parks from 1.3% in 1990 to 2% in 2019 mainly resulted from the establishment of 6 new parks in that period and the enlargement of the area of the others (Zajączkowski G. et al., 2020).

As indicated by the results of the Large-Scale Forest Inventory in the period from 2015 to 2019,the timber resources in Poland reached the volume of 2,645,000,000m^3 of gross merchantable timber, with 2,066,000,000m^3 in the State Forests and 451,000,000 m^3 in private forests. Almost half (49.6%) of the timber resources represents stands of age classed III and IV, with 47% in the State Forests and 65.1% in private forests. The share of stands older than 100 years, including stands in the restocking class, the class for restocking and the class with the selection structure, in the total volume is 20.7% in the State Forests and 6.3% in private forests. As indicated by the results of the Large-Scale Forest Inventory in the period from 2015 to 2019,the average timber resource in the forests in Poland is 286m^3/ha, with 290m^3/ha in the forests administered by the State Forests National Forest Holding and 252m^3/ha in private forests (Zajączkowski G. et al.,2020).The average timber resource in the State Forests is about 15% larger than in the private forests, due to a much better tending level and a much higher average stand age (WISL, 2020).

In Poland, there are about 263 native woody species, representing slightly more than 10% of the national vascular flora, including 259 with the rank of species and 4 subspecies (apart from 2 nominative taxa: downy birch *Betulapubescens* subsp. *pubescen s*and sun rose *Helianthemum nummularium* subsp. *nummularium).*

The threats to the forest environment in Poland are some of the greatest in Europe. This primarily results from Poland's situation on the border of two climates – the continental and the maritime ones, and as a consequence the continuous and simultaneous impacts of many factors generating adverse effects and changes in the health condition of forests (Zajączkowski G. et al., 2020).

Section I. The contributions of forest genetic resources to sustainable development

Chapter 1. The value and importance of forest genetic resources

1.1. Poland's location and nature and climate conditions

Poland is a country located in Central Europe and has an area of 312,679km^2. It borders on Russia, Lithuania, Belarus, Ukraine, Slovakia, the Czech Republic and Germany. Its population is 38,383,000, of which 16,953,000 persons are economically active. Since 2013, the birth rate has remained negative – 0.9 per 1,000 persons (Statistical Yearbook of the Republic of Poland, 2019).

Poland is a lowland country where areas below 300 m a.s.l. represent 91.3% of its territory (including depressions as 0.2%). The average elevation a.s.l. is 173 m, i.e. almost half the average for the European continent (Europe – 330 m a.s.l.). Its highest peak is Mount Rysy in the High Tatra Mountains (2,499 m a.s.l.), whereas its lowest point is situated west of the village of Raczki Elbląskie (– 1.8 m b.s.l.). The land surface in Poland inclines from south to northwest.

In Poland's territory, there are four basic morphogenetic zones:

1. The Carpathian Mountains, which are young mountains of Alpine orogeny, with their foreland basins (Northern Podkarpacie).
2. The Sudety Mountains, which are old mountains of Hercynian orogeny. These morphogenetic zones include belts of uplands, such as the Śląsko-KrakowskaUpland, the Małopolska Upland (including the Świętokrzyskie Mountains), the Lubelsko-Lwowska Upland (including Roztocze) and the Sudety Foothills,
3. The old-glacial areas of Central Poland and the Saxony-Lusatian Lowlands(with the Podlasko-Belarusian Uplands and Polesie);
4. The young-glacial Southern-Baltic and Eastern-Baltic coastal areas and lake districts.

Poland's extreme points include: Cape Rozewie in the north (54°50'N), the Opołonek peak in the Bieszczady Mountains in the south (49°00'N), the bed of the Odra river near Cedynia in the west (14°07'E) and the bed of the Bug River near Strzyżów (24°09'E). Its longitudinal distance is 5°50', i.e. 649 km, which causes a difference in the length of the day between the northern and southern parts of Poland. In the north, the day in the summer is longer by more than an hour than in the south, while in the winter it is more than an hour shorter. During the year this difference is 2 hours and 12 minutes. The 40-minute difference in solar time between the westernmost and easternmost points of the country is the consequence of the latitudinal distance of 10°01' (689 kilometres along the 52nd parallel).

Poland lies in a temperate climate zone and has the typical transition features, varying from the marine climate in the west to the continental climate in the east. Poland's climate is characterised by large weather variability and a substantial seasonal variation. Six seasons can be distinguished in Poland: winter, early spring, spring, summer, autumn and early winter. In 2019, the mean annual temperature in the territory of Poland was 10.2°C, i.e. it was higher by 2.4°C than the long-term average temperature in the period from 1971 to 2000. It was warmest in Wrocław (where the mean annual air temperature was 11.4°C), while it was coldest in Zakopane (7.5°C) and in Suwałki (8.8°C). The national annual precipitation in 2019 was 556 mm,representing 91.7% of its long-term average level in the period from 1971 to 2000 (IMWM Bulletin, 2020). In Poland, most precipitation occurs in the summer months. There are large fluctuations in the thickness and persistence of the snow cover. In the lowlands, the snow cover most often does not exceed a dozen or so centimetres in thickness; moreover, it appears and disappears several times over the course of the winter. In the mountains, depending on the elevation, the snow cover remains for about 150 days and reaches a thickness of about 2 m.

There are numerous lakes in the belt extending in the northern and west-central parts of the country. As a total, there are about 9,300 of them. They cover a total area of 3 200 km^2, which represents about 1% of the country's land area. The largest ones include: Śniardwy–11,487.5ha, Mamry – 9,851ha and Łebsko – 7,020ha (Choiński, 2006).There are about 100 artificial water reservoirs in Poland, which retain only 6% of surface water runoff.

Westerly, north-westerly and south-westerly winds prevail in Poland. The wind velocity is usually the highest in the winter and the lowest in the summer. The mean annual wind velocity in Poland varies between 2.8 and 3.5 m/s. In the mountains, the highest average wind velocities occurred on Mount Śnieżka on 16 March – 41 m/s and on Mount Kasprowy Wierch on 11 March – 25 m/s. The highest wind gust velocities were recorded on Mount Kasprowy Wierch on 12 November –53m/s and on Mount Śnieżka on 30 September –49 m/s(IMWM Bulletin, 2020).

In hydrographic terms, 99.7% of Poland's territory lies in the Baltic Sea basin, of which 53.9% in the basin of the Vistula River and 34% in the basin of the Odra River. The vegetation cover is mostly that of the Central European province (mixed and broadleaved forests). However, with increasing continentality the share of coniferous forests increases. The natural distribution limits of plants typical of the different European regions occur in Poland, such as the north-eastern distribution limit of European beech and the northern distribution limit of silver fir. The zonal distribution of soils is also transitional; thus, the share of brown soils increases in the south-western and western parts of the country, while the share of podzolic soils is higher in its north-eastern and eastern parts (PWN Encyclopaedia,2010; Statistical Yearbook of the Republic of Poland,2010).

1.2. The role of forests and forest-based sector in the national economy

The larger than average volume of timber resources in Poland as compared with other countries in Europe and a steady increase in the rate at which these resources are harvested result, on the one hand, from the climatic conditions, and, on the other hand, from the implementation of sustainable forest management.

At the global scale, 90%of industrial wood is produced in 25 countries and Poland takes the 11^{th} place in this ranking (Przypaśniak, 2015).

Poland takes one of the leading positions among the European producers of wood products. Most of the production of the Polish timber industry goes to external markets; therefore, changes on these markets significantly affect Polish producers (Kruk, 2015).

Taking into account the value of furniture exports, Poland takes the fourth place in the world. At the same time, according to the report of January 2015, the value of Poland's exports of wooden furniture exceeded EUR 350,000,000, putting our country in the second place in Europe(Mederski, 2015).

Wood-based products enable a circular economy almost without raw materials, in which at the final stage they are used to produce heat and electricity. Raw timber harvested under the conditions of sustainable forest management has the largest share in renewable raw materials in Poland. The forest-based sector thus creates an important base of the bioeconomy in Poland which will make the country effectively independent in the long-term of both fossil fuels and imports of scarce raw materials. Forest biomass can have a large share both in the raw materials supplies for innovative products and in renewable energy sources – these are, among others, structural elements, intelligent packaging and transport materials, second- and third-generation biofuels, green chemicals and pharmaceuticals (Strykowski, Kasprzak i Wasiak, 2015).

The State Forests National Forest Holding systematically increases its wood harvest, which is related to the stand maturing process, the age class distribution and primarily the silviculture and management necessary to preserve stable and durable forests. The projected increase in the timber resources indicates that the use in the State Forests may grow and this will ensure the stabilisation of the forest-based sector (Przypaśniak, 2015).

Poland's forest-based industry takes a high position in the European Union in light of the large area of forests and the timber resource in them, the development levels of wood-based industries, the exports of wood products in processed form, the improving quality of production and its modern character. Wood-based industries (the wood industry, pulp and paper production including paper processing and furniture making):

- generate 2.9% of Poland's output, representing at the same time 7.7% of its value in industry and 9.2% in manufacturing,
- generate 2.1%of Poland's gross added value, i.e. 7.9%of its value in industry and 10.9% in manufacturing,

- account for 3% of the average employment in Poland, representing 11.1% of the average employment in industry and 13.3% of the average employment in manufacturing (Strykowski et al., 2015).

In 2018, the share of forestry in the output of the national economy was 0.34%, demonstrating a slightly growing trend over the last nine years. The value of the sold production of the entire wood sector was PLN 142,800,000,000, i.e. it was higher by PLN 627,000,000,000than in 2010 (Statistical Yearbook of Forestry, 2019).

The Polish forest-based sector also plays an important role in international trade, particularly in exports, with its share of 8.5%in 2013 (that of imports 3.9%) (Strykowski et al., 2015).

The forests in Poland also provide employment for more than 55,000 persons who are directly involved in economic and protective activities. The forests also stimulate the industrial production and the maintenance of many jobs in the forest-based sector, including e.g. in the wood industry, pulp and paper production and furniture making where more than 450,000 persons are employed (Zajączkowski G. et al., 2020).

Forestry companies usually have a local character, doing their business in rural areas, often those with high unemployment. The establishment of forestry companies, the overwhelming majority of which are micro-enterprises, often means the creation of jobs for the owners and members of their family. At the same time, a feature distinguishing this group of entities is the limited possibility of observing market trends, which contributes to the higher uncertainty related to the conditions of the functioning of the micro-enterprise. The seasonality of the economic tasks in the State Forests often forces forestry services companies to seek other contracts to ensure that their economic activity is not exclusively limited to services provided for forest management (Kocel, 2013).

1.3. Forest functions

Forests fulfil diverse functions, either naturally or as a result of human activities. The most important of them include:

1. Environmental (protective) functions, consisting, among others, in the positive impact of forests on the global and local climate, the regulation of the water cycle in nature, the prevention of floods, avalanches and landslides, the protection of soil against erosion and of the landscape against steppe formation.
2. Social functions, consisting, among others, in shaping favourable conditions for society in terms of its health and recreation, enriching the labour market and providing on forest nature education for the public.
3. Productive (economic) functions, mostly consisting in the capacity to reproduce biomass, primarily including wood and non-wood products, and game management Zajączkowski G. et al.,2020).

Forests are the most natural formation in Poland's climatic and geographical zone.

They are a crucial factor maintaining the ecological balance, continuity of life and landscape diversity, as well as reducing pollution. The preservation of forests is a prerequisite for the limitation of soil erosion processes, the regulation of the water regime and the shaping of the climatic conditions. Forests are a common public good which shapes the quality of human life and, at the same time, a form of land use ensuring biological production, which has a market value. The climate change now observed, with its direction and intensity difficult to determine, contributes to a gradual change in the composition and structure of forest communities. In turn, the pollution of the environment causes the dieback of particular species or entire forest complexes. The economic growth and the growing human population exert an increasingly large social pressure on forests and generate rising expectations with regard to their functions, in terms of both the harvesting of increasingly large quantities of timber and the conservation of the natural values of forests (Haze, 2012; Zajączkowski G. et al., 2020).

As some of the most diverse communities of living organisms in the world, forest ecosystems absorb enormous quantities of CO_2, thus reducing its concentration in the atmosphere and mitigating the impacts of climate warming. Forests also reduce the concentrations of many other gaseous pollutants and filter out air from particulate matter. At the local scale, forests diminish both the daily and annual temperature amplitudes and wind velocities. In turn, the specific characteristics of the interior of the forest and its large retention capacity contribute to slowing down snow melting and rainwater runoff, thus reducing the flood hazard. The wind velocity reduction and longer water retention not only contribute to preventing soil erosion but also constrain the pace of steppe formation in the landscape. Moreover, the presence of woody vegetation limits the wind strength, thus reducing threats to elements of infrastructure. Forests take on special importance in mountains areas where shallow soils are exposed not only to wind erosion but primarily to water erosion. Plant root systems protect the topsoil from being washed away and prevent the emergence of landslides and stone avalanches. To a substantial extent, forests also stabilize snow cover, thus limiting the possibility of avalanche formation. Moreover, forests participate in the process of the removal of heavy metals, gases and particulate matter from the air and noise abatement, thus having a positive effect on the microclimate of urbanised areas (Zajączkowski G. et al., 2020).

In accordance with the contemporary economic theory, non-productive benefits satisfy human needs and, therefore, constitute a real value for society. In economic terms, the optimum forest management is the one which maximises the overall economic benefits, also including those that arise from non-productive functions. Pursuant to the Forest Act, the productive and non-productive functions of forests are treated equally as part of the features of multifunctional forestry. Formerly, the value of the forest was tantamount to the market value of raw materials which could be harvested from it (wood, game, forest fruit etc.). As the statistical methods developed, other components of its utility value began to be estimated, i.e. those that indirectly contribute to improving well-being, e.g. the benefits brought by biodiversity, those related to the landscape and carbon sequestration, as well as others. Economic studies indicate that for many people the very awareness of that on Earth there are still places where wild nature exists and that the future generations will be able to admire these places is a significant value. It is only the sum total of this value and all the elements of the utility value that produces the total economic value of a natural good (Żylicz and Giergiczny, 2013).

The forests which fulfil to a large extent the protective functions are also perceived as attractive in recreational terms. Such features as the higher age of the oldest trees, age differentiation, an irregular distribution of trees and the medium-level presence of dead wood increase the recreational attractiveness. Foresters can have a significant effect on how the preferences of the public are shaped by the provision of information on the purposes of certain activities. E.g. the perception of dead wood in the forest can change if the visitors are informed about its importance for the forest ecosystem (Żylicz and Giergiczny, 2013).

1.4. Nature conservation

The oldest formal regulations on social and environmental forest functions and, especially, the ones distinguishing the category of protective forests, were included in the first post-war Instructions for Forest Management prepared in 1957. By the year 1975, a total of 1,485,000 ha of protective forests were designated as protective (22.5% of the forest area administered by the State Forests at that time). As of 01.01.2019, their total area grew to 3,829,000 ha, representing 53.8% of the total forest area and 55.3% if the forest area of nature reserves (104,000 ha) is taken into account. Compared with the countries in its region, Poland is characterised by a relatively high proportion of protective forests (33.4%, according to the SoEF 2015 criteria) (State of Europe's Forests Report, 2015; ZajączkowskiG. et al., 2020).

Depending on their predominant functions, protective forests are subject to modified silvicultural practices, e.g. consisting in the limitation of final felling, a higher felling age, a modification of the species composition and their management for recreational purposes (Zajączkowski G. et al., 2020).

In accordance with the Forest Act, the following forests may be recognised as protective forests:

1. Forests which protect the soil against being washed away or soil depletion, prevent landslides, the falling of rocks or the generation of avalanches and limit the formation or spread of quicksand.
2. Forests which protect surface and ground water resources and regulate the water regime in catchments and watershed areas.
3. Forests which have been permanently damaged by the operations of industry.
4. Forests which are seed stands or animal refuges and the sites of plants subject to species-specific conservation.

5. Forests of special importance for nature research or for the defence and security of the state.
6. Forests situated within the administrative limits of cities and within a distance of up to 10 km from the administrative limits of cities with more than 50,000 inhabitants, within the protection zones of health resorts and areas of health resort-related protection, as well as forests in the zone of the upper forest limit (Forest Protection Act, 1991).

The water-protective forests occupy the largest area –1,545,000 ha, suburban forests – 615,000 ha, forests with natural values – 591,000 ha, forests damaged by the operations of industry– 463,000 ha and soil-protective forests – 327,000 ha. The forests in mountain areas and areas affected by the operations of industry have the largest share of protective forests. The area of private forests recognised as protective is estimated at 68,100 ha, representing 3.8% of their total area. The municipal forests of this category cover 22,200 ha (26.2%).The share of protective forests under all ownership forms in the total forest area in the country has already reached 42.3%and even 43.5% if the area of nature reserves is taken into account. The protective forests are managed with a view to preserving their multifunctional role, with particular account taken of the functions for the purposes of which they have been recognised as protective. The maintenance of the protective functions may require modification of the rules adopted for managed forests, e.g. cessation of final felling, a longer regeneration period on shelter wood cutting sites, leaving tree clusters after cleaning cuttings, a conversion of the species composition and stand structure, selection promoting vitality and adaptation capacity of trees, as well as their aesthetic and landscape values (Haze, 2012; Zajączkowski G. et al., 2020).

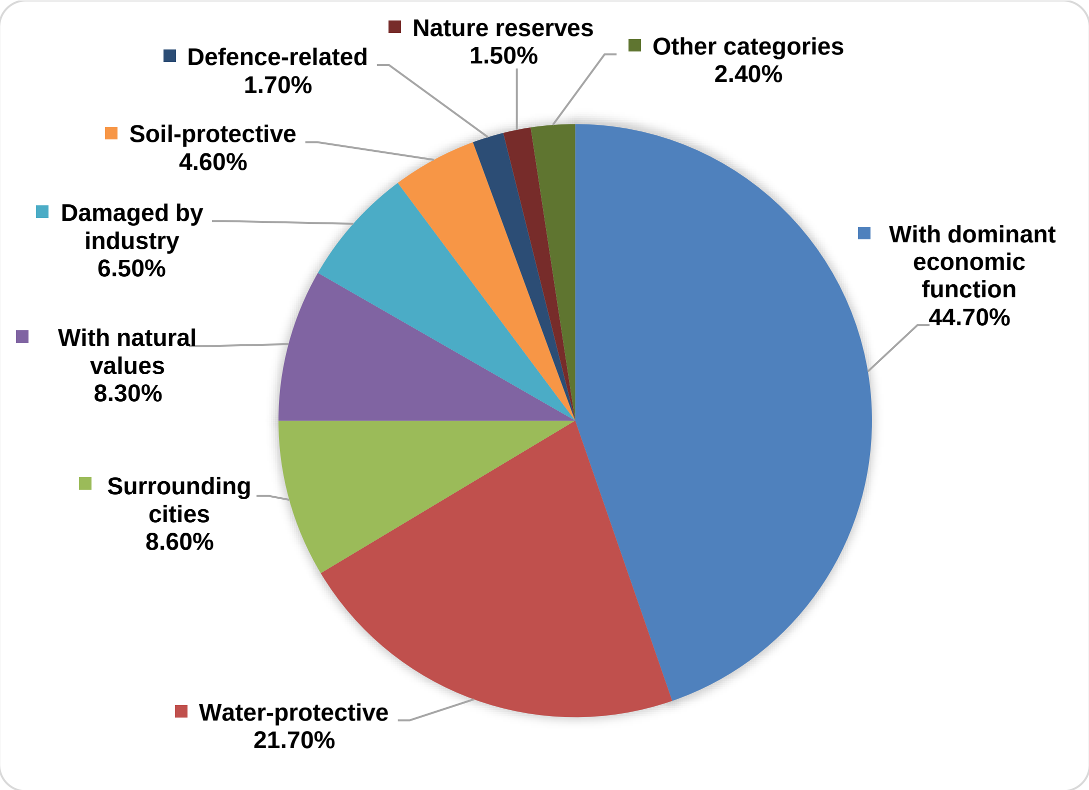

Fig. 1.1. Shares of forest categories in the State Forests.

Source: Zajączkowski G. et al., 2020.

In Poland, forest ecosystems constitute the most valuable and most numerously represented component of all forms of nature conservation. They occupy 38.4% of areas covered by legal protection. Forests in Poland are protected using many different forms of nature conservation. They include: national parks, landscape parks, nature reserves, protected landscape areas, Natura 2000 sites, ecological sites and nature and landscape complexes. Each of the forms listed above plays a different role in the Polish nature conservation system and serves a different purpose; therefore, it is subject to a different conservation regime and scope of restrictions on use. The particular forms of nature conservation can share their space with others (Zajączkowski G. et al.,2020).

Table 1.1 *Percentage shares of the areas covered by legal protection in 1996-2018*

Year	%
1996	29.37
1997	30.04
1998	31.08
1999	32.49
2000	32.50
2001	32.98
2002	33.01
2003	32.54
2004	32.52

2005	32.54
2006	32.12
2007	32.31
2008	32.31
2009	32.31
2010	32.43
2011	32.45
2012	32.45
2013	32.50
2014	32.50
2015	32.50
2016	32.50
2017	32.50
2018	32.60

Source: Statistics Poland – Local Data Bank, 2020.

There are now 23 national parks, which are the highest form of nature conservation, occupying an area of 315,100ha. These are areas characterised by special natural, scientific, cultural and educational values. They are established in areas of at least 1,000 ha to preserve biodiversity and inanimate nature, as well as to restore deformed natural habitats and the habitats of plants, animals or fungi. The forests in natural parks occupy 195,200 ha, i.e. 61.9% of their total area, with 60,800 ha subject to strict conservation.

National parks apply a holistic approach to biodiversity conservation, including the preservation of genetic resources. They have implemented and are implementing a number of projects related to the active conservation of natural resources. These measures can be grouped into several main categories:

- large projects for the comprehensive conservation of the ecosystems in national parks, including the conservation of forest ecosystems (the restoration of the natural state of stands), the conservation of non-forest ecosystems (naturalisation of meadows and pastures, mowing, cultural livestock grazing, extensive farming), the conservation of wetland ecosystems (renaturalisation of swamps and hydrographical network, modernisation of land amelioration systems to restore and improve the habitats of birds, fish and other animals, as well as natural vegetation),
- the purchase of private land situated within national parks for the purpose of renaturalisation and conservation of valuable habitats,
- measures to control and eradicate invasive species,
- long-term measures to monitor and observe natural processes,
- projects for the conservation of rare and endangered species of fauna and flora, including: European bison *Bisonbonasus*, wolf *Canis lupus*, lynx *Lynx lynx*, black grouse *Lyrurus tetrix*, western capercaillie *Tetraourogallus*, greater spotted eagle

Clangaclanga, Apollo butterfly *Parnassiusapollo,* aquatic warbler *Acrocephalus paludicola, Polish pony Equus caballus gmelini, formasylvatica,* mud turtle *Emys orbicularis,* corncrake *Crex crex,* dwarf cherry *Prunusfruticosa* and Pieniny wallflower *Erysimumhungaricum*.

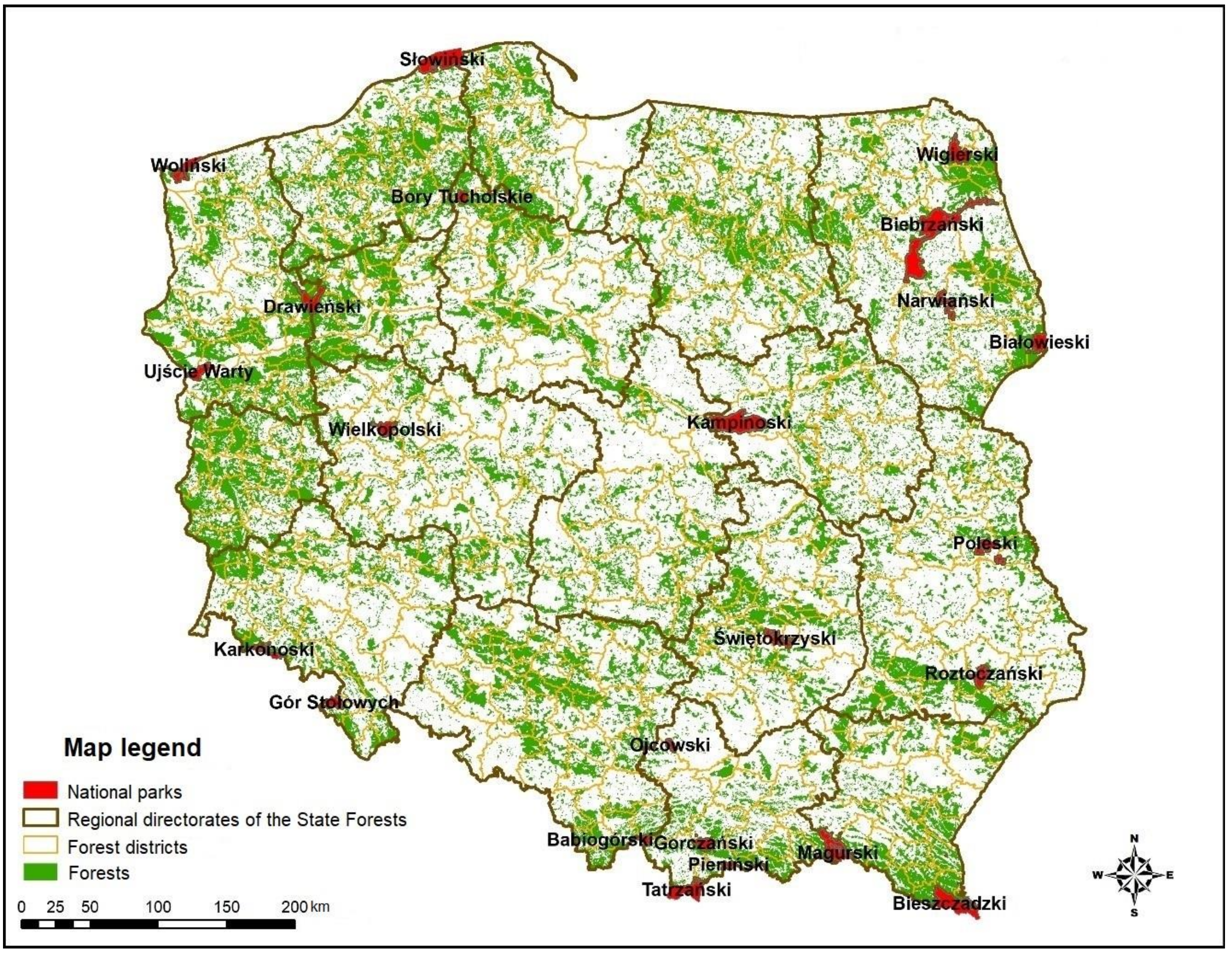

Fig. 1.2. National Parks in Poland.
Source: Own elaboration by the Kostrzyca Forest Gene Bank.

Nature reserves are established to preserve, in a natural or hardly changed state, ecosystems, refuges, the habitats of plants, animals and fungi, as well as formations and elements of inanimate nature which are distinguished by special natural, scientific, cultural or landscape values. There are 1,501 reserves with a total area of 169,600 ha. The majority of reserves (1,285) are situated in the areas of the State Forests. The total forest area in nature reserves is 109,200ha.

Landscape parks are established to protect landscapes which are valuable in terms of nature, history and culture and to make the areas situated within them available for recreation purposes. Landscape parks in Poland (125) occupy a total area of 2,610,800 ha, including 1,437,000ha (55%) of forestland.

Protected landscape areas are designated in view of their landscapes which are diversified in terms of ecosystems, enabling the satisfaction of the needs related to tourism and rest or the function of ecological corridors they perform. 387 natural sites with a total area of 7,021,800ha, including 2,295,800ha (32.7%) of forests, have been designated as protected landscape areas.

In the period from 1980 to 2019, the total area of national parks, landscape parks and protected landscape areas increased from 3.2% to 31.8%of the administrative territory of the country and already amounts to almost 10,000,000 ha, with forests occupying 3,928,000 ha, i.e. 39.5% of the total area of the forms of nature conservation listed above. Relative to the total forest area (9,259,000ha) this increase was even greater – from 5.5% to 42.4 %(Zajączkowski G. et al.,2020).

Ecological sites are protected remnants of ecosystems which are important for biodiversity preservation. They are e.g. natural water reservoirs, mid-field and midforest water ponds, clusters of trees and shrubs, swamps, peat-bogs, natural habitats, as well as the sites of rare species of plants, animals and fungi. Nature and landscape complexes are fragments of natural and cultural landscapes of varying size, deserving to be protected in view of their scenic or aesthetic values, such as remnants of parks or fragments of river valleys (Zajączkowski G. et al., 2020).

Table 1.2 *Area of national parks, nature reserves and landscape parks in 1996-2018*

Year	National, parks(ha)	Nature, reserves,(ha)	Landscape, parks(ha)
1996	301,055.70	128,001.00	2,136,467.70
1997	305,401.10	130,379.10	2,187,748.00
1998	305,675.60	141,224.70	2,482,210.90
1999	307,014.90	144,087.20	2,532,036.40
2000	306,494.10	148,731.50	2,530,953.40
2001	314,527.10	147,708.10	2,552,803.60
2002	314,532.50	148,964.70	2,569,177.70
2003	314,551.20	160,601.90	2,572,958.70
2004	317405.50	162,435.20	2,603,683.60
2005	317,233.80	165,244.70	2,603,575.50
2006	317,233.70	166,900.80	2,602,094.50
2007	317,299.30	168,797.70	2,603,020.20
2008	314,477.40	173,593.90	2,601,699.10
2009	314,483.60	163,402.60	2,607,050.80
2010	314,474.50	164,202.10	2,607,478.20
2011	314,570.50	164,463.40	2,607,728.00
2012	314,619.40	165,531.70	2,607,045.80
2013	314,619.70	165,741.51	2,610,839.44
2014	314,684.46	165,732.76	2,606,038.52
2015	314,699.90	166,918.88	2,606,092.18
2016	315,074.90	168,335.62	2,604,678.65
2017	315,086.51	169,193.84	2,604,726.41
2018	315,107.09	169,555.57	2,611,529.95

Source: Statistics Poland – Local Data Bank,2020.

Natura 2000 sites function within the framework of the European Ecological Network for the purpose of the conservation in Europe of about 200 most valuable natural habitats threatened with extinction and more than 1,000 rare and endangered species, including 50 bird species. Within the framework of the Natura 2000 network, by the end of 2019 all over the country 145 special protection areas designed to protect birds with a total area of 5,560,000 ha, including a terrestrial area of 4,836,000 ha, were designated, and so were 849 special areas of conservation designed to protect habitats with a total area of 3,851,000 ha, including a terrestrial area of 3,415,000 ha. At present, Natura 2000 sites cover about 20% of the national territory. Their share in the area administered by the State Forests National Forest Holding is 38% (Zajączkowski G. et al., 2020).

Table 1.3 *Area of Natura 2000 sites in 2005-2018*

Year	Special, Protection, Areas (ha)	Sites of Community Importance (ha)
2005	2,445,278.00	1,175,876.00
2006	2,445,278.00	1,408,404.00
2007	4,331,650.00	2,490,277.00
2008	4,925,016.20	2,567,442.30
2009	4,863,010.70	3,431,858.10
2010	4,922,366.80	3,431,857.90
2011	4,922,195.50	3,432,830.40
2012	4,926,176.30	3,456,320.60
2013	4,910,074.00	3,456,316.10
2014	4,926,204.90	3,491,103.00
2015	4,926,204.90	3,491,103.00
2016	4,926,204.90	3,491,103.00
2017	4,911,398.90	3,491,346.40
2018	4,911,398.90	3,491,346.40

Source: Statistics Poland – Local Data Bank,2020.

The State Forests National Forests Holding keeps the records on the statutory forms of nature conservation in the areas which it administers, updating the data on an ongoing basis, e.g. when preparing nature conservation plans at Forest Districts. As of 31.12.2019, the following was recorded in the areas of the State Forests:

- 1,285 nature reserves with a total area of 123,500 ha, with 53% of their area occupied by forest reserves,
- Natura 2000 sites with a total area of 2,889,000 ha (38% of the area of the State Forests), including 134special protection areas designed to protect birds with a total area of 2,213,000 ha (29.1%) and710 sites of community importance with a total area of 1,659,000ha(21.8%),
- 11,314 monuments of nature, including9,053single trees and 1,385 groups of trees, 122 historic avenues of trees, 506 erratic boulders, 248 rocks, grottoes and caves, including

161 site-based monuments (347ha),

- 8,253 ecological sites with a total area of 30,442 ha,
- 39 documentation sites with a total area of 735 ha,
- 168 nature and landscape complexes with a total area of 43,014 ha (Zajączkowski G. et al., 2020).

Moreover, the State Forests have established 3,893 protection zones around protected species with a total area of 154,938 ha, of which more than 22% are areas subject to year-round protection. The zones have been established to protect the refuges of birds (3,344), mammals (6), reptiles (113), insects (22), plants (5), lichens (402) and others (1) (Zajączkowski G. et al.,2020).

Taking efforts to preserve biodiversity and to restore endangered species of flora and fauna, the State Forests launches its own initiatives, among others, to maintain habitats and species in a favourable status. Such activities include the operation of animal rehabilitation centres and demonstration enclosures, as well as botanical gardens and arboreta. Animal rehabilitation centres are localised in 8 forest districts, while demonstration enclosures are operated in 9 units, where visitors can see European bison *Bisonbonasus*, Polish horse, E*quus caballus gmelini, forma sylvatica*, mud turtles *Emysorbicularis*, western capercaillies *Tetrao urogallus* and owls. In addition, the State Forests manages 7 botanical gardens and arboreta. Zajączkowski G. et al.,2020). In turn, all over the country there are 40 botanical gardens (Table1.4 and Table1.5).

Table1.4 *Number and area of botanical gardens in 2010-2018*

Year	Number of botanical gardens	Area of botanical gardens(ha)
2010	35	1,336.80
2011	35	1,334.90
2012	38	1,984.00
2013	38	2,000.60
2014	38	2,000.60
2015	40	2,013.00
2016	41	2,049.90
2017	42	2,096.30
2018	40	2,036.10

Source: Statistics Poland Local Data Bank, 2020.

Table1.5 *Botanical gardens in Poland*

Name of botanical garden	Location	Correspondence address
Moravian Gate Arboretum	ul.Markowicka17 47-400Racibórz	Mayor of City of Racibórz ul.StefanaBatorego6,47-400 Racibórz
Karnieszewice Arboretum	Karnieszewice 76-004Sianów	Karnieszewice Forest District ul.Trawica 8A, 76-004 Sianów
Prof.S. Białobok Forest Arboretum in Syców Forest District	ul.Leśna6 56-504StradomiaDolna	Syców Forest District ul. Kolejowa 14, 56-500 Syców

Kielce Geopark	ul.Daleszycka 21 25-202 Kielce	Mayor of City of Kielce Rynek 1, 25-303 Kielce
M.Raciborski Mountain Botanical Garden of Institute of Nature Conservation of Polish Academy of Sciences in Zakopane	ul.Antałówka13 ul.Zborowskiego1 34-500Zakopane	Institute of Nature Conservation of Polish Academy of Sciences Al.Mickiewicza 33, 31-120 Kraków
Forest Arboretum of Warmia and Mazury in Kudypy	Kudypy 2a 11-036 Gietrzwałd	Kudypy Forest District Kudypy 4,11-036 Gietrzwałd
Forest Botanical Garden in Marszewo	ul.Marszewska5 81-081Gdynia	Gdańsk Forest District ul.Morska 200,81-006 Gdynia
Myślęcinek Forest Park of Culture and Recreation in Bydgoszcz	ul.Gdańska 173-175 85-674 Bydgoszcz	Mayor of City of Bydgoszcz ul.Jezuicka1, 85-102 Bydgoszcz
City Botanical Garden in Zabrze	ul.Piłsudskiego60 41-800Zabrze	Mayor of City of Zabrze ul.Powstańców Śląskich 5-7, 41-800 Zabrze
"Wirty Arboretum" Botanical Garden	Borzechowo 83-224 Borzechowo	Kaliska Forest District al.Długa 64,83-260 Kaliska
"Exotarium" Botanical Garden	ul.Marszałka J.Piłsudskiego 116 41-209 Sosnowiec	Mayor of City of Sosnowiec Al.Zwycięstwa 20, 41-200 Sosnowiec
Botanical Garden of Wroclaw Medical University	Al.Jana Kochanowskiego 12 51-601Wrocław	Rector of Wroclaw Medical University ul.Pasteura1, 50-367 Wrocław
Dendrological Garden of Poznań University of Life Sciences – Forest Arboretum in Zielonka	ul.Wojska Polskiego 71d 60-625 Poznań Zielonka 6, 62-095 Murowana Goślina	Rector of Poznań University of Life Sciences ul.WojskaPolskiego28,60-637 Poznań
Botanical Garden of Nencki Institute of Experimental Biology of Polish Academy of Sciences in Mikołajki	ul.Leśna 13 11-730 Mikołajki	Nencki Institute of Experimental Biology of Polish Academy of Sciences ul.Pasteura 3,02-093 Warsaw
Botanical Garden of Plant Breeding and Acclimatization Institute in Radzików near Błonie	Radzików near Błonie ul.Jeździecka 5,85-867 Bydgoszcz	Botanical Garden of Plant Breeding and Acclimatization Institute in Radzików near Błonie ul.Jeździecka 5,85-867 Bydgoszcz
Botanical Garden on the premises of the Forest Experimental Station in Rogów	ul.Leśna1 95-063 Rogów	Rector of Warsaw University of Life Sciences Warsaw, ul.Nowoursynowska 166, 02-787 Warsaw
Botanical Garden of Polish Academy of Sciences –Centre for Biological Diversity Conservation in Powsin	ul.Prawdziwka 2 02-973 Warsaw	Polish Academy of Sciences, Palace of Culture and Science Plac Defilad 1, P.O. Box 24, 00-901 Warsaw
Botanical Garden of Polish Academy of Sciences in Kórnik, Kórnik Arboretum	ul.Parkowa 5 62-035 Kórnik	Institute of Dendrology of Polish Academy of Sciences ul.Parkowa 5, 62-035 Kórnik
Botanical Garden of Adam Mickiewicz University in Poznań	ul.Dąbrowskiego 165 60-594 Poznań	Rector of Adam Mickiewcz University in Poznań ul.Wieniawskiego 1, 61-712 Poznań
Botanical Garden of Jagiellonian University	ul.Kopernika27 31-501 Kraków	Rector of Jagiellonian University in Kraków ul.Gołębia 24,31-007 Kraków

Botanical Garden of Casimir the Great University in Bydgoszcz	ul.Chodkiewicza 30 85-064 Bydgoszcz	Rector of Casimir the Great University in Bydgoszcz ul.Chodkiewicza 30, 85-064 Bydgoszcz
Botanical Garden of Maria Curie-Skłodowska University in Lublin	ul.Sławinkowska3 20-810 Lublin	Rector of Maria Curie-Skłodowska University Plac M.Curie-Skłodowskiej 5, 20-031 Lublin
Botanical Garden of Warsaw University	Al.Ujazdowskie 4 00-478 Warsaw	Rector of Warsaw University ul.Krakowskie Przedmieście 26/28, 00-927 Warsaw
Botanical Garden of University of Wrocław and its branch in Wojsławice	ul.Sienkiewicza 23,50-335 Wrocław Wojsławice 2,58-230 Niemcza	Rector of University of Wrocław, ul.Sienkiewicza 23, 50-335 Wrocław
Botanical Garden of University of Zielona Góra	ul.Botaniczna 50a 65-392 ZielonaGóra	Rector of University of Zielona Góra ul.Licealna 9, 65-417 ZielonaGóra
Botanical Garden in Bolestraszyce	Bolestraszyce130 37-722Wyszatyce	Arboretum and Institute of Physiography in Bolestraszyce P.O. Box 471, 37-700 Przemyśl
Botanical Garden in Glinna	74-106 Gliniec	Gryfino Forest District ul.1 Maja 4,74-100 Gryfino
Botanical Garden in Gołubie	ul.Botaniczna 21 83-316 Gołubie	Golubie Botanical Garden ul.Botaniczna21, 83-316 Gołubie
Botanical Garden in Łódź	ul.Krzemieniecka 36/38 94-303 Łódź	Mayor of City of Łódź ul.Piotrkowska 104,90-926 Łódź
Botanical Garden in Mikołów	ul.Sosnowa 5 43-190 Mikołów	Silesian Botanical Garden ul.Sosnowa 5,43-190 Mikołów
Botanical Garden in Niegoszcz	Niegoszcz 25A 76-032 Mielno	Regnum Vegetabile Foundation ul.Gen.S.Maczka 21, 76-032 Mielno
Botanical Garden in Przelewice	Przelewice17 74-210 Przelewice	Head of Municipality of Przelewice Przelewice 75 ,74-210 Przelewice
Botanical Garden in Radzionków	ul.Księżogórska 90a 41-922 Radzionków	Silesian Botanical Garden ul.Sosnowa 5, 43-190 Mikołów
Botanical Garden -Arboretum in Marcule Forest District	Marcule, 27-100 Iłża	Marcule Forest District Marcule 1,27-100 Iłża
Dendrological Garden in Orle	Orle 35 83-420 Liniewo	Dendrological Garden in Orle Orle 35,83-420 Liniewo
Medicinal Plant Garden of Medical University of Gdańsk	Al.Gen.J.Hallera 107 80-416 Gdańsk	Rectorof Medical University of Gdańsk ul.Skłodowskiej-Curie 3a, 80-210 Gdańsk
Garden of Medicinal Plants of Institute of Natural Fibres and Medicinal Plants in Plewiska	ul.Kolejowa 2 62-064 Plewiska	Institute of Natural Fibres and Medicinal Plants ul.Wojska Polskiego 71b, 60-630 Poznań
Zoobotanical Garden in Toruń	ul.Bydgoska 7 87-100 Toruń	Mayor of City of Toruń ul.Wałygen.Sikorskiego 8, 87-100 Toruń
Poznań Palm House	ul.Matejki 18 60-767 Poznań	Mayor of City of Poznań, pl.Kolegiacki 17 61-841 Poznań
Podlaski Herb Garden	Koryciny73b 17-315 Grodzisk	Podlaski Herb Garden In Koryciny Koryciny 73b, 17-315 Grodzisk

Source: Data of the General Directorate for Environmental Protection (downloaded from the website: https://www.gdos.gov.pl/wykaz-ogrodow-botanicznych-w-polsce).

The State Forests National Forest Holding takes many measures to preserve biodiversity which are financed with both its own resources and external ones. They include projects for the species-specific conservation of plants and animals and the conservation of natural habitats, nature inventories, species restitutions, genetic research and many others. As part of these measures, multiannual projects are launched for the conservation and restitution of protected species of animals and plants, e.g. western capercaillie *Tetrao urogallus,* black grouse *Lyrurustetrix*, common yew *Taxus baccata*, wild service tree *Sorbustorminalis*, mud turtle *Emys orbicularis*, osprey *Pandionhaliaetus*, Eurasian eagle-owl *Bubo bubo*, bats or locally rare populations – e.g. the programme for the restitution of silver fir *Abiesalba*in the Sudety Mountains (Zajączkowski G. et al., 2020).

In the period from 2016 to 2019, an inventory of the natural and cultural riches of the local forest was carried out in the Białowieża Primeval Forest (the Forest Districts: Białowieża, Browsk and Hajnówka and the Białowieża National Park). The many research modules covering a large number of systematic groups of organisms and studies in the scope of dendrometry, soil science and archaeology, also included florist and phytosociological research, e.g. inventories of protected, endangered and threatened plants in the area of Białowieża Forest (covering both vascular and flowering plants, bryophytes and lichenised fungi, i.e. lichens), as well as the identification and determination of the state of forest natural habitats on Natura 2000 sites. It proved possible to localise many plant species, including e.g. green broom moss *Dicranum viride*, green shield-moss *Buxbaumiaviridis*, barnacle lichen *Thelotremalepadiunum*, bractless toadflax *Thesium ebracteatum*, hairy agrimony *Agrimoniapilosa*, eastern pasqueflower *Anemone patens*, smooth pea *Lathyruslaevigatus*, shrub birch *Betulahumilis*, Turkish marsh gladiolus *Gladiolus imbricatus*, red helleborine *Cephalantherarubra* etc. There is no doubt that this three years long research (covering every year the spring and summer aspects) provided knowledge on many new sites of protected and endangered plant species and their current state in the Białowieża Primeval Forest (the data from the Directorate General of the State Forests, 2020).

The inventory was initiated by the Ordinance No. 29 of the Director General of the State Forests of 14.06.2016on: (1) the assessment of the process of establishing Natura 2000 sites occupying the land administered by the State Forests and the assessment of the conservation measures plans for these sites,(2) the preparation of forest management plans which would also play the function of conservation measures plans for Natura 2000 sites, and(3) the establishment of a system for a periodic, general inventory of the species of plants, animals and other organisms, as well as the parametrisation of selected features of biotopes of importance for the assessment of the state of forests and the projection of changes in forest ecosystems.

Table 1.6 *Abundance of selected animal species covered by species-specific conservation in 2003-2018*

Year	European bison *Bison bonasus*	Tatra chamois *Rupicapra rupicapra tatrica*	Brown bear *Ursusarctos*	European beaver *Castorfiber*	Lynx *Lynxlynx*	Wolf *Canislupus*
2003	843	114	127	39,453	192	690
2004	861	148	136	41,823	213	719
2005	901	138	164	43,499	231	800
2006	965	141	130	49,040	217	715
2007	1,070	128	138	51,334	230	759
2008	1,107	150	156	58,847	203	702
2009	1,139	186	119	64,254	212	696
2010	1,224	172	147	68,993	285	770
2011	1,225	244	139	78,174	291	913
2012	1,204	290	158	88,974	309	1,050
2013	1,361	334	164	96,658	308	1,122
2014	1,432	391	163	100,216	309	1,276
2015	1,553	275	224	101,336	390	1,484
2016	1,712	384	262	121,624	434	2,139
2017	1,873	310	304	124,622	432	2,390
2018	1,820	441	292	127,173	427	2,868

Source: Statistics Poland – Local Data Bank, 2020.

In the area of the Regional Directorate of the State Forests in Krosno, an inventory of the natural resources of the local forests has been carried out since 2016. In 2019, complementary work was performed in the area of the Forest District of Bircza, with its scope including an inventory of plant species covered by strict and partial conservation, e.g. green broom moss *Dicranumviride,* green shield-moss *Buxbaumiaviridis* and hart's-tongue fern *Phyllitisscolopendrium.* The inventory provided knowledge on many new sites of protected species in the Bircza forests (Zajączkowski G. et al., 2020).

”The comprehensive project for species and habitats conservation in areas managed by the State Forests National Forest Holding” has been carried out since 2017.Its purpose is to improve the conservation status of natural habitats and species of flora and fauna on Natura 2000 sites situated in the areas administered by the State Forests (Zajączkowski G. et al., 2020).

Since 2017 the Kostrzyca Forest Gene Bank, which is an organisational unit of the State Forests, has realized the project called ”Molecular identification (barcoding) and DNA banking for selected plant species from the Białowieża Primeval Forest”. The basic aim of the project is the development of a database of the genetic codes (so-called DNA barcodes) of selected plant species and the long-term storage of seeds, tissue fragments, herbarium specimens and DNA preparations of selected species. It is extremely important to deposit and secure the seeds of endangered species in order to preserve the populations of these species in the landscape of the Białowieża Primeval Forest and outside it in case of their extinction in nature. As part of the project, the seeds of 47 species were acquired (to be stored in cryogenic conditions), 1,585 tissue fragments of 105 plant species were secured and 451 DNA samples were deposited at the DNA bank. Within the framework of cooperation with the Herbarium of the Faculty of Biology at the University of Warsaw Chemical and Biological Research Centre, 203 herbarium specimens representing 103 plant species were digitalised. The collected information is available via the website www.barkodowanie.pl (Zajączkowski G. et al., 2020).

In accordance with the provisions of the Nature Conservation Act, the Chief Inspectorate of Environmental Protection carries out Nature Monitoring, with its scope also including forest areas, which consists in the observation and assessment of the state of elements of biological and landscape diversity and changes unfolding in it in selected areas, as well as in the assessment of the effectiveness of the nature conservation methods applied. Within its framework, the monitoring of natural habitats is carried out, consisting in the observation of natural habitats and species of flora and fauna for the conservation of which Natura 2000 sites have been designated. A separate module of the State Environmental Monitoring System is the Monitoring of Poland's Birds, covering most of their native species, also including 40 species listed in Annex I to the Birds Directive (Zajączkowski G. et al., 2020).

An important aspect of nature conservation in forests is leaving an appropriate quantity of dead wood on the ground. The average volume of standing dead trees in forests under all forms of ownership is a total of 4.3m^3/ha. The largest volume of standing dead trees per ha can be found in the forests of national parks (17.9m^3/ha). The analogous volume in the State Forests is 3.9m^3/ha, while in private forests it is 4.1m^3/ha. Age class IV and older age classes account for 60.7% of the total volume of standing dead trees in forests under all forms of ownership. Coniferous species represent 59.5% of the total volume of standing dead trees. Their share in the State Forests is 60.3% and it is 59.8% in private forests. The average volume of lying dead trees in forests under all forms of ownership is 4.1m^3/ha, while the largest volume of lying dead trees per ha can be found in the forests of national parks (24.4m^3/ha).The analogous volume in the State Forests is 4.1m^3/ha, i.e. larger than in private forests (2.1m^3/ha). Age class IV and older age classes account for 60.3% of the total volume of lying dead trees in forests under all forms of ownership, while coniferous species represent 53.2%. The analogous values for the State Forests are as follows: 61.5% (the share of age class IV and older age classes), 52.9% (the share of coniferous species), while for private forests they are, respectively: 47.7% (the share of age class IV and older age classes) and 50% (the share of coniferous species). The average volume of standing and lying dead trees in forests under all forms of ownership is a total of 8.4m^3/ha, while the largest volume of standing and lying dead trees per ha can be found in the forests of national parks, i.e. 42.2m^3/ha. The analogous volume in the State Forests is 8m^3/haand it is larger than in private forests (6.2m^3/ha). Age class IV and older age classes account for 60.5% of the total volume of standing and lying dead trees in forests under all forms of ownership, while coniferous species represent 56.4%.The share of coniferous species in the total volume of standing and lying dead trees in the State Forests is 56.5%.The same volume of standing and lying dead trees has been recorded in private forests. These results indicate that at present in the entire territory of the country the average gross merchantable volume of about 8.4m^3/ha of dead wood can be found, consisting of about 4.1m^3/ha of lying dead wood and 4.3m^3/ha of standing dead wood. The total volume of dead trees in all of Poland's forests involves a standard error of 1.66%; specifically, the analogous volume in the State Forests has been determined with an error of 1.96% and in private forests with an error of 2.95% (WISL, 2020).

Table 1.7 *Volume of dead wood*

<table>
<tr><th colspan="3" rowspan="2">Ownership</th><th colspan="2">Volume of standing dead trees</th><th colspan="2">Volume of lying dead trees</th></tr>
<tr><th>m³</th><th>m³/ha</th><th>m³</th><th>m³/ha</th></tr>
<tr><td rowspan="5">Public forests</td><td rowspan="4">State Treasury</td><td>State Forests</td><td>27,803,531</td><td>3.90</td><td>28,990,851</td><td>4.10</td></tr>
<tr><td>National parks</td><td>3,319,456</td><td>17.90</td><td>4,525,968</td><td>24.40</td></tr>
<tr><td>Agricultural, Property Stock of the State Treasury</td><td>198,557</td><td>7.20</td><td>173,465</td><td>6.30</td></tr>
<tr><td>Other</td><td>420,395</td><td>7.70</td><td>271,237</td><td>5.00</td></tr>
<tr><td colspan="2">Municipal forests</td><td>465,284</td><td>5.50</td><td>380,267</td><td>4.50</td></tr>
<tr><td colspan="3">Private forests</td><td>7,382,533</td><td>4.10</td><td>3,794,438</td><td>2.10</td></tr>
</table>

Source: Large-Scale Forest Inventory, 2020.

1.5. Tourism and recreation

The measures to provide access to forests focus on ensuring safe and interesting recreation for persons using the forest and, at the same time, protecting natural resources. These purposes are served, among others, by giving direction to the tourist traffic and introducing unified rules for the management of tourist infrastructure (Zajączkowski G. et al., 2020).

In accordance with the Forest Act, access to forests which are the property of the State Treasury is provided to the population. Permanent prohibitions of entry apply to forests which are second-grown forest up to 4m high, experimental plots and seed stands, animal refuges, sources of rivers and streams, and areas at risk of erosion. The forest district inspector imposes a temporary prohibition of access to the forest which is the property of the State Treasury in the case of destruction of, or substantial damage to, stands or degradation of the forest undergrowth, a high fire danger and the operations related to silviculture, forest protection or logging are carried out. Movement by means of a motor vehicle, a horse-drawn cart or moped in forests is allowed only using public roads, whereas traffic using forest roads is allowed when they are marked with road signs permitting such traffic. This does not apply to disabled persons moving by means of vehicles adapted to their needs. Horse riding in forests is only allowed using forest roads designated by the forest district inspector. Vehicles may park in forest roads only at marked sites. These regulations do not apply to persons who carry out their official or economic activities, employees of selected institutions or other persons (e.g. employees of forest districts, uniformed personnel of the Border Guard, persons fighting fires or saving human life or health, officers of the authorities responsible for public safety and order, persons carrying out activities in the scope of game management, owners of apiaries situated in forest areas and persons using farmland situated in forest areas)(Forest Act, 1991).

In addition to their functions, forests are an excellent place for rest and recreation. This form of contact with nature, especially in the State Forests, is fostered by the existence of an ample tourist infrastructure, such as walking, cycling and horse riding trails, bivouacking sites, forest parking lots, roofed facilities, fitness paths, scenic platforms and many others. Forests are also the destination of numerous excursions, mostly organised by schools, during which children and youth can come into personal contact with nature. The health-enhancing properties of forest ecosystems favour the development of tourism and recreation, primarily in areas recognised to be health resorts. In the areas of the State Forests, there are 45 training and recreation centres, 318 recreation centres/sites, 62 hunting lodges and 313 guest rooms. Outdoor accommodation facilities include 500 bivouacking places and 18 bivouacking sites. 229 scouts camps have also been set up. The tourist facilities in forests also include 1,467 resting places, 85 forest parking lots and 4,262 vehicle stopping places (Zajączkowski G. et al., 2020).

Within the framework of the project called "The Great Forest Trail", the State Forests develops a comprehensive tourist offer. The modern, easily accessible "czaswlas.pl" portal, updated on an ongoing basis, will contain e.g. an information package on a safe stay in a forest, ready proposals of excursions addressed to specific users etc. The main functionality of the portal will be a tourist map of the State Forests, with attractive proposals of spending time in a forest (Zajączkowski G. et al., 2020).

The State Forests has also launched a pilot project for providing access to forest areas to engage in such activities as bushcraft and survival. An agreement has also been signed on the cooperation between the State Forests National Forest Holding and the Polish Tourist and Sightseeing Society, with the aim of an exchange of information and an improvement in the management of tourist trails within the areas of the State Forests (Zajączkowski G. et al., 2020).

The State Forests National Forest Holding is also a signatory to the "Availability Plus" Programme, actively participating in actions to provide access to forest areas for disabled persons. As part of this measure, the State Forests has prepared a map of forest facilities which are partly adapted to the needs of disabled persons (available on the website www.lasy.gov.pl).The audits of 4 education and tourist sites have also been carried out to determine whether they are adapted to the needs of such persons. On their basis, relevant guidelines will be prepared for the units of the State Forests (Zajączkowski G. et al., 2020).

1.6. Forest nature education

Forest nature education is also implemented outside schools by the organisational units of the State Forests, national parks, landscape parks, botanical gardens and nongovernmental organisations.

The forest nature education in the organisational units of the State Forests is carried out outside schools by the organisational units of the State Forests on the basis of "The directions of the development of forest education in the State Forests", adopted by the Ordinance No. 57 of the Director General of the State Forests of 09.05.2003, as well as "the Guidelines for the preparation of the public forest education programme in the forest district", on the basis of which forest district Inspectors prepared such programmes for 10-year periods corresponding to the implementation of the forest management plan (Zajączkowski G. et al., 2020).

The aim of forest nature education is to disseminate in the public the knowledge of the forest environment and the sustainable forest management and to raise the awareness regarding the reasonable and responsible use of all the functions of forests. The educational activities are carried out by qualified education personnel who continuously improve their competences at specialised workshops where, among others, they learn the methods for conducting educational activities for different age groups and the principles of the design, preparation and delivery of multimedia presentations (Zajączkowski G. et al., 2020).

The leaders of forest nature education are the forest districts in the promotional forest complexes where every year more than 30% of the participants of educational activities prepared by foresters attend its different forms (Zajączkowski G.etal., 2020).

In 2019, about 6,100,000 persons participated in different forms of educational activities organised by foresters. They included:

- field classes and guided trips – about 438,000 persons,
- classes in forest education rooms – about 276,000 persons,
- meetings with a forester in schools – about 232,000 persons,
- meetings with a forester outside schools – about 68,000 persons,
- educational actions and events – about 585,000 persons,
- educational exhibitions – about 164,000 persons,
- forest competitions – about 86,000 persons,
- other events, e.g. festivals, fair etc. –about 4,300,000 persons (ZajączkowskiG. et al., 2020).

The classes were delivered using diversified educational infrastructure consisting of: forest education centres (54), educational rooms (271), roofed educational facilities – so-called green rooms (496), educational paths (950), educational points (1,777), other facilities (2,752) and, in addition, the accommodation base. Within the framework of its educational activities, the State Forests cooperated with environmental education centres, national parks, houses of culture and museums, nongovernmental organisations and the media. The educational activities of the State Forests are primarily financed from the own resources of forest districts, the resources of the National Fund for Environmental Protection and Water Management and the provincial funds for environmental protection and water management. The educational activities are also carried out in national parks and forests under different forms of ownership, mostly urban forests. An important element of forest nature education are also projects implemented by the state administration at the national, regional and municipal levels, in cooperation with the units of the State Forests, research centres and the administrative units of the neighbouring countries as part of transboundary projects(Zajączkowski G. e al., 2020).

In the State Forests, the Kostrzyca Forest Gene Bank plays a special role in promoting the conservation of forest genetic resources at the national level, as well as in the actions at the European level undertaken by EUFORGEN.

The aim of the nature education carried out by national parks is to protect natural resources by changing the way in which they are visited and shaping the attitudes of the public to the natural environment, especially to the parks themselves. They also play a social and upbringing role by strengthening the public acceptance of national parks. Indeed, they are places where patterns of public behaviour towards the natural environment and national values should be shaped. Therefore, the education in national parks is treated as one of the forms of their protection and a tool for counteracting social threats which national parks encounter in the present socio-economic realities. Among the specific educational tasks in national parks, it is important to highlight e.g. the generation of an emotional attitude to the environment, the exploration of the surrounding world and the phenomena unfolding in nature, and the preparation for independent and responsible decision-making (Partyka, 2002).

The educational activities of national parks are mainly based on didactic classes for both children and adults within parks and at their educational centres. Among others, they include series of chats, lectures, thematic competitions, meetings with youth, workshops, thematic activities etc. Most of national parks operate nature museums, educational centres or exhibition rooms. Every year more and more persons visit these facilities – about 903,000 in 2015 and almost 980,000 in 2017.

Education in national parks is also carried out on educational paths (with a total length of more than 690km), enabling the delivery of classes during active visits (The activities and financing of national parks in 2015-2017, 2018).

Although the institutions and organisations mentioned above, including those that are directly involved in the management of forest genetic resources, carry out continuous and active forest nature education, it should be noted that the knowledge of society regarding the rules for the implementation of sustainable forest management continues to be insufficient. Both in Poland and Europe as a whole, society is increasingly separated from forests and forestry; therefore, the importance of sustainable forest management should be promoted. Taking into account the significant role of sustainable forest management in the supply of many benefits to the public, there is a large need to provide information on the economic, social and environmental as well as cultural and historical roles of forests, and to manage them as elements of our natural heritage (Resolution on “A new EU Forest Strategy”, 2020). Therefore, it seems necessary to disseminate, as part of the system of education and universities in Poland, the knowledge of the issues of forestry, including the principles of the implementation of sustainable forest management.

1.7. Promotional forest complexes

In order to promote the sustainable forest management and the conservation of natural resources in forests, the Director General of the State Forests can establish promotional forest complexes. The promotional forest complexes consist of forests managed by the State Forests and the forests of other owners (at their request). Promotional forest complexes are areas of ecological, educational and social importance, the operations of which are set out by a uniform economic and protective programme, developed by the competent director of the regional directorate of the State Forests. For each promotional forest complex the Director General of the State Forests appoints a scientific and social council with the tasks of the initiation and assessment of activities undertaken in promotional forest complexes (Forest Act, 1991).

The policy of promoting environment-friendly forest management as pursued by the State Forests has enabled the establishment of 25 promotional forest complexes in all the 17 regional directorate of the State Forests, with a total area of about 1,279,000 ha, including more than 1,256,000 ha in the State Forests, representing more than 17% of the area administered by the State Forests National Forest Holding. The promotional forest complexes are functional areas where management rules are improved, integrating the objectives of the general nature conservation and environment-forming functions of forests, as well as those of the sustainable use of forest resources, the economic stabilisation of forest management and the public participation in the management of forests as a public good. The promotional forest complexes can also be recognised as special areas of importance for science and research, where due to the full knowledge of the forest environment interdisciplinary research is carried out. On the basis of the results of the research, forest management methods can be improved and the permissible limits of intervention into forest ecosystems can be determined. Moreover, they provide an alternative to national parks with their burden of tourist traffic. Due to the promotion of forests and their opening to meet the social needs, the State Forests National Forest Holding provides an opportunity for not only learning the principles of environment-friendly forest management but also for coming into direct contact with nature, without major restrictions on entry and movement in the forest, for disabled persons as well, which is extremely important for the education, especially the education of children and youth (Haze, 2012; Zajączkowski G. et al., 2020).

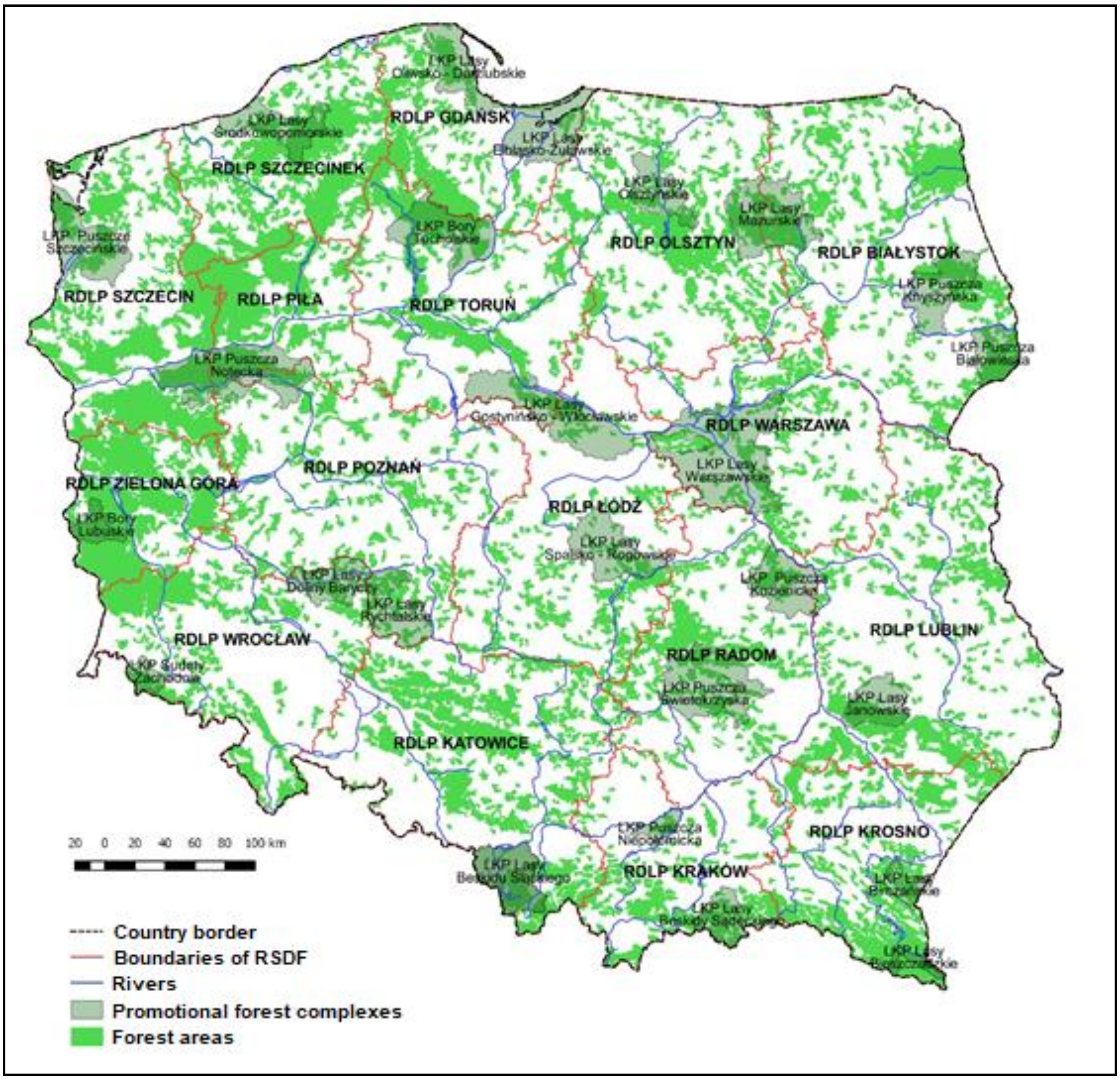

Fig. 1.3.Promotional Forest Complexes in Poland.
Source: Zajączkowski G. et al., 2020.

1.8. Absorption of CO_2 and other greenhouse gases

This issue has become important in practical terms, given the climate warming caused by the increasing quantities of CO_2 in the atmosphere and, in particular, given the public becoming aware of this fact. The so-called Kyoto Protocol adopted on 16.02.2005 listed measures in the scope of forestry which would contribute to increased carbon sequestration. The general principles of balancing the quantities of carbon sequestered in forests and the possibilities of accounting for it in the overall CO_2 emissions balance are based on decisions taken at the Conferences of the States – Parties to the Climate Convention, on the provisions of the Kyoto Protocol, the Paris Agreement of 2015 and the Katowice Declaration

On Forests for the Climate, adopted during the United Nations Conference on Climate Change 2018 (Zajączkowski G. et al., 2020).

The tasks of the State Forests under the Forest Act coincide with the objectives set out in the abovementioned documents and declarations. An improvement in the reduction of the quantities of greenhouse gases can be achieved, among others, by taking appropriate actions related to the implementation of forest management, including by increasing the forest area, by carrying out silviculture operations to increase the growing stock, by extending the service life of wood products and their recycling, by using wood for energy purposes or by enhancing carbon retention in soil. In Poland, these objectives are implemented mainly in the forest areas administered by the State Forests National Forest Holding where over the last 10 years the forest area and timber resources grew, respectively, by 50,000 ha and 194,000,000m^3. Over that period the average timber resource also increased – from 245to274m^3/ha, and so did the average age – from 61 to 64 years (Zajączkowski G. et al., 2020).

Poland's position on the methods for reducing emissions is based, among others, on the use of energy from renewable sources, primarily geothermal energy, and the deployment of forest areas for the absorption of CO_2(Zajączkowski G. et al., 2020).

Since 2017 State Forests National Forest Holding has realized the project called "Forest Carbon Farms". The aim of the project is to work out methods for increasing the absorption of CO_2 and other greenhouse gases by taking additional measures in forests. The project is implemented in forest districts all over the country, in an area of more than 11,000 ha. Measures are taken to increase the forest area, to introduce the second storey, fast-growing species and underplantings, as well as to promote natural regeneration (Zajączkowski G. et al., 2020).

The main aim of the research part of the project is to adapt the carbon balance model to the conditions characteristic of Poland. The Polish carbon balance model is elaborated using the existing software and the inputs to the model include, among others, the species-specific features of trees and soil types. In the first half of 2018, on the basis of the model mentioned above, information was acquired on the quantity of CO_2 estimated to be sequestered in 2017-2046 as a result of additional measures – this quantity was almost 1,000,000t (Zajączkowski G. et al., 2020).

At the same time, in order to elaborate up-to-date regional allometric patterns and new tree and stand growth models, ample empirical data were collected from dendrometric measurements and laboratory analyses. According to the data calculated for 2018 by the National Centre for Emissions Management, the weight of CO_2 absorbed annually by forests in Poland (taking in account the use and absorption of the gas by soils) is 36,600,000t, which translates with approximation into about 10,000,000t of carbon (Zajączkowski G. et al., 2020). Compared with other European countries Poland is one of the leaders in terms of the quantity of carbon sequestered in woody biomass in forest areas. To a large extent, this results from the size and structure of the timber resources in our country. The carbon content in the woody biomass in Poland has been estimated at 822,000,000t, including 685,000,000t in aboveground living biomass, 137,000,000t in its underground part and 32,000,000t in dead wood (Zajączkowski G. et al., 2020).

1.9. Productive functions of the forest

The productive functions of the forest are primarily expressed in the production with the forces of nature and human labour of wood raw materials and other useful and human-friendly products, which are the basis of many branches of production, professions, traditions and cultures.

Silviculture needs, the principles of regulating the structure of forest resources, the need for wood and wood products for economic purposes and the need to ensure economic conditions for forest management justify the use of forests as a renewable source of wood raw material (Zajączkowski G. et al., 2020).

The use of the forest is carried out at the level determined by natural conditions of production, silviculture and protective requirements, and above all, by the principle of forest sustainability and increasing its resources (Zajączkowski G. et al., 2020).

In 2019, 42,366,000 m^3 of raw timber was obtained in Poland, including 40,638,000 m^3 of net raw timber by 3,294,000 m^3 less than in 2018) and 1,728,000m^3 of small wood. In private forests, 1,307,000 m^3 of net merchantable imber was obtained (a decrease of 523,000 m^3 compared to 2018), and in national parks - 166,000 m^3. In the State Forests, a total of 40,626,000 m^3 of raw timber as harvested in 2019. On forest land alone, 38,892,000 m^3 of net round wood was harvested, including 20,502,000 m^3 in merchantable timber and 18,390,000 m^3 in intermediate felling. The general small wood harvest was about 1,717,000 m^3 (Zajączkowski G. et al., 2020).

The timber volume of the forest sanitary management, resulting from the harvesting of deadwood, broken and blown over trees, caused by natural processes and the impact of winds, the gradation of harmful insects, disturbances in water balance, air pollution and weather anomalies, amounted in 2019 to 7,695,000 m^3, which accounted for 19.8% of the net merchantable timber harvest (Zajączkowski G. et al., 2020).

This figure is slightly higher than the average of 17.9% over the last 10 years. The 2019 incidental felling was mainly due to the removal of damage caused by the weakening of the stands as a result of the drought that has been going on since 2015, affecting the disruption of water balance and the development of the gradation of many insect species (Zajączkowski G. et al., 2020).

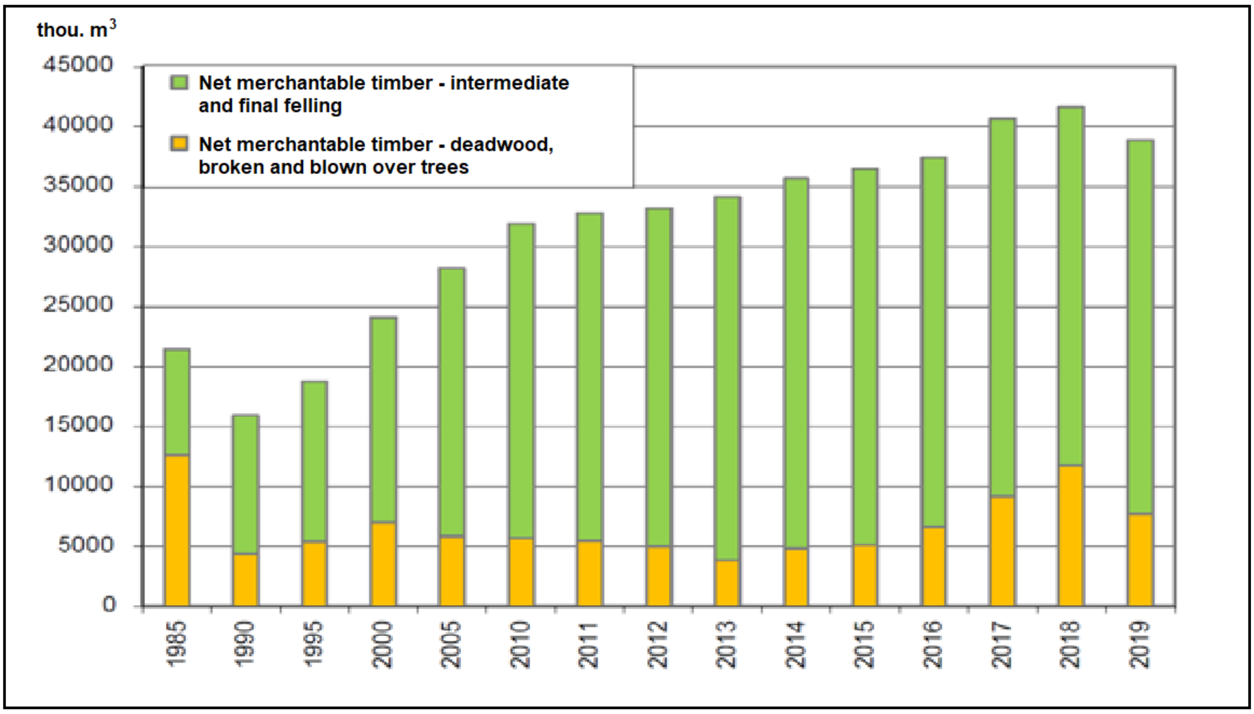

Fig.1.4.The share of harvest of deadwood, broken and blown over trees in total use in the State Forests in the years 1985-2019 in thousand m^3 net merchantable timber.
Source: Zajączkowski G. et al., 2020.

According to the data from 2010, the total gross main use of merchantable timber in forests of all forms of ownership is about 46,000,000 m^3, with about 16,900,000 m^3 for final felling use and about 29,100,000 m^3 for intermediate felling. The average annual use in forests of all forms of ownership is 5.08 m^3/ha gross of merchantable timber. The total main use in the State Forests is estimated at 40,000,000 m^3 per year merchantable timber gross (with an average annual use of 5.66 m^3/ha), divided into final felling and intermediate felling 15,600,000 m^3 and 24,400,000 m^3 per year respectively (WISL, 2020).

In private forests, the total volume is about 5,100,000 m^3 gross merchantable timber (with an average annual use of 3.11 m^3/ha), divided into final felling and intermediate felling: 1,000,000 m^3 and 4,100,000 m^3 per year respectively (WISL, 2020).

According to the data from 2014 onwards, the total gross use of merchantable timber in forests of all forms of ownership amounts to approximately 54,100,000 m^3 of merchantable timber gross, with approximately 23,300,000 m^3 for final felling and approximately 30,900,000 m^3 for intermediate felling. The average annual use in forests of all forms of ownership is 5.9 m3/ha grosses merchantable timber. The total main use in the State Forests is estimated at 47,500,000 m^3 per year gross merchantable timber (with an average annual use of 6.71 m^3/ha), divided into final felling and intermediate felling: 21,700,000 m^3 and 25,800,000 m^3 per year respectively.

In private forests, the total volume is about 5,700,000 m^3 gross merchantable timber (with an average annual use of 3.3 m^3/ha), divided into final felling and intermediate felling:

1,200,000m^3 and 4,500,000 m^3 per year respectively (WISL,2020).

Tab.1.8 *Average annual merchantable timber harvest in 2014-2018*

Ownership			Harvest			
			Final felling		Intermediate felling	
			m^3/ha	m^3	m^3/ha	m^3
Public Forests	State Treasury	State Forests	3.06	21,681,400	3.65	25,861,800
		National parks	0.41	75,800	1.08	199,800
		Agricultural Property Stock of the State Treasury	1.79	54,400	1.05	31,900
		Other	2.15	116,700	2.48	134,600
	Communal forests		1.44	121,400	1.68	141,600
Private forests			0.72	1,251,000	2.58	4,482,600

Source: Large-Scale Forest Inventory, 2020.

Tab.1.9 *Average annual merchantable timber harvest in 009-2018*

Ownership			Harvest			
			Final felling		Intermediate felling	
			m^3/ha	m^3	m^3/ha	m^3
Public Forests	State Treasury	State Forests	2.21	15,612,400	3.45	24,372,300
		National parks	0.36	66,200	1.39	255,500
		Agricultural Property Stock of the State Treasury	1.30	51,500	2.02	80,000
		Other	1.23	66,700	2.25	122,100
	Communal forests		1.22	102,500	1.95	163,800
Private forests			0.64	1,046,600	2.47	4,039,100

Source: Large-Scale National Forest Inventory, 2020.

The timber volume of trees removed in the 5-year interval between measurements is on average about 54,100,000 m^3 gross merchantable timber per year. The estimated main use in the State Forests at about 47,500,000 m^3 (6.71 m^3/ha) is much higher than the corresponding figure in private forests - 5,700,000 m^3 (3.3 m^3/ha). This corresponds to the use intensity of 2.3% and 1.26% of wood resources respectively. The timber volume removed in a 10-year period determines the average annual timber volume removed at about 46,000,000 m^3 (5.08 m^3/ha), including about 40,000,000 m^3 (5.66 m^3/ha) in the State Forests, and about 5,100,000m^3 (3,11m^3/ha) in private forests (WISL, 2020).

It has been found that for private forests, there are large discrepancies between the public statistical yields of timber volume and the Large-Scale National Forest Inventory. The verification of these sizes is of great practical importance, both for the assessment of the economic use of the forest and the anticipated development directions of private forests (WISL, 2020).

Tab.1.10 *Merchantable timber in private and communal forests in the period 1996-2018*

Year	Private forests (m^3)	Communal forests (m^3)
1996	1,298,128.00	117,079.00
1997	1,326,807.00	110,927.00
1998	1,220,855.00	126,422.00
1999	1,174,386.00	123,535.00
2000	1,431,533.00	147,373.00
2001	1,153,236.00	117,791.00
2002	1,110,870.00	129,684.00
2003	1,151,215.00	134,233.00
2004	1,268,319.00	144,415.00
2005	1,123,610.00	128,808.00
2006	1,098,509.00	122,007.00
2007	1,348,486.00	139,746.00
2008	1,248,274.00	147,225.00
2009	1,089,549.00	129,598.00
2010	1,243,486.00	131,234.00
2011	1,633,132.00	152,556.00
2012	1,348,514.00	126,040.00
2013	1,246,651.00	127,249.00
2014	1,526,149.00	143,322.00
2015	1,406,654.00	130,784.00
2016	1,289,503.00	131,261.00
2017	1,641,925.00	126,482.00
2018	1,829,876.00	150,341.00

Source: Statistics Poland - Local Data Bank, 2020.

In main use, according to data from 2014, the share of coniferous species (according to the prevailing species) is 76% and the share of deciduous species is 24%. In the final felling, the share of coniferous species is 77% and of deciduous species 23%. In intermediate felling, the share of coniferous species was 76% and of deciduous species 24%. Relationships of coniferous and deciduous species, within the forest species in the State Forests (77% to 23%) are different from those for private forests (69% to 31%) (WISL, 2020).

In the main use, according to data from 2010, the share of coniferous species (by dominant species) is 77%, and the share of deciduous species is 23%. In the final felling, the same relation was recorded, the share of coniferous species is 77% and of deciduous species - 23%. In the intermediate felling, the share of coniferous species was 78% and of deciduous species 22%. The coniferous and deciduous species ratios, within the species in the State

Forests (78% to 22%) differ from those in private forests (70% to 30%)(WISL, 2020).

Tab.1.11 *Timber harvesting in the years 1999-2018*

Year	Total– without rootwood (m^3)	Roundwood (m^3)	Coniferous roundwood - total(m^3)	Deciduous roundwood - total(m^3)	Smalls (m^3)	Rootwood (m^3)
1999	26,017,801	24,268,179	17,637,323	6,630,839	1,749,464	169
2000	27,659,028	26,024,930	19,540,458	6,484,487	1,633,830	277
2001	26,671,443	25,016,646	18,047,095	6,969,542	1,654,470	343
2002	28,957,109	27,137,227	19,827,710	7,309,511	1,819,658	232
2003	30,835,956	28,737,176	20,838,445	7,898,741	2,098,567	217
2004	32,732,517	30,426,309	22,347,735	8,078,578	2,305,961	243
2005	31,944,561	29,724,964	21,918,723	7,806,247	2,219,378	236
2006	32,384,013	30,228,206	22,325,607	,902,569	2,155,676	144
2007	35,934,563	34,145,587	26,374,716	7,770,864	1,788,870	121
2008	34,273,421	32,406,934	24,544,079	7,862,855	1,866,379	97
2009	34,629,172	32,701,486	24,529,135	8,172,341	1,927,551	151
2010	35,467,471	33,568,291	25,579,421	7,988,866	1,899,123	70
2011	37,179,983	34,877,069	26,277,617	8,599,452	2,302,914	39
2012	37,044,584	34,977,961	26,042,317	8,935,644	2,066,623	133
2013	37,944,495	35,796,037	26,791,974	9,004,062	2,148,458	1556
2014	39,740,543	37,661,503	28,533,037	9,128,466	2,079,040	2224
2015	40,247,249	38,327,082	29,077,586	9,249,496	1,920,167	268
2016	40,900,708	39,129,329	30,077,828	9,051,501	1,771,379	0
2017	44,275,096	42,698,966	33,470,400	9,228,567	1,576,130	428
2018	45589 688	43931 540	34352 104	9579 437	1658 148	7158

Source: Statistics Poland - Local Data Bank, 2020.

Tab.1.12 *Timber harvesting in the years1999-2018– State Forests*

Year	Total– without stump wood rootwood	Merchantable Wood total (m^3)	Coniferous merchantable wood – total (m^3)	Deciduous merchantable timber – total (m^3)	Smallwood (m^3)	Stump Wood (m^3)
1999	24 424 895	22 687 866	16 427 646	6 260 203	1 736 871	169
2000	25 718 114	24 096 570	18 040 606	6 055 979	1 621 276	277
2001	25 114 662	23 470 893	16 862 672	6 608 212	1 643 442	343
2002	27 403 290	25 594 931	18 619 638	6 975 287	1 808 135	232
2003	29 220 228	27 134 082	19 624 259	7 509 833	2 085 933	217
2004	30 993 635	28 699 260	21 034 096	7 665 168	2 294 128	243
2005	30 371 082	28 164 158	20 729 155	7 435 009	2 206 705	236
2006	30 841 537	28 699 794	21 154 368	7 545 396	2 141 612	144
2007	34 090 397	32 313 556	24 888 321	7 425 228	1 776 735	121
2008	32 549 108	30 694 932	23 193 973	7 500 959	1 854 068	97
2009	33 104 230	31 188 063	23 385 131	7 802 922	1 916 032	151
2010	33 769 083	31 882 272	24 267 634	7 614 634	1 886 754	70
2011	35 075 161	32 789 248	24 672 142	8 117 106	2 285 913	39
2012	35 267 383	33 211 951	24 726 268	8 485 683	2 055 432	133
2013	36 288 395	34 152 317	25 574 611	8 577 706	2 136 078	1 556
2014	37 749 580	35 680 495	26 993 044	8 687 451	2 069 085	2 224

2015	38 408 184	36 496 965	27 664 596	8 832 369	1 911 219	268
2016	39 167 597	37 404 707	28 743 063	8 661 644	1 762 890	0
2017	42 199 829	40 631 879	31 788 315	8 843 564	1 567 950	428
2018	43 283 349	41 633 491	32 488 534	9 144 957	1 649 858	7 158

Source: Statistics Poland - Local Data Bank,2020.

