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The Country Report on forest genetic resources • Poland

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THE COUNTRY REPORT ON FOREST GENETIC RESOURCES

POLAND

POLAND The State Forests

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A LIST OF SYMBOLS AND ABBREVIATIONS USED IN THE REPORT

Bb	Bog coniferous forest (forest habitat type)
BbG	Mountain bog coniferous forest (forest habitat type)
BG	Mountain coniferous forest (forest habitat type)
Bk	European beech
BMb	Boggy mixed coniferous forest (forest habitat type)
BMG	Mountain mixed coniferous forest (forest habitat type)
BMśw	Fresh mixed coniferous forest (forest habitat type)
BMw	Moist mixed coniferous forest (forest habitat type)
BMwyż	Upland mixed coniferous forest (forest habitat type)
BP	Selection forest structure (a stand type)
Bs	Dry coniferous forest (forest habitat type)
Bśw	Fresh coniferous forest (forest habitat type)
Bw	Moist coniferous forest (forest habitat type)
BWG	High-mountain coniferous forest (forest habitat type)
BZW	Permissible Moisture Content (PMC)
CBD	Convention on Biological Diversity
CIEP	Chief Inspectorate of Environment Protection
CSO	Central Statistical Office
Db	Pedunculate oak
DNA	Deoxyribonucleic acid
EC	European Commission
EEA	European Environment Agency
EN	Endangered
ENSCONET	European Native Seed Conservation Network
EMPPO	European and Mediterranean Plant Protection Organization
EU	European Union
EUFGIS	Establishment of a European Information System on Forest Genetic Resources
EUFORGEN	European Forest Genetic Resources Programme
FAO	Food and Agriculture Organisation of the United Nations
FMGB	Forest Management and Geodesy Bureau
FRA, 2010	Global Forest Resources Assessment 2010 (FAO Main Report)
FRI	Forest Research Institute in Warsaw
FROM	Forest Reproductive Material Office
FSC	Forest Stewardship Council
F_{ST}	Haplotype fixation index
GDSF	Directorate General of the State Forests
G_{ST}	Genetic variation rate
H_S	Mitochondrial DNA polymorphism markers
ID PAN	Institute of Dendrology in Kórnik, Polish Academy of Science

ICP	International Cooperative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests
IMWM	Institute of Meteorology and Water Management in Warsaw
ISTA	International Seed Testing Association
IUCN	International Union for the Conservation of Nature
IUFRO	International Union of Forest Research Organizations
IUSS	International Union of Soil Sciences
KDO	Class for restocking (stand type)
KO	Restocking class (stand type)
Kostrzyca FGB	Kostrzyca Forest Gene Bank
LG	Mountain broadleaved forest (forest habitat type)
Lł	Riparian forest (forest habitat type)
LMb	Boggy mixed forest (forest habitat type)
LMG	Mixed broadleaved forest (forest habitat type)
LMśw	Fresh mixed broadleaved forest (forest habitat type)
LMw	Moist mixed broadleaved forest (forest habitat type)
LMwyż	Upland mixed broadleaved forest (forest habitat type)
LMP	Forest basic material
LMR	Forest reproductive material
Lśw	Fresh broadleaved forest (forest habitat type)
Lw	Moist broadleaved forest (forest habitat type)
Lwyż	Upland broadleaved forest (forest habitat type)
FGR	Forest Genetic Resources
MCPFE	Ministerial Conference on the Protection of Forests in Europe
NNPA	National Network of Protected Areas
NP.	National Park
NPAFC	National Programme for the Augmentation of Forest Cover
NRFBM	National Register of Forest Basic Material
OECD	Organisation for Economic Cooperation and Development
Ol	Alder forest (forest habitat type)
OlJ	Ash-alder forest (forest habitat type)
PFC	Promotional Forest Complex
PCR	Polymerase Chain Reaction
PEFC	Programme for the Endorsement of Forest Certification Schemes
PKB	Gross Domestic Product (GDP)
RAPD	Random amplification of polymorphic DNA
RDSF	Regional Directorate of the State Forests
RDEP	Regional Directorate of Environmental Protection
RFLP	Restriction fragment length polymorphism
RFBMSF	Register of the Forest Basic Material of the State Forests
RoSL 2010	Reports on the Condition of Forests in Poland, 2010
SCI	Sites of Community Importance
SGGW	Warsaw University of Life Sciences (SGGW)
So	Scots pine

SoEF	State of Europe's Forests
SPA	Special Protection Area for Birds
SSR	Simple Sequence Repeats
Św	Norway spruce
UE	European Union
UNECE	United Nations Economic Commission for Europe
UR	H. Kołłątaj Agricultural University of Kraków
WRB	World Reference Base for Soil Resources
VU	Vulnerable
ZHL	Principles of Silviculture
ha	Hectare
m^3	Cubic metre
μga	Microgram

SECTION I

SUMMARY

The current policy of the Ministry of the Environment is aimed at creating sustainable multifunctional forestry in Poland. Forest Europe and the Natura 2000 network will play a vital role in implementing this policy and the Large-Scale Forest Inventory is one of the tools being used to support it. The role of the Ministry of the Environment is to maintain the competitiveness of forestry, to secure the function of forests in mitigating the effects of climate change and to enhance the potential of private forests. The Minister of the Environment also provides the legal framework for implementing the state's ecological and forest policy and makes new regulations for forestry (Zaleski, 2011).

Forests are the most natural formation in our climatic and geographical zone. They play a crucial role in maintaining environmental balance, continuity of life and environmental diversity, as well as in reducing pollution, which causes environmental degradation. The preservation of forest genetic resources is necessary for the reduction of soil erosion, the preservation of water resources, the regulation of water relations and the protection of the landscape. As a form of land use forests ensure biological production, which has a market value, and constitute a public good that has an effect on the quality of human life (RoSL, 2011).

The period 1945–1989 was a very difficult one for forestry for the following reasons:

- lack of forest management plans and forest administrative staff (mainly on land returned to Poland after World War II)
- massive afforestation of former farmland deemed unsuitable for agriculture (more than 2 million hectares)
- the need to pursue forest-management goals under different political and economic conditions

The current state of forest management, which is conducted in accordance with the adopted principles for the sustainable development of multifunction forests, is satisfactory.

The biological diversity of forests in Poland is above average for the European continent and the principles of forest management applied there are among the most environmentally friendly in the world.

1. Forest ecosystems, which account for over 37.3 per cent of the country's legally protected land area, are the most valuable and best represented components of the natural sites under various forms of nature protection in Poland. The share of protected forests in the total forest area is 40.9 per cent, while the share of protective forests, mainly those protecting water, around cities and of forests damaged by industry, is 38.4 per cent. Natura 2000 sites now cover nearly 20 per cent of the country's land area.
2. The country's timber resources are steadily increasing. This is demonstrated by an increase in the volume of gross merchantable timber to 2.3 billion m^3. According to the available data, timber resources in the State Forests, which is of a higher quality than from forests under other forms of ownership, amount to 1.9 billion m^3. This is reflected in the volume of growing stock, which is 264 m^3/ha compared to 215 m^3/ha in private forests, and in the average stand age of 57 years against 46 years in private forests. The data show that the harvested volume in the State Forests has not exceeded 55 per cent of its increment in recent years.
3. In 2000–2010, the annual average volume of harvested gross timber in Poland was approximately 32 million m^3. It is assumed that this volume will increase each year if the growth trend in timber resources continues.
4. Although the area of post-agricultural land and wasteland afforested in 2010 under the National Programme for the Augmentation of Forest Cover (which assumed an increase in forest cover to 30 per cent by 2020 and to 33 per cent by 2050) slightly increased, there is a danger that the targets may not be met because of the insufficient supply of land for afforestation and the inefficient system of incentives for private land owners to afforest their marginal land. It is a serious limitation that afforestation work in the Natura 2000 areas has been halted until the planning of protection tasks for these areas is completed.
5. Poland's forests are among the most threatened in Europe due to the continuous influence of abiotic, biotic and anthropogenic factors. Atmospheric pollution is a significant hazard to forest ecosystems: the continuous impact of pollutants and their recent accumulation in the forest environment makes forests more vulnerable to diseases.
   a) Poland belongs to the group of countries in which unfavourable phenomena in forests, such as mass outbreaks of insect pests (sometimes violent and over large areas), occur with high diversity and cyclic intensity.

b) For many years, root rot diseases (*Heterobasidion* and *Armillaria* spp.) have posed the major threat to forests (68 per cent) – especially to those established on post-agricultural land.
c) Significant damage to forests has also been caused by large herbivore mammals (mainly red deer and roe deer) and, locally, by rodents (beavers and mice).

6. The species composition of Polish forests has been substantially rebuilt in recent centuries as a result of historical and economic processes. As a consequence, biocoenoses are not adjusted to the capabilities of the habitat in 19 per cent of Polish forests. In line with the State Policy on Forests and the National Environmental Policy, stand conversion is being conducted in Poland on 10 thousand to 12 thousand hectares annually to improve this situation.
7. Forest management in Poland is based on native tree and shrub species. Exotic species in Polish forests account for only 0.5 per cent of the total forest area.
8. The forest seed base in Poland, which is located in 83 regions of origin and registered in the Forest Reproductive Material Office at the Ministry of the Environment, includes 35 140 items (230 421 hectares). The need to select such a large and extensive seed base determines the way forest is renewed in the climatic and habitat conditions of Poland, where about 90 per cent of forests are restocked by planting or sowing (including the afforestation of post-agricultural land).
9. There have been no comprehensive studies until now on the genetic variation of the main forest tree species. The few genetic studies conducted so far have indicated that individual species have a high intra-population genetic variation and a low inter-population genetic variation.
10. There is concern about the protection, management and utilization status of privately-owned forests, which are fragmented, frequently mismanaged or simply neglected. Indeed, a large proportion of privately-owned forests (56 per cent) remain without management plans (Zaleski, 2011). The appropriate conditions for forest owners in Poland to participate as beneficiaries in the subsidy programme supporting forest management have not been created. Furthermore, there are few registered instances of Forest Basic Material (FBM) on private land (81 instances, that is, 0.23 per cent).
11. Poland has neither a Forest Strategy nor a National Forest Programme. However, forest genetic resources in Poland are protected by the implementation of the objectives of the State Policy on Forests, the National Environmental Policy and the National Strategy for the Conservation and Sustainable Use of Biological Diversity, which is reflected in national legislation.

a) The 2011–2035 programme now being implemented in Poland for the Preservation of Forest Genetic Resources and the Selective Breeding of Forest Trees encompasses only the area managed by the State Forests. There is therefore a need to implement a similar programme for forest areas managed by other forest administrators and owners, which should be reflected in the coming Forest Strategy and in the Act on the Conservation of Forest Genetic Resources.

The most important challenge for Polish forestry in the future decades will be to protect forest genetic resources against the harmful effects of climate change, including abiotic, biotic and anthropogenic factors, to recognize the adaptability and production potential of indigenous species of forest tree populations and to mitigate the conflicts that may arise between forestry, environmental organizations and the wood industry.

SECTION II

INTRODUCTION TO THE COUNTRY AND TO THE FORESTRY SECTOR

1. Location and climatic conditions

Poland, which is in Central Europe, has an area of 312 680 km^2. It has borders with Russia, Lithuania, Belarus, Ukraine, Slovakia, the Czech Republic and Germany. Poland's population is 38.167 million, of which 17.724 million are estimated to be economically active. The birth rate for the last two years has shown a slight upward trend (+35 thousand in 2010).

Poland is a lowland country. Areas below 300 metres above sea level, of which 0.2 per cent are depressions, make up 91.3 per cent of its territory. The average height above sea level in Poland is 173 metres, which is almost half the average height for the European continent (330 metres). At 2499 metres a.s.l. Rysy, in the high Tatras is the highest peak, while the lowest point, 1.8 metres b.s.l., is to be found west of the village of Raczki Elbląskie. The land surface in Poland inclines from south to north.

Four basic morphogenetic zones can be distinguished in Poland:

1) The Carpathian Mountains, which are young mountains of Alpine orogeny, with their foreland basins (Northern Podkarpacie);
2) The Sudeten Mountains, which are old mountains of Hercynian orogeny These morphogenetic zones include belts of uplands, such as the Śląsko-Krakowska Upland, the Małopolska Upland (including the Świętokrzyskie Mountains), the Lubelsko-Lwowska Upland (including Roztocze) and the Sudeten 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 in extent are: cape Rozewie in the north (54°50'N), the Opołonek peak in the Bieszczady Mountains in the south (49°00'N), the Oder river bed near Cedynia in the west (14°07'E) and the Bug river near Strzyżowa in the east (24°09'E). The longitudinal distance is 5°50', that is, 649 kilometres, which makes a difference in the length of the day between the north and the south of Poland: in the north, the day in the summer is longer by more than an hour compared to 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 52° parallel).

Poland lies in a temperate climate zone and has typical transition features in that it varies from marine in the west to continental in the east. There are significant weather fluctuations, which are accompanied by a high seasonal variation. Six seasons are distinguished: winter, early spring, spring, summer, autumn and early winter. The mean annual temperatures range from 8.2°C in the south-west (Wrocław) to 6.2°C in the north-east (Suwałki). The average long-term annual precipitation in Poland in the period 2001–2010 was 603.3 mm and it is now showing an upward trend (RoSL, 2011). Precipitation is highest in the summer months. There are large fluctuations in the thickness and persistence of the snow cover. In the lowlands, the snow cover does not usually exceed five or six centimetres and appears and disappears several times over the course of the winter. In the mountains, though, depending on the elevation, the snow cover lingers for about 150 days and reaches a thickness of approximately two-metres.

The majority of lakes in Poland are in the north and west-central part of the country. There are approximately 9300 of them. They cover a total area of 3200 km^2, which represents nearly 1 per cent of the country's land area. Based on data supplied by A. Choiński, the largest are Śniardwy (11 487.5 hectares), Mamry (9851 hectares) and Łebsko (7020 hectares). There are approximately 100 artificial water reservoirs in Poland which hold only six per cent of surface runoff.

Westerly, north-westerly and south-westerly winds prevail in Poland. Wind velocity is usually highest in winter and lowest in summer. The average wind velocity in 2010 ranged from 5.3 m/s in Warsaw, Hel, Kraków and Nowy Sącz to 6.2 m/s on Mt. Śnieżka.

Where hydrographic conditions are concerned, 99.7 per cent of Poland's territory lies in the Baltic Sea basin, of which 53.9 per cent is the basin of the Vistula river, 34 per cent that of the Oder river and 11 per cent is the direct catchment basin of the Baltic Sea.

The vegetation cover is mostly of the Central European province (mixed and broadleaved forests). However, with increasing continentality the share of coniferous forests is increasing. The natural distribution limits of plants typical for a number of regions of Europe occur in Poland, such as the north-eastern distribution limits of European beech and the northern limits of silver fir. The zonal distribution of soils is also transitional, so that the share of brown soils increases in the south-western and western regions, while the share of podzolic soils is higher in the north-eastern and eastern regions of the country (PWN Encyklopedia, 2010; Central Statistical Office, 2010).

Most of the soils that occur in Poland are light and fairly infertile. To cultivate them the enrichment of large amounts of mineral and organic fertilizers is required.

According to the classification and nomenclature of the Polish Society of Soil Science the following genetic classes of soils are found in Poland:

Section I. Litosols, Lithogenic soils:
Order: mineral, non-calcareous, poorly developed soils – they occur mainly in the mountain regions and, among other places, on artificial embankments and excavations; they occupy approximately 2.5 per cent of the country's land area and are of no economic significance (types: litosols, regosols, palaeosols, rankers, arenosols).
Order: calcisols, calcareous soils (types: rendzinas and pararendzinas) – they occur, among other places, on the loess soils of the Lublin Upland, the Świętokrzyskie Mountains, the Silesian Upland and the Kraków-Częstochowa Upland; they occupy approximately 1 per cent of the country's land area and are fertile but difficult to cultivate.

Section II. Autogenic soils:
Order: chernozem soils (type: chernozems) – they occur, among other places, on the loess fragments of the Lublin Upland and the Małopolska Upland; they occupy approximately 1 per cent of the country's land area and are fertile.
Order: brown soils (types: typical brown, acid brown and lessive soils) – they occur, among other places, on the boulder clays of the Mazury and Pomerania Lake Districts and on the loess soils of the Lublin Upland, Małopolska Upland and the Carpathian Foothills; they cover 37 per cent of the country's land area and are relatively fertile.
Order: podzolic soils (types: podzols, podsolic and rustic podzols) – they occur mainly in the Polish Lowlands and the Sandomierska Valley, cover approximately 26 per cent of the country's land area and require organic fertilisation and liming; they are typical soils for rye-potato production.

Section III. Semihydrogenic soils:
Order: gleyic podzolic soils (types: gleyic podzolic soils and gleypodzols);
Order: black soils, vertisols (type: black soil) – they occur primarily in the Kujawy region, around Błonie, Sochaczew, Pyrzyce, Kętrzyn and Wrocław; one of the most fertile of soils; occupies approximately 3 per cent of the country's land area.

Order: gley soils (types: surface-water gley soils, pseudo gley soils and ground-water gley soils) – they occur mainly in the Polish Lowlands and the Carpathian Mountains and occupy approximately 16 per cent of the country's land area; they are usually used as pastures but rarely for cultivation.

Section IV. Hydrogenic soils:
Order: bog soils (types: fluvic bog soils and peat soils) – they occur mainly in the valleys of the Narew tributaries and the Baltic coastal rivers, as well as in the Lublin, Polesie; they occupy 9 per cent of the country's land area and are typical grassland soils.
Order: Histosols – these muck soils usually occur together with the bog soils from which they develop, while mull soils develop as a result of the humification of drained gleysols; they are typical grassland soils.

Section V. Alluvial soils:
Order: alluvial soils: (types: river mud soils and marine soils) – e.g. the alluvial soils of the Vistula estuary (Żuławy Wiślane) and deluvial soils, which are often very fertile.
Order: deluvial soils (at the foot of slopes).

Section VI. Saline soils:
Order: saline natrium soils (types: sodic soils, solonetz soils).

Section VII. Anthrosols:
Order: Anthrosols (types: hortisols, regosols).
Order: urbic technosols (types: anthrosols with undeveloped profiles, humus-rich anthrosols, anthropogenic para-rendzinas, anthropogenic natrium soils).

The soil classification developed by the Polish Society of Soil Science can be regarded as equivalent to the international soil classification system of the World Reference Base for Soil Resources (WRB), which is recognized by the International Union of Soil Sciences (IUSS) and the FAO (Food and Agriculture Organisation of the United Nations).

A specific classification of forest soils, which distinguishes types and subtypes of forest soils, is used in forestry (Table 23).

2. The forestry sector in Poland

Forests, which are the least disturbed natural formations in this climatic and geographical zone, are indispensable to the ecological balance and, as they ensure biological production, also have a market value. Broadly speaking, they represent a public good that enhances the quality of human life.

Forests once covered almost the whole of Poland. However, historical and socio-economic processes involving the expansion of agriculture and increased demand for raw wood transformed them substantially. At the end of the 18^{th} century forests covered 40 per cent of the country's territory (within its borders at that time) but by 1945 this had fallen to just 20.8 per cent. Deforestation and the associated reduction of species composition in stands resulted in a decrease in forests' biological diversity, degradation of the landscape, soil erosion and the upsetting of the water balance. This process was reversed in 1945–1970, when Poland's forest cover increased to 27 per cent following the afforestation of 933.5 thousand hectares of land. The average annual area of afforestation was 35.9 thousand hectares, while in the peak years 1961–1965 it exceeded 55 thousand hectares (RoSL, 2011). Forest cover now accounts for 29.2 per cent of the country's land area.

An assessment performed according to internationally adopted standards, which takes into account land associated with forest management, put the forest area in Poland at 9.3 million hectares (of which 8.9 million are forests established by artificial regeneration). This represents approximately 29.8 per cent of the country's land area. The forest area per capita is 0.24 hectares (FRA, 2010).