The 10 year period of planned wood merchantable timber harvesting is referred to in the forest management plans as annual allowable cut. This size in stands that are ripe for renewal, the so-called final felling annual allowable cut, is treated as the maximum figure for the forest district. On the other hand, the size of the so called intermediate felling annual allowable cut expected to be harvested in younger stands as part of tending treatments, is approximate and may change depending on the current planting and sanitary needs. In 2019, the final felling annual allowable cut was realised in 98.4% of the planned use, and the intermediate felling annual allowable cut in 104.8% (Zajączkowski G. et al., 2020).

Multiannual comparisons show that in the State Forests over the last 20 years (2000-2019), 97% of annual allowable cut capacity was, while the intermediate felling reached 111.7% (in volume terms), defined in the forest management plans as indicative (Zajączkowski G. et al., 2020).

In 2019, 7,772,000 m^3 of merchantable timber was harvested in final felling in the State Forests, representing 20% of the total harvest. The total area of the clear cuts was 32,100 ha. Their relatively large area in recent years resulted mainly from the need to eliminate the effects of hurricane winds, removal of stands weakened as a result of disturbances in water relations and the gradation of insects (Zajączkowski G. et al., 2020).

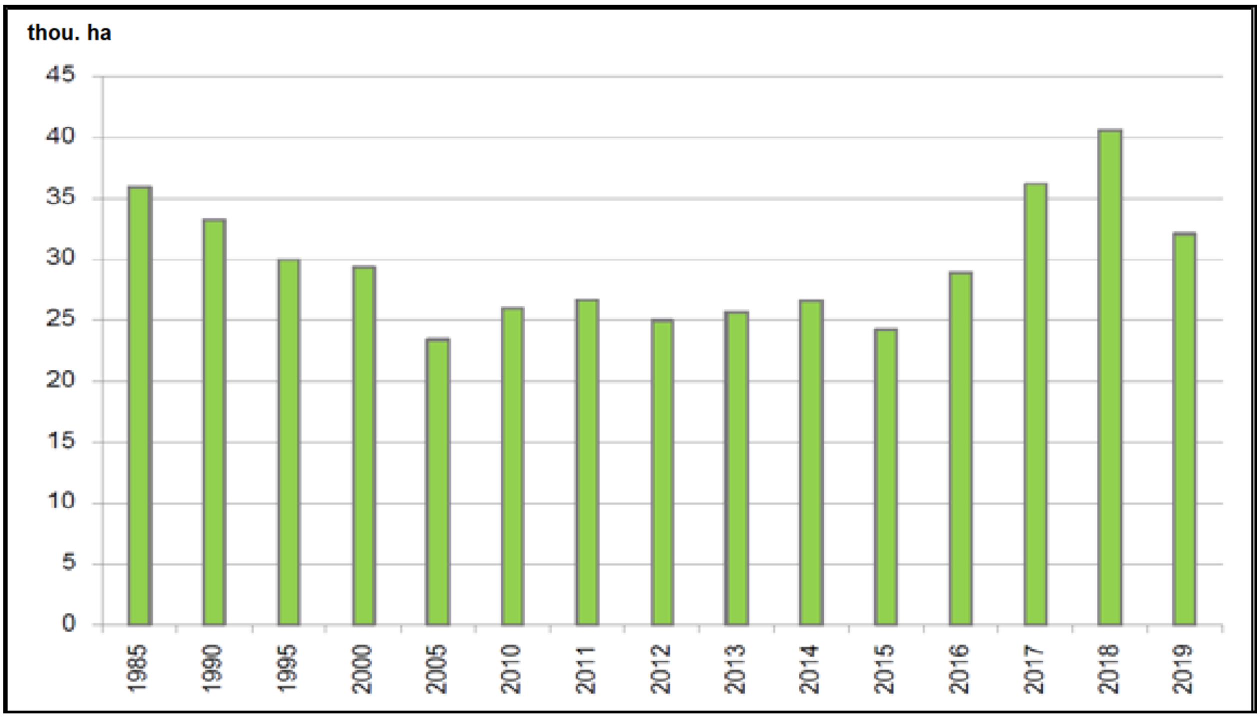

Fig.1.5.The area of the clear cuts in the State Forests in the years 1985-2019.

Source: Zajączkowski G. et al., 2020.

In the State Forests, a gradual increase in the volume of timber harvesting, expressed in net timber volume, per 1 ha of forest area is observed. During 10 years the value of this indicator has increased from 4.41 m^3/ha in 2009 to 5.46 m^3/ha in the year 2019, which was, among other things, linked to a significant increase in wood resources. The average size in this period was 5.11 m^3/ha. However, the volume of harvesting does not exceed the permissible use possibilities. In the case of private forests and national parks the rate is about 1 m^3/ha. Low level of use in private forests may result from incomplete source data. This is confirmed by data from the Large-Scale Forest Inventory, according to which the actual size of this indicator (WISL, 2020) is 6.71 m^3/ha in the State Forests and 3.3 m^3/ha in private forests. In national parks, this value is at the level of 1,49 m^3/ha (Zajączkowski G. et al., 2020).

Tab.1.13 *Merchantable timber harvesting per 100 ha in the period 2002-2018*

Year	**Total (m^3)**	**Public forests – total (m^3)**	**Public forests – State Treasury (m^3)**	**Public forests – State Treasury – SF NFH (m^3)**	**Public forests– communal forests (m^3)**	**Private forests (m^3)**
2002	304.30	353.50	355.60	366.30	162.40	71.40
2003	321.40	373.90	376.20	387.30	166.10	73.60
2004	339.10	394.00	396.40	408.30	177.60	80.60
2005	330.30	386.00	388.50	399.90	157.40	70.70
2006	334.90	392.60	395.40	406.90	148.80	68.40
2007	377.40	441.70	444.70	457.70	169.50	83.10
2008	357.50	419.30	422.10	434.50	175.20	76.40
2009	359.80	425.20	428.30	441.20	155.20	65.90

2010	368.00	434.70	437.90	450.80	156.80	73.80
2011	381.40	447.00	450.00	463.30	182.00	95.70
2012	381.70	452.00	455.50	469.10	149.70	78.20
2013	390.10	464.40	468.00	482.00	150.90	71.80
2014	409.50	485.20	488.90	502.90	170.20	87.20
2015	415.90	495.60	499.60	514.10	155.30	79.70
2016	423.90	507.50	511.70	526.50	156.30	72.70
2017	462.00	550.40	555.30	571.50	150.20	92.10
2018	474.70	563.90	568.40	585.20	178.20	102.30

Source: Statistics Poland - Local Data Bank, 2020.

The relationship between average growth rates and harvesting rates is crucial for the development of stable wood resources and its current and future availability for use. The ratio of harvesting to annual increment is currently a commonly used indicator of sustainable development, particularly for non-forestry professionals. However, this indicator cannot be taken uncritically. Its current values are largely due to the age structure of forests, which are characterised by a high proportion of high-growth stands and a relatively low level of use. Its value is also influenced by extreme weather conditions, especially hurricane winds and biotic damage that can cause large area damage to the forest resulting in an increased harvest of wood biomass (Zajączkowski G. et al., 2020).

The correct intensity of forest use in Poland can be proved by comparing the relevant indicators for a group of countries with similar geographical conditions. In the years 1951-1975 (the analyses concerned 5-year periods), the volume of harvested wood slightly exceeded 70% of the current volume increment only during one of the 5-year periods analysed. Currently, about 60% of the current wood volume increment is harvested in Poland (Szramka and Adamowicz, 2020).

According to SoEF 2015 criteria, the gross increment to which the harvest relates does not include the volume of naturally dead trees (this volume is subtracted from the increment). In addition, this indicator shall be calculated only for land deemed to be available for use. Therefore, this figure is generally higher for data reported for national reporting purposes (Zajączkowski G. et al., 2020).

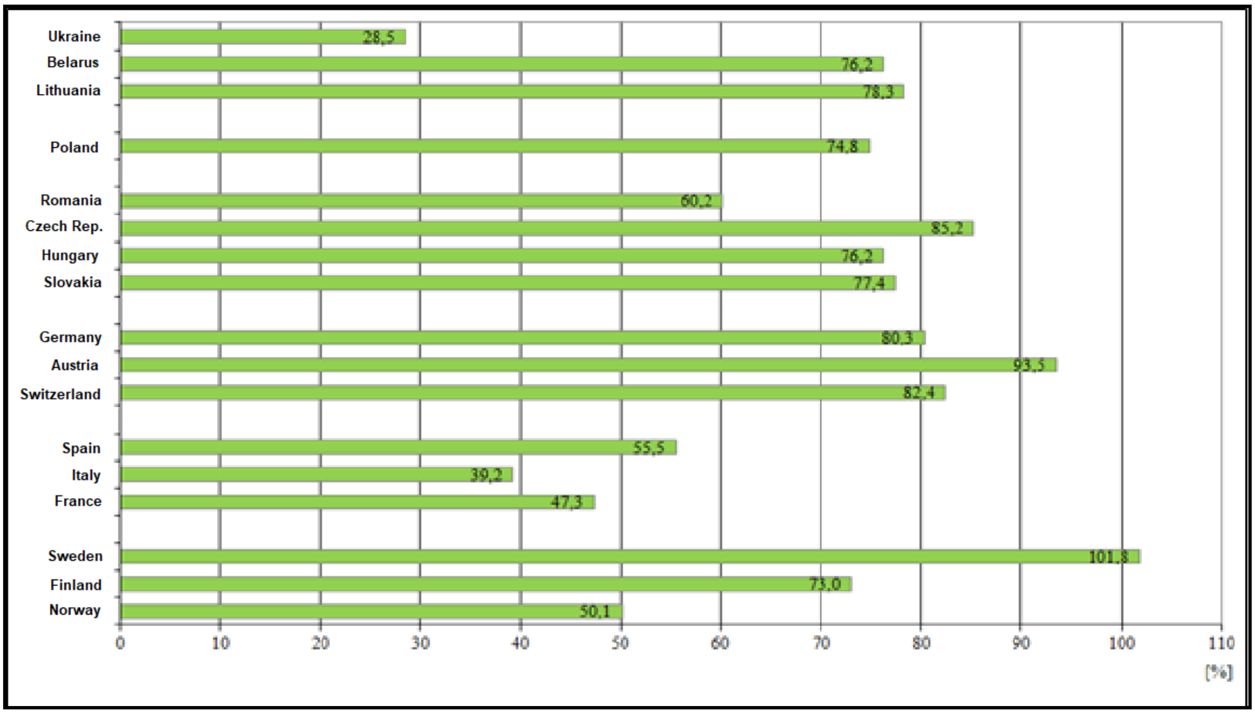

Fig.1.6.The ratio of harvesting volume to annual increment according to SoEF criteria 2015.

Source: Zajączkowski G. et al., 2020.

The share of wood harvesting in forests apart from the State Forests is much smaller than the area and volume share of these forms of ownership in total forest resources in Poland. These disproportions are mainly related to lower intensity of wood harvesting in forests outside the management of the State Forests National Forest Holding. It is assumed, however, that actual wood harvesting in private forests is significantly (about three times) higher than that recorded in public statistics (Dawidziuk and Zajączkowski, 2015).

The representatives of the wood sector report the need to develop a multiannual forest use strategy, including: improving the age structure and condition of resources, increasing biodiversity and improving the supply of timber to the national market (Strykowski et al., 2015).

1.10. Non-wood resources

The forests owned by the State Treasury are made available for the harvesting of groundcover crops for their own use and for industrial purposes. The industrial harvesting of the groundcover vegetation requires the conclusion of an agreement with the forest district (the forest district manager may refuse to conclude an agreement if groundcover vegetation harvesting threatens the forest environment). Locating apiaries in the forests owned by the State Treasury is free of charge (Forest Act,1991).

Tab.1.14 *Harvesting of forest fruit and mushrooms in the years 2009-2019*

Year	Forest fruit		Forest mushrooms	
	Amount (t)	Value (PLN)	Amount (t)	Value (PLN)
2009	12,253.00	66,074,800.00	4,183.00	46,388,800.00
2010	8,380.00	55,540,200.00	4,470.00	55,328,900.00
2011	10,100.00	56,249,000.00	4,013.00	54,261,700.00
2012	16,358.00	115,613,600.00	5,942.00	91,051,800.00
2013	10,564.00	49,707,400.00	4,143.00	56,362,800.00
2014	9,472.00	67,374,700.00	5,215.00	64,565,800.00
2015	8,160.00	48,923,000.00	2,599.00	38,809,700.00
2016	8,803.00	50,362,100.00	4,699.00	60,747,700.00
2017	3,276.00	23,359,900.00	7,302.00	77,846,000.00
2018	4,573.00	41,243,000.00	3,261.00	39,216,800.00
2019	4,448.00	34,472,600.00	5,913.00	88,744,700.00

Source: Statistics Poland - Local Data Bank, 2020.

1.11. Game management

With regard to 2018, the majority of the wildlife population living in the forests has slightly decreased in 2019. In the case of wild boar *Sus scrofa*, there is still a clear national decrease - by around 18% compared to 2018 and by more than 70% compared to 2017. This is the result of continued efforts to reduce the spread of the African swine fever virus, including, in particular, increased hunting of this species, which is intended to lead to the maximum possible population dilution. The decline in numbers of wild boar *Sus scrofa* is also due to the increasing incidence of the disease, which was initially recorded in the eastern part of the country and now also in the western part. In the case of the mouflon *Ovis aries musimon*, the deer *Cervus elaphus* and the roe deer *Capreolus capreolus* the decline was 2%. For the other species, there has been a slight annual increase: in the elk *Alces alces* population by 14%, the fallow deer *Dama dama* by 2%, the hare *Lepus europaeus* by 3% and the pheasant *Phasianus colchicus* by 2%. The population of the fox *Vulpes vulpes* and partridge *Perdix perdix* has remained stable. However, over the last 10 years, most species have experienced an upward trend in the number, the most pronounced being the elk *Alces alces* (348%), the deer *Cervus elaphus* (54%), the mouflon *Ovis aries musimon* (29%) and the fallow deer *Dama dama* (44%), as well as the small game species, that is the hare *Lepus europaeus* (44%) and the pheasant *Phasianus colchicus* (16%). A decline in number during this period was observed only in the populations of the partridge *Perdix perdix* (by about 38%), the fox *Vulpes vulpes* (by 6%) and the wild boar *Sus scrofa* (by 71%). The above changes were mostly influenced by the increase of game population in the areas of hunting districts leased by hunting clubs. In the districts under the State Forests National Forest Holding administration (206), the last hunting season saw a slight decrease in the number of large game, including the deer *Cervus elaphus* by 5%, the fallow deer *Dama dama* by 12%, the roe deer *Capreolus capreolus* by 4%, the mouflon *Ovis aries musimon* by 3% and the wild boar *Sus scrofa* by 8%. The reduction in the number of animals is intended to reduce the pressure on the forests and limit the damage to the fields. In the case of the wild boar *Sus scrofa*, the aim of the continuous reduction in the numbers of this species is to further reduce the threat of African swine fever (Zajączkowski G. et al., 2020).

For many years, the State Forests National Forest Holding has been taking various steps to save endangered species, including the hare *Lepus europaeus* and the partridge *Perdix perdix*, as well as measures to improve individuals' quality (gene pool enrichment). The programmes for restoring the small animal population and maintaining biodiversity, consisting of breeding and then deporting the animals to open hunting areas, implemented in the State Forests animal breeding centres, have contributed significantly to stabilising the downward trend in the numbers of the hare *Lepus europaeus* and, to a slightly lesser extent, the partridge *Perdix perdix*. Increasing attention is also being paid to measures to improve the natural habitat of the animals, such as the establishment of foraging plots, mowing of mid-forest and forest meadows or planting fruit trees (Zajączkowski G. et al., 2020).

Tab.1.15 *Purchase of venison in the years 2009-2019*

Year	Amount– total (t)	Value– total (PLN thousand)	Amount– deer *Cervus elaphus* (t)	Value– deer *Cervus elaphus* (PLN thousand)	Amount– roe deer *Capreolus capreolus* (t)	Value– roe deer *Capreolus capreolus* (PLN thousand)	Amount– wild boar *Sus scrofa*(t)	Value– wild boar *Sus scrofa* (PLN thousand)
2009	7,154	42,753.10	3,016	19,212.70	1,820	16,867.60	2,301	6,539.70
2010	8,995	63,436.20	3,420	26,017.80	1,909	20,959.80	3,643	16,155.30
2011	9,270	80,265.80	3,824	34,370.20	1,954	26,290.20	3,494	19,501.30
2012	9,913	80,715.30	4,103	33,345.90	2,119	29,297.80	3,662	17,785.70
2013	9,368	64,959.10	4,674	30,639.10	2,189	27,252.40	2,450	6,720.00
2014	10,829	81,507.70	5,024	35,733.00	2,393	32,611.40	3,362	12,762.60
2015	12,689	98,192.70	5,223	40,744.90	2,296	33,343.80	5,096	23,504.90
2016	13,253	115,149.30	5,198	45,496.60	2,464	39,154.00	4,958	25,135.30
2017	12,231	102,032.20	5,554	50,854.40	2,370	32,745.20	4,226	17,631.60
2018	13,173	102,449.30	6,208	56,102.80	2,650	33,627.40	4,179	11,263.80
2019	14,747	108,432.40	6,638	54,790.50	2,494	32,686.20	5,479	19,704.00

Source: Statistics Poland - Local Data Bank,2020.

Tab.1.16 *Game numbers in the years 2000-2018*

Year	Fallow deer *Dama dama*	Mouflon *Ovis aries musimon*	Deer *Cervuse laphus*	Roe deer *Capreolus capreolus*	Wild boar *Sus scrofa*
2000	9,050	1,725	117,500	597,100	118,300
2001	9,240	1,616	120,200	614,400	123,400
2002	10,180	1,514	123,300	623,200	138,100
2003	11,365	1,529	130,200	652,600	163,300
2004	12,130	1,559	133,400	668,200	160,500
2005	13,115	1,684	140,700	691,600	173,500
2006	14,966	1,935	147,400	706,500	177,100
2007	15,423	1,811	154,200	705,800	178,600
2008	17,830	2,065	163,700	760,200	211,800
2009	20,667	2,595	176,100	827,500	251,000
2010	23,319	2,811	180,200	822,000	249,900
2011	26,517	2,772	194,700	829,900	267,800
2012	28,008	2,766	204,000	832,600	256,700
2013	28,958	2,748	218,200	879,700	283,200
2014	28,884	2,958	218,800	877,000	285,500
2015	28,324	2,904	214,400	870,600	264,800
2016	29,162	3,004	219,300	890,800	250,500
2017	30,167	3,420	286,900	949,900	215,700
2018	29,014	3,393	275,700	922,400	87,900

Source: Staistics Poland - Local Data Bank, 2020.

Tab.1.17 *Game acquisition in the animal numbers in the years 1999-2018*

Year	Fallow deer *Dama dama*	Mouflon *Ovis aries musimon*	Deer *Cervus elaphus*	Roe deer *Capreolus capreolus*	Wild boar *Sus scrofa*
1999	2,349	304	41,467	154,963	92,038
2000	2,527	444	40,678	157,770	93,197
2001	2,612	341	39,484	148,824	105,171
2002	2,805	321	38,912	146,392	129,938
2003	2,971	251	38,150	148,615	122,011
2004	2,971	273	39,372	151,425	135,566
2005	3,289	319	41,058	147,331	137,606
2006	3,496	187	39,651	134,243	117,732
2007	3,635	184	40,825	141,014	149,279
2008	4,308	243	45,891	157,295	226,007
2009	5,132	336	50,513	176,196	217,941
2010	6,385	438	54,292	160,678	232,688
2011	7,243	442	60,472	167,551	196,466
2012	7,792	484	68,928	172,941	240,804
2013	8,651	455	77,564	187,371	242,746
2014	8,959	518	83,536	195,777	292,366
2015	9,649	566	89,333	203,355	342,093
2016	10,001	698	93,497	213,518	311,652
2017	9,464	707	94,359	214,769	341,411
2018	9,013	647	95,365	210,133	266,047

Source: Statistics Poland - Local Data Bank, 2020.

1.12. Contribution of forest genetic resources to the Sustainable Development Goals

The adoption in September 2015 of Agenda 2030 by the United Nations coincided in Poland with the process of a broad public debate on the definition of a new approach to development policy and the need to identify and give new development impulses. As a result of this process, a model of responsible development has been defined, in which economic factors - while respecting the natural environment - are balanced by social factors, in accordance with the principles of sustainable development. The aim of such an approach is to ensure sustainable economic growth based on new competitive advantages, equal access to the benefits of development for all social groups and, ultimately, improving citizens' quality of life. This is an important direction for changes in public policy. In the environmental dimension, Poland aims to improve the state of the environment and sustainable management of resources. The aim of the state is to increase available water resources and achieve high water quality, rational management of natural and geological resources, as well as effective waste management. The improvement of air quality in Polish cities remains a priority (Report, 2018).

Sustainable forest management, carried out by the Polish State, including the State Forests National Forest Holding, for many years has been part of the implementation of many tasks included in the Agenda 2030 and assigned to particular Sustainable Development Goals.

Objective Goal 1. End poverty in all its forms everywhere

Forestry and the rural areas are strongly linked, and this is why they interact. The model of multifunctional forest management used today and the recognition of the need for acting according to the principles of sustainable development translate into an appropriate forestry policy, which also provides an opportunity to develop rural areas. This can take the form of creating new jobs in areas directly related to basic economic activities in the forest (afforestation, renewal and tending work) and in forest-based industries (furniture, sawmill and paper). Forests for rural areas are also a source of cheap fuel, a guarantor of certain income to local budgets from forest tax or a place to harvest the fruit of forest groundcover. These and many other dimensions of cooperation at the interface between forest management and the countryside give a synergy effect, supporting their development on a regional scale (Kisiel, Zielińska-Szczepkowska and Zielińska, 2016).

The State Forests National Forest Holding, forest service companies, local government bodies and government institutions provide employment for nearly 400,000 people connected with forestry, nature protection and wood industry. Due to the fact that forests are found in Poland in areas which are usually not very urbanised, employment in the forestry and timber sector is important for reducing poverty among the local population. The unemployment rate in the fourth quarter of 2018 in Poland was 3.8%, including 4.2% in the countryside. Although the unemployment rates in the poorly urbanised Podkarpackie, Lubelskie and Warmińsko-

Mazurskie Voivodships reached the highest values for non-urbanised areas, thanks to the employment of the local population in the forest-wood sector they have been significantly reduced(Statistical Yearbook of Forestry,2019;Yearbook of Labour Statistics,2020).

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

The forest is a treasury of healthy, unprocessed food. Mushrooms, berries and other forest fruit can be harvested free of charge and without restrictions. In addition, there are 44 direct sales points for venison in the State Forests units, where you can buy meat without industrial additives. Since 2017, there has been a "Good from the Forest" shop in Warsaw with a carefully selected assortment of forest origin. In Polish forests and fields during the 2018/2019 hunting season, 581,205 pieces of big game were acquired and delivered to the local or foreign market. The State Forests National Forest Holding's fishery farms are the largest carp producer of *Cyprinus carpio* in Poland, providing consumers with more than 1,000 t of healthy fish per year. The carps are bred in ponds where their health is taken care of and they are fed only with grain containing wholesome protein - the remaining nutrients are obtained by the fish themselves. Carps from these farms are completely free of harmful chemicals.

Goal 3.Ensure healthy lives and promotes well-being for all at all ages

Contact with nature is very important for the psychological and physical well-being of the population. The therapeutic benefits of staying in the forest are particularly great for people living in cities, where the pace of life, air quality or noise level do not promote health. Staying in the midst of the trees reduces stress, improves mood and calms down. The trees ionise the air and provide a pleasant feeling of coolness on hot days. The units of the State Forests throughout the country regularly organise marathons, orienteering runs, geocaching, cycling rallies, nordic walking, night walks, shooting competitions, scooter rallies, plogging, duathlon or cross-country skiing. In the area of the State Forests, there are 6,838 facilities available free of charge, gradually adapted for the disabled, 582 green classrooms, 1,467 resting places, 85 forest car parks, 4,262 vehicle parking places, 317 viewpoints, 37 points of water equipment launching and mooring, 37 forest education centres, 251 forest education chambers and 85 playgrounds for children. Forests are also available for bush crafting.

Goal 4. Ensure inclusive and equitable education and promote lifelong learning for all

As part of the ongoing nature and forest education in the State Forests, knowledge and skills concerning broadly understood sustainable development and sustainable lifestyle are also transferred. Thanks to the enormous commitment of the State Forests National Forest Holding employees and a rich educational base, an average of 3,700,000 people are educated each year. The State Forests cooperate with kindergartens, schools, universities and universities of the third age, organizing activities tailored to the needs of the recipients. Their common assumption is contact with nature and creation of committed, pro-ecological attitudes of the participants. In the State Forests, over 9,000 employees are involved in forest education. Similar classes are conducted in national parks, landscape parks and botanical gardens.

Goal 5.Achieve gender equality and empower all women and girls

The forester's profession is stereotypically associated with a typically male occupation. Meanwhile, more and more young women are completing their forestry studies and forestry technical schools, and over 27% of the State Forests National Forest Holding staff are women. They work at all levels of the organisation, both in the office and in the field, and some of them hold managerial positions.

Goal 6. Ensure availability and sustainable management of water and sanitation for all

Water resources management in forest areas, as a strategic project, has been implemented in the State Forests since 2007. During this time, 7,197 small retention facilities were built, thanks to which 43,500,000 m^3 of water was retained in the forest. Within the framework of the project, mid-forest ponds or trench valves are built and the natural structure of streams is maintained. The retention has a positive impact on forest ecosystems and significantly reduces the risk of flooding in their vicinity. Apart from the project mentioned above, foresters work on a daily basis to retain water in the forest, e.g. by selecting appropriate tree species for planting or taking care of multi-storey forest.

Goal 7. Ensure access to affordable, reliable, sustainable and modern energy sources fro all

In Poland, wood is used as a source of heat in a significant percentage. Nowadays, wood in the form of pellets, burned in the latest generation furnaces, is an increasingly common source of energy, renewable, efficient and ecologically cleaner than coal. The potential of untapped wood residues for the production of biofuel components is being studied. Increasing the energy efficiency of buildings and vehicles in use is also an important area of effort. An extensive project of thermal modernisation of buildings is being carried out in the State Forests National Forest Holding.

Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Forestry, alongside agriculture, is the main source of income for many people living in rural areas. The State Forests not only employ over 26,000 people themselves, but also contribute directly to the maintenance of several hundred thousand jobs. The forest services market provides employment for nearly 50,000 people, and the entire wood industry for another 300,000. The dominant form of employment in the State Forests National Forest Holding is the employment contract. This form of employment is promoted among forest service providers by including appropriate social clauses in tender documents.

Goal 10 Reduce inequality within and among countries

Ensuring equal access to forests and the benefits that can be derived from them is one of the priorities of the State Forests. When planning educational activities and the development of tourist infrastructure, care is taken to ensure that they are adapted to the needs of people with visual, hearing and movement disabilities. The offer of the State Forests National Forest Holding includes many events prepared for people with disabilities. As the largest supplier of wood on the Polish market, the State Forests guarantee all operators equal access to its purchase. The sale takes place in the form of Internet auctions on dedicated platforms (Portal Leśno-Drzewny and e-Drewno).

Goal 11.Make cities and human settlements inclusive, safe, resilient and sustainable

Each year, in cooperation with local governments, the State Forests National Forest Holding builds and renovates hundreds of kilometres of roads and participates in the associated costs. Various forms of activity are organised in the forests, serving the social inclusion of groups which are at risk of exclusion. By creating appropriate infrastructure, the State Forests promote the use of renewable raw material - wood. In this way, ecological and energy-efficient facilities are created.

Goal 12.Ensure sustainable consumption and production patterns

The idea of responsible consumption takes into account our indirect influence on the shape of the world in which we live. Wood is a renewable raw material, but its “production” takes about 100 years. Through educational activities and social campaigns, society is encouraged to use wood and the products made from it responsibly. Through targeted forestry education, awareness of the population is also raised concerning the problem of waste in the environment. Each year, the State Forests National Forest Holding allocates about PLN 19,000,000 to cleaning up waste from forests (more than 100,000 m^3 of waste).

Goal 13.Take urgent action to combat climate change and its impacts

One of the biggest challenges for forestry is to properly recognise the impact of climate change on forest ecosystems. This includes new temperature dynamics, rainfall, natural disasters and the spread of pests, as well as changes in water resources and forest soils. Even the most optimistic expert scenarios assume that the climate will change so quickly that the trees will not manage in the new conditions without human help. Therefore, a number of measures are being taken to keep forest ecosystems in good health, which at the same time allows them to absorb CO_2 effectively. In order to counteract the negative effects of climate change, the State Forests every year:

- forecast risks based on insect observation;
- form an efficient network of small retention reservoirs, effective in the fight against drought;
- perform conversion of stands to make the forests more natural and thus more resistant to pests;
- perform treatments to protect the soil from degradation;
- carry out monitoring in order to prevent the occurrence and spread of fires.

Both in the State Forests and in national parks, forests genetic resources are protected in nature reserves and in seed and conservation stands (often excluded from final felling). For renewal and afforestation, high quality nursery stock is used, coming from Europe's largest native seed base registered in the National Register of Basic Forest Material. In terms of demand for forest reproductive material, Poland is a self-sufficient country.

The State Forests National Forest Holding is running a pilot project called "The Carbon Forests Project". The project consists in the search for forest management activities that will increase the absorption of CO_2 by the forests. The project involves 26 forest districts from all over the country. One of the elements of the initiative is to adapt to Polish conditions a model which precisely calculates the amount of CO_2 absorbed. Additionally absorbed units of this greenhouse gas are put up for auction, and the funds obtained are entirely allocated to the implementation of pro-environmental projects.

Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

The State Forests National Forest Holding carries out sustainable forest management, which is confirmed by international FSC and PEFC certificates held for many years. This means that the needs of nature conservation and the expectations of the wood industry regarding the supply of raw material are balanced, while at the same time providing society with universal and safe access to forests. Thanks to the activities of foresters, the area of forest areas in Poland is constantly increasing. One of the priorities of the State Forests is to preserve the biodiversity of Polish forests. This is done through the implementation of the "Programme of conserving forest genetic resources and breeding of trees in Poland for the years 2011-2035" and programmes for the reintroduction, restitution and protection of species which are rare or under protection in Poland, such as among others peregrine *Tetrao urogallus,* black grouse *Lyrurus tetrix,* lynx *Lynx*

lynx, Peregrine falcon *Falco peregrinus,* Polish horse *Equus caballus gmelini, sylvatica form,* hare *Lepus europaeus,* partridge *Perdix perdix,* osprey *Pandion haliaetus,* pond turtle *Emys orbicularis,* mountain Apollo butterfly *Parnassius apollo,* common yew *Taxus baccata, wild service* tree *Sorbus torminalis,* and numerous herbaceous plants*.* For many of the animal and plant species mentioned above, their genetic material, seeds or parts of plants are protected *ex situ* in a gene bank. A "Comprehensive project for the protection of species and natural habitats" is being implemented in the State Forests. There are also 3,798 protection zones for bird, reptile, mammal, insect, plant and lichen habitats. There are also 8 rehabilitation centres for wild animals (Sienkiewicz-Kozyrska, 2018).

The measures taken under the Natura 2000 network are an implementation of the principle of sustainable development, because they favour the development of these areas without causing negative impact on the environment. Therefore, management in the vicinity of protected areas (including Natura 2000 sites) is possible, but on condition that the vulnerability of species and habitats protected in these areas is taken into account and significant threats to them are avoided. In Poland, the availability of protected areas for sustainable management is limited to a small extent. This also applies to commercial availability, i.e. for the material benefit of investors and organisations. In addition, having a natural area on its territory, which is recognised as valuable in the whole of the European Union, is seen as a place with a high quality of life. Due to the large spatial range of the network, many entities using Natura 2000 sites for purposes other than environmental protection, such as agriculture, forestry, fishing, tourism or recreation, are located in its areas or in its immediate vicinity. There is still a negative attitude towards the Natura 2000 network in society, which may result from a lack of knowledge about it. Therefore, institutions at various levels are involved in conducting various types of training on the functioning of Natura 2000 areas, aimed at specific entities.

According to the data of the General Directorate for Environmental Protection, currently in Poland the Natura 2000 network occupies almost 1/5 of the country's land area, which is 38% of the area of the State Forests. According to some NGOs and academics, not all species and habitats are still sufficiently protected, and the need for additions has been identified, but the scale of these additions is already small compared to the initial shortages (Radziwon, 2015).

We should be aware that the implementation of statutory restrictions relating to the protection of habitats and species is causing a deterioration in existing management conditions, which may constitute a claim for compensation, justified as follows: if it is the will of society to preserve environmentally valuable areas which, however, have negative economic consequences for their users, compensation is necessary. It should be borne in mind that Natura 2000 should, above all, be an opportunity and not remain a barrier to the development of sustainable rural areas. Meanwhile, although the presence of the network currently allows both farmers and communes to obtain additional funding from several EU sources, these are too modest, too scattered and inadequate to the costs incurred by local rural communities in connection with the functioning of Natura 2000 sites (Bołtromiuk, 2011; 2012).

Goal 17. Strengthen the means of implementation and revitalize the global partnership for sustainable development

Each year, the State Forests National Forest Holding cooperates with hundreds of external partners. Companies, institutions, non-governmental organisations and all other entities that want to implement pro-environmental or pro-social actions in forest areas (e.g. industry participation in the protection of osprey *Pandion haliaetus* in some Natura 2000 sites or active protection of genetic resources of endangered populations of the wild service tree *Sorbustorminalis*) are invited to cooperate.

Part II. State of diversity in forests and other wooded lands

Chapter 2. State of forests

2.1. State of forests in Poland - general information

The condition of forests in Poland is subject to annual assessment by the state authorities. As part of this assessment, the State Forests National Forest Holding - by virtue of the Forest Act (Polish Forest Act of 1991) - is obliged to prepare reports on the state of forests and financial and economic reports on its activities. In turn, the Council of Ministers submits to the Sejm information on the condition of forests and the implementation of the National Programme for Expanding the Forest Cover. Basic information on the size and structure of wood resources in Poland is provided by the results of the Large-Scale Forest Inventory, including an assessment of the state of forests of all forms of ownership and the directions of changes of this condition on a national scale and in individual regions. The measurements of the Large-Scale Forest Inventory also include land covered with forest vegetation, which are not entered as forests in the land and buildings register. The results of the Large-Scale Forest Inventory allow for the analysis of the current state of the forest, among others, including species structure, age and volume and changes in resources based on the comparison of results from 5-year measurement cycles. In turn, the main source of information on the health condition of the forest and changes in this condition is Forest Monitoring, carried out annually as part of the State Environmental Monitoring (Forest Act, 1991; Zajączkowski G. et al., 2020).

In Poland, forests occur mainly in areas with the poorest soils, which is reflected in the distribution of forest habitat types. According to the latest data, coniferous and broadleaved habitats occur on 50% of the forest area. In both groups, there are also upland habitats, occupying a total of 6.7% of the forest area, and mountain habitats, occurring on 8.5% of the area. In the State Forests National Forest Holding the share of coniferous forest habitats is 49.6% and in private forests 55.4%. According to the data of the Large-Scale Forest Inventory, the dominant forest habitat types in the country are mixed coniferous forests with a share of 29.4% (WISL, 2020; Zajączkowski G. et al., 2020).

The spatial distribution of habitats is largely reflected in the spatial structure of prevailing species. Apart from the mountain area, where a greater proportion of the Norway spruce *Picea abies*, Scots fir *Abies alba* and the common beech *Fagus sylvatica* are observed in the species composition, in most of the country stands with the Scots pine *Pinus sylvestris* as the dominant species prevail. Coniferous species dominate on 68.2% of Poland's forest area. Scots pine *Pinus sylvestris*, which according to data of the Large-Scale Forest Inventory covers 58% of the area of forests of all forms of ownership, 60.1% of the area in the State Forests and 54.5% in private forests, grows mainly in areas with the poorest soils. From the 19th century onwards the timber industry preferred coniferous species, which also contributed to their high proportion. The results of the Large-Scale Forest Inventory from 2005-2009 and 2015-2019 indicate an increase in the share of deciduous species by 2.6% and a decrease in the share of coniferous species, respectively, including Scots pine *Pinus sylvestris* by 2.4%, Scots spruce *Picea abies* by 0.7% and a slight increase in the share of the silver fir *Abies alba* and other coniferous species. In the years 1945-2019 the area of deciduous stands in the State Forests increased from 13% to 24,1% (Zajączkowski G. et al., 2020).

When analysing the current state of forests in Poland and the directions of its changes in the future, we should, above all, take into account global climate change and the associated threats to the decline of species and populations from natural or semi-natural sites. With regard to forest genetic resources, especially in the context of forest management and the stability and sustainability of forest ecosystems, it seems necessary to support natural adaptation processes of forest trees to changing environmental conditions. Indeed, selection breeding activities for forest trees must guarantee the preservation of all genetic variability and the sustainability of forest existence under changing environmental conditions. Counteracting the reduction of biodiversity in forest ecosystems is also becoming an important objective.

2.2. State of forests in Poland - detailed information

According to the Forest Act, the following land is considered a forest in Poland:

1. Of a compact area of at least 0.10 ha, covered with forest vegetation - trees and shrubs and forest groundcover - or temporarily deprived of it:
   a) intended for forest production or,
   b) being a nature reserve or a part of a national park or,
   c) entered in the register of objects of cultural heritage.
2. Related to forest management, occupied for use in forest management: buildings and structures, water drainage facilities, forest division lines, forest roads, areas under power lines, forest nurseries, timber storage sites, as well as used for forest car parks and tourist facilities (Forest Act, 1991).

The area of forests in Poland is subject to annual assessment as part of the public statistics survey programme (Regulation RM, 2014), and the results are presented in the yearbooks of the Statistics Poland (Forestry, 2013; Environmental Protection, 2013). In view of Poland's participation in international organisations and the commitments made on this account, data on forests in Poland are published, among others, in the studies of the Food and Agriculture Organisation of the United Nations (*Global Forest Resources Assessment, 2010*), Forest Europe process reports (*State of Europe's Forests, 2011*) and applications to the United Nations Framework Convention on Climate Change (*Poland's National Inventory Report, 2014*), hereinafter referred to as the Climate Convention. It should be noted that the definition of forest, as proposed by the FAO (*Forest Resources Assessment, 2012*), the Forest Europe process

(*Joint FOREST EUROPE/UNECE/FAO Questionnaire, 2013*) and adopted under the Climate Convention (*Decision*, 2006; Report, 2006), does not comply with the national definition, as set out in the Forest Act (Forest Act, 1991). The Act does not contain quantitative criteria for the presence of forest vegetation and does not define the concept of forest production. The definition of forest proposed by the FAO (*Forest Resources Assessment, 2012*) refers to actual land cover and form of land use. In the case of the Kyoto Protocol (*Decision*, 2006; 2012), only the first of these elements is relevant. However, the Polish Forest Act (Forest Act, 1991) refers to the occurrence of forest vegetation and the use of land for forest production.

According to the provisions of the Forest Act, the minimum forest area in Poland (0.10ha) is the same as reported for the purposes of reporting to the Kyoto Protocol (Report, 2006). On the other hand, the areas with a minimum area of 0.50 ha should be reported to the FAO (*Forest Resources Assessment, 2012; Global Forest Resources Assessment Update 2005, 2004; Specification of National Reporting Tables for* FRA 2010, 2007). It should be noted that the minimum area criterion does not apply to the area of the stand subcompartments or the registered plot of land, but to the area of forest complexes, regardless of forest ownership (Jabłoński,2015).

In the past, forests were found almost all over our country. As a result of historical social and economic processes, which were dominated by economic objectives, primarily as a result of the expansion of agriculture and the high demand for wood raw material, the forests of Poland have undergone significant transformations. The forest cover of Poland, which was still around 40% at the end of the 18th century (within the boundaries of that times), decreased to 20.8% in 1945. Deforestation and the accompanying impoverishment of the tree stand species structure caused a decrease in forest biodiversity and landscape fragmentation, soil erosion and disturbance of the country's water balance. This process was reversed between 1945 and 1970, when, as a result of the afforestation of 933,500 ha, the forest cover of Poland increased to 27%. The average annual afforestation was then 35,900 ha, and at its peak in 1961-1965, it exceeded 55,000 hectares. Currently, the area of forests in Poland is 9,259,000 ha (according to the Statistics Poland - state as of 31.12.2019), which corresponds to 29.6% forest cover (Zajączkowski G. et al., 2020).

The forest area in Poland between 1991 and 2019 increased by 565,000 ha (almost 30,000 ha on average per year), which means that Poland's forest cover in the discussed period increased by 1.8% (Zajączkowski G. et al., 2020).

Calculated according to international standard, forest cover of Poland in 2019 was 30.9% and was lower than the European average of 32.8% in 2015 (Zajączkowski G. et al., 2020).

The Forest Information System for Europe database (www.forest.eea.europa.eu) provides yet different information. Based on 2018 CORINE *Land Cover* data provided by the European Environment Agency and data collected under the Copernicus Land Monitoring Service, the forest cover of Poland was set at 33.53% (as of 10 September 2020).

Tab.2.1 *Forest area in Poland*

Areas of forests					**Private forests (ha)**
State Treasury				**Communal forests (ha)**	
SF NFH (ha)	**National parks (ha)**	**Agricultural Property Stock of the State Treasury (ha)**	**Other(ha)**		
7,114,618.00	185,702.00	27,607.00	54,267.00	84,376.00	1,788,375.00

Source: Large-Scale Forest Inventory, 2020.

The increase in forest area is the result of afforestation of agricultural land or wasteland. The increase in the forest area is also an effect of sorting out the inventory - revealing afforestations made in previous years and reclassification of other land covered with forest vegetation as a result of natural succession. The forest area balance is also affected to a small extent by the exclusion of forest land for non-forest purposes (526 ha in 2019). In 2019, afforestation was carried out on 1,165 ha of land of all ownership categories. The afforestation area in 2019 was 157 ha (12%) lower than in 2018. Moreover, in 2019, 59 ha were considered afforested as a result of natural succession (in 2018 - 69 ha)(WISL,2020; Zajączkowski G. et al., 2020).

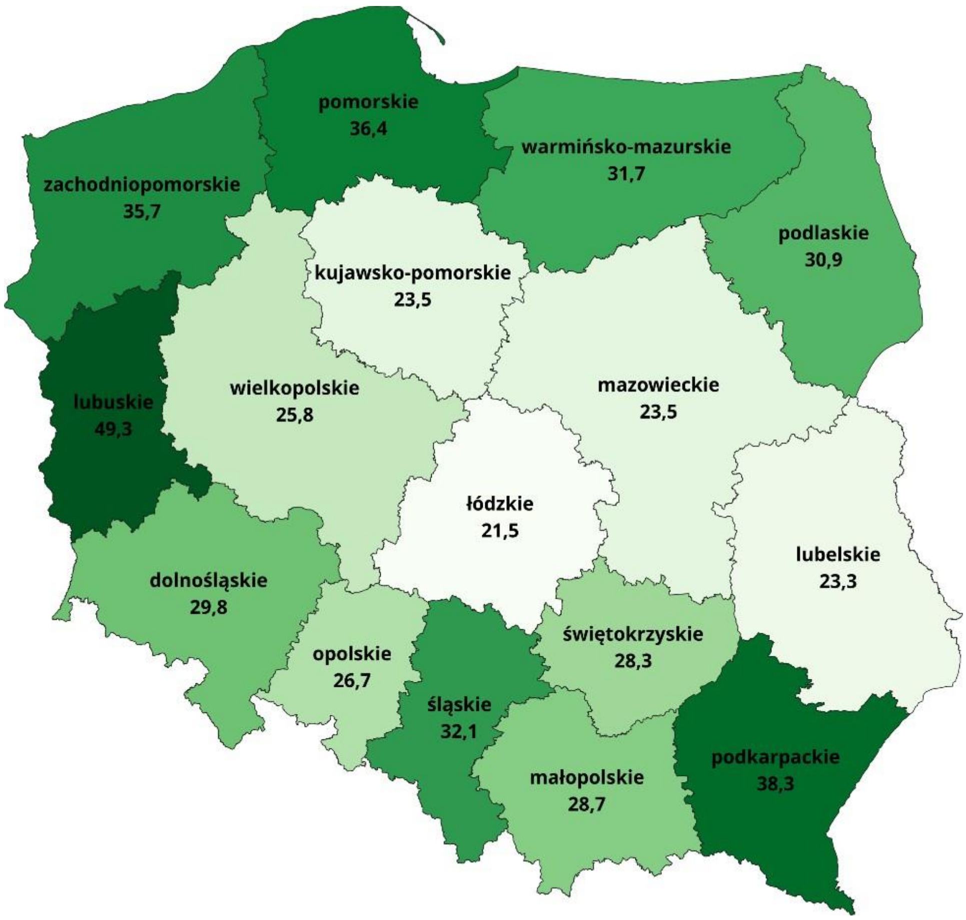

Fig.2.1. Forest cover of Poland by voivodship (%).
Source: Zajączkowski G. et al., 2020.

The appearance of woody plants on uncultivated agricultural land and delays in the reclassification of this land as “afforested” means that the actual coverage of the land by forest vegetation in Poland is not reflected in the Land and Property Register data.

In 2015, the Institute of Geodesy and Cartography, on the commission of the General Directorate of State Forests, carried out a study to determine the actual forest cover of the country. The forest cover determined on the basis of the database of topographic objects, Identification System for Agricultural Parcels, Forest Data Bank, Forest Numerical Map and other available spatial information (including aerial photographs and satellite images) was 32%. It was considered that almost 800,000 hectares of forests are not included in the records and statistics of the Statistics Poland.

Areas meeting the forest criterion but not included in the Land and Property Register were included in the measurements and observations started in 2015 third cycle of the Large-Scale Forest Inventory. According to the measurements of the Large-Scale Forest Inventory (2015-2019), the surface of areas with forest vegetation, not included in the Land and Property Register, amounts to:

- 780,500 ha according to the forested forest area criteria used in the State Forests (in simplified terms, an area with crown cover from 30 to 50% depending on the age of the stand),
- 950,800 ha, using a crown cover of more than 10% as a forest criterion (following the FAO's forest definition).

It should be noted that the mentioned areas cannot be summed up with the forest area as published by the Statistics Poland (due to errors or past records, e.g. registering as forest land areas without woody vegetation, used for non-forest purposes).

As far as the State Forests are concerned, the total forest area (excluding land related to forest management) as of 31.12.2018 was 7,114,618 ha, including: forested land - 6,959,680 ha (97.8%), non-forested land - 154,938 ha (2.2%). The total forest area in the State Forests (excluding land related to forest management) in the years 1967-2019 increased by 648,900 ha, while the forested forest area by 701,000 ha. In the above mentioned period, on average, the total forest area increased by about 12,500 ha per year, and the forested forest area by about 13,500 ha (Zajączkowski, Talarczyk, Myszkowski and Kucab, 2020a).

The area of forests, apart from the State Forests as of 31.12.2018 (excluding land related to forest management) amounted to 2,140,328 ha, which constituted about 23% of the forest area in Poland, including: forested land – 2,062,741 ha (96.4%), non-forested land – 77,587 ha (3.6%). The area of private forests was 1,788,375 ha: about 19.3% of the forest area in Poland, including: forested land – 1,718,038 ha (96.1%), non-forested land – 70,337 ha (3.9%). The area of communal forests was 84,376 ha: approximately 0.9% of the area of forests in Poland, including: forested forest land – 82,063 ha (97.3%), non-forested forest land – 2,313 ha (2.7%). The area of State Treasury forests in national parks was 185,702 ha: about 2% of the forest area in Poland, including: forested land – 182,757 ha (98.4%), non-forested land – 2,945 ha (1.6%). The area of forests of the Agricultural Property Stock of the State Treasury was 27,607 ha, about 0.3% of the forest area in Poland, including: forested land – 26,779 ha (97%), non-forested land – 828 ha (3%). The area of other State Treasury forests (universities, Polish Academy of Sciences, research institutes, Military Property Agency, housing cooperatives and forests of other public entities) was 54,268 ha: about 0.6% of the area of forests in Poland, of which: forested land – 53,106 ha (97.9%), non-forested land – 1,162 ha (2.1%)(Zajączkowski, Talarczyk, Myszkowski and Kucab, 2020b).

Tab.2.2 *Changes in forest area in the period 1999-2018: forests in general, public forests, private forests*

Year	Forest area – General (ha)	Forest area – public forests (ha)	Forest area – private forests (ha)
1999	8,850,237.30	7,331,250.30	1,518,987.00
2000	8,864,993.50	7,341,295.70	1,523,530.00
2001	8,893,886.10	7,348,952.00	1,544,798.00
2002	8,918,083.30	7,362,723.00	1,555,108.00
2003	8,941,920.80	7,378,434.00	1,563,276.00
2004	8,972,760.57	7,399,788.40	1,572,755.40
2005	9,000,631.71	7,410,723.01	1,589,732.30
2006	9,026,410.52	7,419,191.42	1,606,815.00
2007	9,048,743.90	7,425,744.00	1,622,632.80
2008	9,066,362.48	7,431,086.88	1,634,837.50
2009	9,089,092.02	7,434,096.12	1,654,465.30
2010	9,121,928.59	7,435,628.79	1,685,713.50
2011	9,143,313.89	7,437,515.69	1,705,798.20
2012	9,163,786.95	7,439,363.45	1,724,423.50
2013	9,177,193.09	7,439,739.16	1,737,453.93
2014	9,197,879.01	7,447,086.90	1,750,792.11
2015	9,214,885.72	7,449,818.11	1,765,067.61
2016	9,230,030.95	7,456,100.71	1,773,930.24
2017	9,242,439.18	7,460,120.49	1,782,318.69
2018	9,254,945.42	7,466,570.74	1,788,374.68

Source: Statistics Poland - Local Data Bank,2020.

Tab.2.3 *Changes in forest area in the period 1999-2018: State Treasury, State Forests and communal forests*

Year	Public forests – State Treasury (ha)	Public forests – State Treasury– SF NFH (ha)	Public forests – communal forests
1999	7,251,751.00	6,935,879.00	79,499.30
2000	7,261,719.00	6,953,062.00	79,576.10
2001	7,269,558.00	6,967,673.00	79,394.00
2002	7,282,856.00	6,986,950.00	79,867.00
2003	7,297,614.00	7,005,687.00	80,820.00
2004	7,318,488.10	7,029,514.50	81,300.30
2005	7,328,891.71	7,042,529.71	81,831.30
2006	7,337,190.52	7,053,115.22	82,000.90
2007	7,343,271.30	7,059,876.50	82,472.70
2008	7,347,062.18	7,064,444.98	84,024.70
2009	7,350,574.12	7,068,372.32	83,522.00
2010	7,351,934.59	7,072,402.59	83,694.20
2011	7,353,685.89	7,076,630.34	83,829.80
2012	7,355,192.65	7,079,362.05	84,170.80
2013	7,355,429.64	7,085,422.42	84,309.52
2014	7,355,906.40	7,094,696.20	84,226.25
2015	7,344,721.85	7,099,646.11	84,201.18
2016	7,351,270.51	7,104,664.75	83,974.66
2017	7,354,831.49	7,109,976.26	84,200.79
2018	7,361,049.58	7,114,617.67	84,376.09

Source: Statistics Poland - Local Data Bank, 2020.

The share of coniferous species area in the country is 68.2% in total, with the share in forests managed by national parks (52%), in forests of the Agricultural Property Stock of the State Treasury (21.2%) and in communal forests (54.6%) being clearly lower than in the State Forests (70.1%). Pine stands, which occupy the majority of the country's forests (58%), represent the largest share of the management of the State Forests National Forest Holding (60.1%), and slightly smaller in private forests (54.5%). The largest area of deciduous species in the country is covered by oak (7.9%) and birch (7.1%) stands, which in the forests under the management of the State Forests National Forest Holding account for 8.5% and 6.5% respectively, and in private forests 5.6% and 10%, with alder stands also accounting for a large share of the forest area in private forests (8.4%) (WISL, 2020).

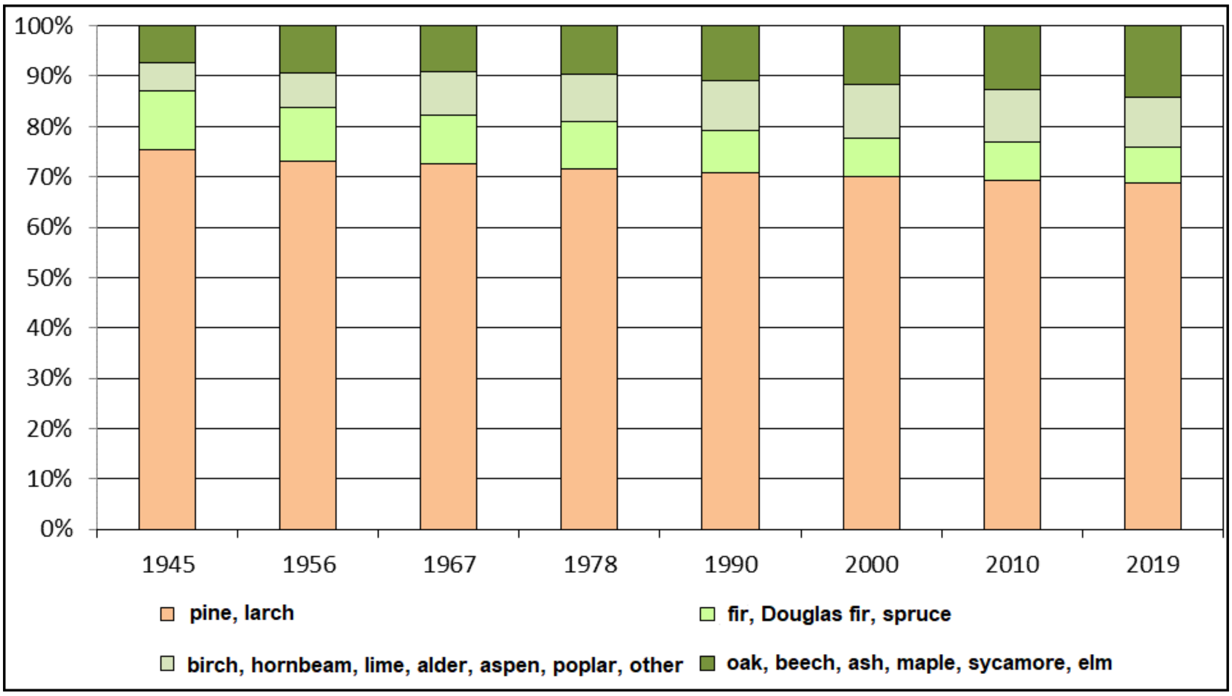

Fig.2.2.Structure of the area share of species in the State Forests in the years 1945-2019
Source: data of the Bureau for Forest Management and Geodesy, 2020;data of the General Directorate of State Forests, 2020;Statistical Yearbook of Forestry, 2019.

Tab.2.4. *Types of forest trees in State Forests*

Type	% area
Birch *Betula*	4.70
Beech *Fagus*	6.10
Oak, maple, elm *Quercus ,Acer, Ulmus*	8.20
Hornbeam *Carpinus*	0.30
Fir *Abies*	2.50

Alder *Alnus*	4.30
Aspen *Populus tremula*	0.20
Pine, larch *Pinus, Larix*	68.80
Spruce *Picea*	4.80
Poplar *Populus*	0.10

Source:(Zajączkowski S. et al., 2020a).

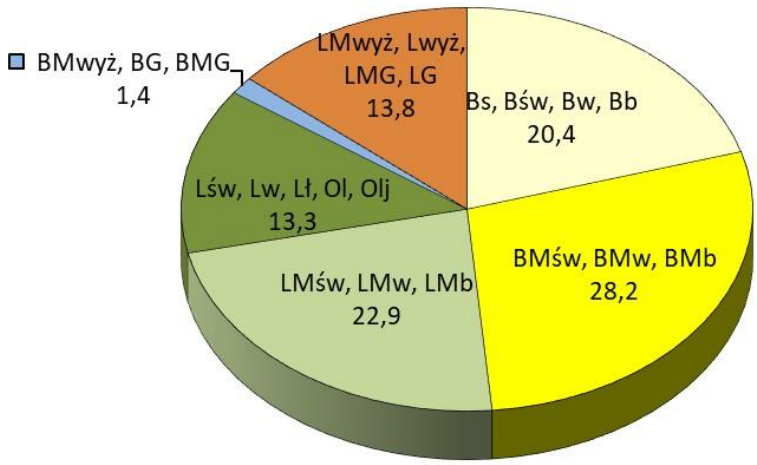

Fig.2.3.The share of the area (%) of forest habitat types in Poland.
Source: Large-Scale Forest Inventory, 2020.

In the State Forests, the forest area on forested forest land according to the prevailing species is 5,292,152 ha, i.e. 76% for coniferous species and 1,667,528 ha, i.e. 24% for deciduous species. The dominant forest habitat types are: fresh mixed coniferous forest (BMśw), fresh coniferous forest (Bśw) and fresh mixed broadleaved forest (LMśw), occupying 23.4%, 19.6% and 19.2% respectively. Coniferous forest habitats occupy 49.8%, broadleaved forest - 47.6%, alder forest - 2.6%. The share of lowland habitats is 87.9%, upland –5,4%, and mountain–6.7%(Zajączkowski S.et al., 2020a).

Tab.2.5 Forest habitat types in the State Forests

Forest habitat type	% area
Fresh mixed coniferous forest (BMśw)	23.40
Fresh coniferous forest (Bśw)	19.60
Fresh mixed broadleaved forest (LMśw)	19.20
Fresh broadleaved forest (Lśw)	9.80
Mixed wet coniferous forest (BMw)	4.40
Mountain broadleaved forest (LG)	4.30
Mixed wet broadleavedforest (LMw)	3.90
Upland broadleavedforest (Lwyż)	3.60
Wet broadleavedforest (Lw)	2.10

Mountain mixed broadleavedforest (LMG)	1.80
Alder forest (Ol)	1.80
Upland mixed broadleavedforest (LMwyż)	1.60
Ash alder forest (OlJ)	0.80
Bog mixed broadleavedforest (LMb)	0.80
Wet coniferous forest (Bw)	0.60
Wet mixed coniferous forest (BMw)	0.60
Riparian forest (Lł)	0.50
Mountain mixed coniferous forest (BMG)	0.50
Upland mixed coniferous forest (BMwyż)	0.20
Dry coniferous forest (Bs)	0.20
Bog coniferous forest (Bb)	0.20
Mountain coniferous forest (BG)	0.10
Total	100.00

Source: Zajączkowski S.et al., 2020a.

The forest area on forested forest land in forests outside the State Forests National Forest Holding according to prevailing species is 1,401,691 ha, i.e. 68% for coniferous species and 661,050 ha, i.e. 32% for deciduous species. The dominant forest habitat types are fresh mixed coniferous forest (BMśw), fresh coniferous forest (Bśw) and fresh mixed broadleaved forest (LMśw), occupying 24.9%, 23.6% and 11.5% respectively. Coniferous forest habitats occupy a total of 54.6%, broadleaved forest - 40.1%, alder forest - 5.3%. The share of lowland habitats is 79.5%, upland habitats are 8%, and mountain habitats are 12.5%. The structure in private forests is as follows: coniferous species - 1,192,369 ha, i.e. 69.4%, deciduous species - 525,669 ha, i.e. 30.6%. The dominant forest habitat types are: fresh mixed coniferous forest (BMśw) and fresh coniferous forest (Bśw), occupying 27% and 26.1% respectively. Coniferous forest habitats occupy 59% in total, broadleaved forest - 35.6%, alder forest - 5.4%. The share of lowland habitats is 82.9%, upland habitats are 8% and mountain habitats are 9.1%. The structure in communal forests is as follows: coniferous species - 51,554 ha, i.e. 62.8%, deciduous species - 30,509 ha, i.e. 37.2%. The dominant forest habitat types are: fresh mixed coniferous forest (BMśw) and fresh mixed broadleaved forest (LMśw), occupying 17.6% and 16.7% respectively. Coniferous forest habitats occupy a total of 31.4%, broadleaved forest - 65.7%, alder forest - 2.9%. The share of lowland habitats is 65%, upland habitats 16% and mountain habitats 19%. The forest area in national parks is as follows: coniferous species - 105,285 ha, i.e. 57.6%, deciduous species - 77,472 ha, i.e. 42.4%. The dominant habitat types of the forest are: mountain forest (LG), fresh mixed coniferous forest (BMśw), fresh coniferous forest (Bśw) and fresh mixed broadleaved forest (LMśw), occupying 29.2%, 10.4%, 10.1% and 9% respectively. Coniferous forest habitats occupy 30.7% in total, broadleaved forest - 63.3%, alder forest - 6%. The share of lowland habitats is 51.5%, upland habitats 5.7%, and mountain habitats 42.8%. The forest area in the forests of the Agricultural Property Stock of the State Treasury amounts to: coniferous species: 15,777 ha, i.e. 58.9%, deciduous species: 11,002 ha, i.e. 41.1%. The dominant habitat types of the forest are: fresh mixed broadleaved forest

(LMśw) and fresh mixed coniferous forest (BMśw) occupying 22.8% each and fresh broadleaved forest (Lśw): 15.2%. Coniferous forest habitats occupy a total of 37.1%, broadleaved forest habitats 56.9% and alder forests 6%. The share of lowland habitats is 91.2%, upland habitats 5.8% and mountain habitats 3%. The forest area in other State Treasury forests is: coniferous species 36,702 ha, i.e. 69.1%, deciduous species 16,404 ha, i.e. 30.9%. The dominant habitat types of the forest are: fresh mixed broadleaved forest (LMśw), fresh mixed coniferous forest (BMśw), fresh coniferous forest (Bśw) and fresh broadleaved forest (Lśw) occupying 22.8%, 19.7%, 13% and 12.9% respectively. Coniferous forest habitats occupy a total of 36.8%, broadleaved forest habitats 60% and alder forests 3.2%. The share of lowland habitats is 81.7%, an upland habitat is 5.9%, and a mountain habitat is 12.4% (Zajączkowski S. et al., 2020b).

Among the most important tasks, improving the process of forest area determination in Poland, there are the following:

- developing solutions acceptable to all stakeholders concerning forest areas reported to the FAO and other international organisations;
- conducting research to determine the actual forest area in Poland, including areas to be reported under Article 3.3 of the Kyoto Protocol;
- determination of areas with woody vegetation that do not meet the forest criteria (tree-covered areas, other land with forest cover);
- conducting continuous measurements, e.g. within the framework of the Large-Scale Forest Inventory aiming at tracking changes in land use in Poland (Jabłoński, 2015).

2.3. Ownership structure of forests

The ownership structure of forests in Poland is dominated by public forests: 80.7%, including forests under the management of the State Forests National Forest Holding: 76.9%. Between 1990 and 2019 the share of private forest ownership increased by 2.3% to the current 19.3%. The share of forests owned by the public domain has decreased accordingly (from 83% to 80.7%). The increase in the share of forests in national parks from 1.3% in 1990 to 2% in 2019 was mainly due to the creation of 6 new parks in the discussed period and an increase in the area of the remaining ones (Zajączkowski G. et al., 2020).

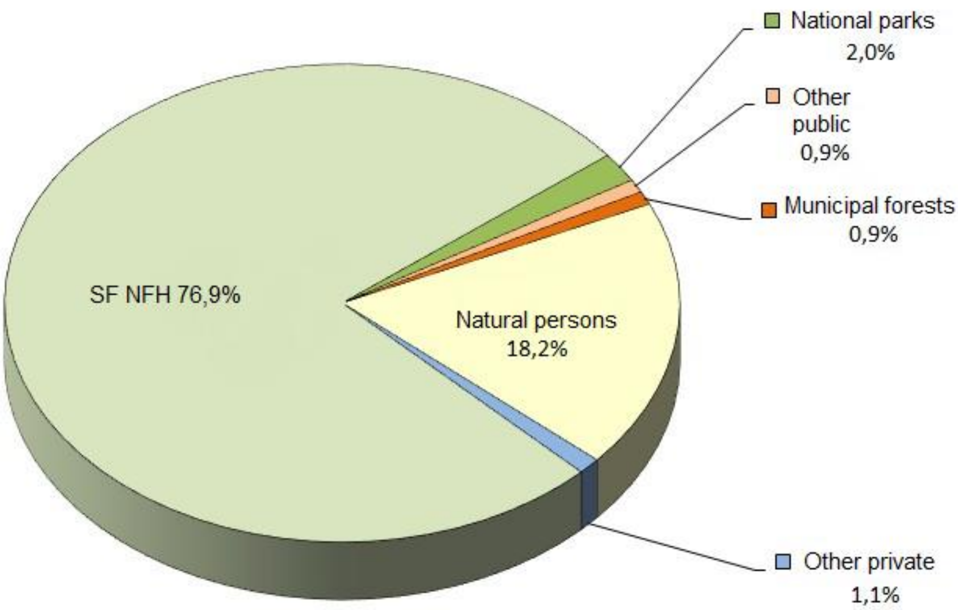

Fig.2.4.Forest ownership structure in Poland.
Source: Statistical Yearbook of Forestry, 2019.

2.4. Afforestations

Unused land, agricultural land not suitable for agricultural production and agricultural land not used for agricultural production and other land suitable for afforestation may be used for afforestation, and in particular: land situated at river or stream springs areas, on watersheds, along river banks and on the outskirts of lakes and water bodies, quicksand and sand dunes, steep slopes, hillsides, cliffs and land hollows, heaps and area of depleted sand, gravel, peat and clay. The size of the afforestations, their distribution and the way of their implementation are determined by the National Programme for Expanding of Forest Cover, developed by the minister responsible for the environment. Land to be afforested is determined by the local spatial management plan or the decision on development and land use conditions. The obligation to afforest land is imposed on forest district managers, with regard to land managed by the State Forests National Forest Holding, and on owners or perpetual usufructaries of other land. Land owners or perpetual usufructaries may receive subsidies from the state budget for total or partial coverage of land afforestation costs (Forest Act, 1991).

The main objective of the National Programme for Expanding of Forest Cover is to increase the country's forest cover to 30% in 2020 and 33% in 2050 and to ensure optimal spatial and temporal distribution of afforestation. The reduction in the area of afforestation observed in recent years results, inter alia, from the change in the criteria for the allocation of private agricultural land for afforestation under the Rural Development Programme, including an increase in the minimum compact afforestation area, exclusion from support for afforestation of permanent grassland and increased competitiveness from direct payments for agricultural production and, in the case of the State Forests National Forest Holding, a reduction in the area of former agricultural land and wasteland transferred for afforestation by the National Support Centre for Agriculture (by 2017 Agricultural Property Agency)(Milewski W.,2019; Wysocka-Fijorek,Gil and Gołos, 2020; Zajączkowski G. et al., 2020).

Tab.2.6 *Afforestations during1999-2018*

Year	Area of afforestation – in total(ha)	Area of afforestation in public forests(ha)	Area of afforestation in public forests– State Treasury (ha)	Area of afforestation in public forests– State Treasury – SF NFH (ha)	Area of afforestation in private forests (ha)
1999	19,605.00	–	–	12,387.00	–
2000	23,386.70	13,243.50	13,070.50	12,987.20	10,143.20
2001	22,972.40	11,660.00	11,466.00	11,360.80	11,312.40
2002	20,275.00	9,873.30	9,703.30	9,626.70	10,401.70
2003	26,473.70	9,308.20	9,179.20	9,113.10	17,165.50
2004	12,681.70	9,897.00	9,738.00	9,677.40	2,784.70
2005	12,870.80	6,335.80	6,201.00	6,143.60	6,535.00
2006	16,932.40	4,567.40	4,466.10	4,418.00	12,365.00
2007	13,286.80	3,043.80	2,979.30	2,948.30	10,243.00
2008	7,876.10	2,929.40	2,852.60	2,773.40	4,946.70
2009	5,611.60	1,878.40	1,773.80	1,729.50	3,733.20
2010	5,864.90	785.90	736.80	724.20	5,079.00
2011	5,277.10	594.50	558.90	542.00	4,682.60
2012	4,902.65	548.25	445.55	413.15	4,354.40
2013	4,077.95	428.01	390.40	383.87	3,649.94
2014	3,775.60	723.81	685.59	674.23	3,051.79
2015	2,270.30	788.74	754.75	747.93	1,481.56
2016	2,011.39	686.78	644.65	643.53	1,324.61
2017	1,628.09	576.39	519.06	486.76	1,051.70
2018	1,321.02	364.28	353.27	347.34	956.74

Source: Statistics Poland - Local Data Bank, 2020.

Tab.2.7 *Forest land intended for non-forestry purposes in the period 2003-2018*

Year	Area(ha)
2003	689
2004	652
2005	472
2006	587
2007	597
2008	621
2009	642
2010	551
2011	604
2012	494
2013	497

2014	774
2015	738
2016	447
2017	1,093
2018	497

Source: Statistics Poland - Local Data Bank, 2020.

2.5. Renewals

In 2019, the forest renewals (without afforestation of tree stand gapds and the introduction of the second storey) was realised on an area of 63,041 ha of land of all ownership categories, of which 8,625 ha (13.7%) were natural renewals. In 2019, the area of the renewals was about 5,700 ha larger than in 2018. The renewals works were carried out on an area corresponding to 0.7% of the total forest area. Most of the renewals (almost 96%) were carried out on land managed by the State Forests National Forest Holding. The area of renewals in private forests (2,239 ha in 2019) represents less than 4% of the total renewals area and represents only 0.1% of the total forest area of this form of ownership. At the same time, the area of renewals in private forests in 2019 was 40% higher than in 2018.

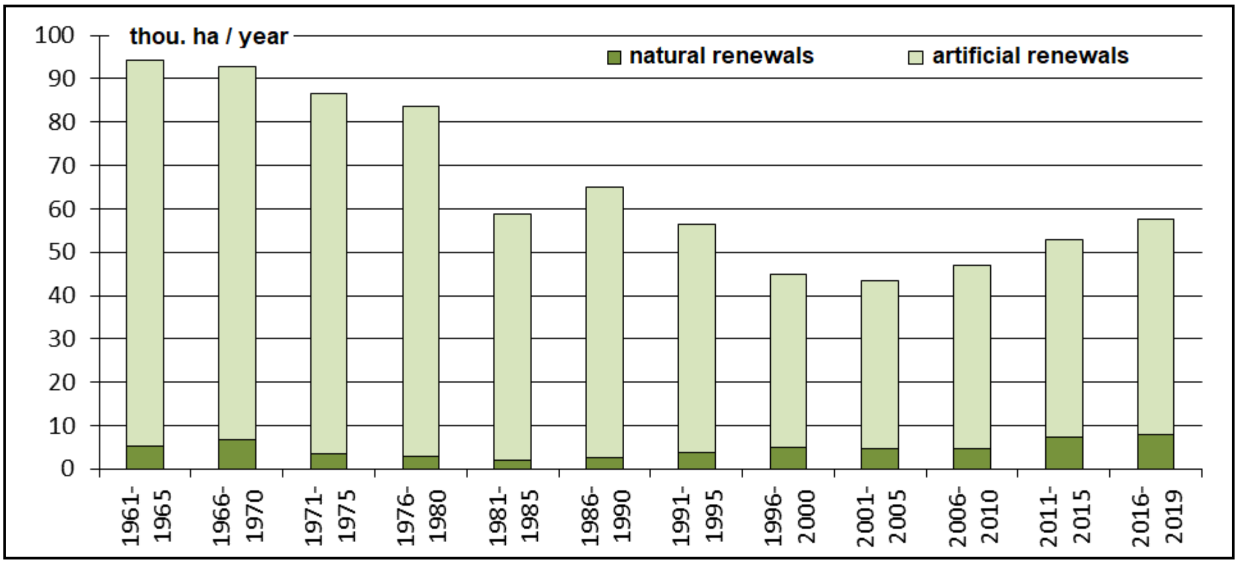

Fig.2.5. Average annual size of renewals in the years 1961-2019.
Source: Statistical Yearbook of Forestry, 2019.

2.6. Stand age structure

The age structure of the forest is dominated by III and IV class stands, which are found on 23.1% and 20.4% of the area respectively. The area of the stands above 80 years (without the “restocking class” - RC and the “for restocking class” - FRC) have increased from about 900,000 ha in 1945 to almost 2,200,000 ha today. During the same period, the average age of stands in forests of all forms of ownership has increased from 44 to 59 years (in the State Forests National Forest Holding - up to 60 years, and in private forests - up to 51 years)(Zajączkowski G. et al.,2020).

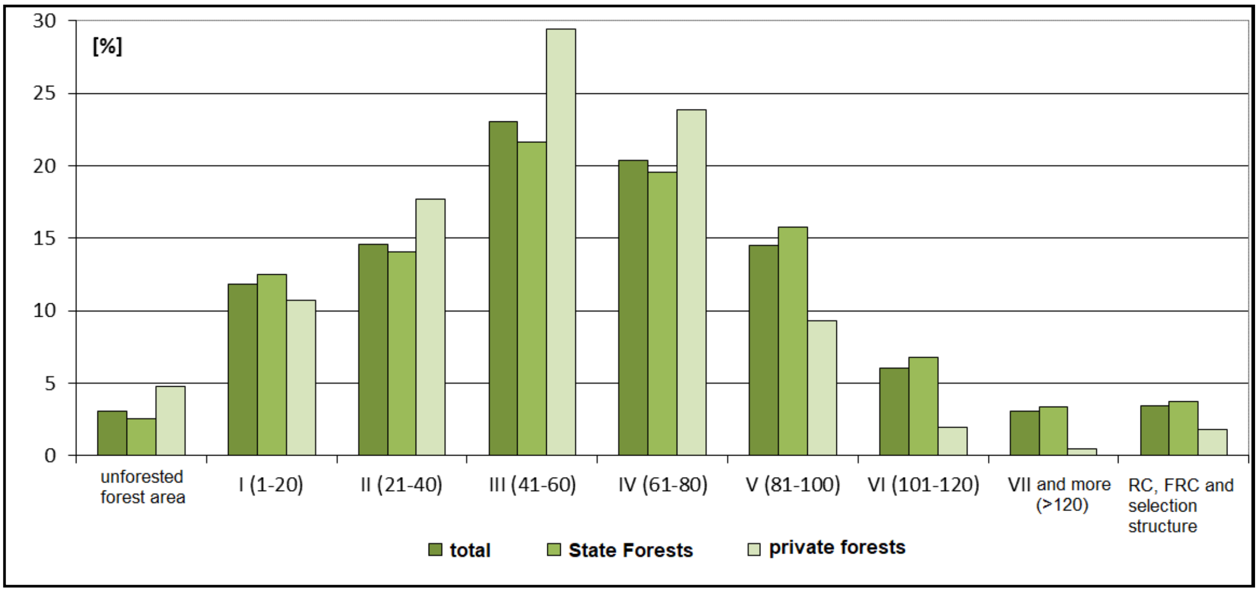

Fig.2.6. Area share of stands by age classes in forests of all forms of ownership, State Forests and private forests.
Source: Large-Scale Forest Inventory, 2020.

According to the Large-Scale Forest Inventory in forests of all forms ownership the share of stands of the first age class is the smallest (of the stands up to 100 years) and is 11.9%. Stands in the State Forests National Forest Holding have a higher share of this age class than in private forests and it amounts to 12.5% and 10.7% respectively. On the other hand, stands over 100 years old occupy about 12.6% in Poland. This share in the State Forests National Forest Holding is much higher than in private forests - it is 14%, and only 4.1% in private forests (WISL, 2020).

The average age of stands in the State Forests National Forest Holding is 64 years. The highest average age is shown here by fir (80 years), hornbeam (76 years) and beech (74 years) stands, and the lowest by poplar (50 years), alder and birch (57 years) stands. The average age of all stands is determined mainly by the average age of pine stands (63 years)(Zajączkowski S.et al., 2020a).

The average age of stands in forests outside the State Forests National Forest Holding is 61 years. The highest average age is shown by beech stands (86 years) and fir stands (79 years), while the lowest by birch, aspen and alder stands. The average stand age is determined by the average age of pine stands (59 years). The average age of stands in private forests is 58 years, and 56 years when the area of non-forested forest area is included. The highest average age is shown by beech and fir stands (74 years), while the lowest in birch, aspen, alder and poplar stands. The average age of the stands is determined by the average age of pine stands (57 years), which occupy 60.8%. The average age of stands in communal forests is 71 years. The highest average age is determined by fir stands (84 years) and beech stands (82 years), while the lowest by alder stands (56 years) and birch stands (57 years). The average stand age is determined by the average age of pine stands (68 years). The average age of stands in the State Treasury forests in national parks is 90 years. The highest average age is shown by hornbeam stands (112 years) and fir stands (111 years), while the lowest - aspen, birch and alder stands. The average age of stands is determined by the average age of pine stands (85 years) and beech stands (107 years). The average age of stands in the Agricultural Property Stock of the State Treasury forests is 61 years. The highest average age is shown by fir stands (80 years) and beech stands (71 years), while the lowest: poplar, birch and alder tree stands. The average age of stands is determined by the average age of pine stands (59 years). The average age of stands in other State Treasury forests is 68 years. The highest average age of stands is determined by fir stands (84 years), while the lowest age of stands are represented by poplar, birch, aspen and alder stands. The average stand age is determined by the average age of pine stands (69 years)(Zajączkowski S.et al., 2020b).

Tab.2.8 *Age of forests in Poland*

Public forests					**Private forests**
State Treasury				**Communal forests**	
SF NFH	**National parks**	**Agricultural Property Stock of the State Treasury**	**Other**		
60	80	54	61	71	51

Source: Large-Scale Forest Inventory, 2020.

Tab.2.9 *Average age of forest trees in Poland - State Forests*

Type	**Average age**
Birch *Betula*	57
Beech *Fagus*	74
Oak, maple, elm *Quercus, Acer, Ulmus*	68
Hornbeam *Carpinus*	76
Fir *Abies*	80
Alder *Alnus*	57
Aspen *Populus tremula*	57
Pine, larch *Pinus, Larix*	63
Spruce *Picea*	65
Poplar *Populus*	50

Source: Zajączkowski S.et al., 2020a.

2.7. Volume structure of wood resources

According to the results of the Large-Scale Forest Inventory from 2015-2019, Poland's wood resources have reached a gross volume of 2,645,000,000 m^3 of merchantable timber, of which the State Forests account for 2,066,000,000 m^3 and private forests for 451,000,000 m^3. Nearly half (49.6%) of the wood resources are in III and IV age class stands, 47% in the State Forests and 65.1% in private forests. The share of stands over 100 years old, together with stands in the “restocking class”, or in the “for restocking class” and in the selection structure in total volume amounts to 20.7% in the State Forests and 6.3% in private forests. According to the results of the Large-Scale Forest Inventory for the period 2015-2019, the average timber resource in Poland is 286 m^3/ha, including 290 m^3/ha in forests managed by the State Forests National Forest Holding and 252 m^3/ha in private forests (Zajączkowski G. et al., 2020). The average wood volume in the State Forests is about 15% higher than in private forests, with a much better condition of tending of stands and much higher average age of stands (WISL, 2020).

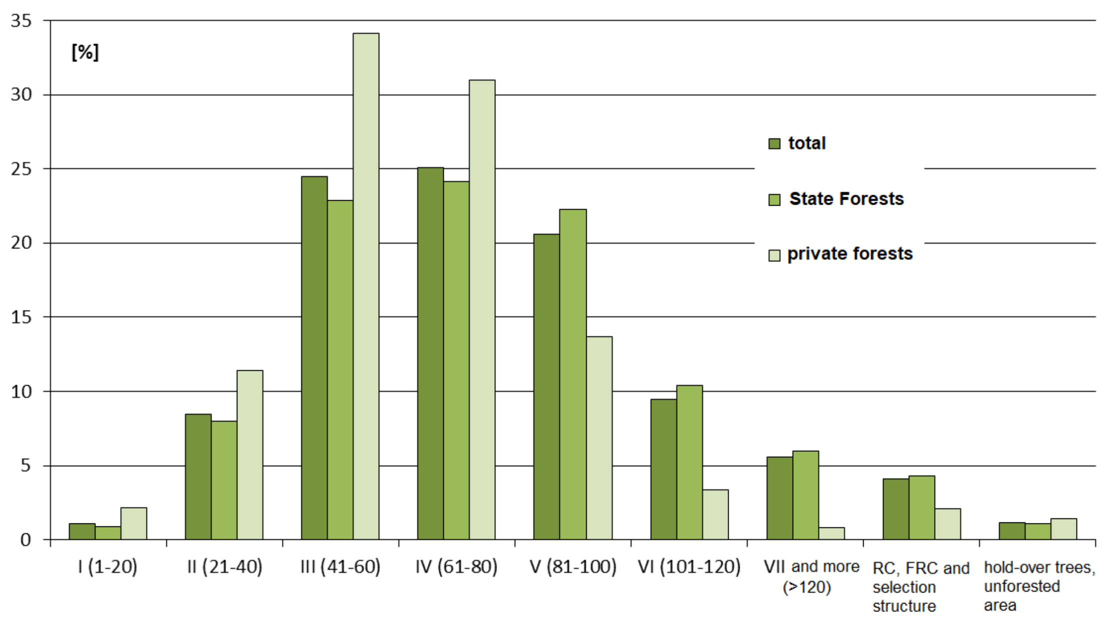

Fig. 2.7. Structure of the share of the volume of stands by age classes in forests of all forms of ownership (total), State Forests and private forests.
Source: Large-Scale Forest Inventory, 2020.

According to the data of the Large-Scale Forest Inventory for the periods 2005-2009 and 2015-2019, total wood resources in the country increased on average by 34,000,000 m^3 per year (Zajączkowski G. et al., 2020). In the volume perspective Scots pine *Pinus sylvestris* represents 56.3% of the wood resources of forests of all forms of ownership. In the State Forests this share is 58.3%, and in private forests: 53.5%. Private forests are characterized by a higher volume share of deciduous species as compared to the State Forests, in particular, such as Scots birch *Betula pendula*, black alder *Alnus* *glutinosa*, Eurasian aspen *Populus tremula* and common hornbeam *Carpinus betulus*, with a lower share of oaks *Quercus sp*. and common beech *Fagussylvatica* (ZajączkowskiG. et al., 2020).