The distribution of forests in Poland varies from region to region. The largest forest areas are in the east, north and west of the country. Central Poland has the least forest cover: in the Łódzkie and Mazowieckie Provinces it accounts for 21.1 per cent and 22.7 per cent of territory respectively (Fig. 3).

The map of potential natural vegetation shows that oak-hornbeam communities (43.39 per cent), pine forests (21.79 per cent) and riparian forests (15.81 per cent) should dominate in Poland (Matuszkiewicz, 2008), (Table 24), (Figs. 1 and 2).

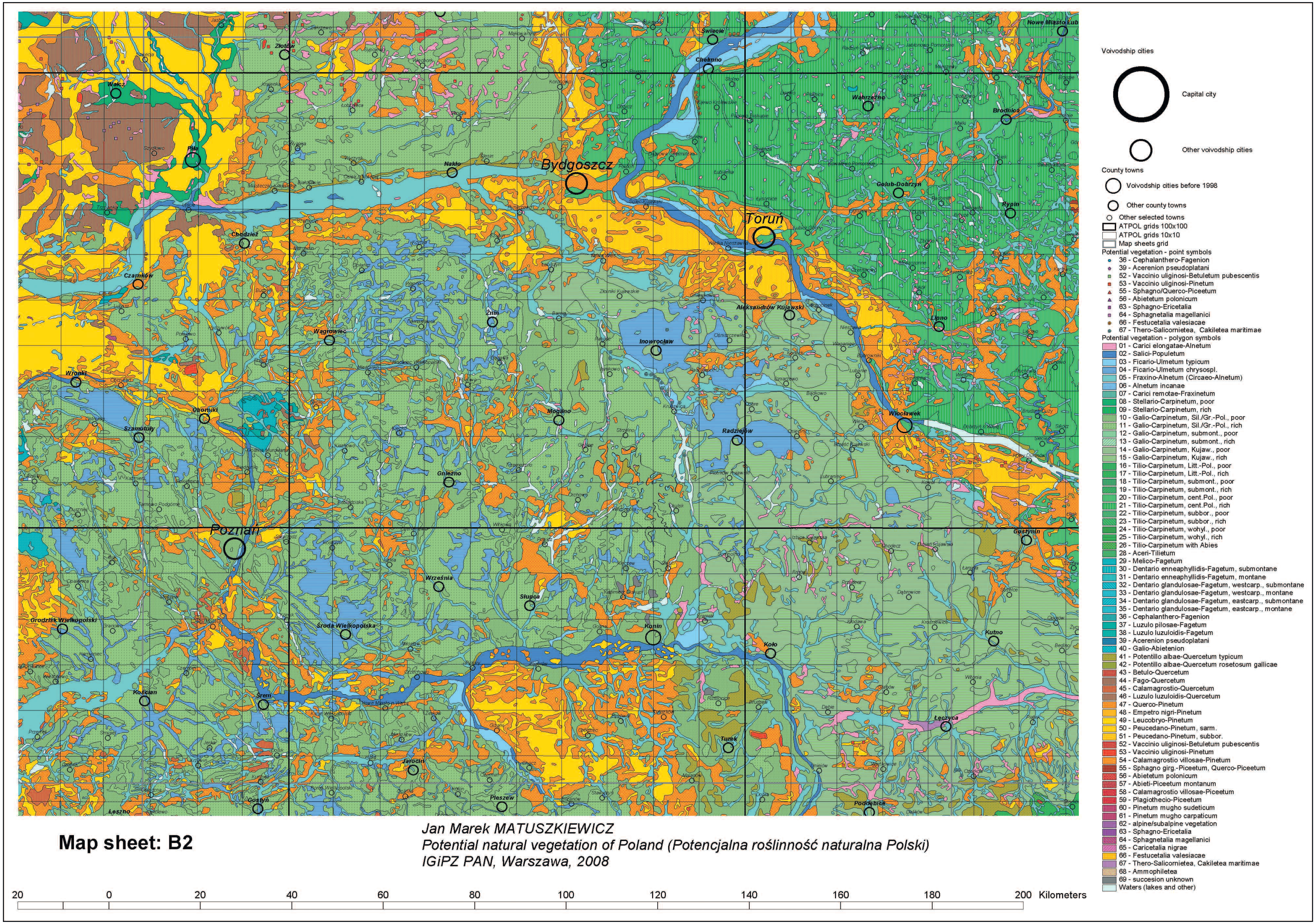


Fig. 1. A sectoral map of the potential natural vegetation in Poland

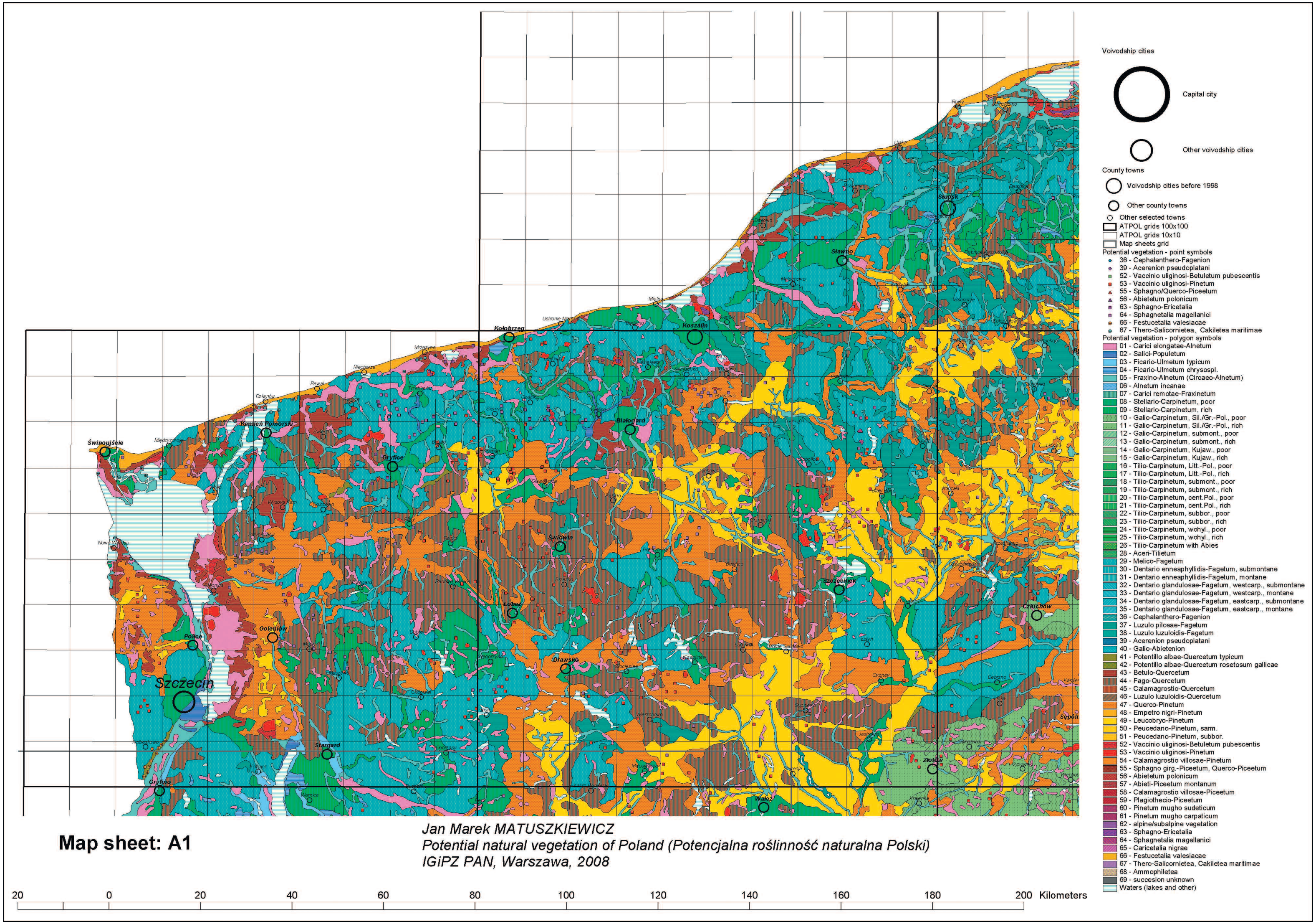


Fig. 2. A sample sector of the potential natural vegetation map (north-western Poland)

2.1. Changes in the forest area in Poland

According to Central Statistical Office data, Poland's forest area had increased by 33 thousand hectares in 2010 compared to 2009 and had increased by 365 thousand hectares compared to 1995 (according to land records).

This is a result of afforestation operations carried out on post-agricultural land and on wasteland. After 2001, the areas forested by natural succession were also included in the general forest statistics. This increase was also the result of the conversion of other woodlands into forests. The exclusion of forest land from timber production and its designation for other purposes affected the total area of forests only slightly (551 hectares in 2010).

The increase in forested areas in 1990–2010 resulted both from afforestation and from updating land records by including plantations that had been established – but not revealed in documents – in previous years. Areas forested by natural succession (209 hectares) made only a slight contribution to the total area of forests (Central Statistical Office 2010). The area of afforested land in the years 1999–2010 is shown in Fig. 4.

All afforestation operations undertaken in Poland are based on the National Programme for the Augmentation of Forest Cover developed by the Forest Research

Fig. 3. Forest cover in Poland by province (Central Statistical Office 2010)

Institute at the request of the Ministry of the Environment, Natural Resources and Forestry, which was adopted for implementation by the Council of Ministers on 23rd June 1995. A need for modifications arose during its implementation and these were eventually completed in 2002. As a result, the area designated for afforestation in 2001–2020 increased by 100 thousand hectares to 680 thousand hectares, while afforestation preferences were revised for each commune in Poland.

The Programme's main tasks are to increase forest cover to 30 per cent by 2020 and to 33 per cent by 2050, to ensure the optimal spatial and temporal distribution of afforestation, to set ecological and economic priorities and to furnish the tools for their implementation. The afforestation of land under all ownership categories carried out in 2010 covered 5864.9 hectares (Fig. 12).

In addition to the afforestation of farmland and wasteland, forest plantations were established in areas where timber stands had been removed. The area restocked in 2010 covered 46 080 hectares of land under all ownership categories, of which 4631.2 hectares (10.1 per cent) were naturally regenerated. The area restocked in 2010 was approximately 1900 hectares larger compared to 2009. There has been a steady decline in the afforestation area within the State Forests in recent decades as a consequence of the share of stands in younger age classes.

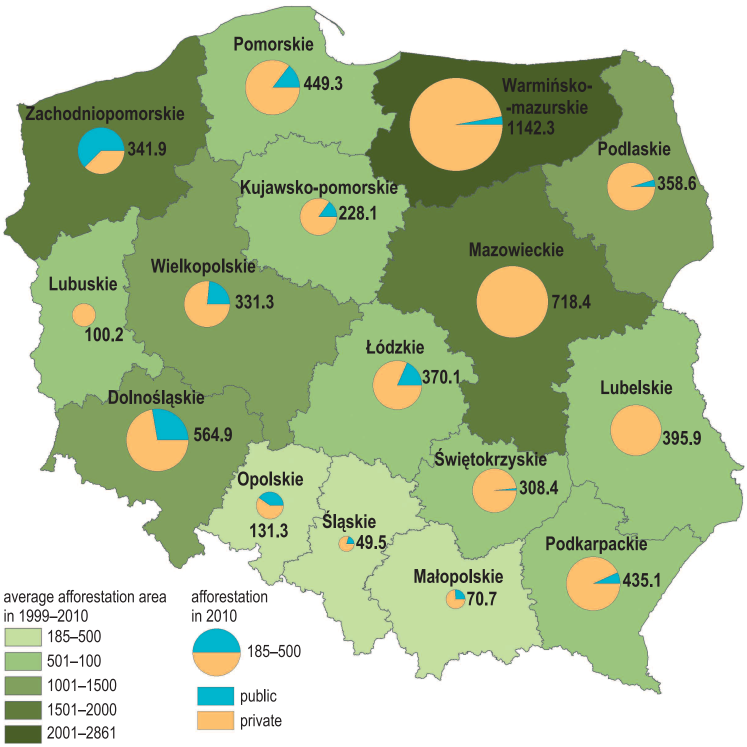


Fig. 4. Afforestation in 2010 by province compared with average afforestation in 1999–2010 (Central Statistical Office, Forest Research Institute)

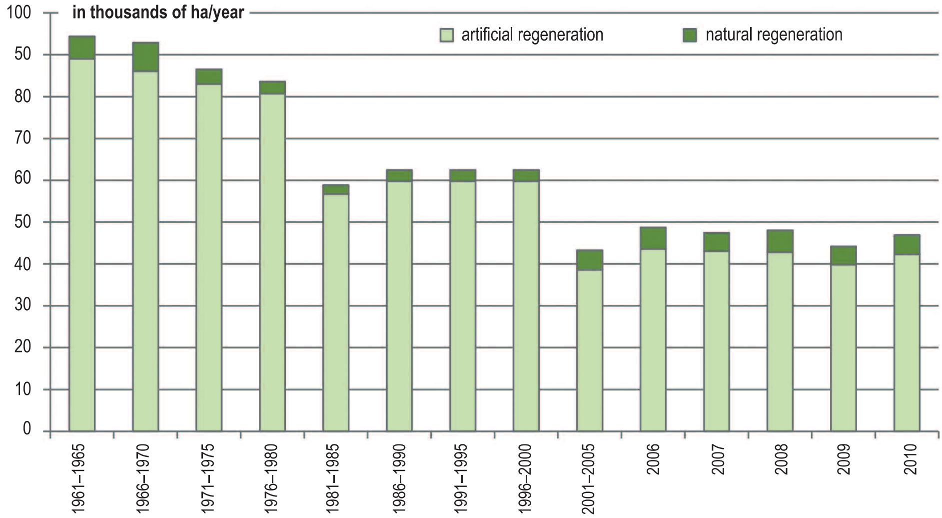


Fig. 5. Afforestation in Poland in 1961–2010 (Central Statistical Office)

The area of natural regeneration observed from the second half of the 1970s amounted to 3.4 per cent of the total regeneration area in 1976–1980, which increased to 10.4 per cent in 2001–2010 (Fig. 5).

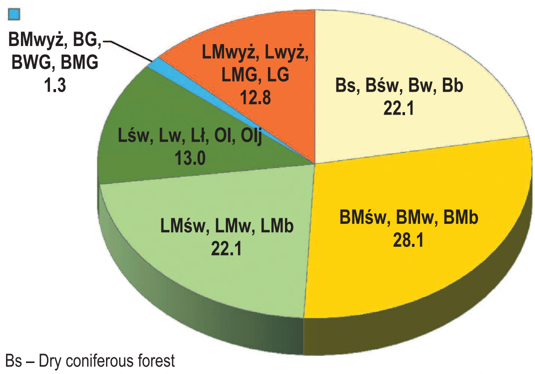
The continuing decrease in the area of the youngest stands (age classes I and II) in Polish forests must arouse concern as it could threaten the future sustainability of forests (to the optimal age-class structure). The reasons for this include the significant reduction of afforestation initiatives, limited final felling (reduced area of renewals) and the move to intermediate felling necessitated by the condition of the forests and fewer (e.g. for environmental reasons) clear-cut areas. The increase in the area of older forest stands is a consequence of limited final harvest, so that the long retained mature sawtimber stands cause timber depreciation (RoSL, 2011).

2.2. Habitat structure

The diversity of habitats in Poland is reflected in the geographical distribution (regionalization) of forests (Fig. 6), taking into account the geological and climatic conditions, natural landscape types and the forest-forming role of woody species.

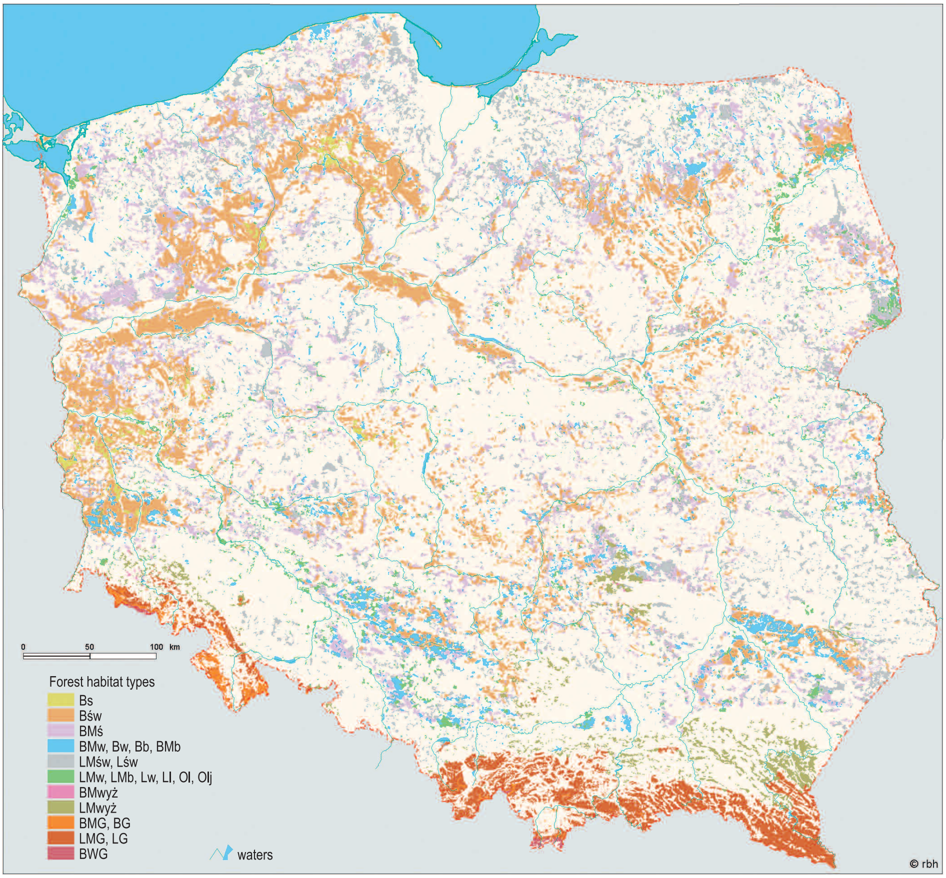
Poland has retained forests mostly on the poorest soils, which is reflected in the structure of forest habitat types (Fig. 7). The predominant forest habitats are coniferous and represent 52.1 per cent of the total forest area, while broadleaved forest habitats account for 47.9 per cent. For both groups, upland habitats occupy 5.5 per cent of the forest area and mountain habitats occupy 8.7 per cent.

Fig. 6. The geographical distribution of forests (Forest Research Institute)



Bs – Dry coniferous forest
Bśw – Fresh coniferous forest
Bw – Moist coniferous forest
Bb – Bog coniferous forest
BMśw – Fresh mixed coniferous forest
BMw – Fresh mixed coniferous forest
BMb – Mixed coniferous bog forest
LMśw – Fresh mixed broadleaved forest
LMw – Moist mixed broadleaved forest
LMb – Mixed broadleaved bog forest
Lśw – Fresh broadleaved forest
Lw – Moist broadleaved forest
Lł – Riparian forest
Ol – Alder forest
OlJ – Alder-ash forest
LMwyż – Upland mixed broadleaved forest
Lwyż – Upland broadleaved forest
LMG – Montane mixed broadleaved forest
LG – Montane broadleaved forest

Fig. 7. Percentage area of forest habitat types under all ownership categories (Large-Scale Forest Inventory)



Bs – Dry coniferous forest
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LMb – Mixed broadleaved bog forest
Lw – Moist broadleaved forest
Lł – Riparian forest
Ol – Alder forest
OlJ – Alder-ash forest
BMwyż – Montane mixed coniferous forest
LMwyż – Upland mixed broadleaved forest
LMG – Montane mixed broadleaved forest
LG – Montane broadleaved forest
Bg – Montane coniferous forest

Fig. 8. Geographical distribution of forest habitat types (RoSL, 2011)

In addition to those in the mountains and uplands of southern Poland, the largest concentration of wetland forest habitats is in the Silesian Lowland and the Sandomierska Valley (Fig. 8). Fresh coniferous forest habitats prevail in central Poland, while coniferous and mixed broadleaved forest habitats occur more frequently along the northern and eastern borders of Poland compared to other regions of the country.