As of 01.01.2019, the total gross volume of merchantable timber in the State Forests is 1,907,684,500 m^3 (coniferous species: 78.2%, deciduous: 21.8%). The average wood volume of all stands in the State Forests on the forested forest area is 274 m3/ha gross merchatable timber and on the total forest area: 268 m^3/ha. The highest average wood volume is shown by the stands with the dominant European silver fir *Abies alba* - 364 m^3/ha and the Norway spruce *Picea abies* - 298 m^3/ha. The average volume of the main forest-forming species in Poland, i.e. Scots pine *Pinus sylvestris*, is 277 m^3/ha gross merchatable timber. The total gross volume of merchatable timber in the forest area increased from 912,700,000 m^3 in 1967 to 1,161,900,000 m^3 in 1985, 1,322,600,000 m^3 in 1995, 1,586,200,000 m^3 in 2005, 1,747,800,000 m^3 in 2010, 1,860,800,000 m^3 in 2015, up to 1,907,700,000 m^3 in 2019. The demonstrated increase in the gross volume of merchatable timber in the State Forests is due to both an increase in the forest area and an increase in the forest stand volume per hectare. The total volume resources in the State Forests in the discussed period increased on average annually by about 19,100,000 m^3, and last year it increased by 9,700,000m^3(Zajączkowski S.et al.,2020a).

As of 01.01.2019, the total gross volume of merchatable timber on the forest area outside the State Forests is 474,785,500 m^3 (coniferous species: 70.9%, deciduous species: 29.1%). The average wood volume in the forests outside the State Forests in the forested area is 230 m3/ha gross merchatable timber and in the total forest area: 222 m^3/ha. As of 01.01.2019, the total gross volume of merchatable timber in the private forest area is 369,769,200 m^3 (coniferous species: 73.2%, deciduous species: 26.8%). The average volume in private forests in the forested forest area is 215 m^3/ha gross merchatable timber and 207 m^3/ha on total forest area. As of 01.01.2019, the total gross volume of merchatable timber in the communal forest area is 21,767,600 m^3 (coniferous species: 67%, deciduous species: 33%). The average volume in the communal forested forest area is 265 m^3/ha gross merchatable timber and 258 m^3/ha on the total forest area. As of 01.01.2019, the total gross volume of merchatable timber in the national parks' forest area is 61,449,700 m^3 (coniferous species: 58.8%, deciduous species: 41.2%). The average forest stock volume of the State Treasury forests in the national parks on the forested forest area is 336 m^3/ha gross merchatable timber and 331 m^3/ha on forest area in general. As of 01.01.2019, the total gross volume of merchatable timber in the Agricultural Property Stock of the State Treasury forests area is 6,672,000 m^3 (coniferous species: 62.9%, deciduous species: 37.1%). The average forest stock volume of the Agricultural Property Stock of the State Treasury's forested forest area is 249 m^3/ha gross merchatable timber and on the total forest area it is 242 m^3/ha. As of 01.01.2019, the total gross volume of merchatable timber on the other State Treasury forests area is 15,127,000 m^3 (coniferous species: 73.3%, deciduous species: 26.7%). The average volume in other State Treasury forested forests area is 285 m^3/ha gross merchatable timber and on the forest area in general it is 279 m^3/ha (ZajączkowskiS.et al., 2020b).

According to data from the Large-Scale Forest Inventory, the volume of forests owned by the State Treasury is 81.8% and those managed by the State Forests National Forest Holding amounts to 78.2% of the total volume of forests in Poland. The share of the volume of older age class stands in the State Forests (20.7%) is significantly higher than in private forests (6.3%). The volume of coniferous species accounts for 72.3% (by dominant species) and 68.6% (by factual species) of the total volume of all forests in the country. The corresponding share of Scots pine *Pinus sylvestris* is 61% and 56.3%, and common beech *Fagus sylvatica*, which is the largest volume of deciduous species in the country amounts to 6.9% and 7.1% respectively. The average wood volume of forests with the above-mentioned dominant species, i.e. pine stands is 301 m^3/ha and beech stands is 321 m^3/ha (WISL, 2020).

From January 1999 to January 2019, in the forests managed by the State Forests National Forest Holding, the gross volume of merchatable timber increments was 1,242,000,000 m^3. At that time, 783,000,000 m^3 of merchatable timber was harvested, which means that 459,000,000 m^3 of gross merchatable timber, corresponding to 37% of the total growth, increased the wood resources of tree stands (Zajączkowski G. et al., 2020).

The current gross annual increment rate of merchatable timber volume from 1999 to 2019, including harvesting and per 1 hectare of forest land managed by the State Forests National Forest Holding, is 8.9 m^3/ha. The current annual increment of gross annual merchatable timber, calculated in the same way, over the last 5 years is significantly lower, i.e. 8.5 m^3/ha, which is due, among other things, to the ageing of the stands. Based on the information from the last 5 years, the usage intensity is 79%, which means that 21% of the total increment has increased the wood resources of tree stands (Zajączkowski G. et al., 2020).

According to the data of the Large-Scale Forest Inventory for the years 2010-2014 and 2015-2019, the current annual gross volume increment of merchatable timber per 1 hectare (5-year average) was 9.4 m^3/ha in the State Forests, and 9.3 m^3/hain private forests (Zajączkowski G. et al., 2020).

The increase in the volume of wood resources in all the country's forests over the last 5 years was about 178,100,000 m^3, which represents an increase of about 1.46% per year in relation to total resources (WISL, 2020). The annual volume increment in the country's forests over the 5-year period is about 9.41 m^3/ha. This increment in the State Forests (9.42 m^3/ha) is slightly higher than in private forests (9.28 m^3/ha). The annual volume increment in the country's forests over a 10-year period is slightly smaller than over a 5-year period. In the country's forests it is 9.17 m^3/ha, in the State Forests 9.19 m^3/ha and in private forests 8.95 m^3/ha (WISL, 2020).

According to the data from 2014, forest volume increment in the State Forests constitutes 77.3% of the overall forest volume increment in Poland. However, the increment that has been deposited in private forests represents 18.7% of the total volume increment estimated. Coniferous stands are characterized by a higher annual volume increment (9.77 m^3/ha) than deciduous stands (8.58 m^3/ha). Analogous data for Scots pine *Pinus sylvestris* and silver birch *Betula pendula* (the species occupying the largest area among coniferous and deciduous species) are 9.43 m^3/ha and 7.31 m^3/ha. According to the data from 2009, the annual volume increment at the State Forests National Forest Holding represents 78.1% of the overall forest volume increment in Poland, while the increment that has been deposited in private forests represents 17.6%. Coniferous stands are characterized by higher annual volume increment (9.5 m^3/ha) than deciduous stands (8.36 m^3/ha). Analogous data for Scots pine *Pinus sylvestris* and silver birch *Betula pendula* are 9.24 m^3/ha and 7.18 m^3/ha (WISL,2020).

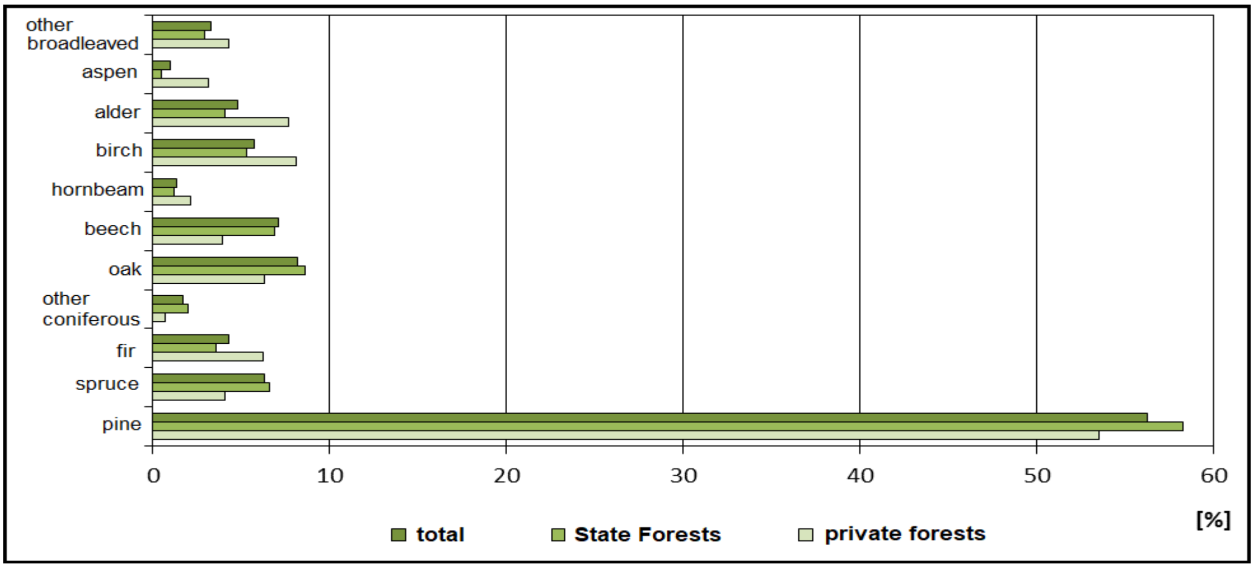

Fig. 2.8. Share of volume by factual species in forests of all forms of ownership (total), State Forests and private forests.
Source: Large-Scale Forest Inventory, 2020.

Tab.2.10 *Average volume of merchatable timber resource of forest trees in Poland - State Forests*

Type	**Average merchatable timber resource on forested land(m^3/ha)**
Birch *Betula*	226
Beech *Fagus*	271
Oak, maple, elm *Quercus, Acer, Ulmus*	244
Hornbeam *Carpinus*	260
Fir *Abies*	364
Alder *Alnus*	259
Aspen *Populustremula*	272
Pine, larch *Pinus,Larix*	277
Spruce *Picea*	298
Poplar *Populus*	265

Source: Zajączkowski S.et al., 2020a.

Tab.2.11 *Structure of wood resources in Poland*

<table>
<tr><th colspan="3">Ownership</th><th>Wood resources (m^3)</th><th>Average wood volume (m^3/ha)</th></tr>
<tr><td rowspan="5">Public forests</td><td rowspan="4">State Treasury</td><td>SF NFH</td><td>2,065,656,137</td><td>290</td></tr>
<tr><td>National parks</td><td>72,734,848</td><td>392</td></tr>
<tr><td>Agricultural Property Stock of the State Treasury</td><td>8,638,913</td><td>313</td></tr>
<tr><td>Other</td><td>16,171,263</td><td>298</td></tr>
<tr><td colspan="2">Communal forests</td><td>31,009,391</td><td>368</td></tr>
<tr><td colspan="3">Private forests</td><td>450,846,898</td><td>252</td></tr>
</table>

Source: Large-Scale Forest Inventory, 2020.

Tab.2.12 *Current annual increment of wood volume over the period 2014-2018*

Ownership			Annual increment(m^3)
Public forests	State Treasury	SF NFH	9.42
		Nartional parks	9.92
		Agricultural Property Stock of the State Treasury	9.09
		Other	9.53
	Communal forests		10.01
Private forests			9.28

Source: Large-Scale Forest Inventory, 2020.

Tab. 2.13 *Current annual increment of wood volume over the period 2009-2018*

Ownership			Annual increment (m^3)
Public forests	State Treasury	SF NFH	9.19
		National parks	9.79
		Agricultural Property Stock of the State Treasury	9.13
		Other	9.93
	Communal forests		10.59
Private forests			8.95

Source: Large-Scale Forest Inventory, 2020.

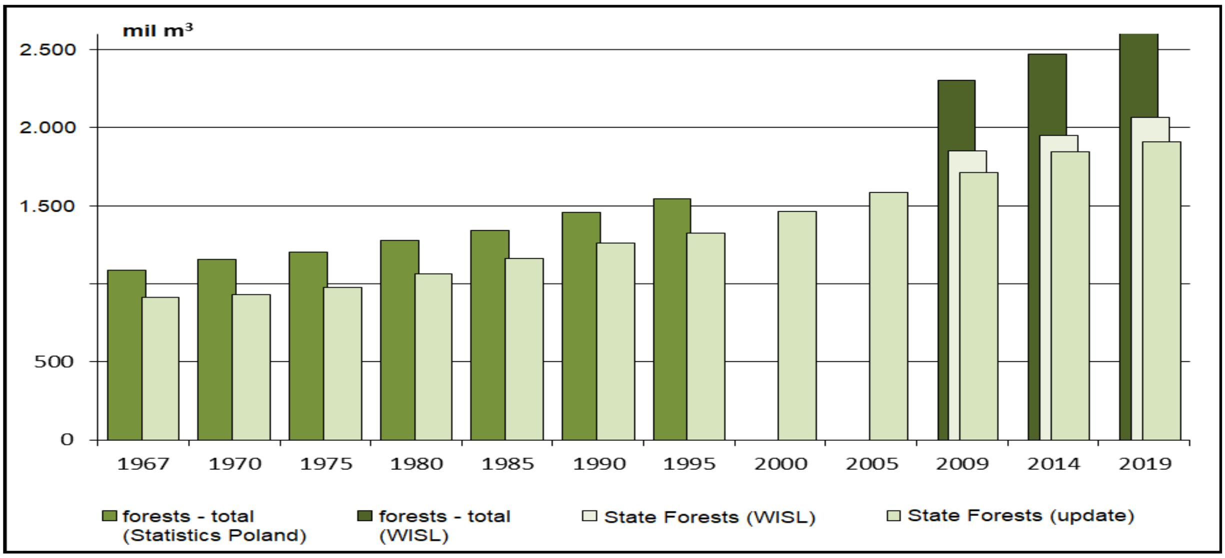

Fig.2.9. Volume of wood resources in the forests of Poland between 1967 and 2019 in million m^3 gross merchatable timber

Source:data of the Bureau for Forest Management and Geodesy, 2020;data of the General Directorate of State Forests, 2020; Statistical Yearbook of Forestry, 2019; WISL, 2020.

2.8. Trends in forest management

The current state of forests results from the consistent implementation of multifunctional forest management in most forest areas. The implementation of this model results from both the regulations in force, including the State Forestry Policy (1997), and the requirements of forest certification. This model may be subject to various modifications in the future, especially in the context of the factors described below.

Over the last 40 years of the last century the area of renewals - and consequently the share of stands of the youngest age classes - has been gradually decreasing. However, data from the last dozen or so years indicate a slight reversal of this trend. Additional attention should be paid to the increase in the share of natural renewals in the total area of renewals, observed since the beginning of the 1990s. In the years 1986-1990 this share was 4.2%; from 1991-1995 it was 6.5%, from 1996 to 2010 it was 10.5%, and in the last 9 years: 13.7%.

Decreasing area of the youngest stands (I and II age classes), observed for several decades, may raise concerns about the desired structure of age classes. The reasons for this trend should be seen, among others, in a significant reduction in afforestation, reduction of final felling use (depletion of the area of renewals) in favour of intermediate felling use forced by the state of the forest and reduction of the area of clearcuts (indicated, among others, for ecological reasons). The consequence of the reduction in final felling use is an increase in the area of older stands. Too long time of keeping resources in the form of stands that are ripe for felling may cause depreciation of the wood raw material and increase the risk of damage caused by abiotic factors (Zajączkowski G. et al., 2020).

In the last few dozen years, the volume of stands of the III age class (41-60 years) and older in the State Forests has significantly increased. The volume of the I age class, due to the marginal occurrence of merchatable timber, does not constitute a significant component of the total volume. The decrease in the volume of the II age class results from large changes in the area of this class. The fact that the overall increase in wood resources is not only due to the increase in forest area is evidenced by the changes in volume in the age classes under consideration. Starting from age class III, an increase of this indicator is observed in the analysed period. The increase in wood resources in the State Forests results from a consistent increase in their area and wood harvesting in accordance with the principles of sustainable forest management and maintenance of forest sustainability. To some extent, the recorded increase in resources also results from the application of more accurate inventory methods (Zajączkowski G. et al., 2020).

The 2014 forecast indicates that by the end of 2030 the area of private forests could increase by about 240,000 hectares, and by 2050 by 420,000 ha, mainly due to reclassification into forests the land that meets the statutory criteria, but which has so far been listed in the Land and Property Register as agricultural land. The volume of wood resources in private forests could increase by about 30% by 2031 and by nearly 55% by 2051, which would mean an increase in wood resources of almost 1.5% per year. In turn, harvesting in the period under consideration could reach about 6,100,000 m^3 net merchatable timber in 2030 and 8,100,000 m^3 net merchatable timber in 2050. This means an increase of about 45% in private forests by 2030 and almost 90% in 2051. It is estimated, however, that this yield will be consistently lower than the current volume increase. It will represent about 60% in 2031 and 70% in 2051. Much smaller opportunities for wood supply growth are in public forests other than the State Forests (national parks, Agricultural Property Stock of the State Treasury, other State Treasury and municipal forests). It is estimated that these opportunities, while maintaining the existing functions of these forests, amount to about 550,000 m^3 of net merchatable timber annually. This capacity will increase to about 630,000 m^3 in 2031 and in 2051 up to 720,000 m^3 net merchatable timber. Over time, an increasing share of wood supply in forests other than those managed by the State Forests National Forest Holding can be expected to reach 14.2% in 2031 and 16.5% in 2051.

Data from the Large-Scale Forest Inventory indicate that, in practice, especially in private forests, wood harvesting may be significantly higher, not only at present and in the perspective of the next few years, but also in the long term, by 2050, filling to a large extent the gap in the wood deficit in the national wood market. There are great opportunities to increase harvesting in private forests without fear that this will lead to excessive final felling and intermediate felling use. It is also possible to think that an increase in the intensity of use, especially intermediate felling, may contribute to an improvement in the condition of stands in terms of silviculture. Wood harvested in private forests has so far been hardly ever included in the wood industry. The rational use of the growing supply of wood from private forests, as well as from other forests not under the management of the State Forests National Forest Holding, requires a significant improvement in the organisation of harvesting and purchasing of wood on the very dispersed wood market in the forests of these forms of ownership. The need to increase the tending and harvesting capacity of forests of other forms of ownership requires the involvement of the state administration responsible for supervising these forests, especially the county authorities. The activities of the administration should consist in updating the information base on the condition of forests other than the State Forests and cooperating in creating a system of motivation to increase the intensity of tending activities (Dawidziuk and Zajączkowski, 2015).

2.9. Factors of change in the forest sector and their consequences for forest genetic resources

Forest management is carried out according to the model of sustainable and multifunctional forest management. It is accompanied by a stable political and economic background, allowing achieving harmony between protective, social and productive functions of forests. The most important factor of change possible today, which may have consequences for the whole forest sector, including forest genetic resources, is the ongoing climate change.

The increase in the threat of climate warming, caused by the increase in the amount of CO_2 in the atmosphere, may have a negative impact on forest ecosystems. Polish forests are still under constant threat from abiotic, biotic and anthropogenic factors; the threat is among the highest in Europe. Although atmospheric air pollution has decreased in recent years, it is still a significant threat to forests.

Disease predisposition of stands and degradation of forest ecosystems results from co-occurrence and synergistic influence of a number of abiotic and biotic harmful factors. This is due to the following factors observed at present: deepening precipitation deficit, droughts, warm snowless winters and a decrease in groundwater level. Harmful organisms that have not been present in Poland so far or were considered to be harmless (e.g. bark beetle *Ips acuminatus*, mistletoe *Viscum* sp.) appear or activate.

Another threat is eutrophication of forest ecosystems, expressed mainly by increased nitrogen deposition in forest soils.

Unstable weather conditions, changes in water availability, biotic and abiotic threats affect the irregularity of forest trees' seed production, and sometimes also threaten to reduce the gene pool of tree species as a result of significant damage to local populations.

Another kind of threat to forest genetic resources are invasive plants, especially tree and shrub species, which find favourable growth conditions in forests. In addition to displacing native species (e.g. black cherry *Prunus serotina*), they also carry the risk of uncontrolled crosses with native species (e.g. Japanese larch *Larix kaempferi*).

2.10. Challenges and opportunities for forest genetic resources

The most important challenge at the moment in the context of protecting forest genetic resources is to strengthen the stability of forest ecosystems and their resistance to harmful factors. An important tool in this respect is the model of forest management close to nature, implemented in Polish forests, which makes maximum use of natural processes taking place in forest ecosystems, including those promoting natural renewals, thus ensuring the preservation of local forest tree origins.

The consequence of using this model is also the conversion of stands growing on inappropriate habitats. Although coniferous forest habitats, specific for coniferous species, occupy 50% of the forest area in the country, stands with dominant coniferous species (mainly Scots pine *Pinus sylvestris*) occupy 68% of the forest area.

The challenge, whose undertaking would have positive effects on the condition of forests and forest genetic resources, is to popularize the model of forest management similar to nature among private forest owners (e.g. in the form of trainings, manuals). Private forests occupy a considerable area (19% of the country's forest area).

Special attention in forestry should be paid to species threatened as a consequence of changes in climate and environment. These include, first of all, the outgoing from the Polish forests common ash *Fraxinus excelsior*. Research and active silvicultural measures are necessary here, which would allow to preserve the surviving populations of this species.

Other species, especially those characterized by dispersed occurrence in Poland, requiring monitoring of health condition, genetic monitoring of the population and active protection of genetic resources, are: silver poplar *Populus alba*, wild service tree *Sorbustorminalis*, European white elm*Ulmus laevis*, wych elm *Ulmus glabra*, field elm *Ulmus minor*, European crab apple *Malus sylvestris*, common pear *Pyrus communis*, wild cherry *Prunusavium*, common yew *Taxusbaccata*etc.

An important element in identifying threats to forest genetic resources is periodic monitoring of the forest environment, which should be continued.

Continuous monitoring of objects under special protection is extremely important due to the preservation of genetic resources (selected seed stands, clonal and seedling seed orchards, conservation stands and plantations). Thanks to them it is possible to propagate in our forests native ecotypes of stand-forming species. Their preservation and development is supported by the developed "Programme of conserving forest genetic resources and breeding of trees in Poland for the years 2011-2035".

The main activities planned for implementation under this program include:

a) in terms of legislative work:

- development of the Biodiversity Protection Act or introduction of supplements to the Nature Conservation Act and the Forest Act, which would sanction active methods of biodiversity protection, including genetic diversity, used in forest management, e.g.: conservation stands and trees, archives of valuable clones and other forms of activity;
- development and implementation of measures to reduce or counteract biodiversity loss in forests, including the development of national and regional programs for the conservation and restoration of endangered or threatened habitats and species;
- legal sanction of objects of active protection of forest genetic resources *in situ* registered in the EUFGIS (*European Information System on Forest Genetic Resources*) database,

b) b) in the scope of field work:

- running selected conservation stands;
- creating pogeny generations in conservative tree stands (plots insitu);
- establishing and running the conservation areas ex situ;
- establishment of progeny plantations
- establishment and managing of conservation and breeding clonal seed orchards, seedling assed orchards and clone archives (ex situ protection of single genotypes);
- harvesting from conservation stands, breeding populations and single genotypes of

reproductive material (seeds, plant parts, pollen) for long-term storage in the Kostrzyca Forest Gene Bank;

- complementary selection, based on systematic genetic research, of subsequent species, populations and genotypes characterized by specific genetic traits, complementing the existing genetic diversity accumulated in the conservation stands and breeding populations;
- implementation of genetic monitoring of selected species and populations;
- implementation of conservation and restoration programmes for endangered species and vulnerable habitats;
- in justified cases, the so-called assisted migration for selected species and populations.
- The following objectives are planned to be achieved as part of the conducted silviculture measures:
- improvement of qualitative and quantitative characteristics of the populations (stands);
- population selection (selection of objects for the production of forest reproductive material of the "selected" and "tested" categories);
- selection of populations and genotypes of high plasticity for breeding in a changing climate (population and individual selection);
- establishing of artificial breeding populations on the basis of seed orchards with specific (relatively high) genetic variability (individual selection of different genotypes for clonal seed orchards and seedling seed orchards based on DNA analysis);
- improving the quality characteristics of genotypes - individual selection;
- improving the resistance characteristics of genotypes to biotic and abiotic factors;
- improving the quantitative characteristics of genotypes - production of wood mass in short and medium production cycles.

There is a risk that climate change will cause an evolutionary change in the species composition of the stands. The Scots pine *Pinus sylvestris*, the Scots spruce *Picea abies*, the European larch *Larix decidua* and the silver birch *Betula pendula* occupy today 75% of the forest area in Poland. At the same time, these are the species which, according to some studies, are most sensitive to global temperature increase and its indirect consequences. As a result of environmental changes, they may lose their climatic optimum in our region and may be replaced by species better adapted to changing conditions.

In order to maintain the functionality of forest ecosystems at the current level, research and active actions are necessary to adapt forest ecosystems, especially stands, to the changing environment. One of such activities is the assisted migration of populations and genotypes better adapted to future growth conditions and the use of selective breeding methods of forest trees, increasing the resistance of trees to adverse environmental conditions.

Chapter 3. State of other wooded land

3.1. Scope of the study

This study is part of the FAO-coordinated study, which has been on going since 2017, of the next assessment cycle of global forest resources for 2020 (*Forest Resources Assessment 2020*).

According to a special FAO study on the inventory of woody plants outside the forest - "*trees outside forest*" (DeForesta et al., 2013), the category "*other wooded land*" includes areas of at least 0.50 ha, where the tree cover does not meet the criterion of a minimum area share (at least 10%) or height of the trees (target height at least 5 m). An additional restriction is land use - this term excludes areas with predominantly agricultural or settlement use, which, apart from forest land, is basically limited to wasteland. In such an approach, the term "*other wooded land*" may be regarded as meaningfully similar to the category "forests off the record" (used in Polish forestry (WISL, 2020).

The concept of trees outside the forest, according to FAO's terminology, also includes agricultural and urbanised areas, if the woody vegetation on them meets the defined for a forest criteria for area (0.50 ha), crown cover (10%) and target height (5 m), as well as some other objects with different forms of use, where the above-mentioned criteria are not met (windbreaks, shelterbelts and hedges at least 3m wide).

In this approach, the concept of trees outside the forest covers a very wide spectrum of tree cover - growing wild, planted in agricultural space (e.g. orchards, plantations, agroforestry systems), introduced as a complement to agricultural production or for ornamental and recreational purposes (urban and residential greenery, areas of religious worship, areas of mass recreation, etc.). These categories are included and characterised in the study by DeForesta et al. (2013) under the terms "*Other land with trees outside forest*" and "*Other land with tree cover*".

According to the expectations of the FAO (Pekkarinen, 2018), the results of the current *Forest Resources Assessment 2020* are to be directly used to assess progress towards the United Nations' 2015 overall objective of sustainable development for societies "*Sustainable Development Goals*" (World Top 20, 2015) - specifically Target No 15: "*Life on Land*", which refers not only to the sustainable management of forests, but also to preventing the degradation of other categories of land and the loss of their biodiversity.

For this reason, it has been decided that this study will continue to cover a wider range of woody vegetation than the category of "*other wooded land*', which is presented in the introduction, because it also includes trees and shrubbery that occur on the agricultural areas - due to their proven beneficial impact on the functioning of the natural environment (Dainese et al., 2019; Ryszkowski, 2002; Quinkenstein et al., 2009) and the possibility of providing ecosystem services on a large spatial scale (Martin et al., 2019). On the other hand, it was decided to omit in the further analysis urban areas, where greenery mainly affects people’s comfort and which are not represented in the data on forests available in Poland.

The group of categories of areas with woody vegetation distinguished in this way corresponds with its scope to the ecological definition of tree-covered by Zajączkowski (1982), covering individual trees and shrubs or their clusters with the area they occupy and the non-woody vegetation present on it, not being part of forest ecosystems or other bio-ecological structures subject to forest-forming processes. This definition - with minor modifications - has been applied in Poland in many scientific and popular studies (Kujawa et al., 2019; Ryszkowski, Bałazy and Jankowiak, 2000; Nowak et al., 2015; Zajączkowski K., 2005), as well as in some legal acts (Act on Nature Protection, 2004).

It is worth stressing that the criterion distinguishing tree-covered from forests in the above definition is the ability of a given vegetation land area to develop a forest ecosystem, which is closely related to the minimum area of the autonomous interior of the land area and the minimum width of its buffer zone. It can be assumed from experience that independent forest communities can develop in land areas (mid-field coppice) of at least 0.5-1.0 ha (Dąbrowska-Prot, 2002; Łuczak, Dąbrowska-Prot and Wójcik, 1995), and for some of the studied populations even over 10 ha (Cieślak, 1996), with a width of the transition buffer zone of at least 30-50 m (Żarska, 1994). Therefore, the above definition of tree-covered areas also includes many mid-field buffer and forest tree-covered areas, which can be defined as forest areas in the register. On the other hand, the presented definition includes small land areas with only single trees or shrubs, and even some fragments of woodless wastelands, if they have an important ecological role (e.g. balks with the character of ecological corridors or various temporarily exposed and not used for agricultural purposes nesting sites of wild pollinating insects).

For the reasons set out above, this study will use the term "tree-covered areas", which in English is closest in meaning - albeit narrower - to "*trees outside forests*". More information on the development of the term tree-covered areas in Poland, as well as their history, classification, functions and design, can be found in the Zajączkowscy textbook (2013).

3.2. Sources of inventory data

There are currently few and incomplete national tree-covered areas datasets available. They include:

- Results of the 3rd cycle of Large-Scale Forest Inventory from 2015-2019 (WISL, 2020), including the category "forests off the record". Among a total of 30,688 areas with forest cover included in the measurement in this cycle, there were 3,096 (approx. 10%) sample plots of this category. In addition, a further 267 plots included in this category were omitted as not available for measurement. The determination and verification of the areas covered by forests off the record was performed by the Institute of Geodesy and Cartography and the Bureau for Forest Management and Geodesy - among others on the basis of various remote sensing materials and the land register. Within each circular area with a horizontal projection size of 200-500 m2 (depending on the estimated age class of the trees), a detailed taxonomy description of all trees with a breast height of at least 7 cm (breast height, species, age estimate, damage types and severity) was made for the part covered by the trees. In addition, on a coaxial circular area of 20m2, the younger generation of tree and shrub species was recorded, estimating their cover (for the youngest generation of stands, not exceeding 0.5 m in height, from natural regeneration under shelter or counting individual specimens (for the saplings), assessing their health condition and herbaceous layer cover. This scope of description should be considered accurate, although it does not take into account some specific features such as anticipated ecosystem services or some structural (shrub-only, treeless) or spatial (with a land area of less than 10 a or without forest character) forms.
- Maps and analyses of the size and fragmentation of natural and semi-natural areas, made for individual European countries by the European Environment Agency on the basis of the analysis of remote-sensing materials from 2000 and 2006 (CORINE, 2015) within the CORINE Land Cover programme. This is the first public consistent assessment of the dynamics of certain tree-covered areas characteristics on a large regional scale (DeForesta et al., 2013), although the spatial resolution used to date (pixel of approximately 25 ha) is insufficient to identify these characteristics precisely.
- Basic statistical information on the use of tree-covered areas wood and the number of trees planted contained in the statistical yearbooks of the Statistics Poland. This information is provided by local administrative units, but its verification must be assessed as poor. The degree of aggregation of the presented results is very high: there are only sums for a few groups of main species, with sections for individual voivodships. It is likely that most of the information on tree planting relates to urban greenery, and harvesting volumes relate mainly to road tree-covered areas.

Other available tree-covered areas inventory results are local. They were created at different times (ca. 1970-2016) as part of research or tree-covered areas establishment projects (many of which were also carried out by scientific institutions). The data mainly include lists of species, as well as the number and size of inventories of land areas, i.e. area and/or length, and sometimes also their conversion into ha or km. Only in individual cases is information about the spatial layout, health status or possible environmental functions of the existing tree-covered areas available.

3.3. Forms of occurrence and tree-covered areas functions

Tree-covered areas of agricultural land show a wide variety of origins, spatial forms and characteristic locations in the landscape. Proper recognition of these characteristics is important because they involve the ability of tree-covered areas to perform specific environmental functions and provide ecosystem services that are useful to people.

In terms of origin, specific tree-covered areas can be classified as natural relics of former forests or as secondary vegetation on former agricultural land, either from spontaneous self-seeding or artificially introduced. Tree-covered areas relics are the survival site of many forest species from various systematic groups, including rare and vanishing ones (Dzwonko and Loster, 1989; Wuczyński et al., 2014). Biodiversity in new tree-covered areas artificially established on former farmland is growing rapidly in the first few years after the planting and is many times greater than in adjacent open areas (Karg and Karlik, 1993).

Tree-covered areas can take spatial linear or non-linear forms (Wołk, 1980), differing in length and relative elongation (in linear at least 25 m, with length more than 5 times bigger than width) and maximum width (maximum 20 m width in linear). The most recent guidelines for the inclusion of linear ecological sites in the landscape for funding under the agricultural land greening scheme (ARiMR brochure, 2018), set the threshold for the maximum width of eligible vegetation belts at 10 m, recognising wider tree-covered areas as forest land. In a more detailed division of spatial forms (Zajączkowski K. et al., 1979), linear tree-covered areas is divided into rows (one row of trees or shrubs), striped (more rows next to each other) and avenues (two or four rows, divided by a linear topographic element). Tree-covered areas not meeting the above criteria is classified as non-linear, further subdivided into group (up to 2 a), cluster (up to 10 a) and surface (over 10 a, which should be classified as forest category).

It is worth noting that many of the tree-covered areas survived the processes of unification of the field space thanks to the fact that they were located on land that was not useful for agriculture (slopes, small valleys with flat wet bottoms and, wetlands on fields or on balks. It appears that such dispersed, small tree-covered areas show greater biodiversity than larger land areas with a similar total area (Aguilar et al., 2006; Bell and Loster, 1989), due, among other things, to the inclusion of a greater diversity of micro-habitats and greater diversity and quantity of ecotones (Fahring, 2020).

Available information on the prevalence of various spatial forms of tree-covered areas in Poland is rare and local in nature, although the potential of remote sensing tools for making such data widely available in the future is already recognised (DeForesta et al., 2013; Nowak et al., 2015; Nowak and Pędziwiatr, 2018).

In the study of Knioła (2016), conducted in the Agro-Ecological Landscape Park in Turew on the environmental preferences of selected bird species, among the 825 tree-covered areas found, about 65% (counting in pieces) were linear forms. Among the remaining non-linear forms, there were significantly less small areas of land - of group form (about 10%) than larger clusters and surface forms (about 25%). Similar relationships are also visible in the results of other inventories. According to the Ziomek's study (2016) carried out in several places in Wielkopolska (communes of Granowo, Kłecko and Krobia, Agro-ecological Landscape Park in the communes of Kościan and Czempiń), the share of linear forms ranged from 72 to 84%, of which the share of wider striped forms usually did not exceed 3%, and only in the Landscape Park near Turew was 10%. A similar (11%) share of wider striped tree-covered areas in the total number of linear tree-covered area forms was also found during the inventory in the commune of Sanniki, considered itself "ecological" already in the 1990s. (Zajączkowski, Latos and Zajączkowska, 1993).

In turn, the Łuszczak analysis (1982) provided information on tree-covered areas rates in large, intensively farmed areas of twenty former state farms in Kutno poviat. There, the area share of linear tree-covered areas forms was 83% (including 7% of wider strips), and group forms constituted only about 3% of the remaining non-linear tree-covered areas. Such results testify to large shortages of non-linear tree-covered areas (mild-field small groups and clusters) in the conditions of planned agricultural management in the People's Republic of Poland.

For comparison, according to the inventory of tree-covered areas made on the land of a dozen or so villages with a dominant small ownership in the commune of Strzelce in Kutno Poviat (Zajączkowski K. and Zajączkowska B., 1998), the surface share of non-linear forms was over 60%.

A high share of the described non-linear forms of tree-covered areas (nearly 50% - this time calculated in relation to the total number of the tree-covered areas) was also found in the studies of Zajączkowski et al. (1993) in the nearby commune of Sanniki. This can be related both to the traditional agrarian structure of the village fostering the survival of small tree-covered areas forms and the generally good condition of tree-covered areas conservation in the communes selected for research, as well as to the broad profile and carefulness of the execution of both inventories by the staff of the scientific institution (the former Tree-covered Areas Research Laboratory of the Forest Research Institute).

In terms of location (attachment to the characteristic element of the topography), tree-covered areas of agricultural land are divided into agricultural, communication, close to water, rural building sites and tourist and recreational areas (Wołk, 1980; Zajączkowski K. et al., 2001). If we consider those relating to the reduction of phenomena unfavourable to the stability of ecosystems and agricultural production on a large spatial scale as the most important ecosystem services (Zajączkowski K., 2005), then such a positive impact will be shown mainly by linear tree-covered areas located in the immediate vicinity and inside arable land (wind belts and anti-erosion belts, networks of ecological corridors), including those located at the contact points between arable land and surface waters (buffer strips). Such tree-covered areas can not only contribute most to stabilising the functioning of the ecosystem, but also bring the greatest financial benefits, expressed in terms of the value of avoided production losses accumulated over the years and the cost of replacement environmental protection management.

The condition for the greatest efficiency of mid-field tree-covered areas in the implementation of large-scale ecosystem services is their correct spatial form, location and vertical structure and species composition. The results of numerous studies and observations allowed formulating detailed guidelines in this respect. They can be found in the studies of Łonkiewicz et al. (1993), Bałazy et al. (1998), Kędziory (2015), Zajączkowski J. (2016) and Kujawy et al. (2019).

3.4. Estimated area and tree-covered areas density

The available information on the share of tree-covered areas in agricultural land and the density of the linear forms and individual specimen that make up the tree-covered areas is only available from local and no longer up-to-date inventories. These are mostly the same sources that were used to characterise the spatial forms of tree-covered areas in the previous section.

On the basis of data on the values of the area share of tree-covered areas, the density of forms in the total area of agricultural land and the density of trees in their linear tree-covered areas in selected communes (Sanniki, Strzelce, Granowo, Kłecko, Krobia, Przelewice) (Kurnicki, 2015; Zajączkowski K. et al, 1993; Zajączkowski K. and Zajączkowska B., 1998; Ziomek, 2016), Agro-ecological Landscape Park (Ziomek, 2016) and Kutno Poviat (Łuszczak, 1982), it can be assumed that the average value of the area share of tree-covered areas in agricultural land in Poland is currently less than 2%, and the density of trees in tree-covered areas is about 5 pcs./ha. This value is similar to the 4.6 pcs./ha, estimated for Poland at the beginning of its political transformation 30 years ago in the study of Górka et al. (1991), in which the results of the tree-covered areas inventory in several selected villages and state farms in Mazovia were used for extrapolation.

In the aforementioned analysis of Górka et al. (1991), one can also find more detailed information on the variation of tree-covered areas density on different land uses and forms of ownership. On grasslands (meadows and pastures) the density of trees was about 32 pcs./ha on rural areas and 2.5 pcs./ha on the land of state farms. On arable land the density values were significantly lower, amounting to about 0.9 and 1.4 pcs./ha respectively.

When analysing the tree-covered areas of agricultural land in terms of location, it is easiest to notice those occurring as linear lanes along communication routes. Such an observation is confirmed by the results of the inventory - for example, in several communes of southern Wielkopolska, the area share of such tree-covered areas exceeded 50%, and only in the Agro-Ecological Landscape Park around Turew it was 43% (Ziomek, 2016). In the same study, a large share of waterside tree-covered areas of over 30% was found, which can be associated with a well-developed network of drainage channels and ditches. An even higher share of road tree-covered areas in the total length of the tree-covered areas in the form of a line was obtained in studies conducted in the commune of Strzelce in Mazovia (Zajączkowski K. and Zajączkowska B., 1998). It amounted to 65%, while the share of mid-field and waterside tree-covered areas was much lower and had similar values (18% and 17% respectively). In the nearby commune of Sanniki (Zajączkowski K. et al., 1993), the available data made it possible to determine the shares of different locations in the total number of trees - instead of, as in Strzelce, in the length of strings. These proportions (about 70, 20 and 10% respectively) are quite similar to those given above for Strzelce commune. This can be interpreted in such a way that the average density (spacing) of trees in linear tree-covered areas is similar in roadside and mid-field locations, and slightly lower in waterside tree-covered areas.

A complementary source of information about the total area of those tree-covered areas, which, due to their size, meet the definition of forest land, is the results of the latest cycle of Large-Scale Forest Inventory (WISL, 2020). The current size of "forests off the record", identical to the meaning range of "*other wooded land*", has been estimated for the whole country at 950,820 ha, i.e. about 10% of the area of forests in the record (9,254,900 ha). A part of this area (about 2%) does not meet the requirements of the Polish definition of a forest, occurring in urbanised and industrial areas or referring to agricultural tree and shrub crops (orchards and plantations).

Interest to the FAO focuses not only forests, but also other areas with woody vegetation. Although the publications of the Statistics Poland nclude information about the area of wooded and shrubs land, this information was not included in the reporting to the FAO. The area of wooded and shrubs land includes areas that do not meet the FAO tree-covered areas criterion, i.e. land covered with wicker and peatlands (with unknown tree cover) (Regulation of the Minister of Administration and Digitization, 2013). On the other hand, the areas classified as wooded and shrubs "clusters of trees and shrubs having the nature of a park" (Regulation of the Minister of Administration and Digitization, 2013) in reports to the FAO should be reported under the so-called other land with forest cover (Jabłoński,2015).

Initial work, leading, among other things, to the estimation of forests off the record, was carried out in 2015 by the Institute of Geodesy and Cartography on the commission of the General Directorate of State Forests. The total area of forests in Poland, meeting the requirements of the Kyoto Protocol, was presented by the Institute of Geodesy and Cartography in 2 variants including:

1. All forests meeting the Kyoto Protocol requirements - 10,461,856 ha.
2. Forests meeting the requirements of the Kyoto Protocol, without forests off the record not included in the 3rd cycle inventory of the Lsrge-Scae Forest Inventory - 9,997,698 ha (WISL, 2020).

Both these areas turned out to be much larger than the forest area in Poland according to the 2015 records - 9,197,879 ha. The difference in the total area of forests in the above mentioned variants, determined by the Institute of Geodesy and Cartography on the basis of available remote sensing materials and the area of forests according to the records, shows that forests off the record, meeting the requirements of the Kyoto Protocol, occupy a total of 1,263,977 ha, while forests off the record, which should be covered by Large-Scale Forest Inventory, occupy a total of 799,819 ha. Based on measurements from all 5 years of the Poland's 3rd cycle of Large-Scale Forest Inventory, the area of forests off the record was determined at 950,820 ha. It follows from the above that the area of forests off the record, determined on the basis of sample areas established in the 3rd cycle of Large-Scale Forest Inventory, may be treated interchangeably with the area of forests off the record, covered by Large-Scale Forest Inventory, as determined by the Institute of Geodesy and Cartography. The data from the sample areas of Large-Scale Forest Inventory allow to divide this area into two groups: forests off the record, meeting the statutory criteria (forested forest area criteria as agreed) - 780,490 ha, and other forests off the record, covered by Large-Scale Forest Inventory - 170,330 ha (WISL, 2020).

According to the assumptions, the work carried out by the Institute of Geodesy and Cartography covered all forests meeting the requirements of the Kyoto Protocol, while the work of Large-Scale Forest Inventory does not include land intended or used for housing, recreation, infrastructure and other municipal or industrial purposes, as well as agriculturally developed land and linear tree-covered areas (WISL, 2020).

In order to make the above mentioned category of forests off the record more unambiguous, the following terminology has been adopted:

1. Forests off the record, covered by Large-Scale Forest Inventory according to the Bureau for Forest Management and Geodesy –950,820ha, including:
   a) forests off the record, meeting the statutory criteria according to the Bureau for Forest Management and Geodesy–780,490ha;
   b) other forests off the record, included in Large-Scale Forest Inventory according to the Bureau for Forest Management and Geodesy –170,330ha.
2. Forests off the record, included in Large-Scale Forest Inventoryaccording to the Institute of Geodesy and Cartography –799,819 ha, including:
   a) forests off the record, meeting the statutory criteria according to the Institute of Geodesy and Cartography – 656,539 ha;
   b) other forests off the record, included in Large-Scale Forest Inventory according to the Institute of Geodesy and Cartography –143,280 ha (WISL, 2020).

The estimated area of forests off the record, covered by Large-Scale Forest Inventory according to the Institute of Geodesy and Cartography, is 799,819 ha and additionally meeting the less stringent criteria of forests under the Kyoto Protocol - 464,158 ha. The total estimated area of forests off the record (including land not covered by Large-Scale Forest Inventory, such as: land intended for residential, recreational, agricultural purposes; e.g. tree plantations or orchards) is 1,263,977 ha in Poland according to the Institute of Geodesy and Cartography (WISL, 2020).

In principle, all forests off the record should be treated as forests meeting the criteria of the Kyoto Protocol. The total area of forests off the record has been allocated to "forests meeting the statutory criteria" and the remaining forests off the record covered by Large-Scale Inventory with at least 10% tree cover not fully meeting the statutory criteria. Both groups do not include non-forested forest land and land connected with forest management (WISL, 2020).

According to the described above assumptions, out of the total area of forests off the record 82% meet the more demanding national criteria of the Forest Act, and the remaining 18% of the area allows them to be counted among the remaining forests meeting the requirements of the Kyoto Protocol (WISL, 2020).

Assuming the current agricultural area size (without forests and water, but with wasteland and ecological sites) on about 19,000,000 ha, the current "forests off the record" area share is about 5% and is clearly higher than the above-mentioned tree-covered areas share estimate (2%). Only a small part (approx. 10%) of the tree-covered areas is accounted for by forms meeting the requirements of Large-Scale Forest Inventory and the Institute of Geodesy and Cartography materials used in it - occurring as compact surface tree-covered areas (>10 a) or wider shelterbelt (>10 m). This means that probably the vast majority of "forests off the record" areas (covering only tree land areas of more than 10 a) will in the future be reclassified as forest - with the intention of producing a forest ecosystem in the future, rather than being left as a forest-field transition zone, typical for tree-covered areas.

Data from Large-Scale Forest Inventory 2015-2019 report also provide information on the geographical variability of the occurrence of forests off the record in Poland and the forms of land use on which this phenomenon was found. In the voivodships, most of these forests occur in the Mazowieckie (15% of the national area), Podkarpackie (11%), Małopolskie (10%), Podlaskie (8%) and Świętokrzyskie (8%) voivodships, i.e. areas with a large fragmentation of agricultural property and a large share of private forest ownership. In the three voivodships with the largest area of forests off the record, it represents about 13% of the total forest area of a given voivodship. The largest amount of forests off the record (ca. 45% of their total area) is on arable land, ca. 20% on grassland, and another 27% on land recorded as wasteland or as wooded and shrubs land on arable land, meadows, pastures or wastelands. In total, about 80% of these forests occur on private land, about 6% on non-forest land owned by the State Treasury, and the remaining 14% on communal land, land remaining in the Agricultural Property Stock of the State Treasury or other public land.

3.5. Tree and shrub species in tree-covered areas

The species composition of the layers of trees and shrubs in tree covered areas is usually more varied than in nearby forest areas. This is due both to the more favourable growth conditions of tree-covered areas vegetation (on average more fertile soil, better access to light and water in ditches, use of field fertilisation) and to the use of extensive, justified by various utility considerations, sets of species introduced artificially into tree-covered areas. Many species of shrubs and herbaceous plants occurring in forests only in tree-covered areas find optimal conditions for flowering and fruiting, which is a premise for their wider introduction and is used for production of food and herbal raw materials (Krasicka-Korczyńska and Borzych, 2002; Milewski J., 1976).

Publication of lists of trees and shrubs recommended for tree-covered areas was intended to facilitate the selection of species for specific planting, improve the production of planting material in state nurseries, and limit the use of certain species in regions where it was not advisable for climatic reasons (Górka, 1990) or due to phytosanitary risks (Puszkar, 1981). Such sets of species appeared in the period of implementation of the Resolution of the Government of the Polish People's Republic of 1959 on mass afforestation of villages on the occasion of the Millennium of the Polish State (Bielańska, 1966; Zajączkowski K., 2010) and took into account the available knowledge of species biology and their possible applications(Ekiert, 1966; Hejmanowski, Milewski and Terpiński, 1964; Milewskiand Hejmanowski, 1965; Zasady gospodarki zadrzewieniowej, 1966).

The subsequent work of the Forest Research Institute led to the creation of a uniform national and voivodship selection - taking into account the regional variability of climate and economic conditions, agreed with the organisational units of the former voivodship offices responsible for tree- covered areas (Zajączkowska, 1983; Zajączkowski K. et al., 1979).The proposals contained there have been verified as a result of new field observations of particular species (Górka, 1990), among others: the findings of sensitivity to winter frosts (e.g. white walnut *Juglans cinerea*, English walnut *Juglans regia*); high invasiveness (e.g. ash-leaved maple *Acer negundo*), favouring diseases of neighbouring agricultural crops (e.g. barberry *Berberis* sp.) or ceasing demand for the supplied non-wood raw material (e.g. staghorn sumac *Rhus typhina* - former source of lacquer). As a result of this work, another, so far last version of the national selection was proposed in 1998 (Zajączkowski K. et al., 2001), also available as a computer application and website (Zajączkowski J., 1998). This selection includes a total of 112 species of shrub trees, including 9 separate cultivated poplar and willow varieties. Native poplar species were not included in the selection due to their specific habitat requirements, susceptibility to shape defects and susceptibility to diseases and pests. Despite the fact that in 1990 the regulations obliging local administrative units to use species from tree- covered areas selection expired, due to a solid scientific basis it is worthwhile to further consider both the proposals contained in the most recent selection (Zajączkowski K. et al., 2001) and the recommendations concerning the characteristics of planting material from the no longer binding industry standard BN-76/9212-02 (Norma, 1977).

It is worth noting that the current selection retains the possibility of using alien species, including those characterised by moderate invasiveness, but only under specific habitat conditions (e.g. some recultivated areas, cliffs) or for specific functions (achieving particularly large sizes or wood production, abundant honey production capacity at a certain time of the season), provided that under given circumstances there are no national substitutes with similar utility characteristics. An appropriate exemption from the general ban on introducing alien species into the environment, justified by the needs of rational forest management, is contained in the current Act on Nature Conservation (Article 120 paragraph 4).

Sets of trees and shrubs are divided into two subcategories in the selection: basic and complementary species. The basic species were distinguished on the basis of their importance in the production of wood and non-wood forest products, as well as biological features justifying their wider use in tree- covered areas (Zajączkowska, 1983). They should form the frame of tree- covered areas and have (each separately) at least 2% share in the establishment of new tree- covered areas. Complementary species can be introduced into tree- covered areas as several at a time, but in a small admixture, to increase the aesthetic, biocenotic and production benefits.

A comparative analysis of the national selection (developed by the Forest Research Institute) and proposals for voivodship selections, some of which were developed independently by local practitioners, was presented by Matras (1982). He drew attention to the large share of regional species not recommended for national selection. Apart from suggestions that did not stand the test of time, such as the postulate of a wider use of black cherry *Prunus serotina*, the author formulated many observations that are still valid today - e.g. on the one hand about the limited possibilities of using instocking the following: spruce *Picea sp.*, birch *Betula* sp., privet *Ligustrum sp.*, caragana *Caragana sp.*, mulberry *Morus sp.* and rowan *Sorbus* sp.in the sweet variety and, on the other hand, the need to introduce sycamore maple *Acerpseudoplatanus* more widely, oaks *Quercus sp.*, hawthorns *Crataegus sp.*, some roses *Rosa sp.*, sea-buckthorn *Hippophae rhamnoides*.

An example of the use of selection methods to enhance the genetic value of tree- covered areas trees is suggested in the latest selection for tree- covered areas male poplar cultivars *Populus*sp.:‘*Androscoggin*’,‘*Berolinensis*’, ‘*BlancduPoitou*’, ‘*Löns*’ and ‘*Hybrida275*’, and, in addition, conditionally, because of the slightly higher risk of fungal diseases, varieties ‘*Gelrica*’ and ‘*Robusta Gostynin* ’(Zajączkowski K., 2013; Zajączkowski K. et al., 1996). These varieties are characterised by significantly better growth, quality and health, as well as better tolerance of tending negligence (Budzyński, 1997a) compared to all domestic poplar species *Populus*sp.and with other formerly used varieties of this species. The above mentioned varieties are without exception male forms (poplars are dioecious), due to the problems that the seed fluff of female varieties of poplars *Populus*sp.caused when cattle were fed on pastures. Recent studies by Niemczyk and Kaliszewski (2020) confirm the economic efficiency of wood production outside the forest (in the orchard system, taking into account the lost benefits of alternative agricultural management) for some long-term used poplar *Populus*sp.varieties in Polandincluding the above-mentioned ‘*Hybrida275*’.

The effect of the selection activities is also the creation at the former Tree-covered Areas Research Station of the Forest Research Institute in Sójki near Kutno of a collection of ten honey linden individual trees from three species (small-leaved linden, *Tilia cordata,* large-leaved linden, *Tilia platyphyllos* and Crimean linden, *Tilia × euchlora*), selected in street greenery planting in Warsaw due to different flowering seasons (Milewski and Zajączkowski, 1966). While one linden tree blooms for about 14 days, the flowering period of the linden tree-covered area built from the vegetative progeny of all individuals from the mentioned collection is extended to nearly two months altogether. The collection is made available for use by nurserymen, who can reproduce it by budding method, for distribution in apiary management areas where it can provide bees with particularly valuable bee forage.

The tree and shrub species found in various local tree-covered area inventories or included in two consecutive national selections are listed in Tab.3.1and Tab.3.2.

Tab. 3.1 *Tree species found in local tree-covered area inventories and in national selections*

Object/Source		**Communes:Granowo, Kłecko and Krobia**	**Agro-Ecological Landscape Park**	**Sanniki Commune**	**Strzelce Commune**	**Opalenica Commune**	**Selection–1983**	**Selection–2001**
English name	**Latin name**	(Ziomek, 2016)	(Ziomek, 2016)	(ZajączkowskiK.et al., 1993)	(ZajączkowskiK. and Zajączkowska B. 1998)	(Szwed and Andrzejewski, 2002)	(Zajączkowska,1983)	(ZajączkowskiK.et al., 2001)
Silver birch	*Betula pendula*			+!	+	+	+!	+!
Downy birch	*Betula pubescens*					+	+!	+!
Common beech	*Fagus sylvatica*					+	+	+
Wild cherry – varieties	*Prunus cerasuscv.*	+	+			+	+	+
Sessile oak	*Quercus petraea*				+	+	+!	+!
Red oak	*Quercus rubra*			+			+!	+!
Pedunculate oak	*Quercus robur*	+	+	+	+	+	+!	+!
Common hornbeam	*Carpinus betulus*			+	+	+	+!	+!
Common pear	*Pyrus communis*			+	+	+	+	+
European crab apple – varieties	*Malus sylvestriscv.*	+	+	+		+	+	+
Wild service tree	*Sorbu storminalis*						+	+
Common whitebeam	*Sorbus aria*						+	+
Rowan	*Sorbus aucuparia*			+	+	+		
Rowan “sweet” variety	*Sorbus aucuparia ‘Edulis’*						+!	+!
Swedish whitebeam	*Sorbus intermedia*			+	+	+	+	+
Douglas fir, “green” variety	*Pseudotsuga taxifolia‘Viridis’*						+	
Green ash	*Fraxinus pennsylvanica*			+				
Common ash	*Fraxinus excelsior*	+	+	+	+!	+	+!	+!
Horse chestnut	*Aesculus Hippocastanum*	+!	+	+	+	+	+	+
Amur maple	*Acertataricumssp. Ginnala*				+			+
Sycamore maple	*Acer Pseudoplatanus*	+	+	+	+!	+	+!	+!
Ash-leaved maple	*Acer negundo*			+	+	+	+	
Field maple	*Acer campestre*				+	+	+	+
Sugar maple	*Acer saccharum*			+			+	+
Norway maple	*Acer platanoides*				+!	+	+!	+!
Turkish hazel	*Corylus colurna*						+	
Small-leaved linden	*Tilia cordata*	+	+	+	+	+	+!	+!
Crimean linden	*Tilia xeuchlora*						+!	+!
Large-leaved linden	*Tilia platyphyllos*						+!	+!
European larch	*Larix decidua*				+	+	+!	+!
Japanese larch	*Larix kaempferi*						+!	

European larch, Polish variety	*Larix deciduassp. Polonica*						+!	+!
White mulberry	*Morus alba*						+	+
Black alder	*Alnus glutinosa*	+	+	+!	+	+!	+!	+!
Grey alder	*Alnus incana*					+	+	+
Eastern American black walnut	*Juglans nigra*						+	+
White walnut	*Juglans cinerea*						+	
English walnut	*Juglans regia*				+	+	+	
Black locust	*Robinia pseudoacacia*	+	+!	+	+!	+	+!	+!
Black pine	*Pinus nigra*						+	+
Scpots pine	*Pinus sylvestris*	+	+	+!	+	+	+	+
European plum – varieties	*Prunus domestica*					+		
Norway spruce	*Picea abies*				+	+	+!	+!
Poplar– genus	*Populus sp.*			+	+	+		
Poplar–varieties	*Populus cv.*	+	+	+	+!	+	+!	+!
Sour cherry	*Cerasus collina*						+	+!
Wych elm	*Ulmus glabra*					+	+	
Field elm	*Ulmus campestre*			+		+	+	
European white elm	*Ulmus laevis*					+		+
Willow – genus	*Salix sp.*	+	+	+!	+	+	+!	+
Willow – varieties	*Salix cv.*						+!	+!
Western redcedar	*Thuja plicata*						+	

! Species identified by the authors of the inventory as being locally abundant, or primary species in tree-covered area *selections*

Tab. 3.2 Shrub species found in local inventories of tree-covered area and in national selections

Object/Source		**Sanniki Commune**	**Strzelce Commune**	**Opalenica Commune**	**Selection–1983**	**Selection–2001**
English name	**Latin name**	(ZajączkowskiK.et al., 1993)	(ZajączkowskiK. and ZajączkowskaB.,1998)	(Szwedand Andrzejewski, 2002)	(Zajączkowska,1983)	(ZajączkowskiK.et al., 2001)
Thunberg's barberry	*Berberis thunbergii*		+		+	
Black elder	*Sambucus nigra*	+	+	+!	+	+
Red elderberry	*Sambucus racemosa*				+	+
Common lilac	*Syringa vulgaris*	+	+	+	+	+
Common boxwood	*Buxus sempervirens*	+				
Common yew	*Taxus baccata*	+	+		+	+
Sawara cypress	*Chamaecyparis pisifera*	+				
Black cherry	*Prunus serotina*		+		+!	+!
Bird cherry	*Prunus padus*		+	+	+	+
Red-barked dogwood	*Cornus alba*		+		+	+
Cornelian cherry dogwood	*Cornus mas*				+!	+!
Red-osier dogwood	*Cornus sericea*	+			+	+
Common dogwood	*Cornus sanguinea*		+	+	+	+
Hawthorn	*Crataegus oxyacantha*		+		+!	+!
Single-seeded hawthorn	*Crataegus monogyna*	+	+	+	+!	+!
Hawthorn – genus	*Cotoneaster sp.*	+				
Chinese juniper	*Juniperus chinensis*	+				
Common juniper	*Juniperus communis*	+	+		+	+
Savin juniper	*Juniperus sabina*	+				
English dogwood	*Philadelphus coronarius*	+	+			
Blackberry - genus type	*Rubus sp.*			+		
Guelder rose	*Viburnum opulus*	+		+	+	+
Caragana peashrub	*Caragana arborescens*	+	+		+!	+!
Tatar maple	*Acer tataricum*				+!	+!
Wolfberry	*Lucium barbarum*	+	+		+	+
Alder buckthorn	*Frangula alnus*		+	+	+	+
Pontica hazelnuts	*Corylus avellana 'Pontica'*	+				
Common hazelnuts	*Corylus avellana*	+	+	+		+!
Common privet	*Ligustrum vulgare*	+	+		+	
Silverberry	*Eleagnus argentea*				+	+
Wild olive	*Eleagnus angustifolia*				+	+
Common ninebark	*Physocarpus opulifolius*					+
Chaenomeles - genus type	*Chaenomele ssp.*				+	
Alpine currant	*Ribes alpinum*				+	+
Blackcurrant	*Ribes nigrum*			+		
Redcurrant	*Ribes rubrum*			+		
Sea-buckthorn	*Hippophae rhamnoides*				+!	+!
Dog rose	*Rosa canina*	+	+	+	+!	+!
Rugosa rose	*Rosa rugosa*		+		+!	+!
Sweetbriar rose	*Rosa rubiginosa*				+!	+!
Dwarf mountain pine	*Pinus mugo*				+	+
Common buckthorn	*Rhamnus cathartica*		+	+	+	+
Staghorn sumac	*Rhus typhina*	+	+		+	

Cherry plum	*Prunus cerasifera 'Divaricata'*	+	+		+!	+!
Blackthorn	*Prunus spinosa*	+	+	+	+	+
Common ninebark	*Physocarpus opulifolius*	+	+	+	+!	+!
Snowy mespilus	*Amelanchier ovalis*				+	
Canadian serviceberry	*Amelanchier canadensis*					+
Tamarisk–genus	*Tamarix sp.*	+			+	
False spiraea	*Sorbaria sorbifolia*					+
Spirea–genus	*Spiraea sp.*	+			+!	+!
Warty spindle	*Euonymus verrucosus*	+			+	+
European spindle	*Euonymus europaeus*		+	+	+	+
Fly honeysuckle	*Lonicera xylosteum*				+	+
Willows – genus	*Salix sp.*	+	+		+!	+!
European dwarf cherry	*Cerasus fruticosa 'Voronov'*				+	+
Common laburnum	*Laburnum anagyroides*	+				
Common broom	*Cytisus scoparius*			+		
Oriental thuja	*Platycladus orientalis*	+				
Northern white cedar	*Thuja occidentalis*	+	+		+	

! Species identified by the authors of the inventory as being locally abundant, or primary species in tree-covered area *selections*

In Tab.3.1 *Tree species found in local* tree-covered area *inventories and in national selections* includes 52 types,species or hybrids of tree species, of which 2 (willow *Salix* sp.and poplar *Populus*sp.) each include several national species and several varieties (cultivars). InTab.3.2 *Shrub species found in local inventories of* tree-covered area *and in national selections* includes 59types, species or hybrids of shrub species, of which 3 (chaenomeles *Chaenomeles*, tamarisk *Tamarix* sp. and willow *Salix* sp.) each comprise several species. The division into trees and shrubs used in these selections is not clear, as several species have been allowed for use in both these forms (e.g. common hornbeam *Carpinus betulus* and sour cherry *Prunus cerasus subsp.acida*). In the areas covered by the inventory, especially within rural settlements and post-manor parks, non-traditional ornamental species outside selections have appeared, such as e.g. green ash *Fraxinuspennsylvanica*, rowan *Sorbusaucuparia*in its wild form, boxwood *Buxus sp.*, hawthorn *Cotoneaster sp.* and laburnum *Laburnum sp*.

Despite the relatively small area covered by the inventories found in the literature and included in the above tables (several communes in the country), a clear majority of tree and shrub species from the national selection were found there (about 70%), which indicates the importance of tree-covered area for maintaining the wealth of the local flora.

An interesting comparison of the diversity of species composition of dense forests and mid-field coppices ("forests off the record") is provided by the results of Large-Scale Forest Inventory (WISL, 2020). While on forest land the total share of deciduous trees volume (as the dominant species) is on average 32%, outside of them the share is as high as 73%, including mostly alder *Alnus*sp.(27%) and birch *Betula*sp. (16%). Even greater difference occurs in the shares of the area of stands with dominant species belonging to the category of deciduous admixtures (i.e.other than beech *Fagus* sp., oak *Quercus sp.*, common hornbeam *Carpinus* sp.,birch *Betula sp.*, alder *Alnus sp.*, poplar *Populus sp.* or aspen *Populus tremula*). In forests, the share of the area of such stands is 1.4% on a national scale, while in "forests off the record" - as much as 13.2%. Nearly 10 times the predominance of mid-field coppices in this respect may be a good indicator of their particular species richness. The lists available in the published results of the 3rd cycle of Large-Scale Forest Inventory do not allow a more accurate recognition of the species composition of trees and shrubs in "forests off the record". However, relevant data exist in the databases of the Bureau for Forest Management and Geodesy and may be analysed in a separate study in the future.

The presence of tree-covered areas in agricultural production space and the associated fragmentation of the landscape has a positive impact on species diversity and the abundance of other groups of plants and animals, including endangered species entered in the so-called red lists (Wuczyński et al., 2014)

The total number of plant and animal species (without microorganisms) present in tree-covered areas in Poland is estimated at least 1500 (Budzyński, 1997a). Only in the Turew region over 800 species of vascular plants and about 600 species of large-fruited mushrooms have been described (Karg, 2010). Such a large number of species testifies to the relatively good (at least until the end of the 20th century) preservation of traditional agricultural landscapes, with a large number of marginal habitats of a refugee character, such as tree-covered areas and shrubs, balks, wastelands, fallow land, slopes, roadside and ponds. A study by Chmielewski (1999) in the Lublin region showed the link between the large faunistic diversity of the landscape and the degree of conservation of its water ecosystems - stronger than its phytocenotic diversity. It can be assumed that also nationwide availability of water in small, uncontaminated watercourses and reservoirs has a positive impact on the richness of both fauna and flora of agricultural landscapes (Kędziora, 2015).

From an economic point of view, wooded landscapes are characterised by a high proportion of various beneficial for agriculture taxa (as predators or parasites, including amphibians, insects, arachnids, birds and mammals, as well as fungi) in their overall biomass, while open fields are dominated by crop pests (Barczak, Bennewicz and Kaczorowski, 2002; Dainese et al., 2019; Gołdyn et al., 2007; Woltz, Rufus and Landis, 2012). The abundance and species diversity of wild bee and honey bee species is also increasing (Banaszak and Cierzniak, 2002; Lipiński, 2010). There are exceptions to this general dependence - observed cases of lack of favourable influence of the presence of natural habitats on the stability of ecosystems of adjacent fields are explained e.g. by inappropriate spatial arrangement of the refuge sites, damage to their potential by agricultural practices, or the presence in the fields of at least as favourable hibernation conditions for predatory organisms as in the neighbouring tree-covered areas (Tscharntkeet al., 2016; Wamser et al., 2011).

Analysing the conditions of species diversity of birds inhabiting the tree-covered areas of Agro-Ecological Landscape Park around Turew in Wielkopolska, Ryszkowski et al. (1999) pointed out its links with the species diversity of tree-covered areas and their spatial form. Multi-species, multi-age tree-covered areas, with a developed layer of undergrowth and the presence of old trees, as well as surface and striped tree-covered areas are richer in bird species, while young, single-species or single-age tree-covered areas, occurring in the form of small groups, alleys and single rows of trees are poorer in bird species. Most bird species, especially forest ones, were found in surface and clusters tree-covered areas, while the highest densities of individuals and breeding pairs were found in wide, structurally diversified, old, tree-covered areas. Both the average recorded densities of birds (141 pairs per hectare) and the total number of their species (76) in the diversified landscape of Turew were clearly higher than in typical agricultural landscape studies of other parts of the country (e.g. Silesia, Mazovia and Pomerania), cited by the above mentioned authors. In other studies on the dynamics of bird groups under conditions of increasing agricultural intensity (Wilson et al., 1999), analogous results were obtained - the stability of the population is higher in landscapes with different forms of tree-covered areas, providing more varied and reliable food sources.

In the case of various forms of insects, many authors, including Barczak et al. (2002), Martin et al. (2019), Woodcock et al. (2010), stress the importance of environmental boundaries (ecotones) for increasing their species diversity, density and average biomass. According to a study by Ryszkowski et al. (1999), all these parameters, as defined for old tree-covered areas ecotones and cropland, are slightly higher than in young ecotones (except for biomass density) and significantly higher than in open fields. The natural value of ecotones increases if they are knotted together. Extensive empirical studies of landscapes at eight locations in the USA (Tewksbury et al., 2002) have shown that connecting dispersed, biologically active fragments of the landscape through corridors facilitates gene exchange in the animal populations that inhabit them, as well as the spread of many plant species (through seeds and pollen).

In recent years, there has been increasing knowledge of positive aspects of the presence of segetal vegetation, including common weeds, on agricultural land. They are the habitat of many insects, arachnids and other invertebrates, a substitute food source for singing birds (capable of controlling the mass emergence of insect pests from cultivated plants) and forage for bee insects, and have positive allelopathic effects. According to good practices of integrated agriculture (Stalenga et al., 2016), each of these species becomes harmful and requires chemical control only if and only there, where its density exceeds the harmful threshold specified for it and for a specific crop species. It has been found that the survival of this group of plants is facilitated by the greatest possible structural diversity of the landscape, with numerous and dense tree-covered areas and shrubs, balks, xerothermic grasslands and other wastelands. The same landscape features positively influence the reproduction possibilities of many other species of wild entomophilous plants (Aguilaret al., 2006).

3.6. Directions and reasons for the tree-covered areas transformation to date

In the post-war period, the peak of the tree-covered areas density was in the late 1970s. (Budzyński, 1997b). Amongst the tree-covered areas activities undertaken at that time, Iwanowski (1976) mentions comprehensive village trees planting (about 8,000 actions), phytomelioration in Żuławy Gdańskie (Zajączkowski K. et al., 1993), edtablishing of tree-covered areas in river valleys (completed entirely along the Drwęca river), as well as recultivation of areas becoming a steppe, eroded and post-industrial wastelands. An important impetus was provided by a government resolution (Resolution of the Council of Ministers, 1959), which provided for the planting of over 100,000,000 trees and shrubs over several years, and which allowed regional tree densities of over 10 trees per hectare to be achieved (e.g. in Upper Silesia and the vicinity of Krakow). In tree-covered areas of this period, poplar cultivars are over-represented, introduced for production purposes (but also because of the easier production of seedlings), now slowly dying out in the last roadside avenues not yet used. According to Górka et al. (1991), the share of poplar *Populus* sp. trees on arable land was the highest and amounted to 25%, while on grassland the most numerous was the alder *Alnus*sp.(45%).

In total, between 1956 and 1995, nearly 350,000,000 trees and 500,000,000 shrubs were planted in tree-covered areas. Due to low planting success and losses caused by lack of proper tending, only 10-20% of them survived to mature age, which is still a very significant amount (Budzyński, 1997b). In order to produce a large number of special seedlings, more grown than for forest plantations (Norma, 1977), special nurseries were established mainly on the grounds of State Forests; their maximum area was 3,600 hectares in 1973 (Budzyński, 1997b). At present, these nurseries practically do not operate anymore: according to the data of the Statsitcs Poland (2019), in 2009 there were about 130 ha of them left. The batches of seedlings currently planted in new tree-covered areas are usually small and come from private ornamental nurseries, but the product they offer is not always optimised (in terms of price and form) for use in tree-covered areas (Budzyński,1997a).

It is estimated that in the last three decades of the 20th century, about 40% of the trees have disappeared from tree-covered areas (Górka, Zajączkowski and Zajączkowska, 1991). This was to a certain extent caused by the short life expectancy of poplars *Populus* sp. and the destruction of tree-covered areas while simplifying the layout of fields and drainage works, but above all it was a consequence of the removal of legal protection of roadside tree-covered areas planted on private land within the framework of the land easement introduced in the 1920s (Górka et al., 1991). With favourable wood sales prices and uncertainty about the durability of legislative changes beneficial for farmers, this resulted in mass felling of roadside trees after 1984 (about 15% of their quantity). A similar effect was caused by the introduction of the obligation for farmers to obtain permits for felling trees on their own land: first in the Act on Environmental Protection and Development of 1980, later developed in the Act on Nature Protection of 2004. Without accepting the very principle of limiting ownership and avoiding administrative difficulties, farmers often preferred to eliminate young self-sowing in advance, which could cause them problems in the future. The unintended consequences of the introduction of a system for controlling direct payments to agricultural production after Poland's accession to the European Union in 2004 were equally acute. Since the first regulations did not take into account the possibility that trees (and other so-called "unwanted vegetation") might be present in pastures, officials counted the area occupied by the trees (calculated on the basis of an analysis of aerial photographs) from the total area of pasture for which the farmer expected to receive subsidies. Although for cows, the shady area around the trees is a sought-after place for midday rest, many farmers preferred to apply for permission to cut down trees in connection with farming rather than lose part of the subsidy.

The noteworthy cases in recent years of cutting down entire roadside avenues are linked to the need to maintain traffic safety and the new regulations on road repairs, which make it practically impossible to keep trees in the road crowns. As indicated by environmental organisations, in most cases, such felling can be carried out in a way that reduces the inevitable loss of biodiversity in the environment, or it can even be given up, correcting the course of the road after a major renovation or introducing additional safety devices and speed limits (Tyszko– Chmielowiec, 2012).

The Statistics Poland ebsite provides basic information on changes in basic tree-covered areas parameters in the period 2010-2018 (Table *3.3 Number of planted trees and shrubs and off-forest wood harvesting 2010-2018*), that is the number of trees planted annually and the quantity of harvested wood (Statistical Yearbook of the Republic of Poland, 2019). However, the available data refers not only to the tree-covered areas of agricultural areas, but also to urban and industrial areas, where most of the reported plantings come from (about 75% of the number of tree seedlings in 2000 and about 40% in 2018).

Tab. 3.3 *Number of planted trees and shrubs and off-forest wood harvesting 2010-2018*

Details	2010	2015	2017	2018
Planting trees in thousands pcs.	2,087.5	1,468.1	1,171.4	567.5
including on land:				
post-industrial land	1,412.8	946.7	745.5	227.7
private land	339.3	215.6	158.0	122.2
Planting shrubs in thousands pcs.	1,045.9	798.1	840.0	459.6
including on land:				
post-industrial land	167.0	316.3	310.3	11.1
private land	128.1	80.5	64.7	62.9
Merchantable timber harvesting in thousand m^3	962.8	1,127.5	792.1	859.3
coniferous	202.1	271.7	202.3	242.0
deciduous	760.7	855.8	589.9	617.3
including large-size general purpose wood	379.4	439.1	306.5	338.9
coniferous	106.9	141.3	100.9	122.8
deciduous	272.5	297.8	205.7	216.1
Including merchantable timber on private land	597.2	812.4	438.5	504.2
coniferous	147.2	202.4	123.1	148.3
deciduous	450.0	610.0	315.4	356.0
including large- size general purpose wood	238.5	324.8	178.1	206.1
coniferous	80.9	111.3	67.7	81.5
deciduous	157.5	213.5	110.4	124.6

a - Estimated data; not included in the total merchantable timber yields from forests
Source: Statistical Yearbook of the Republic of Poland, 2019*.*

The total planting volume was about 4,000,000 trees in 2000, before falling to about 2,000,000 trees per year in the period 2005-2010 and falling further in the last few years (to 600,000 in 2018). Shrub planting also decreased in the analysed period, from 1,500,000,000 in 2000 to 500,000,000 in 2018. It seems that this overall decrease in the size of new plantings is mainly due to the decrease in compulsory establishing of tree-covered areas in post-industrial land reclamation, resulting from the shrinkage of the relevant land pool. It can therefore be estimated that the annual number of seedlings planted on agricultural land is currently no more than 300,000, and is many times lower than in the period of the People's Republic of Poland (1956-1995), when on average around 9,000,000 trees and 12,000,000,000 shrubs were planted (or at least reported as such) annually (Budzyński,1997b).

Unlike the number of seedlings, reported merchantable timber yields have been increasing in recent decades. While between 1970 and 1975 wood harvested from tree-covered areas amounted to about 300,000 m^3 per year (Iwanowski, 1976), this figure has clearly increased after 2000 and over the period 2009-2019 was at 850,000 - 1,120,000 m^3. Probably a significant part of the reported size is related to the use of trees planted at the top of the national tree planting action (ca. 1956), and also to the intensive modernisation of roads in Poland in recent decades. Current technical standards do not allow to leave the trees in the crown of the road (with special exceptions only), which results in removing many valuable but also quite healthy trees.

Data on tree-covered areas changes and the number of trees in specific objects are very rare. The study by Górka et al. (1991) compares the results of the inventory in the same facility (Chodów) in two terms: in the period 1972-1990, about 40% of the trees on agricultural land (both smaller private and large state land) decreased, which, according to the authors, was caused by both improper maintenance and tree diseases, and harvesting by farmers mature poplars *Populus* sp. and spruces *Picea* sp. planted on their private land by a top-down decision of the authorities in the framework of the national tree planting action.

According to satellite detection data of land use forms in Europe (CORINE, 2015), in the years 2000-2006, Poland saw a decrease in the degree of fragmentation of areas with a higher degree of naturalness (overgrown with forest and tree-covered areas caused by the presence of arable fields. This positive trend, achieved, among other things, by connecting larger forest complexes through forest strips and tree-covered areas, was registered in countries covering jointly only 35% of the European area.

3.7. Prospects for managing genetic resources of tree-covered areas

The future of tree-covered areas of agricultural land depends on the legal environment in which local authorities and landowners operate and will continue to operate. The experience of the post-war period shows (Budzyński, 1997b) that the highly justified declarations of goals and suggestions for actions contained in official documents and regulations, e.g. Environmental Policy of the State 1991, Forest Policy of the State 1997, Resolution No. 90 of the Council of Ministers of March 5th 1959, Resolution No. 253 of the Council of Ministers of 6 November 1974, Nature Conservation Act of 2004, do not result in improvement or even maintenance of the tree-covered areas state if they do not provide sources of financing and do not create appropriate incentives for private land owners.

It should be remembered that the beneficial effects of specific tree-covered areas go further than the limits of ownership, while their frequent negative effects (shading of crops, root competition, delaying the drying of land and ripening of crops, transmission of diseases and crop pests), although very limited in space, burden the owner of adjacent land. For this reason, it is becoming necessary to introduce a system of incentives and financial compensation from public funds, for which a convenient legal form would be, for example, to recognise tree-covered areas as environmental protection devices and to indicate their desired characteristics in spatial development plans.

The changes in the agricultural landscape of Western Europe in the second half of the 20th century, analogous to those we are currently experiencing in Poland, consisted in the intensification of agriculture, abandonment of farming in mid-field forests, cutting down hedges and other small tree-covered areas and covering up small water bodies. Their result was, among other things, the disappearance of the existing internal borders in the landscape and the loss of its visual advantages, the decline in biodiversity, the increase in erosion and drought, as well as the fragmentation of valuable natural habitats, sometimes leading to their loss.

The postulate of effective and binding for the parties inclusion of the tree-covered areas management in spatial planning has been articulated for a long time by Polish scientists and practitioners (Bałazy et al., 1998; Bielańska, 1966; Budzyński, 1993; Łonkiewicz et al., 1993; Zajączkowski K. 1989; Zajączkowski J. and Zajączkowski K., 2009), however, so far no appropriate executive tools have been developed for it. It seems that such a real possibility is created by our country's participation in the common agricultural policy of the European Union and adaptation of the proposed packages of pro-ecological actions. These include the policy of "greening", which has been in place since 2015, i.e. making direct payments dependent on maintaining a certain percentage of agricultural land as biologically active (Regulation of the European Parliament and of the Council of the European Union, 2013) and the support projects currently being prepared for the establishment and maintenance of various forms of tree-covered areas (Draft Regulation, 2020).

It is worth noting, however, that the specificity of Eastern European agriculture, expressed, among other things, by better preservation of valuable ecosystems associated with traditional and small-scale agriculture, is still insufficiently known to Western European scientific and decision-making bodies, which may result in a lack of offer of protective measures profiled specifically for our region (Sutcliffe et al., 2015; Tryanovo et al., 2011).

The adaptation of EU guidelines to regional conditions should be carried out at the stage of creating national legislative solutions. Unfortunately, the solutions proposed to farmers in Poland to date practically do not include procedures for optimising the adopted solutions in terms of their environmental effectiveness, which are necessary especially when designing wind protection and anti-erosion tree-covered areas systems to protect the purity of surface waters (Zajączkowski J., 2016), or even tree-covered areas systems with main biocenotic functions due to the need to close ecological corridors (Tewksbury et al., 2002). As the main reasons for omitting spatial and structural aspects in financial support programmes for tree-covered areas, the need to simplify procedures, which is indeed important for farmers, should be pointed out, but also the focus of many experts on the biocenotic benefits of practically every new tree-covered areas, regardless of its location and construction. The literature identifies ecosystem services of agricultural ecosystems with the benefits of maintaining their biodiversity (Berbeć, 2014; Stalenga et al., 2016), while from the perspective of the currently dominant intensive agriculture and the functioning of entire agricultural ecosystems, the most important role of tree-covered areas is considered to be the creation of geochemical barriers that weaken the negative impact of crops on the environment (Bałazy et al., 1998; Ryszkowski and Bałazy, 2003; Ryszkowski et al., 1999). It is also worth noting that the very understanding of the concept of ecosystem services in politicians influencing the establishment of appropriate regulations is low, and sectoral divisions in central authorities (agriculture, spatial management, environmental protection) make it difficult to develop a coherent implementation of necessary solutions (Maczka et al., 2016).

In recent years, in scientific circulation new terms or new interpretations of already known terms related to land management in agricultural landscapes (HERCULES, 2018; Kadoya and Washitani, 2011; Sayer et al., 2013; Sherr et al., 2013) have appeared, whose significance in concept papers and designed agricultural support schemes may increase in the near future, such as e.g.:

- Landscape as socio-ecological system–contains a mosaic of natural and man-made ecosystems, with a characteristic configuration of topography, vegetation, forms of land use, settlement networks and economic and cultural processes and activities.
- Integrated landscape management –long-term, lasting cooperation between different groups of users, shareholders and landowners in order to achieve the multiple benefits expected in a given area. In the short term, it consists of defining specific, achievable objectives around which stakeholder groups are formed, open to the acquisition of more detailed knowledge and integrated by the growing trust, also necessary to achieve more complex or long-term objectives.
- Ecoagriculture – sustainable, multifunctional management of the agricultural landscape, integrating sustainable agricultural production, environmental protection and actions aimed at improving human living conditions.
- Landscape labels–collections of sustainable ecosystem services recognised in a particular cultural landscape, granted by landscape managers and producers of specific consumer goods, with the aim of generating additional income from the certified sustainable production of these goods (similar to wood sales certification schemes).
- Agricultural landscape biodiversity indicators (e.g. "*Satoyama index*") - indicators of the diversity of traditional agricultural landscapes use different image materials, processing them in a 1x1 km matrix, in specific applications well correlate with the occurrence of specific groups of organisms (e.g. birds

of prey or segetal plants).

The requirement for a systematic and space-based approach to tree-covered areas design is even necessary for the proper implementation of an important National Strategy objective (2019), relating to the adaptation of agriculture to climate change (Objective II.5). However, it should be noted that this objective is very poorly taken into account in the practical solutions of the Strategy (Draft Regulation, 2020). The aforementioned requirement, however, is not directly related to the main assumption of the concepts of tree-covered areas support developed so far in Poland, i.e. increasing the biodiversity of arable land. Paradoxically, however, proper consideration of spatial aspects may provide an important argument for many farmers for joining any environmental programmes. Simulations concerning the area of land necessary for the establishment of wind protection tree-covered areas systems indicate that it would be sufficient to occupy about 2.5-4% of the arable land for planting trees (Bałazy et al., 1998). It has also been shown that in order to prevent surface water pollution by chemical compounds flowing from the fields, adequately distributed tree-covered areas with surface area coverage of 4-5% would be sufficient (Ryszkowski and Bałazy, 2003). Meanwhile, the current proposals impose larger shares of excluded land difficult to accept for their owners: from 7% in "greening" to 10% of the biologically active area in the detailed solutions proposed in the new strategy. Assuming that, in addition to wooded areas, such exclusions should also cover other categories of biologically active areas (e.g. small fallow and wasteland areas, catch crops or grasslands), it can be assumed that in order to achieve good protection of the microclimate of the fields, or to stop soil erosion, and at the same time increase the biocoenotic value, it would be sufficient to exclude about 5-6% of the area from cultivation, but under the condition of proper planting location (Zajączkowski J., 2016). The level of 5% of the so-called "ecological margins" in the agricultural space was already indicated in the document of the State Environmental Policy of 1991.