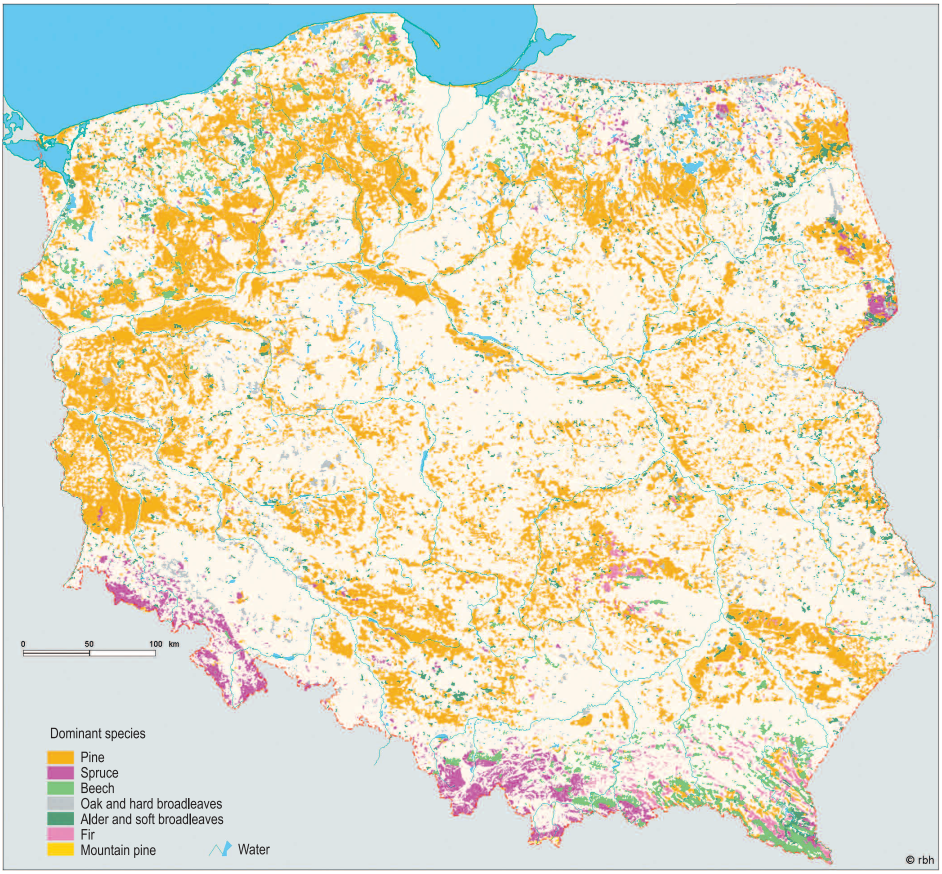


Fig. 9. Geographical distribution of forest stands by dominant species (RoSL, 2011)

Coniferous species, which account for 70.8 per cent of the total area, predominate in Polish forests. Poland provides the optimal climatic and site conditions for pine within its Euro-Asiatic natural range. Pine accounts for 60.4 per cent of forest area in all ownership categories, 62.2 per cent in the State Forests and 57.7 per cent in the privately-owned forests. The large proportion of coniferous species, especially Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) Karst.), is the result of higher demand from the wood processing industry in the 19th century.

In 1945–2009, the species structure of forests in Poland changed substantially. One of the results of this was an increase in the share of predominantly broadleaved stands.

In the State Forests, where these changes are described in the annual updates on forest area and timber resources, the area occupied by broadleaved species in-

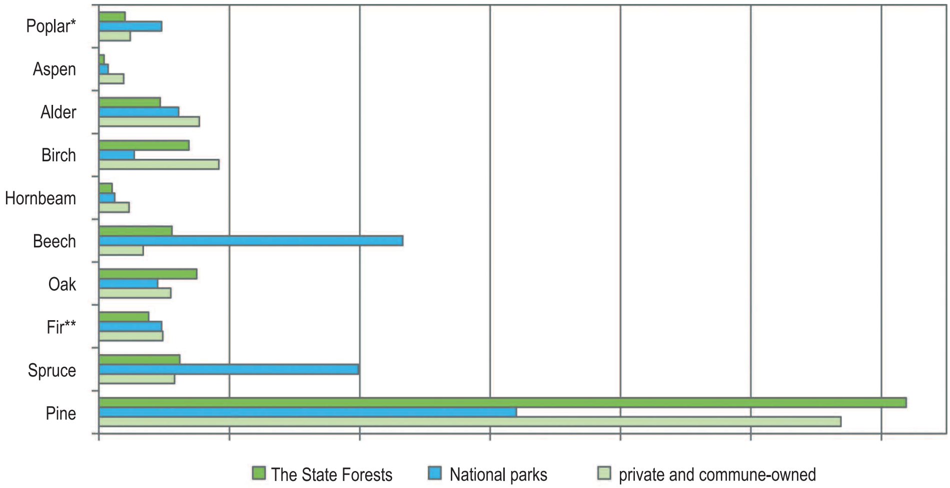


Fig. 10. Percentage area of dominant species in all ownership categories within the State Forests and private forests (Large-Scale Forest Inventory), including:
* with other broadleaves ** with other conifers

creased from 13 per cent to 23.2 per cent. In spite of the increased area of broadleaved stands, their proportion is still below the potential offered by the structure of forest habitats (Fig. 9 and Fig. 10) (RoSL, 2011).

2.3. The age structure of forests in Poland

Stands aged 41–80, which fall into age classes III and IV, prevail in the age structure of forests under all ownership categories and cover 27.1 per cent and 18.3 per cent of the forest area respectively, while in private forests stands of this age range occupy nearly 40 per cent of the forest area.

Stands older than 100 years under state management, including those in restocking class (KO), stands in the class for restocking (KDO) and stands with selection forest structure (BP) account for 11.4 per cent of the forest area, while in private forests the proportion is 2.1 per cent. The share of non-forested land in privately-owned forests is 6.7 per cent, while in the State Forests this share is 2.9 per cent (Fig. 11).

The steady increase reported in the share of stands older than 80 years from approximately 0.9 million hectares in 1945 to nearly 1.89 million hectares in 2006–2010 (excluding the KO and KDO classes) means that there have been significant changes in the age structure of forests.

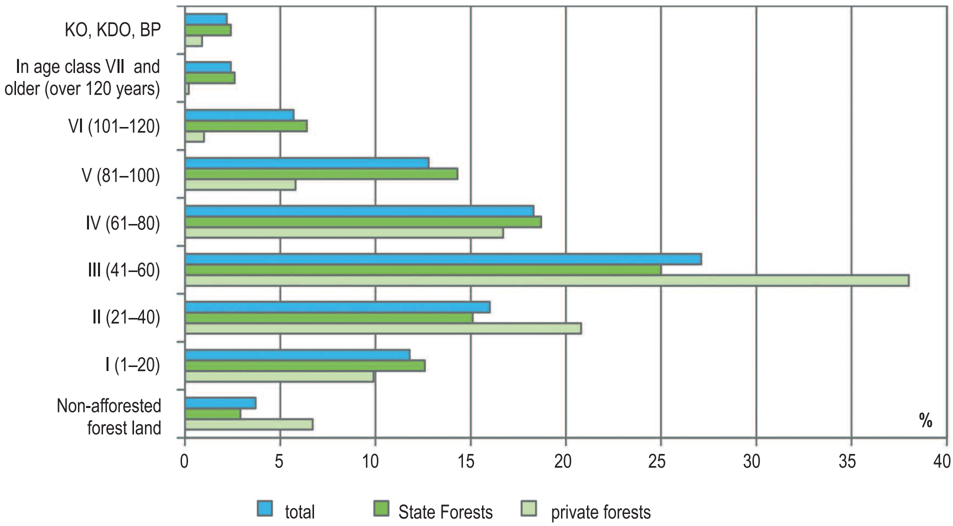


Fig. 11. Percentage area of stands under all forms of ownership in the State Forests and private forests by age class (Large-Scale Forest Inventory)

According to the Large-Scale Forest Inventory, the average age of stands within the State Forests in the period 2005–2010 was 56 years, compared to 46 years in private forests.

2.4. Plantations of fast-growing trees and monocultures

In Poland, semi-natural silviculture is pursued in accordance with the principles of sustainable development based on the knowledge and potential of forest habitats. As a result of the changes in the principles of forest management adopted in 1991, monoculture plantations have practically ceased to be established (Forest Act, 1991, ZHL Principles of Silviculture, 2003). Small scale, medium-rotation plantations of fast-growing tree species, mostly monospecific, began to be established in Poland from the early 1970s to ensure additional production of woody biomass. The area occupied by fast-growing tree plantations in Poland is given in Table A. Other monospecific plantations, such as experimental plantations or progeny plantations, that have been established in Polish forests in addition to the fast-growing tree plantations are of marginal importance.

Table A. A list of species and the area of existing plantations of fast-growing tree species in Poland (GDSF, 2009).

Species	Area in ha
Populus sp.	2457
Larix decidua Mill.	1058
Betula pendula Roth.	311
Picea abies (L.) Karst	82
Pseudotsuga menziesii (Mirb.) Franco	45
Alnus glutinosa (L.) Gaertn.	15
Betula pendula Roth. and *Picea abies* (L.) Karst.*	32
Picea abies (L.) Karst. and *Larix decidua* Mill.*	7
Larix decidua Mill. and *Betula pendula* Roth.*	3
Quercus rubra L.	14
Salix sp.	9
Robinia pseudoacacia L.	6
Abies grandis (Dougl.) Lindl.	3
Other	1
Total	**4043**

** Mixed stands*

Although approximately 90 per cent of the established forest plantations in Poland come from planting or sowing, they should not be regarded as plantation forests for the following reasons:

– the species composition of plantations is being adjusted to the habitat;
– the seedlings and seeds used for afforestation and reforestation come from the seed lots of the registered seed base in the given region of origin. As seeds are collected from local populations and from a large number of trees (usually not less than 100 individuals), these forest plantations can be said to reflect all of the genetic variation of the initial source population. Preservation of the genetic resources and genetic diversity will be considered genetically justified when: 1) the collected material contains all – or almost all – of the genes of the populations to be preserved, 2) the genetic structure of the genotypes in terms of their frequencies and other genetic parameters (e.g. heterozygosity, protein polymorphism) are similar to those of the populations being preserved (Ordinance No. 7A of 7 April 2006 issued by the Director General of the State Forests).

2.5. Forest reproductive material

Reforestation and afforestation works are carried out in forests using reproductive material collected from the seed base established for that purpose. The rules governing the functioning of the seed base (qualification, registration, management and use) have been formulated in accordance with EU Directive 1999/105/EC and the Act on Forest Reproductive Material (FRM). The Forest Basic Material (FBM), which is the main forest seed base in Poland, is registered at the Forest Reproductive Material Office, which reports directly to the Ministry of the Environment. Seeds or other parts of plants derived from this seed base can be used by the registered producers for the production of forest reproductive material (Act on FRM, 2001). FRM producers are mostly organizational units of the State Forests, whose production amounts to approximately 828.8 million plants annually (data as of 2010) (GDSF, 2011). The Act mentioned above also sets out the rules governing the use of FRM outside the regions of origin.

Table B. A list of producers of forest reproductive material in Poland (Forest Reproductive Material Office 2011).

Suppliers (FRM producers)	Number
The State Forests (Forest Districts)	430
National Parks	15
Forest Experimental Station, Forest Gene Bank, Universities	7
Private entrepreneurs	103
Total	**555**

2.6. Employment in the forestry sector

The forests provide employment for nearly 49.8 thousand people, of which 24.8 thousand are in the administration of the State Forests and the remainder in the private sector. The wood processing industry (timber, paper and furniture) employs 129.9 thousand people, which is 10.6 per cent of the overall employment in industry. In total, approximately 1 per cent of the professionally active population in the country works for the forestry sector and the wood processing industry (Central Statistical Office, 2010).

The private sector for forest services is largely fragmented. In 2009, there were as many as 8 999 forest service providers employing a total of 22 388 people. The average number of employees in these firms was only 2.49 (Central Statistical Office, 2010).

2.7. The importance of forests, forest products and services on internal and external markets

Forests are of vital importance in the preservation of the country's ecological safety. This is particularly true with regard to carbon sequestration, forest habitats and the genetic resources of plants and animals. Of no less importance is the role they play in providing large amounts of timber harvested under sustainable forest management for the domestic and foreign markets. Sixteen of the 17 Regional Directorates of the State Forests have FSC certification (Forest Stewardship Council) and 5 have PEFC certification (Programme for the Endorsement of Forest Certification Schemes). Private forests are not subject to certification (DGSF, 2011).

As forests are a part of the national property they should, as with any property, provide benefits (Płotkowski, 1998). Just like other businesses, forestry is largely concerned with generating revenue. Here, though, the money is invested over the long term and so locked up for many years. The income earned from investment in forests typically reaches only approximately 2 per cent (Płotkowski, 1999; cited in Parzych, 2007).

All of the sectors of the national economy benefit to varying degrees from forest products and services (Table C). The greatest demand for forest products is from the processing sector. In 2010, this amounted to PLN 2.564 billion (41 per cent of the total supply, including 37 per cent of the wood sector). The share of the wood sector in the demand for forest products increased by 7 per cent in 2010 when com-

Table C. The demand in the national economy for forest products and services in 2005 (Central Statistical Office: input-output table at current basic prices for 2005).

Specification	Value of products and services (PLN thousands)	Share (%)
Intermediate consumption (sections)		
Agriculture, wildlife management, forestry	**1 526 468**	**24.4**
including forestry	1 523 663	24.4
Wood-processing industry	**2 564 452**	**41.1**
including manufacture of wood products	1 510 344	24.2
pulp and paper production	615 582	9.9
furniture production	167 462	2.7
Other (services)	**211 455**	**3.4**
Household consumption	**975 797**	**15.6**
Accumulation	**664 643**	**10.6**
Export	**303 408**	**4.9**
Total	**6 246 223**	**100**

pared to 2000. The wood, pulp and paper industries are the major customers for forest products. A large proportion of forest-derived products are used for the needs of the forest economy (24.4 per cent) and for the needs of households (15.6 per cent).

The forestry sector also needs products from other segments of the national economy to conduct its business (Table D). In this respect the forestry sector is itself the largest supplier (24.4 per cent). The share of material costs (intermediate consumption) in total production is about 50 per cent in forestry production, while value added, including 28.5 per cent for labour costs and 8.6 per cent for gross profit, also represents a significant share of approximately 40 per cent.

It is noteworthy that most of the revenue derived from wood products goes to wood-processing companies and traders (Parzych, 2007; Central Statistical Office, 2010). This is because the value of the wood harvested in the forest is 13 times lower than the value of the finished industrial product (Zaleski, 2011). As a consequence, the share of forestry in Gross Domestic Product (GDP) is insignificant at approximately 0.3 per cent.

The majority of large-sized and stacked wood goes to the domestic market for further processing, while the majority of the finished products (60 per cent) goes to foreign markets. In 2009, the overall share of manufacturing industry in production sold was 9.6 per cent, of which the wood processing industry's share (excluding furniture) was 6.02 per cent. In the same year, the wood processing industry's

Table D. The demand in the national economy for goods and services of the national economy in 2005 (Central Statistical Office: input-output table at current base prices for 2005).

Specification	Value of products and services (PLN thousands)	Share (%)
Intermediate consumption:		
Products of agriculture, game management and forestry	1 548 562	24.8
Including forestry	1 523 663	24.4
Industrial products	866 996	13.9
Trade	308 100	4.9
Transport services	143 269	2.3
Scientific-research services	6 010	0.1
Other sections (services)	328 696	5.3
Settlement of taxes and subsidies	41 179	0.7
Gross value added	2 488 088	39.8
Including wages and salaries	1 779 325	28.5
Gross income	534 109	8.6
Imports	515 323	8.3
Total	**6 246 223**	**100**

share of total Polish exports was 10.93 per cent. The value of the production sold in the entire timber sector in 2010 was PLN 80.1 billion (Central Statistical Office, 2010). The ratio of exports (USD 2 867 943 thousand) to imports (USD 1 253 355 thousand) of wood and wood products was positive 2.29:1 in 2009.

Forests provide many other non-wood products. These mainly satisfy the needs of local communities engaged in collecting forest-floor products, whose share in exports is also significant. The forests supply an annual quantity of approximately 11 834 tonnes of blueberries, 4186 tonnes of fungi, and 7304 tonnes of other forest fruits. In spite of the ever increasing share of private plantations in Christmas trees, the forests still provide 49 000, which is a significant number (FRA, 2010). As there are few restrictions on public access to forests for collecting non-wood products (the matter is regulated by the Forest Act and Nature Conservation Act), they have become a source of income for local people. The forests are also engaged in providing services for the forest and timber economy. The forests therefore play a significant role in the reduction of poverty and unemployment in the agriculturally and industrially underdeveloped regions of Poland. The cultivation of hunting traditions is a further activity of importance to local communities: hunters holding permits to harvest approximately 450 thousand big game animals annually, including 51 thousand red deer, five thousand fallow deer, 176 thousand roe deer and 218 thousand wild boar (Central Statistical Office, 2010). The revenues derived from the sale of forest floor products and from game management are not included in the income from forestry, but in that from agriculture.

2.8. The organization of the forestry sector

In all, 81.5 per cent of the forests in Poland are publicly-owned, of which 77.5 per cent are under the management of the State Forests (Fig. 12). The ownership structure of forests has remained almost unchanged throughout the entire post-war period. The area of private forests has increased by 1.4 per cent in comparison with 1995, while the area of publicly-owned forests has decreased by the same percentage. With regard to public ownership, the establishment of four new parks increased the forest area in national parks from 1.9 per cent in 1995 to 2.0 per cent in 2010.

The State Forests are composed of the following organizational units:

- Directorate General of the State Forests (GDSF) headed by the Director General,
- Seventeen Regional Directorates of the State Forests (RDSFs) in Białystok, Gdańsk, Katowice, Kraków, Krosno, Lublin, Łódź, Olsztyn, Piła, Poznań, Radom, Szczecin, Szczecinek, Toruń, Warszawa, Wrocław and Zielona Góra,

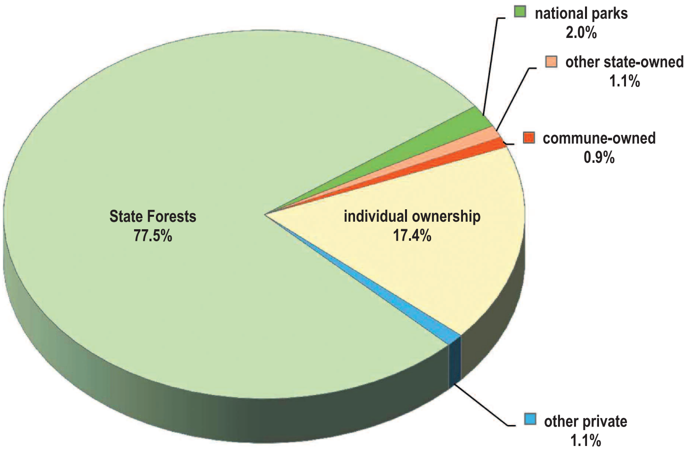


Fig. 12. Ownership structure of forests in Poland (Central Statistical Office, 2010)

– 430 Forest Districts, each of which consists of a dozen or so Forest Sub-Districts totalling 5500,
– Organizational units of nationwide scope: the Kostrzyca Forest Gene Bank (Kostrzyca FGB) in Miłków, the Forest Culture Centre in Gołuchów, the State Forests Information Centre in Warsaw, the Centre for Research and Implementation in Bedoń, the Forest Technology Centre in Jarocin, the Information Centre of the State Forests and the Environmental Project Coordination Centre,
– Seventeen regional service units of the State Forests.

RDSFs are established, merged, divided or disestablished by virtue of a regulation from the minister responsible for the environment at the request of the director general, while Forest Districts and organizational units of nationwide scope are established, merged, divided or disestablished by the Director General of the State Forests. Where the Forest Districts are concerned, the request of an RDSF director is required. The regional organizational units are established, merged, divided or disestablished by the Director of an RDSF with the consent of the Director General.

The head of the State Forests is the director general, who is assisted by the directors of the RDSFs and who is dismissed or appointed by the minister responsible for environmental matters.

The State Forests Committee serves as an opinion-giving and advisory body to the director general. Its members are appointed by the director general for a period of three years from among academics, members of associations and social and professional organizations acting for the benefit of nature conservation, regional directors, district forest managers, sub-district forest managers and other professionals employed in the organizational units of the State Forests.

The Forest District is the fundamental organizational unit of the State Forests. Their managers carry out autonomous forest management in their Forest Districts and are responsible for the state of the forests in their areas of operation (Forest Act, 1991; Fonder, Szabla, 2011).

2.9. Private forests

Private forests that are not Treasury property cover an area of 1655 thousand hectares, of which 1557 thousand hectares are in the hands of individual owners, 68 thousand hectares are the property of land cooperatives, 7 thousand hectares are held by agricultural cooperatives and 24 thousand hectares by the church, other confessional groups and non-governmental organizations (Król, 2011). Private forests make up 18.5 per cent of Poland's forests (RoSL, 2011). In addition, approximately 400 thousand hectares set aside in agricultural households are forested by natural succession. If the statutory requirement placed on the County Governor's Office (Starostwo Powiatowe) to update land records to reflect the actual state on the ground were met, the area of private forests would exceed two million hectares (Chrempińska, 2010).

According to the Agricultural Census of 2002, over 841 thousand (28 per cent) agricultural holdings have forests, of which 59.3 per cent are holdings with a forest area of less than one hectare and only 4.1 per cent have a forest area exceeding five hectares. The average area of forest per holding is 1.3 hectares (Gołos, 2007) and the average area per forest owner is 1.43 hectares (Bernadzki, 2006).

Due to their excessive fragmentation, the privately-owned forests are incompetently managed. Only a few of them are organized into land cooperatives. The first associations of private forest owners – Zawojskie, Gorczańskie, Słopnickie and Wielickie – were established in 2002. The Union of Forest Associations has recently been established.

In spite of the low efficiency of management in privately-owned forests and their lower average tree age (46 years) compared to the State Forests (57 years), their average volume in relation to the total forest area is 220 m^3/ha, which is 44 m^3/ha lower (only 16.7 per cent) than in the State Forests (RoSL, 2011). However, the volume of broadleaved forests under private ownership with regard to some tree species, such as poplar, aspen, birch and hornbeam, is much higher compared to that in the State Forests. The value of this indicator is similar for fir stands (Fig. 17).

A large proportion of privately-owned forests (approximately 56.7 per cent) still do not have valid management plans (Zaleski, 2011; Central Statistical Office, 2010).

The supervision of forest management in privately-owned forests is exercised by County Governor's Offices. They exercise autonomous supervision over private forests within an area of 519 thousand hectares, while the governors' offices have entrusted supervision of the remaining area (1.23 million hectares) to the State Forests (RoSL, 2011).

All of the main forest-forming tree species are represented in the privately-owned forests in Poland. Approximately 70 per cent of the forest areas contain coniferous species and close to 30 per cent are broadleaved forests.

The share of privately-owned forests in Poland varies from region to region (Fig. 13). The largest are in the Mazowieckie Province (43.7 per cent of the province's total forest area of 353.4 thousand hectares), in the Małopolskie Province (43.4 per cent of the province's total forest area of 188.3 thousand hectares) and in the Lubelskie Province (40.3 per cent of the province's total forest area of 232.4 thousand hectares). The smallest share of private forests was reported in Lubuskie (1.4 per cent of the province's total forest area of 9.6 thousand hectares), Western Pomerania (1.9 per cent of the province's total forest area of 15.1 thousand hectares) and Lower Silesia (2.8 per cent of the province's total forest area of 16.4 thousand hectares).

The environment-shaping role of private forests is significant in some regions of Poland and is felt particularly in the southern, eastern and central parts of the country. The economic importance of private forests for their owners and for the national economy is low due to the characteristics of the forest stands and to the organization of the economic activity in these forests. Private forests and forest

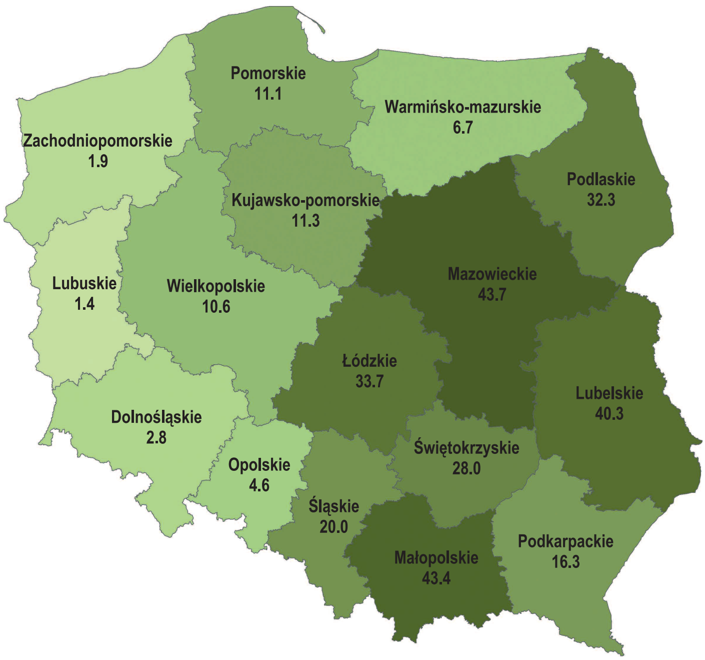


Fig. 13. The proportion of private forests in the total forest area by province (Central Statistical Office)

estates have never been a significant source of income for rural dwellers and only 5 per cent of the harvested timber in Poland comes from private forests (Gołos, 2007). In 2010, the ratio of the volume of harvested net merchantable timber in privately-owned forests to that harvested in forests managed by the State Forests was even lower at 3.7 per cent (RoSL, 2011). The per hectare volume of timber harvested in private forests is only 0.6 m^3 compared with 4.4 m^3 of timber harvested in forests managed by the State Forests. This indicates huge untapped potential for the acquisition of additional quantities of timber from privately-owned forests, which would eliminate wood shortages on the market. If we assume (in very simplified terms) the same intensity of timber harvesting in privately-owned forests as in those managed by the State Forests, the volume of harvested timber in privately-owned forests would amount to between 6 million m^3 and 7 million m^3 (Zaleski, 2011).

The harvesting of timber from woodlots located mainly on privately-owned land compensates to some extent for the shortages of wood on local markets. In this way 851.6 thousand m^3 of timber from woodlots were harvested in 2009 (Central Statistical Office, 2010).

Private landowners made significant contributions to increasing the country's forest cover after 2001. In 1995–2010, 1.27 million hectares of private and communal land were forested, which accounts for 53 per cent of the National Programme for the Augmentation of Forest Cover.

2.10. The role of forest genetic resources in meeting the current expectations for forest products and services in Poland

2.10.1. Forest functions

Forests serve diverse functions, either naturally or as a result of human activity. These functions are:

- Ecological (protective) functions, they have a favourable impact on the climate both locally and globally: in the regulation of the water cycle in nature, in the prevention of floods, avalanches and landslides, in the protection of soil against erosion and in preventing landscape from becoming steppe,
- Productive (economic) functions, primarily the production of renewable biomass, including timber and non-timber products,
- Social functions, providing conditions for rest, recuperation and recreation and so contributing to the labour market,
- The ecological function of forests.

Forests have a beneficial effect on the living environment of humans and their diversified structure supports many human activities.

Forest cover, which is mostly composed of woody vegetation, has a positive influence on the local and global climate. Forest ecosystems, which are some of the most diversified communities of living organisms in the world, absorb huge amounts of carbon dioxide. They also reduce concentrations of many other gaseous pollutants and filter out dust from the air.

The occurrence of forests on a local scale contributes to the reduction of temperature amplitudes (both diurnal and annual) and wind velocity. The specific properties of climate in forests – allied with their high retention capacities – slow down the melting of snow and the outflow of rainwater, which makes flooding less likely.

Forests in mountain areas, where shallow soils are exposed to eolic erosion and, first of all, to water erosion, assume a heightened importance. What is more, forests make a major contribution to stabilizing the snow cover, which reduces the danger of avalanches. The genetic diversity of forests is essential for the sustainable development and moderate use of forest ecosystems. That determines adaptability to changing environmental conditions and global climate change.

The growing understanding of the ecological and social functions of forests in forest management, which are frequently referred to as non-productive functions, has resulted in the establishment of protective forests, which began in 1957. The total area of protective forests managed by the State Forests as reported on 31 December 2010 was 3.29 million hectares, which represents 46.6 per cent of the total forest area and, if the nature reserves are added, 48.3 per cent of the total forest area. In the category of protective forests, water-protecting forests occupy the largest area (1.41 million hectares) followed by those around cities (637 thousand hectares), those damaged by industry (531 thousand hectares) and soil-protecting forests (344 thousand hectares) (Fig. 14). The majority of protective forests are found in the uplands and industrial areas.

The area of private forests recognized as protective is estimated at 65.8 thousand hectares, or 3.9 per cent of their total area. Protective forests owned by communes cover an area of 25.1 thousand hectares (29.4 per cent). In comparison with other countries in our region, Poland has a relatively high proportion of protective forests being in private hands (approximately 36 per cent). Protective forests are subject to modified procedures, including limits on clear-cutting, increases in rotation age, adjustment of species composition to the functions served or recreational management depending on their predominant function (RoSL, 2011).

By comparison with those in other European countries, the forests in Poland significantly contribute to CO_2 sequestration. According to estimates, Poland's forests contain more than 968 million tonnes of carbon accumulated in forest biomass, of which 80 per cent is accumulated in the aboveground biomass (FRA, 2010).

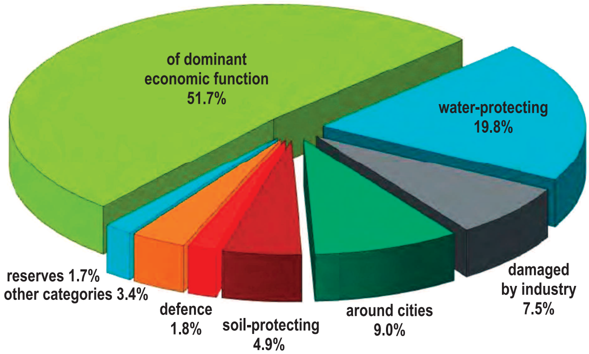


Fig. 14. The proportion of protective forest categories within the State Forests in 2010 (DGSF)

The social functions of forests

People, especially those who live in large urban agglomerations, find forests attractive places for recreation and leisure. They are also popular among schoolchildren and young people in general as they come into direct contact with the natural world and learn about forests as they do so.

The health-enhancing properties of forest ecosystems are conducive to the development of tourism and recreation – primarily in the areas classified as health resorts. The healing capacities of forests, such as hornbeam, oakwoods, mixed coniferous, pine and dry coniferous (and even poplar and willow from riparian forests), include stimulating the cardio-respiratory system. Moreover, forests contribute to cleaning the air of heavy metals and dusts and help reduce noise levels. In this way they have a beneficial effect on the microclimate of urban areas.

Nearly 50 thousand people are directly involved in the protection and management of forests, which makes them a major source of employment. What is more, they stimulate industrial production and support many jobs in other sectors of the economy, such as in the timber, pulp-and-paper or power industries.

The productive functions of forests

The productive functions of forests manifest themselves in the production, by the forces of nature and human activity, of timber and other goods that can be useful and friendly to man. These products are used by many industries and trades and contribute to traditions and cultures.

The use of forests as a renewable raw material resource is driven not only by market demand, which provides the economic conditions for forest management, but also by silvicultural needs and the principles that regulate the structure of forest resources. Forest utilization takes place at the level determined by the natural conditions of timber production and by the needs of silviculture and protection. The dominant principles, though, are those of the persistence of forests and the augmentation of their resources. The average annual volume of timber harvested in Poland based on these criteria in 2000–2010 was 31.95 million m^3 (Table 25).

The volume of timber harvested in Poland in 2010 was 33.57 million m^3 of net merchantable timber, including 1.24 million m^3 from private forests and 201 thousand m^3 from forest stands in national parks (Central Statistical Office, 2011). As long as the current methods of forest management in Poland are continued and the reduction of timber production in protected areas stays at a similar level, the estimated volume of harvested timber in 2030 will be approximately 40 million m^3 in the State Forests, and 1.5 million m^3 in the private forests (DGSF, 2011).

The significance of the productive functions of forests in protected areas

The past decade has seen a reorientation in sustainable forest management from the dominant productive function towards the protective function. Despite the year-on-year increase in the volume of harvested timber, which is a result of the need to fell aging stands and to apply tending treatments (mainly in stands aged 41–80 years), more and more forest land is either being withdrawn from timber production altogether or is becoming subject to limits imposed due to the growing importance of forests' ecological functions (Natura 2000 sites, areas around national parks).

A plus tree of the Istebna spruce provenance (photo by K. Murat)

2.11. Transformations in the forestry sector and the factors determining them

According to the National Policy on Forests, the reorientation of forest management from the previously dominant productive function towards multifunctional forest management is to be completed by 2020. This process began in the 1990s with the introduction of a series of acts and regulations, including the Forest Act (1991), the Nature Conservation Act (2004), the Act on the Protection of Agricultural and Forest Land (1995), the internal regulations of the State Forests, such as Ordinance No. 11A on the establishment of Promotional Forest Complexes (PFCs) and the Ordinance issued by the Director General of the State Forests on the principles of silviculture. Poland's accession to the European Union significantly accelerated this process of reorientation.

In 2000–2010:

1. The new 'Ujście Warty' National Park was established, which resulted in an increase in the total area of national parks by 8.0 thousand hectares and, in consequence, in an increase in the *in situ* protected forest area in national parks by 3.8 thousand hectares.
2. The area of forest reserves increased by 51.8 thousand hectares (Central Statistical Office, 2010).
3. The new 'Warcińsko-Polanowskie Forests' Promotional Forest Complex was established, which covers 37 335 hectares, of which 35 161 hectares are forest (DGSF, 2011).
4. An inventory of 823 natural habitat sites covering 3792 hectares was conducted (Directorate General for Environmental Protection, 2010).
5. A network of Natura 2000 sites was established with an area of 9.37 million hectares and the process of drawing up protection plans for these sites was begun (Directorate General for Environmental Protection, 2010).
6. The size of the clear-cut area was reduced from 29 thousand hectares in 2000 to 26 thousand hectares in 2010 in favour of complex felling, while the harvested volume of merchantable timber was increased by 9 million m^3 (RoSL, 2011).
7. The harvesting of seeds from the main forest tree species from outside the registered seed base was forbidden.
8. The *ex situ* collection of the genetic resources of forest trees and shrubs in the Kostrzyca Forest Gene Bank was reported to have increased by 6940 items (Kostrzyca FGB, 2011).
9. New progeny and conservation plantations were established on 33 362 hectares (DGSF, 2011).

10. In all, 86 gene conservation units from the territory of the RDSFs in Szczecin, Kraków, Wrocław, Olsztyn, Katowice and Zielona Góra were registered in the EUFORGEN database, which increased their total number to 218 (Bioversity International, 2011).
11. A total of 3164 hectares of gene conservation stands (218 populations) and 2539 hectares of stands from national parks (117 populations) were entered in the State Forests' FBM (GDSF, 2011; Forest Research Institute, 2011).
12. In addition to the legislation mentioned above, the following acts and their executory provisions were implemented:
    a) The Environmental Protection Act of 27 April 2001 (consolidated text, Journal of Laws 2001, No. 25, item 150, with subsequent amendments),
    b) The Act on the Prevention and Repair of Environmental Damage of 13 April 2007 (Journal of Laws 2007, No. 75, item 493, with subsequent amendments),
    c) The Act on Sharing Information about the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessment of 3 October 2008 (Journal of Laws 2008, No. 199, item 1227, with subsequent amendments),
    d) The Act on Forest Reproductive Material of 7 June 2001 (Journal of Laws 2001, No. 73, item 761, with subsequent amendments),
    e) The Act on Plant Protection of 18 December 2003 (consolidated text, Journal of Laws 2008, No. 133, item 849, with subsequent amendments).

The political transformation that took place in Poland in 1989 also led to changes in the organization of the forest economy. The State Forests initiated revolutionary changes in the approach to forest management, which involved beginning of the transition from the timber production model towards the multifunctional model.

However, the productive function of forests still plays a vital role in Poland. By comparison with 2000, the timber harvest in Poland has increased by approximately 10 million m^3. The revenues generated from timber sales in The State Forests are earmarked for the implementation of other forest functions (RoSL, 2011). In the past 10 years, the demand for quality timber has remained at more or less the same level, while the general demand for timber has increased significantly. Despite the ever-growing timber harvest in Poland, the demand for timber continues to be high. The annual shortfall in timber at maximum market demand is estimated at 1–2 million m^3 (GDSF, 2011).

As Poland has adopted the climate package, there is growing pressure from the energy market for the supply of wood biomass. In its forestry strategy though, which is still in preparation, the Ministry of the Environment does not foresee the provision of significant amounts of utility wood for energy purposes (Zaleski, 2011).

It is estimated that to satisfy the demand of the energy market at least partially, the forests in Poland would need to provide the power industry with approximately 4.5 million m^3 of timber per year from stump wood and slash (DGSF, 2011).

This under-supply may lead to conflicts between forestry, the wood and power industries and ecological organizations in the near future. With increasing frequency and effectiveness, non-governmental organizations are now seeking to change the role of the forest to that of a renewable source of timber and to emphasize the importance of non-productive forest functions (e.g. ecological and protective).

2.12. The next decade in forest management

The most important goals of the forest economy in the coming decade are related to the continuation of sustainable forest management in accordance with the principles of sustainable development and the permanence of forests expressed in the State Policy on Forests (1997), the Forest Act (1991) and elsewhere such as:

a) augmentation of the country's forest resources,
b) improvement of the state of forest resources and their comprehensive protection,
c) increasing the country's forest cover,
d) the restitution and rehabilitation of forest ecosystems, which is to be achieved mainly by replacing monocultures with mixed stands on appropriate sites,
e) the regeneration of devastated and neglected stands in private forests followed by their ecological rehabilitation,
f) changing the proportion of broadleaved species in the forests,
g) increasing the area of plantations established by natural regeneration,
h) limits on clear-cuts in favour of complex felling with a long regeneration period,
i) action to enhance water retention in forest communities in the mountains and lowlands,
j) retaining larger amounts of deadwood in forests until it naturally decays,
k) use of FRM of known silvicultural value, including material with increased adaptability for artificial regeneration,
l) active *in situ* and *ex situ* conservation of forest genetic resources from valuable stands in forest areas under different forms of management and ownership, including in protected areas.

2.13. Limitations on sustainable forest management, including forest productivity

Forest management is being conducted in a new way in valuable natural areas and it is limiting forest productivity and the utilisation of timber resources. This particularly involves the Natura 2000 areas and, to a lesser extent, the establishment of new protected areas and the expansion of existing ones, such as national parks and nature reserves, whose main purpose is to protect forest communities.