Looking for practical ways to encourage farmers to introduce new tree-covered areas, it is worth noting the large size of wood production and its rapid growth in tree-covered areas - on average twice as large as in forests (Górka et al., 1991). The most recent research on the use of wood from small privately owned forests shows the dominant role of subsistence fuel (about 80% harvested volume), compared to other forms of economic use of wood: subsistence processing or sale (Gołos and Gil, 2020). It should be stressed that providing farmers with large quantities of their own wood in a short period of time is an important premise for maintaining high-production varieties of poplars *Populus*sp.and willows *Salix*sp.as temporary admixtures (Bałazy et al., 1998).

With a view to removing the barriers to wide acceptance by farmers of the new agri-environmental programmes, studies are currently being carried out on the relationship between the development of ecosystem services and the achievement of farming objectives (Louah, Visser, Blaimont and de Cannière, 2017; Maes et al., 2016; Rosin et al., 2011), on the basis of which conceptual and IT tools are being proposed to help farmers and other landowners to accommodate this knowledge (González-Changaet al., 2020).

A new, although growing out of the old traditions of different regions in Europe, way of managing agricultural land is the agroforestry system (Borek, 2015), which consists of conducting simultaneous agricultural and forestry production on the same area. The agricultural products included in this system may include both yields of different crops and grazing of different livestock. Forest products are primarily wood, but also edible fruit, leaf or cork. Using the same space for the production of different goods increases the overall economic result (up to 130% of the baseline value, depending on the shares of the space occupied by the two specific forms of development and environmental conditions). In addition, the system facilitates the adaptation of agriculture to climate change (Hernandez-Morcillo et al., 2018), brings additional environmental benefits (Moreno et al., 2016; Torralba et al., 2016) or provides additional products, such as bee forage (Varahet al., 2013).

European Union regulations (EU Regulation, 2005) allowed Member States to support agroforestry systems in the form of subsidies to owners for the introduction of trees inside or outside agricultural parcels, up to 100 pcs. per hectare. To date, Poland has made virtually no use of such solutions due to the lack of tradition of such forms of management. In recent years, there has been an increased awareness of the benefits and interest in them in many regions of the country, due to among others the activities of the Polish Agroforestry Association based in Puławy. Intensive promotional activities of the Association and other non-governmental organisations have contributed to the inclusion of agro-forestry systems in the currently implemented project to support agro-environmental activities in Poland (Draft Regulation, 2020) in the new national strategy for sustainable rural development, agriculture and fisheries (Strategy, 2019). In addition to support for the establishment and maintenance of tree-covered areas (considered non-productive), the project provides for co-financing the planting of trees on arable land under the agroforestry system, i.e. for production purposes, including their further tending.

Other activities that may result in an increase in overall genetic diversity in wooded areas include:

- pond restoration as an element of improving water relations and enrichment of biocenosis (Kędziora, 2015);
- active protection in tree-covered areas of selected rare, admixed forest tree species associated with riparian or xerothermic habitats which, in the light of expected climate change, are particularly vulnerable to degradation and may prove to be insufficiently extensive or too hostile (in terms of competition from

other species) in the future, recommendations for the protection of genetic resources of such species have been developed within EUFORGEN (Kelleheret al., 2015);

- timely tending in young tree-covered areas (e.g. animal protection and crown formation) if planting is to provide wood in the future (Bałazy et al., 1998), and maintaining the correct condition of old tree-covered areas, usually showing large losses that make it difficult to perform certain functions (the need for replenishment or replacement was found e.g. in 1/3 of old linear tree-covered areas in Turew) (Kujawa, 1998);
- meticulous compliance of habitat ranges in the selection of species for new plantings and careful production of planting material and execution of planting in order to strengthen the future vitality of trees, this is particularly important in extreme habitats - e.g. in eroded loess areas (Piotrowski, 1958).

The suggestions of different professions regarding the composition of the tree-covered areas species need to be commented on. According to landscape architects (Wolski, 1996), the structural features of the new tree-covered areas should be compatible with habitat and geographically appropriate natural forest plant communities. In practice, if applied literally, such an assumption would make it difficult for tree-covered areas to perform most of the protective functions that would be assigned to them. A similar reservation should be made to the recommendation by many naturalists and ecology enthusiasts to use only native species in tree-covered areas (Tyszko–Chmielowiec, 2012).

Recently, there has been an opportunity for owners of land with tree-covered areas to obtain certificates of origin for harvested wood from a sustainably managed source under the “*Programme for the Endorsement of Forest Certification*”. (PEFC, 2018; 2019). In order to maintain the effectiveness of currently developed pro-ecological programmes in agriculture, it is important that Polish implementations of the PEFC or FSC standards already known in forest management, in their extensions relating to tree-covered areas, take into account reasonably justified cases of the use of alien species in order to achieve the specific environmental benefits described earlier.

3.8. Suggestions for new organisational solutions

It must be assumed that all measures aimed at increasing the overall tree-covered areas will contribute to increasing the genetic resources protected in tree-covered areas. Large-scale interference in space, such as the establishment of tree-covered areas systems, requires it to be properly incorporated into regional and local land-use plans. Any assessments of tree-covered areas conditions and planning of changes to them require precise inventory information, which is currently not available.

The above mentioned premises warrant the presentation of the following exemplary suggestions for solutions favouring the development of tree-covered areas in Poland, both developed individually and presented in recent years by scientists and practitioners:

- It is recommended to extend the scope of Large-Scale Forest Inventory in Poland in such a way as to include all tree and shrub land areas, regardless of their height and area, on trial plots located outside the forest grounds, describing their surface, individual species composition of layers and spatial form. The extended scope requires the provision of additional funding.
- It is estimated that the Polish thought of spatial planning at the beginning of the 21st century has been regressing, expressed, among other things, by a shift from separating natural and functional areas to dividing the country into economic development centres and marginal areas (Kozłowski, 2005). Hoping for a practical return to the concept of sustainable development of the country in the coming years, a framework should be created for a more effective impact of central authorities on planning works carried out by local governments - among others through the creation of awaited legal solutions and supervision over the implementation of regulations concerning environmental protection and landscape shaping (Czerniak et al., 2005). An example of a practical change in this respect would be the enforcement of the requirement to include the costs of restoring the violated state of the environment in the cost estimates of investments carried out on the basis of development plans, or the preparation of a national set of indicators of ecosystem services (Albert et al., 2016; MAES, 2014), which should be identified as part of environmental impact assessments or agro-environmental payments. The solutions developed should take into account national guidelines for spatial planners concerning the analysis of tree-covered areas needs and design of tree-covered areas systems (Łonkiewiczet al., 1993).
- When financing the private land maintenance of tree-covered areas functions resulting from the development plan, periodic checks should be carried out on the ability of the tree-covered areas to continue to perform these functions, e.g. maintaining density, species composition, groundcover state, etc. (Zającczkowski J., 2014).
- The flexibility of procedures for the qualification of land with ecological sites (including tree-covered areas for funding under direct subsidy schemes and agroforestry programmes should be increased. Slight overruns of the adopted limit values (e.g. too large a cluster of tree-covered areas, too small density or tree height, maximum number of trees per hectare of the agri-forestry system) should not eliminate such facilities from financing, but only reduce its size (Zającczkowski J.and

Zajączkowski K., 2009).

- The potential for CO_2 sequestration through modification of agricultural practices, including the establishment of various forms of tree-covered areas, is estimated for the European Union area to be 1,500,000,000 t per year (Aertsens, DeNocker and Gobin, 2013). The CO_2 binding capacity of tree-covered areas in Poland is estimated, on the basis of an estimated wood volume increase of about 3,000,000 m^3 per year, at about 750,000 t per year in terms of coal (Zajączkowski K. and Zajączkowska B., 1995). One of the effects of the implementation of a reliable annual tree-covered areas inventory will be the possibility of quantifying the anticipated increase in coal sequestration by stockings, which would make it possible to take this beneficial effect into account in accounting for the emission limits granted to our country.
- The "greening" policy should also be extended to farms with less than 15 hectares of land.
- Within the framework of agricultural land consolidation projects, places for new sequestration should be designated (Woch and Głażewski, 2014). An inventory of ecological sites and land marginal to agriculture and knowledge of the course of the agro-forest border can be used for this purpose (Stańczuk-Gławiaczek, 2014). The re-parcelling projects should take into account the environmental assessment available to the site, adapting the construction and location of new tree-covered areas to them.
- Taking as example foreign solutions that increase the effectiveness of environmental projects financed under agro-environmental programmes, it should be made easier for groups of landowners to submit Community applications (Stalengaet al., 2016).
- The possibility of planning a single cut-out of long sections of roadside avenues and other linear tree-covered areas should be limited, which would reduce the adverse effects of their elimination on the environment (Karg, 1998; Tyszko–Chmielowiec, 2012).
- Financial arrangements for local authorities should be put in place to allow tenders for seedlings for planned planting to be held several years in advance in order to adapt the characteristics of the available planting material to the real needs of the planned tree-covered areas and, moreover, to reduce its price (Budzyński, 1993). In addition, contracts for establishing tree-covered areas with a deferred part of the payment should be facilitated, stimulating effective maintenance and watering of the tree-covered areas at the contractor's expense in the first year after planting.

Chapter 4. State of diversity of trees and other woody plant species

4.1. General information

The vascular flora of Poland includes about 2,500 native species (Mirek, Piękoś-Mirkowa, Zając and Zając, 2002; Zając A. and Zając M. ,2001; Zając M. and Zając A., 2003; 2009) and is similar in terms of richness to the flora of neighbouring countries such as the Czech Republic, where 2,256 species were found (Danihelka, Chrtek and Kaplan, 2012) and Slovakia, where 2,560 species were reported (Marhold and Hindák, 1998). The flora of Germany with 3,000 species (Korneck, Schnittler and Vollmer, 1996) and Ukraine (without the Crimea) is richer, with 2,831 species (Mosyakin and Fedoronchuk, 1999), and the richest flora on our continent is that of the countries in the Mediterranean regions (Bilz, Kell, Maxtedand Lansdown, 2011).

In Poland there are about 263 native species of woody plants, which is slightly more than 10% of the national vascular flora, including 259 in the rank of species and 4 subspecies (except for 2 nominative taxa: downy birch *Betulapubescens*subsp.*pubescen s*and common rock-rose *Helianthemum nummularium* sub sp.*nummularium).*The national list does not include species of uncertain status in the flora, as well as several others, treated by some authors as indigenous, but undoubtedly belonging to anthropophytes (e.g.snowy mespilus *Amelanchier ovalis*and sour cherry *Prunus cerasus*subsp.*acida*). Polish woody plants, among which there are only 10 species of gymnosperm trees and shrubs, belong to 32 families and 67 genera. The most numerous *Rosaceae*f (135 species) and *Salicaceae* (30) and the *Rubus* (95) and willow *Salix* (26).This number does not include trees and shrubs whose status in the flora is questionable and most inter-species hybrids. Among our woody plants the main fraction of the 6 basic groups of life forms are shrubs. Typical trees (without shrubs, which can take the form of a tree in particularly favourable conditions) include 40 species. The most numerous type in Polish dendroflora is blackberry *Rubus*, comprising, according to the latest information, 95 species. The genus has 26 species, and rose *Rosa*- 14. Most of the indigenous species of dendroflora are included in two geographical elements - holarctic (mainly the European-moderate sub-element) and liaison. Lowland and low-mountain species are predominant. In terms of belonging to ecological and sociological groups, representatives of mesophilous and fertile deciduous forests dominate. The category of common plants includes 40 species, and about 20% are very rare species. In the case of 20% of taxa, a decrease in the number of sites and a reduction in local populations was found. The causes of this phenomenon are most often related to anthropopressure on the environment, but sometimes it is caused by factors independent of people (genetic, biological and ecological properties of species and spontaneous changes of the environment, as well as historical conditions of current plant ranges) (Danielewicz and Wiatrowska, 2015).

In terms of growth forms, shrub species clearly dominate, with more than 50% of them being, for the most part, apomictic blackberries from the *Ideobatus* and *Rubus* subgenus, with a specific development cycle and shoots living for only two years, which, despite this, are usually included in the group of shrubs, i.e. nanophanerophytes (Zarzycki et al. ,2001; Zieliński ,2004).

Most of the species are found in our country on both lowland and mountain sites, and these species, together with exclusively lowland trees and shrubs, account for more than 85% of the national dendroflora. There are about 10% of typical mountain species and about 5% of mountain species with lowland sites.

Due to the young age of the Polish flora, trees and shrubs, which are newcomers of the Holocene age, are the most numerous. The Tertiary relic is savin juniper *Juniperussabina,* the following are classified as glacial relics: dwarf birch *Betulanana,* mountain avens *Dryasoctopetala,* twinflower *Linnaeaborealis,* snowbed willow *Salix herbacea,* downy willow *Salix lapponum* and swamp willow *Salix myrtilloides,* while a younger historical species includeshort birch *Betula humilis* and leatherleaf *Chamaedaphnecalyculata.* As in the case of the whole vascular flora (Matuszkiewicz, 1999; Hare M. and Hare A., 2009), most of the woody plants are species belonging to 2 geographical elements - holarctic and liaison. Half of the species represent the temperate European sub-element, which includes almost all blackberries and trees such as the silver fir *Abiesalba*, Swiss pine *Pinuscembra*, Norway spruce *Piceaabies*, common beech *Fagussylvatica*, small-leaved linden *Tiliaplatyphyllos* and European white elm *Ulmuslaevis.* More than 50% of our trees are in the group of species representing the liaison element e.g. field maple *Acer campestre,* sycamore maple *Acerpseudoplatanus,* Norway maple *Acerplatanoides,* black alder *Alnusglutinosa*, common hornbeam *Carpinus betulus*, common ash *Fraxinusexcelsior*, silver poplar *Populusalba*, black poplar *Populusnigra*, poplar aspen *Populustremula*, wild cherry *Prunus avium*, sessile oak *Quercus petraea*, pedunculate oak *Quercusrobur*, white willow *Salixalba*, brittle willow *Salixfragilis*, wild service tree *Sorbus torminalis*, sessile elm *Ulmusglabra*, field elm *Ulmusminor*, common yew *Taxusbaccata*. The Arctic-Alpine sub-elements are much less numerous (grey alder *Alnusincana*, mountain avens *Dryas octopetala*, black crowberry *Empetrumhermaphroditum*, willow *Salixbicolor*, halberd willow *Salixhastata*, snowbed willow *Salixherbacea*, net-leaved willow *Salixreticulata*, meadowsweets *Spiraeamedia* and northern bilberry *Vaccinium gaultherioides*), Altai-Alpine (sea-buckthorn *Hippophaerhamnoides,* savin juniper *Juniperus sabina,* and *Myricaria germanica*)*,* Pontic-Pannonian (yellow azalea *Rhododendronluteum*) and submediterranian). Among the 17 species from the circumboreal sub-element, there are plants as rare as these:dwarf birch *Betula nana,* leatherleaf *Chamaedaphne calyculata,* twinflower *Linnaeaborealis,* bog-myrtle *Myricagale*and swamp willow *Salix myrtilloides,*and the Eurosiberian sub-element is represented by common trees, shrubs and bushes, for example: silver birch *Betulapendula,* common heather *Calluna vulgaris,*alder buckthorn *Frangula alnus, Scots* pine *Pinus sylvestris,* grey willow *Salixcinerea,* basket willow *Salixviminalis,* small-leaved linden *Tilia cordata,* European blueberry *Vaccinium myrtillus* and shrubs that are rare and threatened plants, e.g.short birch *Betulahumilis,* European dwarf cherry *Prunusfruticosa* and downy willow *Salixlapponum* (Danielewicz and Wiatrowska,2015).

According to the definition of a woody species, however, according to *Global TreeSearch* (a project within the framework of *Botanic Gardens Conservation International*) (Global Tree Search, 2020), agreed by the Kostrzyca Forest Gene Bank with IUCN Global Tree Specialist Group, there are 61 woody species in Poland (Tab. 4.1).

Tab.4.1 *List of tree plant species in Poland according to the Global Tree Search definition*

No.	Species from the GlobalTreeSearch
1.	Black elder *Sambucus nigra*
2.	Red elderberry *Sambucus racemosa*
3.	Silver birch *Betula pendula*
4.	Downy birch *Betula pubescens*
5.	Common beech *Fagus sylvatica*
6.	Common yew *Taxus baccata*
7.	Bird cherry *Prunus padus*
8.	Wild cherry *Prunus avium*
9.	Sessile oak *Quercus petraea*
10.	Downy oak *Quercus pubescens*
11.	Pedunculate oak *Quercus robur*
12.	Midland hawthorn *Crataeguslaevigata*
13.	Single-seeded hawthorn *Crataegusmonogyna*
14.	Hawthorn *Crataegus rhipidophylla*
15.	Common hornbeam *Carpinus betulus*
16.	Common pear *Pyrus communis*
17.	European crab apple *Malus sylvestris*
18.	Common juniper *Juniperus communis*
19.	Wild service tree *Sorbus torminalis*
20.	Greek whitebeam *Sorbus graeca*
21.	Common whitebeam *Sorbus aria*
22.	Rowan *Sorbus aucuparia*
23.	Swedish whitebeam *Sorbus intermedia*
24.	Common ash *Fraxinus excelsior*
25.	Silver fir*Abies alba*
26.	Sycamore maple *Acer pseudoplatanus*
27.	Field maple *Acer campestre*
28.	Norway maple*Acer platanoides*
29.	European bladdernut *Staphylea pinnata*
30.	Alder buckthorn *Frangula alnus*
31.	Common hazelnuts *Corylu savellana*
32.	Small-leaved linden *Tilia cordata*
33.	Large-leaved linden *Tilia platyphyllos*
34.	European larch *Larix decidua*
35.	Black alder *Alnus glutinosa*
36.	Grey alder *Alnus incana*
37.	Green alder *Alnus alnobetula*
38.	Silverberry *Elaeagnus rhamnoides*
39.	Dwarf mountain pine *Pinus mugo*
40.	Swiss pine *Pinus cembra*

41.	Scots pine *Pinus sylvestris*
42.	Common buckthorn *Rhamnus cathartica*
43.	Blackthorn *Prunus spinosa*
44.	Norway spruce *Picea abies*
45.	Silver poplar*Populus alba*
46.	Black poplar *Populus nigra*
47.	Poplar aspen*Populus tremula*
48.	European spindle *Euonymus europaeus*
49.	Wych elm *Ulmus glabra*
50.	Field elm*Ulmus minor*
51.	European white elm *Ulmus laevis*
52.	White willow *Salix alba*
53.	Dark-leaved willow *Salix myrsinifolia*
54.	Goat willow *Salix caprea*
55.	Bay willow *Salix pentandra*
56.	Purple willow *Salix purpurea*
57.	Bitter willow *Salix eleagnos*
58.	Grey willow *Salix cinerea*
59.	Almond willow *Salix triandra*
60.	European violet willow *Salix daphnoides*
61.	Basket willow *Salix viminalis*

Source: Global TreeSearch, 2020.

However, 77 woody species were registered in the State Forests Register of Basic Forest Material in 2020, so it can be concluded that the number of woody species treated as forest genetic resources is now 77, including 55 native species. On the other hand, in the National Register of Basic Forest Material, maintained by the Forest Reproductive Material Office, there were fewer species registered in 2020, i.e. 33, including 23 native species (Tab.4.2).

Tab. 4.2 *List of species recognised as forest genetic resources in Poland and listed in the Annex to the Act on Forest Reproductive Material (covered by the National Register of Basic Forest Material)*

No.	**Tree and woody plant species recognised in Poland as forest genetic resources**	**A species listed in the Annex to the Act on Forest Reproductive Material (YES/NO)**	**Native species (YES/NO)**
1.	Common barberry *Berberis vulgaris*	NO	YES
2.	Black elder*Sambucus nigra*	NO	YES
3.	Red elderberry *Sambucus racemosa*	NO	YES
4.	Silver birch *Betula pendula*	YES	YES
5.	Downy birch*Betula pubescens*	YES	YES
6.	Common beech *Fagus sylvatica*	YES	YES
7.	Common yew *Taxus baccata*	NO	YES
8.	Bird cherry *Prunus padus*	NO	YES
9.	Wild cherry*Prunus avium*	YES	YES
10.	Douglas fir *Pseudotsuga menziesii*	YES	NO
11.	Sessile oak *Quercus petraea*	YES	YES
12.	Turkey oak *Quercu scerris*	NO	NO
13.	Red oak *Quercus rubra*	YES	NO
14.	Downy oak *Quercus pubescens*	YES	YES
15.	Pedunculate oak *Quercus robur*	YES	YES
16.	Red-barked dogwood *Cornus alba*	NO	NO
17.	Common dogwood *Cornus sanguinea*	NO	YES
18.	Midland hawthorn *Crataegus laevigata*	NO	YES
19.	Single-seeded hawthorn *Crataegus monogyna*	NO	YES
20.	Common hornbeam *Carpinus betulus*	YES	YES
21.	Common pear *Pyrus communis*	NO	YES
22.	Common cotoneaster *Cotoneaster integerrimus*	NO	YES
23.	European crab apple *Malus sylvestris*	NO	YES
24.	Common juniper *Juniperus communis*	NO	YES
25.	Wild service tree *Sorbus torminalis*	NO	YES
26.	Rowan *Sorbus aucuparia*	NO	YES
27.	Swedish whitebeam *Sorbus intermedia*	NO	YES
28.	Common ash *Fraxinus excelsior*	YES	YES
29.	Grand fir *Abies grandis*	NO	NO
30.	Silver fir *Abies alba*	YES	YES
31.	Guelder rose *Viburnum opulus*	NO	YES
32.	Sweet chestnut *Castanea sativa*	YES	NO
33.	Horse chestnut *Aesculus hippocastanum*	NO	NO
34.	Sycamore maple *Acer pseudoplatanus*	YES	YES
35.	Field maple *Acer campestre*	NO	YES
36.	Norway maple *Acer platanoides*	YES	YES
37.	Alder buckthorn *Frangula alnus*	NO	YES
38.	Common hazelnuts *Corylus avellana*	NO	YES
39.	Common privet *Ligustrum vulgare*	NO	YES
40.	Small-leaved linden *Tilia cordata*	YES	YES

41.	Large-leaved linden *Tilia platyphyllos*	YES	YES
42.	Eurasian larch *Larix xeurolepis*	YES	NO
43.	European larch *Larix decidua*	YES	YES
44.	Black alder *Alnus glutinosa*	YES	YES
45.	Grey alder *Alnus incana*	YES	YES
46.	English walnut *Juglans regia*	NO	NO
47.	Japanese quince *Chaenomeles japonica*	NO	NO
48.	Cassis *Ribes nigrum*	NO	YES
49.	Black locust *Robinia pseudoacacia*	YES	NO
50.	Silverberry *Elaeagnus rhamnoides*	NO	YES
51.	Dog rose *Rosa canina*	NO	YES
52.	Rugosa rose *Rosa rugosa*	NO	NO
53.	Mud pine *Pinus uliginosa*	NO	YES
54.	Black pine *Pinus nigra*	YES	NO
55.	Dwarf mountain pine *Pinus mugo*	NO	YES
56.	Swiss pine *Pinus cembra*	YES	YES
57.	Pitch pine *Pinus rigida*	NO	NO
58.	Eastern white pine *Pinus strobus*	YES	NO
59.	Lodgepole pine *Pinus contorta*	YES	NO
60.	Scots pine *Pinus sylvestris*	YES	YES
61.	Common buckthorn *Rhamnus cathartica*	NO	YES
62.	Cherry plum*Prunus cerasifera*	NO	NO
63.	Blackthorn *Prunus spinosa*	NO	YES
64.	Niorway spruce *Picea abies*	YES	YES
65.	Sitka spruce *Picea sitchensis*	NO	NO
66.	Silver poplar *Populus alba*	YES	YES
67.	Black poplar*Populus nigra*	YES	YES
68.	Canadian poplar *Populus×canadensis*	YES	NO
69.	Mongolian poplar *Populus maximowiczii*	YES	NO
70.	Poplar aspen *Populus tremula*	YES	YES
71.	Warty spindle *Euonymus verrucosus*	NO	YES
72.	European spindle *Euonymus europaeus*	NO	YES
73.	Wych elm *Ulmus glabra*	NO	YES
74.	Field elm *Ulmus minor*	NO	YES
75.	European white elm *Ulmus laevis*	NO	YES
76.	Mahaleb cherry *Cerasus mahaleb*	NO	NO
77.	Northern white cedar *Thuja occidentalis*	NO	NO

Source:data from the National Register of Basic Forest Material and the State Register of Basic Forest Material, 2020.

The composition of the Polish flora is enriched with about 120 domesticated species of trees and shrubs of foreign origin. The ability to penetrate forest communities shows 85 species, 10 of which are the most invasive (Danielewicz and Wiatrowska, 2015).

Species introduced into Polish forests do not play an important economic role. In total, they cover an area of approximately 39,000 ha (FAO Report, 2015) (i.e. 0.41% of forest area), and their abundance is 25,000,000 m^3 (FAO Report, 2020), i.e. approximately 1% of the abundance of Polish forests. The most important of these include red oak *Quercus rubra,* black locust *Robinia pseudoacacia* and Douglas fir *Pseudotsuga menziesii*.

4.2. Threats to forest genetic resources

The threat to the forest environment in Poland is among the highest in Europe. This is primarily due to Poland's location on the border of two climates - continental and maritime, and as a consequence, the constant and simultaneous impact of many factors causing adverse phenomena and changes in the health condition of forests (Zajączkowski G. et al., 2020).

Disease predisposition of stands and degradation of forest ecosystems results from co-occurrence and synergistic impact of a number of abiotic and biotic harmful factors. Deepening precipitation deficit, droughts, warm and snowless winters and a decrease in groundwater levels are significant factors that weaken the health of the stands and, at the same time, initiate the formation of epiphytoses, infectious diseases and insect pests. There are also other harmful organisms, which have not been present in Poland so far or were considered to be of little harm (e.g. mistletoe *Viscum sp.*) (Zajączkowski G. et al., 2020).

In 2019, the main national abiotic factors were extreme drought and strong winds. In stands over 20 years old, managed by the State Forests National Forest Holding, 113,400 ha of stands damaged by abiotic factors were recorded, including 62,500 ha of disrupted water balance and 42,300 ha of wind. Damage caused by one or more abiotic factors was found in 94% of forest districts (1 factor - 28%, 2 factors - 35%, 3 factors - 22%, 4 factors - 8% and 5 factors - 1%). Only 6% of forest districts did not report damage caused by abiotic factors. Symptoms of stand weakening caused by disturbance of water balance, mainly drought, were reported in 242 out of 430 forest districts, while strong wind damaged forests in 145 forest districts. Removing the direct effects of abiotic factors required urgent implementation of cost-intensive protective tasks, involving the removal of dead or damaged trees, including those caused by wind, drought and other factors. The volume of broken and blown over trees of the main forest-forming species, obtained from sanitary cuttings, reached 3,200,000 m^3 in 2019 (broken and blown over trees in 2019 as well as in previous years) (Zajączkowski G. et al., 2020).

In 2019, the total area of primary pests' occurrence exceeded 465,000 hectares. Due to the high threat from 38 species/groups of harmful insects, it was necessary to carry out measures reducing their numbers. The total area of the stands where chemical, biological and mechanical protective treatments were carried out in 2019 exceeded 244,000 ha. They mainly concerned cockchafers, pine foliophages and tree pests in nurseries, secondary forest plantations and young stands (Zajączkowski G. et al., 2020).

The main primary pests plaguing the forests were imagines of *Melolontha sp.* cockchafers. Their total control area was 146,000 ha. The second most important group of insects were pine stand foliophages. Protective treatments were carried out on 86,200 ha of stands, including against the black arches *Lymantria monacha* - 56,600 ha, the pine beauty *Panolis flammea* - 17,600 ha, the pine sawfly *Diprion sp*. - 3,900 ha and the pine-tree lappet *Dendrolimus pini* - 2,100 ha. The starry *Acantholyda posticalis*, controlled on the area of 6,000 ha was locally significant (Zajączkowski G. et al., 2020).

The total area of nurseries, secondary pine forest plantations and young pine stands covered by protective treatments was 4,900 ha, including protective treatments against small banded pine weevil *Pissodes castaneus* applied on 2,700 ha. The second significant pest was pine weevil *Hylobius sp.* which was controlled on the area of 1,800 ha. In nurseries and plantations established in 44 forest districts, protective treatments against pests of roots of forest trees and shrubs (mainly grubs of cockchafers *Melolontha sp.*) were carried out on the area of 206 ha (Zajączkowski G. et al., 2020).

The total area of spruce, larch and fir stands, covered by treatments to reduce the number of harmful insects, was 126 ha. On the largest area (91 ha), the silver fir woolly adelgid *Dreyfusia nordmannianae* (Zajączkowski G. et al., 2020) was controlled.

In 2019, the total area of secondary pests reached 107,000 hectares. Due to the high risk from this group of insects, it was necessary to take measures to prevent the development of their gradation, especially in pine, spruce and oak stands. A total of 7,700,000 m^3 of wood was obtained from sanitary cuttings, including 4,500,000 m^3 of dry deadwood and 3,200,000 m^3 of broken and blown over trees. Actively inhabited deadwood constituted 56% of the deadwood harvested in 2019. Broken and blown over trees caused by strong wind were actively inhabited by cambio- and xylophagic insects to a small extent (11%). The volume of pine wood harvested from sanitary cuttings was 3,500,000 m^3, including deadwood - 2,000,000 m^3, broken and blown over trees - 1,500,000 m^3. The greatest threat was posed by: bark beetle *Ips acuminatus*, steelblue jewel beetle *Phaenops cyanea* and common pine shoot beetle *Tomicus sp*., which occurred on a total area of 47,000 ha. An increased occurrence of bark beetle *Ips acuminatus* was recorded on a total area of 26,000 ha. It was necessary to carry out protective measures, consisting in removing the inhabited trees, on an area of more than 13,000 ha of pine stands. Gradual occurrence of steelblue jewel beetle *Phaenops cyanea* was recorded on an area of about 17,000 ha. Reduction of this insect (removal of inhabited trees) was carried out on an area of 14,500 ha. The third group that posed a significant threat to pine stands were common pine shoot beetle *Tomicus sp.* They occurred on a total area of 4,700 ha. These bark beetles were subject to control activities on a total area exceeding 4,000 ha (ZajączkowskiG. et al., 2020).

A significant level of risk has been identified also in spruce stands. In 2019, 2,700,000 m^3 of spruce wood, mostly deadwood (1,900,000 m^3), was harvested as part of sanitary cuttings. Broken and blown over trees constituted 800,000 m^3. The greatest threat was posed by the European spruce bark beetle *Ips typographus*. Its mass occurrence was found on an area of 40,000 ha (Zajączkowski G. et al., 2020).

In oak stands, 370,000 m^3 of deadwood and broken and blown over trees had to be obtained in sanitary cuttings. The main causative factor was, apart from abiotic factors, the oak splendour beetle *Agrilus biguttatus*. The increased occurrence of this insect was recorded on an area of 5,700 ha. Protective treatments covered over 5,000 ha of oak stands in the whole country (Zajączkowski G. et al., 2020).

In 2019, infectious diseases occurred on a total area of 222,500 ha. The increase in the area of damaged stands was a consequence of the phenomenon of drought observed for several years and anomalous temperature and precipitation distributions. In 2019, an increase in the area of occurrence of 2 diseases affecting the crowns of forest trees in particular was recorded - the dying out of pine shoots (1,191%) and powdery mildew of oak (770%). A large decrease in the incidence was recorded in the case of a dangerous disease of the Scots pine - pine needle cast (by 87% (Zajączkowski G. et al., 2020).

In 2019, a slight increase in the area of stands with root diseases (armillaria root rot and root rot) was recorded. These diseases occurred on a total area of 149,900 ha, which is 14,100 ha more than in the previous year. In secondary forest plantations and young stands, damage from root diseases was found on a total area of 8,500 ha, which is 200 ha more than in the previous year. In the stands of older age classes, both these diseases increased their total extent by 13,900 ha - they were recorded on an area of 141,500 ha. The problem of armillaria root rot affected mainly tree stands over 20 years old, in which damage was observed on the total area 47,000 hectares. In the stands of up to 20 years this area was 5,700 ha. The occurrence of root rot in 2019 was recorded on an area of 97,100 ha, over 12,000 ha more than in the previous year. Similarly to the threat of armillaria root rot, the problem of root rot mainly concerned the stands of older age classes (Zajączkowski G. et al., 2020).

Protective treatments, used in forestry to reduce fungal pathogens, are carried out mainly in forest nurseries and on a temporary basis in stands. In 2019, the total area of various types of protective treatments was 8,400 ha. Among the methods used by foresters to control fungal pathogens, biological (4,300 ha) and mechanical (3,100 ha) methods prevailed. Chemical treatments were applied only on an area of less than 1,000 ha (Zajączkowski G. et al., 2020).

The August 2019 inventory of coniferous stands for the settlement by the European mistletoe *Viscum album* showed the presence of these semi-parasitic plants on more than 166,000 hectares. Of these stands, as many as 123,000 ha were permanently damaged (Zajączkowski G. et al., 2020).

In 2019, livestock damage to forests managed by the State Forests National Forest Holding was recorded on a total area of 65,000 hectares. The hunting species, namely deer *Cervus elaphus*, fallow deer *Dama dama*, roe deer *Capreolus capreolus*, wild boar *Sus scrofa* and hare *Lepus europaeus* damaged stands on 43,700 ha, including secondary forest plantations on 23,700 ha, secondary forest plantations on 16,600 ha, and older stands on 3,500 ha. Species subject to different forms of protection (elk *Alcesalces*, European bison *Bisonbonasus* and Eurasian beaver *Castorfiber*) led to stand damage on 21,300 ha, including secondary forest plantations on 4,400 ha, young stands on 7,000 ha and older stands on 9,900 ha. The main perpetrator of forest damage is the deer *Cervus elaphus*. The total area of stands damaged by this species was 32,100 ha. In the majority of the stands, the main type of damage was bark stripping, which was found on 18,900 ha, including 14,400 ha in young stands.Other types of damage caused in 2019 by deer *Cervus elaphus* are browsing, tree topping and breaking down the main shoot. The area of thus damaged stands amounted to 12,600 ha, including 10,900 ha in secondary forest plantations. The second most harmful species was Eurasian beaver *Castor fiber*. The total area of damage caused by these rodents was 11,800 ha. The most frequent type of damage was flooding (9,400 ha). In 2019, roe deer *Capreolus capreolus* caused damage of slightly lower level. The area of stands damaged by this species was 10,400 ha. The main type of damage caused by the roe deer *Capreolus capreolus* is browsing and tree topping of the main shoot or shoots of lateral seedlings growing on secondary forest plantations, found on the area of 9,700 ha. The elk *Alces alces* caused damage to 8,700 ha of forest. It damaged both young stands (4,500 ha) and secondary forest plantations (3,7000 ha). The main types of damage caused by elk *Alces alces* in 2019 were fractures, tree topping and browsing of main shoots (5,300 ha) and bark stripping (3,300 ha). The European bison *Bison bonasus* caused damage to a 700 ha forest. The main type of damage was bark stripping (500 ha) and browsing and tree topping (200 ha) (Zajączkowski G. et al., 2020).

In order to prevent damage caused by animals, chemical and mechanical means, especially in secondary forest plantations and young stands are used. Protection of the area in the form of secondary forest plantations fences is also used. In 2019, chemical prevention was applied on 53,100 ha and mechanical prevention on 9,400 ha. The fenced area was 213,400 ha, including 19,500 ha of newly fenced in 2019 (Zajączkowski G. et al., 2020).

In 2019, 9,635 forest fires were registered, 768 more than in the previous year, and 3,572 ha of forest stands were burnt, 876 ha more than in 2018. In the State Forests in 2019, 3,239 fires were registered (33.6% of forest fires in Poland) on an area of 947 ha (26.5% of total). In 2019, 7 large fires (>10 ha) occurred in the State Forests, which resulted in 179.78 ha of forest being burnt. In Poland, in 2019, a total of 23 large fires were recorded and none very large (>100 ha). The average fire area in forests of all types of ownership in 2019 was 0.37 ha (0.07 ha more than in 2018). In the State Forests this area increased by 0.09 ha and amounted to 0.29 ha. In the forests of other forms of ownership, the size was 0.41 ha. The main causes of fires in the State Forests were arson (37.1%) and negligence (14.1%), while the share of fires whose cause was unknown was 38.8%. Accidents resulted in 6.9%, natural causes in 2.4%, and re-ignition in 0.7% of the fires. In forests of all forms of ownership, 42.6% of fires were caused by arson, 26% by negligence, 4.6% by accidents, 1.2% by natural causes, 0.3% by re-ignition, while the causes of 25.3% of fires were unidentified (Zajączkowski G. et al., 2020).

Forest monitoring provides information on the main pollutants reaching the forest areas. The intensive monitoring network is based on 12 permanent observation plots. In recent decades, SO_2 and NO_2 emissions have significantly decreased in Poland. Decreasing emissions have been accompanied by decreasing concentrations of gaseous pollutants registered in forest areas under air quality monitoring. Concentrations of SO_2 clearly decreased until 2007, followed by a period of their slower decrease. In turn, NO_2 concentrations remained relatively stable over the period 1998-2019 (Zajączkowski G. et al., 2020).

The main burden of carrying out the tasks of keeping forests in an appropriate state of health and a structure conducive to maintaining the stability of the stands is shouldered by the State Forests National Forest Holding. This result, among others, from the provisions of 10-year management plans. In 2019, the conversion of stands in the State Forests was carried out on an area of 4,300 ha, cleaning was carried out on 119,300 ha, thinning - on 384,000 ha. Moreover, the stability of the stands was strengthened by introducing undergrowth (400 ha) and second storey (2,100 ha), reforestation of gaps (1,100 ha) and agrotechnical and water drainage treatments (74,500 ha). In the areas managed by the State Forests National Forest Holding, measures are implemented annually to limit the possibility of fire and the spread of fires. In 2019, 4,389 km of existing fire protection belts were maintained and 75 km of new belts were established. Moreover, flammable biomass was cleaned from 17,936 hectares. Important elements of fire protection are the fire observation posts, 684 of which are part of the State Forests National Forest Holding observation system. The system also includes a charter of 7 patrol aircraft and 344 light patrol cars, 340 of which are equipped with fire-fighting modules. The effectiveness of the fire observation posts in 2019 was 32.1% (out of all the fires that occurred, this share were noticed from the fire observation posts), fire patrols and employees of the State Forests reported 5% of the fires, while the planes noticed almost 2% (1.7%), while outsiders reported 61.2% of the fires. Water supply for extinguishing purposes was provided by 11,517 water supply points, including 4,200 natural and over 2,500 artificial ones (Zajączkowski G. et al., 2020).

Tab.4.3 *Number of forest fires in the years 2009-2018*

Year	Number of fires - total (pcs.)	Arsons (pcs.)	Imprudence (pcs.)	Lightning(pcs.)	Defects of technical equipment and means of transport and their improper operation (pcs.)	Other and non-identified(pcs.)
2009	9,162	4,113	3,099	24	90	1,836
2010	4,680	2,032	1,594	34	65	955
2011	8,172	3,470	2,884	73	112	1,633
2012	9,265	3,853	3,389	46	114	1,863
2013	4,883	2,015	1,704	22	51	1,091
2014	5,245	2,066	1,668	53	97	1,361
2015	12,257	5,134	3,808	123	206	2,986
2016	5,286	2,240	1,644	43	88	1,271
2017	3,592	1,590	1,082	32	53	835
2018	8,867	3,561	2,577	70	240	2,419

Source: Statistics Poland - Local Data Bank, 2020. Tab.4.4Tab. 4.4

Tab. 4.4 *Area of forest fires in the years 2009-2018*

Year	Number of fires - total (ha)	Arsons (ha)	Imprudence (ha)	Lightning(ha)	Defects of technical equipment and means of transport and their improper operation (ha)	Other and non-identified(ha)
2009	4 400,48	2 035,38	1 169,28	1,02	33,72	1 161,08
2010	2 126,24	685,81	512,25	3,69	25,25	899,24
2011	2 677,77	1 140,09	763,70	14,46	24,54	734,98
2012	7 235,27	2 967,03	2 248,69	3,97	77,89	1 937,69
2013	1 288,54	547,73	373,72	1,32	20,66	345,11
2014	2 690,45	841,59	1 132,24	4,15	49,04	663,43
2015	5 509,90	2 085,97	1 658,33	24,22	88,72	1 652,66
2016	1 451,05	515,60	420,80	5,23	12,96	496,46
2017	1 022,53	477,42	314,87	6,70	7,55	215,99
2018	2 696,13	971,23	1 083,86	5,08	87,47	548,49

Source: Statistics Poland - Local Data Bank,2020.

In 2019, 51,377 offences referred to as forest damage were registered in the area administered by the State Forests National Forest Holding. In particular, 2,260 cases of wood theft, 629 cases of theft or destruction of property, 157 cases of poaching and 48,331 offences of illegal use of forest were recorded. As a result of forest damage, losses in 2019 amounted to PLN 3,126,987, of which PLN 1,363,951 were due to wood theft (Zajączkowski G. et al., 2020).

The proportion of damaged stands in the State Forests amounts to 35.6%, and in private forests 39.8%. Among the causes of damage, apart from the category "other factors", damage caused by game (3.7%) and fungi (1.5%) and insects (0.6%) dominate. Stand damage in the damage classes above 40% is 12% in the State Forests and 10.5% of all damage in private forests. Damaged pine stands constitute 52.1% and oak stands 7.6% of the total area of damaged forests. The respective share in the State Forests is 52.5% for pine stands and 8.5% for oak stands, while in private forests: 56.5% and 4.4% for oak stands. The share of total damaged trees in the country's forests is 22.4%, and the share of trees in the total damage class of over 40% is 1.3%, while this value in relation to damaged trees is 6%. The shares in the State Forests are 21.9%, 1.2% and 5.5% respectively, while in private forests 23.2%, 1.7% and 8.2%. Damaged Scots pine *Pinus sylvestris* accounts for 18.8%, while damaged oaks of *Quercus sp*. is 26.9% of the total number of damaged trees. The largest share of damaged Scots pine *Pinus sylvestris* trees was recorded in forests in the communes management (31.9%). This share in the State Forests is 17.8% and 22.3% in private forests. The largest share, in the case of damage to oak trees *Quercus sp.*, was also recorded in forests managed by communes (37.4%). This share is 27.6% in State Forests and 21% in private forests (WISL,2020).

One of the consequences of increased penetration of forest areas by tourists is littering the forests. Despite the educational campaign and the expansion of the small forest infrastructure, the costs of maintaining cleanliness in the forests are constantly increasing - in 2019; the State Forests National Forest Holding spent nearly PLN 19,900,000 on this purpose, i.e. PLN 700,000 more than in 2018. In total, about 107,600 m^3 of rubbish was removed from the forest areas (Zajączkowski G. et al., 2020).

4.3. Monitoring and prevention of threats

In order to ensure widespread forest protection, forest owners are obliged to shape the balance of forest ecosystems, increase the natural resilience of stands, and in particular to: perform preventive and protective measures to prevent the occurrence and spread of fires, prevent, detect and combat the excessive occurrence and spread of harmful organisms and to protect soil and forest waters (Ustawaolasach,1991).

The state of forest damage in Poland has been assessed annually since 1989 as part of the Forest Monitoring Programme, which is one of the elements of the National Environmental Monitoring system and, at the same time, *"The International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests"* (ICP Forests). Since 2006, the network of Level I Permanent Observation Areas, with a density of 8 x 8 km, has been integrated with Large-Scale Forest Inventory and concerns forests of all forms of ownership (Zajączkowski G. et al., 2020).

The basic parameter used to assess the state of damage to trees, and more broadly to entire stands, is the level of their defoliation, i.e. the percentage loss of leaves or needles. The results of estimating the defoliation of trees are grouped into 5 classes:

- 0 – no defoliation < (10%),
- 1 – slight defoliation, warning class (11–25%),
- 2 – medium defoliation (26–60%),
- 3 – severe defoliation (>60%),
- 4 – dead trees.

The trees in classes 2, 3 and 4 shall be defined as damaged trees. In 2019, crown condition observations were carried out on 40,840 trees over 20 years old, located on 2,042 Level I Permanent Observation Areas. Medium defoliation of all species together amounted to 23.4% (1% more than in the previous year), coniferous 23.3% and 23.7% of deciduous ones. The share of healthy trees (up to 10% defoliation) was 8.3%, and of damaged trees (more than 25% defoliation) - 21.1%. Among coniferous species, the silver fir *Abies alba* was in the best health condition, while the worst was Norway spruce *Picea abies*. Among deciduous species the least damaged one was common beech *Fagus sylvatica*, and the most damaged one was oak *Quercus sp*. The analysis of the health condition in various forms of ownership showed that the weakest condition characterized trees in forests classified as "other" - the highest number (30.3%) of damaged trees and the highest medium defoliation (25.7%) were recorded here. In turn, trees located on private land (medium defoliation 23%) and managed by the State Forests National Forest Holding (23.4%) were in the best condition. In national parks this figure was 24.5% (Zajączkowski G. et al., 2020).

Tab.4.5 *The area of damaged forests in 2018.*

Ownership			**The area of damaged forests (ha)**
Public forests	State Treasury	SF NFH	2,467,788
		National parks	88,310
		Agricultural Property Stock of the State Treasury	12,640
		Other	20,787
	Communal forests		39,289
Private forests			677,546

Source: Large-Scale Forest Inventory, 2020.

The consequence of the threats to the genetic resources of Polish forests presented above is the loss of genetic variability and an increase in the level of genetic differentiation between populations of tree and shrub species characteristic of the forest landscape of Poland. Populations of species characterized by dispersed occurrence are the most endangered. Such distribution may significantly contribute to spatial isolation, with its negative consequences. An increase in fragmentation, population isolation and reduction of effective population size may cause erosion of the gene pool through increased genetic drift, increased inbreeding mating, limited gene flow and decreased migration rate. As a result, local populations may lose genetic variability and consequently decrease their vitality and adaptability, e.g. common ash *Fraxinus excelsior* (Nowakowska, Jablonowski, Mockeliunaite and Bieniek, 2004), wild service tree *Sorbus torminalis* (Jankowska-Wróblewska, Meyza, Sztupecka, Kubera and Burczyk, 2016a; Jankowska- Wróblewska, Warmbier and Burczyk, Jankowska-Wróblewska et al., 2016b), silver poplar *Populus alba* (Lewandowski and Litkowiec, 2017; Wójkiewicz, Żukowska, Wachowiak and Lewandowski, 2019), elms *Ulmus*sp.(Chudzińskaet al., 2018; 2019), common yew *Taxus baccata* (Chybicki, Oleksa and Burczyk, 2011; Chybicki, Oleksa and Kowalkowska, 2012a; Chybicki and Oleksa, 2018; Litkowiec, Lewandowski and Wachowiak, 2018b; Litkowiec, Plitta-Michalak, Lewandowski and Iszkuło, 2015), field maple *Acer campestre* (Chybicki, Waldon-Rudzione and Meyza, 2014), silver birch *Betula pendula* (Bona, Kulesza and Jadwiszczak, 2019; Chrzanowska, Jadwiszczak, Kłosowski,Banaszek and Sozinov, 2016; Jadwiszczak, Jabłońska and Banaszek, 2011; Jadwiszczak, Drzymulska, Banaszek and Jadwiszczak, 2012; Jadwiszczak, Jabłońska, Kłosowski and Banaszek, 2015), downy oak *Quercus pubescens* (Chybicki, Oleksa, Kowalkowska and Burczyk, 2012b), Swiss pine *Pinus cembra* (Dzialuket al., 2014).

Due to negative effects of weather anomalies occurring more and more frequently in our region, it has become necessary to find long-term solutions related to the protection of endangered forest ecosystems in Poland, including protection of seed material from trees, shrubs and groundcover plants. As a result of the work undertaken, in the mid-1990s, the Kostrzyca Forest

Gene Bank, located at the foot of the Karkonosze Mountains, for which programme guidelines were jointly developed by representatives of the State Forests and the Institute of

Dendrology of the Polish Academy of Sciences (Zajączkowski G. et al., 2020), was opened.

4.4. Invasive species

In accordance with the applicable laws in Poland, the invasive tree species include ailanthus *Ailanthus altissima* (Regulation of the Minister of the Environment, 2011), as well as species of shrub-like nature, i.e.common gorse *Ulex europaeus*, Japanese knotweed *Reynoutria japonica*, Sakhalin knotweed *Reynoutria sachalinensis*, knotweed (medium) *Reynoutria×bohemica*.

Of the alien woody species commonly known to us, which exhibit the characteristics of invasive plants in free nature, mainly in forests, the following trees are mostly mentioned:black cherry *Prunus serotina*, red oak *Quercus rubra*, black locust *Robinia pseudoacacia,* ash-leaved maple *Acer negundo*and green ash *Fraxinus pennsylvanica*.The first three of them belong to the most frequently introduced foreign species in the past in forest areas in Poland. Today, each of them occurs on an area of at least several thousand hectares. The main, original purpose of their introduction was related to the expectations of obtaining high quality, valuable wood, but over time it turned out that foresters' hopes of achieving the expected production results were not fulfilled. Attempts to use black cherry *Prunus serotina* as a species with phytomelioration and biocoenotic function on the poorest forest soils did not bring positive results. Additional argument in favour of abandonment of cultivation, especially black locust *Robinia pseudoacacia* and black cherry *Prunus serotina*, became the difficulty in restoring the forest after felling of black locust and cherry shrubs.

Two other species–ash-leaved maple *Acer negundo*and green ash *Fraxinus pennsylvanica*, have rarely been introduced into the forests, but due to their ease of cultivation and rapid growth, they have often been used in tree-covered areas, from where, with the help of abundantly produced fruit, carried by wind and water, they have spread into free nature, above all into thicket clusters and riverside forests, often taking on a dominant role in the stand or shrub layer.

One might venture to say that if other trees and shrubs of foreign origin were to be grown on such a large spatial scale as the alien tree species already mentioned, the list of invasive plants recorded throughout the country would be much richer. This is demonstrated by spectacular cases of alien species taking over forests and thickets on individual sites or in one or more regions. Among a few places in the forests of western Poland, spontaneous, self-seeded, uniform and compact young stands and even older stands of introduced coniferous species are known, e.g. Eastern white pine *Pinus strobus*, western redcedar *Thuja plicata*and Canadian hemlock *Tsuga canadensis*. One of the most invasive shrub species turned out to be thesteeplebush *Spirea tomentosa*,whose numerous secondary sites were recorded in the Lower Silesian Forest, Niemodlinski Forest and Drawsko Lake District. There, it is not only an alien element of flora, which has a reducing effect on plant communities, but it has become a very burdensome plant for forest management, making it difficult to renew stands on wet and marshy habitats. A similar problem, but on a smaller territorial scale, is posed by thechokeberry *Aronia prunifolia*, in the marshes, and in the habitats of fresh mixed coniferous forests and deciduous forests–dwarf serviceberry *Amelanchier spicata* and service berry *Amelanchier lamarckii*, among others in the forests of Wielkopolska, Kujawy and Bolimowska Forest. The ability to spontaneously master different layers of forest communities was also revealed by such species as:red-osier dogwood *Cornus sericea*, common laburnum *Laburnum anagyroides,* hedge cotoneaster *Cotoneaster lucidus*, goat-leaf honey suckle *Lonicera caprifolium*, thicket creeper *Parthenocissus inserta*, woody vine *Clematis vitalba*, oriental bittersweet *Celastrus orbiculatus*, bitter-berry *Prunusvirginiana*and Turkey oak *Quercus cerris*.The conversion of scrub communities may be caused, among others, by: heart-leaved willow *Salix eriocephala,* common hackberry *Celtis occidentalis*, confused bridewort *Spireax pseudosalicifolia*, cherry plum *Prunus cerasifera*, Mahaleb cherry *Cerasus mahaleb*, multiflora rose *Rosa multiflora* and Himalayan blackberry *Rubus armeniacus* (Tokarska-Guziket al.,2012).

Chapter 5. State of diversity within trees and other woody plant species

5.1. General information

Genetic diversity allows species to evolve over time and space, and plays a key role for both the long-term survival of the species and the stability of forest ecosystems (Lindenmayer, Franklin and Fischer, 2006). Genetic diversity is therefore gaining increasing attention in forest management planning. It is considered to be an important element in managing the protection of species and habitats, especially for forest trees, which are long-lasting organisms (Aravanopouloset al., 2014).

In Poland, there are few comprehensive analyses of the level of genetic variability and genetic diversity of forest-forming species. The variability of microsatellite markers of the nuclear and chloroplast and (to a lesser extent) mitochondrial genomes is most often used for research. In seeking a correlation between adaptive capacity and climate change, researchers use the polymorphism of single nucleotides,using, inter alia, SNP markers (*Single Nucleotide Polymorphism*). ISJ markers are also used (*Intron-Exon Splice Junction*) together with the RAPD analysis (*Random Amplification of Polymorphic DNA*).

The genetic structure of the main forest-forming species in Poland is not fundamentally different from that in Europe, although many species are present at the edges of their natural occurrence, i.e. individual species show a high genetic variability within the population and a low genetic differentiation between populations.

Of the 61 Polish woody species included in the Global Tree Search database, 29 have information on the level of genetic variability and genetic diversity, of which 4 have a comprehensive knowledge of the entire natural range (Tab.5.1).

Tab.5.1 *The state of knowledge on the genetic diversity of woody species in Poland.*

No	Species	Endangered (YES/NO)	Protected (YES/NO)	Recognized genetic diversity (YES/NO)	Examples of publications	Genetic diversity poorly or very poorly recognised (YES/NO)	Examples of publications
1	Black elder *Sambucus*	NO	NO	NO	-	NO	-
2	Red elderberry *Sambucus*	NO	NO	NO	-	NO	-
3	Silver birch *Betula pendula*	NO	NO	NO	-	NO	-
4	Downy birch *Betula*	NO	NO	NO	-	NO	-
5	Common beech *Fagus sylvatica*	NO	NO	NO	-	YES	1. (Chybicki, Trojankiewicz, Oleksa,Dzialuk and Burczyk,2009) 2. (Meger,Ulaszewski, Vendraminand Burczyk,2019) 3. (Sułkowska, Gömöry and Paule, 2012) 4. (Krameret al., 2015)
6	Common yew *Taxus baccata*	YES Polish Red Book of Plants - category VU (exposed)	YES– partial protection	YES	1. (Chybickiet al.,2011) 2. (Chybickiet al.,2012a) 3. (Litkowiecet al.,2015) 4. (Litkowiecet al.,2018b)	NO	-
7	Bird cherry *Prunus padus*	NO	NO	NO	-	NO	-
8	Wild cherry *Prunus avium*	NO	NO	NO	-	YES	(Szyp-Borowska,Zawadzkaand Zajączkowski,2012)
9	Sessile oak *Quercus petraea*	NO	NO	NO	-	YES	1. (Dering i Chybicki,2012) 2. (Sandurska et al.,2019)

No	Species	Endangered (YES/NO)	Protected (YES/NO)	Recognized genetic diversity (YES/NO)	Examples of publications	Genetic diversity poorly or very poorly recognised (YES/NO)	Examples of publications
10	Downy oak *Quercus pubescens*	YES Polish Red Book of Plants - EN category (endangered). Polish red list of ferns and floral plants (2016) - EN category (endangered).	NO	YES	(Chybickiet al.,2012b)	NO	-
11	Pedunculate oak *Quercus robur*	NO	NO	NO	-	YES	1. (Burczyk et al., 2018) 2. (Dering I Chybicki,2012) 3. (Krameret al., 2015) 4. (Sandurska et al.,2019)
12	Midland hawthorn *Crataegus laevigata*	NO	NO	NO	-	NO	-
13	Single-seeded hawthorn *Crataegus monogyna*	NO	NO	NO	-	NO	-
14	Hawthorn *Crataegus rhipidophylla*	NO	NO	NO	-	NO	-
15	Common hornbeam *Carpinus betulus*	NO	NO	NO	-	NO	-
16	Common pear *Pyrus communis*	NO	NO	NO	-	YES	1.(Wolko,Antkowiak, Lenartowicz and Bocianowski,2010) 2. (Dolatowski,Nowosielski, Podyma, Szymańska and Zych, 2004)
17	European crab apple *Malus sylvestris*	NO	NO	NO	-	NO	-
18	Common juniper *Juniperuscommunis*	NO	NO	NO	-	NO	-

No	Species	Endangered (YES/NO)	Protected (YES/NO)	Recognized genetic diversity (YES/NO)	Examples of publications	Genetic diversity poorly or very poorly recognised (YES/NO)	Examples of publications
19	Wild service tree *Sorbus torminalis*	YES Polish red list of fern and flower plants (2016)-NT category (close to danger).	YES - strict protection	NO	-	YES	1. (Bednorzi Kosiński,2006) 2. (Jankowska-Wróblewskaet al., 2016b) 3. (Jankowska-Wróblewskaet al., 2016a)
20	Greek whitebeam *Sorbus graeca*	YES Polish red list of fern and flower plants (2016)- category DD (degree of danger cannot be specified).	NO	NO	-	NO	-
21	Common whitebeam *Sorbus aria*	NO	NO	NO	-	NO	-
22	Rowan *Sorbus aucuparia*	NO	NO	NO	-	NO	-
23	Swedish whitebeam *Sorbus intermedia*	YES Polish red list of fern and flower plants (2016) - EN category (endangered).	YES - strict protection	NO	-	NO	-
24	Common ash *Fraxinus excelsior*	NO	NO	NO	-	YES	(Nowakowskaet al.,2004)
25	Silver fir *Abiesalba*	NO	NO	YES	1. (Kempf,Zarekand Paluch, 2020) 2.(Masternak, Niebrzydowskaand Glebocka,2015) 3. (Dzialuket al., 2013) 4. (Pawlaczyket al.,2013)	NO	-

No	Species	Endangered (YES/NO)	Protected (YES/NO)	Recognized genetic diversity (YES/NO)	Examples of publications	Genetic diversity poorly or very poorly recognised (YES/NO)	Examples of publications
26	Sycamore maple *Acer*	NO	NO	NO	-	NO	-
27	Field maple *Acer Campestre*	NO	NO	NO	-	YES	(Chybicki,Waldon-Rudzione and Meyza,Chybickiet al.,2014)
28	Norway maple *Acer*	NO	NO	NO	-	NO	-
29	European bladdernut *Staphyleapinnata*	NO	NO	NO	-	NO	-
30	Alder buckthorn *Frangula alnus*	NO	NO	NO	-	NO	-
31	Common hazelnuts *Corylus avellana*	NO	NO	NO	-	NO	-
32	Small-leaved linden *Tilia cordata*	NO	NO	NO	-	NO	-
33	Large-leaved linden *Tilia*	NO	NO	NO	-	NO	-
34	European larch *Larix decidua*	NO	NO	NO	-	YES	1. (Lewandowski and Mejnartowicz, 1992) 2. (Lewandowski, 1995) 3. (Lewandowski and Burczyk, 2000)
35	Black alder *Alnus glutinosa*	NO	NO	NO	-	YES	(Mejnartowicz,2008)
36	Grey alder *Alnus incana*	NO	NO	NO	-	YES	(Dering, Latalowa, Boratyńska, Kosiński and Boratyński,2017)
37	Green alder *Alnus alnobetula*	NO	NO	NO	-	NO	-
38	Silverberry *Elaeagnus rhamnoides*	NO	YES - partial protection	NO	-	NO	-

No	Species	Endangered (YES/NO)	Protected (YES/NO)	Recognized genetic diversity (YES/NO)	Examples of publications	Genetic diversity poorly or very poorly recognised (YES/NO)	Examples of publications
39	Dwarf mountain pine *Pinus mugo*	NO	YES - partial protection	NO	-	YES	1. (Dzialuk, Boratyński, Boratyńska and Burczyk, 2012) 2. (Prus-Głowacki, Bączkiewicz and Wysocka)
40	Swiss pine *Pinus cembra*	NO	YES - partial protection	NO	-	YES	1. (LewandowskiandBurczyk, 2000) 2. (Dzialuket al., 2014) 3. (Wojnicka-Półtorak, Celiński, Chudzińska, Prus-Głowackiand Niemtur, 2015)
41	Scots pine *Pinus sylvestris*	NO	NO	NO	-	YES	1. (Androsiukand Urbaniak,2014) 2. (Wojnicka-Półtoraket al.,2017) 3. (Burczyket al., 2000)
42	Common buckthorn *Rhamnus cathartica*	NO	NO	NO	-	NO	-
43	Blackthorn *Prunus spinosa*	NO	NO	NO	-	YES	(Pelcet al.,2010)
44	Norway spruce *Picea abies*	NO	NO	YES	1. (Dering et al., 2012) 2. (Lewandowski et al., 2012) 3. (Litkowiec, Dering and Lewandowski, Litkowiec et al., 2009) 4. (Krameret al., 2015)	NO	-
45	Silver poplar *Populus alba*	NO	NO	NO	-	YES	(Dering, Rączka and Szmyt, 2016)
46	Black poplar *Populus nigra*	NO	NO	NO	-	YES	1. (Lewandowski and Litkowiec, 2017) 2. (Wójkiewicz et al., 2019)

No	Species	Endangered (YES/NO)	Protected (YES/NO)	Recognized genetic diversity (YES/NO)	Examples of publications	Genetic diversity poorly or very poorly recognised (YES/NO)	Examples of publications
47	Poplar aspen *Populus tremula*	NO	NO	NO	-	NO	-
48	European spindle *Euonymus europaeus*	NO	NO	NO	-	NO	-
49	Wych elm *Ulmus glabra*	NO	NO	NO	-	YES	(Chudzińska et al.,2018)
50	Field elm *Ulmus minor*	NO	NO	NO	-	YES	(Chudzińska et al.,2019)
51	European white elm *Ulmus laevis*	NO	NO	NO	-	NO	-
52	White willow *Salix alba*	NO	NO	NO	-	NO	-
53	Dark-leaved willow *Salix myrsinifolia*	YES Polish red list of fern and flower plants (2016) - NT category (close to danger).	NO	NO	-	YES	(Mirskiet al.,2017)
54	Goat willow *Salix caprea*	NO	NO	NO	-	NO	-
55	Bay willow *Salix pentandra*	NO	NO	NO	-	NO	-
56	Purple willow *Salix purpurea*	NO	NO	NO	-	YES	1. (Sulimaand Przyborowski,2013) 2. (Sulima,Prinzand Przyborowski, 2018)
57	Bitter willow *Salix eleagnos*	NO	NO	NO	-	NO	-
58	Grey willow *Salix cinerea*	NO	NO	NO	-	NO	-
59	Almond willow *Salix triandra*	NO	NO	NO	-	NO	-
60	European violet willow *Salix daphnoides*	NO	NO	NO	-	NO	-
61	Basket willow *Salix viminalis*	NO	NO	NO	-	NO	-

The results of genetic analyses of the main forest-forming tree species in Poland and selected admixture species are presented below, described on the basis of available literature published after 2011, i.e. since the last edition of *The National Report on Forest Genetic Resources - Poland* (Kozioł and Matras, 2013).

5.2. Common yew *Taxusbaccata*

The common yew *Taxus baccata* is an example of a rare and endangered species that needs to be protected both *ex situ* and *in situ*. The common yew *Taxus baccata*, considered to be a Tertiary relic, once a forest-forming species with a wide range and important ecological and economic importance (Szafer, 1954), deserves an attempt to restore its function in nature and its usefulness to man. Slow growth, dioecy, problems with renewal and the use of clear-cut felling have led to the phenomenon of the extinction of this species in Poland. In addition, the difficulties in propagation and its low competitiveness in relation to other forest tree species have meant that it has never formed compact and pure stands. Common yew *Taxus baccata* sites in Poland are often characterised by their natural origin. However, these sites are scattered and usually far away from each other. Such a location may significantly contribute to spatial isolation with its negative consequences. An increase in fragmentation and isolation of the population and reduction in the effective size of the population may cause erosion of gene pools through increased genetic drift, increased inbreeding mating, limited gene flow and decreased migration rate. As a result, local populations may lose genetic variability, and consequently their vitality and adaptability may decrease.

Genetic analyses to date, based on isoenzyme markers and DNA markers, show that the common yew *Taxus baccata* in Poland is characterised by a high genetic variability within the population and significant genetic diversity between populations (Chybicki et al.,2011; 2012b; Lewandowski, 1995; Litkowiec et al.,2015; 2018b, Zarek, 2009).

A comprehensive study was conducted in Poland to determine the level of genetic variability and differentiation of 31 natural populations of common yew *Taxus baccata* (2,725 individuals) and the impact of demographic processes on the genetic structure of the species using a set of 5 nuclear microsatellite loci SSR (Litkowiec et al., 2018b). The conducted research is a supporting element of the State Forests National Forest programme entitled "Common yew (*Taxus baccata* L.) conservation and restitution programme in Poland". The research complemented the existing knowledge of the genetic structure of common yew *Taxus baccata*, thanks to which Polish populations are among the best known sites of this species in Europe. It was found that most of the studied populations had a high level of genetic variability, comparable to the populations of this species from Western Europe. In general, with the exception of 2 populations, the level of genetic variability of the other common yew *Taxus baccata* populations in Poland was similar. The mean value of the allele richness parameter (AR) for the studied populations was 8.5. The lowest level of mean allele richness in locus was found in Bogdaniec population (AR = 2.4) and the highest in Cisowa Góra population (AR = 12.5). The expected heterozygosity ranged from 44.4% in Bogdaniec population to 83.9% in Cisy population near Bard, with the average 74%. In the studied populations the level of observed heterozygosit (Ho) was usually lower than the level of expected heterozygosit (He). It ranged from 26.2% (Bogdaniec population) to 59.3% (Cisy w Czarnem population), with the average value of 47.8%

An important level of differentiation between populations has been estimated, which mainly reflects the effect of genetic drift (the mutation effect is negligible, as the permutation test for R_{ST} showed). Spatial isolation significantly affects the genetic structure of the species, as confirmed by the Mantel test. The overall genetic differentiation among the populations was 15.5%. This means that the main component of the overall variability in the analysed populations is contained in intra-population variability. The genetic diversity of common yew was comparable to other temperate climate forest tree species, which usually have a high level of intra-population genetic variability. Significant genetic distances between closely lying populations were also found. This is probably due to the spatial isolation of the population and the genetic processes associated with it. Against this background, there is little population differentiation between regions of occurrence.

The geographical isolation of the common yew population has also contributed to an increase in homozygosity and inbreeding of the population by reducing the number of mating individuals. The limited gene flow through pollen and seeds leads to the consolidation of the family structure in the populations and thus to an increase inbreeding mating. In all studied populations, the proportions of genotypes differed from those typical of panmictic populations. In most cases, a significant excess of homozygotes was recorded. The level of inbreeding (after taking into account the presence of null alleles) ranged from 1 to 35%, with an average of 9%. The highest inbreeding rate was found in the population of Czerska Struga (F_{IS} = 0.35), while the lowest in the populations of Bogdaniec and Boleszkowice (F_{IS} = 0.01). The recorded inbreeding rate should be interpreted as relatively high, considering that the common yew *Taxus baccata* is a dioecious species.

All the populations surveyed have experienced demographic processes, such as the bottleneck effect, and significant variations in population size. The estimated values of effective population size ranged from 8 (Boleszkowice, Bogdaniec populations) to 56 (Cisowa Góra) and were generally lower than those observed in trees forming large, continuous populations.

The active protection of the common yew *Taxus baccata* requires, among other things, an answer to the question from what source to obtain reproductive material in order not to cause erosion of the gene pool of the species. In general, the results obtained so far suggest that the choice of population for *ex situ* conservation, based solely on its census size, is often misleading. Relatively large populations have high levels of inbreeding and low levels of genetic variability within the population. In contrast, populations with much smaller census sizes may have a low level of inbreeding and a high level of genetic variability. It would seem that populations of large numbers of individuals will have higher parameters of genetic variability, so any action taken to conserve genetic resources should be preceded by a thorough analysis of the level and distribution of genetic variability of the species.

5.3. European silver fir *Abiesalba*

The natural range of Silver fir *Abiesalba*in Poland was formed in the sub-Atlantic period, about 2,000 years ago. In Poland silver fir *Abiesalba*reaches its north-eastern limit of natural range. This boundary runs along the parallel 52°N, from the Silesian Lowland along the northern edge of the Belt of the Lublin Upland and Roztocze. The natural range of this species in our country is relatively small and is usually fragmented (it only creates larger clusters in some sites). Silver fir *Abies alba*alba occurs mainly in the southern part of Poland, mainly in the Carpathians, Sudetes and Swietokrzyskie Mountains, and in smaller quantities in Roztocze.

To date, there are only a few reports based on isoenzyme tests and DNA markers and provenance research on the variability of the gene pool of silver fir *Abies alba* in Poland. They indicate a lower level of genetic variability in populations and higher genetic diversity in population than in the case of other coniferous species (Lewandowski, Filipiak and Burczyk, 2001; Mejnartowicz, 2004). In addition, these studies confirm the hypothesis of the existence of 2 separate gene pools of European silver fir a*bies alba* in Poland. The results of provenance research also indicate separate origins of populations from these regions (Barzdajn, 2009; Skrzyszewska, 2006). Hence, it is likely that the Sudetes were colonised by populations originating from the refuge located in northern Italy and the eastern Carpathians by Balkan populations (Ralska- Jasiewiczowa, 2004). However, this is not confirmed by recent studies of 10 populations from Poland using a maternally inherited mitochondrial DNA marker (Pawlaczyk, Kroplewska and Bobowicz, 2013). However, these studies do not take into account the possibility of participation of the Balkan pollen pool in the creation of Polish populations of the silver fir *Abies alba*. Molecular markers are also used to try to identify the origin of the population. Dzialuk et al. (2013) analysed the level of genetic variability and origin of the silver fir *Abies alba* in two artificial plantings in the Osusznica Forest District in Pomerania. The obtained results showed that populations from Osusznica differ in the level of genetic variability. The fir from the western part of this forest district was characterized by a high level of genetic variability, comparable to the level of genetic variability of populations growing within the natural range. On the other hand, the low level of genetic variability of the population coming from the eastern part of the area could be influenced by genetic drift and the founder's effect, as a result of using seeds harvested from a small number of trees. The authors suppose that the likely source of seeds for the population in Osusznica was the Sudetes, as mitochondrial DNA analyses confirmed the presence of one allele, characteristic of the Apennine refuge population.

Comprehensive research, which was based on the analysis of 88 populations of silver fir *Abies alba* (1,810 individuals), originating from its entire natural range in Poland, with the use of mitochondrial DNA (mtDNA) inherited exclusively in the maternal line and paternal line - chloroplast DNA (cpDNA) inherited in the paternal line, unequivocally demonstrated that the entire population of silver fir *Abies alba* in Poland, in the maternal line, comes exclusively from Apennine refuge (100% share of allele 1 of the size 230 pz characteristic of Apennine refuge). In the paternal line it comes from 2 separate refuges - Apennine and Balkan. The share of individual haplotypes was very different in the studied populations. There was also no clear geographical trend in the percentage share of these alleles in populations. Both haplotypes were found to occur simultaneously in all studied populations. Haplotype A, characteristic for the Balkan refuge, was found with a range of 15-85%, while haplotype B, characteristic for the Apennine refuge, with a 20-80% range. Both haplotypes were found with a similar mean frequency: 47% for the Balkan refuge and 53% for the Apennine refuge (Litkowiec et al., 2015). Genetic analyses, carried out using nuclear DNA (unpublished data, publication in preparation) inherited from both parents, based on an identical population set of the silver fir*Abies alba*, showed a high level of genetic variability (He = 0.709; AR = 6.4; Ae = 4.1). The level of genetic variability of silver fir*Abies alba* corresponds to the level of variability of species such as Scots pine *Pinus sylvestris* or oaks *Quercus* sp., which are considered to be the most variable. The heterozygotic deficit (inbreeding) in the studied populations of European silver fir *Abies alba* was low (Fis = 0.038) and mainly caused by underestimation resulting from the presence of null alleles. The observed level of genetic diversity of Polish populations (Fst = 7.6%), was 2 times higher than that estimated for 41 populations originating from the Ukrainian Carpathians (F_{ST} = 3.5%, p<0.001) (Gömöry, Paule, Krajmerová, Romšáková and Longauer, 2012). This is not surprising if we consider that all Polish populations are of hybrid origin, as opposed to Ukrainian populations. However, compared to other forest tree species in Poland, this diversity is slightly higher. For Norway spruce *Picea abies* it is 2.8% (Lewandowski and Burczyk, 2002), and for European larch *Larix decidua*: 4% (Lewandowski and Mejnartowicz, 1992). The results obtained with the use of nuclear microsatellite markers do not confirm the results of the research to date, which speaks about the genetic distinctiveness of the population of the Sudetes fir from the Carpathians fir. This result is consistent with the results obtained from analyses of mitochondrial and chloroplast DNA, because all Polish populations of silver fir *Abies alba* in the maternal line (tracing seed dispersions) come only from Apennine refuge. However, in the paternal line (tracing pollen dispersions), there are two separate refuges - Alpine and Carpathian, without clear geographical differentiation.

This fact indicates that the possible genetic differentiation, which resulted from isolation during the last glacial period, was modified in Poland by distant transport of pollen from the Balkan refuge.

5.4 Norway spruce *Picea abies*

The Norway spruce *Picea abies* naturally grows throughout Poland, with the exception of Western Pomerania and Wielkopolska, where it is bred artificially. It is most common in Eastern Pomerania and in the mountains. In Eastern Pomerania, Norway spruce *Picea abies*, after Norway pine *Pinus sylvestris*, is the most important component of forests. Its occurrence is optimal in the south and in the mountains, where it grows from their foot to the alpine level. The natural stands are formed in the upper forest level and upper parts of the lower forest level. The genetic structure of contemporary populations of Norway spruce *Picea abies* in Poland results from numerous processes. The most important one was the natural formation of the range during the spreading of the species after the last glacial period. Additionally, the natural process of shaping the range was also influenced by human activities connected with deforestation and establishment, since the beginning of the 19th century, of artificial spruce secondary forest plantations, usually from seeds of unknown origin.

It is assumed that after the last glacial period Norway spruce *Picea abies* entered our country from the Carpathian refuge (in the late glacial period) and north-eastern refuge (in the boreal period). The meeting of migrating spruces from both refuges probably took place in the Atlantic period in a belt running along the middle and lower Bug River. It is an area of the so-called "Central European disjunction" and a territory occupied today by the Białowieża Forest. This is confirmed by comprehensive research on the post-glacial history of Norway spruce *Picea abies* in Poland carried out at the Institute of Dendrology of the Polish Academy of Sciences in Kórnik. 1,353 trees, coming from 58 populations, from the natural range of this species in Poland were analysed, using the DNA mitochondrial marker (mtDNA nad1) inherited only in the mother line (Dering and Lewandowski, 2009; Litkowiec, Dering and Lewandowski, 2009).

Until the time of research using exclusively inherited in the mother line mitochondrial DNA markers, it was believed that after the last glacial period, the Norway spruce *Picea abies* came only from the north-eastern refuge into the Białowieża Forest and the area was included in this range. However, research conducted at the Institute of Dendrology of the Polish Academy of Sciences in Kórnik using mitochondrial DNA markers marked “nad1” and “mt15-D02” (Dering and Lewandowski, 2009; Dering, Misiorny, Lewandowski and Korczyk, 2012; Nowakowska et al, 2017) have unequivocally indicated that the Białowieża Forest region is a meeting place for two ranges of Norway spruce in Poland - north-eastern (Nordic-Baltic) and southern (Hercynian-Carpathian). The Norway spruce *Picea abies* of Carpathian origin in the mother line is more numerous.

Research was carried out (publication sent to print, Lewandowski et al., Sylwan, 2020), in which analyses covered 48 stands of Norway spruce *Picea abies* growing in 3 forest districts: Białowieża, Browsk and Hajnówka. The focus was on production stands only and mainly younger than 100 years. In total, 854 trees were analysed, including 214 trees from Browsk Forest District (13 stands), 249 trees from Białowieża Forest District (13 stands) and 391 trees from Hajnówka Forest District (22 stands). The applied marker mt15D02 allowed to identify haplotypes of northern, southern (Carpathian) and alpine origin. Not a single tree of alpine origin was found in the material studied. Norway spruce *Picea abies* of alpine origin, as it is assumed, was artificially dragged with the import of seeds of foreign origin into our country. In general, there were slightly more trees of Carpathian origin (55% on average) than north-eastern (45% on average). In the following years, the research using the same mitochondrial DNA marker inherited in the maternal line was carried out to verify the post-glacial origin of Norway spruce *Picea abies* trees growing in the Gołdap Forest District and Skrwilno Forest District (Lewandowski, Litkowiec, Grygier and Dering, 2012). In the western part of the "spruceless zone", located today in the Skrwilno Forest District (Regional Directorate of the State Forests in Toruń) and according to Jedliński, which belongs to the natural range of Norway spruce *Picea abies*, the study covered 9 populations (8 in the Skrwilno Forest District and 1 in the Dwukoły Forest District). In 3 of the studied populations, all 3 fragments of mitochondrial DNA were found (southern, northern and alpine mitotypes), but their share in the populations was varied. In the remaining 6 populations, trees of Carpathian origin were identified. According to a previous study (Litkowiec et al., 2009), in the area constituting the western end of the "spruceless belt", the occurrence of an alien, imported with seeds, alpine mitotype could be expected, similarly to other parts of this belt. However, its limited number indicates that in the area under study, unlike in the rest of the belt, spruce planting with foreign material was sporadic. Identical research was conducted in the north-eastern part of the natural range of Norway spruce *Picea abies* in Gołdap Forest District, where the following number of trees were studied: 24 mother trees growing in 6 forest districts, 115 trees from Boczki, Dziki Kąt, Mechacz, Wielkia Struga, Żytkiejmska nature reserves, 467 trees from 21 production seed stands and 148 trees from 4 selected seed stands; it was found that the trees belong to all 3 lines: Alpine, Carpathian and north-eastern. Pollution of spruce stands in the Gołdap Forest District with foreign material of southern origin is not entirely surprising, as previous studies have indicated this possibility. The scale of this phenomenon is a big surprise. Practically, there are no areas in the Forest District free of Norway spruce trees of foreign origin, having an alpine mitotype. The places where no trees of foreign origin were found were nature reserves. However, a very worrying fact is the finding of foreign material (of Alpine origin) contamination of the local seed base, in the form of some maternal trees, production seed stands, and especially selected seed stands. On the basis of results using mitochondrial DNA, inherited in the maternal line, especially the mitochondrial DNA marker "mtD02", it is worth emphasising its great application significance for the verification of the origin of Norway spruce *Picea abies* in Poland, especially trees which constitute the seed base.

In Poland there is a high variability of Norway spruce *Picea abies*, resulting from morphological and physiological adaptations to the different habitats in which the species lives. The high racial variability in Poland is not reflected in the results of research usingisoenzyme markers (Lewandowski and Burczyk, 2002), where the inter-population variability accounts for only less than 3% of the total species variability. A relatively even gene pool can be the result of the natural process of gene flow among origins through pollen and the mixing of seed material by people. These studies have confirmed the high level of genetic variability of our populations. On average more than 70% of the loci were polymorphic, the average and effective number of alleles in the locus is: 2.17 and 1.26, respectively, and the expected heterozygosity is 0.156. These values do not differ from the data obtained for other populations of the Norway spruce *Picea abies* in Europe, obtained from isoenzyme markers (Fst = 5.3%).

Subsequent research carried out in 20 natural stands of Norway spruce *Picea abies* in Poland by employees of the Forest Research Institute (Nowakowska J. A., 2009), using both mitochondrial and nuclear DNA markers, confirms the hypothesis of the post-glacial history of this species. Additionally, the level of genetic variability and differentiation of the studied populations was estimated. Based on the results obtained from the analysis of nuclear microsatellite loci, the authors concluded that the studied populations have a high level of genetic variability (Ae = 16.17, H_T = 0.851). The overall level of genetic diversity expressed by parameter Fst between 20 tested stands was moderate and amounted to 8.8%. For the north-eastern spruce region, Fst was 8.7%, a slightly lower level of genetic variation was recorded between populations coming from the southern range (Fst = 8.5%), while among populations of this species from the spruceless belt, the level of genetic variation was two times lower and amounted to 3.5%.

Over the last decades, there has been a process of mass extinction of spruce forests in some parts of our country. The most serious problem affected the Sudetes in the 1980s and 1990s and now the Beskids, which often resulted in the complete destruction of forest stands. While the dying out of spruce trees in the Sudetes was initiated by industrial pollution, the current problem of dying out in the Beskids is mainly related to the distortion of the composition and structure of the stands caused by forest management and the postponement of decisions related to the felling and conversion of mature stands. Uncontrolled mixing of spruces of different origins may cause difficult to define silvicultural consequences in our country.

In the last two centuries, significant amounts of Norway spruce *Picea abies* of Alpine origin have been brought to Poland. There is practically no area free of this origin. Its presence was found in half of the populations studied so far. The contamination of the population with Alpine spruce varies from several percentage points to 100%. It is even found in maternal microregions which have been set up to protect native ecotypes and among maternal trees. As in other countries, genetic diversity can be threatened by the fragmentation of continuous forest areas and the uncertain reaction of the species to the expected droughts associated with global warming. A serious threat to the species, especially in areas with different forms of nature conservation, is the failure to take action against the bark beetle *Ips typographus*, which is the most serious biotic threat to Norway spruce *Picea abies*.

5.5. Black poplar *Populus nigra*

In Poland, as in the whole of Europe, black poplar *Populus nigra* is one of the main species of woody specied of riparian forests. It can be found throughout the country, with the exception of Western Pomerania and north-eastern areas. It is most abundant in the valleys of the Vistula River and its larger tributaries. Fragments of willow-poplar riparian forests, with black poplar *Populus nigra*, have also survived in the valley of the central Warta River, the upper and central Oder River and in the valleys of the Podkarpacie rivers, flowing into the Vistula. This species was also often planted by roads and in parks. In the black poplar *Populus nigra* the intra-species variability is very clear, so at least there are 3 subspecies of this tree. It is assumed that in south-eastern and Central Europe (including Poland) and in Siberia, the sub-species *Populus nigra* ssp. *nigra* is found. The most characteristic signs of individual variability are the trunk and crown construction features. Black poplar *Populus nigra* crosses easily with cultivated poplars of hybrid origin, therefore there are often difficulties in determining the species purity of individual trees. Nowadays, as a result of centuries of human activity carried out within large lowland rivers, it is classified as a rare and endangered species in Europe, as well as increasingly rare in Poland.