Climate changes and the associated weather anomalies, as well as biotic and anthropogenic factors harmful to the forest environment (Table E), are the main reasons for the reduction in timber production (RoSL, 2011).

In the Treaty of Athens of 16 April 2003, Poland made a commitment to designate areas for the Natura 2000 network, which was confirmed by incorporating the EU regulations that underpin the network into the Polish legal system with the publication of the Nature Conservation Act of 16 April 2004.

However, many mistakes were made in constructing the Natura 2000 network. The first problem was that the processes were allowed to become excessively formalised and bureaucratic. What is more, the arrangements neglected a number of parties with vital interests while showing too much favour to NGOs – especially

Table E. Stress factors affecting the forest environment.

ABIOTIC	BIOTIC	ANTHROPOGENIC
1. Atmospheric factors • weather anomalies – warm winters – low temperatures – late frosts – hot summers – heavy snow & hoarfrost – storms • thermal-moisture – moisture deficit – floods • wind – prevailing direction – hurricanes **2. Soil properties** • moisture – low groundwater level • fertility – sandy soils – post agricultural land **3. Physiographic conditions** • mountain conditions	**1. Stand structure** • species composition – dominance of coniferous species inadaptability to habitat – coniferous stands broadleaved habitats **2. Insect pests** • primary • secondary **3. Infectious fungal diseases** • foliage and shoots • trunks • roots **4. Excessive number of herbivorous mammals** • game animals • rodents	**1. Air pollution** • power industry • municipal economy • transport **2. Water and soil pollution** • industry • municipal economy • agriculture **3. Transformation of the Earth's surface** • mining **4. Forest fires** **5. Activities harmful to forests** • poaching and theft • excessive recreation • mass mushroom-picking **6. Incorrect forest management** • schematic procedure • excessive utilization • abandonment of tending

those that were developing 'shadow lists'. The implementation of the Natura 2000 programme, the establishment of the principles and methods of protection and clearly dividing responsibilities between the nature protection bodies – the Directorate General for Environmental Protection (DGEP), the Regional Directorate for Environmental Protection (RDEP) and the administrator of the protected areas (the State Forests) – were all issues included in the strategy (see above) for the development of forestry and forest management at the State Forests (Fonder, Szabla, 2011) .

The scale of the anticipated restrictions concerning the productive functions of forests in the Natura 2000 network is not yet known. As the Natura 2000 sites occupy approximately 20 per cent of the country's land area and include mainly forest areas (40 per cent of the territory of the State Forests), a drastic reduction of timber production in these areas and a significant extension of the production cycles may upset the financial stability of the State Forests. This would clearly also affect other forest managers and owners and may also adversely affect the timber market. This is of particular importance, especially in the regions where forests are an essential source of income for local communities. Sustainable forest and agricultural management should be carried out across the Natura 2000 network with only the restrictions contained in EU directives, such as the Habitats Directive 92/43/EEC and the Birds Directive 79/409/EEC, taken into account.

Due to the steadily growing demand for timber and the increasing area of protected sites, plantations of fast-growing trees from proven and selected families, and clones of the tree species outside the protected forest habitats, should be established on a larger scale. Furthermore, action should be taken to increase the area of afforestation on marginal lands through a system of incentives for private landowners. It is estimated that forest plantations occupying 7 per cent of the world's forests provide approximately 50 per cent of global timber production (Oudara Souvannavong, 2011). Although such a high yield from the plantations of fast growing trees will never be obtained in the environmental and climatic conditions of Poland, small-scale plantation forestry might successfully compensate for the lack of wood biomass from protected areas.

FRM of high plasticity and increased tolerance should be used in areas where there is exposure to damage from highly intense and frequent biotic and abiotic factors.

2.14. The role of forest genetic resources regarding forest goods and services in Poland in the next decade

The integrated effort to protect and improve the state of the environment and its adaptation to climate change are the main objectives of the LTDS (Long-Term Development Strategy for Poland; Maćkowiak-Pandera, 2011). It is based on the principle of preserving the country's natural and geological resources for future generations. Due to the specific geographical and natural conditions of Poland, multifunctional forest management plays a crucial role in the implementation of the Strategy, which in Poland is being carried out by the State Forests. Achieving sustainable and multifunctional forest management by ensuring access to all forest functions, while maintaining the sustainability of forest ecosystems and their resources is therefore the main objective of Polish forestry.

Polish forests will have to face a number of challenges over the next decade as expectations from the forest sector continue to grow:

– the growing demand for wood due to its steadily increasing consumption in Poland and other European countries, including for energy needs,
– the growing public demand for access to forests, including for recreation and leisure,
– the reduction in the area of forests due to the development of transport, industrial and housing infrastructure,
– the effects of climate change manifested by sudden catastrophic events, such as hurricanes, floods, heavy snowfalls, hoarfrost, and drought and the resulting forest fires,
– the effects of the deteriorating health of forest stands as manifested by insect outbreaks and fungal and bacterial diseases,
– tendencies to limit the productive functions of forests in favour of protective ones by creating new national parks, nature reserves, Natura 2000 sites and other protected areas or by expanding existing ones,
– a steady increase in the costs of forest management, including those of forest services,
– the implementation of protection tasks and plans as an integral part of the forest management plan for the Natura 2000 sites.

The medium-term objectives for the period to 2016 formulated in the Forest Strategy of the Ministry of the Environment, which await enactment, assume that the drive to use forest resources rationally – by shaping their desirable species and age structure while maintaining their biological diversity in accordance with sustainable and multifunctional forest management – will be continued.

The most important operational objectives for 2009–2012 were also identified:
- implementation of the National Programme for the Augmentation of Forest Cover (NPAFC) by the State Forests,
- water retention in forests through the restoration of drained wetlands,
- adjustment of the species composition of stands to habitat conditions and increasing the genetic and species diversity of forest biocoenoses, including the implementation of the Programme for the Restitution of Fir in the Sudetens and the Programme for the Protection and Restitution of the Yew in Poland,
- increasing the role of forest gene banks,
- introducing an alternative forest certification system (Zaleski, 2011).

SECTION III

THE MAIN PART OF THE REPORT

Chapter 1:

The current status of forest genetic resources

1. Diversity within and between forest tree species

According to the FRA 2000 classification, forest communities in Poland fall into three ecological zones: transition zone forests with oceanic influences, transition zone forests with continental influences and mountain forests. Poland lies in two biogeographic regions that are distinguished for the needs of nature conservation management: Continental, which accounts for over 90 per cent of the country's land area and Alpine, which is accounted for by the Polish part of the Carpathian Mountains (European Environment Agency website; http://www.eea.europa.eu). The main tree species are: *Pinus sylvestris* L., *Picea abies* (L.) Karst., *Larix decidua* Mill., *Abies alba* Mill., *Quercus robur* L., *Quercus petraea* Liebl., *Fagus sylvatica* L., *Betula pendula* Roth. and *Alnus glutinosa* (L.) Gaertn.

As a result of historical processes there are large tracts of near natural forest stands in Poland established from native species, which have adjusted over centuries to Poland's climate and soils in the process of natural selection. Habitats of outstanding natural value and a high degree of naturalness account for 33 per cent of all areas subject to legal protection. These are the national parks, nature reserves, landscape parks and areas of protected landscape (Andrzejewski and Weigle, 2003). Nearly 40 per cent of the protected areas in Poland are included in the Natura 2000 network (EEA, 2010), which occupies 20 per cent of the country's land area. Of this, 38 per cent are the State Forests and 18 per cent private forests (Pigan, Błasiak, 2010; Referowska-Chodak, 2010).

Forest ecosystems make up 51 per cent of the Natura 2000 sites in Europe. Only 21 per cent of the 76 forest habitat types occurring in Europe and listed in Appendix 1 to the Habitats Directive have a favourable conservation status (EEA, 2010).

In Poland, however, only the orchid beech forests, whose area does not exceed 2 thousand hectares, have a favourable conservation status (Report to the European Commission http://www.gios.gov.pl/siedliska/pdf/ocena_stanu_zachowania_siedliska_con.pd). The poor conservation status of many habitats in Poland may be due to the high requirements set by Polish experts for the indicators characterising

Beech trees in the Szczecinek Forest District (photo by K. Murat)

habitat structure and function (Czerepko, 2010). The amount of deadwood in a forest is an indicator which may serve as an example. In most forest habitats this should exceed 10 per cent of stand volume, which would allow the habitat to be assigned the appropriate conservation status.

Table 26 shows forest habitats whose condition has been significantly influenced by forest management procedures.

1.1. Genetic variation in the main forest tree species estimated by molecular analysis

There have so far been no comprehensive studies of the genetic variation and diversity of the main forest tree species in Poland. Instead, this type of research has been conducted for many years by a number of different research institutions, including the Institute of Dendrology, of the Polish Academy of Sciences (PAS) in Kórnik, the Forest Research Institute in Warsaw and Kazimierz Wielki University in Bydgoszcz. However, the amount of genetic material tested and the use of markers has always been limited by the available funds.

The picture of genetic variation in forest trees that emerges from the few studies carried out so far in Poland does not differ essentially from that in Europe: the individual species show a high level of intra-population genetic variation and a low level of inter-population diversity. These inter-population differences account for only a few per cent of the total genetic variation in the species. The high level of genetic variation in forest tree species is determined by factors such as wide distribution range, the dominant cross-mating system, a long period of generation and a relatively large refuge area in which species that survived the ice age permitted the populations that colonized Europe to maintain a high genetic polymorphism following the gradual warming of the climate. There is no doubt that the short time which has elapsed since the last ice age, the capacity to transfer and exchange genes via pollen movement over long distances and, in recent times, the uncontrolled transfer of seeds for planting, are factors that limit the inter-population diversity.

Scots Pine (*Pinus sylvestris* L.)

The level of genetic variation and similarity between mother stands and their progeny from artificial and natural regeneration was tested in the Institute of Dendrology, PAS, in Kórnik using isozymes as genetic markers. All the populations studied revealed high levels of genetic variation. There were always more similarities between the progeny and mother stands than between the mother stands themselves. The results indicated that both the natural and artificial regenerations are a good copy of the mother stands – although in some cases the random loss of some rare alleles in progeny populations can be expected. Instead, new pollen-transferred alleles, which are absent in mother stands, may occur in these populations (Kosińska *et al.*, 2007).

The scope of the studies also included genetic variation in pine in the Gniewkowo clonal seed orchard. This represented a high level of genetic variation comparable to that observed in other seed orchards and in natural forests, which indicated that the orchard had significant genetic potential and that the population studied was highly useful as a seed base. The level of inbreeding in the parental population (seeds) is not a problem here: in fact a certain excess of heterozygosity may have positive effects (Burczyk *et al.,* 2000).

In 2002–2010, the Forest Research Institute examined 42 Scots pine stands representing a seed base, whose DNA had a genetic structure in accordance with the forest seed regionalization principles adopted by the State Forests (Zaleski, 2005). Of these forest stands, 30 were tested using nuclear DNA markers (RAPD and microsatellite) and 42 using mitochondrial DNA markers (STS). The investigated stands were in 35 different FRM regions of origin in six Natural Forest Regions:

Baltic (7 populations), Mazury-Podlasie (8 populations), Wielkopolska-Pomerania (6 populations), Mazowsze-Podlasie (8 populations), Silesia (2 populations) and Małopolska (11 populations).

The results showed that the Polish populations of Scots pine tested had low genetic diversity (G_{ST} = 0.215 for RAPD markers, F_{ST} = 0.033 for SSR markers, F_{ST} = 0.118 for STS markers), which indicates that genetic variation is highly similar in the stands. Low levels of F_{ST} were also reported for other pine species analysed using SSR markers, that is F_{ST} = 0.092 for *P. pinaster* and F_{ST} = 0.0054 for *P. strobus*.

In Poland, the stands with the greatest genetic diversity estimated based on SSR markers occur in the Baltic Natural Forest Region (F_{ST} = 0.036) and the stands with the greatest genetic diversity estimated based on STS markers occur in the Silesian and Wielkopolska-Pomerania Natural Forest Regions (with H_S = 0.323 and 0.207, respectively). The stands in the Silesian Natural Forest Region (F_{ST} = 0.013) show the lowest genetic diversity when determined based on SSR markers, which is probably because only the minimum number of populations was tested (two) in the region. The markers of mitochondrial DNA polymorphism show the lowest diversity in the Mazury-Podlasie Natural-Forest Region (H_S = 0.006). The phylogenetic relationships between the Scots pine populations tested revealed genetic similarity in three provenances using RAPD markers and in two groups of provenances using microsatellite DNA markers.

Using microsatellite DNA markers, which detect genome polymorphisms more precisely, a strong similarity was shown in the genotypes of provenances in the following seed zones: 101, 108, 104, 302, 303, 305 (northwest), 106, 205, 206, 204, 401, 402, 403 and 207 (northeast), 307, 501 and 654 (southwest), 601 (centre) and 606 and 405 (southeast). The other seed zones with provenances showing genetic similarity (105, 107, 306, 352, 504, 607, 404 and 602) are in north-western, southern and central Poland. The geographical distribution of individual groups of Scots pine provenances with genetically similar genotypes showed a mosaic pattern. For both SSR and STS markers, the Mazury-Podlasie Natural Forest Region was the most homogeneous. Both markers distinguished the Białowieża population (208) as a separate gene pool that was the least related to the genotypes of other populations.

Because of the high frequency of the rare mitochondrial haplotype *nad*1 and the largest intrapopulation variation in the Silesian and Wielkopolska-Pomerania Natural-Forest Regions when compared to other regions, it can be assumed that the genetic structure of pine stands in these regions reflects the impact of human economic activity on the development of forests in Poland in the past centuries. The higher genetic diversity observed is probably due to the increased trading of the reproductive material of Scots pine in the regions under German forest management in the 19th century compared to the rest of the country.

Norway spruce (*Picea abies* (L.) Karst.)

The Institute of Dendrology, PAS, in Kórnik examined the level of genetic variation and genetic diversity in 29 spruce populations in Poland using isozyme analysis. The research confirmed a high level of genetic variation within species and a surprisingly low diversity between populations (only 3 per cent of the species variation). The application of this marker did not allow the origin of spruce populations in Poland from different refugia to be established. Because the examined marker is inherited from both parents, the widespread gene transfer *via* pollen movement has led to the disappearance of differences between regions of origin (Lewandowski, Burczyk, 2002). These differences were observed using maternally inherited mitochondrial DNA markers, which made it possible to prove that the spruce in Poland came from two separate refugia. The study was conducted with 1352 trees from 58 populations, which represented the entire natural range of spruce in Poland as well as the so-called 'spruceless zone'. The majority of the trees examined in north-eastern Poland originated from the Russian refugium, while all those in the southern regions came from the Carpathian distribution range. Spruce from both the refugia occurred in the spruceless zone. This area should therefore be regarded as one where the two distribution ranges naturally cross. Spruce from the Białowieża Primeval Forest region were also shown to be a mixture of the two origins, although until then the origin of the Białowieża spruce had been assigned to the north-east (Dering, Lewandowski, 2009; Dering *et al.,* 2011).

Studies of genetic variation in spruce were also conducted by the Forest Research Institute. In all, 20 stands of Norway spruce, which constituted a seed base according to the forest seed regionalization of the State Forests, were subjected to molecular analysis using microsatellite and mitochondrial DNA markers (Zaleski, 2005). The stands examined were located in 17 different FRM regions of origin.

Based on the results of the research into the microsatellite DNA *loci* of spruce stands, those from the north-eastern region of Poland were found to have a slightly higher genetic diversity (F_{ST} = 0.087) than the populations from southern Poland (F_{ST} = 0.085), when compared to the spruceless zone of the Polish Lowland and Central Carpathian Depression (F_{ST} = 0.039). These values did not differ from the data obtained for other spruce populations in Europe using protein markers (F_{ST} = 0.053).

The distribution of mitochondrial DNA haplotypes across the country showed a clear division of spruce populations into the north-eastern populations and those from other regions of Poland. Populations from the spruceless zone of the Polish Lowland and Central-Carpathian Depression revealed a similarity in the genetic structure of the tested haplotypes to the spruce populations from southern Poland. The gene structure of one population from the northern range of Norway spruce in Poland – Białowieża – was more similar to the genotypes of the populations from the southern range of the species than to the gene pool of its northern populations.

Pedunculate and sessile oaks (*Quercus robur* L. and *Quercus petraea* Liebl.)

A total of 46 populations of pedunculate oak (*Quercus robur* L.) and sessile oak (*Quercus petraea* Liebl.) were tested in Poland. Analysis of their chloroplast DNA (PCR-RFLP) showed that three quarters of the tested oak populations, mainly from southern and western Poland, were of Balkan origin, that the Mazury populations were of Iberian origin and that the populations from Pomerania and north-western Poland were of Apennine Peninsula origin. A detailed map of haplotype distribution was drawn up for the oaks from the Krotoszyn (7 stands) and Elbląg (6 stands) Forest Districts. In the Krotoszyn oak region (seed zone 308), two populations, Jarocin and Karczma Borowa, were of Balkan origin while the remaining populations originated from the Apennines, and the Balkan and Iberian Peninsulas. In seed zone 103, the Elbląg populations of oak were characterized by a high frequency of the Apennine and Balkan Peninsula haplotypes, while one population from Górowo Iławskie originated exclusively from the Balkans.

In general, the populations of *Q. robur and Q. petraea* tested were characterized by a high genetic diversity between populations (G_{ST} = 0.700), which was comparable to the level of genetic diversity of other European oak populations (G_{ST} = 0.780).

Pedunculate oak (photo by K. Murat)

In addition, the origin of Polish oak trees older than 200 years was tested using the maternally inherited chloroplast DNA markers. The tests included 310 individuals from 78 sites. The majority of the trees were found to have originated in the Balkan line (71.4 per cent), while the second highest proportion was of the Apennine line (23.2 per cent) and the lowest (5.4 per cent) of the Iberian line. Finding the Iberian haplotype among trees between four-hundred and seven-hundred years old proved the natural spread of individuals from that line on Polish territory (Dering *et al.*, 2008).

European beech (*Fagus sylvatica* L.)

One of the ways genetic variation in beech populations was tested was by analysis of microsatellite chloroplast DNA. Thirty populations of European beech selected based on the phytosociological characteristics of forest communities were studied. The most genetically varied were stands from northern and south-eastern Poland (Kwidzyn h = 0.505 and Tomaszów Lubelski h = 0.417), while the mountain populations from Suchedniów and Zdroje had an average level of genetic variation at h = 0.352 and h = 0.338 respectively. The Gryfino populations (h = 0.242) and stands from the Bieszczady National Park (h = 0.310) were the least genetically varied. The genetic variation for all of the tested populations taken together was low (G_{ST} = 0.267) and was much lower than the genetic variation estimated for 400 beech populations from Europe (G_{ST} = 0.810).

A high degree of genetic polymorphism, ranging from 81.82 per cent to 100 per cent, was found in the nine beech populations tested using DNA-RAPD markers (Gryfino, Kartuzy, Zdroje, Miechów, Suchedniów, Tomaszów Lubelski, Zwierzyniec, Lutowiska, Łosie). The highest share of polymorphic *loci* was recorded for the Gryfino, Łosie and Zdroje populations and the lowest was recorded for the Kartuzy and Miechów populations. The heterozygosity value ranged from h = 0.268 in the Kartuzy population to h = 0.334 in the Gryfino population. There was a slight decline from south to north in the genetic diversity of the beech populations tested. This trend, however, was not clearly marked and was more indicative of an ecotypic and mosaic structure of species variation. The overall level of genetic variation obtained in the tests of beech populations using protein markers was high (G_{ST} = 0.102) compared to those of the beech populations in Germany (G_{ST} = 0.045) and Denmark (G_{ST} = 0.006).

European ash (*Fraxinus excelsior* L.)

The research embraced 10 populations of European ash (*Fraxinus excelsior* L.) from the Bartoszyce, Elbląg, Szczecinek, Nowogród, Choszczno, Jamy, Jawor, Tułowice and Złoty Potok Forest Districts, based on RAPD and microsatellite chloroplast DNA (SSR) tests. Analyses of the genetic diversity of the selected ash populations showed that the populations from the north-western (Szczecinek h = 0.201 and Choszczno h = 0.164), northern (Elbląg h = 0.156) and southern regions of Poland (Złoty Potok h = 0.169) had a larger number of polymorphic alleles compared with the Bartoszyce population in the north-eastern region of the country, which had the lowest number of alleles at h = 0.138. In addition, the chloroplast DNA analysis confirmed the distinctiveness of the populations from the Szczecinek and Choszczno Forest Districts of north-western Poland, which were genetically similar to the populations in the North-Carpathian refugium from the stands of Alpine provenance in the Jawor and Jamy Forest Districts.

The stands examined in the Choszczno, Jawor, Jamy, Nowogard and Szczecinek Forest Districts had intermediate genotypes between these two ranges of ash distribution in Poland. The overall genetic variation in the Polish ash populations was low (G_{ST} = 0.198 using RAPD markers; F_{ST} = 0.027 using microsatellite DNA markers: lower than the values obtained for other ash populations from Central Europe at G_{ST} = 0.799).

Common yew (*Taxus baccata* L.)

When the mechanisms of genetic control and inheritance of several enzymatic proteins in this species were described for the first time ever they became efficient genetic markers used in genetic and population studies (Lewandowski *et al.*, 1992).

The genetic structure of the yew from the Wierzchlas Reserve was examined using isozyme markers. A very high level of genetic variation in the species was detected, which refuted the argument that a low level of genetic variation in the yew was contributing indirectly to the dieback of old trees and lack of natural regeneration in the reserve. The research proved this population to be a valuable genetic base for the protection and restoration of the common yew (Lewandowski *et al.*, 1995).

Douglas fir (*Pseudotsuga menziesii* (Mirb.) Franco)

The results of the research into the Douglas fir, which revealed that the F1 generation of this introduced species had retained the same level of genetic variation as the populations from their natural range (Mejnartowicz, Lewandowski, 1994), aroused a good deal of interest – particularly in Western Europe.

Silver fir (*Abies alba* Mill.)

In all, 18 Carpathian and 10 Sudeten populations of silver fir were examined using isozymes as genetic markers. The level of genetic variation of the populations examined was found to be relatively high. It was, however, lower than in the populations of other forest tree species that had so far been investigated. The Sudeten populations of silver fir showed significant genetic differences compared to the Carpathian populations. The results clearly indicated that these two population groups had different origins (Mejnartowicz, 1979, 2004; Lewandowski, Filipiak, Burczyk, 2001).

Bergmann (1995) suggests that fir from the Polish Sudeten is genetically similar to fir from the Harz Mountains (Saxony) and that it can be used to reproduce the species in that area.

Based on the polymorphism of five of the 15 *loci* studied, Longauer (1994) includes the Sudeten fir in the Hercynian-Alpine group, which differs from the Western Carpathian (Poland, Slovakia and Ukraine) and south-eastern groups (Romanian Carpathians and the mountains of Bulgaria).

Skrzyszewska (1999) described three regions in Poland in which the fir differs in the content of monoterpenes in the needles: the Sudetens and western Carpathians, the central and eastern Carpathians and Roztocze. The genetic separateness of the Sudeten fir is thus fundamentally proven. Svoboda (1953) assigned this fir to the Lusatian fir (*Abies alba lusatica*) climatype.

European larch and Polish larch (*Larix decidua* Mill. and *Larix decidua* var. *polonica*)

When the genetic control and inheritance mechanisms of several enzymatic proteins in this species were described for the first time ever they became efficient genetic markers for use in genetic and population studies (Lewandowski, Mejnartowicz, 1990).

When five populations of Polish larch from the Świętokrzyskie Mountains, several populations of the European larch from Europe and of the Siberian larch from Russia were examined using isozyme markers, the populations were found to have a high level of genetic variation and a low level of inter-population diversity (only 4 per cent of the total variation of the species). It was also demonstrated that the Polish larch was not a separate species but instead, at the most, a subspecies of the European larch. Many researchers had believed it (Lewandowski, 1997) to be a hybrid taxon between the European larch and the Siberian larch, but this was not proven.

The genetic structure and mating system of Polish larch trees aged 200 years and above in Ciechostowice were also tested using isozyme markers. It was shown that the population had a high level of genetic variation and that approximately 94 per cent of viable seeds were the result of cross-fertilization. Concerns about the high proportion of selfed seeds among the viable seeds of the species were therefore not confirmed (Lewandowski *et al.*, 1991).

The mating system and the formation of empty seeds, depending on the position of cones in the crown of grafts of different European larch clones in a seed orchard, were examined. Generally, a high level of cross-fertilization (93 per cent) was proven. The self-fertilization level was lower in the lower part of the crown, which was probably due to the reduced availability of the pollen of other clones. The similarity detected in cross-fertilization between grafts of the same clones may indicate a genetic control of self-fertilization (Burczyk *et al.*, 1991).

1.2. Genetic diversity in forest tree populations in Poland

Natural selection taking place in a population permanently present in a changing environment is an ongoing process that, from generation to generation, modifies the frequency and set of genotypes and, as a consequence, the frequency and proportion of genes in the population. The selections made by foresters for the needs of timber production have a similar effect so that well-performed silvicultural treatments (cleaning and thinning) in stands do not differ from the natural thinning of stands in their effects on the genetic diversity of the population, but only accelerate the process. Through rational management it is possible to produce high-quality wood in managed stands while assuring the natural level of genetic diversity necessary for the long-term and stable development of forest tree populations.

Selection has an impact on the changes taking place in the level of genetic diversity in populations. A radical change in population size from 10 000 to 250 trees causes a reduction of approximately 53 per cent in the number of alleles. At the same time, a reduction in the number of individuals only minimally affects the level of heterozygosity and reduces the level of genetic diversity by only 0.2 per cent. The removal of 75 per cent of trees in a stand caused a loss of 80 per cent of rare alleles, which means a 25 per cent reduction in the overall number of alleles. Interestingly, no losses were detected in the group of high-frequency alleles in the populations. It may perhaps be that with such a reduced pool of alleles the population eliminates the recessive and defective alleles representing the so-called genetic load first. In this way the population adaptability is not significantly affected.

The 'storage' of most of the gene pool of a species within its population has important implications for the economic activity of the breeder, as it justifies population selection as the correct breeding procedure to comply with the requirement to maintain the genetic diversity of the species. In this way a well-designed selective breeding programme can permanently secure an appropriate level of genetic diversity in forest trees. In the case of artificial regeneration, the use of a sufficiently genetically diverse planting stock becomes the basic requirement of the breeding procedure.

1.2.1. The population and progeny variation of breeding traits in the main forest tree species

Both natural selection and selective breeding lead primarily to quantitative changes but cause no major qualitative changes in the genetic diversity of populations and species. Even if progeny populations have not inherited all the alleles, new alleles appear in them. Thus, the gene pools of the progeny populations, though not identical (because they cannot be!) with the gene pools of their parental populations, are able to maintain a level of genetic variation similar to their parents'. The conclusion is that – in spite of the generational changes in the proportions of genotypes and gene frequencies – the level of genetic diversity and the range of genetic variation do not change in the successive generations.

The ongoing changes in genetic diversity should not overwhelm the forest manager and thus prevent him from acting, but should instead encourage him to recognize and understand the genetic processes occurring in forest tree populations. Breeding decisions should be supported by a knowledge of these processes, which research is continually extending. A rational compromise is required between the need for intensive production of high-quality wood and that to conserve the gene resources of forest trees. The current state of knowledge on forest tree genetics offers many arguments in favour of such a compromise and it is expected that intensified research into the molecular genetics of trees will provide further useful information and guidelines for silvicultural management.

Forest renewal is another important aspect of tree breeding that is designed to preserve genetic diversity. As stated above, maintaining the appropriate range of genetic variation and sustainable productivity in future forests depends on the production and selection of genetically diverse planting stock and on silvicultural treatments at the establishment and thicket stage.

It would appear that modern selective breeding will increasingly require the development of control mechanisms for the genetic variation of the breeding populations which, for a variety of reasons, are proposed for use in forest management. The constant enrichment of these populations with different highly plastic genotypes will also be required. These valuable genotypes are to be found in populations at various experimental sites (e.g. provenance and provenance-progeny trials) whose importance is therefore increasing. They thus need to be doing more systematic research because the older they are, the more valuable and more reliable are the results.

Concerns are sometimes raised about the genetic effects of using seeds from breeding populations, such as seed orchards, for regeneration, or about the genetic effects of different tending treatments. Behind these concerns lies the risk of mistakes whose negative effects might be seen in future generations of forests – hence the need for new research and deeper knowledge of the genetic processes taking place, which can then be transferred to silvicultural practice. Forest trees have a stable genetic structure that is able to restore its original state. There is therefore a need to take care of each individual genotype to ensure the genetic diversity of populations and species. Factors such as gene flow and cross-fertilization, or the recombination mechanism, efficiently generate new combinations of alleles in populations and therefore new genotypes. As a result, forests established by artificial regeneration retain at least the same level of genetic diversity as natural forests.

Analyses of the relationships between the genetic structure of the population and the changing environment (changing climatic conditions, air and soil pollution) have played an important role in genetic research in Poland. This has shown, among other things, that environmental pollution first eliminates trees with lower levels of genetic variation.

Synthetic studies of genetic variation in some important forest species based on the results of international provenance trials, which have included research into the population variation in Scots pine covering a large area of land stretching from Poland to the Pacific coast, have been important for forest geneticists in Europe.

These decades-long provenance trials produced selection criteria for so-called elite trees based on genotypic characteristics, which in turn made it possible to work out a methodology for establishing and managing new-generation seed orchards.

A method for restoring lost populations and their genetic variation using the genetic resources from provenance trials was developed based on the example of the Norway spruce.

Forest seed science is, indisputably, one of the leading European and global research strands. The results it has yielded have made it possible to establish a modern Forest Gene Bank and a network of modern seed stores in Poland and have projected Polish seed science into the European front rank.

Scots pine (*Pinus sylvestris* L.)

The comparative studies on the variation in breeding traits of populations and progenies of Scots pine (*Pinus sylvestris* L.) are a continuation of the long-term studies of the silvicultural value of the Polish provenances of Scots pine that were begun after 1965 by most of the forest-related research institutes, including the Forest Research Institute.

The first trials representing 12 northern provenances and the local provenance of Scots pine were established in Jabłonna in 1962 and 1964 by the Silviculture Department of the Institute. The next series of trials, which used the same initial material and a similar methodology, were established by the department jointly with other research units: the Warsaw University of Life Sciences (SGGW), the University of Agriculture in Kraków and the University of Life Sciences in Poznań. The following sites were established as part of the joint experiments: five sites with 15 Scots pine provenances in 1966, three sites of the IUFRO 82 series with 20 European provenances of Scots pine in 1982–1984 and three sites with 20 Polish provenances of Scots pine in 1989. Progeny trials on the mechanisms of intrapopulation variation were begun in 1994. The research focused on a population of Taborska pine. An experimental site in the Nowe Ramuki Forest District was established in the same year followed by a comparative experimental site in the Kutno Forest District in 1995. The department began another series of provenance-progeny trials in 2004, which involved the open-pollinated progeny of trees from selected seed stands in the Spała, Syców, Gubin, Woziwoda and Supraśl Forest Districts. In total, measurements and observations were carried out on 26 experimental sites.

Changes in the population dynamics in each successive measurement period have been observed at the oldest experimental sites established in 1962 and 1964, which indicates the need for further studies. The populations represented in the 1966 provenance experiment show statistically significant differences. The location of experimental sites and the genotype x environment interaction (provenance x location) are also important.

After forty years of growth, the Rychtal, Gubin, Bolewice, Tabórz, Wyszków, Dłużek and Lipowa populations have seen the fastest growth on most of the experimental sites. These can be used on a larger scale than previously, but only in lowland areas. The pines from Nowy Targ, Józefów, Łącka and Rozpuda grow poorly and should not be used on a larger scale. After twenty years of growth of different European provenances of Scots pine in the IUFRO 1982 experiment, the Central European populations (including the Polish populations) have demonstrated the best growth and adaptation to the environmental conditions. Among the Polish populations of pine those from Rychtal, Spała and Bolewice have shown the best growth traits. The diversity in the progeny of the Taborska pine populations is very high. It is already possible after the initial period of growth to choose the fastest growing progenies and to include this reproductive material in the 'tested' category. The best progeny of mother trees are those described by the FRI symbols 2157, 2226 and 335, and the worst those described by FRI symbols 2141, 2162 and 2112.

Most of the studies carried out by the University of Agriculture in Kraków are based at the experimental site in Polany near Grybów. They have confirmed that it is possible to use forest basic material from the northern range of Scots pine as a nurse crop and for the afforestation of post-agricultural land in the foothills and mountain areas of the Beskid Niski Mountains. These are mainly Scots pine provenances representing a climatic zone with a growing season of 205–215 days (Sabor, 1993). The groups of fast-growing provenances with the greatest dynamics (while remaining stable in terms of adaptive potential) were distinguished using Finlay-Wilkinson's method. These are the provenances of Scots pine from Dłużek and Ruciane. The provenances from Karsko, Ruciane and Nowy Targ, as well as from Lipowa, Dłużek, Starzyna and Jegiel, make up a select population.

A pine stand in the Warcino Forest District (photo by K. Murat)

It is thus possible to develop an individual selection programme for pine in the Carpathian Foothills. The programme should take into account the selected provenances of pine, including the Mazury provenances, when establishing nurse crop plantations in the foothills and mountain areas of the Carpathian Mountains. Analyses of the terpene compounds in the bark of selected trees and of their vegetatively-propagated progeny have made it possible to develop efficient genetic markers for the forest reproductive material. Delta-3-carene and beta-phellandrene are significant terpene compounds used as markers of pine.

Twenty-five maternal seed zones have been distinguished based on the available information on the variation of Scots pine in Poland. They include populations which demonstrated very good growth, plasticity and quality in the provenance trials. Among these are the Tabórz pine (106), Napiwoda pine (205), Pisz pine (206), Augustów pine (204), Supraśl pine (207), Tuchola pine (305), Bolewice pine (308), Rychtal pine (501), Spała pine (601), Kozienice pine (602) and Parczew pine (404) (Matras, 1989). The maternal seed zones also include populations with above-average breeding values occurring in areas where pine is of very poor quality, such as the Łochów pine (403), Goleniów pine (101) and Bytów pine (105).

Norway spruce (*Picea abies* (L.) Karst.)

There is a great deal of interest in the genetic variation of spruce in Poland. Even before World War II, due to the activity of Professor S. Tyszkiewicz, provenances from Poland had become part of the progeny collection from the first IUFRO experiment in 1938 (Białowieża, Istebna, Garbatka-Radom, Stolpce, Vilnius and Dolina). Regretfully, this experiment did not survive World War II.

In 1968, on the initiative of Professor T. Krzysik, Professor S. Bałut established the IUFRO 1964–1968 series of experiments in Krynica using 1 096 provenances, of which 91 were from Poland. This was a milestone in expanding our knowledge of genetic variation in the Norway spruce.

The IUFRO 1964–1968 series has been complemented by international and national provenance trials, including the IUFRO 1972 series with 20 Polish provenances and the national trials carried out earlier by the Forest Research Institute in Warsaw (Tyszkiewicz, 1968) and the Institute of Dendrology, PAS, in Kórnik (Giertych, 1970). The results of these experiments form the base for determining population variability and the genetic and breeding value of spruce in its natural range in Poland (Kocięcki 1968, 1977).

There have been species monographs by many authors, including the work edited by Tjoelker, Boratyński and Bugała (2007), as well as materials from numerous scientific conferences on the Norway spruce, which summarize the research findings on the population variation of this species in Poland. A broader presentation of the genetic variation in Polish provenances based on provenance trials can be found in several collective studies, such as the Conference Materials Concerning Research on the Norway Spruce in Poland (Institute of Dendrology, PAS, Kórnik, 1967) Population Studies on the Norway Spruce in Poland (Forest Research Institute, 1968) the monographs on the spruce from 1977 and 1998 and the results from the IPTNS-IUFRO 1964–1968 experiment (Assessment of the Seed Base for the Main Forest Tree Species in the Carpathian and Sudeten Forests and the Selective Choice of the Best Provenances; Bałut, Sabor 2001, 2002). The materials and conclusions from the national conferences on the mountain spruce (in the Carpathians and Sudetens) and on the lowland spruce (from the north-eastern range) populations held in Poland in 1994–1998 complement these studies. The results confirm the high genetic and breeding value of Polish Norway spruce populations.

The provenance experiments have been augmented by numerous physiological and biochemical studies. The major ones include the research projects on the Norway spruce that have been conducted for many years at the Institute of Dendrology, PAS, in Kórnik. These include studies by Chmura (2006) on the phenology of Norway spruce populations in the Beskidy Mountains, by Rudawska, Leski, Trocha and Górnowicz (2006) on the ectomycorrhizal status of Norway spruce seedlings from bare-root forest nurseries, by Trocha, Rudawska, Leski, Dabert (2006) on the genetic diversity of naturally established ectomycorrhizal fungi on Norway spruce seedlings, by Oleksyn, Reich, Tjoelker, Vaganov, Modrzyński (2006) on the growth response of Norway spruce to climate along an altitudinal gradient in the Tatra Mountains, by Misiorny (2007) on the polymorphism of generative organs of spruce, by Misiorny and Chałupki (2006) on the variation and phenology in the flowering and cone bearing of *Picea abies* grafts in second-generation seed orchards, by Szczygieł, Hazubska, Bojarczuk (2007) on the somatic embryogenesis of selected coniferous tree species and by Finer, Helmissari, Lõhmus, Maj di, Brunner, Borja, Eldhuset, Goodbold, Grebenc, Konopka, Kraigher, Mòttònen, Ohashi, Oleksyn, Ostonen, Uri and Vanguelova (2007) on the variation in fine root biomass.

The current research into the establishment of plantations for the gene conservation of endangered spruce populations and the genetic evaluation of seed orchards established from clones representing geographically distant provenances (Chałupka, Mejnartowicz, Lewandowski, 2008; Chałupka, Misiorny, Rożkowski, 2008) is important for genetic resource conservation programmes. The studies by Nowakowski (2004) and Prus-Głowacki *et al.* (2007) provide examples of advanced research into the genetic structure of spruce stands in Poland.

Owing to the impact of a number of biotic and abiotic factors the spruce has become one of the most endangered species. There has been a decline in spruce populations in Poland throughout their natural range and it has gathered pace in recent years. It is due to 'spiral disease' (forest decay), which involves the rapid self-thinning of trees, poor growth, reduction of the assimilation apparatus and, finally, their death. The causes are to be found in environmental pollution, droughts, attacks by pathogenic fungi and insect pests, as well as in winds and global warming. Spiral disease leads to the death of whole stands and even of whole forest ecosystems. The reason for this lies in the weakening of spruce forests of foreign origin (Barzdajn, Ceitel, Modrzyński, 2003). In Poland, ecological disasters in the Sudetens (Jizera and Karkonosze Mountains) and recently in the Beskid Śląski and Żywiecki Mountains (Sierota, 2001) have provided examples of the decline of spruce forests on a massive scale. This affects the most valuable selected stands, which are recognized in the world as a genetic population (such as the Istebna spruce), with the most valuable breeding traits. As recently as 2008 an ecological disaster reduced the area of seed stands of this population by an estimated 16 per cent and reduced the area of seed stands of plus trees by over 35 per cent (Urbaczka, 2008). This demonstrates the need to develop effective programmes to protect the genetic resources of this species.