So far, there is very little information on the level and degree of genetic diversity of black poplar *Populus nigra* from Polish areas, including the frequency of occurrence of pure-bred and hybrids. In 2016, 52 individual trees from the population of Dęblin at the Vistula River (Lewandowski and Litkowiec, 2017) were tested. To analyse genetic variability and spatial genetic structure, 10 nuclear microsatellite loci in the population of very old trees were used. The studied population had a high level of genetic variability (He = 0.792, Ho = 0.731, A = 14.7), which was similar to other natural European populations. The results showed that sexual reproduction is the dominant mode of reproduction in the studied population, leading to a high genotypic richness (R = 0.91). 47 unique genotypes were identified. In addition, no spatial genetic structure was detected, which indicates random, spatial distribution of genotypes. Both seeds and black poplar *Populus nigra* pollen are widely dispersed by the wind, which explains the lack of spatial structure in the population. However, it is possible that the original genetic structure of the population may have been distorted by man.

In the latest research of 360 individuals (seedlings and adult trees) from the area of the Vistula River, 14 nuclear microsatellite loci were used to determine the level of genetic and clonal variability and genetic differentiation. Additionally, using the chloroplast marker cpDNA *TrnS - trnfM* and nuclear marker (nDNA) *Win3*, potential hybrids were identified in subsequent generations. The results indicate high level of genetic variability of the species (A = 12.17, Ae = 6.01, Ho = 0.680, He = 0.77). In 5 of the studied populations private alleles were identified (32 in total) (Wójkiewicz et al., 2019). The level of genetic variability was comparable between adults and their offspring, the gene pool was homogenous. Overall, the inter-population genetic variation in Poland was low at 0.34%. There were no strong interferences in random spatial distribution of genotypes in the studied populations, and there was no spatial genetic structure. Low spatial genetic structure was observed in 2 groups of seedlings and among individuals from the Wysoczyn population. Low clonality level was found in the analysed populations. Genotypic richness was R = 92% for Dęblin and R = 83% for Wysoczyn populations, where repeated genotypes were found. The mean inbreeding rate was low and was Fis = 0.009 and was statistically significant in all populations. The studied populations showed a high effective population size, with the mean Ne = 192.6. The studied populations showed signs of bottleneck effect. Most of the examined trees were classified as "clean" with a probability higher than 90%. Nine hybrid specimens were found among one year old poplar seedlings. The obtained results confirm previous reports on the genetic structure of black poplar *Populus nigra* in Europe.

5.6. European larch *Larixdecidua*

The great diversity of climatic and ecological conditions in which the European larch *Larix decidua* is found has favoured the production of local breeds and a number of ecotypes. Currently it is assumed that there are 3 subspecies or breeds of larch in Poland: the Sudetes larch variety *Larix decidua subsp. decidua var. sudetica*, Polish larch *Larix decidua subsp. polonica* and the Tatra larch variety *Larix decidua subsp. decidua var. adenocarpa*. The occurrence of the Sudetes larch is limited to the north-eastern Sudetes. It grows here at an altitude of between 300 and 800 metres above sea level, at a transition between oceanic and continental climate. In the Tatra Mountains, the local breed of European larch grows up to the upper forest boundary, in the form of single trees, with the Norway spruce *Picea abies* and Swiss pine *Pinus cembra*. In the lower parts it is mainly found with the Scots pine *Pinus sylvestris*. The centre of the occurrence of the Polish larch is located in the Świętokrzyskie Mountains.

It is found here in an area with an elevation from 150 to 600 m above sea level, where a moderate continental climate prevails. In addition, the European larch *Larix decidua* is grown throughout the country as a valuable admixture tree.

Studies using isoenzyme markers indicate that as much as 96% of the total species variability is realised within the population, and only 4% is attributable to inter-population variability (Lewandowski, 1995; Lewandowski and Burczyk, 2002; Lewandowski and Mejnartowicz, 1992). Of the group of European larches, the Sudetes larch is the most variable and diverse and the Alpine larch is the least variable. These studies have not confirmed the species distinctiveness of the Polish larch. Populations of the European larch *Larix decidua* are characterized by a relatively high level of genetic variability. On average, over 50% of the studied isoenzyme loci are polymorphic. The mean and effective number of alleles in locus for Polish populations ranges from 1.89 to 2.11 and 1.18 to 1.19, while the mean expected heterozygosity ranges from 0.15 to 0.16. All these values do not differ from the parameters calculated for the species throughout its range of occurrence.

The research using a set of 11 nuclear microsatellite loci included 3 populations of Polish larch from Chełmowa Góra (2 adults, 1 juvenile) and showed a high level of genetic variability (He = 0.752, Ho = 0.75) and a low level of genetic variability (Fst = 2.2%) of larch growing on Chełmowa Góra, similar to that reported in the literature for the European larch *Larix decidua* population in Europe (Litkowiec, Lewandowski and Burczyk, 2018a). The effective population size was large and homogeneous between subpopulations (mean Ne = 90.7). Additionally, the spatial structure of the studied populations was analysed. The spatial genetic structure was found in 2 older populations, which suggests their natural origin - the creation by natural sowing. The supposition that the adolescent subpopulation was formed in an unnatural way (not from natural sowing of seeds) was confirmed, as evidenced by the lack of genetic spatial structure and that it most probably did not originate from seeds from Chełmowa Góra.

The occurrence of natural populations in the form of small groups of scattered trees may adversely affect the genetic processes in the populations. Nevertheless, in Polish populations of European larch *Larix decidua*, a high level of genetic variability and small inter-population differentiation has been found so far. The exception is the population from Chełmowa Góra, which seems to have originated from sowing a small number of curved trees. The European larch *Larix decidua* may sometimes even experience significant self-fertilisation, due to the low volatility of airborne pollen without air chambers, resulting in a large number of empty seeds. Despite the high mortality rate of embryos produced after self-fertilisation, some of them survive. Calculated on the basis of isoenzyme markers, self-fertilisation for full seeds is usually a few percent, with this value varying among the trees and populations studied. As in the whole of Europe, the threat to the species purity of European larch *Larix decidua* in Poland may be posed by the stands of hybrid larch from Japanese larch *Larix kaempferi*. They are found all over the country, but mostly in Western Pomerania.

5.7. Pedunculate oak *Quercus robur*, sessile oak *Quercus petraea*

The use of microsatellite DNA markers allows not only to estimate genetic parameters, but also to differentiate species belonging to the same genus, e.g. pedunculate oak and sessile oak. Morphological differences are not always fully sufficient to differentiate between species that are co-occurring on a given site, especially when it comes to seedlings.

Sandurska *et al.* (2019) have studied the genetic and species diversity of adult specimens and seedlings of natural origin of 2 species of oak: the pedunculate oak (also known as English oak, *Quercus robur*) and the sessile oak (*Quercus petraea*), growing in the *Jamy* Nature Reserve in north-central Poland. The purpose of creating this reserve was to protect beech communities: *Galio odorati-Fagetum* and *Luzulo pilosae-Fagetum*. The trees are dominated by oaks, over 215 years old, with DBH (diameter at breast height) about 100 cm.

Using a set of 19 microsatellite loci, specimens of species have been identified, assigned to one of the 2 genetic clusters, defined using STRUCTURE software v. 2.3.4 (Pritchard, Stephens, and Donnelly, 2000). Genetic identification was particularly important for seedlings, for which it is difficult to clearly identify the species.

Both oak species showed a similar level of genetic diversity, both in adult and juvenile groups. Analysis of 19 microsatellite markers showed extremely high polymorphism of selected loci. In the case of adult pedunculate oak (*Quercus robur*) trees, the number of alleles per locus ranged from 5 to 30, with an average of 15.158 (± 7.338) and a similar value of the allelic richness (15.052). In the seedlings of the pedunculate oak (*Quercus robur*) a slightly higher average number of alleles as well as average allelic richness (about 16.7) has been noted.

The mean observed heterozygosity (Ho) was at the same level as the mean expected heterozygosity (He), both in adults and seedlings, which caused the inbreeding rate (Fis) to be close to null. The frequency of the null alleles was generally low. In adult trees significant levels of null alleles have been observed only for 2 loci (QrZag11, QrZag65) and in seedlings for 5 loci (PIE242, PIE243, QrZag101, QpZag110, QrZag65). Nevertheless, considering the presence of null alleles, a low but significant level of inbreeding has been observed only for seedlings (Fis = 0.0115, 95% CI: 0.0065–0.0163).

The analysis of genetic diversity in adult sessile oak (*Quercus petraea*) trees showed slightly lower average values of population genetic parameters than those observed in pedunculate oak (*Quercus robur*). The average number of alleles per locus was 13.368, ranging from 6 (QrZag112) to 27 (QrZag65). The value of the allelic richness factor was similar to the average number of alleles (13.269). In the case of seedlings, these parameters had values similar to the pedunculate oak (*Quercus robur*), except for the effective number of alleles, which was the lowest of all the examined groups.Similarly, as in the case of the pedunculate oak (*Quercus robur*), the values of expected heterozygosity He = 0.778 (± 0.128) and observed heterozygosity Ho = 0.773 (± 0.106) were similar, which resulted in a low value of the inbreeding rate equal to -0.0035. Most loci had statistically insignificant levels of null alleles, only for 3 loci in adults (PIE102, QrZag20, QrZag7) and 5 loci in seedlings (QpZag15, QrZag65, QrZag7, QrZag87, QpZag9) the level of null alleles was significantly different from zero. It was found that the level of inbreeding estimated considering the presence of null alleles is statistically significant only for seedlings (Fis = 0.0184, 95% C.I.: 0.0115–0.0252).

Genetic differences between various groups of individuals within the same species were generally low and not statistically significant. The consistency between Fst and Rst coefficients suggests that the main reason for the genetic differences between the parent and offspring populations within the species was genetic drift. A significant level of genetic differentiation between species has also been noted. The differences between parameters Fst and Rst - during the analysis of both oak species showed that inter-species diversity is also the result of mutations occurring during the process of differentiation of these species.

The level of the effective population size (Ne) proved to be slightly higher for pedunculate oak (*Quercus robur*) than for sessile oak (*Quercus petraea*).

The genetic structure parameters obtained by this study in the *Jamy* Nature Reserve were similar to those observed by other authors (Burczyk, Chybicki and Trojankiewicz, 2018; Cottrell *et al.*, 2003; Curtu, Craciunesc, Enescu, Vidalis and Sofletea, 2015; Neophytou, Aravanopoulos, Fink and Dounavi, 2010; Streiff *et al.*, 1998). However, an interesting aspect of population genetic testing is how genetic variability is transmitted from adult generation to offspring. This is particularly important for populations where natural regeneration occurs.

Genetic diversity is important to ensure the adaptability of forest trees to changing biotic and abiotic factors.Kramer *et al.* (2015) developed a concept for genetic monitoring using genetic and population factors to estimate changes in genetic diversity. Material from adults, seedlings, and seeds of 4 European forest species, common beech (*Fagus sylvatica*), oaks (*Quercus sp.*), Norway spruce, *Picea abies*) and maritime pine (*Pinus pinaster*) were used for the analyses.In the analyses, in which 2 types of nuclear genetic markers were used, i.e., microsatellite (SSR) markers and single-nucleotide polymorphism (SNP) markers, the spatial configuration of the stands (spatial location of adults and seedlings), demographic parameters (DBH) and geographical location were checked together with genetic parameters in order to find the correlation of genetic diversity.

Among the stands selected for analysis was the stand of the pedunculate oak (*Quercus robur*) from *Lubartów*. DNA from dried leaves or wood was extracted according to the protocol (Dumolin, Demesure and Petit, 1995), and then a set of 8 nuclear SSR markers described by Guichoux *et al.* (2011) was used to genotype the individuals. Separation of the fragments took place in the ABI 3730 capillary sequencer and DNA fragment length analysis was performed using GeneMarker v. 2.4.0 programme.Then samples from adults and seedlings were genotyped with SNP.

In order to describe the genetic diversity of the population, the values of the following genetic parameters were estimated: effective number of alleles (Ae), disordered number of single locus genotypes (NG), intrapopulation inbreeding coefficient (Fis) and genetic distance (*Gregorius*) between adults and seedlings.

In the case of the stand of pedunculate oak (*Quercus robur*) from Poland the results were as follows: the effective number of alleles in adults and seedlings was Ae = 5.866 and Ae = 5.511 respectively, the disordered number of single locus genotypes was NG = 269 among trees and NG = 147 among seedlings, the value of the Fis coefficient was: Fis = 0.0085 for adults and Fis = 0.0169 for seedlings. The genetic distance (*Gregorius*) between adults and seedlings was 0.176. This can be explained by the low number of available seedling genotypes.

No signs of inbreeding were found in adult oak trees (or in the other species studied), which is consistent with their vital signs (high population size, high crossing rates, extensive gene flow within and between populations, low level of genetic affinity within populations, etc.).

The authors of the publication, based on the results obtained, recommend that when genetic monitoring is carried out: taking samples only from adults and seedlings, using only one type of molecular marker (SNP) and taking material for analysis from at least 100 adult trees and 100 seedlings, respectively distributed in the stand. In order to provide access to information on the dynamics of changes in genetic diversity, the analysis should be repeated every 10 years.

The process of adaptation of forest trees can be facilitated if the seeds resulting from the crossbreeding of adults of different provenance will be used to establish a seed orchard.Burczyk *et al.* (2018) characterized the genetic diversity of the pedunculate oak (*Quercus robur*) orchard, which is considered a possible source of highly diverse seed lots. For the study, a provenance/national experiment with repetitions from *Oleszyce* in Poland, consisting of 8 to 19 families of 6 Polish provenances, has been selected.Using 16 nuclear microsatellite markers 1,812 trees were genotyped. The standard genetic parameters of the population were calculated, and genetic variability and inbreeding were compared between provenances. The mean value of expected heterozygosity was He = 0.847, while allelic richness AR = 23.5. The value of inbreeding factor was close to zero (Fis = 0.006), and the level of genetic diversity among provenances was Fst = 0.016.

A high allelic differentiation (Ast = 0.137) was also found between provenances, although an uneven share of each origin in the total allelic richness was noted. The effective population sizes, estimated for each origin, were highly correlated with the number of families within the provenance.The research carried out indicates that provenance experiments of different origins of a given species are an extraordinarily rich source of reproductive material which is genetically diverse and, consequently, adaptive. This material, especially after checking genetic parameters, should be a source for new afforestation or for strengthening existing populations, as well as in species conservation projects - especially in the face of climate change.

5.8. Field elm *Ulmus minor*

The field elm (*Ulmus minor*), also known as the common elm, occurs in Poland in lowlands and foothills, mainly in river and stream valleys, in riparian forests and in forests growing on sunny and often quite dry slopes (Napierała-Filipiak, Filipiak and Jaworek, Napierała-Filipiak *et al.*, 2014). Currently, the share of field elm (*Ulmus minor*) in the Polish forests is small.The stands of this species are scattered and usually far away from each other, and the majority of them are stands where trees occur locally or individually (Napierała-Filipiak, Filipiak, Łakomy, Kuźmiński and Gubański, 2016). Such distribution may significantly contribute to spatial isolation with its negative consequences, such as fragmentation, reduction of the effective population size, erosion of the gene pool, inbreeding growth, limited gene flow and decrease of migration rate.

Chudzińska *et al.* (2019) estimated the clonal structure of the field elm (*Ulmus minor*) in Poland. The aim of the study was to determine the level of genetic variability and degree of clonality in Polish populations of this species. The material for the study were leaves collected from 409 individuals growing in 12 populations.The analysis showed a low level of genetic variability of 8 nuclear microsatellite loci. 56 alleles have been found. The number of alleles in the locus ranged from 4 (locus UR141, UR188a) to 13 (locus Ulmi1-165), with an average of 7. The effective number of alleles in the locus (Ae) was significantly lower, ranging from 1.4 (locus UR188a) to 2.7 (locus Ulmi1-21), with an average of 1.9.The mean value of observed heterozygosity (Ho) was 0.555. The lowest value of expected heterozygosity (He = 0.181) has been found in locus UR188a and the highest value (He = 0.583) in locus Ulmi1-21. The mean value of expected heterozygosity (He) was 0.382. Only the Ulmi1-165 locus deviates from Hardy-Weinberg's equilibrium and this deviation is statistically significant ($p<0.001$).

As only in 3 out of 12 examined populations more than 10 separate genotypes were identified, no analysis of genetic variability for individual populations has been performed.

The clonal structure of individual populations has been determined using the GENCLONE 2.0 programme (Arnaud-Haond and Belkhir, 2007), based on the following parameters: number of individuals in the population (N), number of observed genotypes (genetes, G), number of unique genotypes (genetes consisting only of a single ramet, Gu) and richness wealth of genotypes (R=(G-1)/(N-1)). Additionally, the number of ramets (trees) in particular genet (Nc) has been determined.

The level of clonality found among the studied populations was remarkably diverse. The number of identified genotypes ranged from 1 in the populations of *Dobieszyn 3*, *Staszów* and *Toruń*, which means that in each of these populations all trees were one genet, to 12 in the population of *Wołów*.Genetes with the highest number of ramets (trees) were found in populations of *Krotoszyn* and *Dobieszyn* 1, 49 and 46, respectively. Unique Gu genotypes (that is, those that occurred only in one individual) were observed in 8 populations. Their number ranged from 1 in *Czerniejewo* and *Krotoszyn* populations to 9 in *Łąck* population. In 4 populations no specimens with the unique Gu genotype have been found. The highest genotypic richness (R) has been found in the population of *Łąck* (0.667), with the mean of 0.148.

The research conducted showed a low level of genetic variability of the field elm (*Ulmus minor*) in Poland and its relatively high clonality.The low level of genetic variability may be the result of post-glacial history of the species, as well as demographic processes associated with population reduction and Dutch elm disease, which also contributed to the decline of the elm population.In the populations of *Dobieszyn* 3, *Staszów* and *Toruń* only 1 genotype has been identified, which means that in each of these populations all trees are one genet. Particularly noteworthy are the populations with a large number of genetes, including unique ones such as *Łąck*, *Jamy Wołów*. The above results indicate the necessity of verification of the clonality level of field elm (*Ulmus minor*) populations, especially in conservation and restitution programmes.

5.9. Wych elm *Ulmus glabra*

The wych elm, *Ulmus glabra* can be find almost all over Europe, with the exception of the north-eastern ends of Scandinavia, the northern part of the Russian Lowland the south-western part of the Pyrenean Peninsula and the west of France. In the east it reaches about 60° east longitude (Boratyńska, Sękiewicz and Boratyński, 2015). The area of Poland is completely within the range of this species.In Poland it occurs in lowlands, in lower mountain locations, although outside the mountains it is a rare species (Zając A. and Zając M., 2001).After the last glaciation, the elm trees entered the territory of Poland from the south-eastern direction, reaching the maximum occurrence about 6,500 years ago. Then, as it is believed, the pressure of Neolithic tribes on the natural environment and probably the elm disease spreading throughout Europe, similar to the epidemic we are dealing with nowadays, led to a gradual decrease in the share of elm in the forest composition (Ralska-Jasiewiczowa, Nalepka and Goslar, Ralska-Jasiewiczowa *et al.*, 2003).All native elm species are species with the dominant share of local occurrence, i.e., from 5 to 10% in the stand composition, and the reduced area occupied by these species is about 17,600 ha (0.24% of the total area of the State Forests) (Napierała-Filipiak *et al.*, 2014). This type of occurrence creates a real threat of gene pool erosion. Small, fragmented populations are more susceptible to adverse effects of random processes, such as the effects of the "founder" and "bottleneck". (Jump, Woodward, and Burke, 2003; Leroy *et al.*, 2017). Previously, in Poland, no studies have been conducted using genetic markers to determine the level of variability of native elms.

Chudzińska et al. (2018) estimated the level of genetic variability and diversity between 17 populations of the mountain elm (*Ulmus glabra*). The studied populations were characterized by an average level of genetic diversity.The average number of alleles in locus (A) was 6.2, ranging from 5 in *Lesko* and *Staszów* to 8 in *Choszczno*. The average value of the AR10 allele richness was 4.7 and was quite homogeneous, ranging from 4 in 6 populations to 6 in 3 populations.The mean value of the observed heterozygosity (Ho = 0.583) was lower than the mean value of the expected heterozygosity (He = 0.602), indicating a small level of inbreeding of the analysed material (Fis = 0.031, $p<0.001$). However, in 6 studied populations (*Krościenko*, *Lesko*, *Ostrowiec Świętokrzyski*, *Drawno*, *Jamy* and *Świdnica* 2) an excess of heterozygous individuals was found in relation to Weinberg's equilibrium. The highest excess of heterozygous individuals was observed in the *Świdnica* 2 population (Fis = -0.13). The most inbreeding (Fis = 0.151) was the population of *Jarocin*.

The above analyses are reflected in the calculated values of the genetic coefficient of diversity between the examined populations of the wych elm (*Ulmus glabra*) (Fst). On average, the coefficient of genetic diversity between 17 populations was high (Fst = 0.089) and statistically significant ($p<0.01$). The smallest genetic diversity (Fst = 0.010) has been found between populations from *Ruda Raciborska* and *Wałbrzych* and the largest between populations from *Jarocin* and *Staszów*. Genetic diversity was statistically insignificant only between populations form *Ruda Raciborska* and *Choszczno*, *Drawno*, *Świdnica* 1 and *Wałbrzych*, between *Choszczno* and *Drawno* as well as between *Drawno* and *Świdnica* 1. All other values were statistically significant ($p<0.01$).

The analysed populations also differed in terms of the estimated value of the effective population size (Ne), which ranged from only 1.7 to 237.1. This indicates that the studied populations were formed from a remarkably diverse number of individuals. Sometimes, as in the case of the populations from *Jarocin* and *Świdnica* 2, it could be just a few individuals (a strong narrowing of the gene pool).The first such studies on Polish populations confirmed the results of previous studies on species variability in Europe, indicating that it is a species with a relatively low level of genetic diversity and high inter-population variability (Martín del Puerto, Martínez García, Mohanty and Martín, 2017; Nielsen and Kjær, 2010).

Since in nature, the wych elm (*Ulmus glabra*) very often crosses with the field elm (*Ulmus minor*), producing hybrids, in order to better understand the genetic diversification processes of Polish wych elm populations (*Ulmus glabra*), it is necessary to undertake studies of the field elm population (*Ulmus minor*) as well.

5.10. European white elm *Ulmus laevis*

The European white elm, *Ulmus laevis* is the least variable species among European elm trees. Only a few varieties and forms that are sporadically grown in Europe have been identified.It occurs from central France to the Ural. In the north it occupies only the southern part of Finland, in the south it reaches the end of Albania and Bulgaria and, in addition, it grows on several isolated sites in Turkey.It is generally more common in Eastern than Western Europe. In Poland it occupies lowland areas, most often on fertile and humid habitats in river valleys, often in flood plains. It grows individually or in small groups (Wojterski, 1960). In the mountains it occurs rarely and does not exceed the level of the foothills (Kosiński, 2007).

Lewandowski *et al.* (2018) (unpublished data, publication in preparation) carried out genetic analyses on 1,672 trees belonging to 41 populations distributed throughout Poland. The variability of 6 nuclear microsatellite loci has been investigated.The studied loci were heterogeneous in terms of the level of genetic variability. The lowest number of alleles (6) has been found in the Ulm6 locus and the highest (15) in the Ulm3 and Ulm9 locus. A total of 59 alleles have been found in all analysed loci.The effective number of alleles in the locus (Ae) was significantly lower, ranging from 1.98 in the locus UR 188a to 2.97 in the most variable locus Ulm9, with an average of 2.37. Low values of the so-called null alleles have been found in the material studied, on average 1.31 (from 0 to 4.8). The lowest value of expected heterozygosity, He = 0.468, has been found in locus UR 188a and the highest value of He = 0.647 in locus Ulm9.In all of the studied loci an excess of heterozygotes over Hardy-Weinberg's equilibrium has been found. The mean value of Fis inbreeding coefficient was -0.157 and was statistically significantly different from null. Between the examined populations a relatively high level of genetic differentiation has been found, with the mean value of Fst = 0.083. Of the analysed loci the most diversifying was locus Ulm 3 (Fst = 0.108). The smallest differentiation between the studied populations has been found in locus Ulm 6 (Fst = 0.028).

Only 59 alleles were detected in the examined material. Of all alleles, 14 were private. Tested populations were characterized by a low level of genetic variability. The average number of alleles in locus (A) was 4.21. An exceptionally low frequency of null alleles (1.21% on average) was detected in the examined populations.The average value of allelic richness was 4 and was quite homogeneous, ranging from 2.98 in the population of *Baborowo* to 4.88 in the population of *Przekop*. Much lower was the effective number of alleles in locus. It ranged from 2.15 in the population of the *Mątawski Forest* to 2.58 in the population of the *Wiązy Reskie Nature Reserve*, with the average of 2.38.The mean value of observed heterozygosity (Ho = 0.641) was higher than the mean value of expected heterozygosity (He = 0.553), indicating a statistically significant excess of heterozygotes (Fis = -0.149). Excess heterozygous individuals in relation to Hardy-Weinberg's equilibrium has been found in all studied populations, although it was not statistically significant in all cases.

The studied populations were most likely formed from a remarkably diverse number of individuals, as indicated by the differences in the estimated value of the effective population size (Ne): from 3 (*Stubno*) to 361 (*Lemierzyce*), with a harmonic mean of 16.5. The analyses showed that all the studied populations in their history went through the stage of gene pool narrowing caused by the so-called "bottleneck effect". The coefficient of genetic diversity between the studied populations was relatively high (Fst = 0.076) and statistically significant ($p<0.01$).

It is highly possible that the elms have lost the high level of genetic diversity that most European woody species have, already in refuges or during the migration of the species after the last glaciation, or as a result of the elm disease spreading throughout Europe, similar to the epidemic we are dealing with nowadays (Ralska-Jasiewiczowa *et al.*, 2003).

5.11. Common ash*, Fraxinus excelsior*

Common ash, *Fraxinus excelsior* can be found all over Poland, with the exception of the upper part of the mountainous region. It is a valuable forest-forming species, with great tolerance to drought and frost. The limitation of the population in Poland, as in the whole Europe, is largely due to the pathogenic action of the anamorphic fungal pathogen *Hymenoscyphus fraxineus*.

Burczyk *et al.* (2018) (unpublished data, publication in preparation) estimated based on 10 microsatellite markers of the nuclear genome and 5 microsatellite markers of the chloroplast genome the genetic diversity and the level of genetic variability of the common ash (*Fraxinus excelsior*) in Poland.For the study 771 trees were selected from 16 stands located in Natura 2000 sites. The number of individuals covered by the study in the single population ranged from 30 to 51. In total, 434 alleles in all 10 loci of the nuclear genome have been found. In single populations the number of alleles in locus ranged from 2 to 36.The highest level of polymorphism has been found in the populations of *Płock* (190 alleles), *Lubsko* and *Pniewy* (188 alleles), while the lowest level of polymorphism has been found in the populations of *Pińczów* (116 alleles) and *Spychowo* (117 alleles). The population of *Płock* was characterized by the highest level of variability, also in terms of the effective number of alleles. The highest number of private alleles has been recorded in the *Przytok* population (15 alleles). On the other hand, the lowest number of private alleles has been found in *Wejherowo* (1 allele) and *Spychowo* (2 alleles).

The analysis of genetic diversity between the populations showed that the studied populations differ significantly in terms of the observed number of alleles (Chi2 = 76.47, df = 15, $p<0.001$), the effective number of alleles (Chi2 = 43.92, df = 15, $p<0.001$), the expected heterozygosity (Chi2 = 44.04, df = 15, $p<0.001$) and the observed heterozygosity (Chi2 =

25.13, df = 15, p<0.05).

The genetic diversity between populations (Gst), measured at the nuclear genome level, averaged 0.054 and was statistically significant. In the case of the chloroplast genome, much higher genetic diversity between the populations has been found (65.4%). The genetic diversity at the level of chloroplast haplotype amounted to 0.627. Thus, on average, only about 37% of the total variability is found in a single population, and about 63% of the variability of the examined metapopulation results from inter-population differences.

The genetic diversity between population pairs at the nuclear genome level did not show a statistically significant relationship with geographical distance (Mantel test: r = 0.106, p = 0.224). In the case of the chloroplast genome, the positive correlation between genetic diversity and geographical distance was statistically significant (r = 0.221, p = 0.029).

The effective population size (Ne), estimated for individual populations, ranged from 15.9 (*Browsk*) to infinity (*Strzyżów*), with a harmonic mean equal to 57.6. Apart from the *Browsk* and *Spychów* populations, for which relatively low values of the effective population size have been recorded, several populations showed intermediate values between 40-60 (*Gołdap*, *Pińczów*, *Sulęcin*, *Tomaszów*). The remaining populations presented high ratings for the effective population size.

The analysed populations are characterized by a relatively high level of genetic diversity, expressed by the number of alleles, the effective number of alleles, and the expected heterozygosity. The populations of *Płock*, *Płońsk*, *Strzyżów*, *Lubsko*, *Pniewy* and *Przytok* are characterized by above-average parameters of genetic diversity, which may constitute the basis for creating genetic resources. Maintaining as wide as possible the genetic diversity of the common ash (*Fraxinus excelsior*) is fundamental for the stability of stands and entire forest ecosystems, especially important in the context of diseases caused by the anamorphic fungal pathogen *Hymenoscyphus fraxineus*.

5.12. Common beech, *Fagus sylvatica*

Common beech, *Fagus sylvatica* is one of the most important deciduous tree species in Europe in ecological and commercial terms, whose current distribution is linked to the influence of the Atlantic and sub-Atlantic climate and the migration processes during Pleistocene and the Holocene.

Ulaszewski (2018) analysed adaptive genetic diversity of the species in Poland based on material collected from 1,080 individuals, selected in 2 provenance experiments - *Choczewo* and *Siemianice*, which consisted of 85 unique populations of a pan-European range, particularly in Poland and Germany. For genetic diversity studies 20 nuclear microsatellite loci (nSSR) and genetic markers associated with single nucleotide polymorphism (SNP) have been used. The data for SNP loci have been obtained as a result of DNA sequencing using ddRADseq (double digest restriction-site associated DNA).

Using 20 SSR loci, 237 alleles have been identified, while 17 markers showed the presence of null alleles, which slightly affected the estimated inbreeding level.

The genetic diversity between the populations was statistically significant and amounted to 2.74%. A similar value (significantly different from zero) has been assumed by the genetic diversity coefficients Fst and Rst ≈ 0.027.The level of genetic variability was similar to the values observed in previous studies. There has been a weak upward trend in Fst for south-western populations, which may be due to their different migration history. It has been demonstrated that there are 3 main clusters, whose distribution corresponds to the refuges and migration routes during the last ice ages and the Holocene.The evaluation of markers under the influence of selection has been carried out by analysing 12,833 SNP loci with a set of 3 programmes, which allowed to extract 8,207 potentially neutral SNP loci and 541 SNP loci significantly related to adaptive variability.

The overall assessment of inter-population diversity based on neutral SNP loci estimated by AMOVA analysis was 3.4% and the value of fixation index, which was significantly different from zero, was Fst = 0.033. There was a strong significant positive correlation between the results of Fst analysis for population pairs obtained with SSR and SNP markers ($r = 0.68$, $p<0.00001$).The evaluation of the spatial system of neutral genetic diversity of the population is similar to that of SSR loci analyses, but the results obtained for SNP loci are more stable and independent of the number of individuals per population. More distinct trends of population genetic grouping have also been observed.

The assessment of adaptive variability has been examined for correlation between the genotype and variables describing population climatic factors and variables related to spring and autumn phenology. The study comprised 150 SNP loci associated with bioclimatic variables, 307 SNP loci associated with spring phenology and 259 markers associated with autumn phenology. In total, 541 unique SNP markers showing adaptive signal have been obtained. The differentiation on the inter-population level was higher than in the case of neutral loci.

Genetic diversity between populations has been also influenced by other factors, apart from the demographic history of the population, in this case variable climatic conditions. The parameters of population genetic diversity for these sets of SNP markers had a wider range of variability and a higher mean value compared to analyses based on neutral loci.

The developed reference genome of common beech (Fagus sylvatica) and the methodology of genotyping optimization on genomic data contribute to a better understanding of the mechanisms determining genetic diversity.

Sandurska *et al.* (2019), using the microsatellite markers of the nuclear genome, analysed the genetic diversity of adult and posterity generations in the populations of the common beech (*Fagus sylvatica*) and the pedunculate oak (*Quercus robur*), coexisting in the stand that is part of the *Jamy* Nature Reserve.

The following microsatellite markers of nuclear DNA have been used to estimate genetic parameters of adult common beech (*Fagus sylvatica*): Fc3(FcC00468), Fc5 (FcC00730), Fc6 (FcC00927), Fc9 (FcC03095) (Ueno, Taguchi, Tomaru and Tsumura, 2009); csolfagus_05, csolfagus_06, csolfagus_19, csolfagus_29, csolfagus_31, concat14_A_0, DE576_A_0, DUKCT_A_0, DZ447_A_0, EEU75_A_0, EJV8T_A_0, EMILY_A_0, ERHBI_A_0 (Lefèvre, Wagner, Petit and de Lafontaine, 2012); sfc_0036, fc_1143 (Asuka, Tani, Tsumura and Tomaru, 2004); FS1_15 (Pastorelli *et al.* , 2003).

As a result of the analyses, it turned out that all the loci were polymorphic with the number of alleles in the locus ranging from 3 to 14 (mean 8.4). The average effective number of alleles was 3.628.The observed and expected heterozygosity had a similar level, respectively: Ho = 0.65 and He = 0.657. The mean value of the coefficient of allelic richness was AR = 8.323. The frequencies of the null alleles were low, with the mean value of 0.011.Taking into account the presence of null alleles, only a low but significant level of inbreeding for seedlings has been observed. The level of differentiation between seedlings and adults was low for both parameters (Fst and Rst). The mean effective population size amounted to 119 (100.7-141.8) for adult individuals and 91.3 (78.7-106.4) for seedlings.

From the genetic point of view, the analysed population of common beech (*Fagus sylvatica*) achieved particularly good results at the studied stand - genetic diversity indicators were equally high in all analysed groups of individuals, which suggests that this population achieves maximum variability, considering the set of genetic markers used.

5.13. Scots pine, *Pinus sylvestris*

Scots pine, *Pinus sylvestris* is a Euro-Siberian species with a very wide range of occurrence. The range from east to west is about 14,000 km and from north to south is 2,700 km. It is one of the most numerous forest tree species in Poland.As a species of great ecological and commercial importance, the Scots pine (Pinus sylvestris) is well known for its silvicultural value. Provenance trials of Polish populations from different geographical locations have shown a large variety of adaptive morphological and physiological features, growth dynamics and stress resistance (Boratyński, 1993; Giertych and Oleksyn, 1992; Sabor, 2006). Based on morphological and performance characteristics, several local ecotypes of the species have been distinguished in the whole range of occurrence (Boratyński, 1993). The genetic studies to date have used some molecular and biochemical markers to assess genetic variability within and between populations in relation to mating systems (Burczyk, Dzialuk and Lewandowski, 2000), as well as natural hybridization in contact zones with mountain pine, *Pinus mugo* (Wachowiak and Prus-Głowacki, 2008).

The large genetic diversity makes Scots pine (*Pinus mugo*) an ideal material for breeding and conservation research. One of the most convenient sources of material for variability testing are provenance experiments. Androsiuk *et al.* (2014) studied genetic diversity and population diversity from the IUFRO 1982 provenance test. The IUFRO 1982 experiment collected samples from 20 populations of the species from sites along a transect running through Europe from north to south (20° west longitude) and from west to east (52° north latitude) (Oleksyn, 1988). Previous analyses of this material have provided valuable information on growth, plasticity and productivity, susceptibility to biotic and abiotic factors, as well as morphological variability and physiological characteristics of the provenances studied (Androsiuk, Zielinski and Polok, 2011; Oleksyn, 1988; Oleksyn, Tjoelker and Reich, 1992a; 1992b; Oleksyn, Reich, Chałupka and Tjoelker, 1999) (Oleksyn *et al.*, 2000; Oleksyn *et al.*, 2003; Reich, Oleksyn and Tjoelker, 1994).

Androsiuk *et al.* (2014) used ISJ markers (Intron-Exon Splice Junction) and RAPD analysis to study genetic diversity and population differentiation from 2 Polish locations from the IUFRO 1982 provenance experiment (in *Kórnik* and *Supraśl*). The applied categories of DNA markers differed in terms of revealing genetic diversity of the species. In the study 10 RAPD primers were used, which gave a total of 75 bands, of which 21 (28%) and 15 (20%) were polymorphic, in *Kórnik* and *Supraśl,* respectively.6 Intron-Exon Splice Junction (ISJ) primers revealed 42 bands, 4 (9.52%) and 14 (33.3%) of which were polymorphic, in *Kórnik* and *Supraśl,* respectively. Genetic diversity and differentiation were low, expressed by He = 0.071 and He = 0.085, respectively, and by values of genetic distance, which ranged from 0 to 0.24 (0.081 on average) and from 0.017 to 0.188 (0.094 on average) for *Kórnik* and *Supraśl*, respectively. Location of the provenance test seems to have a significant impact on the revealed level of genetic polymorphism and differentiation pattern of interpopulation.

For both locations (*Kórnik*, *Supraśl*), AMOVA analyses of molecular variance revealed the presence of a population structure when populations were divided into 3 groups (northern, central, and southern) according to the latitude of their origin. Based on AMOVA analysis the differences between the populations were significant, but a larger variance was observed between the populations (*Kórnik* 79.98%, *Supraśl* 83.76%), while between population groups the variance was 20.02% and 16.24% for the provenance sample from *Kórnik* and *Supraśl,* respectively.

Wojnicka-Półtorak et al. (2017) estimated the genetic diversity and studied the demographic structure of the population of the Scots pine (*Pinus sylvestris*) in the Białowieża Forest. The analyses used both microsatellite markers of the chloroplast genome (cpSSR) and mitochondrial DNA markers.

The samples for genetic research were collected from 156 individuals from the *Sitki* Nature Reserve. The specimens were divided into age groups: E - embryos isolated from germinated seeds, S - individuals aged 1-3 years, Y - individuals aged 10-20 years, M - individuals aged 40-80 years, O - individuals over 100 years.

Loci cpSSR were highly polymorphic in age classes: from 80% (class E) to 100% (class O). A total of 48 alleles have been found. The lowest average number of alleles per locus (Na = 3.1) was observed in the embryo class and the highest (Na = 3.6) was observed in the S, Y, M classes.The average effective number of alleles per locus (Ne) was lower and ranged from 2 to 2.2. A total of 12 private alleles have been found: 1 on the oldest trees, 5 on middle aged trees and 2 alleles in the remaining classes. The frequency of alleles between the different age classes has been observed, especially in relation to loci Pt15169, Pt30204 and Pt45002. Fisher's exact probability test showed that the allele frequencies in locus Pt30204 of the oldest tree classes were significantly different from those of E, Y and M (p values were 0.013, 0.035 and 0.011 respectively).

117 haplotypes have been identified, from 23 (class M) to 32 (class O). Most of these haplotypes (77%) were detected only once (unique haplotypes) and the rest were observed in 2 to 6 individuals. Molecular variance analysis (AMOVA) using cpSSR revealed significant (0.027 probability) variability between age classes, representing about 2% of total variance.

In the case of mitochondrial markers, the results of analyses showed that all analysed individuals had a single mitotype (217 pz) for locus nad1. In locus nad7 2 mitotypes were observed in all age classes: a - universal as of 300 pz (65-80%, total 74%) and northern b - of 295 pb (20-36%, total 26%).The diversity of H haplotype (calculated for polymorphic locus nad7) ranged from 0.32 (Y class) to 0.455 (O class) and 0.42 (E class), which indicates that the highest values occurred in the oldest and youngest age class. The distribution of H values in different classes showed the opposite tendency in comparison with chloroplast loci. The AMOVA analysis did not show significant variation between age classes, and all genetic diversity has been found inside these age classes. Nei's genetic distances between the different generations were exceptionally low: from 0 to 0.013.

Populations of long-lived forest tree species, such as the Scots pine (*Pinus sylvestris*), have a structure of overlapping generations, whose dynamic changes inevitably entail genetic diversity both over time and space. Genetic research of subsequent generations allows us to conclude about long-term demographic processes. The cpSSR markers indicated that the natural population of Scots pine (*Pinus sylvestris*) from the area of the Białowieża Forest seems to maintain a high level of genetic diversity between the generations, while the markers of the mitochondrial genome represent a stable level of variability.

5.14. Summary

Due to the fact that there is no permanent genetic monitoring of species and their populations in Poland, it is impossible to precisely determine whether their intra-population variability and genetic diversity fluctuate. It can be assumed that populations of widely distributed forest-forming species such as Scots pine (*Pinus sylvestris*), common beech (*Fagus sylvatica*), pedunculate oak (*Quercus robur*) or sessile oak (*Quercus petraea*) still maintain high intra-population variability, however, locally, populations of species such as common ash

(*Fraxinus excelsior*), Norway spruce (*Picea abies*), silver fir, *Abies alba* have been strongly influenced during the last years by biotic and abiotic factors that have either contributed to the total abandonment of these species from the forest ecosystems, or have contributed to a strong reduction of individuals in these populations.Among the admixture species, the disappearance of the field elm (*Ulmus minor*), wych elm (*Ulmus glabra*) and black poplar (*Populus nigra*) is still observed.In the case of protected tree species, it seems that it would be more beneficial to enrich the genetic diversity of these species by abandoning their passive conservation and actively stimulating the flowering and seed production of the population, as well as introducing new genotypes within these populations, in order to increase gene flow between them and thus increase their genetic diversity and adaptation potential. This is especially true for species such as the wild service, *Sorbus torminalis*), the common yew, *Taxus baccata*, Swiss pine, *Pinus cembra*, the elms (*Ulmus sp.*) and the downy oak, *Quercus pubescens*. Within the framework of the programmes of restitution of protected species to their proper habitats, the State Forests try to counteract these phenomena. In the years 2002-2019, about 268,000 seedlings of the wild service tree (*Sorbus torminalis*) and in the years 2006-2019 – 607,300 seedlings of the common yew (*Taxus baccata*) were introduced to forest cultivation (data from the General Directorate of the State Forests, 2020; data from the Kostrzyca Forest Gene Bank, 2020).

There is a need to continuously train forest managers and owners and inform them about the fact that forest resource management is the same as the management of forest genetic resources, as it still seems that the knowledge of these stakeholders in this area is insufficient (Resolution on the EU Forest Strategy, 2020).

Research needs in the field of genetic diversity shall include:

1. The introduction of permanent genetic monitoring of selected species and populations in time and space (including the objects registered in the EUFGIS database), considering more qualitative and quantitative traits.
2. Conducting analyses of genetic diversity of species on a large scale.
3. Conducting new international provenance experiments.
4. Collecting a large number of samples (young and mature trees for several selected species, e.g., *Fraxinus excelsior*) for future analyses using modern tools.
5. The change of approach from candidate genes to full genome analysis, with the determination of adaptability and reproductive capacity of trees.
6. The concentrated research focused on prediction of the dynamics of forest ecosystems change due to climate change, using new modelling methods - multidisciplinary approach.
7. Studies to better understand the plasticity and epigenetics of trees on a local scale for the population's adaptive response to climate change.
8. Economic analyses of the use of forest reproductive material and the implementation of new technologies to assess the mortality, plasticity, and

regeneration of forest reproductive material in the long-term conditions of stressful environment.

9. The implementation of a method of assisted migration of species and populations and the identification of the ecological risks of these methods (Resolution on the EU Forest Strategy, 2020; GenTree Conference, 2020).

Part III State of forest genetic resources conservation

Chapter 6 In situ conservation of forest genetic resources

In situ conservation allows for long-term interaction with other species and organisms, enabling evolution in the natural environment, and the selection pressure depends on local conditions and influences the natural regeneration from sexual reproduction. *In situ* conservation connects the original environment and identifies it with local natural history. Although in Poland, passive conservation is still dominant in the *in situ* protection of the populations of many tree species, in particular protected species, it is becoming more and more often seen by managers and officials responsible for the condition of forests that active conservation of forest genetic resources is much more effective.

For some time now, specific dynamic strategies for the *in situ* conservation of forest tree populations have been promoted worldwide due to their low degree of domestication and widespread local adaptation (Alberto *et al.*, 2013). In Europe, this strategy has been reflected especially in the EUFORGEN programme (European Forest Genetic Resources Programme) (Koskela *et al.*, 2013; Lefèvre *et al.*, 2013).

Dynamic conservation of forest genetic resources aims to maintain the evolutionary processes and adaptive potential in natural and man-made populations and stands in order to ensure their long-term sustainability (Namkoong, 1997) and to ensure that the genetic diversity existing in the protected population will ensure not only its current adaptive capacity but also the evolutionary continuity of the species.Actions for dynamic conservation of forest genetic resources contribute to the conservation of broad genetic diversity as well as adaptive potential, through the impact of environmental selection pressure and sexual reproduction in the population. By maintaining these conditions, new genotypes will emerge as a result of recombination and mating, without executing the phenotypic selection of parental trees. Such new genotypes may be influenced by natural selection, which will promote adaptation.

Dynamic *in situ* conservation combines the selection pressure with the original environment where the population grew and identifies it with the local environment where the population has been selected.

Forest ecosystems are the most valuable and represented component of all forms of nature conservation in Poland. They occupy 38.4% of areas under legal protection. Forests in Poland are protected using many different spatial forms of nature conservation. These are: national parks, landscape parks, nature reserves, protected landscape areas, Natura 2000 sites, ecological landscapes and nature and landscape complexes (Zajączkowski G. *et al.*, 2020).

In Poland there is a system of in situ conservation at the national level. It includes:

- Objects of *in situ* conservation of forest genetic resources,
- protected areas,
- production forests for the production of wood and non-wood products.

For the functioning of the system, they are responsible:

- the Forest Reproductive Material Office (under the authority of the minister responsible for the environment) – for basic forest material throughout the country,
- the State Forests National Forest Holding - in the scope of managed basic forest material,
- the General Directorate for Environmental Protection - for protected areas.

The highest forms of nature protection are the national parks, which, currently in number 23, cover an area of 315,100 ha. These are areas characterized by special natural, scientific, social, cultural, and educational values. They are created on areas no smaller than 1,000 ha in order to preserve biodiversity, inanimate nature and landscape values, as well as to restore deformed natural sites, habitats of plants, animals or fungi.The forests in national parks cover 195,200 ha, i.e., 61.9% of their total area, 60,800 ha of which are under strict protection. Forests in national parks can be considered as forests where forest genetic resources are protected *in situ*, although sometimes we can encounter quite a significant dynamics of natural generational transformation processes taking place in them, and thus of species compositions, as well as entire plant populations, especially in times of climate change. Nature reserves are established in order to preserve in the natural state or in a little changed state ecosystem refuges as well as habitats of plants, animals and fungi, and inanimate nature formations and components, distinguished by their specific natural, scientific, cultural or landscape values. The 1,501 nature reserves cover an area of 169,600 ha. Most of the nature reserves (1,285) are located within the State Forests. The total forest area in the nature reserves is 109,200 ha (Zajączkowski G. *et al.*, 2020). Forest nature reserves, like the forest parts of national parks, can also be considered as forests where forest genetic resources are protected *in situ*.

Seed bases, created as a result of population selection, based on a broad genetic basis, and representing the genetic variability of individual species, are of fundamental importance for forest reproduction. Seed bases created as a result of individual selection are of complementary importance (Haze, 2012).

In Poland, due to the necessity of artificial regeneration and afforestation of large areas (55.581 ha in 2019), which is connected with the layout of forest habitats, as well as with the species composition of stands, the largest seed base among European countries has been organized. It includes both production seed stands, which are subject to traditional management at the time of maturity for felling, as well as selected seed stands that are out of use for an exceptionally long period of time or remaining for the purpose of natural decomposition. The objects of this base are at the same time objects of *in situ* conservation of forest genetic resources. Although the number of these stands is subject to fluctuations as a result of their use, this base is constantly being supplemented with new objects (appropriate silviculture methods). In 2020, their number was 18,303 and the area of 178,441 ha (Tab. 6.1 Area and number of seed facilities in Poland production and seelcetd seed stands)).

Tab. 6.1. *Area and number of seed objects in Poland production and selected seed stands*

Species	Area(ha)	Number of objects(pcs)
Black locust (*Robinia pseudoacacia*)	15.29	6
Common beech (*Fagus sylvatica)*	17,216.55	1,569
Silver birch (*Betula pendula*)	4,134.87	678
Ojców birch (*Betula oycoviensis*)	1.14	1
Wild cherry (*Prunus avium*)	61.16	10
Sessile oak (*Quercus petraea*)	7,965.48	641
Northern red oak (*Quercus rubra*)	74,65	17
Pedunculate oak (*Quercus robur*)	17,806.35	1,929
Douglas fir (*Pseudotsuga menziesii*)	457.42	140
Common hornbeam (*Carpinus betulus*)	279.9	47
Silver fir (*Abies alba*)	7,485.89	547
European ash (*Fraxinus excelsior*)	383.46	70
Sycamore maple (*Acer pseudoplatanus*)	356.61	55
Norway maple (*Acer platanoides*)	39.86	9
Small-leaved lime (*Tilia cordata*)	917.14	141
European larch (*Larix decidua*)	2,219.19	421
Black alder (*Alnus glutinosa*)	5,086,46	905
European red pine (*Pinus sylvestris*)	107,570.74	10,268
European black pine (*Pinus nigra*)	99.48	25
Eastern white pine (*Pinus strobus*)	11.67	5
Norway spruce (*Picea abies*)	6,246.04	816
European white elm (*Ulmus laevis*)	11.18	3
Total:	**178,440.53**	**18,303**

Source: Data from the General Directorate of the State Forests, 2020.

An important role in the *in situ* conservation of forest genetic resources has been played for some time by the so-called conservation stands created in the area of the State Forests and national parks, which are permanently excluded from use and whose primary goal is to maintain the sustainability of species and their populations in a given habitat and to sustain genetic processes occurring within the population. *In situ* conservation areas are stands and their progeny from natural or artificial regeneration in the area of population occurrence, selected for the conservation of genetic resources.

Among the woody species in Poland which form forest genetic resources, 19 are covered, as conservation stands, by the system of *in situ* protection. The largest area of *in situ* protection, taking into account the objects in the basic forest material registers, is covered by the Scots pine (*Pinus sylvestris*) (8,364.36 ha), common beech (*Fagus sylvatica*) (2,541.67 ha), silver fir (*Abies alba*) (2,316.89 ha), sessile oak (*Quercus petraea*) and pedunculate oak (*Quercus robur*) (1958.06 ha and 1,907.79 ha respectively), and Norway spruce (*Picea abies*) (1,778.72

ha). There are 1,461 such conservative stands in Poland and they cover an area of 20,704 ha (Tab. 6.2).

Tab. 6.2. *Area and number of conservation stands in Poland in the State Forests and national parks.*

Species	Area(ha)	Number of objects(pcs)
Black locust (*Robinia pseudoacacia*)	7.5	3
Common beech (*Fagus sylvatica)*	2,541.7	156
Silver birch (*Betula pendula*)	213.35	28
Sessile oak (*Quercus petraea*)	1,958.06	80
Red oak (*Quercus rubra*)	9.08	3
Pedunculate oak (*Quercus robur*)	1,907.79	140
Douglas fir (*Pseudotsuga menziesii*)	148.57	41
Common hornbeam (*Carpinus betulus*)	15.08	2
Silver fir (*Abies alba*)	2,316.89	113
Common ash (*Fraxinus excelsior*)	23.72	4
Sycamore maple (*Acer pseudoplatanus*)	15.01	4
Small-leaved lime (*Tilia cordata*)	225.37	17
European larch (*Larix decidua*)	684.13	88
Black alder (*Alnus glutinosa*)	434.43	49
Scots pine (*Pinus sylvestris*)	8,364.36	627
Black pine (*Pinus nigra*)	43.05	9
Eastern white pine (*Pinus strobus*)	7.88	3
Norway spruce (*Picea abies*)	1,778.72	93
European white elm (*Ulmus laevis*)	10.02	1
Total:	**20,704.33**	**1,461**

Source: Data from the General Directorate of the State Forests and national parks, 2020.

In total, about 323,120 ha of forest genetic resources are under *in situ* conservation in Poland, which constitutes 3.5% of the forests in Poland (Tab. 6.3).

Tab. 6.3. Area of *in situ* conservation of forest genetic resources in Poland

Type of object	Area(ha)
Selected seed stands (without national parks)	15,170.00
Conservation stands (without national parks)	3,550.00
Forests in national parks	19,5200.00
Forests in nature reserves	10,9200.00
Total:	**323,120.00**

Source: Data from the General Directorate of the State Forests and national parks, 2020; Zajączkowski et al., 2020.

Within the framework of pan-European *in situ* conservation of forest genetic resources (www.euforgen.org) a total of 611 dynamic gene conservation units (DGCU) have been registered in Poland. They cover a total area of 9,289.99 ha and concern 30 tree species of our flora (i.e., 49.2% of the species listed in the Global Tree Search database). The above objects have been registered in the EUFGIS database, mainly among the objects of *in situ* conservation listed in Tab. 6.3. (www.euforgen.org).

Research needs in the field of *in situ* conservation of forest genetic resources include:

– monitoring of changes in genetic diversity in forests, with particular emphasis on areas under the influence of anthropogenic factors,

- collecting genetic information about silvicultural and conservation objects,
- testing the genetic diversity and variability based on quantitative trait analyses and molecular analyses (comparative studies and identification of valuable populations),
- testing the populations in protected areas (nature reserves, national parks, Natura 2000 sites), in terms of identifying valuable populations,
- assessing the degree of autochthonous populations and identifying non-autochthonous populations,
- linking the variability of quantitative traits with the variability at the molecular level, studying the mechanisms that determine the maintenance of genetic diversity and assessing the possibility of using natural regeneration in the process of genetic resources conservation (Chałupka et al, 2011).

Chapter 7. Ex situ conservation of forest genetic resources

Ex situ conservation activities are aimed at reducing the risk of loss of valuable objects as a result of unforeseen environmental phenomena such as climate change, fires, floods, insect outbreaks, fungal and viral pathogen activity, game, or succession changes in forest ecosystems. The protection of genetic diversity *ex situ* is carried out simultaneously through the establishment of conservation areas, progeny plantations, clonal seed orchards, seedling seed orchards, clone archives *in vivo* and through the collection and long-term storage of genetic material in the form of seeds or parts thereof in gene banks (Chałupka *et al.*, 2011).

Active (dynamic) *ex situ* conservation is a complementary measure to *in situ* conservation, especially when there are visible threats to the population of a given species functioning *in situ*. *Ex situ* conservation plantations (stands), defined as forests outside the natural site of genetic resources, may constitute genetic resources with unknown genetic diversity or be genetically characterised by phenotypic features or molecular markers. Dynamic conservation can take place in *ex situ* stands when natural selection occurs and when artificially introduced trees (species, provenance, families) can be renewed without major human intervention, i.e., from seeds. If the initial populations are sufficiently representative in terms of genetic diversity and are sufficiently large in terms of the size of the viable population, according to FAO guidelines (FAO, 1992), they can also be a source of reproductive material for commercial forestry (Kelleher *et al.*, 2015).

As a complementary approach to *in situ* conservation, dynamic *ex situ* conservation combines selection pressure with non-local environments to foster adaptation to new environmental conditions. Therefore, new secondary forest plantations established under different conditions, which are intended to promote the natural regeneration of these artificial secondary forest plantations, would allow the natural selection of new adapted genotypes, different from those originally introduced when establishing a conservation or progeny plantations.

Some factors will determine the success of dynamic conservation (both *in situ* and *ex situ*) in relation to effective population size, mating system, levels of permanent genetic diversity and phenotypic plasticity and selection pressure under new environmental conditions.

In Poland, there are currently registered 1,801 ha of *ex situ* conservation secondary forest plantations, including 1,740 ha in the State Forests and 61 ha in national parks (Tab. 7.1). The role ofconservation plantations for selected seed stands is also played by the so-called progeny plantations, established in Poland under the "Programme of cnserving frest gnetic rsources and beeding of trees in Poland for the years 2011-2035". To date, about 67,000 ha of *ex situ* progeny plantations have been registered, established in special large-area blocks for several tree species (Tab. 7.1).

Assisted migration, defined as the conscious relocation of species, populations and genotypes of trees from exposed to biotic and abiotic factors areas to new sites, considered suitable for future climate projections, has not been sanctioned in Polish legislation so far and is therefore practically not applicable in Polish forestry today.

Ex situ static conservation involves the creation of collections that preserve specific genetic compositions, without reacting to possible environmental changes and without generating new diversity. Static methods of protection of forest genetic resources are used for biological material, which is well identified genetically, and which stabilizes its current genetic composition, included in a collection or gene bank. Seed orchards, conservation plantations and clone archives are examples of *ex situ* static objects where no changes in the genetic structure of the population can (should) occur naturally. Currently, 207 ha of clonal archives and 1,841 ha of seed orchards and conservation plantations are registered in Poland (Tab. 7.1).

Efforts of static conservation of forest genetic resources also focus on the conservation of individual populations and genotypes, which can be preserved in many different ways, such as seeds, pollen, plant parts or whole plants. *Ex situ* static conservation of forest genetic resources can be carried out in seed banks (where the storage time of the material depends on a noticeable decrease in germination capacity), or in clonal banks, in vitro collections, vegetatively propagated or maintained for exceptionally long periods using cryopreservation techniques.Currently, 8,740 seed lots of numerous plant species have been collected in the Kostrzyca Forest Gene Bank in Poland, including 8,421 seed lots or other parts of 62 woody species and 319 seed lots, representing 220 plant species threatened with extinction and protected by Polish law (Tab. 7.2). In the aforementioned gene bank, the use of cryopreservation techniques for the conservation of genetic diversity, both difficult to store seeds of plant species, representing the recalcitrant category, but also numerous herbaceous plant species, is becoming increasingly important. By 2020, 1,380 lots of seeds of woody and herbaceous species from Polish forests and non-forest communities have been collected in the Kostrzyca Forest Gene Bank, using liquid nitrogen.

To protect genetic resources effectively, it is usually required to use several methods simultaneously and to duplicate genetic resources. For example, an endangered population may appear to be fully preserved *in situ*, but unpredictable abiotic events may completely destroy the protected population, so the ways of conservation need to be diversified in order to minimize the risk of losing valuable genetic resources. Pre-emptive measures to prevent the loss of genetic resources *in situ* should also be developed, taking into account developed scenarios of future climate change and evolution of forest habitats and stand species composition.Such actions would implement genetic resources of endangered populations to new environments in order to speed up the adaptation process. Thus, the principles of assisted migration should be implemented in the current Forest Reproductive Material Act. However, during the implementation of assisted migration, it should be based more on verified populations (with significant adaptation potential) than on species (Konnert *et al.*, 2015).

Recommendations related to the protection of forest genetic resources should be more integrated with forest management principles. As part of sustainable forest management, conservation of genetic diversity is essential. The need to implement appropriate practices for sustainable forest management based on the active protection of forest genetic resources is undeniable. When they are not implemented, the negative impact of such management on forest genetic resources can be observed.

Species and populations selected for *ex situ* conservation, both dynamic and static, should be prioritized, considering: the conservation status of the species, its rarity, threats of spatial isolation of the population and genetic drift, the presence of a population at the limit of natural range, threats from biotic and abiotic factors, as well as invasive species. In Poland, experience from other countries, e.g., the United States, concerning such activities should be used, where a strategy of prioritization of genetic resources conservation based on vulnerability to climate change is proposed (Potter, Crane, and Hargrove, 2017).

Tab. 7.1. *Objects of dynamic and static ex situ protection in Poland.*

Species	Area(ha)						
	Seed and conservation orchards (SF NFH)	Clone archives (SF NFH)	Progeny plantations (SF NFH)	Conservation plantations orchards (SF NFH)	Clone archives (national parks)	Conservation and progeny plantations (national parks)	TOTAL
Silver birch (*Betula pendula*)	73,17	1,87	611,28	0,00	0,00	0,00	686,32
Common beech (*Fagus sylvatica*)	73,77	9,88	4842,71	28,51	0,00	0,00	4954,87
Wild cherry (*Prunus avium*)	44,30	0,41	0,00	0,00	0,00	0,00	44,71
Douglas fir (*Pseudotsuga menziesii*)	58,43	9,34	0,00	0,00	0,00	0,00	67,77
Sessile oak (*Quercus petraea*)	83,49	5,15	2399,30	74,13	0,00	0,00	2562,07
Pedunculate oak (*Quercus robur*)	53,60	13,88	3420,36	118,03	0,00	8,13	3614,00
Common ash (*Fraxinus excelsior*)	6,62	0,34	0,00	0,00	0,00	0,00	6,96
Silver fir (*Abies alba*)	99,68	42,50	2599,73	17,50	11,73	0,00	2771,14
Sycamore maple (*Acer pseudoplatanus*)	8,31	0,06	0,00	0,00	0,00	0,00	8,37
Small-leaved lime (*Tilia cordata*)	108,96	1,74	125,52	0,00	0,00	0,00	236,22
European larch (*Larix decidua*)	365,35	10,10	2332,41	19,11	0,00	0,00	2726,97
Black alder (*Alnus glutinosa*)	66,96	6,27	1115,40	0,00	0,00	0,00	1188,63
Black locust (*Robinia pseudoacacia*)	6,74	0,00	0,00	0,00	0,00	0,00	6,74
Black pine (*Pinus nigra*)	83,39	2,55	0,00	0,00	0,00	0,00	85,94
Swiss pine (*Pinus cembra*)	10,03	0,00	0,00	0,00	0,00	0,00	10,03
Scots pine (*Pinus sylvestris*)	589,15	60,47	46 536,02	1395,46	0,00	46,45	48627,55
Norway spruce (*Picea abies*)	96,33	22,15	2397,11	80,23	0,00	6,95	2602,77
Other coniferous	3,50	2,03	570,85	4,23	1,30	0,00	581,91
Other deciduous	9,12	4,90	26,19	2,50	0,00	0,00	42,71
TOTAL	1840,90	193,64	66 976,88	1739,70	13,03	61,53	70825,68

Source: Data from the General Directorate of the State Forests and national parks, 2020.

Tab. 7.2. *List of species and lots of seeds (or other parts of plants) of woody and herbaceous plants, stored as resources of static ex situ conservation in the Kostrzyca Forest Gene Bank.*

No.	**Species**	**Storage of seeds**	
		Cold rooms (number of lots	**Cryogenic containers (number of lots)**
1.	Common barberry (*Berberis vulgaris*)	6	0
2.	Silver birch (*Betula pendula*)	231	143
3.	Dwarf birch (*Betula nana*)	5	9
4.	Shrub birch (*Betula humilis*)	2	3
5.	Ojców birch (*Betula pendula var. oycoviensis)*	1	1
6.	Downy birch (*Betula pubescens*)	1	0
7.	Common beech (*Fagus sylvatica*)	2	0
8.	Common yew (*Taxus baccata*)	18	2
9.	Wild cherry (*Prunus avium*)	46	27
10.	Douglas fir (*Pseudotsuga menziesii*)	300	0
11.	Sessile oak (*Quercus petraea*)	0	34
12.	Pedunculate oak (*Quercus robur*)	0	81
13.	White dogwood, *Cornus alba*)	1	0
14.	Midland hawthorn, *Crataegus laevigata*)	1	0
15.	Single-seeded hawthorn, *Crataegus monogyna*)	2	0
16.	Common hornbeam (*Carpinus betulus*)	2	1
17.	Common pear, (*Pyrus communis*)	1	0
18.	*Cotoneaster nebrodensis* (Guss.) K.Koch	1	0
19.	Common cotoneaster (*Cotoneaster integerrimus*)	1	0
20.	European crab apple (*Malus sylvestris*)	1	1
21.	Common juniper (*Juniperus communis*)	2	0
22.	Wild service tree (*Sorbus torminalis*)	2	2
23.	Silver whitebeam (*Sorbus aria*)	0	1
24.	*Sorbus sudetica*	0	1
25.	Common ash (*Fraxinus excelsior*)	28	145
26.	Silver fir (*Abies alba*)	1	278
27.	Crunberrybush (*Viburnum opulus*)	2	0
28.	Sycamore maple (*Acer pseudoplatanus*)	4	0
29.	Field maple (*Acer campestre*)	1	0
30.	Norway maple (*Acer platanoides*)	1	0
31.	European bladdernut (*Staphylea pinnata*)	1	0
32.	Small-leaved lime (*Tilia cordata*)	27	34
33.	Large-leaved lime (*Tilia platyphyllos*)	1	0
34.	European larch (*Larix decidua*)	546	0
35.	Polish larch (*Larix polonica*)	1	0
36.	Black alder (*Alnus glutinosa*)	265	264
37.	Grey alder (speckled alder, *Alnus incana*)	4	0
38.	Black locust (*Robinia pseudoacacia*)	21	0
39.	Sea-buckthorn (*Hippophae rhamnoides*)	0	1
40.	Rugosa rose, (*Rosa rugosa*)	2	0
41.	Azalea alpine, (*Rhododendron ferrugineum*)	0	1
42.	Yellow azalea, (*Rhododendron luteum*)	1	1
43.	Peat-bog pine (*Pinus uliginosa*)	2	0

44.	Black pine (*Pinus nigra*)	193	0
45.	Rhaetic pine (*Pinus × rhaetica*)	14	2
46.	Mountain pine (*Pinusmugo*)	2	0
47.	Swiss pine (*Pinus cembra*)	1	0
48.	Scots pine (*Pinus sylvestris*)	4,547	0
49.	Pitch pine (*Pinus rigida*)	1	0
50.	Eastern white pine (*Pinus strobus*)	30	0
51.	Norway spruce (*Picea abies*)	854	0
52.	Black poplar (*Populus nigra*)	1	0
53.	European spindle, (*Euonymus europaeus*)	1	0
54.	Mezereum, (*Daphne mezereum*)	1	1
55.	Wych elm (*Ulmus glabra*)	30	94
56.	Field elm (*Ulmus minor*)	0	2
57.	European white elm (*Ulmus laevis*)	22	48
58.	Pomeranian honeysuckle (*Lonicera periclymenum*)	1	0
59.	Downy willow (*Salix lapponum*)	5	3
60.	Dwarf cherry, (*Prunus fruticosa*)	0	1
61.	Dutch myrtle, (*Myrica gale*)	2	0
62.	Scotch broom, (*Cytisus scoparius*)	1	0
63.	Protected and threatened herbaceous plant species	120	199
	TOTAL	**7,360**	**1,380**

Source: Inventory data of the Kostrzyca Forest Gene Bank, 2020.

Part IV State of use, development, and management of forest genetic resources

Chapter 8. State of use of forest genetic resources

8.1. General information

The choice of suitable forest reproductive material has taken on new importance, both because trees are long-lived species and because rapid climate changes will affect the environmental conditions of trees during their growth and development. Climate changes are one of the reasons why countries need to reassess and modify their policy framework and guidelines concerning the use of forest reproductive material.An important additional practical challenge is that forest managers and owners must take into account the climatic conditions in which the new generation of trees may find themselves in the future. It is therefore important to choose reproductive material that will grow well now, in the current climate and also in the future, under changed climate conditions. At present, many forest owners see forest reproductive material as a cost to be minimised and not as an investment for which they should seek better profits.

Most national laws of European countries only regulate the production and trade in forest reproductive material, but not its use. In order to safeguard the correct use of forest reproductive material, some European Union Member States have included relevant recommendations in their national legislation for forest owners and managers. In some European Union Member States, forest administrations have given recommendations on the use of selected provenances in different regions. However, adaptive molecular markers are generally still in development and have not yet been widely used for mapping genetic diversity and comparing it with neutral variability markers. Therefore, provenance experiments remain the main source of information about adaptation processes and their effects on forest trees. From these experiments we conclude, among other things, that there is a strong interaction between the genotype and the environment and that it is a common interaction that occurs in forest tree populations, which also means that the "best" origin does not necessarily have to be the best in every location (Konnert *et al.*, 2015).

In Poland, based on Directive 1999/105/EC, the Forest Reproductive Material Act regulating the production and marketing of forest reproductive material has been implemented (Forest Reproductive Material Act, 2001). It regulates the registration of basic forest material, the control of basic forest material and forest reproductive material placed on the market, as well as seed regionalisation (division into regions of origin and the use of forest reproductive material of certain species). Marketing of forest reproductive material includes acquisition, offering for sale or disposal, and acting as an intermediary in the above-mentioned activities (Forest Reproductive Material Act, 2001).

The provisions of the Forest Reproductive Material Act apply to tree species and their artificial hybrids, the list of which is set out in the appendix to the Act (silver birch (*Betula pendula*), downy birch (*Betula pubescens*), common beech (*Fagus sylvatica*), Atlas cedar (*Cedrus atlantica*), Lebanon cedar (*Cedrus libani*), wild cherry (*Prunus avium*), Douglas fir (*Pseudotsuga menziesii*), sessile oak (*Quercus petraea*), Burgundy oak (*Quercus cerris*), red oak (*Quercus rubra*), cork oak (*Quercus suber*), downy oak (*Quercus pubescens*), holm oak (*Quercus ilex*), pedunculate oak (*Quercus robur*), common hornbeam (*Carpinus betulus*), black locust (Robinia pseudoacacia), common ash (*Fraxinus excelsior*), including the narrow-leafed variety, the Greek fir (*Abies cephalonica*), the Spanish fir (*Abies pinsapo*), grand fir, *Abies grandis*), silver fir (Abies alba), chestnut (*Castanea sativa*), sycamore maple (*Acer pseudoplatanus*), Norway maple (*Acer platanoides*), small-leaved lime (*Tilia cordata*), large-leaved lime (*Tilia platyphyllos*), European larch (*Larix decidua*), Eurasian larch (*Larix x eurolepis*), Japanese larch (*Larix kaempferi*), Siberian larch (*Larix sibirica*), black alder (*Alnus glutinosa*), grey alder (*Alnus incana*), Aleppo pine (*Pinus halepensis*), including the Calabrian variety, Bosnian pine (*Pinus heldreichii*), black pine (*Pinus nigra*), Canary Island pine (*Pinus canariensis*), Swiss pine (*Pinus cembra*), Monterey/California pine (*Pinus radiata*), maritime pine (*Pinus pinaster*), stone pine, *Pinus pinea*), eastern white pine (*Pinus strobus*), lodgepole pine, *Pinus contorta*), Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), Sitka spruce (*Picea sitchensis*), poplar (*Populus poplar sp.*) and its artificial hybrids) (Forest Reproductive Material Act, 2001).

The following categories of forest reproductive material have been established: from an identified source, selected, qualified, tested (forest reproductive material may belong to only one category) (Forest Reproductive Material Act, 2001).

The minister responsible for the environment is the governmental authority competent for the marketing of forest reproductive material. His/her tasks include:

1. Maintaining the National Register of Basic Forest Material and the simplified Register of Basic Forest Material.
2. Maintaining a list of forest reproductive material certificates of origin issued and a register of suppliers of forest reproductive material.
3. Issuing permits for import of forest reproductive material from countries outside the European Union.
4. Issuing certificates of origin for forest reproductive material.
5. Inspections of basic forest material, subject to registration in the National Register of the Basic Forest Material, controls of forest reproductive material, controls of suppliers of forest reproductive material.
6. Cooperation with international organisations on forest breeding and seed management.
7. Developing methods for the assessment of forest reproductive material and basic forest material in cooperation with stakeholders.

These tasks are performed by the Minister with the help of the Forest Reproductive Material Office (Forest Reproductive Material Act, 2001).

In Poland, there is the National Forestry Seed Commission, acting as a consultative and advisory body for the minister responsible for the environment. It is composed of 4 permanent members, appointed from among experts in the field of forest tree breeding and seed management, i.e., 2 representatives of the minister, a representative of the Director General of the State Forests and a representative of the Director of the Forest Research Institute.The Commission's tasks include issuing opinions on the registration of basic forest material in the National Register of the Basic Forest Material in Parts II, III and IV, and giving opinions on methods of assessing basic forest material and forest reproductive material. The costs of the Commission's activities are financed from the state budget from the part which is administered by the minister responsible for the environment (Forest Reproductive Material Act, 2001).

Basic forest material is registered in the National Register of the Basic Forest Material, kept by the minister responsible for the environment (using computerised data). The National Register of the Basic Forest Material is public, and anyone can request certified extracts and copies from it. The National Register of the Basic Forest Material includes the following parts:

1. Part I, in which basic forest material intended for the production of forest reproductive material belonging to the category "source identified" is recorded.
2. Part II, in which basic forest material intended for the production of forest reproductive material belonging to the category "selected" is recorded.
3. Part III, in which basic forest material intended for the production of forest reproductive material belonging to the category "qualified" is recorded.
4. Part IV, in which basic forest material intended for the production of forest reproductive material belonging to the category "tested" is recorded. (Forest Reproductive Material Act, 2001).

Basic forest basic material, which is subject to registration in the National Register of the Basic Forest Material, should have a certain quality, particularly in terms of phenotypic and genetic characteristics. The minister responsible for the environment determines these requirements by means of regulations (Forest Reproductive Material Act, 2001).

Registration in the National Register of the Basic Forest Material is carried out by the minister responsible for the environment at the request of the owner or manager of the forest basic material. He/she shall refuse to register the basic forest material if he/she finds that the data contained in the application or its annexes are false and if the basic forest material does not meet the specified requirements.The registration of basic forest material in parts II, III and IV of the National Register of the Basic Forest Material requires consultation with the National Forestry Seed Commission. The registration of basic forest material containing genetically modified organisms requires consent for the release of such organisms into the environment, issued pursuant to the provisions on genetically modified organisms. Registered basic forest material shall be periodically verified for compliance with certain requirements. The verification is carried out by the minister responsible for the environment at least once every 5 years (Forest

Reproductive Material Act, 2001).

The minister responsible for the environment also keeps an Simplified Register of Basic Forest Material, made available to the European Commission and the Member States of the European Union on request.

Imports of forest reproductive material from countries which are not members of the European Union require a permit of the minister responsible for the environment. A permit shall be issued for forest reproductive material which fulfils certain conditions for the registration of basic forest materials in the country in which the forest reproductive material has been produced and for the marketing of forest reproductive material. The application for such a permit shall specify the quantity of imported forest reproductive material. The permit shall be issued under conditions laid down by the competent authority of the European Union (Forest Reproductive Material Act, 2001).

The marketing of forest reproductive material may only be carried out by suppliers registered in the suppliers' register kept by the minister responsible for the environment (registration is carried out on request of the supplier concerned).

The minister responsible for the environment shall determine by regulation the list, areas, and maps of the regions of origin, taking into account that the boundaries of the regions of origin shall include areas with the same or similar ecological conditions and where there are stands or seed sources with similar phenotypic or genetic characteristics. The areas of the regions of origin shall be delimited on the basis of an administrative division, taking into account differences in altitude a.s.l. (Forest Reproductive Material Act, 2001).

Most of the basic forest material is located on the grounds of the State Forests. On the grounds of other properties there are 283 objects (mainly in national parks and experimental forest), of which only 6 objects are registered in non-state forests. A significant part of forest reproductive material in the form of seeds, cones and fruit is harvested under the supervision of employees of the State Forests National Forest Holding. Also, a large part of nursery production takes place on the land of the State Forests, which, on the one hand, is a guarantee of the quality of the forest reproductive material supplied, its proper origin, as well as the reliable documentation that is attached during the marketing of forest reproductive material, including certificates of origin and guality.Thus, it can be concluded that the management of forest tree seed in Poland is carried out mainly by the State Forests, starting from the registration of new objects of basic forest material, through the organisation of seed harvests from various categories of basic forest material, seed storage in local cold stores and in the Kostrzyca Forest Gene Bank, as well as production of seedlings in forest nurseries. Also, the distribution of forest reproductive material mainly takes place in the units of the State Forests, providing an appropriate amount of high-quality nursery material also for the purposes of reforestation and afforestation for private recipients and national parks.

The numbers of managers of basic forest material registered in Poland as well as suppliers and producers of forest reproductive material are presented in Tab. 8.1.

Tab. 8.1. *Managers of basic forest material as well as suppliers and producers of forest reproductive material (data from the National Register of the Basic Forest Material, Register of Basic Forest Material of the State Forests and Register of Suppliers of Forest Reproductive Material - as of 06.10.2020).*

	Number of entities	Including SF NFH
Managers of basic forest material	460	430
Suppliers of forest reproductive material	533	431
Producers of forest reproductive material	498	427

Source: Forest Reproductive Material Office data, 2020.

Poland is a country that is completely self-sufficient in terms of the seed base of forest-forming and biocenotic species, which is why there was no need in the past and there is no need at present for seed regionalisation to allow the import of forest reproductive material from outside the state.The Forest Reproductive Material Act allows only for the import of forest reproductive material from border areas of neighbouring countries, i.e., from the objects of basic forest material located up to 100 km from the borders of our state, for species: silver birch (*Betula pendula*), common beech (*Fagus sylvatica*), sessile oak (*Quercus petraea*), pedunculate oak (*Quercus robur*), silver fir (*Abies alba*), European larch (*Larix decidua*), black alder (*Alnus glutinosa*), Scots pine (*Pinus sylvestris*), Norway common spruce (*Picea abies*) (Regulation of the Minister of Environment, 2015).Thus, Poland is also a country that is completely self-sufficient in supplying, to the local market, planting material for afforestation and renewals on state and private land, as well as collected forest reproductive material from seed base in our country is often exported to other countries.Between 2016 and 2019, 1,795.75 kg of seeds and about 1,300,000 tree seedlings per year on average were transferred abroad (Tab. 8.2). The above data may be burdened with a slight error, resulting from the fact that part of forest reproductive material was transferred to Polish producers for final production or nursery treatment, so the material did not come from the Polish forest base of basic forest material (Forest Seed Office data, 2020).

Tab. 8.2 *Export of forest reproductive material from Poland to EU countries in the years 2016-2019.*

Destination country	Species	Seeds (kg)	Seedlings with covered root system (pcs)	Seedlings with exposed root system (pcs)
Austria	Silver fir (*Abies alba*)	0.0000	0.00	63,000.00
	Common beech (*Fagus sylvatica*)	0.0000	116,370.00	44,240.00
Czech Republic	Silver fir (*Abies alba*)	0.0000	5,000.00	199,000.00
	Common beech (*Fagus sylvatica*)	0.0000	0.00	47,500.00
	European larch (*Larix decidua*)	0.0000	8,2180.00	39,440.00
	Norway spruce (*Picea abies*)	0.0000	2,000.00	0.00
Denmark	Norway maple (*Acer platanoides*)	270.0000	0.00	0.00
	European larch (*Larix decidua*)	15.0000	0.00	0.00
	Large-leaved lime (*Tilia platyphyllos*)	85.0000	0.00	0.00
France	European larch (*Larix decidua*)	9.5000	0.00	0.00
The Netherlands	Silver fir (*Abies alba*)	0.0000	1,8591.00	0.00
	Norway maple (*Acer platanoides*)	50.0000	0.00	0.00
	Common beech (*Fagus sylvatica*)	4,925.0000	0.00	0.00
	European larch (*Larix decidua*)	0.0000	20,850.00	2,650.00
	Eurasian larch (*Larixx eurolepis*)	0.0000	9,250.00	1,025.00
	Japanese larch (*Larix kaempferi*)	0.0000	17,825.00	1,200.00
	Norway spruce (*Picea abies*)	0.0000	143,002.00	4,875.00
	Black pine (*Pinus nigra*)	2.3200	107,450.00	5,000.00
	Scots pine (*Pinus sylvestris*)	0.0000	12,500.00	0.00
	Douglas fir (*Pseudotsuga menziesii*)	0.0000	128,775.00	1,086,025.00
	Pedunculate oak (*Quercus robur*)	1,000.0000	0.00	0.00
	Small-leaved lime (*Tilia cordata*)	379.0000	0.00	0.00
Lithuania	Silver birch (*Betula pendula*)	0.0000	0.00	70,000.00
	Common beech (*Fagus sylvatica*)	5.0000	0.00	14,900.00
	European larch (*Larix decidua*)	0.0000	1,000.00	16,000.00
	Scots pine (*Pinus sylvestris*)	0.0000	0.00	60,000.00
	Pedunculate oak (*Quercus robur*)	0.0000	0.00	725,000.00
Germany	Black alder (*Alnus glutinosa*)	0.0000	0.00	475,900.00
	Common hornbeam (*Carpinus betulus*)	0.0000	0.00	1,939.00
	Common beech (*Fagus sylvatica*)	0.0000	0.00	98,810.00
	European larch (*Larix decidua*)	5.9900	0.00	2.00
	Norway spruce (*Picea abies*)	3.0000	0.00	52,000.00
	Sessile oak (*Quercus petraea*)	300.0000	0.00	58,4650.00
	Pedunculate oak (*Quercus robur*)	0.0000	0.00	253,500.00
Slovakia	Silver fir (*Abies alba*)	0.0000	0.00	265,000.00
	Norway spruce (*Picea abies*)	0.0000	0.00	36,000.00
Sweden	Silver birch (*Betula pendula*)	0.0000	18,060.00	0.00
	European larch (*Larix decidua*)	6.8921	0.00	0.00
	Norway spruce (*Picea abies*)	0.0000	227,900.00	0.00

Hungary	European larch (*Larix decidua*)	21.1926	0.00	0.00
	Black pine (*Pinus nigra*)	33.3100	0.00	0.00
	Scots pine (*Pinus sylvestris*)	65.0000	0.00	0.00
United Kingdom	Silver fir (*Abies alba*)	0.4900	0.00	0.00
	Norway maple (*Acer platanoides*)	0.7000	0.00	0.00
	Sycamore maple (*Acer pseudoplatanus*)	0.7150	0.00	0.00
	Black alder (*Alnus glutinosa*)	0.0160	0.00	0.00
	Grey alder (*Alnus incana*)	0.0600	0.00	0.00
	Silver birch (*Betula pendula*)	0.1025	0.00	0.00
	Common hornbeam (*Carpinus betulus*)	0.0862	0.00	0.00
	Common beech (*Fagus sylvatica*)	1.0000	0.00	0.00
	Common (*Fraxinus excelsior*)	1.0000	0.00	0.00
	European larch (*Larix decidua*)	0.1380	0.00	0.00
	Norway spruce (*Picea abies*)	0.0900	0.00	0.00
	Scots pine (*Pinus sylvestris*)	0.0700	0.00	0.00
	Black poplar (*Populus nigra*)	0.0098	0.00	0.00
	Wild cherry (*Prunus avium*)	1.2000	0.00	0.00
	Small-leaved lime (*Tilia cordata*)	0.6900	0.00	0.00
	Large-leaved lime (*Tilia platyphyllos*)	0.4540	0.00	0.00
TOTAL:		**718,302.62**	**91,075.00**	**4,147,656,00**

Source: Forest Reproductive Material Office data, 2020.

8.2. Storage and quality of seeds

The specificity of forest maintenance requires the long-term storage of large quantities of seeds of different species of trees and shrubs in order to ensure regular coverage of the need to sow forest nurseries. Seed stocks for current needs and for years with no harvest are placed in storage facilities. The developed technologies allow for several or several dozen years of storage of seeds in controlled humidity and air temperature conditions. One of the methods of storage, especially in the case of species producing seeds particularly sensitive to dehydration and species that species irregularly and seeds which lose their vitality during storage, is cryopreservation (Chałupka *et al*., 2011).

The cones, fruit and seeds, after being harvested during the seed years, from the registered basic forest material objects go to seed extraction and ectraction seed storage facilities scattered throughout the country. In Poland, there are 24 forest tree seed extractor and storage facilities (Table 8.3, Fig. 8.1). Seeds of forest trees and shrubs are stored for a short period of time, for the purpose of achieving the objectives of silviculture, in seed storage facilities, and also for a long period of time, for the purpose of achieving the objectives of conservation of forest genetic resources in the Kostrzyca Forest Gene Bank (Tab. 8.4, Fig. 8.2).

Seed testing stations started operating in the State Forests as early as in the 1930s. Currently, the following seed quality methods are in force: germination method, tetrazoline method, indigocarmine method, cutting method, X-ray method.The network of seed testing and control stations allows the systematic collection of data on the quality of seeds and cones from regions of origin throughout the country. The system of information collected makes it possible to track the yield and quality of seeds on an ongoing basis, and to quickly produce annual communications on the expected yield of the most important forest trees and shrubs. The information and documents produced are also the basis for management decisions (Chałupka *et al.*, 2011).

Tab. 8.3. *Seed extraction and storage facilities in the State Forests National Forest Holding.*

No.	Location	Type of facility
1.	Kostrzyca Forest Gene Bank	Extraction and storage facility
2.	Białogard Forest District	Extraction and storage facility
3.	Bielsko Forest District	Storage facility
4.	Brzesko Forest District	Extraction and storage facility
5.	Czarna Białostocka Forest District	Extraction and storage facility
6.	Dębno Forest District	Extraction and storage facility
7.	Dukla Forest District	Extraction and storage facility
8.	Grotniki Forest District	Extraction and storage facility
9.	Gryfino Forest District	Storage facility
10.	Jabłonna Forest District	Storage facility
1.	Jarocin Forest District	Extraction and storage facility
12.	Jedwabno Forest District	Extraction and storage facility
13.	Kaliska Forest District	Extraction and storage facility

14.	KluczborkForest District	Extraction and storage facility
15.	Łochów Forest District	Extraction facility
16.	Łopuchówko Forest District	Storage facility
17.	Maskuliskie Forest District	Extraction and storage facility
18.	Nowa Sól Forest District	Extraction and storage facility
19.	Rudy Raciborskie Forest District	Storage facility
20.	Rytel Forest District	Extraction and storage facility
21.	Smolarz Forest District	Storage facility
22.	Świerczyna Forest District	Storage facility
23.	Wisła Forest District	Storage facility
24.	Zwierzyniec Forest District	Extraction and storage facility

Source: data from the General Directorate of the State Forests, 2020.

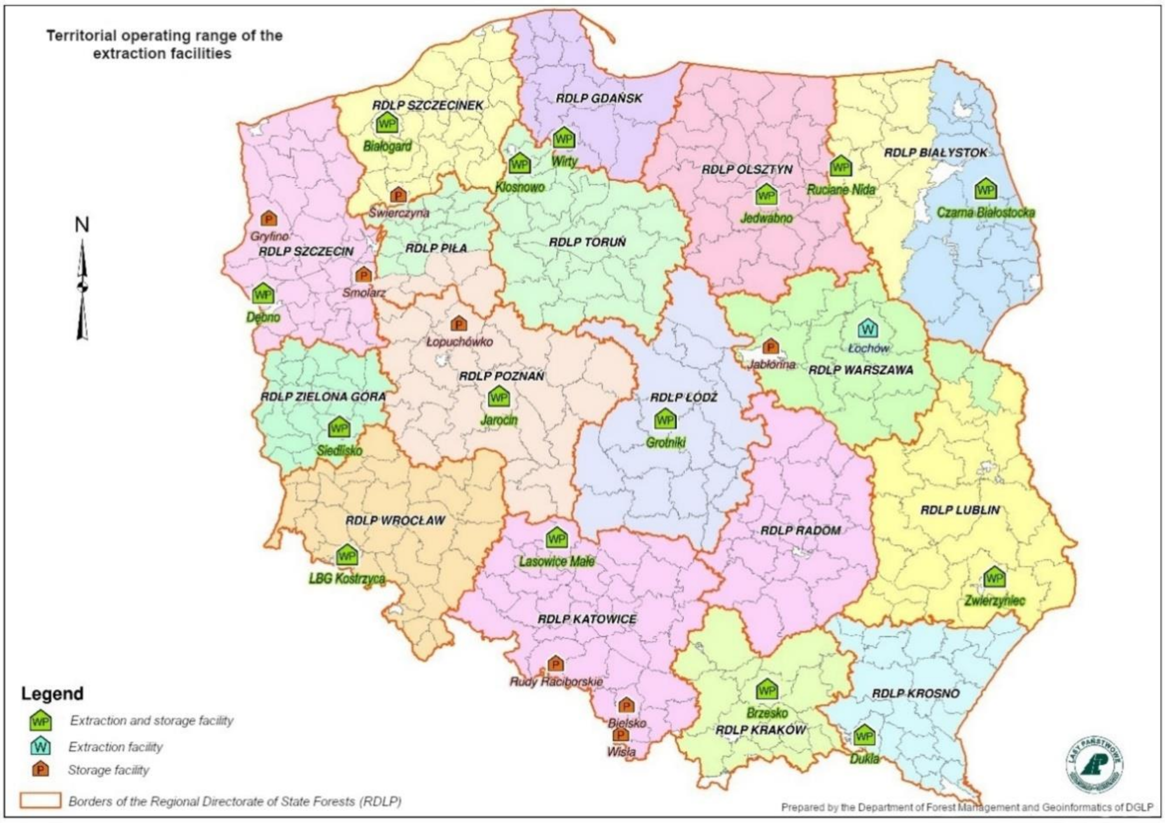

Fig. 8.1. Territorial operating ranges of extraction and storage of forest tree seeds facilities in Poland.
Source: Chałupka *et al.*, 2011.

Tab. 8.4. *Seed testing and seed quality control stations in the State Forests National Forest Holding.*

No.	Location	Type of facility
1.	Forest Research Institute	Seed testing station
2.	Kostrzyca Forest Gene Bank	Seed testing station
3.	Białogard Forest District	Seed testing station
4.	Bielsko Forest District	Seed quality control station
5.	Dukla Forest District	Seed testing station
6.	Jarocin Forest District	Seed quality control station
7.	Kaliska Forest District	Seed quality control station
8.	KluczborkForest District	Seed testing station
9.	Rudy Raciborskie Forest District	Seed quality control station
10.	Rytel Forest District	Seed testing station
11.	Wisła Forest District	Seed quality control station
12.	Zwierzyniec Forest District	Seed testing station
13.	Centre for Development and Implementation Centre of State Forests in Bedoń	Seed testing station
14.	Production, Service and Commercial Department of State Forests in Olsztyn	Seed testing station

Source: data from the General Directorate of the State Forests, 2020.

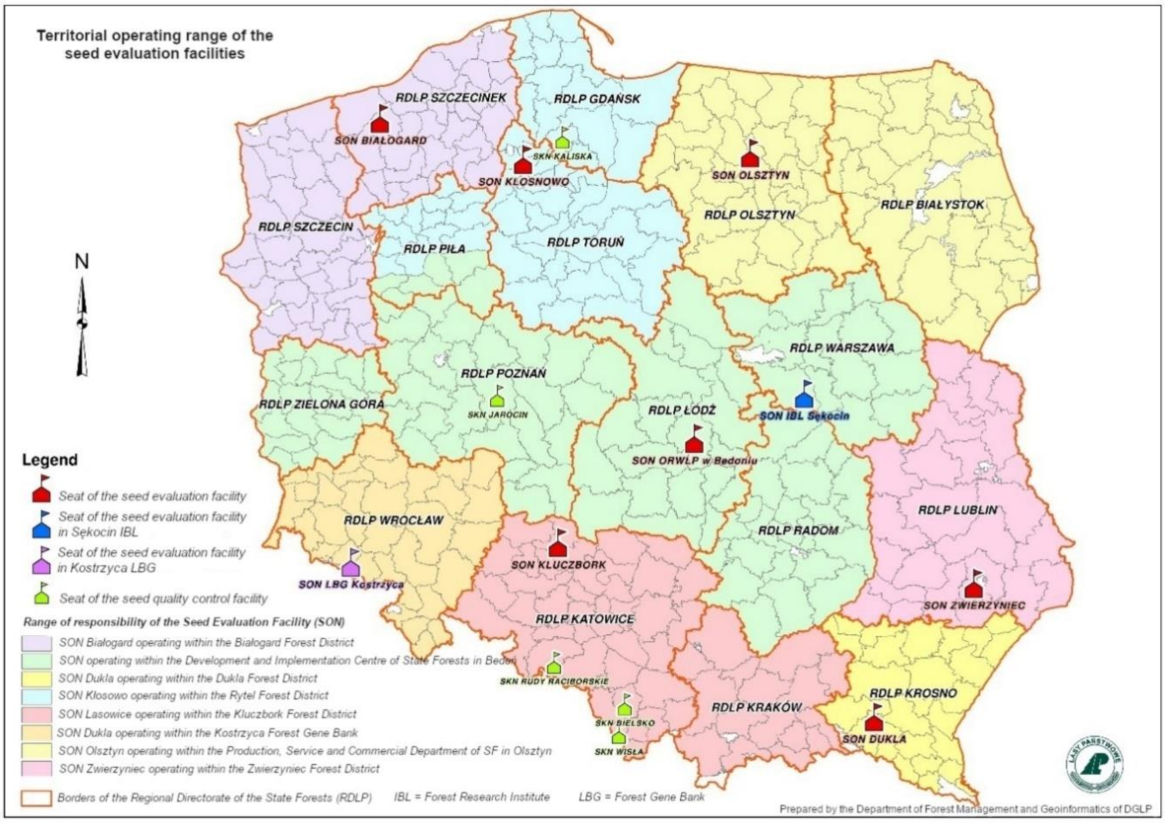

Fig. 8.2. Territorial operating ranges of forest tree and shrub seed testing stations in Poland.
Source: Chałupka *et al.*, 2011.

8.3. Nursery production

The seedlings for renewals and afforestation are produced in forest nurseries. According to the data from Statistics Poland, the production area of forest nurseries in 2019 was 1,860 ha, of which 1,838 ha in the State Forests National Forest Holding, 14 ha in national parks and 8 ha in other public forests (Zajączkowski G. *et al.*, 2020).

The production of seedlings in the State Forests takes place in a ground, container and tunnel system. Nearly 88% of the total production of seedlings comes from ground nurseries. In 2019, a total of 784,000,000 seedlings of forest trees and shrubs were produced in the State Forests, 55,000,000 (7.5%) more than during the previous year. The increase in production resulted from the need to plant areas destroyed by the wind in 2017. More than half of the seedlings (52.1%) were trees of deciduous species (Zajączkowski G. *et al.*, 2020).

In connection with updating the state of forest habitats, reducing the supply of post-agricultural land for afforestation, increasing the share of deciduous tree species in renewals and afforestation, usually planted in a looser bond than coniferous species, as well as in connection with conversion of stands and increasing share of natural regeneration in Polish forests, the area of forest nurseries in the State Forests is constantly decreasing. In the years 2014-2019 it decreased by 223 ha (Tab. 8.5).

Tab. 8.5. *Changes in the area of forest nurseries in the State Forests National Forest Holding in the years 2014-2018*

Area of forest nurseries in the State Forests National Forest Holding					
Year	2014	2015	2016	2017	2018
Production area (ha)	2,104	1,993	1,949	1,916	1,881

Source: data from the General Directorate of the State Forests, 2020.

Due to the structure of forest habitats and climatic conditions, the model of artificial forest renewals will always remain dominant in Poland. Usually, in a given year, natural regeneration of forests in Poland takes place on the area of a dozen or so per cent of the renewed area (Fig. 8.3). In 2019, this indicator was 13.7% (Zajączkowski G. *et al.*, 2020).

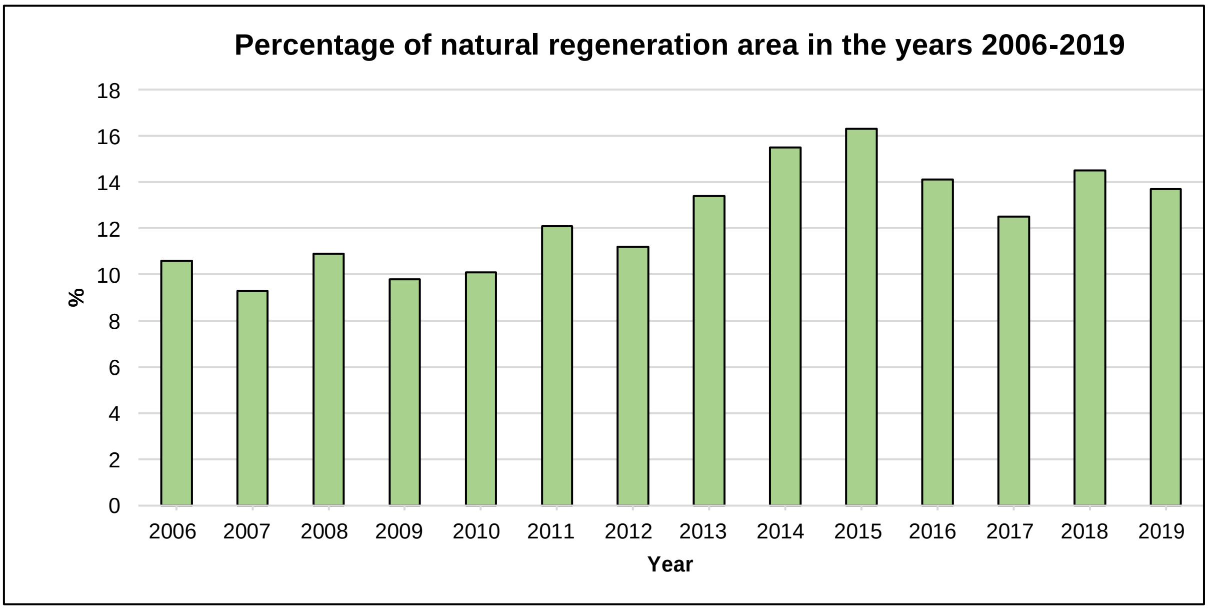

Fig. 8.3. Percentage of natural regeneration area in the years 2006-2019.
Source: data from the General Directorate of the State Forests, 2020.

Over the last 10 years, the production of conifer seedlings has remained at a similar level, while for deciduous tree species it has fluctuated with an upward trend in recent years (Fig. 8.5). In total, the nursery production of coniferous and deciduous tree species has remained at an average level of about 800,000,000 seedlings per year with a slight upward trend in the last few years (Fig. 8.6).

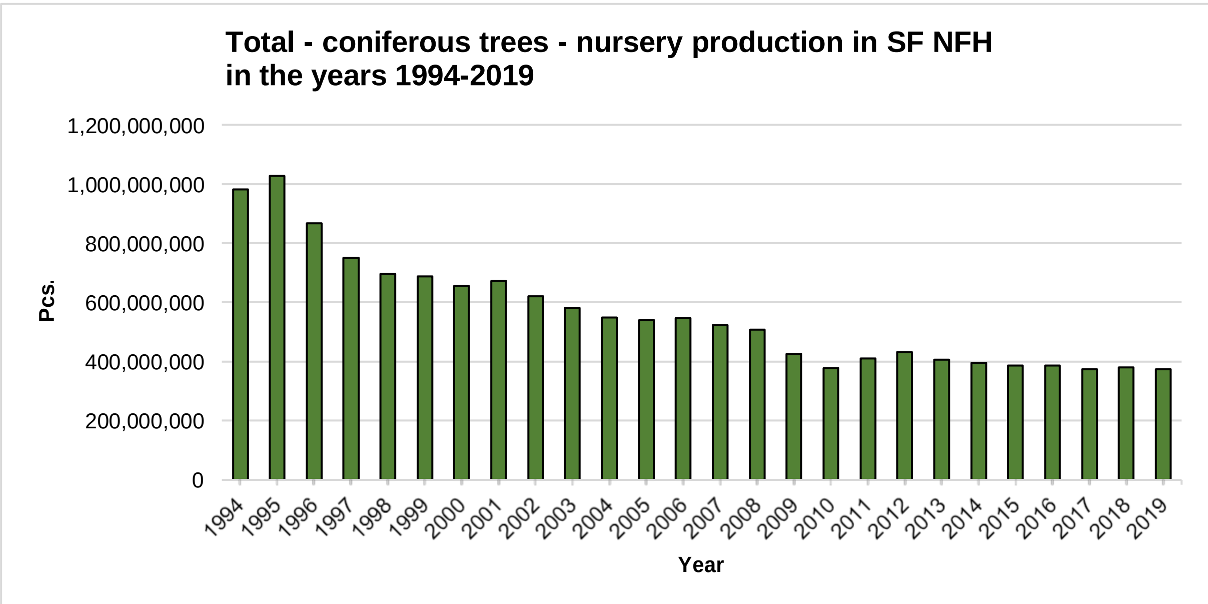

Fig. 8.4. Nursery production of coniferous tree species in the State Forests in the years 1994-2019.
Source: data from the General Directorate of the State Forests, 2020.

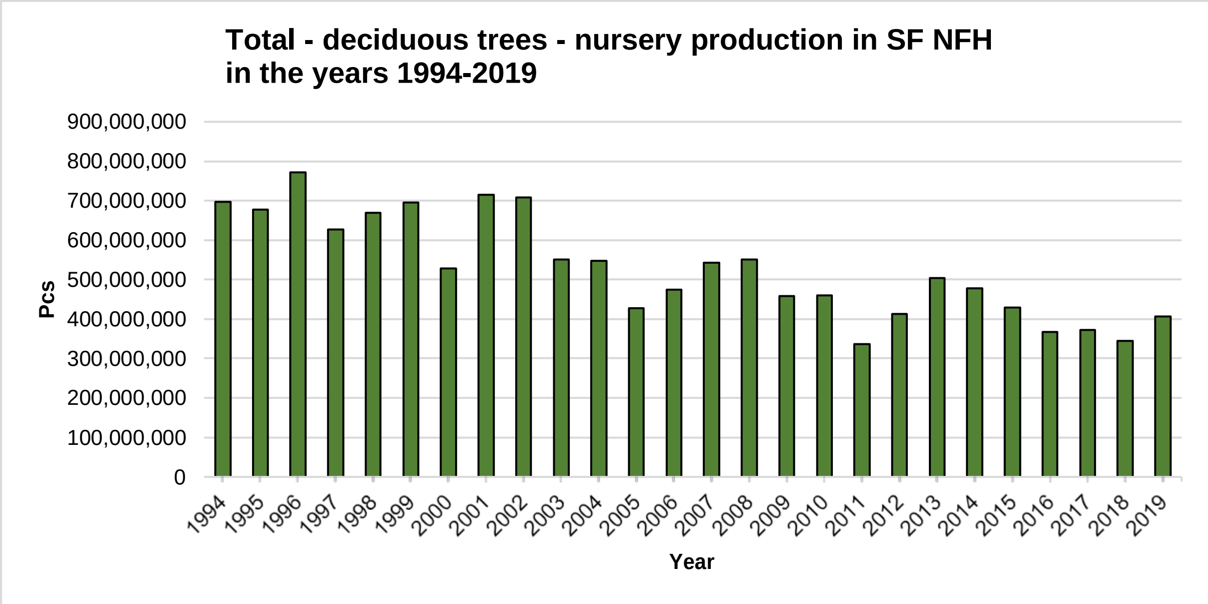

Fig. 8.5. Nursery production of deciduous trees species in the State Forests in the years 1994-2019.

Source: data from the General Directorate of the State Forests, 2020.

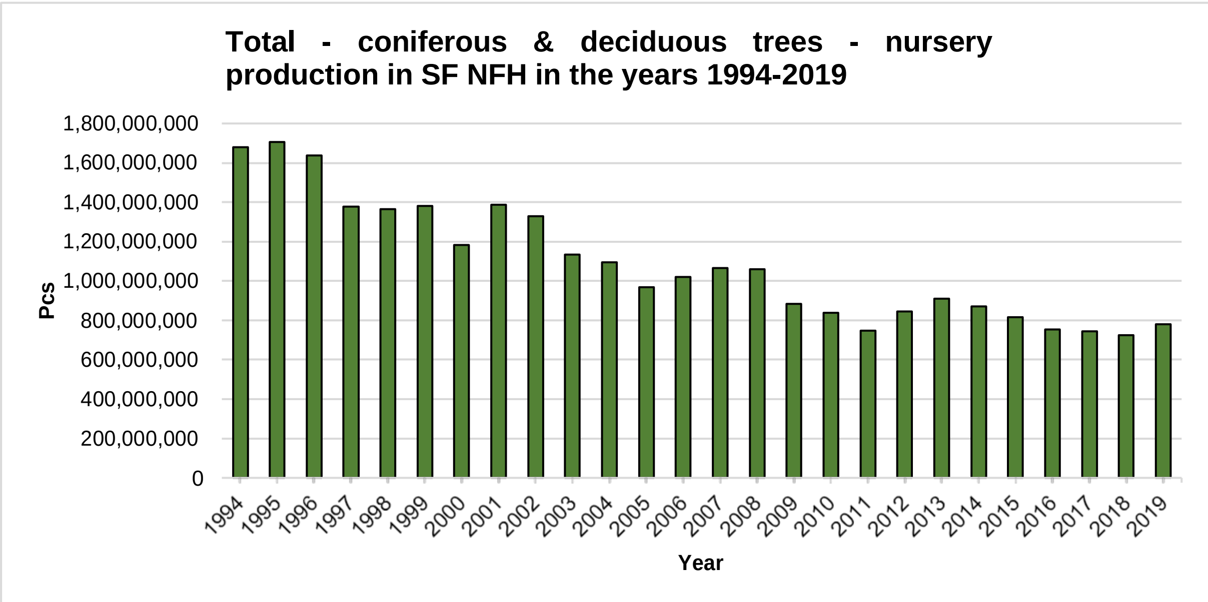

Fig. 8.6. Nursery production of coniferous & deciduous trees species in the State Forests in the years 1994-2019.

Source: data from the General Directorate of the State Forests, 2020.

8.4. The seed management of forest trees in Poland

Seed bases, created as a result of population selection, based on a broad genetic basis, representing the genetic variability of individual species, are essential for forest reproduction. Seed bases created as a result of individual selection are of complementary importance (Haze, 2012).

Seeds of the main forest tree species listed in the Appendix to the Forest Reproductive Material Act, necessary for the reproduction of the forest, may only be obtained from basic forest material registered in the National Register of the Basic Forest Material. Tree seeds of species not listed in the Appendix to the Forest Reproductive Material Act may be obtained from the seed base registered in the National Register of the Basic Forest Material of the State Forests.The harvesting of cones, fruit and seeds of the main forest-forming species is determined annually by the district forest manager, taking into account the possessed seed stocks and their quality, own demand, reports of other forest districts and supervised forests for the coming years and the possibilities of seed harvesting in a given year. For particular forest tree species, seed reserves or planting stock reserves are created, considering the frequency of good seed yields and the period of nursery production (Haze, 2012).

The aim of forest seed management is to:

1. Preserve a natural richness of the forest at ecosystem, species, and genetic level.
2. Ensure a constant supply of tree seeds of forest-forming and admixture species at an appropriate quantitative and qualitative level.
3. Preserve the natural genetic diversity of populations of native forest tree species and to strengthening the best populations in the areas where they occur.
4. Select, manage, and use the most valuable populations of native tree species with established phenotypic and genotypic characteristics and to extend the use of their offspring in forest renewals.
5. Increase the area in which the best populations, coming from maternal regions and characterised by their high capacity to adapt to changing environmental conditions, can be found.
6. Improve the methodology of quality testing.
7. Eliminate from the market seeds of unknown origin (Haze, 2012).

In the State Forests, issues related to broadly defined forest genetic resources are regulated by the "Programme of conserving forest genetic resources and breeding of trees in Poland for the years 2011-2035". The selected premises of this Programme are presented below:

1. Limiting the productive functions of forests due to the application of pro-ecological principles of forest management and increasing the importance of non-productive functions of the forest.
2. Demand outweighs supply of wood, despite increased harvesting.

3. Under-utilisation of the production potential of Polish forests.
4. The need to guarantee the maintenance of genetic diversity and the sustainability of forests under changing environmental conditions, while preventing the reduction of forest genetic diversity. Breeding of forest trees should be aimed, among other things, at genetic modification of populations, enhancing their natural ability to adapt to changing environmental conditions.
5. The need to adapt the principles of seed management to the requirements of the European Union and to protect forests in Poland against an uncontrolled inflow of seeds and seedlings of unknown origin, threatening the sustainability and stability of forest ecosystems (Chałupka *et al*., 2011).

The strategic objectives of the programme include:

1. Protecting and enriching existing genetic diversity of the forests.

The preservation of forest genetic diversity is necessary to ensure the continuity of basic ecological processes, the sustainability of forest maintenance and the use of ecological systems, the restoration of forests in degraded habitats, the enhancement of the natural resilience of stands and communities and the preservation of genetic diversity for future generations.Forest trees with their genetic resources are the most important component of forest ecosystems, forming ecological niches for other species of flora and fauna. The forest also satisfies growing, multiple social and economic needs.In many cases, forms of passive protection do not have the desired effect, often leading to replacement of ecosystem elements, valuable for the natural heritage, by other, more dynamic ones. It is therefore necessary to develop programmes for the active protection and restitution of certain plant species, including forest-forming, admixed and rare tree species.The most important objects of interest of the State Forests National Forest Holding in the field of protection and conservation of genetic resources are basic forest-forming species of commercial importance. Many populations of these tree species, often due to activation of biotic factors, as secondary to abiotic and anthropogenic, show features of instability and even extinction.Therefore, there is an urgent need to preserve existing natural or locally acclimatised populations.A significant threat to deciduous tree species are changes in habitat conditions. In recent decades, significant weakening of deciduous stands, mainly ash and oak, has been observed. It is believed that the primary cause of the loss of stability of deciduous stands and the occurrence of disease phenomena are drastic fluctuations in groundwater levels as well as the activation of fungal pathogens and insect pests, which have not been economically significant before.Rare tree species, which are at risk of extinction, require the greatest commitment to protecting genetic diversity.The "Red list of plants and fungi in Poland" and the "Red list of the vascular plants in Poland" note six such species: common yew (*Taxus baccata*), Swiss pine (*Pinus cembra*), wild service tree (*Sorbus torminalis*), rhaetic pine (*Pinus* × *rhaetica*), the savin (savin juniper, *Juniperus sabina*) and downy oak (*Quercus pubescens*). For these species, individual genetic diversity conservation programmes should be implemented, combined with their reintroduction.The material tasks to be carried out by the units of the State Forests in the field of genetic diversity protection are, first of all, to run the already qualified objects, to select further conservation objects and to establish conservation plantations and clone archives for selected objects. These tasks will be increased as the number of objects selected for genetic diversity protection increases (Chałupka *et al.*, 2011).

2. The breeding of forest trees.

The concept of breeding refers to the science of improving the useful characteristics of trees on a genetic basis and to practical measures aimed at producing varieties that are more productive, of better quality and more resistant to biotic and abiotic risks than wild populations or varieties created to date. Genetic diversity is a prerequisite for successful selection, and therefore all breeding work begins with the recognition and use of natural diversity or its artificial enhancement.The most effective way to increase, improve and maintain the sustainability of the productive and non-productive functions of the forest is through various methods of selection of forest trees. Artificial selection, as opposed to natural selection, is controlled by the breeder, and carried out under consciously selected environmental conditions. The best results are achieved when selection is carried out according to one selected feature. The subject of selection can be entire populations (population selection) or individual trees (individual selection). Population selection consists of the selection of the best populations, taking into account the adopted objective of selection and maintaining their phenotypic variability. This ensures a high level of genetic diversity of the stands and their adaptation to local conditions. There is relatively little possibility for improvement of breeding traits, by 10-15% at most, compared to the selected traits for which the stands are selected.Individual selection consists of selecting the best individual trees in terms of specific characteristics and improving such characteristics to the extent specified by the breeder. Individual selection methods are a more effective way to improve the selected traits. To consolidate the positive effects of selection in the offspring, it is necessary that mating takes place only between selected individuals and that the selected species are effectively isolated from the influence of unselected individuals of the same species. Breeding of forest trees and the creation of basic forest material are carried out using population and individual selection methods. Population selection is of key importance - it should meet the seed needs of the State Forests units in 60%. The remaining part will consist of seeds from clonal seed orchards and seedling seed orchards.The programme of breeding includes selection of stands of known origin (production seed stands), selected stands (reserved seed stands) and maternal trees, as well as establishment of progeny plantations, clonal seed orchards and seedling seed orchards for selected species. Breeding of forest trees for already existing objects will benefit primarily from the results of testing of selected stands, trees and seed orchards and the basic forest material objects created from them, registered in Part IV of the National Register of the Basic Forest

Material. An important task is also the verification and modification of the principles of use and transfer of reproductive material (Chałupka *et al.*, 2011).

The selection work shall, among other things, pursue the following objectives:

a) improving the quality and increasing the productivity of the populations,
b) selecting populations and genotypes of high plasticity under changing climate conditions (population and individual selection),
c) increasing the stability of the stands by creating breeding populations based on seed orchards with specific genetic diversity,
d) improving quality features - selecting genotypes with specific traits, creating artificial breeding populations,
e) increasing resistance to biotic and abiotic factors,
f) increasing production of wood mass in short and medium production cycles, (Chałupka *et al.*, 2011).

The planned tasks in the field of breeding of forest trees shall include:

a) continuation of the tasks carried out: selection, management and use of selected stands, selection and use of maternal trees, establishment of clonal seed orchards and seedling seed orchards of the first generation, establishment of blocks of progeny plantations, assessment of the silvicultural characteristics of progeny plantations entering the age of the reproduction,
b) new tasks related to the evaluation of the genetic quality of basic forest material:

- establishment, management and evaluation of basic forest material for the production of category II and III forest reproductive material (selected stands, maternal trees, clonal seed orchards and seedling seed orchards),
- selection of objects of basic forest material for the production of forest reproductive material of the "tested" category,
- development of rules for the maintenance and use of basic forest material registered in Part IV of the National Register of the Basic Forest Material,
- establishment of clonal seed orchards and seedling seed orchards of higher generations,
- establishment of plantations from basic forest material of known genetic value, (Chałupka *et al.*, 2011).

The long-term breeding strategy to be implemented shall be based on the following general assumptions:

a) breeding populations with a certain number of selected genotypes shall be established for each species,
b) the size of the breeding populations shall be similar in each selection cycle,
c) in the next selection cycle, breeding populations shall be formed by selection in progeny derived from free pollination or controlled crossbreeding of genotypes selected from the

previous cycle,

d) the selection criteria shall be quantitative, qualitative and plasticity characteristics which guarantee the durability of forest production,

e) the intensity of selection in subsequent cycles should be, for particular characteristics, similar (Chałupka et al., 2011).

The tasks for the State Forests, in terms of breeding, include:

a) establishment of breeding populations within the framework of long-term selection using the results of the progeny testing programme of such species as: Scots pine (Pinus sylvestris), Norway spruce (Picea abies), European larch (Larix decidua), Douglas fir (Pseudotsuga menziesii), silver birch (Betula pendula), common beech (Fagus sylvatica), pedunculate oak (Quercus robur), sessile oak (Quercus petraea) and black alder (Alnus glutinosa),

b) establishment of breeding populations within the framework of selection for special purposes of such species as: silver birch (Betula pendula), European larch (Larix decidua), Douglas fir (Pseudotsuga menziesii), pedunculate oak (Quercus robur), sessile oak (Quercus petraea), Norway spruce (Picea abies), common ash (Fraxinus excelsior), the elms (Ulmus sp.),

c) reproduction of the particularly valuable populations of Norway spruce (Picea abies) and Scots pine (Pinus sylvestris),

d) restoration of dying populations: common ash (Fraxinus excelsior), black poplar (Populus nigra), white poplar (silverleaf poplar, Populus alba), grey poplar (Populus canescens), common yew (Taxus baccata), European white elm (Ulmus laevis), wych elm (Ulmus glabra), field elm (Ulmus minor), small-leaved lime (Tilia cordata), large-leaved lime (Tilia platyphyllos), wild service tree (Sorbus torminalis), wild cherry (Prunus avium), European crab apple (Malus sylvestris), common pear (Pyrus communis), silver fir (Abies alba) and Norway spruce (Picea abies),

e) creation and maintenance of basic forest material at an appropriate quantitative and qualitative level for renewals and afforestation.

It is necessary to maintain a specified size of the seed base, which is used to harvest seeds for the current renewals and afforestation tasks. The most important task is to maintain the existing stands and orchards and to exchange them by replacing the deleted objects. At the same time, scientific research should be carried out in the field of progeny testing, allowing for detailed knowledge of genetic diversity and value, as well as the possibility of using the possessed basic forest material.A special role in the programme is played by autochthonous and indigenous seed stands of the most important tree species, which stand out from other stands growing under the same habitat conditions, by their quality, health and adaptability, high production of wood mass and preserving the specific characteristics of indigenous tree ecotypes. They are a valuable source of seeds with the highest silvicultural and genetic value for creating new generations of higher value stands (Chałupka *et al.*, 2011).

In order to perform silvicultural tasks in forests related to renewals and afforestation it is necessary to have a seed base of a certain size. The optimal size of the area of seed objects is determined primarily by:

- the total area of the renewals and afforestation work,
- share of artificial regeneration in the total area of renewals and afforestation,
- production capacity (seeds, cones) of particular species (Chałupka *et al.*, 2011).

Forest reproductive material for renewals and afforestation may be obtained from objects registered in the National Register of the Basic Forest Material and the Register of the Basic Forest Material of the State Forests. The basic task of stands of known origin is to provide seeds for the establishment of secondary forest plantations. Selected stands are used to set up progeny plantations, provenance experimental areas and to qualify tested stands.Objects for the production of forest reproductive material of the category "qualified" – maternal trees, clonal seed orchards and seedling seed orchards, are used for the establishment of progeny plantations, the establishment of small blocks and dispersed progeny plantations only from seed orchards, the establishment of plantations of fast-growing tree species and the certification of trees, clonal seed orchards and seedling seed orchards to the category "tested". Objects for the production of forest reproductive material of the "tested" category will be used for the establishment of progeny plantations' blocks of known genetic value, clonal seed orchards and seedling seed orchards of higher generations and for the establishment of plantations of fast-growing tree species. Conservation stands shall be used for the establishment of *in situ* and *ex situ* conservation secondary forest plantations and for the collection of reproductive material for long-term storage in gene banks (Chałupka *et al.*, 2011).

The implementation of the "Programme of conserving forest genetic resources and breeding of trees in Poland for the years 2011-2035" should ensure:

- the creation of a population seed base at 60% of renewals and afforestation needs and 40% from individual selection,
- the creation of a tested seed base at 10% of the country's seed needs,
- maintaining the selected seed base at 30% of the country's seed needs,
- maintaining a stable seed base from an identified source at 60% of the country's seed needs (Chałupka *et al.*, 2011).

The programme covers the following categories of sites: tree stands, maternal and conservation trees, other endangered plant components of forest communities. Within these categories it is necessary to protect:

- populations valuable for forestry due to their favourable phenotypic characteristics,
- specimens with valuable genotypes of silvicultural value that are the result of intended

selection,

- native populations and tree specimens that came into being before 1860. It is also advisable to preserve the genetic resources of other valuable tree stands and trees because of their adaptability,
- populations and specimens with genotypes considered valuable on the basis of genetic research,
- populations and specimens of tree species and other plant species which, due to their dispersed occurrence and the lack of active protection, are at risk of withdrawal or extinction from forest ecosystems (Chałupka *et al.*, 2011).

In the State Forests, a "Programme for testing progeny of selected seed stands, maternal trees, clonal seed orchards and seedling seed orchards" is being implemented. The aim of testing conducted within the framework of breeding is to determine the genetic and silvicultural value of basic forest material, which is used in forest management, to develop principles of rational use of the seed base by defining the area of possible transfer according to the accepted principles of seed regionalisation, as well as to modify these principles on the basis of genetic information obtained during tests.The results of the tests are used to optimise the tasks carried out in the State Forests in the scope of maintaining the durability of forests, i.e., improving forest management based on ecological basis as well as on preserving the forest genetic resources. On the established areas, observations and measurements are carried out in accordance with the developed methodology (Chałupka *et al.*, 2011).

The specific aims of progeny testing include:

1. Determining the genetic and silvicultural value of selected stands, maternal trees, clonal seed orchards and seedling seed orchards.
2. Classification of basic forest material, i.e., selected stands, maternal trees, clonal seed orchards and clonal seed orchards into the "tested" category.
3. Verification of the existing boundaries of the regions of origin and the rules on the transfer of forest reproductive material.
4. Development of a database on genetic characterisation of basic forest material registered in the National Register of the Basic Forest Material for species covered by the testing programme.
5. Increasing the commercial value of forest reproductive material (Chałupka *et al.*, 2011).

8.5. Needs and recommendations for sustainable use and development of forest genetic resources in Poland.

The needs for legislation include:

1. Implementation of a national forestry strategy, of which a strategy for the conservation of forest genetic resources would be a part.
2. Implementation of the National Forest Programme, of which a part would be a national programme for the conservation of forest genetic resources and breeding of forest trees, also taking into account genetic resources of non-state forests.
3. Amending the Forest Reproductive Material Act in terms of changing the criteria for selection and registration of seed objects, with particular emphasis on conservation objects (trees and stands), to enable the registration of these objects in the National Register of the Basic Forest Material (showing a significant potential for adaptation, and not necessarily high quality of wood material). The above applies in particular to species under strong environmental pressure from climate change, e.g. common ash (*Fraxinus excelsior*), Norway spruce (*Picea abies*), silver fir (*Abies alba*) etc.
4. Evaluation and verification of the current rules for the transfer of forest reproductive material in Poland, taking into account assisted migration of selected species and populations.
5. Implementation of rules for controlling the marketing of forest reproductive material on genetic basis. Harmonised control mechanisms and close cooperation between the agencies controlling the marketing of forest reproductive material in the Member States of the European Union are necessary. Recent technological developments in molecular biology show that the agencies responsible for controlling the marketing of forest reproductive material can easily and relatively cheaply monitor and trace the transfer of forest reproductive material and make this information available to final consumers (Konnert *et al.*, 2015; Resolution on the European Forestry Strategy, 2020).

The education needs concern increased number of trainings for all stakeholders (politicians, government officials, forest managers and owners, NGOs, etc.) on the proper management of forest genetic resources for the conservation of forest maintenance, especially in times of dynamic changes in forest ecosystems.The scientific community has considerable knowledge and information on the potential of forest reproductive material to facilitate the adaptation of forests to climate change (Konnert *et al.*, 2015; Resolution on the European Forestry Strategy, 2020). The lack of proper genetic-based management of forest tree populations is not due to a lack of relevant scientific studies on the subject, but due to the lack of implementation of genetic aspects into forest practice (Frankham, 2010).

Recommendations for amendments to the Forest Reproductive Material Act:

- It should be possible for the minister responsible for the environment to derogate from the law in the case of forest reproductive material intended for: conservation of genetic resources naturally adapted to local conditions and at risk of genetic erosion; research, scientific purposes, selection work or *ex situ* conservation of genetic resources; programmes of restitution, assisted migration and mitigation of the adverse effects of climate change; use in the event of negative phenomena caused by biotic, abiotic or anthropogenic factors; as well as in the event of an exceptional shortage or absence of forest reproductive material of appropriate quality and origin.

- The provisions concerning the removal of objects from the National Register of the Basic Forest Material should be relaxed in the case of faults that can be remedied by means of proper management.
- In matters relating to the mixing of seeds, it is important: to allow mixing of forest reproductive material of the "selected" and "qualified" categories if it comes from the same region of origin, and; to provide for the possibility of mixing forest reproductive material of the "qualified" category and derived from basic forest material of the maternal tree with forest reproductive material of "identified source" or "selected" categories and derived from basic forest material of the forest stand in which the maternal tree is located.

Chapter 9. The state of genetic improvement and breeding programmes

9.1. Methods usedin tree bredding and silviculture

Forest genetic resources are the basis for tree selection and breeding programmes which contribute to the creation of forest reproductive material used in production forestry, during renewals and afforestation, in the conversion of stands or on fast-growing tree plantations. Forest reproductive material is also used for planting in tree-covered areas and producing decorative material for planting in parks and gardens. Recent years have also focused on the important role of forest trees in storing carbon to mitigate climate change. In breeding work to regenerate forests in areas temporarily deforested, it is important to use appropriate forest reproductive material that provides both genetic gain and maintains genetic diversity.

In Poland, work on improving forest trees through selection activities has been carried out for many years. The first targeted actions in the field of breeding of forest trees were undertaken as early as in the 1930s, when the Regulation of the Director General of the State Forests of 29.12.1933 introduced the division of Poland into 8 seed regions, also recommending the selection of "seed stands" and defining the principles of collecting, storing, and transferring seeds between forest districts.The actual start of selection work in the State Forests took place in the 1950s, when an regulation was issued to select the seed stands of the most important forest tree species. These stands had 3 objectives to meet, i.e., to secure valuable populations for scientific research, to serve for the harvest of seeds and to be a place for the selection of maternal trees and then to establish (from the selected trees) seed orchards.

In practice, selection work methods and concepts for the development of breeding are implemented for many decades in the form of programmes, the implementation of which has laid the foundations for the current system of selection work in Poland. On the initiative of the Seed and Selection Department of the Forest Research Institute and the General Directorate of the State Forests, the "Programme for improvement of seed management and implementation of the achievements of forest genetics applied in the State Forests in 1975-1990" was developed and implemented (Programme 1975). This document clearly and for the first time set out the material tasks that had to be performed in the State Forests during the 15 years.The technical document regulating the methodology of the works was the Order No. 7 of the Director-General of the State Forests of 07.04.1988 on the selection of forest trees for the needs of forest seed management, specifying in detail the rules for the selection, management, maintaining and use of selected seed stands and production seed stands, the selection and use of maternal trees, the design, establishment, operation and use of clonal seed orchards and seedling seed orchards and the establishment and maintaining of progeny plantations (Kocięcki, 1988).

The next stage of these activities was the "Programme of conserving forest genetic resources and breeding of trees in Poland for the years 1991-2010" introduced in the State Forests in 1991, amended in 2000 (Matras *et al.*, 1993; Matras *et al.*, 2000). It should be stressed that it was a continuation of the previously implemented forest tree breeding programmes.The programme highlighted the need to protect genetic diversity of the State Forests. This was caused, among other things, by the threats to the natural environment that occurred in the 1980s, especially the industrial pollution, which in large areas of the forest caused disease processes in trees, the deterioration of forest health and the local dying of stands. One example of this was the disappearance of forests in the Western Sudetes.The objectives of the programme included:

- conservation of forest genetic resources, aimed at maintaining the continuity of ecological processes in forest ecosystems, and in particular at ensuring the sustainability of forest maintenance and the possibility of using the forest and restoring the stands on degraded or damaged habitats, as well as preserving biodiversity and genetic diversity for future generations,
- improvement of the seed base to ensure a constant supply of forest reproductive material to forest users at the necessary qualitative and quantitative level,
- selection of forest trees to ensure intensification of production and improvement of quality characteristics, considering the plasticity and resistance of trees to biotic factors.

The next programme has been implemented in 2011 (Chałupka et al., 2011). "Programme of conserving forest genetic resources and breeding of trees in Poland for the years 2011-2035" defined 3 priorities:

- protecting and enriching existing genetic diversity of the forests,
- breeding of forest trees,
- establishment and maintenance of basic forest material at an appropriate quantitative and qualitative level for renewals and afforestation.

All the breeding programmes carried out so far in Poland have always taken into account the issue of protecting the genetic diversity of forest ecosystems, on the one hand, and, on the other hand, have sought to achieve genetic gain, placing emphasis primarily on quality features such as straightness of the trunk, width of the crown, equal branching, health, etc.The selection work was carried out in two ways, on the basis of slow and non-intensive long-term population improvement, and through classical selection, focused on individual selection methods.Population selection traditionally prevails in Poland. Its methods consist in selecting entire populations and seed stands. The focus was on appropriate management of selected stands and preparation of trees for seed harvesting. There are two types of seed stands in Poland, the so-called production seed stands and selected seed stands. Selected (excluded) seed stands owe their name due to the exclusion from felling. The seeds are obtained there from living trees and used for the establishment of secondary forest plantations and registered progeny plantations. What distinguishes the approach used in Poland is a unique programme aimed at transferring genes of phenotypically selected populations by establishing registered progeny plantations.Progeny plantations may be established in large blocks in a single area, duplicating the area of the stand even several times, or in a dispersed form. Such selection activities aim at improving the populations of forest trees, promoting phenotypically selected populations, and additionally improving them in terms of features useful to the forest manager.In practice, this was done using so-called genetic felling, during which unwanted trees were removed. On the other hand, production seed stands were used for felling and usually the seeds from the felled trees were collected on this occasion. The collected seeds were used to establish secondary forest plantations. So far, non-intensive methods of selection are mostly used in Poland.In the previously implemented programme, 59,000 ha of progeny plantations were established by 2010 (Matras *et al.*, 1993). It was over three times more than the area of the selected seed stands.In the currently implemented programme for the years 2011-2035, it was assumed that in 2035, the area of progeny plantations will be more than five times bigger than the area of the selected seed tands (Chałupka *et al.*, 2011). However, due to the difficulties in implementing the plans, caused by various objective factors, it is unrealistic to achieve the planned area of 100,000 ha in 2035. The planned areas to be achieved by 2035 will be adjusted and updated according to the needs and economic and financial situation of the State Forests.

Breeding of forest trees, where units are the subject of improvement, is based on the selection of maternal trees and establishment of seed orchards (vegetative and generative) from them. Orchards are mostly established from trees selected exclusively phenotypically. There are also first orchards of trees planted after taking into account the results of growth tests.Since we are using backward selection here and returning to the genotypes of maternal trees whose progeny from free pollination have been tested, these are 1.5 generation seed orchards. Such orchards were established for Scots pine (Pinus sylvestris) and European larch (Larix decidua) (Lewandowski, Kowalczyk, Litkowiec, Urbaniak and Rzonca, 2017). Another method implemented in practice is to assess the breeding value of maternal trees by analysing the progeny growing on generative seed orchards. Generative seed orchards can be treated as family experiment nd allow the evaluation of genetic parameters of maternal trees (Kowalczyk, 2007). Then, having information about the genetic value of the trees forming the orchards, genetic felling can be performed. Thus, the value of seed orchards is improved.

Since 2005 the "Programme for testing progeny of selected seed stands, maternal trees, clonal seed orchards and seedling seed orchards" has been implemented in Poland on an large scale. The research work, consisting in testing progeny of forest trees, is a consequence of the work carried out so far on selection of forest trees in Poland. This is the next step on the way to improving the populations of forest trees. Testing is an integral part of the currently implemented programme of conserving forest genetic resources and breeding of trees in Poland. This programme has been developed by a team appointed by Order No. 44 of the Director-General of The State Forests of 18.04.2003 chaired by Professor Maciej Giertych and Professor Janusz Sabor. It was introduced by the Order No. 85 of the Director-General of the State Forests of

31.12.2004 on the implementation in the organizational units of the State Forests of the Programme for testing progeny of selected seed stands, maternal trees, clonal seed orchards and seedling seed orchards (Sabor *et al.*, 2004).The purpose of testing the progeny of forest trees is to determine the breeding value in terms of the hereditary transfer of the characteristics of basic forest material used in silviculture and to develop principles for the rational use of the seed base by determining the area of possible transfer according to the accepted principles of seed regionalisation.The specific aims of progeny testing are defined in the programme as (Sabor *et al.*, 2004):

- determining the genetic and breeding value of selected seed stands, maternal trees, clonal seed orchards and seedling seed orchards,
- qualifying the basic forest material, i.e., selected seed stands, maternal trees, cclonal seed orchards andseedling seed orchards to the "tested" category,
- verifying the existing boundaries of the regions of origin and the rules on transfer of forest reproductive material,
- developing a database on the genetic characterisation of basic forest material recorded in the National Register ob f the Basic Forest Material for the species covered by the testing programme,
- increasing the commercial value of forest reproductive material.

The principles of testing basic forest material, registered in the National Register of the Basic Forest Material, are specified in the Regulation of the Minister of Environment of 23.04.2004 on the method of conducting basic forest material tests (Journal of Laws 2004 No 94, item 928).The purpose of the above tests is to confirm that the requirements necessary to register basic forest material in Part IV of the National Register of the Basic Forest Material have been met. Assessment of the genetic value of the progeny of a specific seed base category, as provided for in EU Directive 105 (L11/17: (17-40)), shall be carried out in relation to standards which are either stands (when testing populations) or trees (when testing maternal trees), the characteristics of which constitute the benchmark for the characteristics of the tested basic forest material.The regulation sets out the essential requirements to be met in carrying out the tests as well as the range of information needed to accept their results.

During the implementation of the programme of breeding, the aim was to achieve genetic gain. Gain is differentiated for specific populations and depends on heredity and intensity of selection.In breeding of forest trees, it is the seed orchards that are the tool through which the genetic gain achieved at a given level of the breeding cycle is transferred to forestry practice. Genetic gain is a separate concept from economic profit. From a breeding point of view, genetic gain indicates how much improved material is better in terms of certain characteristics than non-improved material. However, the commercial value of the improved material will be a source of economic profit.The expected genetic gain for the assumed breeding strategy is calculated on the basis of the breeding value of the trees, obtained in progeny tests. However, the most interesting, from the point of view of forestry practice, is the realized genetic gain.Available data on realised genetic gain in different programmes of tree breeding indicate that the realised gain for timber volume is on average about 10% from 1st generation of seed orchards without genetic cutting (Ahtikoski *et al.*, 2020a; Ahtikoski *et al.*, 2020b; Carson, Garcia, and Hayes, 1999; Jansson, Hansen, Haapanen, Kvaalen and Steffenrem, 2017). This value has been averaged from data for different conifer species under different environmental conditions, so it is to be expected that similar genetic gain values can also be obtained under our conditions.

9.2. Prioritisation of applications and features in improving trees and breeding

The Polish model of breeding aims to improve many traits at the same time, not preferring single traits. Such a procedure in population selection is traditionally accepted. In individual selection, maternal trees are selected according to the instructions contained in the guidelines of the Director-General of the State Forests for selection purposes. The National Forestry Seed Commission is responsible for recognizing the trees as maternal trees. For each maternal tree 4 comparative trees are selected. The thickest trees are not chosen. The selection takes into account mainly quality, while diameter at breast height (DBH) as well as height should be above the average for the stand (Kocięcki, 1988; Matras and Fonder, 2006).

The testing programme currently includes tests for the Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), silver fir (*Abies alba*) and common beech (*Fagus sylvatica*) (Tab. 9.1). However, the choice of species does not fully reflect the priorities.The reason for starting work on testing the common beech (*Fagus sylvatica)* and the silver fir (*Abies alba*) was not because these species are the most important, but because of the surplus seed accumulated from many selection objects in the year of good seed harvest. Undoubtedly, the priority species in Poland is the Scots pine (*Pinus sylvestris)*.Evaluation and measurements of the features were performed according to detailed guidelines. Theoretically, the selection of objects for category 4 "tested" is possible in various ways. It is possible to carry out testing with only one feature or to take into account multiple features and assign different economic weights to them. About priorities in the breeding the owner interested in testing the material, in this case the State Forests, decides. It is exceedingly difficult to define such priorities because what we will choose will in fact be evaluated by the next generations, when the trees will grow up to the age of felling. Up to now, the focus has been on the overall appearance of the tree and its growing capacity, hoping that trees of good technical quality and good growth will also come at a price after 100 years. Nowadays, as a result of the observed environmental and climate change, selection priorities are also changed. Greater consideration is being given to the adaptability of trees and their plasticity in warmer and drier growing conditions. So far, however, despite the work that has been going on for nearly 15 years, no basic forest material has been registered in category 4 "tested " as a result of such research.

Tab. 9.1. *Overview of test areas for species*

Species	Age and number of test areas – maternal seed stands				Age and number of test areas – maternal trees				Total
	< 5years	5-10years	>10 years	Total	<5 years	5-10 years	>10 years	Total	
Common beech (*Fagus sylvatica*)	-	-	16	16	-	-	12	12	28
Silver fir (*Abies alba*)	-	-	17	17	-	-	20	20	37
Scots pine (*Pinus sylvestris*)	12	24	12	48	16	40	12	68	116
Norway spruce (*Picea abies*)	4	4	-	8	6	4	-	10	18
Total	16	28	45	89	22	44	44	110	199

Source: data from the Forest Research Institute, 2020.

9.3. Organisation of tree improvement and breeding programmes

Breeding of forest trees has so far been carried out using population and individual (clonal and family) selection methods. Population selection is assumed to meet the seed needs of the State Forests organisational units in 60%. The remaining part is to be made up of seeds coming from clonal seed orchards and seedling seed orchards. A scheme of selection activities in Poland is presented in Fig. 9.1. Work on breeding and improvement of forest trees in Poland is conducted and performed in the public sector. Most of the practical work is carried out for the State Forests and is financed by this institution.The research and conceptual work and supervision of the selection is carried out mainly by the Forest Research Institute. The Institute conducted part of this research in cooperation with forest universities in Warsaw, Poznań and Kraków and the Institute of Dendrology of the Polish Academy of Sciences in Kórnik.The selection of selected stands and practical supervision over the maintaining and management of basic forest material is carried out by a commission appointed by the Director-General of the State Forests and chaired by an employee of the Forest Research Institute. These works are financed entirely by the State Forests. There are no private stakeholders and the public sector, not directly connected with the State Forests, also does not participate in the work on breeding of forest trees.At the same time, a programme of testing the progeny of seed stands and maternal trees is being implemented. From a scientific point of view, it is conducted by a team of scientists dealing with forest genetics, in particular the Forest Research Institute, the Institute of Dendrology of the Polish Academy of Sciences in Kórnik, the Warsaw University of Life Sciences, the Poznań University of Life Sciences and the University of Agriculture in Kraków.The State Forests units carry out technical work related to seed harvesting, seedling production, planting, tending and protection. The research institutions in the programme perform scientific and research work and supervise the implementation of the programme. The activities of the Kostrzyca Forest Gene Bank include coordination, acquisition, quality assessment, storage, and pre-sowing preparation of material for testing.

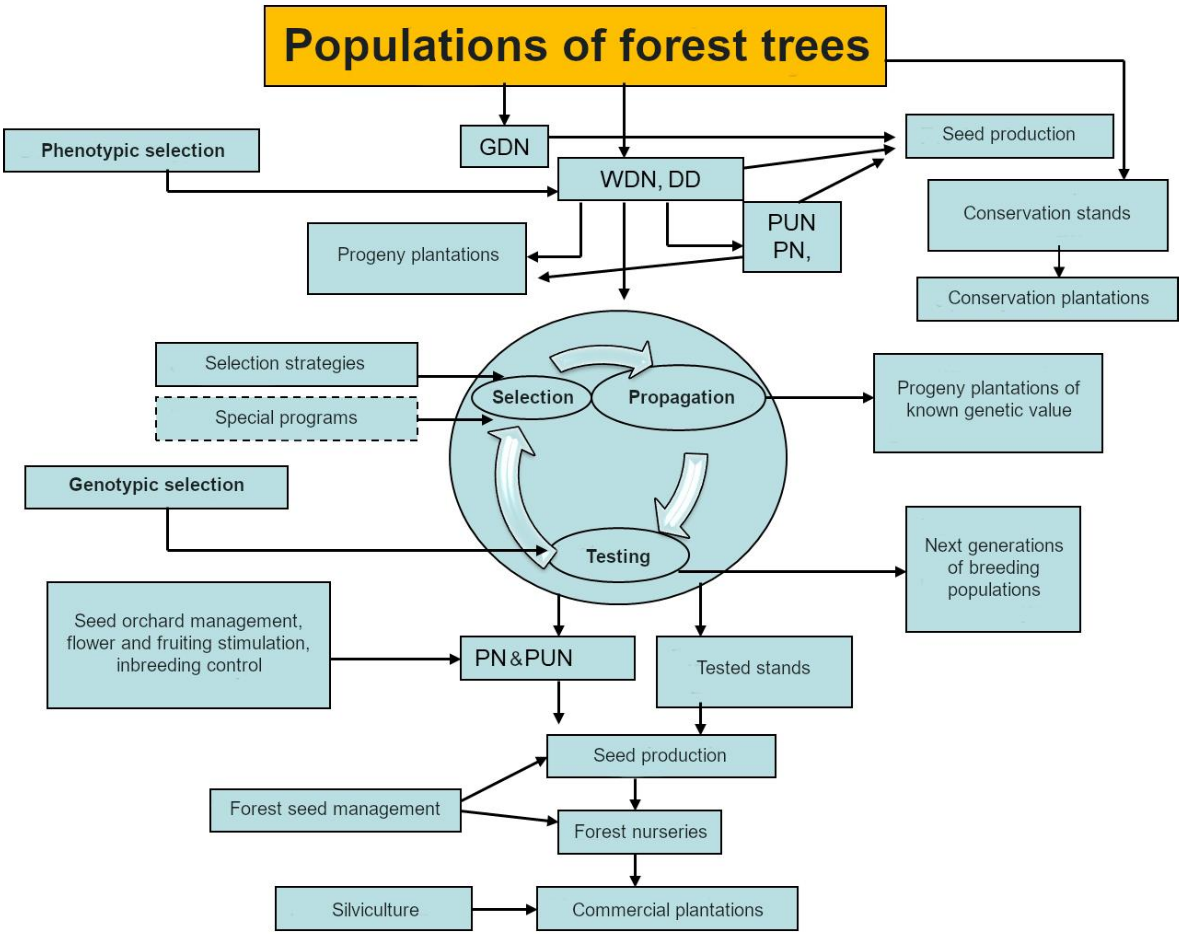

Fig. 9.1. Scheme of selection activities in Poland. Explanations: "GDN" - stands of known origin - formerly production seed stands, "WDN" - selected stands - formerly reserved seed stands, "DD" - mother trees – formerly protected trees, "PUN" - seed orchards (generative), "PN" - seed plantations (vegetative).

Source: Chałupka et al., 2011

The list of selection objects is presented in Tab. 6.1 in Chapter VI, while the list of research areas included in the programme of the forest tree selection conducted by various scientific institutions is presented in Tab. 9.2.

Tab. 9.2. *List of research areas for the forest tree selection scheme carried out by different scientific institutions*

No.	Institution	Species	Area (ha)	Establishing year	Remarks
1.	Forest Research Institute	Silver birch (*Betula pendula*)	7.00	1979	Assessment of family variability / provenance/family area (19 origins)
2.	Forest Research Institute	Silver birch (*Betula pendula*)	0.74	1999	Assessment of family variability (family area, 59 families)
3.	Forest Research Institute	Silver birch (*Betula pendula*)	0.88	1999	Assessment of family variability (family area, 51 families)
4.	Forest Research Institute	Silver birch (*Betula pendula*)	0.94	1999	Assessment of family variability (family area, 80 families)
5.	Warsaw University of Life Sciences	Silver birch (*Betula pendula*)	2.00	-	Population selection area, 10 native populations, 8 foreign populations
6.	Warsaw University of Life Sciences	Silver birch (*Betula pendula*)	3.00	-	Individual selection area, 3 areas of approx. 1 ha each
7.	Forest Research Institute	Silver birch (Betula pendula), dwny birch (Betula pubescens)	1.80	1998	Evaluation of provenance variability (provenance area, 9 origins of silver birch, 1 origin of dwny birch)
8.	Forest Research Institute	Silver birch (Betula pendula), dwny birch (Betula pubescens)	2.19	1998	Evaluation of provenance variability (provenance area, 16 origins of silver birch, 2 origins of dwny birch)
9.	Warsaw University of Life Sciences	Common beech (*Fagus sylvatica*)	9.00	-	Progeny testing of selected seed stand, 3 areas of about 3 ha each
10.	Warsaw University of Life Sciences	Common beech (*Fagus sylvatica*)	4.00	-	Progeny testing of selected seed stand, 2 areas of about 2 ha each
11.	Forest Research Institute	Common beech (*Fagus sylvatica*)	2.00	1995	Evaluation of the provenance variability of European origins (international provenance area, 49 origins)
12.	Forest Research Institute	Common beech (*Fagus sylvatica*)	0.12	1996	Evaluation of provenance variability (provenance area, 7 origins)
13.	Forest Research Institute	Common beech (*Fagus sylvatica*)	0.12	1996	Evaluation of family variability (family area)
14.	Forest Research Institute	Common beech (*Fagus sylvatica*)	1.50	1996	Evaluation of provenance variability (provenance area, 23 origins)
15.	Forest Research Institute	Common beech (*Fagus sylvatica*)	3.10	1996	Evaluation of provenance variability (provenance area)
16.	Warsaw University of Life Sciences	Common beech (*Fagus sylvatica*)	1.20	-	Provenance area (4 native populations)
17.	Warsaw University of Life Sciences	Common beech (*Fagus sylvatica*)	4.00	-	Provenance area (27 native populations)

No.	Institution	Species	Area (ha)	Establishing year	Remarks
18.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	0.46	1964	Material from open and under canopy nursery
19.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	0.60	1964	Provenance area (7 native populations)
20.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	0.60	1964	Provenance area (7 native populations)
21.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	0.60	1964	Provenance area (7 native populations)
22.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	0.60	1964	Provenance area (7 native populations)
23.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	0.60	1964	Provenance area (7 native populations)
24.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	1.94	1976	Provenance area (20 native populations)
25.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	1.07	1990	Provenance area (12 native populations)
26.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	0.89	1990	Provenance area (12 native populations)
27.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	0.50	1990	Provenance area (7 native populations)
28.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	5.00	1992	Provenance area (42 native populations)
29.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	3.50	1992	Provenance area (28 native populations)
30.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	3.00	1992	Provenance area (71 native and European populations)
31.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	1.04	1995	Provenance area (71 native and European populations)
32.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	-	2005	Testing
33.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	-	2005	Testing
34.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	1.65	2008	Testing
35.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	2.52	2008	Testing
36.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	1.66	2008	Testing

No.	Institution	Species	Area (ha)	Establishing year	Remarks
37.	Poznań University of Life Sciences	Common beech (*Fagus sylvatica*)	1.68	2008	Testing
38.	University of Agriculture in Kraków	Common beech (*Fagus sylvatica*)	4.50	1995	Provenance experiment (47 populations from Poland)
39.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Common beech (*Fagus sylvatica*)	2.70	1996	Provenance experiment (47 populations from Poland)
40.	University of Agriculture in Kraków	Common beech (*Fagus sylvatica*), silver fir (*Abies alba*), Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*)	85.00	-	Progeny testing programme - 34 testing plantations
41.	Forest Research Institute	Wild cherry (*Prunus avium*)	0.45	2012	Evaluation of growth in case of different spacing
42.	Forest Research Institute	Wild cherry (*Prunus avium*)	1.02	2012	Evaluation of the variability of growth and adaptive traits (provenance/family area)
43.	Forest Research Institute	Wild cherry (*Prunus avium*)	1.18	2012	Evaluation of the variability of growth and adaptive traits (provenance/family area)
44.	Forest Research Institute	Douglas fir (*Pseudotsuga menziesii*)	3.10	1969	Plantation studies and evaluation of growth traits variability orchard
45.	Forest Research Institute	Douglas fir (*Pseudotsuga menziesii*)	5.32	1970	Evaluation of provenance variability (provenance area)
46.	Forest Research Institute	Douglas fir (*Pseudotsuga menziesii*)	0.80	1974	Evaluation of provenance variability (provenance area)
47.	Forest Research Institute	Douglas fir (*Pseudotsuga menziesii*)	0.91	1974	Evaluation of provenance variability (comparative area, 56 origins)
48.	Forest Research Institute	Douglas fir (*Pseudotsuga menziesii*)	0.70	1977	Evaluation of the variability of growth and adaptive traits (comparative area)
49.	Forest Research Institute	Douglas fir (*Pseudotsuga menziesii*)	9.00	1991	Evaluation of provenance variability (experimental area)

No.	Institution	Species	Area (ha)	Establishing year	Remarks
50.	Warsaw University of Life Sciences	Douglas fir (*Pseudotsuga menziesii*)	1.30	-	Provenance area (5 populations, including 4 from the USA)
51.	Warsaw University of Life Sciences	Douglas fir (*Pseudotsuga menziesii*)	1.30	-	Provenance area (5 populations, including 4 from the USA)
52.	Poznań University of Life Sciences	Douglas fir (*Pseudotsuga menziesii*)	2.18	2001	Family area
53.	Poznań University of Life Sciences	Douglas fir (*Pseudotsuga menziesii*)	3.20	2001	Family area
54.	Poznań University of Life Sciences	Douglas fir (*Pseudotsuga menziesii*)	12.85	2001	Family area
55.	Poznań University of Life Sciences	Douglas fir (*Pseudotsuga menziesii*)	1.35	2001	Family area
56.	Poznań University of Life Sciences	Douglas fir (*Pseudotsuga menziesii*)	4.44	2001	Family area
57.	Poznań University of Life Sciences	Douglas fir (*Pseudotsuga menziesii*)	2.00	2001	Family area
58.	Poznań University of Life Sciences	Douglas fir (*Pseudotsuga menziesii*)	0.68	2001	Family area
59.	Poznań University of Life Sciences	Douglas fir (*Pseudotsuga menziesii*)	4.10	2001	Family area
60.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Douglas fir (*Pseudotsuga menziesii*)	-	1971	International provenance experiment (100 populations from Canada and the USA)
61.	Poznań University of Life Sciences	Oak (*Quercus sp.*)	-	-	Family area
62.	Poznań University of Life Sciences	Oak (*Quercus sp.*)	2.03	2000	Family area
63.	Poznań University of Life Sciences	Oak (*Quercus sp.*)	2.12	2003	Family area
64.	Poznań University of Life Sciences	Oak (*Quercus sp.*)	0.48	2006	Family area
65.	Poznań University of Life Sciences	Oak (*Quercus sp.*)	2.11	2007	Family area

No.	Instituion	Species	Area (ha)	Establishing year	Remarks
66.	Poznań University of Life Sciences	Oak (*Quercus sp.*)	-	2007	Family area
67.	Poznań University of Life Sciences	Oak (*Quercus sp.*)	2,11	2007	Family area
68.	Poznań University of Life Sciences	Oak (*Quercus sp.*)	5,59	2001	Family area of sessile oak
69.	Poznań University of Life Sciences	Oak (*Quercus sp.*)	0,72	2001	Family area of pedunculate oak
70.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Sessile oak (*Quercus petraea*)	1,50	1992	Provenance experiment (19 populations from 7 European countries)
71.	Forest Research Institute	Pedunculate oak (*Quercus robur*)	0,59	1996	Determination of the variability of adaptive and growth traits family area, 24 families)
72.	Forest Research Institute	Pedunculate oak (*Quercus robur*)	0,59	1996	Determination of the variability of adaptive and growth traits (family area, 36 families)
73.	Forest Research Institute	Pedunculate oak (*Quercus robur*)	0,64	1996	Determination of the variability of adaptive and growth traits (family area, 24 families)
74.	Forest Research Institute	Pedunculate oak (*Quercus robur*)	0,64	1996	Determination of the variability of adaptive and growth traits (family area, 40 families)
75.	Forest Research Institute	Pedunculate oak (*Quercus robur*)	0,82	1999	Determination of the variability of adaptive and growth traits (family area, 60 families)
76.	Forest Research Institute	Pedunculate oak (*Quercus robur*)	1,99	2000	Determination of the variability of adaptive and growth traits (family area, 180 families)
77.	Forest Research Institute	Pedunculate oak (*Quercus robur*)	2,09	2000	Determination of the variability of adaptive and growth traits (family area, 180 families)
78.	University of Agriculture in Kraków	Pedunculate oak (*Quercus robur*)	0,30	1996	Provenance/family experiment (3 origins from Poland, 1 from France, 25 families)
79.	University of Agriculture in Kraków	Pedunculate oak (*Quercus robur*)	1,00	1999	Provenance/family experiment (5 origins from Poland, 58 families)
80.	University of Agriculture in Kraków	Pedunculate oak (*Quercus robur*)	2,50	2000	Provenance/family experiment (8 origins from Poland, 180 families)
81.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Pedunculate oak (*Quercus robur*)	0,20	1996	Provenance/family experiment (3 populations, 24 families, from Poland and France)
82.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Pedunculate oak (*Quercus robur*)	0,88	1999	Provenance/family experiment (7 origins from Poland, 58 families)
83.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Pedunculate oak (*Quercus robur*)	2,00	2000	Provenance/family experiment (8 origins from Poland, 188 families)
84.	Poznań University of Life Sciences	Pedunculate oak (Quercus robur), sessile oak (Quercus petraea)	2,50	1983	Provenance area

No.	Institution	Species	Area (ha)	Establishing year	Remarks
85.	Poznań University of Life Sciences	Pedunculate oak (Quercus robur), sessile oak (Quercus petraea)	2.65	1983	Provenance area
86.	Poznań University of Life Sciences	Pedunculate oak (Quercus robur), sessile oak (Quercus petraea)	1.50	1994	Provenance area
87.	Poznań University of Life Sciences	Pedunculate oak (Quercus robur), sessile oak (Quercus petraea)	2.50	1994	Provenance area
88.	Poznań University of Life Sciences	Pedunculate oak (Quercus robur), sessile oak (Quercus petraea)	0.77	1999	Provenance/family area
89.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Pedunculate oak (Quercus robur), sessile oak (Quercus petraea)	1.22	1967	Provenance experiment (9 populations from Poland)
90.	Forest Research Institute	Wild service tree (*Sorbus torminalis*)	1.20	2012	Evaluation of the variability of growth and adaptive traits (provenance/family area)
91.	Forest Research Institute	Wild service tree (*Sorbus torminalis*)	2.15	2012	Evaluation of the variability of growth and adaptive traits (provenance/family area and clone archive)
92.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Common ash *(Fraxinus excelsior)*	0.43	1964	Collection of clones of selected common ash trees from Poland (24 clones)
93.	Warsaw University of Life Sciences	Grand fir (*Abies grandis*)	9.00	-	Provenance area (4 native plus US and German populations)
94.	Poznań University of Life Sciences	Grand fir (*Abies grandis*)	1.44	1979	9 provenances from Professor Bellon
95.	University of Agriculture in Kraków	Grand fir (*Abies grandis*)	1.30	1976	Provenance experiment (7 origins - 6 from Canada, 1 - Abies alba)
96.	Kostrzyca Forest Gene Bank	Silver fir (*Abies alba*)	1.21	2013	Progeny of maternal from seed removed from the Kostrzyca Forest Gene Bank
97.	Kostrzyca Forest Gene Bank	Silver fir (*Abies alba*)	3.06	2013	Progeny of maternal trees from seed removed from the Kostrzyca Forest Gene Bank
98.	Kostrzyca Forest Gene Bank	Silver fir (*Abies alba*)	7.83	2013	Progeny of maternal rees from seed removed from the Kostrzyca Forest Gene Bank

No.	Institution	Species	Area (ha)	Establishing year	Remarks
99.	Warsaw University of Life Sciences	Silver fir (*Abies alba*)	8.00	-	Testing of progeny of maternal trees, 4 areas of about 2 ha each
100.	Warsaw University of Life Sciences	Silver fir (*Abies alba*)	12.00	-	Progeny testing of selected seed stands, 4 areas of about 3 ha each
101.	Warsaw University of Life Sciences	Silver fir (*Abies alba*)	0.50	-	Provenance area (4 native populations)
102.	Warsaw University of Life Sciences	Silver fir (*Abies alba*)	1.20	-	Provenance area (12 provenances, including 8 Polish and 4 European)
103.	Warsaw University of Life Sciences	Silver fir (*Abies alba*)	0.50	-	Provenance area (4 native populations, 4 foreign populations, under different light conditions)
104.	Warsaw University of Life Sciences	Silver fir (*Abies alba*)	1.75	-	Provenance area (10 native populations, 2 foreign populations, under different light conditions)
105.	Warsaw University of Life Sciences	Silver fir (*Abies alba*)	0.50	-	Provenance area (8 native populations)
106.	Warsaw University of Life Sciences	Silver fir (*Abies alba*)	0.50	-	Provenance area (4 native populations, as second storey
107.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	2.30	2002	Family variability
108.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	34.79	1992	Experimental control unit, selection cutting structure
109.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	1.50	2005	Family variability
110.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	-	2002	Circular plots - restitution programme
111.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	-	2004	Provenance area
112.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	-	2002	Circular plots - restitution programme
113.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	-	2004	Provenance area
114.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	-	2004	Provenance area
115.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	-	-	Circular plots - restitution programme
116.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	-	-	Circular plots - restitution programme
117.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	-	-	Circular plots - restitution programme

No.	Instituion	Species	Area (ha)	Establishing year	Remarks
118.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	1.63	2009	Circular plots - restitution programme
119.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	1.63	2009	Circular plots - restitution programme
120.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	1.63	2009	Circular plots - restitution programme
121.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	1.63	2009	Circular plots - restitution programme
122.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	-	2012	Family area
123.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	2.50	2012	Family area
124.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	-	2012	Family area
125.	Poznań University of Life Sciences	Silver fir (*Abies alba*)	-	2012	Family area
126.	University of Agriculture in Kraków	Silver fir (*Abies alba*)	11.20	2000	Provenance experiment (41 origins from the Polish Carpathians)
127.	University of Agriculture in Kraków	Silver fir (*Abies alba*)	3.00	2000	Provenance experiment (37 origins from the Polish Carpathians)
128.	University of Agriculture in Kraków	Silver fir (*Abies alba*)	1.65	2005	Provenance experiment (32 origins from the Polish Carpathians)
129.	University of Agriculture in Kraków	Silver fir (*Abies alba*)	0.80	2005	Provenance experiment (17 origins: Macedonia - 1, Bulgaria - 1, Serbia - 1, Austria - 1, Czech Republic - 1, Romania - 2, Germany - 2, Slovakia - 2, Poland - 6)
130.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Silver fir (*Abies alba*)	0.49	1977	Provenance experiment (13 populations from Poland and the Czech Republic)
131.	University of Agriculture in Kraków	Silver fir (*Abies alba*)	15.00	1990	Provenance experiment (100 origins and 543 families from Poland, from and outside the range of occurrence)
132.	Forest Research Institute	European larch (*Larix decidua*)	1.70	1932	Evaluation of provenance variability (provenance area, 18 origins)
133.	Forest Research Institute	European larch (*Larix decidua*)	2.75	1949	Evaluation of provenance variability (provenance experimental area, 4 origins)
134.	Forest Research Institute	European larch (*Larix decidua*)	7.17	1966	Evaluation of the family variability, growth and adaptive traits (family area)
135.	Forest Research Institute	European larch (*Larix decidua*)	0.73	1967	Evaluation of provenance variability (observation and provenance area, 24 origins)
136.	Forest Research Institute	European larch (*Larix decidua*)	2.80	1968	Evaluation of provenance variability (comparative area, 23 origins)

No.	Instituion	Species	Area (ha)	Establishing year	Remarks
137.	Forest Research Institute	European larch (*Larix decidua*)	1.90	1998	Evaluation of the family variability,growth and adaptive traits (family area)
138.	Forest Research Institute	European larch (*Larix decidua*)	2.22	2000	Evaluation of the family variability, growth and adaptive traits (family area)
139.	Forest Research Institute	European larch (*Larix decidua*)	1.50	-	Provenance area (15 native populations)
140.	Poznań University of Life Sciences	European larch (*Larix decidua*)	4.84	1965	20 provenances from the Forest Research Institute
141.	Poznań University of Life Sciences	European larch (*Larix decidua*)	-	1995	Seed orchard
142.	Poznań University of Life Sciences	European larch (*Larix decidua*)	-	-	Clone archive
143.	Poznań University of Life Sciences	European larch (*Larix decidua*)	0.56	1965	Seed orchard
144.	Poznań University of Life Sciences	European larch (*Larix decidua*)	-	-	Family area
145.	Poznań University of Life Sciences	European larch (*Larix decidua*)	-	-	Family area
146.	University of Agriculture in Kraków	European larch (*Larix decidua*)	4.00	1968	Provenance experiment (21 origins from Poland)
147.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	European larch (*Larix decidua*)	0.82	1964	Model seed orchard (58 clones from Poland)
148.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	European larch (*Larix decidua*)	0.40	1985	Provenance experiment (22 populations from southern Poland)
149.	University of Agriculture in Kraków	European larch (*Larix decidua*), Japanese larch (*Larix kaempferi*), Siberian larch (*Larix sibirica*), Eurasian larch (*Larix x eurolepis*)	5.50	1949	Experience of the IUFRO 1944 series (25 origins of European larch, 2 origins of Japanese larch, 2 origins of Siberian larch, 2 origins of Eurasian larch)
150.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	European larch (*Larix decidua*),Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*)	0.70	1967	Collection of progenies from controlled crossbreeding (226 progenies)
151.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Polish larch (*Larix polonica*)	1.40	1968	Family experiment (28 families from Poland - Świętokrzyskie Mountains)

No.	Institution	Species	Area (ha)	Establishing year	Remarks
152.	Warsaw University of Life Sciences	Black alder (*Alnus glutinosa*)	9.00	-	Provenance area (progeny research of 12 production seed stands and 8 seed orchards, 3 areas of about 3 ha each)
153.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Black alder (*Alnus glutinosa*)	-	1968	Provenance experiment (11 populations from Poland)
154.	Forest Research Institute	*Black locust (Robinia pseudoacacia)*	0.53	2015	Evaluation of variability of growth and adaptive traits (provenance area, 10 origins)
155.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	3.80	1962	Determination of variability of adaptive and growth traits of Polish provenances (provenance area, 8 origins)
156.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	1.65	1964	Determination of variability of adaptive and growth traits of Polish provenances (provenance area, 7 origins)
157.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	1.92	1966	Determination of variability of adaptive and growth traits of Polish provenances (comparative provenance area, 15 origins)
158.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	4.29	1966	Determination of variability of adaptive and growth traits of Polish provenances (provenance area, 15 origins)
159.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	5.00	1966	Evaluation of provenance variability (comparative provenance area, 15 origins)
160.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	4.20	1977	Determination of variability of adaptive and growth traits of Polish provenances (comparative experiment)
161.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	3.15	1984	Determination of the variability of the adaptive and growth traits of European provenances (IUFRO 82 experiment, 20 origins)
162.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	4.00	1984	Determination of the variability of the adaptive and growth traits of European provenances (IUFRO 82 experiment, 20 origins)
163.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	3.28	1989	Determination of variability of adaptive and growth traits of Polish provenances (comparative area, 20 origins)
164.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	4.19	1994	Evaluation of the family variability,growth and adaptive traits (family area)
165.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	3.20	1995	Evaluation of the family variability, growth and adaptive traits (family area)
166.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	2.71	2004	Determination of the provenance/family variability of adaptive and growth traits of Polish provenances (provenance/family area, 5 populations, 250 progenies)
167.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	2.80	2004	Determination of the provenance/family variability of adaptive and growth traits of Polish provenances (provenance/family area, 5 populations, 250 progenies)
168.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	3.21	2004	Determination of the provenance/family variability of adaptive and growth traits of Polish provenances (provenance/family area, 5 populations, 250 progenies)

No.	Institution	Species	Area (ha)	Establishing year	Remarks
169.	Forest Research Institute	Scots pine (*Pinus sylvestris*)	3.25	2004	Determination of the provenance/family variability of adaptive and growth traits of Polish provenances (provenance/family area, 5 populations, 250 progenies)
170.	Warsaw University of Life Sciences	Scots pine (*Pinus sylvestris*)	36.00	-	Testing of progeny of maternal trees, 18 areas of about 2 ha each
171.	Warsaw University of Life Sciences	Scots pine (*Pinus sylvestris*)	18.00	-	Testing of progeny of selected seed stands, 6 areas of about 3 ha each
172.	Warsaw University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.54	-	Provenance area (16 native populations)
173.	Warsaw University of Life Sciences	Scots pine (*Pinus sylvestris*)	1.00	-	Provenance area (provenance/family research, progeny of shapely trees and spreaders)
174.	Warsaw University of Life Sciences	Scots pine (*Pinus sylvestris*)	1.20	-	Provenance area (19 populations from the entire natural range, IUFRO)
175.	Warsaw University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.20	-	Provenance/family area (progeny of shapely trees and spreaders from 2 forest districts)
176.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	1.91	1958-64	Generative progeny of trees of different quality
177.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	0.05	1959	Vegetative progeny of trees of different quality
178.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	1.05	1964	Provenance area
179.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	1.30	1966	Grafts
180.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	0.60	1967	Seed orchard
181.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	0.20	1968	Norway provenances
182.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	4.33	1960	Provenance area
183.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.45	1960	Provenance area
184.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	0.70	1963	Provenance area
185.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	3.89	1986	Provenance area
186.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	3.73	1981	IUFRO area
187.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2001	Seeding seed orchard

No.	Institution	Species	Area (ha)	Establishing year	Remarks
188.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	0.60	2006	Different seed bases
189.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	0.60	2008	Different seed bases
190.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2001	Population and family area
191.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.00	2004	Białowieża origins
192.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.17	2010	Family area – testing
193.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.17	2010	Family area – testing
194.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.17	2010	Family area – testing
195.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.17	2010	Family area – testing
196.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	1.89	2010	Family area – testing
197.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	1.85	2010	Family area – testing
198.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.32	2011	Family area – testing
199.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	3.54	2011	Selected seed stands – testing
200.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.32	2011	Family area – testing
201.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	3.95	2011	Selected – testing
202.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	4.76	2013	Provenance area – testing
203.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	4.12	2013	Family area – testing
204.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	5.00	2013	Family area – testing
205.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	4.08	2013	Family area – testing
206.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.35	2014	Family area – testing

No.	Institution	Species	Area (ha)	Establishing year	Remarks
207.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2014	Family area – testing
208.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2014	Family area – testing
209.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2014	Family area – testing
210.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2015	Family area – testing
211.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2015	Family area – testing
212.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.03	2015	Family area – testing
213.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	2.03	2015	Family area – testing
214.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2016	Provenance area – testing
215.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2016	Provenance area – testing
216.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2016	Provenance area – testing
217.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2016	Provenance area – testing
218.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2016	Provenance area - testing of selected seed stands and production seed stands
219.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2016	Provenance area - testing of selected seed stands and production seed stands
220.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2019	Family area – testing
221.	Poznań University of Life Sciences	Scots pine (*Pinus sylvestris*)	-	2019	Family area – testing
222.	University of Agriculture in Kraków	Scots pine (*Pinus sylvestris*)	5.00	-	Provenance experiment (16 origins from Poland)
223.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	0.85	1964	Model seed orchard (94 clones from Poland)
224.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	3.10	1989	Collection of clones of elite trees from Poland, Russia, Sweden and Germany (67 clones)

No.	Institution	Species	Area (ha)	Establishing year	Remarks
225.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	0.95	1967	Provenance experiment (35 populations from Poland and Sweden)
226.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	0.95	1967	Provenance experiment (35 populations from Poland and Sweden)
227.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	0.92	1967	Provenance experiment (34 populations from Poland and Sweden)
228.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	0.89	1967	Provenance experiment (33 populations from Poland and Sweden)
229.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	-	1938	Provenance experiment (18 populations from 10 European countries)
230.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	2.82	1912	Provenance experiment in Puławy (21 populations from Eastern Europe and Asia)
231.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	1.68	1999	Experiment with testing of progeny populations from free pollination in native seed orchards (39 populations)
232.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	1.68	1999	Experiment with testing of progeny populations from free pollination in native seed orchards (39 populations)
233.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	1.68	1999	Experiment with testing of progeny populations from free pollination in native seed orchards (39 populations)
234.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	1.68	1999	Experiment with testing of progeny populations from free pollination in native seed orchards (37 populations)
235.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	1.76	1999	Experiment with testing of progeny populations from free pollination in native seed orchards (37 populations)
236.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	1.70	2004	Experiment with testing of progeny from 22 seed orchards (32 populations)
237.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	1.70	2004	Experiment with testing of progeny from 22 seed orchards (28 populations)
238.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	1.70	2004	Experiment with testing of progeny from 22 seed orchards (28 populations)
239.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	1.70	2004	Experiment with testing of progeny from 22 seed orchards (28 populations)
240.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Scots pine (*Pinus sylvestris*)	1.70	2004	Experiment with testing of progeny from 22 seed orchards (28 populations)
241.	Forest Research Institute	Norway spruce (*Picea abies*)	3.40	1963	Evaluation of variability of growth and adaptive traits of Polish provenances (comparative area of northern spruce, 11 origins)
242.	Forest Research Institute	Norway spruce (*Picea abies)*	1.80	1965	Evaluation of variability of growth and adaptive traits of Polish provenances (comparative area, 9 northern and Beskid origins)

No.	Institution	Species	Area (ha)	Establishing year	Remarks
243.	Forest Research Institute	Norway spruce (*Picea abies*)	3.75	1975	Determination of the variability of adaptive and growth traits of Polish origins (provenance area IUFRO 1972)
244.	Forest Research Institute	Norway spruce (*Picea abies*)	0.55	1983	Evaluation of the variability of the growth and adaptive traits of clones and generative progeny (comparative area)
245.	Forest Research Institute	Norway spruce (*Picea abies*)	1.22	1983	Evaluation of the variability of growth and adaptive traits (generative comparative area)
246.	Forest Research Institute	Norway spruce (*Picea abies*)	1.93	1986	Evaluation of the variability of growth and adaptive traits of clones (comparative area)
247.	Forest Research Institute	Norway spruce (*Picea abies*)	2.71	1988	Evaluation of variability of growth growth and adaptive traits (comparative area - clones from Białowieża and Istebna)
248.	Forest Research Institute	Norway spruce (*Picea abies*)	1.60	1992	Evaluation of variability of growth and adaptive traits (comparative area - clones from Białowieża and Istebna)
249.	Forest Research Institute	Norway spruce (*Picea abies*)	1.90	1995	Determination of family variability origins Zwierzyniecand Bilżyn (family area)
250.	Warsaw University of Life Sciences	Norway spruce (*Picea abies*)	2.00	-	Testing the progeny of maternal trees
251.	Poznań University of Life Sciences	Norway spruce (*Picea abies*)	3.24	1973	IUFRO area
252.	Poznań University of Life Sciences	Norway spruce (*Picea abies*)	1.05	1972	Norway provenances
253.	University of Agriculture in Kraków	Norway spruce (*Picea abies*)	8.00	1964	Inventory experiment IPTNS-IUFRO 1964/68 (1100 provenances)
254.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Norway spruce (*Picea abies*)	1.34	1981	Second generation seed orchard of the Kolonowskie population (109 clones)
255.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Norway spruce (*Picea abies*)	0.42	1969	Provenance experiment (26 populations from Poland, Germany, and Sweden)
256.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Norway spruce (*Picea abies*)	0.93	1969	Provenance experiment (35 populations from Poland, Germany, and Sweden)
257.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Norway spruce (*Picea abies*)	1.23	1969	Provenance experiment (33 populations from Poland, Germany, and Sweden)
258.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Norway spruce (*Picea abies*)	2.18	1976	Provenance and family experiment (22 populations from north-eastern Poland, 93 families)
259.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Norway spruce (*Picea abies*)	0.63	1998	Family experiment from seed orchard of the second generation of Kolonowskie provenance and *deflexa* forms (206 families)
260.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Norway spruce (*Picea abies*)	0.35	1999	Second generation seed orchard experiment (99 families)
261.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Norway spruce (*Picea abies*)	2.58	2009	Experiment testing Kolonowskie family populations (78 families from free pollination)

No.	Institution	Species	Area (ha)	Establishin g year	Remarks
262.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Norway spruce (*Picea abies)*	2.58	2009	Experiment testing Kolonowskie family populations (78 families from free pollination)
263.	Institute of Dendrology of the Polish Academy of Sciences in Kórnik	Norway spruce (*Picea abies)*	2.48	2009	Experiment testing Kolonowskie family populations (75 families from free pollination)
264.	Forest Research Institute	Common spen (*Populus tremula*)	1.75	1978	Evaluation of growth capacity and adaptive traits (comparative area - hybrids of common aspen)
265.	Forest Research Institute	Poplar (*Populus sp.*)	2.81	1969	Evaluation of growth capacity and adaptive traits (comparative area of poplar from *Leuce* section)
266.	Forest Research Institute	Poplar (*Populus sp.*)	5.18	1973	Evaluation of growth i capacity and adaptive traits (comparative area of poplar from *Leuce* section)
267.	Forest Research Institute	Poplar (*Populus sp.*)	3.50	1980	Evaluation of the growth capacity and adaptive traits (varieties area - *Populus deltoides* varieties)
268.	Forest Research Institute	Poplar (*Populus sp.*)	4.06	1982	Evaluation of the growth capacity and adaptive traits (varieties area)

9.4. Using current and new technologies in tree improvement and breeding

Breeding in our country consists mainly in choosing, using phenotypic features, the best stands and maternal trees, conducting growth tests and making measurements. IT technologies for building databases in which information is collected about the experiments carried out and the measuring tools used, as well as programmes for statistical data processing, are being improved. Selection activities are also supported by techniques related to the use of molecular markers. Molecular techniques are used to identify individuals and to certify the origin of the reproductive material. On a large scale, the Kostrzyca Forest Gene Bank has carried out genetic labelling of maternal trees of Scots pine (Pinus sylvestris) and European larch (Larix decidua). This allows for verification of contamination by foreign genotypes of selected seed orchards. Molecular methods have also been used in the assessment of threats and risks of loss of genetic diversity of populations of a number of forest tree species.