The results of studies conducted at the University of Agriculture in Vienna may be helpful in developing forecasts of climate change in Poland. According to an analysis by Kromp-Kolb (2002), climate change in Europe is both global and local and varies in time and space. The analysis of temperature and precipitation trends has made a significant impact on the accuracy of predictions for climate change over the course of the century. These predictions foresee an increase in air temperature in the south and north-east of Europe by 0.1°C to 0.4°C, rapid winter warming in the continental climate zone and significant differences in average temperatures between the north and the south of Europe in the summer. Also, precipitation is expected to increase in the north of the Continent by between 1 per cent and 4 per cent in the winter and by 2 per cent in the summer, while rainfall is expected to decrease by 5 per cent in the south. In addition, stronger winds and more frequent storms are predicted along with a shorter period of persistent snow cover at an elevation of 600 m–1400 m a.s.l. as a result of global warming by 1°C during snow melt.

Many other research institutes have conducted studies of the variation in the populations and progenies of the Norway spruce (*Picea abies* (L.) Karst.). The most substantive information about the variation in this species comes from six experimental sites of the Forest Research Institute, three sites of units co-operating with the Institute and thirty sites established under the IUFRO 1972 series of experiments. The research covered a total of 40 populations from the entire range of this species in Poland and 300 progenies of Norway spruce from Zwierzyniec Lubelski, Suchedniów and the Białowieża Primeval Forest. In the IUFRO 1964–1968 series of experiments, Poland established an additional experimental site with 1 100 spruce populations. The populations from the north-eastern range are more homogeneous in terms of growth traits than the southern populations. The differences on the experimental sites in the populations' growth traits up to the thirty-year growth point were not found to be statistically significant. The Bukowiec–Istebna population is by far the best in terms of all the analysed traits and the southern populations are definitely better than the populations from the north-eastern distribution range.

The population growth of spruce on experimental sites in Poland in the IUFRO 1972 series varies. This diversity, expressed in standard deviation units, is half the diversity in the entire experiment, including sites established in Europe and Canada. The total genetic diversity in breast height diameter, height and volume for all spruce populations across all of the experimental sites was very high (6.0491 standard deviation units) and fell in a range from +2.6262 to -3.4229. For individual populations, meanwhile, the range was +1.9181 to -2.756 for Kartuzy and 1.437 to -0.755 for Rycerka Zwardoń. Five main groups can be created by classifying the populations in intervals of 0.5 standard deviations.

Group I, which is the best group, includes populations from Istebna–Bukowiec and Zwierzyniec Lubelski. These populations can be regarded as exceptionally valuable throughout the evaluated area. Group II includes populations from Wisła, Istebna–Zapowiedź, Zwierzyniec Białowieski 2, Rycerka–Praszywka 700 m, Rycerka–Zwardoń, Tarnawa and Bliżyn, which are valuable, but do not guarantee the desired economic results in all conditions. The Międzygórze, Kartuzy, Wigry, Zwierzyniec Białowieski 1, Orawa, Przerwanki, Borki, Rycerka–Praszywka 950 m, Nowe Ramuki and Stronie Śląskie populations make up Group III and Group IV. The growth of these populations is generally below average, which means that they should not be used on a larger scale without detailed studies. The Witów population should under no conditions be grown in lowland regions.

The most recent genetic evaluation of Polish spruce was written by Giertych in the monograph "The Biology of the Norway Spruce" (1998). Based on the results of provenance experiments, 13 seed zones of spruce were distinguished within a framework of seed regionalization: four Beskidy seed zones in the western Carpathians (801, 802, 805, 808), three Sudeten seed zones (701, 702, 703), one seed zone in the eastern and southern Carpathians (807) and five seed zones (202, 203, 204, 208, 605) of lowland spruce from its north-eastern range (Zaleski, Zajączkowska, Matras, Sabor, 2000).

The provenance trials of the population of Norway spruce from the Polish lowlands, mainly from its north-eastern range, found the Mazury-Podlasie provenances from the Knyszyn Primeval Forest and the Augustów Primeval Forest, and the Baltic provenances from the Rominta Primeval Forest, to be of high value. It should be noted that the lowland spruce populations in the IUFRO 1964–1968 and 1972 tests involved native stands within the natural range as well as stands established by artificial regeneration (Sabor, 1999). The analysis conducted by Giertych (1999) found the Białowieża populations to be of relatively poor quality, which disqualified them from wider use. However, as has been shown in some provenance tests (IUFRO 1972), single Białowieża populations from the managed part of the Białowieża Primeval Forest (Zwierzyniec Forest District) displayed high plasticity and swift growth. Based on the plasticity tests for spruce from the Knyszyn, Augustów, Rominta, Borki and Pisz Primeval Forests these populations can be recommended for use abroad and in some parts of Poland. The spruces from these areas were well-received in Scandinavia and western Canada and went on to perform very well there (Giertych, 1977, 1999). In addition, a comparative study conducted by the Forest Research Institute, which was based mainly on the results of the IUFRO 1972 experiments (Matras, 2006 a, b) confirmed the generally poorer quality of lowland spruce forests from the north-eastern range compared with the Carpathian spruce forests. It should be added, however, that spruce provenances from Zwierzyniec had better growth traits.

Spruce as a forest-forming species in the mountains occupies 196 658 hectares in the Sudeten and Carpathian Natural-Forest Regions, which accounts for 32.6 per cent of the mountain area and 7.6 per cent of the country's land area (Sabor, 1995). An analysis of mature spruce stands revealed a significant site quality variation in these populations under the homogeneous site conditions of the Carpathian Mountains and found the average site-index class of spruce forests in this region to be 0.4 above the national average. It also found that the mature Sudeten stands were of a much lower quality (by one class) compared to the Carpathian spruce stands. This variation can be considered genetic because of the comparable stand age and the homogeneity of site conditions.

The results of provenance trials found the genetic quality in most stands of the Istebna population from the Beskid Śląski and Beskid Żywiecki Mountains to be high. This concerned all of the main Polish provenance tests, including IUFRO 1972, but above all the IUFRO 1964–1968 tests. The Ujsoły and Rycerka-Kiczory provenances are considered to have the best height growth traits in Krynica. They are also resistant to spring frosts and could be said to constitute a genuine 'elite' (Sabor, 1996). The role of the Istebna spruce was emphasized in the Programme for the Selection and Conservation of Forest Genetic Resources. Its seeds are recommended for use in 50 Forest Districts in the country and its reproductive material (seeds, grafts) has been exported and been the object of international studies for years. The assessment of the intrapopulation variation of Istebna spruce and the degree of autochthony of its subpopulations lies at the heart of the present studies. Of equal importance is the *in situ / ex situ* evaluation of the progeny of selected trees and the protection of the genetic resources of Istebna spruce in the provenance-progeny archives of the Regional Gene Bank (Sabor, 1996).

The Orava spruce is, in the light of the existing principles of seed regionalization, the main reproductive base in the central Carpathian Mountains and across the Carpathian Foothills. In the provenance experiments, this population was found to improve its growth dynamics and showed high plasticity. Its widespread use in Carpathian conditions is, nevertheless, not yet scientifically justified (Sabor, Kulej, 1997).

The test results for the Bieszczady spruce population are ambiguous. In the IUFRO 1964–1968 experiment, the spruce from Tarnawa recorded poor height growth throughout the 25-year growth cycle. This population is characterized by slow spring growth and an average degree of resistance to green spruce gall adelgids (*Sacchiphantes viridis*). However, the Dolina provenance from this region, which was tested in the IUFRO 1938 experiment, is ranked among the best. In the IUFRO 1972 test, however, the Tarnawa spruce was ranked closer to the good provenances rather than to the best (Matras, 1997). Despite the differing assessments, this population should be regarded as valuable and in need of urgent protection as its distribution range is continuing to shrink. The provenance experiments pointed to the suitability for supplementary planting of the Ukrainian populations from Jasina and Dolina as well as of the Romanian provenances (Sabor, 1998a).

The Sudeten population

In provenance trials, the Sudeten spruce was classified as a population with a very low genetic value (Matras, Kowalczyk, 1998; Sabor, 1998b). The overall assessment of the genetic value of the Sudeten population of this species conducted by Giertych (1998) found that the spruce from the Kłodzka Valley were of poor quality and that the provenances from the Izera, Karkonosze and Kaczawskie Mountains in the Western Sudetens and from Jesioniki in the Eastern Sudetens were of high plasticity. These populations can be recommended for introduction into the lowlands of western Poland, while the Karkonosze populations can be recommended for planting in the mountains. It should also be noted that the Szczytna Śląska provenance tested in the IUFRO 1964–1968 experiment is regarded as valuable.

Twelve maternal seed zones of spruce are distinguished in Poland in the context of seed regionalization. They do not entirely overlap with the areas of occurrence proposed by Giertych (1977), as seed zones should ensure the supply of appropriate quantities of seeds – both for their own needs and for adjacent areas. It is therefore difficult to establish seed zones in areas where Norway spruce are sparse. The largest number of maternal seed zones (seven) are in the western Carpathians and the Sudetens. There are four in Beskidy (801, 802, 805, 808) two in the Sudetens (701, 702), and only one in the eastern and southern Carpathians (807). The remaining five spruce seed zones (202, 203, 204, 208, 605) are in north-eastern Poland.

European larch (*Larix decidua* Mill.)

Research on population and progeny variation in the breeding traits of selected origins of larch (*Larix decidua* Mill.) was carried out on four populations and at four progeny experimental sites of the Silviculture Department of the Forest Research Institute, as well as on three provenance sites of units cooperating with the Institute. A total of 42 populations of larch from the territory of Poland, Austria and Germany, and 217 families of Polish and Sudeten varieties of larch were studied. The long-term studies of the genetic and breeding value of larch trees growing on the population and progeny sites found considerable, statistically significant differences in the provenances and families tested. This applied not only to the basic growth traits (height, dbh, diameter, volume), but also to the quality of stems and to health. The diversity of these traits is primarily determined by the genotypes of the populations analysed. As the interpopulation and progeny diversity in larch may show up only in the later period of development, after the cumulation of the average volume increment, long-term studies ensure more reliable results than those that cover only the juvenile growth phase.

The European larch (photo K. Murat)

Because of the relatively high diversity in population characteristics, even across a relatively small area, it is difficult to distinguish areas with populations which may be regarded as genetically homogeneous, except perhaps for the regions where the Polish and Sudeten varieties occur. For this reason, the selection of larch populations should be conducted primarily at the stand level.

The Polish and Sudeten larch provenances growing in the lowlands (at experimental sites in Sękocin and Rogów) showed no clear differences in growth traits. There were individuals showing both fast and slow growth in both the Sudeten (Kłodzko) and Polish (Skarżysko) populations. The Czerniejewo population of larch from areas where it occurs sporadically in north-western Poland, which was tested at Sękocin and Rogów, did not differ in growth dynamics from the valuable populations of Sudeten and Polish larch. The Sudeten larch growing in the lowlands of central Poland is of a significantly poorer quality than the majority of Polish larch populations, including those from the areas where they occur sporadically. The Polish larch was clearly predominant, in terms of both quantitative and qualitative traits, at the experimental site (Bliżyn) in the Świętokrzyskie Mountains. The populations from the areas of sporadic occurrence are definitely inferior to the local populations of Polish larch. However, not all of the local populations of this variety are valuable: those from Mount Chełmowa, Grójec, Rawa Mazowiecka and Pilica are of a very poor quality and therefore can only be used locally.

In mountain conditions, the Sudeten larch provenances – especially those from Szczytna Śląska, Prószków and Kłodzko – are the ones with the highest growth, while those from the Świętokrzyskie Mountains (Skarżysko and Moskorzew) grow slightly more slowly. It has been found that the growth intensity of the northern provenances of larch from Myślibórz-Północ, from the Płonne and Tomkowo reserves in Konstancjewo and from Czerniejewo, which were hitherto poorly recognized and untested locations, increases with age. The Krościenko and Marcule provenances definitely proved to be the worst in mountain conditions. The quality of stems in the mountain populations of larch was found to increase significantly with age. At the present stage of research, the best larches are from Czerniejewo, the Płonne reserve in Konstancjewo, Myślibórz and from the selected locations (Bliżyn) in the Świętokrzyskie Mountains. The larch provenances from Grójec, Rawa and Pilica showed stem deformation. The greatest diversity of this trait was observed in the Sudeten larch. The tested populations also exhibited a significant diversity in their resistance to the larch canker (*Lachnellula willkommii* (Hartig) Dennis). Of the populations analysed in lowland conditions, only the larch from Grójec showed no symptoms of disease caused by this pathogen. Generally speaking, the Polish larch populations were much less susceptible to the disease than the Sudeten populations, while larch from Pelplin and Hołubla were very highly susceptible. The share of infested trees in Polish larch populations did not exceed a few per cent, while in the Sudeten larch the proportion was several times higher. The Polish larch populations from Grójec, Skarżysko and Moskorzew were also the most highly resistant to canker under mountain conditions.

The progeny variation in larch is several times higher than the population variation. This gives breeders the opportunity to produce artificial populations of larch with a production potential far exceeding that of natural populations and base material for finding clones for timber production in short and medium rotations.

For the purposes of seed regionalization, four maternal seed zones were distinguished in the two main areas of larch occurrence in Poland. There were three zones for the Sudeten larch (701, 702, 503) and there was one seed zone for the Polish larch ssp. (604). As was shown in the provenance experiments, a large number of the selected seed stands and most of the fast growing, good quality populations are to be found in these zones (Kocięcki, 1987).

Silver fir (*Abies alba* Mill.)

Because of the regional occurrence of silver fir populations, most of the study results on the variation in this species come from the University of Agriculture in Kraków, where Professor Stanisław Bałut set up an extensive fir experiment that involved analysing ninety-nine populations of this species from throughout its distribution range in Poland on six comparative sites. The traits of the tested fir progenies were representative of the entire range of this species. Over 58 per cent of the tested populations of silver fir (58 provenances) are considered the most valuable genetic populations (selected seed stands) and they therefore constitute the current seed base of this species. The genetic evaluation of silver fir in the Jd PL 1986–1990 experiment also included the progeny of the Powroźnik stand, which was adopted as a national standard in the Programme for Progeny Testing of the Selected Seed Stands, Plus Trees, Seed Orchards and Seedling Seed Orchards launched by the GDSF. The Jd PL 1986–1990 experimental sites were established in the mountains (Baligród and Stary Sącz), in upland areas (Łagów and Zwierzyniec) and in lowland habitats (Bielsk Podlaski and Nowe Ramuki).

The two decades of research found a high variation in the selection value of silver fir at provenance and regional levels. At the regional level, the index evaluation revealed high selection values of silver fir from the Biłgoraj Upland, as well as from the Beskid Sądecki and Świętokrzyskie mountains. It also revealed the negative selection value of the provenances from the Beskid Śląski, Beskid Żywiecki, Beskid Makowski, Beskid Mały and Sudeten mountains. Throughout the twenty years of research, silver fir from the regions of the Biłgoraj and Roztocze Uplands, as well as from the Ciężkowickie, Dynowskie and Przemyskie Foothills, exhibited high plasticity of the adaptive traits described by the effect of genotype x location interaction. Silver fir from the Beskid Śląski Mountains showed poor survival and height growth in all habitat types. The provenances from the seven regions with high plasticity, which responded positively to plantation conditions, are recommended as *elite* provenances. The Powroźnik fir provenance from the Beskid Sądecki Mountains and the Ułów provenance from the Roztocze Upland are among the best. The current assessment of the selection value of these provenances confirms their high stability over the entire period of juvenile growth. In the FBM maternal regions, the diversity of the average selection index value of silver fir indicated the stability of its adaptive traits and the very high selection values for the Roztocze populations. The index value for the Roztocze fir was high at all of the Jd PL 1986–1990 experimental sites. The Sądeckie and Świętokrzyskie firs should also be included in the group of populations that perform well. However, after being transplanted to Bieszczady conditions, the Świętokrzyskie fir showed negative adaptive values. Indeed, the Bieszczady fir had the poorest genetic and breeding quality. In the FBM of maternal regions, three provenances of the Roztocze fir with very high selection values were classified as elite populations (Ułów, Hedwiżyn and Rybnica). Four provenances of the Sądeckie fir: Berest, Kudłoń, Łomnica and Powroźnik also confirmed their superior breeding value. The Jastrzębia fir was found to be the best of the Świętokrzyskie populations.

Seven maternal seed zones of fir were distinguished based on recent research findings: two zones of the Bieszczady fir (804 and 806) one zone of the Sądeckie fir (803) two zones of the Roztocze fir (605 and 606) and one seed zone of the Świętokrzyskie fir (604).

Pedunculate oak (*Quercus robur* L.)

Research on the variation in breeding traits of the population and progeny of pedunculate oak (*Quercus robur L.*) was conducted on nine experimental sites. The growth and development of six oak provenances, represented by 60 families, was tested on four experimental sites set up in 1999, while the growth and development of eight provenances of this species, represented by 180 families, was tested on five sites established in 2000.

The intraprovenance diversity in the growth and qualitative traits of the tested pedunculate oak was higher than the interprovenance diversity after seven years of growth. The best growth on the experimental sites was reported for the Krotoszyn oaks, as well as for the Dobra Pomoc, Opole and Siena provenances. The Krotoszyn 92 and Opole provenances, meanwhile, exhibited little ability to adapt to different growth conditions. The progeny of the Młynary, Płock, Chojnów and Durowo provenances showed the poorest growth, the Młynary and Krotoszyn provenances had the best qualitative traits, while the Sienawa and Opole provenances had the worst.

What the individual provenances had in common was that, regardless of the climatic conditions, they began and ended growth at a similar time on each experimental site. The south-western provenances were the first to start spring growth, while the northern and eastern provenances were the last. The differences in the time of terminating growth between the provenances were small but a trend was noted toward early termination of growth by the provenances that began spring growth earlier and toward a longer autumn growth for the provenances that began spring growth later.

Studies of genetic variation in pedunculate oak and of the adaptability of the lowland provenance progeny to the foothill conditions in southern Poland were carried out at three experimental plantations in the Carpathian Natural-Forest Region and on its northern boundary. The results of the analysis conducted after 1996 indicated that some of the progenies had a high adaptive potential, including those from the Krotoszyn Plateau and from the selected stands in the north of the country, such as Zaporowo. On one of the plantations, the progenies of the populations from the Massif Central in central France also exhibited a relatively high adaptability. The very high survival rate detected in oaks in the juvenile phase of development and the lack of a marked effect of the genotype (of provenance and of families within provenance) on the variation in this trait indicated that the progeny of the tested subpopulations were adapting positively to changes in the environmental conditions. In terms of physiology (beginning and ending growth), the oak provenances from northern Poland were better adapted to the foothill environment, as their progenies were found to be less vulnerable to damage caused by late (spring) and early (autumn) frosts. Though the progenies of the populations from the south-western range of the species grew very fast, their quality was slightly worse because of the large proportion of oaks with proleptic shoots and poorly-shaped crowns (bushy or fork-shaped). In general terms, the research findings indicated that positive results would be achieved by using reproductive material of pedunculate oak from regions of origin other than those permitted by the current seed regionalization rules. With regard to growth, a wide diversity and a significant effect of the genotype (provenance), as well as an increasing effect of families within the provenance, was observed. In addition, the high provenance and progeny heritability suggested the possibility of effective selection straightaway in the juvenile phase of oak development. The assessment of selection values found a large diversity in the subpopulations analysed, as it was possible to select progenies with a high index value in each provenance. The genetic gain will therefore be higher as a result of the selection of trees in the stand than it would be as a result of the selection of stands.

Seven maternal zones were distinguished in Poland based on the research results and on the location of the most valuable seed base of oak. They included valuable and acknowledged populations, such as the Krotoszyn population (308), the Lower-Silesian population (502), and the Krajeńska population (304).