9.5. Needs, challenges and opportunities for tree improvement and breeding

Silvicultural practices basically imitate the natural selection, through recombination and selection pressure, but with two main differences: artificial selection is faster and more targeted, focusing on socio-economic needs and adaptation requirements. Tree breeding is mainly focused on species of high economic importance, where improved varieties are used for afforestation and plantation crops (Pâques, 2013). In view of the unpredictable effects of climate change, there is a serious risk of jeopardising the provision of a permanent and undiminished supply of high-quality timber. Therefore, the rules of conduct set out in the "Progeny testing programme for selected seed stands, maternal trees, clonal seed orchards and seedling seed orchards should be revised to include adaptation as a criterion in the testing of progeny.The weight of selection should be shifted from the population level to a more efficient, individual one, focusing first and foremost on testing the progeny of maternal trees in the widest possible range of environmental variability. This will allow for intensified individual genotype selection and the establishment of 1.5 and 2 generation seed orchards based on quality, growth and resistance characteristics. Taking into account the long waiting period for the results of testing of progeny of single maternal trees, in order to be able to shorten the selection process, the possibility of implementing the breeding without breeding method in forests should be urgently tested and considered (El-Kassaby, Cappa, Liewlaksaneeyanawin, Klápště and Lstibůrek, 2011).

Work should begin on developing programmes, within the framework of the so-called selection for special purposes, of the following species: Scots pine (Pinus sylvestris), silver birch (Betula pendula), European larch (Larix decidua), Douglas fir (Pseudotsuga menziesii), pedunculate oak (Quercus robur), sessile oak (Quercus petraea), Norway spruce (Picea abies),common ash (Fraxinus excelsior), the elms (Ulmus sp.). These works are aimed both at resistance selection and selection of specific traits. It is also important to start research and practical action to restore dying out populations of: common ash (Fraxinus excelsior), black poplar (Populus nigra), white poplar (Populus alba), grey poplar (Populus canescens), common yew (Taxus baccata), European white elm (Ulmus laevis), wych elm (Ulmus glabra), field elm (Ulmus minor), small-leaved lime (Tilia cordata), large-leaved lime (Tilia platyphyllos), wild service tree (Sorbus torminalis), wild cherry (Prunus avium), European crab apple (Malus sylvestris), common pear (Pyrus communis), silver fir (Abies alba) and Norway spruce (Picea abies) in the Sudetes.

The State Forests have the appropriate infrastructure and resources to run a breeding programme for the main species of forest trees. There is a large base of maternal trees, seed orchards and progeny tests. It is necessary to promote the use of improved material through selection.This is done by developing the programme of seed orchards and using, to a greater extent than at present, seeds from seed orchards (the objective is to achieve a level of 40% use of seeds from seed orchards for renewals and afforestation). The priority in this respect is also to increase the competence of the Forest Service in the field of breeding. It is necessary to educate about the objectives and needs of tree breeding in forestry, so that these activities are understood and supported by the staff at every organizational level of the State Forests.

Similarly, to the needs and challenges facing the breeding of forest trees, research and development priorities are described synthetically in the "Programme of conserving forest genetic resources and breeding of trees in Poland for the years 2011-2035" (Chałupka *et al.*, 2011). The aim of this research and implementation work is to increase economic efficiency of forest management in the first place.The ongoing climate and environmental changes, for example, resulting in the catastrophic hurricane in 2017 and the disappearance of Norawy spruce (Picea abies) and Scots (Pinus sylvestris) over large areas, are shifting the focus of research work towards preserving and maintaining the functionality of forest ecosystems, without reducing measures to increase the productivity of forest trees and improve populations in terms of quantitative and qualitative characteristics.These activities should include:

1. Evaluation of the testing programme and improvement of its methodology.
2. Research and evaluation studies on the genetic variability of breeding traits for selected breeding programmes aimed at improving and increasing the plasticity of genotypes and populations in terms of biotic and abiotic resistance characteristics, as well as quantitative and qualitative traits, enabling cost-effective production of timber in short and medium production cycles.
3. Use of molecular methods to characterise and modelling the genetic diversity of breeding populations, investigation of the possibility of using molecular markers in the selection and breeding process, including the identification of DNA markers for the genetic characterisation of quantitative and resistance characteristics of forest trees and marker-based selection, genetic identification of basic forest material and forest reproductive material (DNA certificates for lot of seeds from maternal trees and seed orchards).

Knowledge of current achievements in the selection of forest reproductive material should be constantly improved and, to this end, constant international cooperation is essential. The TreeBreedex Programme (Pâques, 2013) is an excellent example of such cooperation.

Chapter 10. Management of forest genetic resources

10.1. General information

The conservation of genetic diversity is essential as an element of the sustainable forest management and thus the importance of applying good practices in the forest management is indisputable. Promoting wrong methods of management can negatively affect genetic resources of forests through selection of fast-growing, pest-resistant stands, which can lead to the increasing number of trees with dysgenic traits. Inappropriate forest management of the genetic resources can thus contribute to the economic losses that arise as a result of the interaction of abiotic and biotic factors.

Measures related to forest restoration (renewals and afforestation) for the production of woody biomass, including indirectly the activities for carbon sequestration to mitigate climate change and restore ecological functions in degraded landscapes, are undertaken all over the world. It is extremely important that forest reproductive material preferred for such activities (species and provenances), was selected not only because of its productive capacity but also because of its ability to maintain or enhance the genetic variability of the forest tree populations and the ability to adapt these populations to future climatic conditions.

Basic activities related to forest management (tending, thinning, sanitary-selection cuts, cutting, selection of single genotypes, renewals) should go hand in hand with the protection of genetic diversity - not only to preserve the genetic diversity of the dominant species populations but the entire ecosystem. Every effort should be made to make the forest reproductive material from the moment of obtaining the seeds to the establishment of the secondary forest plantation have an appropriate representation of the genetic variability of the maternal population. The above is extremely important for the sustainability of the forest. Such activities should be supported by conducting proper forest management, including management of seed stands in such a way as to maintain or increase their genetic diversity. That is why one should constantly integrate genetic resources conservation activities as part of the conducted silviculture with measures for the sustainable use of the forest resources.

10.2. Silviculture

The term silviculture is understood as forestry activity in the field of forest management, protection and development, maintenance and expansion of resources and forest plantations, game management, acquiring (except purchase) of wood, resin, Christmas trees, stumps, bark, needles, game and undergrowth fruits as well as the sale of these products and the implementation of non-productive functions of the forest. In turn, permanently sustainable forest management is an activity aimed at shaping the structure of the forests and their use in a manner and at a rate that ensures the permanent conservation of their biological richness, high productivity and regenerative potential, durability and the ability to fulfil all important protective, economic and social functions at local, national and global levels without harming other ecosystems. Supervision over forest management in Poland is carried out by the minister responsible for the environment - in forests owned by the State Treasury, or the staroste - in the forests not being the ownership of the State Treasury. The starost may, by way of agreement, entrust the management of the matters related to the supervision of the forest to the forest district manager of the State Forest Holding State Forests (Forest Act, 1991).

The inventory of forests emerged as a result of regeneration is carried out in Poland, which includes older stands and stands came into being as a result of natural succession. There are approximately 2,054,000 ha of the forests in Poland resulting from natural regeneration (FAO Report, 2015). The below-described principles of sustainable forest management in Poland apply to all forests arising from natural regeneration, sowing and planting.

Permanently sustainable forest management is carried out according to the forest management plans or simplified forest management plans, taking into account the following objectives:

1. Maintaining of the forests and their beneficial influence on climate, air, water, soil, conditions of human life and health as well as natural balance.
2. Protection of forests, especially forests and forest ecosystems, which are natural fragments of the native nature or forests especially valuable for preservation due to their natural diversity, preservation of forest genetic resources, landscape values, needs of science.
3. Protection of soils and areas especially exposed to pollution or damage and of special social importance.
4. Protection of surface and deep waters, catchment retention, in particular, on watershed areas and in the areas of supplying groundwater reservoirs.
5. Production, on the basis of rational economy, of wood and non-timber forest raw materials and products (Forest Act, 1991).

Forest owners are obliged to sustain the forests and provide the continuity of their use, and, in particular, to:

1. Maintain forest vegetation in the forests as well as natural swamps and peat bogs.
2. Reintroduce forest secondary forest plantations in the forests within 5 years of the stand removal.
3. Tend and protect the forests, including fire protection.
4. Converse the stand that does not achieve the objectives of the forest management
5. Use rationally the forest in a sustainable manner that ensures optimal implementation of all its functions by harvesting wood within limits not exceeding the production capacity of the forest and the acquiring of non-timber forest raw materials and products in the way ensuring the possibility of their biological regeneration as well as the protection of the undergrowth (Forest Act, 1991).

Forest management is carried out according to the following principles:

1. Universal forest protection.
2. The sustainability of forest maintenance.
3. Continuity and sustainable use of all forest functions.
4. Increasing forest resources (Forest Act, 1991).

The "Principles of Silviculture" applied in the State Forests take into account, among others:

1. Spreading the risk over as many species as possible adapted to their habitats.
2. Increasing the scope of conversion of the stands that are excessively depleted in terms of species and structurally simplified.
3. Preferring natural regeneration of the forests whenever possible and justified.
4. Supporting natural processes increasing biological diversity.
5. Orientating tending cuttings towards stability and vitality and sustainability of the forests and to improve the quality of production.
6. Preferring the tree species and individual trees that can adapt to changing environmental and climate conditions (Haze, 2012).

According to the provisions of the Forest Act, the task of forest management is to ensure durability of the forest and continuity of its multifunctional role in the spatial development of the country.

In the changing conditions of the natural environment, it is possible to preserve the sustainability of the forests thanks to taking into account the natural processes observed in nature in the management of the forest resources. One of the important goals of silviculture is the rationality of use and ongoing renewal of the forest resources while maintaining their natural biodiversity. Multifunctional forest management should provide an opportunity ensuring that forests fulfil all their natural functions in sustainable manner and enhance the functions recognized as leading for a given area. In silvicultural procedures it is necessary to take into account both natural and economic conditions as well as legal requirements on pursuing a stable, sustainable and multifunctional forest resources management. The basis for determining the silvicultural goals and directions of silvicultural measuers in the forests are:

1. Geobotanical regionalization of the country, nature and forest regionalization and seed regionalization.
2. Recognition of the natural potential of forest habitats using typological method.
3. Identification of the protected natural forest habitats.
4. Natural conditions shaped by man (Haze, 2012).

Proper use of the forest habitats is achieved by adjusting species composition and stand structure to the requirements specified in the types of stands for individual habitats adopted in the forest management plans, for individual natural lands, taking into account their variants of moisture, state of the habitats and forest types conditioned by natural factors. Increasing overall volume of the forest production takes place, among others, through:

1. Selection of the proper species composition and shaping the spatial, age and storeyed structure of the stands in the direction compatible with the natural conditions.
2. Using the genetic values of the trees and stands.
3. Increasing forest cover.
4. Limiting damage to the forests and losses in the forest production (Haze, 2012).

Forest renewal is aimed at initiating and shaping the young generation. The bases for the determination of the methods and rules for conducting the renewals are the silvicultural goals. The renewal takes place in a natural and artificial way. In artificial renewals, the existing natural regeneration should be used, as long as it is compatible with the adopted silvicultural goals or increases species diversity. The natural renewal should only be used with good silvicultural quality of the maternal stands. The natural renewal inconsistent with the silvicultural purpose can be used as an element of conversion the stand (Haze, 2012).

The increase in the share of the natural regeneration in the total area of the restorations is noteworthy, observed from the beginning of the 90s of the last century. In the years 1986-1990 this share was 4.2%, in 1991-1995 - 6.5%, in 1996-2010 - 10.5%, and in the recent nine years - 13.7% (Zajączkowski G. et al., 2020).

In the regeneration process, the valuable fragments of the stands (e.g. younger and more stable clumps of the stand forming trees, admixture and biocenotic species, non-felled individuals performing the function of the seed producing trees, hollow trees and natural monumental trees) should remain as desirable structural and functional elements of the new stand (Haze, 2012).

Annually in Poland, about 60,000 hectares of secondary forest plantations are established as part of the renewal and afforestation (Tab. 10.1 and Tab. 10.2). All plantations of natural and artificial origin are subject to evaluation. The success of artificially established secondary forest plantations is obligatorily assessed in the 5th year of their existence.

The assessment is made on the basis of:

1. The degree of coverage of the area by the plantation, determined by the number of the seedings grown, including valuable natural regeneration, compared to the number of seedlings resulting from the adopted spacing of planting.
2. Silvicultural suitability, expressed as a total percentage share found in the plantation of the seedlings with disease symptoms and damaged to the extent significant for their further development (Haze, 2012).

Until the obligatory assessment of the secondary forest plantations, they should be monitored for the degree of aera coverage and silvicultural suitability. In case it is needed, the corrections and supplements should be applied. There are corrections, supplements and additional plantings aimed at maintaining and regulating the assumed species composition, increasing the species diversity and increasing the production capacity of the existing plantations and young trees as well as older stands in which, for various reasons, the gaps and depletion appeared (Haze,2012).

Tab. 10.1 *Renewals and afforestation in the period of 1999-2018*

Year	Renewals and afforestation in general		Artificial renewals and afforestation		Natural renewals		Corrections and supplements	
	Total (ha)	SF NFH (ha)	Total (ha)	SF NFH (ha)	Total (ha)	SF NFH (ha)	Total (ha)	SF NFH (ha)
1999	63,300.00	51,819.00	59,355.00	49,118.00	3,945.00	2,701.00	12,138.00	11,092.00
2000	68,946.00	54,656.00	63,686.00	50,413.00	5,260.00	4,243.00	11,552.00	10,598.00
2001	65,394.00	50,069.00	60,786.00	46,410.00	4,608.00	3,659.00	12,788.00	11,467.00
2002	56,837.00	42,711.00	52,352.00	39,217.00	4,485.00	3,494.00	8,821.00	7,675.00
2003	66,124.00	45,855.00	62,171.00	42,714.00	3,953.00	3,141.00	8,022.00	6,871.00
2004	61,705.20	55,499.40	56,491.90	51,341.40	5,213.30	4,158.00	8,881.00	7,647.00
2005	62,044.90	52,469.60	57,041.60	48,356.60	5,003.30	4,113.00	7,685.00	6,516.00
2006	65,690.20	50,273.00	60,502.70	45,916.00	5,187.50	4,357.00	8,628.00	7,463.00
2007	60,756.20	47,821.30	56,339.60	44,142.30	4,416.60	3,679.00	9,511.00	8,146.00
2008	55,937.20	47,937.40	50,710.20	43,658.40	5,227.00	4,279.00	7,254.00	6,089.00
2009	49,684.00	43,279.50	45,454.00	39,938.50	4,230.00	3,341.00	6,858.00	5,871.00
2010	51,944.90	44,491.20	47,313.70	40,784.20	4,631.20	3,707.00	5,887.00	4,827.00
2011	56,459.10	49,277.00	50,243.90	44,214.00	6,215.20	5,063.00	6,011.00	5,047.00
2012	57,661.55	50,675.15	51,812.05	45,850.15	5,849.50	4,825.00	6,678.00	5,688.00
2013	55,493.84	49,489.87	48,628.82	43,658.87	6,865.02	5,831.00	5,667.00	4,362.00
2014	56,716.50	51,171.20	48,536.20	44,104.20	8,180.00	7,067.00	4,800.00	3,799.00
2015	58,665.69	54,919.93	49,488.74	46,668.93	9,176.00	8,251.00	4,629.00	3,705.00
2016	58,106.33	54,203.53	50,194.48	47,290.53	7,911.85	6,913.00	5,081.00	4,091.00
2017	55,381.90	51,985.80	48,643.60	46,170.80	6,738.30	5,815.00	5,143.00	4,155.00
2018	58,702.70	55,578.30	50,364.20	48,082.30	8,338.60	7,496.00	4,851.00	3,790.00

Source: Statistics Poland - Local Data Bank, 2020.

Tab. 10.2 *Afforestation and renewals in 1997-2018 - private forests and communal forests*

Year	*Afforestation*		*Renewals*	
	Private forests (ha)	*Communal forests (ha)*	*Private forests (ha)*	*Communal forests (ha)*
1997	8 375.50	241.00	4 292.70	471.00
1998	5 931.20	236.00	3 507.20	495.00
1999	6 892.60	178.00	3 290.70	528.00
2000	10 143.20	173.00	3 020.20	436.00
2001	11 312.40	194.00	2 879.80	436.00
2002	10 401.70	170.00	2 702.20	359.00
2003	17 165.50	129.00	2 144.30	360.00
2004	2 784.70	159.00	2 513.50	348.00
2005	6 535.00	134.80	2 111.30	327.60
2006	12 365.00	101.30	2099.80	277.00
2007	1,0243.00	64.50	1,966.40	233.00
2008	4,946.70	76.80	2,122.50	483.60

2009	3, 733.20	104.60	1,740.20	419.20
2010	5,079.00	49.10	1,652.80	358.20
2011	4,682.60	35.60	1,780.50	342.50
2012	4 354.40	102.70	1,835.90	286.00
2013	3,649.94	37.61	1,860.09	220.80
2014	3,051.79	33.86	1,937.81	261.09
2015	1,481.56	24.65	1,748.49	211.10
2016	1,324.61	33.29	2,038.91	238.99
2017	1,051.70	56.80	1,750.60	242.40
2018	956.70	11.00	1,601.20	252.90

Source: Statistics Poland - Local Data Bank, 2020.

The average natural trees coverage in relation to the forested area of the country, is 2.82%, and the average young shrub cover is 1.03%. The average coverage of the natural young generation trees in the State Forests is 2.96%, and the average young cover is 0.96%. The average coverage of the natural trees in the private forests is 2.26%, and the average young shrub coverage is 1.34%. In case of natural natural trees coverage among the groups of species, deciduous species with 2.08% coverage are more numerous than conifers - with coverage of 0.74%. The total area of natural trees in the country is 253,150 ha. In the State Forests the number of 206,226 ha of the natural young generation trees was registered and 37,535 ha in the private forests (WISL, 2020).

The average number of low sapling trees is 2,461 trees/ha, while the average number of low shrubs is 2,836 items/ha. In the State Forests, the average number of low sapling trees is 2,545 trees/ha and the average number of low shrubs is 2,576 items/ha. In private forests the average number of low sapling trees is 2 126 trees/ha and the average number of low shrubs is 3,983 items/ha (WISL, 2020). The average number of high tall saplings in the country is 364 trees/ha, while the average the number of the high shrubs is 139 items/ ha. In the State Forests, the average number of the high saplings is 342 trees/ha, and the average number of high shrubs is 117 items/ha. In private forests the average number of high saplings is 477 trees/ha and the average number of high shrubs 221 items/ha (WISL, 2020).

The results of the Large-Scale Forest Inventory and the data from the forest management plans signal the occurrence of the following phenomena and processes in the forest management:

- systematic increase in the final cutting and limiting the size of the pre-final cutting use,
- aging of the stands and maintaining a significant number of old trees in commercial and protection forests,
- increase in the accumulation of the wood stock in the State Forests,
- attempts to limit the productive function of the forests with increasing ecological and social expectations, in particular in protected areas (Przypaśniak, 2015).

10.3. Cutting systems used in Poland

Cutting system is one of the activities aimed at creating a new stand with the desired character and established silvicultural purpose. Cutting systems define the directional rules of the procedures that may be modified depending on specific conditions and adopted silvicultural goals. In each cutting system it is possible to implement both natural and artificial methods of the forest regeneration (Haze, 2012).

A clear cutting is a one-time removal of the whole stand from a given area. As a result, the separated plantations of the same age are created on the open area.. Clear cutting is not aapplied directly at springs, rivers, lakes as well as in places of worship and around maternal trees. On clear cutting areas, in stands with a short regeneration period, the fragments of old tree stands are left with the bottom layers intact, till their natural decay. The area of the leftover fragments of the old tree stands should not be less than 6a and in total not more than 5% of the clear cutting area. It is not necessary to leave fragments of the old tree stands in case of threat to the forest sustainability and human safety, on clear cutting areas smaller than 1 ha and in the case of the block of the progeny plantations if they are composed of tree species for which the given block was established (Haze, 2012).

The shelterwood system is distinguished by its regular use of the stand over time, conducted with the use of shelterwood cuttings, of medium or long-term regeneration period. The natural regeneration, mainly of heavy-seeded species, is taking place by top sowing under the cover of the maternal stand. In principle, one seed year is used (exceptionally further seed years), and the resulting renewals jointly with supplements (species compatible with the sivicultural purpose, introduced after the last cutting) form the young stand with a relatively low age and height variation. This system can also be used in stands composed of light-demanding species (Haze, 2012).

Group cutting is a one-time or gradual cutting in mature or conversed stand gaps of 5 to 50 a, with or without upper cover, depending on the ecological requirements of the species to be renewed. The natural or artificial regeneration arising under lateral or upper cover creates basically single-species clumps, over 1–3 m higher than the later renewed trees on the area between the gaps (Haze, 2012).

The gradual cutting is performed in a stand, on the same manipulation area by using various types of the renewal cuts, leading to uneven depletion over time. The renewal centres being created are expanding usually during a long regeneration period with edge cuttings This type of cutting is used for shaping the multi-species stands, including those composed of light-demanding and shade-tolerant species and upper mountain spruce forests in the compact coniferous forest belt. It can also be used for the conversion of lower mountain spruce stands and pine stands in the brad-leaved forests habitats. It makes it possible to grow multi-species stands, of different ages, with a clump form of mixing species. The irregularity of cuttings is determined by the habitat conditions, the compactness of the stand and the existing groups of saplings. Many seed years are used in this system and the renewal process on the manipulation area is not taking place at the same time, thanks to which all stages of regeneration occur side by side (Haze, 2012).

The selection cutting, also known as continuous, is recommended to be used primarily in pure fir stands and mixed stands with a large predominance of silver fir, Abies alba, with a multi-storey structure as well as in the form of mountain selection cutting in upper Mountain spruce stands in the depleted coniferous forest belt. It involves the continuous cutting over the entire area of the stand. The process of natural regeneration is taking place continuously and seedlings and saplings permanently use the stand canopy (Haze, 2012).

Since 1990, in the State Forests, the share of combined cutting system has been systematically growing, preferring complex felling and hence, the systematic increase in the share of natural regeneration. Systematic increase in the area share of the deciduous species, mainly oaks *Quercus sp.* and common beech *Fagus sylvatica* has been observed. It is a response to the need to reconstruct stands on former agricultural land and reconstruct the species composition in connection with the proper recognition of the habitats (Przypaśniak, 2015).

Throughout the country, the area of forest stands with a clear-cut management system is 46.9% in relation to the forest area. In the State Forests, this share is 45%, and in the private forests 61%. Tree stands with selection cutting system constitute 2.2%, 1.7% in the State Forests and 3.8% in the private forests, respectively. The share of the stands managed in a combined system is 43.8%, and in a special system - 7.1% (WISL, 2020).

10.4. Forest tending

In order to maintain the proper condition of the forest habitats as well as stands and individual trees, the forests are subject to tending measures. The tending of the forest includes:

1. Tending of the stand, consisting in tending cuttings and trees tending.
2. Tending of the habitat, including works related to the tending of the soil, introducing shrubs and the lower storey as well as shaping the stand edges (Haze, 2012).

Annually, approximately 500,000 ha of the forests are subjected to thinning measures in Poland (Table 10.3).

Tab. 10.3 *Area of thinning in the years 1999-2018 in the Polish forests*

Year	Total (ha)	SF NFH ha)
1999	601,872.00	540,108.00
2000	600,607.00	521,987.00
2001	563,491.00	500,452.00
2002	517,413.00	450,268.00
2003	513,517.00	445,866.00
2004	566,709.00	494,649.00
2005	545,250.00	480,961.00
2006	541,753.00	478,293.00
2007	515,923.00	448,182.00
2008	522,521.00	453,381.00
2009	520,536.00	456,756.00
2010	517,265.00	447,030.00
2011	542,109.00	443,736.00
2012	526,504.00	440,281.00
2013	544,024.00	456,370.00
2014	538,792.00	450,098.00
2015	534,175.00	440,795.00
2016	509,463.00	423,288.00
2017	497,001.00	412,190.00
2018	468,937.00	380,217.00

Source: Statistics Poland Local Data Bank, 2020.

Regardless of the cyclical tending cuttings in individual stands, the sanitary and sanitary-selective cuttings are made in them as needed. The forest stands that do not ensure the possibility of achieving the objectives of a durable, sustainable and multifunctional forest management are undergoing conversion. It takes place both in the stands with an unadjusted species composition, but also in the stands heavily influenced by industry (Haze, 2012).

The conversion of the stands involves a change (total or partial) of the tree species composition or its structure by means of the silvicultural measures in order to adapt to the habitat conditions. The change of the species composition is achieved most often by cutting down the existing stand and establishing a plantation with a different composition, while change in the structure - as a result of the properly conducted tending cuttings. In 2019 the conversion of the stands in the State Forests was carried out on the area of 4,300 ha.

The conversion of stands in industrial areas is aimed at: preventing the formation of large complexes of plantations and young stands, inhibition by the old tree stands of the spreading of dust and gases, forest landscape protection, taking into account the needs of tourism, maintaining production continuity, avoiding depreciation of the wood raw material. The conversion of such stands should primarily be determined by: the degree of their damage, current vitality and anticipated changes in the threat of the industrial impact. Tending and protective measures in the stands of all age classes in the industry damaged areas should seek to increase biodiversity and take into account viability, stability, quality and sensitivity to emissions of individual tree and shrub species (Haze, 2012).

Increasing the biological resistance of the stands within the range of permanent gradation outbreaks of the insects, it is possible through the use of measures aimed at:

1. Establishing the new secondary forest plantations with an enriched species composition, adapted to the habitats.
2. Adjusting the species composition to the habitats production capacity.
3. Accelerate the conversion and diversify the species, age and spatial structure of single-species stands.
4. Increasing the physiological resistance of the trees and stands by application of tending, protection and agro-and phytomelioration measures.
5. Maintaining the highest possible level of groundwater and increasing the retention capacity of the forests.
6. Limiting damage caused by deer, especially by keeping their population in the appropriate number.
7. Diversify and enrich the food base and living places of birds, insects and mammals (Haze, 2012).

10.5. Management of the forest genetic resources in the protected areas

The forest management meets the objectives of the nature protection on forest land and in forest ecosystems in a broad sense that goes beyond the concept of care. The tasks in this regard are included in the nature protection plan, which is part of the forest management plan according to which the forest management is carried out (art. 7.1 of the Forest Act). Economic and protective objectives, and therefore costs and benefits, coincide here. However, some tasks related to nature protection, also resulting from the international obligations, may require activities contrary to the principles of silviculture, the cycle of forestry work and the method and tools for their execution, which justifies the need to exclude certain areas from the normal silviculture and create a second, more restrictive line of protection. Ten legal forms listed in the Nature Conservation Act, i.e. national parks, nature reserves, landscape parks, protected landscape areas, Natura 2000 sites, nature monuments, documentation sites, ecological sites, nature and landscape complexes, protection of species of plants, animals and fungi, may be located on the forest lands, and nine of them on the land managed by the State Forests (national parks are exception). The Nature Conservation Act provides a detailed list of prohibitions regarding these forms. They are respected in the forest management, but in practice the contradictions emerge, e.g. related to the species protection and Natura 2000 sites (Olaczek, 2014).

Due to the limitations of sustainable forest management on protected areas in Poland, in the public forests (the State Forests and national parks) approximately 2,900,000 m^3 less of the wood material is harvested annually, compared to the potential habitat production capacity, theoretically assuming that all forest areas perform economic functions and there are no exemptions from logging because of nature protection requirements (Grzywacz, 2019).

The forest management in nature reserves is carried out on the basis of the applicable protection plan, and in its absence, on the basis of the protection tasks. If for the nature reserve none of those documents have been prepared, the forest district manager may apply to the nature protection authority with the information on the existing threats or with the request for the enforcement of the necessary measures. The forest management in the buffer zones of the nature reserves is carried out in agreement with the nature protection authority. The arrangements are made at the preparation stage of the drafted forest management plan (Haze, 2012).

The principles of silviculture in the protected natural habitats should promote the species composition of the stands as well as the directions and principles of their maintaining in accordance with their characteristic priority of protection (Haze, 2012).

In Poland, the type of environment with the largest area share in the Natura 2000 site is forests as they cover 43% of all sites. Both bird and habitat areas are established there. In accordance with Nature Conservation Act in the areas managed by the State Forests in Natura 2000 sites, the tasks in the field of nature protection are performed by the local forest district manager (they are included in the forest management plan). The general principle of the activities in the Natura 2000 sites is such management with the purpose of not deteriorating the condition of the habitats and populations of the individual species. Introducing the rules of the so-called forest management ecologization has resulted in favourable changes that have had an impact on the biodiversity growth in the forests. The Polish model of forestry based on the integration of all forest functions does not eliminate the need for the existing forms of nature protection, in which a special category of protection may be applied - strict protection.

It allows to protect the natural processes that occur without human interference, including, among other, full cycle of the forest growth phases. It is also necessary to intensify concerns for the resources of the decaying wood in the forest, which many protected species in the Natura 2000 sites depend on.

The bases for forest management in the national parks are conservation plans, established within 5 years from the creation of the national park. Draft of a conservation plan is drawn up by the director of the national park, ensuring the possibility of the public participation in the proceedings. In addition, the draft requires an opinion from the local municipality councils (Act on Nature Conservation, 2004).

The minister responsible for the environment establishes by means of regulation the conservation plan for the national park, within 6 months from the date of receipt of the draft or refuses its establishment if the draft plan is inconsistent with the nature protection objectives (Act on nature conservation, 2004).

The conservation plan for the national park is drawn up for a period of 20 years, taking into account, among other: assessment of the state of nature, assessment of the existing and potential internal threats, external evaluation of the social and economic conditions as well as analysis of the effectiveness of the current protection methods (Act on Nature Conservation, 2004).

Until the establishment of the conservation plan, a draft of the conservation tasks is prepared, established by way of an regulation by the minister responsible for the environment. They include: assessment of the existing and potential internal and external threats, description of methods of active protection of ecosystems, description of methods of active protection of plant, animals or fungi species and indication of the areas under strict, active and landscape protection (Act on Nature Conservation, 2004).

The measures to protect the forest ecosystems in the national parks include:

- protection of durability, continuity and stability of the ecological processes,
- preservation of the diversity of the habitats and microhabitats being the living environment of the forest organisms,
- maintaining the proper conservation status of Natura 2000 forest habitats,
- monitoring the condition of the forest ecosystems and their protection,
- silvicultural measures in accordance with the provisions of the conservation plans or the conservation tasks.

The minister responsible for the environment prepares annual summary reports on the activities of national parks, on the basis of reports submitted by directors of national parks (the Nature Conservation Act, 2004).

10.6. Management of the forest genetic resources in the tree-covered areas

In publications on the subject of the tree-covered areas, most often the definition of Zajączkowski (1982) is quoted, according to which the tree-covered areas are "single trees and shrubs or their clusters that do not constitute the forest communities, together with the occupied area and the rest of their vegetation". Also in the Act on Nature Conservation, the tree-covered areas are defined as above, but in a slightly changed form (Act on Nature Conservation, 2004) - trees and shrubs within the road belt were added to the definition and they were separated from the definition of a forest within the meaning of art. 3 of the Forest Act (1991), which says that "a forest within the meaning of the Act is a land with a compact area of at least 0.10 ha, covered with forest vegetation (forest plantations) - trees and shrubs and undergrowth - or temporarily deprived of it (...)". Many naturalists do not agree with the definition of a forest of the area starting from 0.10 ha because it is impossible in such small areas to create the forest environment - especially without specifying the width of the forest belt. Most of the small clumps on the agricultural land does not have the characteristics of a forest but has the characteristics of an ecotone zone, which is characteristic of the tree-covered areas. None of the definitions given earlier contains information on the land use category.

In the Regulation of the Minister of Regional Development and Construction regarding the land and buildings records (Regulation of the Minister of Regional Development and Construction, 2001) woody and shrubby areas are marked in the records with the symbol Lz, while in the case of mid-field tree-covered areas existing on the lands covered by the soil classification, this symbol is completed with the designation of the land use, constituting a component of the determination of the soil class. Moreover, in appendix 4 of that document one can find information that the woody and shrubby areas include:

- mid-field clusters of trees and shrubs,
- areas of peat bogs partially covered with the clumps of shrubs and dwarf trees,
- land covered with the shrubby willow forms, covered with the wicker in the river valleys and places of ground depressions,
- land with trees and shrubs constituting a protection zone adjacent to the surface waters,
- ravines and gorges covered with trees to protect against erosion,
- stone dumps and rubble, closed cemeteries overgrown with trees and shrubs,
- clusters of trees and shrubs of the park character but without the necessary equipment and structures for recreation and relaxation.

Each of the above-mentioned cases cannot be a forest based on the minimum forest area (0.10 ha) (Orzechowski and Trzcianowska, 2016). So, there are such forests outside the records and until they are reclassified to forest land are considered as tree-covered areas.
tree-covered areas can be a significant provider of many ecosystem services, includingsignificant source of wood raw material - mainly fuel. Annually on average in Poland, approx. 800,000 m^3 of merchantable timber is obtained from the tree-covered areas, which is approx. 2% of the amount of merchantable timber harvested in the Polish forests (Tab. 10.4). One should also take into account that a certain part of the merchantable timber obtained from the tree-covered areas may remain outside the records.

Tab. 10.4 *Tree-covered areas - planting trees and shrubs as well as harvesting of merchantable timber in the years 2002-2018*

Year	Number of trees planted (pcs.)	Number of shrubs planted (pcs.)	Harvesting of large timber (m^3)
2002	26,157.00	9,418.00	3,905.00
2003	34,863.00	11,597.00	4,388.00
2004	27,285.00	8,561.00	4,709.00
2005	19,834.00	8,938.00	5,448.00
2006	27,988.00	7,502.00	5,718.00
2007	20,780.00	5,011.00	6,193.00
2008	19,558.00	9,489.00	7,273.00
2009	23,160.00	9,686.00	8,516.00

2010	20,875.00	10,459.00	9,628.00
2011	16,757.00	8,781.00	9,506.00
2012	18,034.00	17,408.00	9,708.00
2013	18,434.00	13,330.00	9,943.00
2014	17,173.00	14,941.00	11,19 3.00
2015	14,681.00	7,981.00	11,27 5.00
2016	15,138.00	8,220.00	12,35 5.00
2017	11,714.00	8,400.00	7,921.00
2018	5,675.00	4,596.00	8,593.00

Source: Statistical Yearbook of Forestry, 2019.

10.7. Protection of tree-covered areas

The Act on Nature Conservation contains provisions to protect trees and shrubs in chapter 4 under the name of the "Protection of green areas and tree-covered areas", concerning, inter alia, the permits for the removal of a tree or a shrub, replacement plantings or pruning branches. The cited Act also includes quite restrictive provisions on illegal activities of removing tree-covered areas and single trees as well as shrubs or damaging them.

Trees and shrubs are an important landscape factor and at the same time fulfil very important ecological functions (e.g. neutralization of anthropogenic pollutants), enrich the biodiversity of a given area, they are a shelter for many species of animals, they shape the microclimate and fulfil a very important social function. Taking into account the objectives of creating landscape parks and protected landscape areas i.e. preservation of natural, historical and cultural values and landscape values, tree-covered areas, as an important element of these areas, should be specially protected. Consequently, in many landscape parks and protected landscape areas, it is forbidden to eliminate and destroy the field and the roadside tree-covered areas as well as the tree-covered areas by the water. If the above prohibition is in force – the cutting of road, water and field tree-covered areas in the landscape park or in the protected landscape area is unacceptable. At the same time, the above prohibition does not apply to the cutting resulting, among others from the need of flood protection or ensuring road and water traffic safety or construction, reconstruction, maintenance, renovation or repair of the water devices. According to art. 5 point 27 of the act on nature protection, tree-covered areas are single trees, shrubs or their clusters, which are not forests in the sense of the Forest Act or orchard, together with the area where they occur and other components of the vegetation of such area. On the other hand, the mid-field tree-covered areas should be considered the tree-covered areas that are among the fields kept for the agricultural production or other activities related to farming, e.g. pastures. These include both single trees or shrubs and their clusters, either self-seeding or intentionally planted.

In relation to the tree-covered areas, it is forbidden to liquidate or destroy them. The removal of the tree-covered areas should be understood as the cutting of all trees and shrubs constituting the tree-covered areas. On the other hand, the destruction of the tree-covered areas should be understood as a reduction in the number of the trees and shrubs constituting the tree-covered areas. It is permissible to reduce the number of the trees and shrubs, if such an activity is performed as part of tending, related to maintaining the tree-covered areas in proper condition. Assessment whether a given tree-covered areas is mid-field, roadside or above-water is on case by case basis. Such an assessment is carried out by the authority as part of the proceedings for the issue of a tree or shrub removal permit or as part of the analysis of the notification of the intention to remove a tree, or such assessment is made by the entity, which wants to remove such trees or shrubs (in a situation where neither a permit is required nor notification for the purpose of cutting down the trees or shrubs).

At the same time, pursuant to art. 127 of the Act on Nature Conservation, anyone who intentionally violates the prohibitions applicable, among others, in the landscape parks and the protected landscapes areas, is punished by a fine or arrest.

In the Natura 2000 sites there is no defined catalogue of the activities that may be implemented or unrealized. The possibility of undertaking a specific investment depends on the effects that the investment may have on the Natura 2000 site's conservation objectives. According to art. 33 sec. 1 of the Act on Nature Conservation, it is prohibited to undertake activities that may, alone or in combination with other activities, have a significant negative effect on the conservation objectives of the Natura 2000 site, including, in particular:

- deterioration of the natural habitats or habitats of plant and animal species, for the protection of which the Natura 2000 site has been designated,
- could have a negative impact on the species for the protection of which Natura 2000 site has been designated,
- deterioration of the integrity of the Natura 2000 site or its links with other sites.

The cuttings carried out in the Natura 2000 site, if carried out on a large scale or if referring to trees of exceptional natural value (e.g. that are habitats for the valuable insect species), can potentially have significant negative effects on the protected objects of this site (although those will also not be frequent situations).

Trees or shrubs protected as nature monuments have special natural, scientific, cultural, and historical or landscape value. They stand out by their individual traits that distinguish them from other trees or shrubs. Hence, they are subject to special care and are covered by the ban preventing their destruction, damage, or transformation. However, when cutting down a tree or shrub constituting a nature monument, it is necessary, in the first place, to remove the protection status from the given tree or shrub in the form of a nature monument. This is only possible in the event of the loss of the nature and landscape value, due to which a form of nature protection has been established.

All trees that are nature monuments located in the undeveloped area, are protected until their natural, complete decay – if it does not pose a threat to people or property.

When the felling of trees or shrubs is planned within the forms of nature protection (national parks, nature reserves, nature monuments, documentation sites, ecological sites, nature and landscape complexes), it is necessary, before starting the works, to assess whether as a result of the work and of the removing of the trees or shrubs, the prohibitions established for a given form of nature protection would not be violated (GDOŚ, 2017).

10.8. Summary of the management and maintaining of tree-covered areas

The greatest threat to the initiation and implementation of the tree-covered areas enterprises, is a lack of executive regulations defining their legal status and principles of their management, as well as the institutions and entities responsible for their protection (Bałazy and Ziomek, 2009). There are no legal regulations in the assumptions of the State Ecological Policy, enabling the fulfilment of the significant tree-covered areas planting needs and establishment of the compensations accepted by the farmers. Moreover, since 1990 establishing tree-covered areas has become own task of the communes, which as a result contributed almost completely to the suspension of tree planting on agricultural land throughout the country (Act on the local government, 1990). The farmers do not show the will to introduce the tree-covered areas on their plots as they occupy the areas excluded from the agricultural production and hence, they are excluded from the payment-covered areas under direct payments scheme of the European Union. Moreover, there is a belief in the rural environment about the adverse impact of the trees and shrubs on the adjacent farmlands, the consequence of which is a reduction in yields in the zone of direct contact with the crop. Many farmers are against establishing tree-covered areas, claiming that the roots of the trees deplete the soil, which results in poor growth and limited yields of the plants in their vicinity (Orzechowski and Trzcianowska, 2016).

Despite these conditions, the farmers or other managers and owners of land within the framework of establishing tree-covered areas or restoring the existing ones, plant about 2,000,000 trees and shrubs annually although there is a clear downward trend in these activities (Tab. 10.4).

Properly developed green infrastructure in the agricultural landscape is essential to maintain a high-quality of rural living and production of good quality food. The requirement to take care of green infrastructure, including tree-covered areas, gains particular importance in the period of climate change (Kujawa et al., 2019).

The urgent need for the establishing of tree-covered areas in Poland requires an effective measures on many levels. The legal status must be regulated first and the principles of managing the mid-field tree-covered areas. The detailed guidance on the possibilities and sources of their funding is also needed since the introduction of a large-scale tree-covered areas system in a given region is an expensive investment. It requires considerable expenditure on compensation for owners of the tree-covered areas - to cover the costs of excluding the area from the agricultural production, and the establishment, tending and protection of the tree-covered areas. Due to the strict protection of every trees (except fruit trees) growing on non-forest land, the tree-covered areas should be divided due to their functions. This will make easier the management of wood raw material produced in the mid-field plantings, which will further encourage the users of the agricultural land to plant trees and shrubs on their plots. On a regional scale, it will allow for the development of a network of mid-field tree-covered areas, which will improve not only the biodiversity of agroecosystems and cultivated plant growth conditions, but will contribute significantly to the restoration of the beautiful landscape of the Polish countryside (Orzechowski and Trzcianowska, 2016).

10.9. Recommendations for managing the tree-covered areas

Planning and management recommendations:

1. Inventory of natural resources, including tree-covered areas, in communes and their valuation according to a uniform nationwide methodology, and then treating them as an asset of the commune.
2. Implementation of mandatory monitoring of natural resources, including tree-covered areas, taking into account the ecosystem services and the assessment of the environmental problems. Such monitoring should be carried out in each commune and constitute the basis of the comprehensive management and use of those resources, taking into account the studies concerning the region and the country (e.g. the National Ecological Network).
3. Establishing the rules of managing the tree-covered areas in the commune should lie in the competences of the qualified persons employed for this purpose. For individual municipalities the specific recommendations should be developed, meeting the needs of the tree-covered areas establishing, including optimization guidelines for meeting the demand for various ecosystem services. The tree-covered areas should be included in spatial development plans, the studies on conditions and decisions on development conditions.
4. There should be a legal possibility to make the State Treasury land available, being in the resources of the National Agricultural Support Centre, for the introduction of the new tree-covered areas, including, the legal possibility of free land transfer from the National Agricultural Support Centre to the municipal authorities for the purposes of tree-covered areas establishing..
5. In the case of the new road investments, the obligation to plan the tree-covered areas along the roads should be introduced, regardless of the replacement and compensation planting.
6. The possibility of recognizing the establishment of mid-field plantings as public purpose investments should be introduced (Kujawa et al., 2019).

The tree-covered areas establishing should be planned with the participation of the environmental experts, including the employees of the forest districts. In the tree-covered areas the protected species of trees and shrubs should be used to a greater extent.

Financing recommendations:

1. The financial support for the farmers keeping and increasing the area of tree-covered areas should be extended in the future Common Agricultural Policy 2021-2027 (in conjunction with the results of the monitoring of the needs of the tree-covered areas in the commune). Such support should primarily concern the introduction of the new tree-covered areas in accordance with the needs resulting from the inventory and monitoring conducted in the municipalities. However, further maintenance of the proper condition of the tree-covered areas should be a necessary condition for receiving direct payments.
2. Agri-environmental programs should support the development of the new form of land development such as agroforestry systems.
3. In addition to the mechanisms under the Rural Development Program, it is important to launch the funds earmarked for setting up and maintaining the tree-covered areas as green infrastructure on a national, regional and local scale.
4. The financial support should be given to the development of the bottom-up initiatives and activities aimed at tree-covered areas establishing by social associations and villages, e.g. through the funds within the Local Action Groups as well as village and communal funds.
5. The possibility of introducing the financial mechanisms connected with Poland's climate policy should be considered (including CO_2 sequestration – potential of tree-covered areas in this area is estimated at several million tons of captured carbon annually).

Recommendations in the field of legislation:

1. The records relating to the inventory of tree-covered areas, the valuation of ecosystem services, determining the needs of tree-covered areas establishing and activities for the development of tree-covered areas should be included in the official strategic documents of the country (e.g. State Ecological Policy) and in the relevant legislation.
2. The National Tree-covered Areas Development Program should be developed. It should be strategically placed, e.g. as an element of rural areas' adaptation to climate change within the framework of the Strategic Adaptation Plan for sectors and areas sensitive to climate change.
3. Under the National Tree-covered Areas Development Program, the public road managers should be obliged to restore and plant new trees at the roadside. They should also be able to benefit from the funding under the program.
4. It is necessary to introduce the principles of tree management by farmers, facilitating the acquisition of wood, while maintaining the durability of tree-covered areas, since the

current regulations are too restrictive in this respect. This will be conducive to the development of tree-covered areas and the introduction of agro-forestry systems (Kujawa et al., 2019).

Part V. The state of legal and political conditions

Chapter 11. Institutional framework for the conservation, use and development of forest genetic resources

11.1. National coordination mechanisms and other institutions dealing with forest genetic resources.

Forest policy at the international level in Europe is shaped within two main processes. The pan-European forum was launched in 1990 within the Ministerial Process of Forest Protection in Europe, currently operating under the name of Forest Europe. The second forum for policymaking concerning or affecting the forests and forestry in Poland is created by the European Union. No treaty basis to run common forest policy results in this that due to the subsidiarity principle, the forestry matters, first of all, is the competence of the Member States, and at the EU level, the policy matters, directly or indirectly relating to forestry, remain scattered across the range of the areas of activity of the European Union. This situation leads to the domination of the forest sector by other sectors, whereby forest-related action is primarily and increasingly taken in sectors other than the forestry. Another big problem is the lack of coordination and coherence of measures within individual policy areas on Union level and between the institutions of the Member States and the institutions of the European Union, which favours the adoption of potentially conflicting goals and creates conflict situations (Kaliszewski, 2018b).

In Poland, the institution responsible for the development, implementation and coordination of all matters related to forestry and the protection of the forest genetic resources is the minister responsible for the forestry. Mainly the State Forest National Forest Holding, General Directorate for Environmental Protection, Forest Reproductive Material Office, Forest Research Institute and the Office of Forest Management and Geodesy are involved in the implementation of the relevant programs, plans and the tasks. All of these entities cooperate with each other on the sustainable use and development of the forest genetic resources as well as in the field of constant increase of knowledge about the existing variability of the forest genetic resources and the risks and mitigation of the impact of climate change on the forest genetic resources.

The condition of forests in Poland is assessed by the state authorities. As part of this assessment the State Forests - by virtue of the Forests Act - has been obliged to annually prepare a report on the condition of the forests. This report is based on the materials of the Directorate General of the State Forests, Forest Research Institute, Statistics Poland, Office of Forest Management and Geodesy and international statistics. The Council of Ministers submits to the Polish Parliament the information on the condition of the forests and on the implementation of the national program for increasing the forest cover. The basic information on the size and structure of the wood resources in Poland is provided by the results of the Large-Scale Forest Inventory. Since 2015, the third, its 5-year cycle has been implemented. The purpose of this inventory is the assessment of the condition of the forests of all ownership forms and the directions of change thereof on the scale of the country and individual regions. In turn, the main source of information about the health status of the forest and the occurrence of damage to the forests and changes in this state is the Forest Monitoring, carried out annually as part of the State Environmental Monitoring. Due to the conditions of data collection and processing information, the data concerning the forests in Poland are currently available as of 31 December 2019. For the purpose of presentation of the characteristics of the Polish forests against the background of the selected European countries, the information was used which was published in the latest cyclic report on the state of the Europe's forests.

11.2. Principles and strategies concerning the forest genetic resources

The precedent act of the Polish law is the Constitution of the Republic of Poland, which also refers to matters related to the ecological safety of the society.

The Constitution of the Republic of Poland, pursuant to art. 5, protects the national heritage and ensures environmental protection, being guided by the principle of sustainable development. Furthermore, the public authorities pursue a policy ensuring ecological safety for present and future generations, and environmental protection is the responsibility of the public authorities, which also support citizens to protect and improve the environment (art. 74) (Constitution of the Republic of Poland, 1997).

Several dozen strategic and program documents have been implemented in Poland covering the issues of the forests and the forestry in the field of ecological policy and biodiversity protection, agricultural policy and rural development, climate, energy, spatial, as well as national and supra-regional development strategies. Below, most of them are presented and the characteristics of the most important policies on forest genetic resources are highlighted.

State forest policy

Among the main objectives of the State forest policy of 1997, established on the basis of the Forest Act, are:

a) the need to ensure the sustainability of the forests, together with their multifunctionality that will be achieved by increasing the country's forest resources, including:
- improvement of the condition of forest resources and their comprehensive protection,
- reorientation of the forest management from the previous dominance of the raw material model to a model of pro-ecological and economically sustainable, multifunctional forest silviculture, meeting the criteria formulated for Europe within the Helsinki process, taking into account the specificity of the Polish forestry,

b) increasing the forest resources, which will be achieved by increasing the forest cover over the country to 30% in 2020 and 33% in the mid-21st century, successively as it is transferred for afforestation of land unsuitable for agriculture and achievement of spatially optimal forest structure in the landscape through protection and full use of the habitat production capacity,

c) restitution and rehabilitation of the forest ecosystems, mainly through conversion, on suitable habitats, single-species stands to mixed stands and through biomelioration measures,
d) regeneration of devastated and neglected stands in the private forests, and then their ecological rehabilitation,
e) increasing the genetic and species diversity of the forest biocoenoses, and ecosystem diversity in the forest complexes based on natural patterns (State Forest Policy, 1997).

To improve the condition and protection of the forests so that they can better and more broadly fulfil various functions, the need to continue the following activities in the area of the forest management was taken into account:

a) increasing the health and resistance of stands to abiotic and biotic harmful factors through the dissemination of biological and ecological methods of forest protection,
b) reducing the use of chemicals to necessary measures (including pesticides, mineral fertilizers),
c) the provision of the protective and social functions by the forests so that these activities cannot threaten the sustainability of the forests and do not adversely affect the condition of the stands,
d) the below principles:

- the use of wood resources, regulated by the prescribed cut, is a derivative of the needs resulting from the silvicultural and protection goals of the forest and is to ensure the continuity of the production of as much of the best quality wood as possible,
- the volume of timber harvested in tending cuttings should not exceed the current increment, but guarantee the accumulation of the wood in the stands, giving the basis for the extended reproduction,
- the volume of timber harvested from the mature stands should take into account the limitations resulting from the implementation of the protective and social functions, the current state and the future species and age structure of the forest and the degree of its compliance with the habitat conditions, the level of achievement of the planned silvicultural goal and the needs in the area of the tree stands renewal and conversion,
- regulating the number of game to a level that does not endanger the purposes of silviculture and forest protection,
- regulating and targeting the recreation and tourism in the forest areas in a way that reconciles the social functions of forests with the protective and productive functions,
- increasing the effectiveness of legal protection of all forest land (State Forest policy, 1997).

Despite profound social, economic, institutional and legal changes in the forest management in the past 20 years, the state's forest policy has not been reviewed and updated. The document refers to the provisions of the "State Ecological Policy", adopted by the Polish Parliament in 1991, "Forest Principles" and "Agenda 21", adopted at the *United Nations Conference on Environment and Development* in Rio de Janeiro in 1992, and European declarations of the forestry ministers on forest protection, adopted in Strasbourg in 1990 and in Helsinki in 1993, but does not include the political processes, international and national agreements and documents shaping the forest policy and the conditions of the forestry functioning in the following years (Kaliszewski, 2018a). In the last two decades, there has been intensive development of the forestry policy and forest-related policy areas. The most important political process in this scope at the European level is the Forest Europe process. Most identified forest policy priorities, adopted at the European level since 1998, are not found in the "State Forest Policy". They were expressed, however directly or indirectly in numerous programme documents of the sectors connected with the forestry. It can be assumed that lack of revision and update of the provisions in the "State Forest Policy" and the formulation of the important forestry goals in the programme documents of others sectors of the economy have an impact on the progressive marginalization of the forest sector in the political and social space. It seems necessary to produce and adopt the national forest program (in line with the recommendations of the *United Nations Conference on Environment and Development*), enabling ongoing adaptation of the conducted forest policy to the changing of natural, social and economic as well as institutional and legal conditions (Kaliszewski and Gil, 2017).

No treaty basis for the conduct of the common forest policy by the European Union leaves forest and forestry issues first and foremost under the competence of the Member States. The regulations concerning the forest sector are adopted within individual sectoral policies of the European Union, primarily, policies on environmental protection and biodiversity conservation, climate and energy, agriculture, industry and trade. This situation leads to the dominance of the forestry by other sectors, each with its own policies and a variety of accompanying policy instruments. In this context, a significant problem is the lack of coordination and coherence of measures within individual policy areas at EU level and between the institutions of the Member States and the institutions of the European Union, which is conducive to adopting potentially conflicting goals and creates conflict situations. Despite the difficulties mentioned above in the implementation of the coherent activities relating to the forest sector over the last dozen or so years, the forests are increasingly being regulated by the European Union. It is thanks to the dynamic development of the biodiversity protection policy (Natura 2000), climate and energy policy (carbon caught by forests, use of wood as a source of energy) or agricultural policy (forests as a factor of the development of rural areas), supported by legal regulations and economic instruments. The inclusion of the forests and the forestry obliges the member states to implement various direct sectoral policies (in the case of regulations) or indirect (directives, strategy papers) to adapt the national legislation as well as to update the strategic and programme forest policy documents so that they are consistent with the objectives and activities undertaken at the Community level (Kaliszewski, 2018b).

Strategy of the State Forests National Forest Holding for the years 2014-2030

The strategic goals of the State Forests in the document include:

1. Ensuring the durability of the forests (forests as the most important element of the environment).
2. Ensuring the availability of forests to the society (forests as a social value).
3. Ensuring a significant contribution of the State Forests to the development of the economy (forestry as an important sector of the economy and creator of the development of rural areas).
4. Striving to make State Forests National Forest Holding, a modern, well-managed and efficient organization.
5. Developing human resources and competences as well as motivating to implement the strategy.
6. Ensuring the ability to self-finance the activity.

The most important strategic projects related to realisation of sustainable management of the forest genetic resources are:

1. Building and maintenance of the Forest Data Bank.
2. Program of conserving forest genetic resources and breeding of the trees in Poland.
3. Program of increasing the country's forest cover.
4. Reclamation of degraded, post-military areas for natural purposes.
5. Increasing the retention capacity and preventing floods and droughts in forest ecosystems (small retention).
6. Nurseries development program.
7. Endangered species protection programs.
8. Protection of biodiversity in the forest areas, including, the network of Natura 2000 sites - promotion of best practices.
9. Information campaigns promoting the activity of the State Forests.

National program for increasing the forest cover

The national program for increasing the forest cover, adopted by the Council of Ministers in 1995, is a case study document of a strategic nature. It is an instrument of forest policy in the field of shaping the natural space of the country which contains the general guidelines for the preparation of the regional spatial development plans in the field of increasing the forest cover. The methodological assumptions and afforestation preferences criteria used in the program can be helpful in creating the original solutions on regional and local level. The program aims to provide a strategic framework for increasing the country's forest cover to 30% by 2020 and 33% after 2050 as well as the optimal distribution of afforestation areas, setting ecological and economic priorities and adjustments of implementation instruments. New afforestations are part of the implementation of the multifunctional and sustainable development of the country.

The problem with the further implementation of the program results from the low supply of the vacant land to afforestation. The above is a consequence of direct payments under EU subsidies for agricultural production, no possibility of afforestation of the permanent grassland and limited possibility of afforestation in Natura 2000 sites. Nevertheless, it should be emphasized that after 1945 the forest area, as a result of afforestation, on average increased by approx. 20,000 ha per year. Currently, this process has slowed down to around 2,000 ha per year due to the high costs involved in the reclassification of agricultural land into forestry and restrictive regulations on the reverse activities, i.e. reclassification of the forest land for other purposes of use (Kaliszewski, 2016; Szramka and Adamowicz, 2020). Another important factor is the insufficient system of financial incentives for owners of agricultural land to afforest their agricultural land (Kozioł and Matras, 2013).

National Ecological Policy 2030

The National Ecological Policy 2030 is the most important strategic document in this area. It is a strategy compliant with the Act on the principles of development policy (Act on the principles of development policy, 2006). Its role is to provide Poland's ecological safety and high quality of life for all residents. In the system of strategic documents, it clarifies and operationalizes "Strategy for Responsible Development until 2020 (with a perspective until 2030)" (State Ecological Policy 2030, 2019).

In the field of the forest genetic resources, the State Ecological Policy 2030 includes:

a) Management of natural and cultural heritage resources, including protection and improving biodiversity and landscape.

   Poland is characterized by valuable natural resources, including high level of biodiversity. Nevertheless, it is necessary to counteract factors and phenomena having a negative impact on the state of the biological diversity, which includes, in particular: transformations and degradation of the habitats, changes of land use, overexploitation of natural resources, environment pollution or the spread of invasive alien species. The biological diversity is an inheritance, and its preservation is a condition for ensuring access to the richness of nature for future generations. Stability disorder of the ecosystems can lead to multidimensional negative effects on economy and society. The effective protection of biodiversity resources and landscape requires an objective assessment and verification of the protected areas. The measures planned for implementation will be focused primarily on stopping the decline in biodiversity and protecting habitats and valuable landscapes as well as combating crime in this area. They will support projects related to the preservation of biological diversity, development of green and blue infrastructure and projects for *in situ* or *ex situ* conservation of the endangered species and habitats. The activities implemented under the direction of the intervention contribute to the implementation of the Sustainable Development Goals No. 6, 11, 14 and 15 (State Ecological Policy 2030, 2019).

b) Supporting multifunctional and sustainable forest management. Conducting multifunctional and sustainable forest management enables maintaining a balance between the functions provided by the forests: social and economic. At the same time, it creates conditions for preserving the natural richness of the forests, while using their resources for the purpose of meeting the social and economic needs. The forests are also a place for the implementation of the game management. Forests have great potential for mitigating climate change that can be enhanced by carrying out additional activities in the forest sector. Such activities also contribute to increasing the biodiversity. The implementation of the system is planned as part of the scheduled measures aimed at increasing carbon sequestration. The additional action system related to the sustainable forest management is aimed at development of the long-term programs for the conversion of the species composition of the stands and programs for shaping their multi-storey structure. The implementation of tasks in the field of the forest management will contribute to the exploitation of the opportunities in the forest production in order to systematically increase the supply of wood, while maintaining the principles of protecting the natural richness and making forests available to the public. The activities implemented under the direction of the intervention contribute to the implementation of the Sustainable Development Goals No: 6, 13 and 15 (State Ecological Policy 2030, 2019).

Other documents related to ecological policy in Poland, implemented in recent 20 years:

1) **II State Ecological Policy.**
2) **State ecological policy for the years 2003-2006 with the perspective for the years 2007-2010.**
3) **National strategy for the conservation and sustainable use of diversity with the action program.**
4) **State ecological policy for the years 2007-2010, including prospective or the years 2011-2014.**
5) **The ecological policy of the state in the years 2009-2012 with the perspective up to the year 2016.**

6) **Program for the conservation and sustainable use of diversity with the Action Plan for the years 2015-2020.**
7) **Rural Areas Development Plan for the years 2004-2006.**
8) **Rural Areas Development Program for the years 2007-2013.**
9) **Rural Areas Development Program for the years 2014-2020.**
10) **Strategy for sustainable development of rural areas, agriculture and fisheries for the years 2012-2020.**

The need to protect the forest genetic resources in relation to tree-covered areas has been formulated with the specific goal of: Environmental protection and adaptation to climate change in rural areas where one of the priorities (5.2) emphasizes the preservation of the unique forms of the rural landscape. The importance of sustainable forest and game management in rural areas (5.4) was also underlined, including the rational increase of the forest resources and restoration of the stands after damage caused by the natural disasters. In the new strategy until the year of 2030, the need was emphasised to maintain and as much as possible make available the land for afforestation, increase the overall forest cover of the country and the density of the forest complexes and of the afforested areas (Horizontal actions, point 2.4.6.) (Resolution of the Council of Ministers, 2012).

11) **Strategies for reducing greenhouse gas emissions in Poland until 2020.**
12) **Strategic adaptation plan for sectors and areas sensitive to climate change by 2020 with the perspective by 2030.**

The activities in the field of forestry are included in the measure 1.4 – protection of biodiversity and forest management in the context of climate change. It was established that the activities conducive to sustainable forest management will be important in the conditions of the climate change as well as for the preparation of the forest ecosystems to increased pressure resulting from the intensification of the extreme weather phenomena, including the periods of drought, heat waves, violent rainfall, gusty winds (Strategic Adaptation Plan, 2013). The document defines 7 lines of action, which relate directly to forestry:

- Development of forestry adaptation programs to climate change taking into account the conditions and needs of the industry, energy and agriculture, tourism and recreation, regional development, biodiversity (1.4.1).
- Increasing forest cover, both as a result of the artificial afforestation and succession in the natural environment, and rationalizing the land use, reducing fragmentation of the forest complexes (1.4.2).
- Introducing the principles of ecosystem forestry to forest management, dynamic protection of the existing biological diversity, using both natural genetic processes and human activities, aimed at preserving the existing biodiversity, targeting the artificial

selection towards the development of the traits of adaptation to changing climatic conditions (1.4.3).

- Diversity of the stand, especially during conversion, in terms of: density, species composition (increasing the share of the deciduous species), height, age, patchness/mosaic structure (1.4.5).
- Continuation of the soil protection program against erosion, continuation and extension of the small retention and soil retention program, especially in forests and grassland (1.4.6).
- Monitoring of forests in terms of tree responses to climate change, including phenological observations, zonalchanges in species range, especially in the mountain areas (1.4.8).
- Strengthening forest fire protection through the development of the systems of monitoring the fire risk and fire infrastructure, related to forest protection (1.4.10) (Strategic Adaptation Plan, 2013).

The program for adaptation of forests and forestry to climate changes was developed and implemented by 2020. In line with the long-term goal by 2030, the State Forests National Forest Holding will be a unit prepared for threats related to the climate change and it will have the effective system for forecasting, quick response and removing the effects of the threats related to the climatic factors. Short-term goals include:

- Reducing the vulnerability of the forest ecosystems to the drought related threats and strengthening the retention functions.
- Reducing the scale of damage to forest ecosystems related to water erosion in the forest areas.
- Development and modernization of the recognition and fast response system to the threats related to the forest fires.

In order to achieve the long-term goal, the role of genetic diversity must be taken into account in the forest adaptation to climate change. The conservation of the genetic variation is the "insurance policy" for the future. It is important to keep both the species diversity as well as intraspecific variability. The natural process of natural regeneration will contribute to the conservation of the populations *in situ*, provided that those populations will be adapted to the changing climate. Especially vulnerable species and populations should be *ex situ* protected in clone archives and gene banks (Cloud, Howe, Anderson, and St Clair, 2010).

13) Poland's energy policy until 2030.

14) National renewable energy action plan until 2020

15) Strategy "Energy Safety and Environment - perspective to 2020".

This strategy is one of the 9 integrated development strategies developed on the basis of on the Act on the Principles of Development Policy. The document details the provisions of the

Mid-term National Development Strategy 2020 in the field of energy and environment and constitutes guidelines for the Polish Energy Policy. The main goal of the Strategy "Energy Safety and Environment" is to ensure a high quality of life of the present and future generations, taking into account the environmental protection and creation of the conditions for the sustainable development of the modern energy sector, capable of ensuring the Poland's energy safety as well as the competitive and effective economy (Resolution of the Council of Ministers, 2014). The specific objectives are:

- Sustainable management of the environmental resources.
- Providing the national economy with safe and competitive energy supply.
- Improving the condition of the environment (Resolution of the Council of Ministers, 2014).

Moreover, the document also indicates horizontal issues that go beyond the indicated time perspective. In the context of the threats posed by the process of climate change, the adaptation of the multifunctional forest management to the changing conditions becomes essential (action 14). It is necessary to define the approach to management of the forest resources that would take into account the threats resulting from the climate change, affecting the state of biodiversity in the forest areas as well as assuming the wood raw material base and wood demand structure as the basis for the development of the industries based on this natural resource and the role of the forestry as a development factor in the rural areas. The sustainable nature of the forest management, allowing for the use of the forest resources and their simultaneous expansion is an example of managing the natural resources with the use of the active methods of protecting the nature and good forest practices. The effective protection of the diversity of biological resources requires the creation of conditions for the protection of the ecological corridors and counteracting the fragmentation of the natural space (measure 12), which will make possible the migration and dispersion of the species both on the European, regional and local level. Moreover, Poland should implement measures aimed at restoration/maintenance of the proper conservation status of the habitats and species (measure 13), i.e. identification of the habitats and species sensitive to the climate change. Additionally, the designation of areas with the lowest adaptation potential and designation of the networks of the ecologically important areas that act as migration corridors, and designation of the flood-prone areas will reduce the probability of locating investments in the key areas from the point of view of the adaptation to the climate change, exposed to the effects of the phenomena of weather intensification.

16) National Spatial Development Concept.

17) Environmental protection policy.

Environmental protection policy is a set of measures aimed at creating conditions necessary for the implementation of the environmental protection, in accordance with the principle of the sustainable development. The environmental protection policy is conducted on the basis of the development strategies, programs and programme documents referred to in the Act on the principles of the development policy (Consolidated text, Journal of Laws 2019, item 1295, 2020, 2020, item 1378). The environmental protection policy is also pursued with the help of voivodeship, poviat and communal environmental protection programs.

18) **National development strategy 2007-2015.**
19) **Poland 2030. Development challenges.**
20) **National Strategy for Regional Development 2010-2020: Regions, Cities, Rural areas.**
21) **Poland 2030. The third wave of modernity. Long-term Development Strategy of the Country.**
22) **National Development Strategy 2020. Active society, competitive economy, efficient state.**
23) **Strategy for innovation and efficiency of the economy "Dynamic Poland 2020".**
24) **Strategy for Responsible Development until 2020 (with perspective till 2030).**
25) **Poland 2025 - Long-term strategy of permanent and sustainable development.**

The document defines the directions of the country's development until 2025 and recommends measures for the sustainable development, including development in the ecological dimension. According to the strategy, it should create such conditions to stimulate the development processes so that they endanger the environment the least and speed up the processes restoring the environment to its proper state wherever the violation of the natural balance has occurred.

Among the main directions of the intervention indicated in the Strategy, the following should be distinguished:

- Development and implementation of the strategic plan for adaptation to climate change, including, among others, the detailed criteria used to determine the priorities of the investments in the area of adaptation to the climate change, assessment of the current impact and the impact of future climate change on particularly vulnerable sectors and areas and appropriate adaptation measures with their estimated costs.
- Introducing biodiversity monitoring and protection and counteracting the fragmentation of ecosystems.
- Introducing public policy instruments that integrate activities in the individual sectors (water management, agriculture, forestry, transport, health, construction, spatial planning, marine economy, tourism, energy) to increase climate protection.
- Limiting the negative effects of floods by minimizing the risk of flooding, implementation of the integrated management system of the catchment areas and restoration of the

natural water retention.

– Implementation of small water retention programs, in particular, on the areas exposed to flood and drought (Poland's strategy 2025, 2000).

26) Strategy for the socio-economic development of Eastern Poland up to a year 2020.

27) Development strategy of southern Poland until 2020.

28) Western Poland Development Strategy until 2020.

29) Central Poland Development Strategy until 2020 with a perspective to the year of 2030.

11.3. Legislation and regulations concerning the forest genetic resources

The issues of legal protection and management of the forest genetic resources are included in five basic legal acts in force in Poland:

1. The Act of 6 April 2004 on nature protection (consolidated text, Journal of Laws of 2020, item 55, 471, 1378).

   The Act defines the scope of protection necessary for the Natura 2000 sites – execution of the obligations under the Habitats and Birds Directives and implementation within the relevant scope of the purpose of the directives, i.e. to maintain or restore the proper status of the protected objects in the Natura 2000 network. The Act also regulates the issues of *in situ* and *ex situ* conservation of the species of the plants and animals under protection and the tree-covered areas protection.

2. The Act of 27 April 2001 Environmental Protection Law (Consolidated text, Journal of Laws 2020, item 1219, 1378, 1565).

   The act defines the rules governing the protection of the animals and plants in Poland. The protection of animals and plants consists in:

   – preserving valuable ecosystems, biodiversity and maintenance of the natural balance,
   – creating conditions for proper development and optimal fulfilment by animals and plants of the biological function in the environment,
   – preventing or reducing the negative impacts on the environment, which could adversely affect the resources and condition of the animals and plants,
   – preventing threats to natural complexes and creations of nature.
   – The protection referred to above is implemented, in particular, through:
   – protecting areas and objects of natural value,
   – establishing the protection of animal and plant species,
   – limiting the possibility of harvesting wild animals and plants,

- restoring animal populations and plant sites and ensuring the reproduction of wild animals and plants,
- safeguarding the forests and tree-covered areas against pollution and fires,
- limiting the possibility of cutting down trees and shrubs and of removing greenery areas,
- afforestation, establishing of tree-covered areas or the formation of vegetation clusters, especially when it is supported by the need to protect soil and animals and shaping the climate as well as other needs related to ensuring the biological diversity, natural balance and meeting the recreational and leisure needs,
- supervising the intended release of the genetically modified organisms into the environment and placing them on the market in the sense of provisions of the Act on Microorganisms and Genetically Modified Organisms (Consolidated text, Journal of Laws of 2019, item 706, of 2020, item 322).

3. The Act of 28 September 1991 on forests (Consolidated text, Journal of Laws of 2020, item 1463).

   The act defines the rules for the preservation, protection and expansion of the forest resources and the principles of the forest management in connection with other elements of the environment and the national economy. Permanently sustainable forest management is carried out according to the forest management plan or simplified forest management plan, taking into account:

   - preserving forests and their beneficial influence on the climate, air, water and soil,
   - the conditions of human life and health and the natural balance.
   - forest protection, especially of the forests and forest ecosystems constituting natural fragments of the native environment or of the forests especially valuable due to: preservation of natural diversity, preservation of the forests genetic resources, landscape values, science needs,
   - protection of soils and areas particularly exposed to pollution or damage and of special social importance,
   - protection of the surface and ground waters, catchment retention, in particular, on the outskirts of the watersheds and in groundwater supply areas,
   - production, based on rational management, of wood and non-timber forest raw materials and products.

   Pursuant to the provisions of the Act, the forest management is carried out according to the following principles: general forest protection, sustainability of the forest maintenance, continuity and sustainable use of all forest functions, forest resources augmentation.

4. The Act of 3 February 1995 on the protection of agricultural and forest land (consolidated text, Journal of Laws of 2017, item 1161, of 2020, item 471).

   The Act regulates the principles of agricultural and forest land protection and reclamation and improving the usable value of the land as well as identifies the possible transformations of the forest areas for non-forest purposes. The solutions contained therein are intended to counteract the irrational economy in the agricultural and forest production space.

   The following regulations contribute to the achievement of the goal:

   - limiting the allocation of agricultural land to non-agricultural or non-forest purposes, preventing the processes of degradation and devastation of the agricultural land and damage in the agricultural production, arising from non-agricultural activities and mass movements of the land,
   - land reclamation and development for the agricultural purposes,
   - maintaining peat bogs and ponds as natural water reservoirs,
   - limiting changes in the natural shape of the earth's surface.

5. The Act of 7 June 2001 on forest reproductive material (consolidated text, Journal of Laws 2019, item 1097).

   The act regulates the registration of the basic forest material and marketing of the forest reproductive material, control of the basic forest material and the forest reproductive material, forest reproductive material introduced into the seed regionalization.

The programs for the protection of the forest genetic resources in Poland:

1. **Program for the conservation and sustainable use of the biological diversity along with the Action Plan for the years 2015-2020 "(Monitor Polski of 07.12.2015, item 1207, Resolution of the Council of Ministers of 16 November 2015)**

The main goal of the program is to improve state of biodiversity and more complete linking of its protection with the social and economic development of the country. The specific objectives and directions of the intervention are:

- increasing the level of knowledge and increasing the involvement of the society in the field of activities for the protection of biodiversity,
- improvement of the nature protection system,
- preservation and restoration of the natural habitats and the populations of the endangered species,
- maintenance and restoration of the functions of ecosystems that provide services for humans,
- increasing the integration of economic sectors' activities with the objectives of the biodiversity protection,

- limiting threats resulting from climate change,
- increasing Poland's participation in the international forum in the field of the protection of biodiversity (Resolution of the Council of Ministers, 2015).

2. **Program of conserving forest genetic resources and breeding of trees in Poland for the years 2011-2035**

The Program includes the main strategic goals. They are:

- protection and enrichment of the genetic diversity existing in forests,
- breeding of the forest trees,
- establishing and maintaining of the basic forest material on the proper quantitative and qualitative level for the renewals and afforestation.

The Program emphasizes very clearly the fact that the preservation of the forest genetic diversity is necessary to ensure fundamental continuity of the ecological processes, sustainability of the forest maintenance and ecological systems use, forest restitution in the degraded habitats, improving of the natural resistance of the stands and communities and the preservation of the genetic diversity for future generations. The forest meets the growing multiple social and economic needs. Preserving the genetic diversity of the forest tree populations, in view of the increasing anthropopressure and the expected climate changes, becomes of the special importance. In many cases, the passive protection forms do not bring the desired effect, often leading to the replacement of those natural elements of the ecosystem valuable for natural heritage by other, more dynamic ones. Therefore, it is necessary to develop the programs of active protection and restitution of the specific plant species, including forest-forming, admixture and rare tree species (Chałupka et al., 2011).

The Program focuses on the need to protect:

- populations valuable to the forestry due to favourable phenotypic traits (objects for the production of the forest reproductive material of the category "selected"),
- trees with valuable genotypes, economically important for the forest management, resulting from intended selection (objects for the production of the forest reproductive material of the category "qualified"),
- native populations and individual trees established before 1860, it is also indicated that other valuable stand and tree genetic resources should be preserved due to their adaptive abilities (conservation stands and trees),
- populations and individuals with genotypes considered valuable on the basis of the genetic research,
- populations and individuals of admixture tree species and other plant species which, due to their scattered occurrence and lack of active protection, are exposed to withdrawal or extinction in the forest ecosystems - efforts to preserve the genetic

diversity must be carried out both *in situ*, through their active support in the forest environment and *ex situ*, depending on the degree of risk (Chałupka et al., 2011). *Ex situ* conservation measures are aimed at reducing the risk of losing the valuable objects as a result of the unforeseen phenomena in the forest environment, such as climate changes, fires, floods, insect outbreaks, activity of the fungal and viral pathogens, the impact of animals or successive changes in the forest communities. *Ex situ* protection of genetic diversity is carried out simultaneously by establishing the conservation areas, progeny plantations,clonal seed orchards, seedling seed orchards, clone archives *in vivo* and through the collection and long-term storage of the genetic material in the gene banks. The program should become an element of the National Forest Program and include forests of all forms of ownership.

3. **Large-Scale Forest Inventory**

   Since 2010, the Large-Scale Forest Inventory has been one of the main sources of information on forests of all forms of ownership, both for national statistics as well as international. In 2015, its third cycle began, which will allow for better capturing of the trends of changes in the forests. Completed in 2014, the second cycle delivered first information about the current increment of the stands, significant from the point of view of the calculations related to the determination of emission/removals. The third cycle will provide better results from a longer observation period, regarding the current increment of the stands, dead wood resources and forest use (WISL, 2020).

4. **Data bank on forest resources and state of the forests – Forest Data Bank**

   In order to improve the state supervision over forest management in the forests of all forms of ownership, work was commenced on the construction of the Forest Data Bank. The tool was launched in 2014. From 2015, the work was undertaken to extend the scope of the collected and shared information by including data from the studies on habitat and phytosociological information as well as information on game management. The development activities also include the improvement of the forecasting processes in the development of the resources and the possibility of using them on macro scale in the time horizon 10-30 years Statistics Poland - Local Data Bank, 2020). In 2016, the act on forests was amended, which introduced a subsidy mechanism to drawing up the simplified forest management plans. Within the Forest Data Bank, the guidelines for the preparation of those plans and data standards were developed as well as the descriptive, spatial and cartographic studies as well as software supporting the contractors of the projects of the simplified forest management plans. These activities aimed at improving the quality of planning in non-state forests, increasing the level of their standardization and creating mechanisms to improve the timeliness and completeness of the documentation for forests outside the State Forests National Forest Holding.

11.4. Summary

Due to the fact that the State Forest Policy (1997) has not been updated in Poland for many years, the numerous identified priorities of the forest policy adopted at the European Union level since 1998, do not find an equivalent in the wording of the Policy. Many of them stayed however, expressed directly or indirectly in the numerous steering documents and sector programs related to forestry. Problems of the forests and forest management should also be much more emphasized in almost all national and supra-regional development strategies developed and adopted over the past 20 years. It should be assumed that the lack of revision and update of the provisions in the "State Forest Policy" and the fact that the important forestry goals are formulated in the programme documents of others sectors of the economy can result in inconsistencies and contradictions in the adopted goals and priorities in the field of the forest resources management (Kaliszewski, 2018b).

Another document, required under the provisions of the Convention on Biodiversity (1992), and not yet implemented in Poland, is the national forest program. In connection with the ongoing work on the new European Union Forest Strategy and The European Strategy for Forest Genetic Resources, the implementation of the similar strategic documents should be considered in the near future also in Poland.

Sustainable forest management practices should be adapted to the changing environmental conditions by increasing adaptability and resilience of forests. The appropriate measures should be selected based on sound scientific evidence combined with the practical experience and the expert knowledge on the conditions and requirements of the tree species. These measures should increase the genetic diversity of the secondary forest plantations and stands during silvicultural activities, through the assisted migration or implementation of other system solutions in silviculture, favouring structural diversity and preventing the risk of disturbances.

At the international and national level, the legal framework and policy can make difficult the adaption of the practices to the changing climatic conditions, e.g. by reducing active forest management or transfer of the forest reproductive material. The government of Poland and its subordinate institutions at all levels should create the favourable conditions for adapting to climate change through the appropriate revision of their policies, e.g. by implementing the national forest program, guidelines for the forestry practice and legislation. The national guidelines and regulations governing the transfer of the forest reproductive material should be reviewed to allow for the assisted migration and selection of the appropriate places of origin of the basic forest material, taking into account the occurring and forecast climate changes (Lindner et al., 2020).

Chapter 12. International and regional cooperation in the field of forest genetic resources

12.1. International agreements with the countries from the European Union and outside the European Union

In recent years, Poland has adopted for implementation the provisions of the numerous international agreements in the field of broadly understood environmental protection. Their implementation should create a favourable environment for the measures undertaken within the protection of the forest genetic resources (12.6. Tables on international and regional cooperation on forest genetic resources Tab. 12.1, Tab. 12.2, Tab. 12.3).

12.2. International conventions covering the issues of the forest genetic resources

Joint nature conservation, carried out by many countries, can be much more effective than the independent measures of the individual countries. That is why Poland is a party to many conventions, including several aimed at the protection of the biological diversity (Tab.12.4, Tab. 12.5).

12.3. Cooperation within the framework of the European Process of Forest Protection in Europe - Forest Europe

The provisions of the "State Forest Policy" refer to, inter alia, the European Declaration of the Forestry Ministers on the Protection of the Forests (Strasbourg 1990 and Helsinki 1993), which provided guidelines of the sustainable forest management and led to the criteria-setting process and indicators (Tab. 12.6). Poland signed both resolutions of the first two ministerial conferences as well as all the subsequent ones. For the protection of the forest genetic resources in Poland, Resolution S2 (Strasbourg 1990) turned out to be extremely important, which had direct impact on Poland's accession to EUFORGEN and the establishment of the Kostrzyca Forest Gene Bank (Tab. 12.6).

12.4. International cooperation within organizations and associations

Governmental and scientific institutions in Poland are members of numerous organizations and associations actively involved in shaping the forest policy, research and the protection of the forest genetic resources (Table 12.7).

12.5. International scientific cooperation in the field of the forest genetic resources

Many research units from Poland actively participate in the international projects concerning research and conservation of the forest genetic resources. The most active units in this area include: Forest Research Institute, Institute of Dendrology of the Polish Academy of Sciences in Kórnik, Kazimierz Wielki University in Bydgoszcz, Faculty of Forestry of the University of Life Sciences in Poznań, Faculty of Forestry of the Warsaw School of Life Sciences, Faculty of Forestry of the Agricultural University in Kraków (Tab. 12.8). These units established with the participation of a representative from Adam Mickiewicz University in Poznań, the DendroGen consortium, whose goal is the consolidation of the research potential of the Polish scientific units in the implementation of research, implementation of the achievements of genetics into the forestry practice and promotion of knowledge in the field of forest trees genetics (Tab. 12.8).

12.6. Tables on international and regional cooperation in the field of forest genetic resources

Table 12.1 *Agreements with the countries outside the European Union*

State	Date of concluding	Status	Agreement or arrangement
Australia	17.03.2006	In force	Joint Declaration of the Minister of the Environment of the Republic of Poland and the Minister of Industry, Tourism and Resources of Australia on the technological, scientific and investment cooperation in the field of environmental and climate protection.
Peoples' Republic of China	10.04.2014	In force	Memorandum on cooperation in the field of forestry between the Ministry of the Environment of the Republic of Poland and the Office of the State Forest Administration of the People's Republic of China.
Iran	10.10.2002	In force	Agreement on environmental cooperation between the Minister of the Environment of the Republic of Poland and the Office for the Environmental Protection of the Iran Islamic Republic.
USA	24.06.2016	In force	Executive Agreement between the Government of the Republic of Poland and the Government of the United States of America to the Agreement between the Government of the Republic of Poland and the Government of the United States of America on the status of the United States Armed Forces on the territory of the Republic of Poland concerning environmental issues.
Venezuela	27.01.2013	In force	Framework Agreement on cooperation between the Republic of Poland and the Bolivarian Republic of Venezuela
Vietnam	28.11.2017	In force	Memorandum of Understanding between the Minister of the Environment of the Republic of Poland and the Ministry of Natural Resources and Environment of the Socialist Republic of Vietnam on cooperation in the field of natural resources and the environment.

Source: data of the Ministry of the Environment, 2020.

Table 12.2 *Agreements with the European countries outside the European Union*

State	Date of concluding	Status	Agreement or arrangement
Belarus	26.10.1994	In force	Agreement between the Government of the Republic of Poland and the Government of the Republic of Belarus on early notification of nuclear accidents and radiological safety cooperation.
	25.01.1996	In force	Agreement between the Ministry of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the State Ecology Committee of the Republic of Belarus on cooperation in the field of forestry.
	12.09.2009	In force	Agreement between the Government of the Republic of Poland and the Government of the Republic of Belarus on cooperation in the field of protection of the environment.

State	Date of concluding	Status	Agreement or arrangement
Norway	15.11.1989	In force	Agreement between the Government of the Republic of Poland and the Government of the Kingdom of Norway on nuclear accidents and cooperation in the field of nuclear safety and radiation protection.
	14.10.2004	In force	Memorandum of the Norwegian Financial Mechanism 2004-2009, established in accordance with the agreement of 14 October 2003 between the Kingdom of Norway and the European Community on the Norwegian Financial Mechanism for the period 2004-2009 (intended as part of the aid for the environmental protection).
	17.12.2007	In force	Agreement to amend the Memorandum for the implementation of the Norwegian Financial Mechanism 2004-2009, established in accordance with the agreement of 14 October 2003 between the Kingdom of Norway and the European Community on the Norwegian Financial Mechanism for the period 2004-2009 (earmarked as part of the aid for the environmental protection).
Republic of Moldova	22.10.2003	In force	Agreement between the Minister of the Environment of the Republic of Poland and the Minister of Ecology, Construction and Territorial Development of the Republic of Moldova on cooperation in the field of environmental protection and management of natural resources.
Russia	22.05.1992	In force	Agreement between the Government of the Republic of Poland and the Government of the Russian Federation on cooperation between the northeast provinces of the Republic of Poland and the Kaliningrad District of the Russian Federation.
	02.10.1992	In force	Agreement between the Government of the Republic of Poland and the Government of the Russian Federation on cooperation between the regions of the Republic of Poland with the Saint Petersburg Region.
	25.07.1993	In force	Agreement between the Government of the Republic of Poland and the Government of the Russian Federation on cooperation in the field of prevention against the industrial accidents, natural disasters and liquidation of their consequences.
	25.08.1993	In force	Agreement between the Government of the Republic of Poland and the Government of the Russian Federation on cooperation in the field of the environmental protection.
	18.02.1995	In force	Agreement between the Government of the Republic of Poland and the Government of the Russian Federation on early notification of nuclear failure, information exchange related to nuclear facilities and cooperation in the field of nuclear safety and radiation protection.
	06.12.2010	In force	Agreement between the Government of the Republic of Poland and the Government of the Russian Federation on cooperation in combating sea pollution with oils and other harmful substances in the area of the Baltic Sea, including the Vistula/Kaliningradzki Lagoon.
	21.11.2013	In force	Memorandum on cooperation in the field of the forest management between the Ministry of the Environment of the Republic of Poland and the Ministry of Natural Resources and Ecology of the Russian Federation.

State	Date of concluding	Status	Agreement or arrangement
Switzerland	20.12.2007	In force	Framework Agreement between the Government of the Republic of Poland and the Swiss Federal Council on the implementation of the Swiss-Polish Cooperation Program in order to reduce the socio-economic differences within the enlarged European Union.
Ukraine	24.05.1993	In force	Agreement between the Government of the Republic of Poland and the Government of Ukraine on early notification of nuclear accidents, on information exchange and cooperation in the field of nuclear safety and radiological protection.
	24.01.1994	In force	Agreement between the Government of the Republic of Poland and the Government of Ukraine on cooperation in the field of environmental protection.
	10.10.1996	In force	Agreement between the Government of the Republic of Poland and the Government of Ukraine on cooperation in the field of water management of border waters.
	19.02.2002	In force	Agreement between the Government of the Republic of Poland and the Cabinet of Ministers of Ukraine on cooperation and mutual assistance in the field of the prevention and recovery of disasters, natural calamities and other extraordinary events
	04.03.2005	In force	Agreement between the Government of the Republic of Poland and the Cabinet of Ministers of Ukraine on economic cooperation.

Source: data of the Ministry of the Environment, 2020.

Table 12.3 *Bilateral agreements with the European Union countries*

State	Date of concluding	Status	Agreement or arrangement
Austria	24.11.1988	In force	Agreement between the Republic of Poland and the Republic of Austria on cooperation in the field of the environmental protection.
	15.12.1989	In force	Agreement between the Government of the Republic of Poland and the Government of the Republic of Austria on the exchange of information and cooperation in the field of nuclear safety and radiation protection.
Belgium	10.09.1990	In force	Agreement between the Government of the Republic of Poland and the Government of the Kingdom of Belgium on cooperation in the field of environmental protection.
	10.10.1996	In force	Cooperation agreement between the Government of the Republic of Poland and the Government of the French Community of Belgium and the Government of Wallonia.
Czech Republic	15.01.1998	In force	Agreement between the Government of the Republic of Poland and the Government of the Czech Republic on cooperation in the field of protection environment.
	27.09.2005	In force	Agreement between the Government of the Republic of Poland and the Government of the Czech Republic on early notification of nuclear power failure and information exchange on the peaceful uses of nuclear energy and nuclear safety and radiation protection.

State	Date of concluding	Status	Agreement or arrangement
Czech Republic cont.	19.08.2008	In force	Agreement between the Minister of the Environment of the Republic of Poland and the Minister of the Environment of the Czech Republic on the performance of geological works in the area of the common state border.
	20.04.2015	In force	Agreement between the Government of the Republic of Poland and the Government of the Czech Republic on cooperation in border waters in the field of water management.
Denmark	22.12.1987	In force	Agreement between the Government of the Republic of Poland and the Government of the Kingdom of Denmark on the exchange of information and cooperation in the field of nuclear safety and radiation protection.
	06.07.2004	In force	Agreement between the Minister of the Environment of the Republic of Poland and the Minister of the Environment of the Kingdom of Denmark on implementation of joint projects to reduce greenhouse gases emissions.
Finland	07.05.1990	In force	Agreement between the Government of the Republic of Poland and the Government of the Republic of Finland on cooperation in the field of protection of the environment.
France	14.06.1989	In force	Agreement between the Government of the Republic of Poland and the Government of the French Republic on cooperation in the field of environmental protection.
Lithuania	13.12.1995	In force	Agreement between the Ministry of Environment Protection, Natural Resources and Forestry of the Republic of Poland and the Ministry of Forestry of the Republic of Lithuania on cooperation in the field of forestry.
	02.06.1995	In force	Agreement between the Government of the Republic of Poland and the Government of the Republic of Lithuania on early notification of failure of the nuclear safety and cooperation in the field of nuclear safety and radiological protection.
	27.05.2004	In force	Agreement between the Government of the Republic of Poland and the Government of the Republic of Lithuania on the implementation of the Convention on Assessments of the environmental impact in the transboundary context.
	07.06.2005	In force	Agreement between the Government of the Republic of Poland and the Government of the Republic of Lithuania on cooperation in the field of use and protection of border waters.
Germany	17.06.1991	In force	Agreement between the Government of the Republic of Poland and the Government of the Federal Republic of Germany on the establishment of the Polish-German Council for Environmental Protection.
	19.05.1992	In force	Agreement between the Republic of Poland and the Federal Republic of Germany on cooperation in the field of water management on border waters.
	07.04.1994	In force	Agreement between the Government of the Republic of Poland and the Government of the Federal Republic of Germany on cooperation in the field of environmental protection.

State	Date of concluding	Status	Agreement or arrangement
Germany cont.	18.06.2001	In force	Agreement between the Minister of the Environment of the Republic of Poland and the Federal Minister of the Environment, Nature Conservation and Reactor Safety of the Federal Republic of Germany on the implementation of the joint pilot projects in the field of environmental protection in the Republic of Poland in order to reduce the cross-border environment. pollution
	02.02.2005	In force	Agreement between the Minister of the Environment of the Republic of Poland and the Federal Ministry of the Environment, Protection of Nature and Reactor Safety of the Federal Republic of Germany on the implementation of the joint projects in the field of environmental protection in the Republic of Poland.
	24.04.2005	In force	Joint Statement of the Ministers of the Environment of the Republic of Poland and the Bavarian Minister of Environment, Health and Consumer Protection
	11.04.2006	In force	Agreement between the Government of the Republic of Poland and the Government of the Federal Republic of Germany on the implementation of the Convention of 25 February 1991 on the assessment of the environmental impact in the transboundary context.
	30.07.2009	In force	Agreement between the Government of the Republic of Poland and the Government of the Federal Republic of Germany on early notification of a nuclear accident, on the exchange of information and experience, and on cooperation in the field of nuclear safety and radiological protection.
	27.04.2015	In force	Agreement between the Government of the Republic of Poland and the Government of the Federal Republic of Germany on joint improvement of the situation on the Polish-German border waterways (flood protection, flow and navigation conditions).
	10.10.2018	In force	Agreement between the Government of the Republic of Poland and the Government of the Federal Republic of Germany on environmental impact assessments and strategic environmental impact assessments in the transboundary context.
Slovakia	18.08.1994	In force	Agreement between the Government of the Republic of Poland and the Government of the Slovak Republic on cooperation in the field of environmental protection.
	14.05.1997	In force	Agreement between the Government of the Republic of Poland and the Government of the Slovak Republic on water management of border waters
	17.09.1996	In force	Agreement between the Government of the Republic of Poland and the Government of the Slovak Republic on early notification of nuclear accidents, information exchange and cooperation in the field of nuclear safety and radiological protection.
	10.07.2009	In force	Agreement between the Minister of Environment of the Republic of Poland and the Ministry of Environment of the Slovak Republic on cooperation in the field of geology.
Sweden	10.02.1989	In force	Agreement between the Government of the Republic of Poland and the Government of the Kingdom of Sweden on the demarcation of regions for combating pollution of the Baltic Sea.
	01.10.1999	In force	Agreement between the Government of the Republic of Poland and the Government of the Kingdom of Sweden on the implementation of debt conversion for environmental protection.
	22.01.2004	In force	Agreement between the Minister of the Environment of the Republic of Poland and the Swedish Agency for Cooperation and Development on the implementation of pilot projects in the field of environmental protection under the DemoEast program.

State	Date of concluding	Status	Agreement or arrangement
Italy	17.01.1974	In force	Agreement on economic, industrial and scientific cooperation between the Government of the Republic of Poland and the Government of the Republic of Italy.
	19.07.2003	In force	Joint Statement on cooperation in the field of environmental protection between the Minister of Environment of the Republic of Poland and the Minister of Environment and Territorial Protection of Italy.

Source: data of the Ministry of the Environment, 2020.

Tab. 12.4 *International conventions*

Dates: R - ratification O -announcement W - entry into force	Status	Convention or agreement	Unit responsible for supervision over the implementation	Websites where you can find more information
R - 26.01.1978 O - 29.03.1978 W -22.03.1978	In force	Convention on Wetlands of International Importance Especially as the Habitats of Waterfowl, done at Ramsar on 02/02/1971 (Ramsar Convention)	General Directorate for Environmental Protection (Department of Nature Resource Management)	www.ramsar.org www.bagna.pl www.poleskipn.pl www.zb.eco.pl www.wigry.win.pl
R - 12.12.1989 O - 04.04.1991 W - 12.03.1990	In force	Convention on International Trade in Endangered Species of Wild Fauna and Flora, drawn up in Washington on 03/03/1973 (Washington Convention - CITES)	Ministry of Environment (Department of Nature Conservation), State Council for Nature Conservation	www.mos.gov.pl www.cites.orgcites.site 50.net
R - 12.07.1995 O - 25.05.1996 W - 01.01.1996	In force	Convention for the Protection of Wild European Flora and Fauna and Their Natural Habitats, drawn up in Bern on 19 September 1996 (Bern Convention)	General Directorate for Environmental Protection (Department of Nature Resource Management)	www.coe.int/en/web/bern-convention www.gdos.gov.pl
R - 13.12.1995 O - 10.01.2003 W - 01.05.1996	In force	Convention for the Conservation of Migratory Species of Wild Animals, drawn up in Bonn on June 23, 1979 (Bonn Convention)	Ministry of Environment (Department of Nature Conservation)	www.mos.gov.pl www.cms.int
R - 25.06.1990 O - 23.12.1992 W - 01.05.1996	In force	Vienna Convention of March 22, 1985 on the protection of the ozone layer	Ministry of Environment (Department of Climate Transformation Strategy and Planning)	-
R - 19.07.1985 O - 28.12.1985 W - 17.10.1985	In force	Convention of November 13, 1979 on Long-Range Transboundary Air Pollution (LRTAP Convention)	Ministry of Environment (Department of Air Protection and Urban Policy)	-
R - 20.03.1992 O - 10.01.1992 W - 18.06.1992	In force	Convention of March 22, 1989 on the Control of Transboundary Movements of Hazardous Wastes and Disposal (Basel Convention)	Chief Inspectorate of Environmental Protection (Market Control Department)	-
R - 16.06.1994 O - 16.06.1994 W - 26.10.1994 r.	In force	United Nations Framework Convention on Climate Change of 09/05/1992	Ministry of Environment (Department of Climate Transformation Strategy and Planning)	www.unfccc.int
R - 04.12.1991 O - 03.12.1999 W - 10.05.1996 r.	In force	Agreement on the protection of bats in Europe, signed in London on 04/12/1991	Ministry of Environment (Department of Nature Conservation)	www.mos.gov.pl www.eurobats.org

R - 17.03.1992 O - 03.12.1999 W - 18.02.1996 r.	In force	Agreement on the protection of small cetaceans of the Baltic and the North Sea, drawn up in New York on March 17, 1992	Ministry of Environment (Department of Nature Conservation)	www.mos.gov.plhel.univ.gda.pl www.ascobans.org
R - 13.12.1995 O - 06.11.2002 W - 19.12.1996	In force	Convention on Biological Diversity, drawn up in Rio de Janeiro on 09/05/1992	Ministry of Environment (Department of Nature Conservation)	www.mos.gov.pl www.cbd.int
R - 10.12.2003 O - 04.10.2004 W - 09.03.2004	In force	Cartagena Protocol on Biosafety to the Convention on Biological Diversity.	Ministry of Environment (Department of Nature Conservation)	www.cbd.int
W - 20.05.2014	In force	Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Use	Ministry of Environment (Department of Nature Conservation)	www.mos.gov.pl
R - 02.10.2001 O - 07.11.2002 W - 12.02.2002	In force	United Nations Convention to Combat Desertification in Countries Experiencing Severe Drought and/or Desertification, especially in Africa	Ministry of Environment (Department of International Affairs)	-
R - 24.06.2004 O - 29.01.2006 W - 01.01.2005	In force	European Landscape Convention drawn up in Florence on October 20, 2000	General Directorate for Environmental Protection (Department of Nature Resource Management)	-
R - 27.02.2006 O - 31.05.2007 W - 19.06.2006 R - 19.06.2008 O - 27.05.2010 W - 09.12.2009	In force	Framework Convention on the Protection and Sustainable Development of the Carpathians	Ministry of Environment (Department of Nature Conservation)	www.mos.gov.pl www.zielonekarpaty.org.pl www.carpathianconvention.org
R - 12.01.2009 O - 29.01.2009 W - 12.01.2009 r.	In force	Convention of August 28, 2003 on the European Forest Institute	Ministry of Environment (Department of Forestry)	-
R - 06.05.1976 O - 30.09.1976 W - 30.09.1976	In force	Convention of November 16, 1972 on the Protection of the World Cultural and Natural Heritage	Ministry of Environment (Department of Nature Conservation)	ww.eko.org.pl www.unesco.pl
R - 30.09.2008 O - 29.01.2009 W - 21.01.2009	In force	Stockholm Convention of May 23, 2001 on Persistent Organic Pollutants	Ministry of Environment (Waste Management Department)	www.mos.gov.pl
R - 13.03.2009 O - 03.09.2009 W - 17.04.2009	In force	International Convention of 02/12/1946 on the Regulation of Whaling	Ministry of Environment (Department of Nature Conservation)	-
Not subject to ratification	In force	Agreement on the protection of Aquatic Warbler	General Directorate for Environmental Protection (Department of Nature Resource Management)	-

Source: Data of the Ministry of the Environment, 2020.

Tab. 12.5 *Other agreements*

Dates: R - ratification O -announcement W - entry into force	Status	Convention or agreement	Unit responsible for supervision over the implementation	Websites where you can find more information
R - 12.06.1997 O - 30.04.1999 W - 10.09.1997 r.	In force	Convention on Environmental Impact Assessment in the Transboundary Context, drawn up in Espoo on February 25, 1991	General Directorate for Environmental Protection (Department of Environmental Impact Assessment)	www.unece.orgwww.gdos.gov.pl
R - 21.06.2011 O - 31.08.2011 W - 19.09.2011	In force	Protocol of 2003 on Strategic Environmental Assessments to the Convention on Environmental Impact Assessment in the Transboundary Context	General Directorate for Environmental Protection (Department of Environmental Impact Assessment)	www.gdos.gov.pl www.unece.org
Date of signing: 15.12.1999	The convention is in the process of ratification	Convention of May 24, 1983 on the establishment of the European Organization for the Exploitation of Meteorological Satellites	Institute of Meteorology and Water Management	www.imgw.gov.pl
R - 31.10.2001 O - 03.12.2002 W - 04.12.2001	In force	Cooperation agreement with the European Organization for the Exploitation of Meteorological Satellites	Institute of Meteorology and Water Management	www.imgw.gov.pl
R - 31.12.2001 O - 09.05.2003 W - 16.05.2002	In force	Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, drawn up in Aarhus on June 25, 1998	Ministry of the Environment (Department of Environmental Management)	cpe.eko.org.pl/aarhusclearinghouse.unece.org/ www.unece.org
R - 21.05.2003 O - 26.11.2012 W - 25.09.2012	In force	Protocol on Pollutant Release and Transfer Registers to the 2003 Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention)	General Inspectorate of Environmental Protection (Department of Inspection and Jurisprudence)	-
R - 30.09.2008 O - 29.01.2009 W - 21.01.2009 r.	In force	Convention on Persistent Organic Pollutants (Stockholm Convention)	Ministry of Environment (Waste Management Department)	www.srodowisko.ekologia. pl
R - 08.09.2003 O - 06.07.2004 W - 07.12.2003 r.	In force	Convention of March 17, 1992 on the Transboundary Effects of Industrial Accidents of March	Chief Inspectorate of Environmental Protection, General Headquarters of the State Fire Service	www.unece.org www.ciop.pl

Source: Data of the Ministry of the Environment, 2020.

Table 12.6 *Declarations, decisions and resolutions of the Ministerial Conferences on Forest Protection in Europe - Forest Europe*

<table>
<tr><th>Name</th><th>Date and place of the conference</th></tr>
<tr><td>Ministerial Conference Declaration: 25 years of joint promotion of sustainable forest management in Europe.</td><td rowspan="4">Seventh Ministerial Conference on Forest Protection in Europe
20-21.10.2015
Madrid</td></tr>
<tr><td>Ministerial Conference Decision: Future direction of FOREST EUROPE.</td></tr>
<tr><td>Resolution 1: The forestry sector at the heart of the "green economy".</td></tr>
<tr><td>Resolution 2: Forest protection in the changing environment.</td></tr>
<tr><td>Ministerial mandate to negotiate the legally binding agreement on forests in Europe.</td><td rowspan="2">Sixth Ministerial Conference on Forest Protection in Europe
June 14-16, 2011
Oslo</td></tr>
<tr><td>Ministerial Conference Decision: European forests 2020.</td></tr>
<tr><td>Ministerial Conference Declaration.</td><td rowspan="3">Fifth Ministerial Conference on Forest Protection in Europe
5-7.11.2007
Warsaw</td></tr>
<tr><td>Resolution 1: Forests, Wood and Energy.</td></tr>
<tr><td>Resolution 2: Forests and Water.</td></tr>
<tr><td>Ministerial Declaration: European forests - shared benefits, shared responsibility.</td><td rowspan="6">Fourth Ministerial Conference on Forest Protection in Europe
April 28-30, 2003
Vienna</td></tr>
<tr><td>Resolution 1: Strengthening synergies in sustainable forest management in Europe through cross-sector cooperation and national forest programs.</td></tr>
<tr><td>Resolution 2: Increasing the economic efficiency of sustainable forest management in Europe.</td></tr>
<tr><td>Resolution 3: Protecting and enhancing the social and cultural dimensions of the sustainable forest management in Europe.</td></tr>
<tr><td>Resolution 4: Protection and enhancement of the forest biodiversity in Europe.</td></tr>
<tr><td>Resolution 5: Climate change and sustainable forest management in Europe.</td></tr>
<tr><td>General Declaration of the Conference.</td><td rowspan="3">Third Ministerial Conference on Forest Protection in Europe
June 2-4, 1998
Lisbon</td></tr>
<tr><td>Resolution 1: People, forests and forestry - strengthening the socio-economic aspects of the sustainable forest management.</td></tr>
<tr><td>Resolution 2: Pan-European operational level criteria, indicators and guidelines for sustainable forest management.</td></tr>
<tr><td>General Declaration of the Conference.</td><td rowspan="5">Second Ministerial Conference on Forest Protection in Europe
June 16-17, 1993
Helsinki</td></tr>
<tr><td>Resolution 1: General guidelines for the sustainable forest management in Europe.</td></tr>
<tr><td>Resolution 2: General guidelines for the protection of biodiversity in European forests.</td></tr>
<tr><td>Resolution 3: Cooperation in the field of forestry with countries in the period of economic transformation.</td></tr>
<tr><td>Resolution 4: Strategies for the process of long-term adaptation of forests in Europe to climate change.</td></tr>
</table>

Name	Date and place of the conference
General Declaration of the Conference.	First Ministerial Conference on Forest Protection in Europe December 18, 1990 Strasbourg
Resolution 1: European network of permanent experimental plots for forest ecosystem monitoring.	
Resolution 2: Conservation of forest genetic resources.	
Resolution 3: Decentralized European forest fire databank.	
Resolution 4: Adaptation of mountain forests management to new environmental conditions.	
Resolution 5: Development of the EUROSILVA tree physiology research network.	
Resolution 6: European Forest Ecosystem Research Network.	

Source: Forest Europe data (retrieved from foresteurope.org/wpcontent/uploads/ 2016/11 / Commitments_all.pdf).

Table 12.7 *International cooperation within organizations and associations*

Name of the organization / association	**Membership**	**Name of the national representative**
BBMRI-ERIC	Institutions associated with the Polish Biobanks Network (BBMRI.pl), including the Kostrzyca Forest Gene Bank (observer)	Elżbieta Gocek (Biobanking National Coordinator)
COFFI (UNECE *Committee on Forests and the Forest Industry)*	The State Forests National Forest Holding - General Directorate of the State Forests	Marta Gaworska (*Vice-chair*)
ConDDEFFS (*Conference of Deans and Directors of European Forestry Faculties and Schools)*	• Warsaw University of Life Sciences - Faculty of Forestry • University of Agriculture in Krakow - Faculty of Forestry • Poznań University of Life Sciences - Faculty of Forestry	Marcin Pietrzykowski (*Chair*)
EFC (FAO *European Forestry Commission)*	Ministry of Environment	Representatives of the Ministry of Environment
EFI (*European Forest Institute)*	• Forest Research Institute • Wood Technology Institute • Polish Academy of Sciences • Warsaw University of Life Sciences - Faculty of Forestry • University of Agriculture in Krakow - Faculty of Forestry • University of Warmia and Mazury in Olsztyn	Representatives of member organizations
ENSCONET (*European Native Seed Conservation Network*)	• Kostrzyca Forest Gene Bank • Polish Academy of Sciences - Botanical Garden - Center for the Preservation of Biological Diversity in Powsin	Representatives of member organizations
EUFGIS (*European Information System on Forest Genetic Resources*)	• Ministry of Environment • The State Forests National Forest Holding - Kostrzyca Forest Gene Bank	Czesław Kozioł (*National Focal Point*)

Name of the organization / association	Membership	Name of the national representative
EUFORGEN (*European Forest Genetic Resources Programme)*	• Ministry of Environment • The State Forests National Forest Holding - Kostrzyca Forest Gene Bank	Czesław Kozioł (*National Coordinator*)
EUSTAFOR	The State Forests National Forest Holding - General Directorate of the State Forests	Andrzej Konieczny (*Executive Committee member*)
FAO Intergovernmental Technical Working Group on Forest Genetic Resources	• Ministry of Environment • The State Forests National Forest Holding - Kostrzyca Forest Gene Bank	Czesław Kozioł (*National Focal Point - Report on the State of the Worlds Forest Genetic Resources*)
Forest Europe	Ministry of Environment	Representatives of the Ministry of the Environment
GGBN (*Global Genome Biodiversity Network)*	Kostrzyca Forest Gene Bank (observer)	Czesław Kozioł
ISTA (*International Seed Testing Association)*	Kostrzyca Forest Gene Bank	Magdalena Beza (member of *Forest Tree and Shrub Seed Committee*)
IUFRO (*International Union of Forest Research Organizations)*	• Forest Research Institute • Forest Research Institute - Department of Mountain Forests • Wood Technology Institute • Polish Academy of Sciences - Institute of Dendrology • Polish Academy of Sciences - Committee for Forest Sciences and Wood Technology • Warsaw University of Life Sciences - Faculty of Forestry • Poznań University of Life Sciences - Faculty of Forestry • Poznań University of Life Sciences - Faculty of Wood Technology • University of Agriculture in Krakow - Faculty of Forestry	Krzysztof Stereńczak (*International Council Representative*), Marcin Pietrzykowski (*Alternate Representative*)

Name of the organization / association	**Membership**	**Name of the national representative**
Joint UNECE/FAO *Working Party on Forest Statistics, Economics and Management*	In terms of the employee participation in Teams of Specialists (ToS): • Office of Forest Management and Geodesy (FMGO) • Forest Research Institute (IBL) • Wood Technology Institute (ITD) • Ministry of Environment • The State Forests National Forest Holding - Information Center of the State Forests (PGL LP – CILP) • PEFC Poland	*ToS on Sustainable Forest Products:* Krzysztof Jodłowski (PEFC), Ewa Ratajczak (ITD), Magdalena Sajdak (ITD), Andrzej Talarczyk (FMGO), Łukasz Wróbel (Ministry of Environment) *ToS on Monitoring Sustainable Forest Management:* Roman Michalak (Secretary, Marek Jabłoński (IBL), Bożydar Neroj (FMGO), Andrzej Talarczyk (FMGO) *ToS on the Forest Sector Outlook:* Ewa Leszczyszyn (ITD), Ewa Ratajczak (ITD), Andrzej Talarczyk (FMGO) *ToS on Forest Communication - Forest Communicators' Network:* Ewa Ratajczak (ITD), Jolanta Stankiewicz (PGL LP - CILP), Magdalena Wolicka (Ministry of Environment)), Łukasz Wróbel (Ministry of Environment) *ToS on Green Jobs - Joint ILO/ECE/FAO Expert Network:* Alicja Kacprzak (Secretary, Adam Wasiak (FMGO) *ToS on Forest Products Statistics:* Ewa Leszczyszyn (ITD), Ewa Ratajczak (ITD)
MSBP (*Millennium Seed Bank Partnership)*	Institutions from 95 countries, including: the State Forests National Forest Holding – The Kostrzyca Forest Gene Bank	Czesław Kozioł
UEF (*Union of European Foresters)*	Association of Forestry and Woodworking Engineers and Technicians	Tomasz Markiewicz (*UEF Contact Person*)

Source: Own study of the Kostrzyca Forest Gene Bank.

Table 12.8. *International scientific cooperation in the field of forest genetic resources*

No.	Project name	Project short name	Partner institutions from Poland	Project duration
1.	Trees for the Future	Trees4Future	Forest Research Institute, Institute of Dendrology of the Polish Academy of Sciences	2011-2016
2.	Evolution of trees as drivers of terrestrial biodiversity	EVOLTREE	Forest Research Institute, Kazimierz Wielki University in Bydgoszcz, Institute of Dendrology of the Polish Academy of Sciences	2006-2010
3.	Conservation and sustainable utilization of forest tree diversity in climate change	SUSTREE	Forest Research Institute	2016-2019
4.	Sustainable forest management; Multifunctional Forestry, European Forest Policy	SUMFOREST	Forest Research Institute	2014-2017
5.	European Forest Fire Monitoring using Information Systems	EFFMIS	Forest Research Institute	2007-2013
6.	Global Tree Seed Bank Project	-	Kostrzyca Forest Gene Bank	2015-2024
7.	Towards the Sustainable Management of Forest Genetic Resources in Europe	FORGER	Kazimierz Wielki University in Bydgoszcz	2012-2016
8.	A working Model Network of Tree Improvement towards a Competitive, Multifunctional and Sustainable European Forestry	TreeBreedex	Forest Research Institute, Institute of Dendrology of the Polish Academy of Sciences	2006-2011
9.	Increasing Sustainability of European Forests: Modelling for Security Against Invasive Pests and Pathogens under Climate Change	ISEFOR	Forest Research Institute	2010-2014
10.	Spatio-temporal dynamics of genome-wide diversity of *Fagus sylvatica*	-	Kazimierz Wielki University in Bydgoszcz	2020-2022
11.	European Forest Fire Networks	EUFOFINT	Forest Research Institute	2010-2012
12.	Water Management in Baltic Forests	WAMBAF	Forest Research Institute	
13.	Flexible Wood Supply Chain	FlexWood	Forest Research Institute	2009-2012
14.	FORest Management strategies to enhance the MITigation potential of European forests	FORMIT	Warsaw University of Life Sciences	2012-2016

15.	Development of a cross-border decision support system for remote and model assessment of wood biomass in the forests of the POMERANIA support area.	-	Poznań University of Life Sciences	2011-2013
16.	Development and Harmonisation of New Operational Research and Assessment	-	Warsaw University of Life Sciences	2009-2013
17.	USEWOOD: Improving Data and Information on the Potential Supply of Wood Resources - A European Approach from Multisource National Forest Inventories.	USEWOOD	Warsaw University of Life Sciences	2010-2014
18.	European non -wood forest products (NWFPs)network	NWFPs	Warsaw University of Life Sciences	2012-2016
19.	European mixed forests. Integrating Scientific Knowledge in Sustainable Forest Management	-	Warsaw University of Life Sciences	2012-2016

Source: Own study of the Kostrzyca Forest Gene Bank.

Part VI. Challenges and opportunities

Chapter 13. Recommended measures

13.1. Access to information on forest genetic resources

The information on the condition of forests and measures in the field of sustainable forest management in Poland, nature conservation in the forests and forest habitats, etc. are subject to cyclical reporting under international obligations - e.g. in the studies of the Organization of the United Nations on Food and Agriculture (Global Forest Resources Assessment, State of the World's Forest Genetic Resources, State of the World's Biodiversity for Food and Agriculture), Forest Europe process reports (State of the Europe's Forests), notifications to the United Nations Framework Convention on Climate Change (Poland's National Inventory Report), reports to the relevant Commission institutions of the European Union, the National Report on the Implementation of the Convention on Biological Diversity, Report on the condition of the forest ecosystems, etc.

The main source of knowledge in this field at the national level is the annual results presented in the statistical yearbooks of the Statistics Poland, National report on the condition of forests in Poland as well as publicly available data from the Forest Data Bank and the data presented every 5 years in the Large-Scale Forest Inventory. Although it might seem that the public has wide access to information on forests, and thus about forest genetic resources and methods of conducting sustainable forest management in Poland, , the specificity of data presentation is quite difficult and the hermetic language describing the presented data and processes, make the public information contained in the publications presented above quite unreadable for the average inhabitant of Poland. Similarly, the nature and forest education conducted in the State Forests, national parks, botanical gardens and schools, focuses more on nature conservation issues rather than presenting the contemporary principles of conducting sustainable forest management. Hence, it seems necessary to implement, within the system of higher education in Poland, the forestry issues, including the principles of conducting the sustainable forest management as well as the issues of active protection and management of the forest genetic resources. The training should also be intensified for all stakeholders (politicians, government officials, forest managers and owners, NGOs, etc.) in the field of proper management of the forest genetic resources in order to maintain the sustainability of the forests, especially in the era of dynamic changes taking place in the forest ecosystems.

13.2. Conservation of the forest genetic resources

Recommended measures for the conservation of the forest genetic resources:

1. Complementary selection based on systematic genetic research of the subsequent species, populations and genotypes with specific genetic traits complementary to the genetic diversity existing in the conservation stands and breeding populations. The analysis of the genetic diversity of the forest tree species should be carried out on a large scale.
2. Implementation of genetic monitoring of the selected species and populations, including objects registered in the EUFGIS database - taking into account more qualitative and quantitative traits.
3. Development and implementation of the programs for the preservation and restitution of the dying and endangered habitats and woody species, including knowledge about their genetic structure.
4. The use of the so-called assisted migration for the chosen species and populations, along with the assessment of the ecological risk of the measures undertaken.
5. Establishing new international provenance experiments in real environmental conditions, in order to learn about the adaptive capabilities of the trees.
6. Commencement of collecting a large number of genetic samples of young and mature trees of a few selected species for future analysis using modern tools in order to designate the selected genotypes and populations showing significant adaptability to the environmental stress conditions. Their registration in the National Register of Basic Forest Materia in case of positive test results should be allowed. Trees and populations subjected to genetic verification in the existing numerous provenance and family studies should also be registered.
7. Change in the approach towards the genes being the candidates to full genome analysis, with the identification of the adaptive and reproductive abilities of the trees.

8. Focusing research on predicting the dynamics of changes in the forest ecosystems under the influence of the climate change, using new modelling methods (multidisciplinary approach).
9. Conducting research in order to better understand the plasticity and epigenetics of the trees on a local scale for the adaptive response of the population to the climate change.
10. Implementation of the new technologies of the assessment of mortality, plasticity and regeneration of the forest reproductive material in the stressful environment in the long-term perspective.

13.3. Use, development and management of the forest genetic resources

Recommendations for changes in the records of the forest areas in Poland:

1. Development of solutions acceptable to all stakeholders regarding the determination of the forest areas, reported to FAO and other international organizations.
2. Conducting research aimed at determining the actual forest area in Poland, including areas subject to reporting under art. 3.3. of the Kyoto Protocol.
3. Determining the area with woody plants that do not meet the forest criteria (tree-coveerd areas, other land with forest cover).
4. Conducting constant measurements, e.g. Large-Scale Forest Inventory, aimed at tracking the land use changes in Poland.
5. Extending the scope of the Large-Scale Forest Inventory in such a way that on the trial plots located outside the forest land, all patches of trees and shrubs, regardless of their height and area should be taken into account.

Recommendations for the sustainable use of tree-covered area in Poland:

1. Preparation and implementation of the national set of indicators for ecosystem services, which should be identified in the environmental impact assessments and at agri-environmental payments. The created solutions should include the developed national guidelines for the spatial planners, regarding the analysis of the needs of the trees planting and design of the tree-covered area systems.
2. Conducting periodic inspections of the tree-covered area ability to continue the performance of the indicated functions - when financing the maintenance of the tree-covered area with protective functions on the private land (resulting from the management plan).
3. Increasing the flexibility of land qualification procedures with objects of ecological importance (including the tree-covered area) for co-financing under the direct subsidy payment systems and agroforestry programs.
4. Implementation of a reliable, annual tree-covered area inventory, which will make possible to quantify the expected increase in their carbon absorption and, as a

consequence, it will make possible to include this beneficial effect in the settlements of the emission limits assigned to our country.

5. Extending the policy of "greening" to farms with an area smaller than 15 ha.
6. Designation of a place for the new tree-covered area as part of the agricultural land consolidation projects.
7. Limiting the possibility of one-time cutting of long sections of the roadside lines of trees and of other linear tree-covered area.
8. Inventory of natural resources, including tree-covered area in municipalities and their valuation according to the uniform nationwide methodology.
9. Implementation of mandatory monitoring of natural resources, including tree-covered area, taking into account the ecosystem services and the assessment of the environmental problems.
10. Establishing the rules of managing the tree-covered area in the municipality by competently qualified persons.
11. Establishment of legal possibility to make the State Treasury land in the resources of The National Agricultural Support Centre available for the introduction of the new tree-covered areas, including the possibility of free transfer of land to municipal authorities to meet their targets regarding tree-covered areas.
12. Introducing the obligation to plan the tree-covered area along the roads in case of the implementation of the road investments, regardless of the replacement and compensation planting.
13. The introduction of the possibility of recognizing the establishment of the mid-field tree-covered area as public purpose investment.

<u>Recommendations for the sustainable use of the forests in Poland for the purpose of increasing the biological resistance of the stands:</u>

1. Establishing the new plantations with the enriched species composition, adapted to the habitats.
2. Adjusting the species composition to the habitats production capacity.
3. Accelerate the conversion and diversify the species and age structure as well as spatial structure of the single-species stands.
4. Increasing the physiological resistance of trees and stands by application of the tending, protection, agro and phytomelioration treatments.
5. Maintaining the highest possible level of groundwater and increasing the retention capacity of the forests.
6. Limiting the game damage, especially by keeping damages caused by deer population in the appropriate number.
7. Diversify and enrich the food base and living places of birds, insects and mammals.

8. Conducting economic analyses of the use of the forest reproductive material.
9. Constant improvement of the qualitative and quantitative characteristics of the populations.
10. Improvement of the resilience traits of genotypes to biotic and abiotic factors and quantitative traits for the production of wood mass in the short and medium production cycle– the seed prchards of 1.5 and 2 generation should be planned as part of these measures.
11. Use of the research results from the existing provenance and family experiments and registration of the appropriate objects in the National Register of the Basic Forest Material.
12. Shorten the selection process by urgently testing and considering the possibilities of implementing the "breeding without breeding" method in forests.

13.4. Institutions, policy and development of knowledge on the forest genetic resources

Recommendations for legislative work:

1. Development of the Act on the Protection of Biological Diversity or introduction of changes to the Act on Nature Conservation and the Forest Act, which would sanction the active methods of biodiversity conservation, including genetic diversity by the forest management methods.
2. Development and implementation of measures to limit or counteract the reduction of biodiversity in the forests, including the national and regional conservation and restitution programs for the dying or endangered habitats and species.
3. Legal sanctioning of the active protection of the forest genetic resources *in situ*, recorded in the EUFGIS database.
4. Implementation of the national forest strategy (adjusted to the New Strategy of the European Union 2030 and to the declarations and resolutions of the Forest Europe process and the EUFORGEN guidelines), part of which would be a national strategy for the conservation of the forest genetic resources.
5. Develop and adopt a national forest program (as recommended by the United Nations Conference on Environment and Development), enabling ongoing adapting of the forest policy to the changing natural, social, economic and institutional-legal conditions. Part of such program should be the national program for the conservation of the forest genetic resources and the breeding of the forest trees, taking also into account the genetic resources of the non-state forests.
6. Introduction of the effective system of the financial incentives for the afforestation of the agricultural land.

7. Amendment of the Forest Reproductive Material Act in terms of changing the selection criteria of the seed objects, taking into account the conservation bjects (trees and stands), in order to enable the registration of the objects in the National Register of the Basic Forest Material (showing a significant adaptive potential and not necessarily high quality of the wood material). The above applies to, in particular, species that are under high environmental pressure related to the climate changes, e.g. common ash, *Fraxinus excelsior*, Norway spruce *Picea abies*, silver fir *Abies alba*, elm *Ulmus* sp. etc.
8. Enabling the derogations from the Forest Reproductive Material Act by the minister responsible for the environment, in the case of the forest reproductive material: intended to preserve the genetic resources, naturally adapted to the local conditions and threatened by the genetic erosion; intended for research, scientific and selection work or *ex situ* conservation of the genetic resources; intended for implementation of the restitution programs and assisted migration as the measures mitigating the adverse impact of the climate change; intended to be used in the case of occurrence of the negative phenomena caused by the biotic, abiotic or anthropogenic factors and in the event of the exceptional shortage or lack of the forest reproductive material of adequate quality and origin.
9. Easing the provisions on deleting the objects from the National Register of the Forest Basic Forest Material, due to defects that can be removed through proper management.
10. Allowing the possibility of mixing the forest reproductive material of “selected” and “qualified” category, if it comes from the same region of origin.
11. Allowing the possibility of mixing the forest reproductive material belonging to the “qualified category” and derived from the basic forest material of maternal tree when the maternal tree is located within the boundaries of the above-mentioned objects of the basic forest material.
12. Evaluation and verification of the applicable rules for the transfer of the forest reproductive material in Poland, including the assisted migration for the selected species and populations.
13. Implementation of the principles of control of trading the forest reproductive material on genetic bases.
14. Regulate the legal status and the principles of managing the mid-field tree-covered areas in Poland. The detailed guidelines are also needed on the subject of funding opportunities and sources, including financial compensation to the land owners to cover the costs of excluding the area from agricultural production and establishing, tending and protecting the tree-covered areas.
15. Taking into account the entries relating to the inventory of tree-covered areas, valuation of the ecosystem services, determining the needs of the inventory of tree-covered areas

and measures for the development of the establishment of tree-covered areas in the official strategic documents of the country (e.g. State Ecological Policy) and in the relevant legislation.

16. Development of the national tree-covered areas development program. It should be strategically empowered, for example, as an element of the adaptation of the rural areas to the climate change under the Strategic Adaptation Plan adopted by the Polish government for the sectors and areas sensitive to the climate change.
17. Obliging the public road managers to restore and plant new roadside tree-covered areas (as part of the national tree-coveerd areas development program).
18. Introducing the principles of managing the trees by the farmers, facilitating the wood harvesting while maintaining the durability of the tree-covered areas (currently in force regulations are too restrictive in this regard).
19. The use of the adaptive possibilities of the species, populations and genotypes in the new perspective of the "Program for adaptation of the forests and the forestry to climate change by the year 2030 "(based on their natural genetic diversity). The above requires the greater use of the results of the provenance studies and testing of the progeny. The possibility of increasing the genetic diversity of the secondary forest plantations and stands during silvicultural activities should also be emphasized, through the assisted migration or implementing other systemic solutions in silviculture, favourable to structural diversity and preventing the risk of disturbances.

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Aneks – Progress report on the implementation of the Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources

Welcome to preparing a country progress report on the implementation of the Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources

Country: POL Poland

This report was prepared by:

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Add

Remarks: The Kostrzyca FGB is an operational unit of The State Forests National Forest Holding. The majority of Polish forests (80,7%) are publically-owned, including those administered by the State Forests - 76,9% (The report on the state of forests in Poland, 2019).

Question 1: Does your country have an operational national (or sub-national) FGR inventory (-ies)?

Please select:

- (●) Yes
- ( ) No, but a process for establishing a national FGR inventory has been initiated
- ( ) No
- ( ) Information not available

Year when it was established: 2005

Areas of work/activities documented:

- [x] 1 - Conservation of FGR
- [x] 2 - Production of forest reproductive material
- [x] 3 - Research and development efforts (provenance trials, tree breeding etc)
- [x] 4 - FGR transferred internationally
- [x] 5 - Other (please specify under Comments)

Comments: The operational national FGR inventory is conducted by the Forest Reproductive Material Office (Ministry of the Environment). It consists of different registers, e.g.:

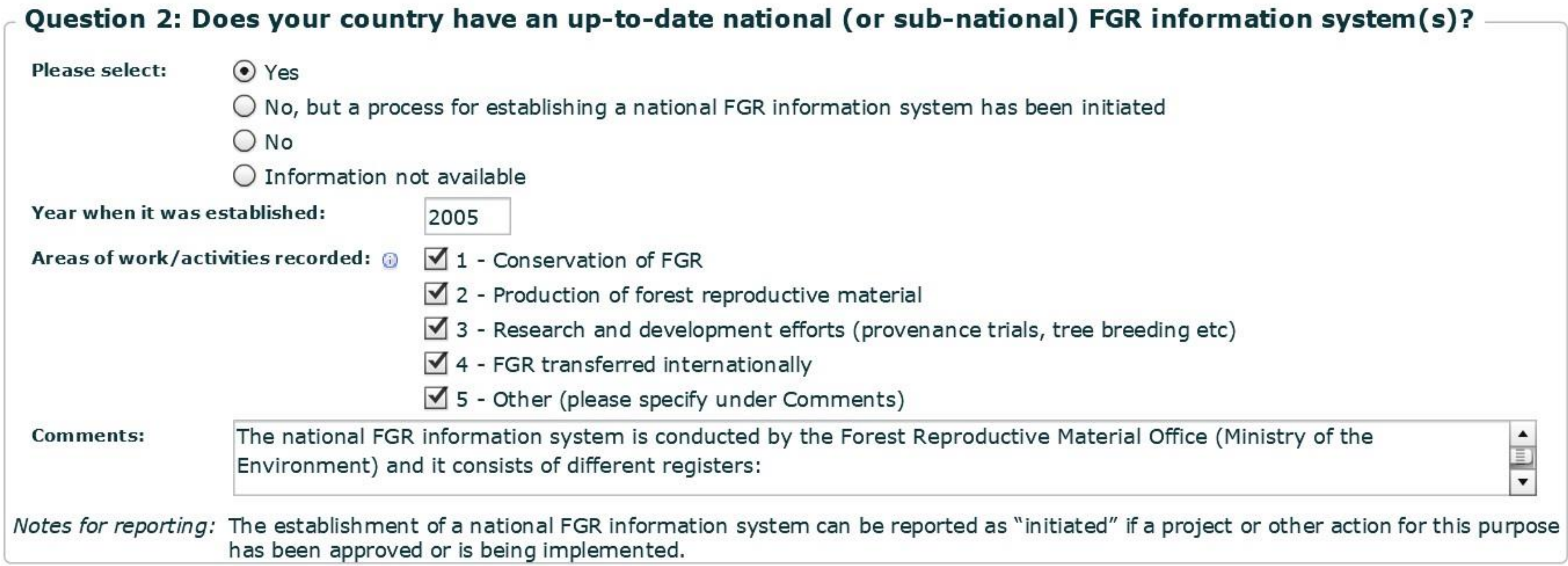
Notes for reporting: This verifier focuses on the existence of a national FGR inventory as a mechanism or process, not on the completeness of the inventory. In case the exact establishment year is not known, or if the national FGR inventory was developed over many years, the establishment year can be estimated based on the available information. The establishment of a national FGR inventory can be reported as "initiated" if a project or other action for this purpose has been approved or is being implemented.

<u>Comments:</u>

The operational national FGR inventory is conducted by the Forest Reproductive Material Office (Ministry of the Environment). It consists of different registers, e.g.:

- National Register of the Basic Forest Material,
- Register of the forest reproductive material certificates,
- Register of the forest reproductive material suppliers.

The research and development efforts are documented by the Forest Research Institute and universities.


Question 2: Does your country have an up-to-date national (or sub-national) FGR information system(s)?

Please select:
- (•) Yes
- ( ) No, but a process for establishing a national FGR information system has been initiated
- ( ) No
- ( ) Information not available

Year when it was established: 2005

Areas of work/activities recorded:
- [x] 1 - Conservation of FGR
- [x] 2 - Production of forest reproductive material
- [x] 3 - Research and development efforts (provenance trials, tree breeding etc)
- [x] 4 - FGR transferred internationally
- [x] 5 - Other (please specify under Comments)

Comments: The national FGR information system is conducted by the Forest Reproductive Material Office (Ministry of the Environment) and it consists of different registers:

Notes for reporting: The establishment of a national FGR information system can be reported as “initiated” if a project or other action for this purpose has been approved or is being implemented.

<u>Comments:</u>

The national FGR information system is conducted by the Forest Reproductive Material Office (Ministry of the Environment) and it consists of different registers:

- National Register of the Basic Forest Material,
- Register of the forest reproductive material certificates,
- Register of the forest reproductive material suppliers.

Question 3: Does your country have an operational national (or sub-national) in situ conservation system(s) for FGR?

Please select:

- (•) Yes
- ( ) No, but a process for establishing a national in situ conservation system has been initiated
- ( ) No
- ( ) Information not available

Year when it was established: 2005

Components of the system:

- [x] 1 - In situ conservation units of FGR
- [x] 2 - Protected areas
- [x] 3 - Forests managed for production of wood and/or non-wood products
- [x] 4 - Other (please specify under Comments)

Comments: The operational national in situ conservation systems for FGR are conducted by:
- the Forest Reproductive Material Office (Ministry of the Environment) - basic forest material,

Notes for reporting: This verifier focuses on the existence of a national in situ conservation system (or programme) for FGR, not on completeness of the conservation network.

<u>Comments:</u>

The operational national in situ conservation systems for FGR are conducted by:

- the Forest Reproductive Material Office (Ministry of the Environment) - basic forest material,
- the State Forests National Forest Holding - basic forest material,
- the General Directorate for Environmental Protection - protected areas.

Question 4: Does your country have an operational national (or sub-national) ex situ conservation system(s) for FGR?

Please select:

- (●) Yes
- ( ) No, but a process for establishing a national ex situ conservation system has been initiated
- ( ) No
- ( ) Information not available

Year when it was established: 1991

Components of the system:

- [x] 1 - Ex situ conservation stands
- [x] 2 - Field collections
- [x] 3 - Storage facilities for seed, pollen or other tissue
- [ ] 4 - Other (please specify under Comments)

Comments: The operational national ex situ conservation system is conducted by the State Forests National Forest Holding, under the "Program of conserving forest genetic resources and breeding of trees in Poland". Scientific supervision has been

Notes for reporting: This verifier focuses on the existence of a national ex situ conservation system (or programme) for FGR, not on the amount of FGR conserved ex situ.

Comments:

The operational national ex situ conservation system is conducted by the State Forests National Forest Holding, under the "Program of conserving forest genetic resources and breeding of trees in Poland". Scientific supervision has been carried out by the Forest Research Institute.

Question 5: Does your country have an operational national (or sub-national) tree seed programme(s)?

Please select:

- (•) Yes
- ( ) No, but a process for establishing an operational national tree seed programme has been initiated
- ( ) No
- ( ) Information not available

Year when it was established: 1991

Comments: The operational national tree seed programme is conducted by the State Forests National Forest Holding, under the "Program of conserving forest genetic resources and breeding of trees in Poland".

Notes for reporting: The establishment of a national tree seed programme can be reported as "initiated" if a project or other action for this purpose has been approved or is being implemented.

Question 6: Do public entities, private companies and/or other stakeholders operate a tree breeding programme (or programmes) in your country?

Please select:

- (●) Yes
- ( ) No, but a process for establishing a tree breeding programme (or programmes) has been initiated
- ( ) No
- ( ) Information not available

Main stakeholder groups:

- [x] 1 - Public entities
- [ ] 2 - Private companies
- [ ] 3 - Private-public partnerships
- [x] 4 - Other stakeholders (please specify under Comments)

Comments: Other stakeholders: Forest Research Institute, universities.

Notes for reporting: If "Other stakeholders" are the main group operating tree breeding programme(s), please identify them under the Comments section. The establishment of a tree breeding programme can be reported as "initiated" if a project or other action for this purpose has been approved or is being implemented.

Question 7: Does your country have an extension programme (or programmes) that organizes extension activities on FGR use on a regular basis?

Please select:

- (●) Yes
- ( ) No, but a process for establishing an extension programme (or programmes) on FGR use has been initiated
- ( ) No
- ( ) Information not available

Year when it was established: 1991

Targeted FGR users:

- [ ] 1 - Farmers
- [ ] 2 - Local communities
- [x] 3 - Forest owners
- [ ] 4 - Others (please specify under Comments)

Comments: The extension programme is conducted by the State Forests National Forest Holding, under the "Program of conserving forest genetic resources and breeding of trees in Poland".

Notes for reporting: The establishment of an extension programme can be reported as "initiated" if a project or other action for this purpose has been approved or is being implemented.

Question 8: Does your country have a national (or sub-national) coordination mechanism(s) on FGR?

Please select:

- (•) Yes
- ( ) No, but a process for establishing a national coordination mechanism on FGR has been initiated
- ( ) No
- ( ) Information not available

Year when it was established: 2005

Stakeholders involved:

- [ ] 1 - Farmers
- [x] 2 - Forests owners
- [ ] 3 - Private sector
- [x] 4 - Non-governmental organizations
- [x] 5 - Governmental organizations (including state-owned enterprises)
- [x] 6 - Research organizations (including universities)
- [x] 7 - Relevant ministries
- [ ] 8 - Others (please specify under Comments)

Comments: The national coordination mechanism is conducted by the Forest Reproductive Material Office (Ministry of the Environment).

Notes for reporting: The establishment of a national coordination mechanism on FGR can be reported as "initiated" if a project or other action for this purpose has been approved or is being implemented.

Question 9: Does your country have a national strategy (or sub-national strategies) for FGR conservation and use?

Please select:

- ◯ Yes
- ◯ No, but a process for preparing a national strategy for FGR conservation and use has been initiated
- ◉ No
- ◯ Information not available

Comments: Poland does not have a national strategy / sub-national strategies for FGR conservation.

Notes for reporting: The process for preparing a national strategy for FGR can be reported as "initiated" if a project or other action for this purpose has been approved or is being implemented. In case the preparation of the national strategy has been initiated, please indicate under Comments if the strategy will cover all areas of work (i.e. conservation, use and development of FGR) or only some of them.

Question 10: If your country has a national strategy for FGR, is it aligned with a regional or sub-regional FGR conservation strategy (-ies)?

Please select:

- ◯ 1 - Yes
- ◯ 2 - No, but a process for aligning the national strategy with a regional conservation strategy has been initiated
- ◯ 3 - No
- ◯ 4 - Information not available

Comments: Not applicable.

Notes for reporting: In case no regional or sub-regional FGR conservation strategy exist, please indicate this under Comments. The process for aligning the national FGR strategy with a regional conservation strategy can be reported as "initiated" if a project or other action for this purpose has been approved or is being implemented.

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Abies alba

Q11 - Up-to-date national distribution range is available: [x]

Q12 - Characterized based on non-molecular information: [x]

Q13 - Characterized based on molecular information: [x]

Q14 - Included in in situ conservation programme(s): [x]

Q15 - Number of in situ conservation units: 113

Q16 - Area of in situ conservation units: 2317 ha

Q17 - Included in ex situ conservation programme(s): [x]

Q18 - Number of ex situ conservation units: 188

Q19 - Area of ex situ conservation units: 2771 ha

Q20 - Number of ex situ accessions: 279

Q21 - Included in a national (or sub-national) tree seed programme(s): [x]

Q22 - Included in a tree breeding programme: [ ]

Q23a - Area of seed stands: 7486 ha

Q23b - Number of seed stands: 547

Q24a - Area of seed orchards: 100 ha

Q24b - Number of seed orchards: 16

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: 27108410

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Acer campestre
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☐
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☐
Q15 - Number of in situ conservation units:	0
Q16 - Area of in situ conservation units:	0 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	0
Q19 - Area of ex situ conservation units:	0 ha
Q20 - Number of ex situ accessions:	1
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	0 ha
Q23b - Number of seed stands:	0
Q24a - Area of seed orchards:	0 ha
Q24b - Number of seed orchards:	0
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Acer platanoides
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☐
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☐
Q15 - Number of in situ conservation units:	0
Q16 - Area of in situ conservation units:	0 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	1
Q19 - Area of ex situ conservation units:	1 ha
Q20 - Number of ex situ accessions:	1
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	40 ha
Q23b - Number of seed stands:	9
Q24a - Area of seed orchards:	0 ha
Q24b - Number of seed orchards:	0
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	1843950
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Acer pseudoplatanus

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☑

Q13 - Characterized based on molecular information: ☐

Q14 - Included in in situ conservation programme(s): ☑

Q15 - Number of in situ conservation units: 4

Q16 - Area of in situ conservation units: 15 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 3

Q19 - Area of ex situ conservation units: 8 ha

Q20 - Number of ex situ accessions: 4

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 357 ha

Q23b - Number of seed stands: 55

Q24a - Area of seed orchards: 8 ha

Q24b - Number of seed orchards: 2

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: 4265950

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Alnus glutinosa
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☑
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☑
Q15 - Number of in situ conservation units:	49
Q16 - Area of in situ conservation units:	434 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	98
Q19 - Area of ex situ conservation units:	1189 ha
Q20 - Number of ex situ accessions:	529
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	5086 ha
Q23b - Number of seed stands:	905
Q24a - Area of seed orchards:	67 ha
Q24b - Number of seed orchards:	10
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	15051790
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Alnus incana

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☐

Q13 - Characterized based on molecular information: ☐

Q14 - Included in in situ conservation programme(s): ☐

Q15 - Number of in situ conservation units: 0

Q16 - Area of in situ conservation units: 0 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 0

Q19 - Area of ex situ conservation units: 0 ha

Q20 - Number of ex situ accessions: 4

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 0 ha

Q23b - Number of seed stands: 0

Q24a - Area of seed orchards: 0 ha

Q24b - Number of seed orchards: 0

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: -

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Betula pendula
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☑
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☑
Q15 - Number of in situ conservation units:	28
Q16 - Area of in situ conservation units:	213 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	39
Q19 - Area of ex situ conservation units:	686 ha
Q20 - Number of ex situ accessions:	374
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☑
Q23a - Area of seed stands:	4135 ha
Q23b - Number of seed stands:	678
Q24a - Area of seed orchards:	73 ha
Q24b - Number of seed orchards:	13
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	36203110
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	1

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Betula pubescens

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☐

Q13 - Characterized based on molecular information: ☐

Q14 - Included in in situ conservation programme(s): ☐

Q15 - Number of in situ conservation units: 0

Q16 - Area of in situ conservation units: 0 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 0

Q19 - Area of ex situ conservation units: 0 ha

Q20 - Number of ex situ accessions: 1

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 1 ha

Q23b - Number of seed stands: 1

Q24a - Area of seed orchards: 0 ha

Q24b - Number of seed orchards: 0

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: -

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Carpinus betulus
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☐
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☑
Q15 - Number of in situ conservation units:	2
Q16 - Area of in situ conservation units:	15 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	0
Q19 - Area of ex situ conservation units:	0 ha
Q20 - Number of ex situ accessions:	3
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	280 ha
Q23b - Number of seed stands:	47
Q24a - Area of seed orchards:	0 ha
Q24b - Number of seed orchards:	0
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Fagus sylvatica

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☑

Q13 - Characterized based on molecular information: ☑

Q14 - Included in in situ conservation programme(s): ☑

Q15 - Number of in situ conservation units: 156

Q16 - Area of in situ conservation units: 2542 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 375

Q19 - Area of ex situ conservation units: 4955 ha

Q20 - Number of ex situ accessions: 2

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 17217 ha

Q23b - Number of seed stands: 1569

Q24a - Area of seed orchards: 74 ha

Q24b - Number of seed orchards: 12

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: 57863240

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Fraxinus excelsior

Q11 - Up-to-date national distribution range is available:	☑	
Q12 - Characterized based on non-molecular information:	☐	
Q13 - Characterized based on molecular information:	☐	
Q14 - Included in in situ conservation programme(s):	☑	
Q15 - Number of in situ conservation units:	4	
Q16 - Area of in situ conservation units:	24	ha
Q17 - Included in ex situ conservation programme(s):	☑	
Q18 - Number of ex situ conservation units:	2	
Q19 - Area of ex situ conservation units:	7	ha
Q20 - Number of ex situ accessions:	173	
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑	
Q22 - Included in a tree breeding programme:	☐	
Q23a - Area of seed stands:	383	ha
Q23b - Number of seed stands:	70	
Q24a - Area of seed orchards:	7	ha
Q24b - Number of seed orchards:	1	
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	150450	
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...	

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Larix decidua
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☑
Q13 - Characterized based on molecular information:	☑
Q14 - Included in in situ conservation programme(s):	☑
Q15 - Number of in situ conservation units:	88
Q16 - Area of in situ conservation units:	684 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	220
Q19 - Area of ex situ conservation units:	2727 ha
Q20 - Number of ex situ accessions:	546
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☑
Q23a - Area of seed stands:	2219 ha
Q23b - Number of seed stands:	421
Q24a - Area of seed orchards:	365 ha
Q24b - Number of seed orchards:	54
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	6834840
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	1

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Malus sylvestris
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☐
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☐
Q15 - Number of in situ conservation units:	0
Q16 - Area of in situ conservation units:	0 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	0
Q19 - Area of ex situ conservation units:	0 ha
Q20 - Number of ex situ accessions:	2
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	0 ha
Q23b - Number of seed stands:	0
Q24a - Area of seed orchards:	0 ha
Q24b - Number of seed orchards:	0
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Picea abies

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☑

Q13 - Characterized based on molecular information: ☑

Q14 - Included in in situ conservation programme(s): ☑

Q15 - Number of in situ conservation units: 93

Q16 - Area of in situ conservation units: 1779 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 209

Q19 - Area of ex situ conservation units: 2603 ha

Q20 - Number of ex situ accessions: 854

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☑

Q23a - Area of seed stands: 6246 ha

Q23b - Number of seed stands: 816

Q24a - Area of seed orchards: 96 ha

Q24b - Number of seed orchards: 16

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: 32795520

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): 1

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Pinus cembra
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☑
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☐
Q15 - Number of in situ conservation units:	0
Q16 - Area of in situ conservation units:	0 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	2
Q19 - Area of ex situ conservation units:	10 ha
Q20 - Number of ex situ accessions:	1
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	0 ha
Q23b - Number of seed stands:	0
Q24a - Area of seed orchards:	10 ha
Q24b - Number of seed orchards:	2
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Pinus mugo
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☐
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☐
Q15 - Number of in situ conservation units:	0
Q16 - Area of in situ conservation units:	0 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	0
Q19 - Area of ex situ conservation units:	0 ha
Q20 - Number of ex situ accessions:	2
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	0 ha
Q23b - Number of seed stands:	0
Q24a - Area of seed orchards:	0 ha
Q24b - Number of seed orchards:	0
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Pinus nigra
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☑
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☑
Q15 - Number of in situ conservation units:	9
Q16 - Area of in situ conservation units:	43 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	17
Q19 - Area of ex situ conservation units:	86 ha
Q20 - Number of ex situ accessions:	193
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	99 ha
Q23b - Number of seed stands:	25
Q24a - Area of seed orchards:	83 ha
Q24b - Number of seed orchards:	16
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Pinus strobus

Q11 - Up-to-date national distribution range is available:	☑	
Q12 - Characterized based on non-molecular information:	☐	
Q13 - Characterized based on molecular information:	☐	
Q14 - Included in in situ conservation programme(s):	☑	
Q15 - Number of in situ conservation units:	3	
Q16 - Area of in situ conservation units:	8	ha
Q17 - Included in ex situ conservation programme(s):	☑	
Q18 - Number of ex situ conservation units:	0	
Q19 - Area of ex situ conservation units:	0	ha
Q20 - Number of ex situ accessions:	30	
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑	
Q22 - Included in a tree breeding programme:	☐	
Q23a - Area of seed stands:	12	ha
Q23b - Number of seed stands:	5	
Q24a - Area of seed orchards:	8	ha
Q24b - Number of seed orchards:	2	
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-	
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...	

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Pinus sylvestris

Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☑
Q13 - Characterized based on molecular information:	☑
Q14 - Included in in situ conservation programme(s):	☑
Q15 - Number of in situ conservation units:	627
Q16 - Area of in situ conservation units:	8364 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	3837
Q19 - Area of ex situ conservation units:	48628 ha
Q20 - Number of ex situ accessions:	4547
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☑
Q23a - Area of seed stands:	107571 ha
Q23b - Number of seed stands:	10268
Q24a - Area of seed orchards:	589 ha
Q24b - Number of seed orchards:	74
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	304082460
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	1

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Pinus x rhaetica
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☐
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☐
Q15 - Number of in situ conservation units:	0
Q16 - Area of in situ conservation units:	0 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	0
Q19 - Area of ex situ conservation units:	0 ha
Q20 - Number of ex situ accessions:	16
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	0 ha
Q23b - Number of seed stands:	0
Q24a - Area of seed orchards:	0 ha
Q24b - Number of seed orchards:	0
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Populus nigra
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☑
Q13 - Characterized based on molecular information:	☑
Q14 - Included in in situ conservation programme(s):	☐
Q15 - Number of in situ conservation units:	0
Q16 - Area of in situ conservation units:	0 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	0
Q19 - Area of ex situ conservation units:	0 ha
Q20 - Number of ex situ accessions:	1
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	0 ha
Q23b - Number of seed stands:	0
Q24a - Area of seed orchards:	0 ha
Q24b - Number of seed orchards:	0
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Populus tremula

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☐

Q13 - Characterized based on molecular information: ☐

Q14 - Included in in situ conservation programme(s): ☐

Q15 - Number of in situ conservation units: 0

Q16 - Area of in situ conservation units: 0 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 2

Q19 - Area of ex situ conservation units: 3 ha

Q20 - Number of ex situ accessions: 0

Q21 - Included in a national (or sub-national) tree seed programme(s): ☐

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 0 ha

Q23b - Number of seed stands: 0

Q24a - Area of seed orchards: 0 ha

Q24b - Number of seed orchards: 0

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: -

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Prunus avium
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☑
Q13 - Characterized based on molecular information:	☑
Q14 - Included in in situ conservation programme(s):	☐
Q15 - Number of in situ conservation units:	0
Q16 - Area of in situ conservation units:	0 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	11
Q19 - Area of ex situ conservation units:	45 ha
Q20 - Number of ex situ accessions:	73
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	61 ha
Q23b - Number of seed stands:	10
Q24a - Area of seed orchards:	44 ha
Q24b - Number of seed orchards:	10
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Pseudotsuga menziesii

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☑

Q13 - Characterized based on molecular information: ☑

Q14 - Included in in situ conservation programme(s): ☑

Q15 - Number of in situ conservation units: 41

Q16 - Area of in situ conservation units: 149 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 17

Q19 - Area of ex situ conservation units: 68 ha

Q20 - Number of ex situ accessions: 300

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☑

Q23a - Area of seed stands: 457 ha

Q23b - Number of seed stands: 140

Q24a - Area of seed orchards: 58 ha

Q24b - Number of seed orchards: 10

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: -

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): 1

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Pyrus pyraster

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☐

Q13 - Characterized based on molecular information: ☐

Q14 - Included in in situ conservation programme(s): ☐

Q15 - Number of in situ conservation units: 0

Q16 - Area of in situ conservation units: 0 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 0

Q19 - Area of ex situ conservation units: 0 ha

Q20 - Number of ex situ accessions: 1

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 0 ha

Q23b - Number of seed stands: 0

Q24a - Area of seed orchards: 0 ha

Q24b - Number of seed orchards: 0

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: -

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Quercus petraea

Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☑
Q13 - Characterized based on molecular information:	☑
Q14 - Included in in situ conservation programme(s):	☑
Q15 - Number of in situ conservation units:	80
Q16 - Area of in situ conservation units:	1958 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	289
Q19 - Area of ex situ conservation units:	2562 ha
Q20 - Number of ex situ accessions:	34
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	7965 ha
Q23b - Number of seed stands:	641
Q24a - Area of seed orchards:	83 ha
Q24b - Number of seed orchards:	14
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	84364600
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Quercus robur

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☑

Q13 - Characterized based on molecular information: ☑

Q14 - Included in in situ conservation programme(s): ☑

Q15 - Number of in situ conservation units: 140

Q16 - Area of in situ conservation units: 1908 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 298

Q19 - Area of ex situ conservation units: 3614 ha

Q20 - Number of ex situ accessions: 81

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 17806 ha

Q23b - Number of seed stands: 1929

Q24a - Area of seed orchards: 54 ha

Q24b - Number of seed orchards: 10

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: 184846490

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Quercus rubra

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☐

Q13 - Characterized based on molecular information: ☐

Q14 - Included in in situ conservation programme(s): ☑

Q15 - Number of in situ conservation units: 3

Q16 - Area of in situ conservation units: 9 ha

Q17 - Included in ex situ conservation programme(s): ☐

Q18 - Number of ex situ conservation units: 0

Q19 - Area of ex situ conservation units: 0 ha

Q20 - Number of ex situ accessions: 0

Q21 - Included in a national (or sub-national) tree seed programme(s): ☐

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 75 ha

Q23b - Number of seed stands: 17

Q24a - Area of seed orchards: 0 ha

Q24b - Number of seed orchards: 0

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: -

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Robinia pseudoacacia

Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☑
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☑
Q15 - Number of in situ conservation units:	3
Q16 - Area of in situ conservation units:	7 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	2
Q19 - Area of ex situ conservation units:	7 ha
Q20 - Number of ex situ accessions:	21
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	15 ha
Q23b - Number of seed stands:	6
Q24a - Area of seed orchards:	7 ha
Q24b - Number of seed orchards:	2
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Sorbus torminalis

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☑

Q13 - Characterized based on molecular information: ☑

Q14 - Included in in situ conservation programme(s): ☐

Q15 - Number of in situ conservation units: 0

Q16 - Area of in situ conservation units: 0 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 0

Q19 - Area of ex situ conservation units: 0 ha

Q20 - Number of ex situ accessions: 4

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 0 ha

Q23b - Number of seed stands: 0

Q24a - Area of seed orchards: 0 ha

Q24b - Number of seed orchards: 0

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: -

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Taxus baccata

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☑

Q13 - Characterized based on molecular information: ☑

Q14 - Included in in situ conservation programme(s): ☐

Q15 - Number of in situ conservation units: 0

Q16 - Area of in situ conservation units: 0 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 3

Q19 - Area of ex situ conservation units: 3 ha

Q20 - Number of ex situ accessions: 20

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 0 ha

Q23b - Number of seed stands: 0

Q24a - Area of seed orchards: 3 ha

Q24b - Number of seed orchards: 2

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: -

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Tilia cordata

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☑

Q13 - Characterized based on molecular information: ☐

Q14 - Included in in situ conservation programme(s): ☑

Q15 - Number of in situ conservation units: 17

Q16 - Area of in situ conservation units: 225 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 46

Q19 - Area of ex situ conservation units: 236 ha

Q20 - Number of ex situ accessions: 61

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 917 ha

Q23b - Number of seed stands: 141

Q24a - Area of seed orchards: 109 ha

Q24b - Number of seed orchards: 23

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: 8833810

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Tilia platyphyllos
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☐
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☐
Q15 - Number of in situ conservation units:	0
Q16 - Area of in situ conservation units:	0 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	0
Q19 - Area of ex situ conservation units:	0 ha
Q20 - Number of ex situ accessions:	1
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	0 ha
Q23b - Number of seed stands:	0
Q24a - Area of seed orchards:	0 ha
Q24b - Number of seed orchards:	0
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species: Ulmus glabra

Q11 - Up-to-date national distribution range is available: ☑

Q12 - Characterized based on non-molecular information: ☐

Q13 - Characterized based on molecular information: ☐

Q14 - Included in in situ conservation programme(s): ☐

Q15 - Number of in situ conservation units: 0

Q16 - Area of in situ conservation units: 0 ha

Q17 - Included in ex situ conservation programme(s): ☑

Q18 - Number of ex situ conservation units: 1

Q19 - Area of ex situ conservation units: 4 ha

Q20 - Number of ex situ accessions: 124

Q21 - Included in a national (or sub-national) tree seed programme(s): ☑

Q22 - Included in a tree breeding programme: ☐

Q23a - Area of seed stands: 0 ha

Q23b - Number of seed stands: 0

Q24a - Area of seed orchards: 4 ha

Q24b - Number of seed orchards: 1

Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation: -

Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed): Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Ulmus laevis
Q11 - Up-to-date national distribution range is available:	[x]
Q12 - Characterized based on non-molecular information:	[ ]
Q13 - Characterized based on molecular information:	[ ]
Q14 - Included in in situ conservation programme(s):	[x]
Q15 - Number of in situ conservation units:	1
Q16 - Area of in situ conservation units:	10 ha
Q17 - Included in ex situ conservation programme(s):	[x]
Q18 - Number of ex situ conservation units:	2
Q19 - Area of ex situ conservation units:	5 ha
Q20 - Number of ex situ accessions:	70
Q21 - Included in a national (or sub-national) tree seed programme(s):	[x]
Q22 - Included in a tree breeding programme:	[ ]
Q23a - Area of seed stands:	11 ha
Q23b - Number of seed stands:	3
Q24a - Area of seed orchards:	5 ha
Q24b - Number of seed orchards:	1
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Species included in the report: Please answer Questions 11-2...

Please answer Questions 11-26 by first inserting the name of a species and then providing information as applicable

Type the genus name and select species:	Ulmus minor
Q11 - Up-to-date national distribution range is available:	☑
Q12 - Characterized based on non-molecular information:	☐
Q13 - Characterized based on molecular information:	☐
Q14 - Included in in situ conservation programme(s):	☐
Q15 - Number of in situ conservation units:	0
Q16 - Area of in situ conservation units:	0 ha
Q17 - Included in ex situ conservation programme(s):	☑
Q18 - Number of ex situ conservation units:	0
Q19 - Area of ex situ conservation units:	0 ha
Q20 - Number of ex situ accessions:	2
Q21 - Included in a national (or sub-national) tree seed programme(s):	☑
Q22 - Included in a tree breeding programme:	☐
Q23a - Area of seed stands:	0 ha
Q23b - Number of seed stands:	0
Q24a - Area of seed orchards:	0 ha
Q24b - Number of seed orchards:	0
Q25 - Amount (average number / year) of planting stock produced through macro and/or micropropagation:	-
Q26 - State of breeding programme (please indicate the generation number of the most advanced material deployed):	Information n...

Comments:

Question 18/19 - the adequate indicator for Poland is "Area of ex situ conservation units", for example some conservation plantations are connected or consists of several species, as a result it is difficult to assess real number of units. In 2017 the State Forests National Forest Holding introduced changes in the evidence of ex situ progeny plantations (since then only the progeny plantations in blocks have been reported, without scattered progeny areas). Additional information about ex situ conservation units: other conifers - 50 units, 582 ha; other broadleaves: 18 units, 43 ha.

Question 20 - additional information: other conifers - 4 ex situ accessions, other broadleaves - 62 ex situ accessions, protected and endangered plant species: 319 ex situ accessions.

Question 25 - planting stock production in 2019 for Abies alba, Larix decidua, Picea abies, Pinus sylvestris, Betula pendula, Fagus sylvatica, Quercus robur, Quercus petraea, Acer pseudoplatanus, Acer platanoides, Tilia cordata, Fraxinus excelsior, Alnus glutinosa (other conifers: 3 363 340, other broadleaves: 13 149 550, shrubs: 3 334 520).

Question 26 - state of breeding programme assessed for: Betula pendula, Larix decidua, Picea abies, Pinus sylvestris, Pseudotsuga menziesii. Other species without breeding measures (field marked as "Information not available”).

Question 27 - Have FGR conservation and use been integrated into a national (or sub-national) forest programme(s) and/or national (or sub-national) forest policy (-ies) in your country?

Please select:

- ◯ 1 - Yes
- ⦿ 2 - No, but a process for integrating FGR conservation and use into a national forest programme and/or national fo
- ◯ 3 - No, because my country does not have a national forest programme and/or national forest policy
- ◯ 4 - No
- ◯ 5 - Information not available

Comments: The work on national forest programme is being coordinated by the Forest Research Institute.

Question 28 - Have FGR conservation and use been integrated into a national (or sub-national) biodiversity action plan(s) and related polices in your country?

Please select:

- (•) 1 - Yes
- ( ) 2 - No, but a process for integrating FGR conservation and use into a national biodiversity action plan has been init
- ( ) 3 - No, because my country does not have a national biodiversity action plan
- ( ) 4 - No
- ( ) 5 - Information not available

Comments: Biodiversity action plan implemented in 2015.

Question 29 - Have FGR conservation and use been integrated into a national (or sub-national) adaptation strategy (-ies) for climate change in your country?

Please select:

- (•) 1 - Yes
- ( ) 2 - No, but a process for integrating FGR conservation and use into a national adaptation strategy for climate chan
- ( ) 3 - No, because my country does not have a national adaptation strategy for climate change
- ( ) 4 - No
- ( ) 5 - Information not available

Comments: Polish National Strategy for Adaptation to Climate Change (NAS2020) with the perspective by 2030 (implemented in 2013).

Question 30 - Is your country a member of a regional and/or sub-regional network(s) on FGR?

Please select:

- (•) 1 - Yes
- ( ) 2 - No, but my country is considering joining a regional and/or sub-regional network(s)
- ( ) 3 - No
- ( ) 4 - Information not available

Network(s): ork; International Seed Testing Association; Millennium Seed Bank Partnership; BBMRI-ERIC; Global Genome Biodiversity N

Comments: -

Network(s):

European Forest Genetic Resources Programme; European Information System on Forest Genetic Resources; European Native Seed Conservation Network; International Seed Testing Association; Millennium Seed Bank Partnership; BBMRI-ERIC; Global Genome Biodiversity Network.

Question 31 - Is your country participating in international research and development collaboration on FGR?

Please select:

- ( ) 1 - Yes
- (•) 2 - No, but my country and its national organizations have sought opportunities for participating in international R
- ( ) 3 - No
- ( ) 4 - Information not available

Number of national organizations currently participating: 11

Comments: European Forest Genetic Resources Programme; European Information System on Forest Genetic Resources; European Native Seed Conservation Network; International Seed Testing Association; Millennium Seed Bank

Comments:

European Forest Genetic Resources Programme; European Information System on Forest Genetic Resources; European Native Seed Conservation Network; International Seed Testing Association; Millennium Seed Bank Partnership; BBMRI-ERIC; UNECE Committee on Forests and the Forest Industry; FAO European Forestry Commission; European Forest Institute; FAO Intergovernmental Technical Working Group on Forest Genetic Resources; Forest Europe; Global Genome Biodiversity Network; International Union of Forest Research Organizations; Joint UNECE/FAO Working Party on Forest Statistics, Economics and Management; Union of European Foresters, Global Tree Seed Bank Project.

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