European beech (*Fagus sylvatica* L.)

It was not until the last two decades that studies on the genetic variation in European beech began to be conducted in Poland. The handful of earlier experiments addressed only a small number of populations and provided information of little use in forest practice. The main experiment, which consisted of Polish sites with beech progeny that were mainly from selected stands and two international sites with European populations of beech, was established in 1996. The purpose of the nationwide provenance experiment with European beech was to investigate the genetic variation in beech, its adaptability to different environmental conditions and its suitability for use in other geographical regions and seed zones in Poland. By establishing a series of comparative sites (with identical populations and similar site design, observation types and measurements), it was possible to determine genotype x environment interactions for individual populations, to identify populations useful in certain edaphic and climatic conditions and to find populations with high plasticity. Two experimental sites with European populations, including Polish ones, were tested for their genetic variation, which allowed for a more general assessment

Fruiting of the European beech (photo by K. Murat)

of the breeding value of Polish beech populations in comparison with European provenances.

The research found an exceptionally high diversity of beech populations in Poland. The statistical analysis showed significant differences in most of the quantitative and qualitative traits in the Polish populations of European beech throughout the experiment. The genotype was also shown to interact with the environment for the survival and spring growth of the populations. The beech populations from Kwidzyń, Wipsowa, Gryfin, Kartuzy and Lipusz, which were mostly from northern Poland, exhibited the best growth before reaching 15 years of age. Meanwhile, of the southern populations, only beech from the Bieszczady National Park, Zdroje, Rymanów and Prudnik had positive growth traits. However, both the northern and southern populations from Lesko, Łagów, Szczecinek, Tomaszów, Wejherowo, Milicz, Pniewy, Krucz and Łosie were in the group of populations that grew slowly. A high variation in European beech was also observed over a relatively small area so that, of the three populations from the Bieszczady National Park, only the population located in area 161a in the Moczarne Forest Sub-District demonstrated fast growth. The performance of European beech from the Kwidzyn populations was very interesting. At first, the three stands of beech were superior in height growth and breast height diameter. However, the other Kwidzyn populations, though they remained in the group of fast-growing trees, did not show such intensive growth. There were also statistically significant differences in the survival rate of Polish populations on comparative sites: a fairly high survival rate was observed on the Bystrzyca sites, a relatively high survival rate on the Choczewo, Brzeziny and Łobez sites and an average survival rate on the Krynica and Siemianice sites. Survival was found to be a trait reflecting strong interaction with the environment, which means that the transfer of beech populations was usually associated with breeding risk. The diversity in the survival rate of populations was also relatively high and reached 1.71 standard deviation units. Lowland populations, primarily the Kwidzyn beech, definitely showed the highest survival rate, although there were some lowland populations (Krucz, Lipinki, Szczecinek) for which a low survival rate was recorded. The populations with a relatively high survival rate were found in three regions of origin: the Gdańsk region, the Lublin region and the mountain region. The regions with beech populations exhibiting a poor survival rate were primarily in the Bieszczady Mountains and in north-western Poland.

It may be stated based on an analysis of variation in beech populations and their traits that it is undoubtedly the environment (experimental site conditions) that has the highest impact on population growth and development. The findings from six research sites showed that location is, like genotype, an important factor influencing the growth and development of beech populations. There is, in fact, no population in the experiment that grows fast enough and is sufficiently plastic to be used on a national scale. However, there are significant differences in the plasticity of individual populations. This trait can be helpful in determining the scale of use of selected populations. The beech populations from Gryfin, Kwidzyn, Bierzwnik, Lipusz, the Bieszczady National Park, Ustronie and Szczecinek can be regarded as highly plastic and therefore promising, while those from Krucz, Łagów, Milicz, the Bieszczady National Park, Grodzisk, Tomaszów and Karnieszewice should be used on a limited scale due to their low plasticity and should not be spread beyond their current area of occurrence.

This assessment should be regarded as approximate only. Changes in the growth of individual populations on experimental sites are so prevalent that none of the populations can be considered to have stable growth. In general, there are variations (fluctuations) in the traits analysed that cause changes in population ranks in the subsequent measurement periods – although directional changes in the ranking were also observed, which reflected a systematic increase in the case of positive changes and a decline in the case of negative changes in the traits analysed. The changes observed suggested that the assessment of the breeding values of the populations studied was seriously flawed and that this must be checked when the traits are fully developed. An analysis of the dynamics of spring development showed that a certain population diversity is typical for a certain region: the mountain populations, and the lowland populations in the west of Poland, start to develop significantly earlier than the eastern populations. The mountain populations are therefore not recommended for use on a commercial scale in the lowlands, nor should we allow transfer of the lowland beech over too long a distance from west to east.

Six maternal seed zones of European beech are established in Pomerania, including the valuable Gryfińska (102) and Drawieńska (301) populations. In the upland area, two seed zones of European beech are established in the form of the valuable Kielce (604) and Roztocze (605) populations. In the mountains, five seed zones of European beech are established: two in Bieszczady (804 and 806), one in Beskidy (801) and two for the Sudeten Mountains (701 and 702). The area of selected seed stands in the latter three regions is not as large as those mentioned earlier. They should, however, be used to the greatest possible extent as a local seed base in the conditions of the Beskidy and the Sudeten Mountains, which differ from those in the eastern Carpathians.

Silver birch (*Betula pendula* Roth.)

The economic importance of the silver birch has been increasing recently. Both large-and medium-sized wood from the silver birch is a valuable material for mechanical or chemical processing. The silver birch is also one of the main elements of the species composition of forest plantations set up on post-agricultural land and, furthermore, is suitable for fast-growing tree plantations. However, we still have insufficient knowledge of the intrapopulation diversity of silver birch in Poland. Prospects for further study appeared only in the period 1978–2007, when the Forest Research Institute established eleven comparative provenance and progeny experimental sites with silver birch, which are so far the only ones in the country.

The aim of the studies discussed in this report was to obtain information that would make it possible to establish FBM regions of silver birch and to formulate rules for the admission and transfer of the material to other regions. The data collected on the thirty-year growth period of birch provenances and families from the experimental site set up in the Nidzica Forest District in 1978, and on the ten-year growth period of birch from the six comparative sites set up in the Kutno, Wichrowo and Kwidzyn Forest Districts in 1998–1999, have been summarized. The report also contains preliminary information on four new comparative sites established in 2006–2007.

The growth of 19 provenances of birch from various regions of Poland was compared to the growth of birch in provenance-progeny trials in Nidzica. The highest average breast height diameter and the average volume of a single, 30-year-old tree were recorded for the birch provenances from Siedlce, Augustów Sztabin, Augustów Balinka, Grodziec, Białowieża 500 Cd and Augustów Bal.111b. The Siedlce provenance was the best in this respect: the volume of a single tree was approximately 60 per cent higher compared to the least productive Łomża provenance. The birch provenances of the Second (II) Mazury-Podlasie Natural-Forest Region were of the highest quality. They had straighter trunks and thinner branches (though often extending at more acute angles from the trunk) compared to the average from other regions, as well as thinner bark. The provenances of silver birch from the experimental site in Nidzica were ranked by average tree volume in conjunction with the most important qualitative trait: trunk straightness. The Augustów Sztabin, Augustów Balinka, Białowieża 500 Cd and Augustów Bal. 111b provenances from the north-eastern part of Poland were the best – both in terms of productivity and trunk shape. The Siedlce and Grodziec provenances, though very good in terms of growth, were inferior with regard to trunk straightness. The same birch families as in Nidzica were also tested on five comparative sites in Lower Saxony. The data published from these sites concern the height and trunk straightness of individual provenances aged 21. The ranking of these provenances by average height in conjunction with trunk straightness showed that the six best also came from the Mazury-Podlasie Natural-Forest Region.

Of the 16 provenances on the sites established in 1998, the Czarna Białostocka, Głusek, Augustów and Dobrzyń-Golub provenances were the best in terms of breast height diameter. In the three progeny experiments set up in 1999 with families from the selected seed stands in Janów Lubelski, Miechów and Siedlce, and from the seed orchard in the Jastrów Forest District, those produced from the seeds collected in the seed orchards were definitely the best.

The research completed to date found a high intraspecific variation in the silver birch in Poland and populations of the tree with good growth and qualitative traits can be found throughout the country's lowlands. It is therefore possible in every region to find valuable stands and plus trees whose progeny should be used as forest reproductive material. The area of the highest concentration of birch populations valued for their growth and qualitative traits is to be found in north-eastern Poland (the Mazury-Podlasie Natural-Forest Region) and, first of all, in the Augustów Primeval Forest. The birch populations in this region should therefore serve as the forest basic material for individual selection – mainly for the needs of birch plantations.

Although research has been concentrated on the silver birch, there are also provenances or families of downy birch on some ten-year comparative sites. It was found that silver birch grew on soils derived from loose sand, loamy sand or sandy loam with ground water below the rhizosphere and that it had much greater breast height diameters and heights compared to the downy birch growing in the same habitat conditions. Downy birch trees, however, usually had straighter trunks than most of the silver birch provenances.

Cherry (*Prunus avium* (L.) L.)

The fast-growing cherry is considered one of the most valuable forest tree species in Europe and it is cultivated for its wood in plantations (usually established from selected clones of the species) in many countries. In 2003, the Forest Research Institute undertook an assessment of the distribution and timber resources of cherry in Poland.

Forest survey data obtained from the database of the Forest Management and Geodesy Bureau show that this species occurred in different forest layers and in different proportions in 9141 sub-compartments with a total area of 48 375 hectares within the State Forests. The presence of cherry in the species composition of the main stand was found in 819 sub-compartments covering 3 309 hectares. In the remaining area, there were forest stands with individual trees, groups of trees or reserved old-age cherry trees. The total standing volume of cherry in the State Forests was estimated at 80 721 m^3. The largest forest resources of cherry are in the south of Poland within the limits of its natural range where four main distribution centres can be distinguished: the Lublin-Lwów Upland, the Central Beskidy Foothills, the Western Beskidy Mountains and the Sudeten Foothills. Cherry is less abundant in northern and western Poland but does occur there in many isolated groups, which seems to confirm the opinion that this species was planted there. The cherry usually occurs and grows well in Poland in the fresh broadleaved, upland broadleaved and montane forests, as well as in the moist broadleaved forests and the mixed moist broadleaved forests.

The State Forests have a fairly large reproductive material base for the selective breeding of birch cherry in the form of 1624 hectares of stands with cherry trees aged 50 and above. If the depletion of the genetic resources of the indigenous cherry is to be prevented, it is a matter of urgency to develop a comprehensive programme for its conservation and genetic improvement.

Wych elm (*Ulmus glabra* Huds.)

Studies of the wych elm are still at an early stage of development. They are focused on testing the progeny of nine trees on seven experimental plantations. The study has found significant diversity in the analysed traits, both in the nurseries and in the conservation plantations. There is a significant variation into two leaf morphotypes (ssp. *glabra* and *montana)*, which depends mainly on the genotype, while the heritability of this trait is very high at 0.810. The variability of the wych elm reported by the few other European experiments was thereby confirmed.

Grand fir (*Abies grandis* (Dougl.) Lindl.)

The many years of research into the genetic and breeding value of the grand fir in the habitat conditions of the Beskid Sądecki Mountains have found a significant diversity in the tested provenances. This applies above all to the survival, growth, trunk shape, productivity, volume increment and selected morphological characteristics of its needles and branches. The variability of these traits is largely determined by genotype. The diversity in the survival percentage between provenances is of a clinal nature and depends on the height above sea level and latitude of the parent stands. According to the Muller division of the range, grand fir from the first natural range show a higher growth rate compared to the second range. The growth of grand fir trees can be predicted with high likelihood from observations of grand fir trees aged 8–14 years. The Salmon River provenances of the grand fir from British Columbia in Canada, which perform well in the habitat conditions of the Beskid Sądecki Mountains, are regarded as the best for breeding. The provenances from Vancouver Island in Canada and from the western slopes of the Cascade Mountains should be considered useful for introduction and adaptation to the mountain forest conditions in Poland.

A few experimental sites were also established for other forest tree species, such as the European ash, the black alder and the Douglas fir. However, due to the limited range of the tests conducted with these species their variation was difficult to characterize.

2. The importance of forest genetic resources

2.1. Poland's most economically important timber resources and forest tree species

The tree species with the highest volume share in forests in Poland under all forms of ownership are as follows: Scots pine (62 per cent), Norway spruce (8 per cent), European beech (7 per cent), pedunculate and sessile oaks (6 per cent) and silver birch, silver fir and black alder (approx. 5 per cent each). These are also the most important tree species for timber production.

According to the Large-Scale Forest Inventory data, timber resources in forests under all forms of ownership in the years 2006–2010 amounted to 2336 million m^3 of gross merchantable timber, including 1865 million m^3 in the State Forests and 355 million m^3 in private forests. The latest data from 1 January 2010 estimated timber resources in forests managed by the State Forests at 1748 million m^3 of gross merchantable timber. According to the Forest Management and Geodesy Bureau, timber resources in private and commune-owned forests stood at 188.6 million m^3 of gross merchantable timber as of 1 January 1999. The last data prepared by the Central Statistical Office on Poland's timber resources are from 1997. Timber resources under the management of the State Forests and under other forms of ownership in Poland were estimated by experts at 1914 million m^3 of gross merchantable timber as of 1 January 2008.

There has been a steady growth in timber resources since the first inventory made by the State Forests in 1967 (Fig. 15).

Stands aged 41–80 years account for more than 50.6 per cent of timber resources within the State Forests and nearly 70 per cent in forests in private ownership (Fig. 16). The volume of stands older than 100 years (including classes KO, KDO and BP) accounts for 7.7 per cent of all timber resources within the State Forests and 3.1 per cent of those in privately-owned forests (Fig. 17).

According to the forest area and timber resource update of 1 January 2010, the average standing volume of afforested land in the forests managed by the State Forests was 250 m^3/ha, while the latest available figure for private and commune-owned forests (1 January 1999) put the volume at 119 m^3/ha (Fig. 18). The Large-Scale Forest Inventory showed that the average standing volume of forests managed by the State Forests in relation to the total forest area was 264 m^3/ha, while in private and commune-owned forests it was 220 m^3/ha.

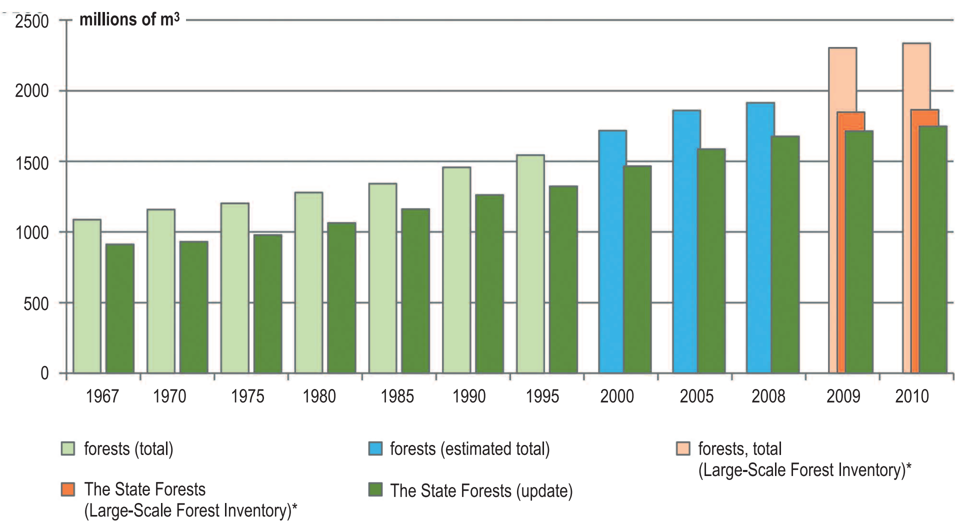


Fig. 15. Forest timber resources in Poland in 1967–2010 in millions of m^3 of gross merchantable timber (data from the Central Statistical Office, Forest Management and Geodesy Bureau and Large-Scale Forest Inventory)

* data from Large-Scale Forest Inventories 2005–2009 and 2006–2010

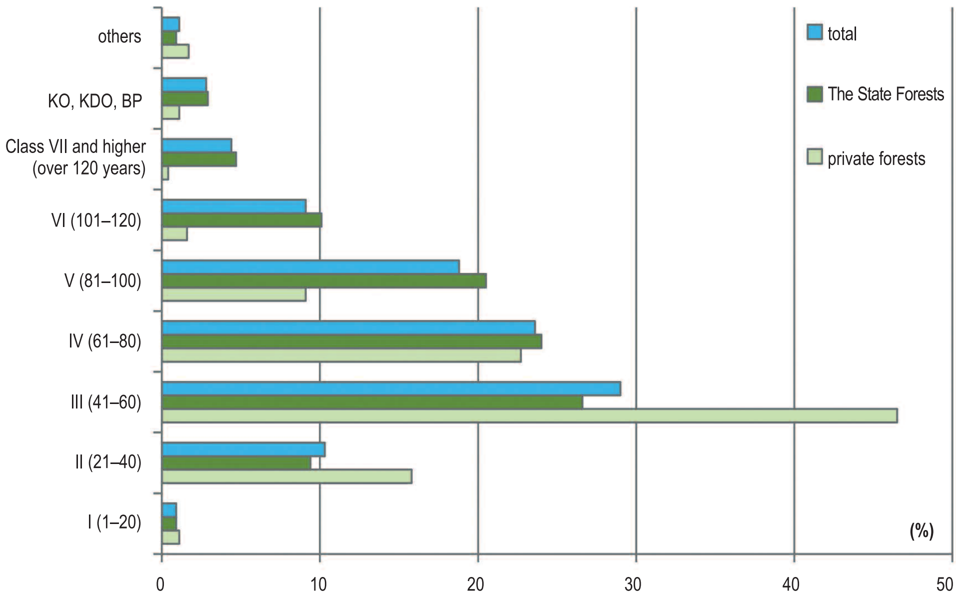


Fig. 16. Volume structure of timber resources under all forms of ownership in the State Forests and private forests by age class (Large-Scale Forest Inventory)

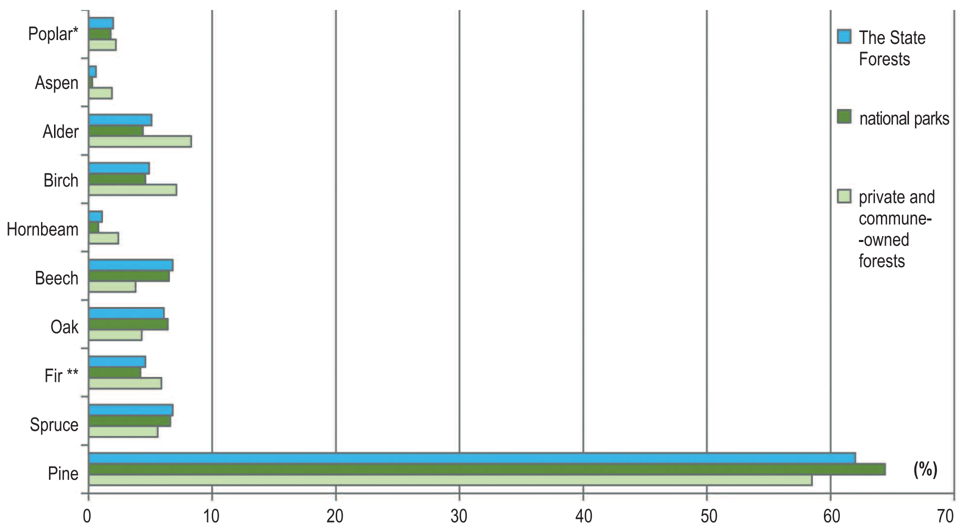


Fig. 17. Volume share of dominant tree species in forests under all forms of ownership in the State Forests and in private forests (Large-Scale Forest Inventory)
* with other broadleaves, ** with other conifers

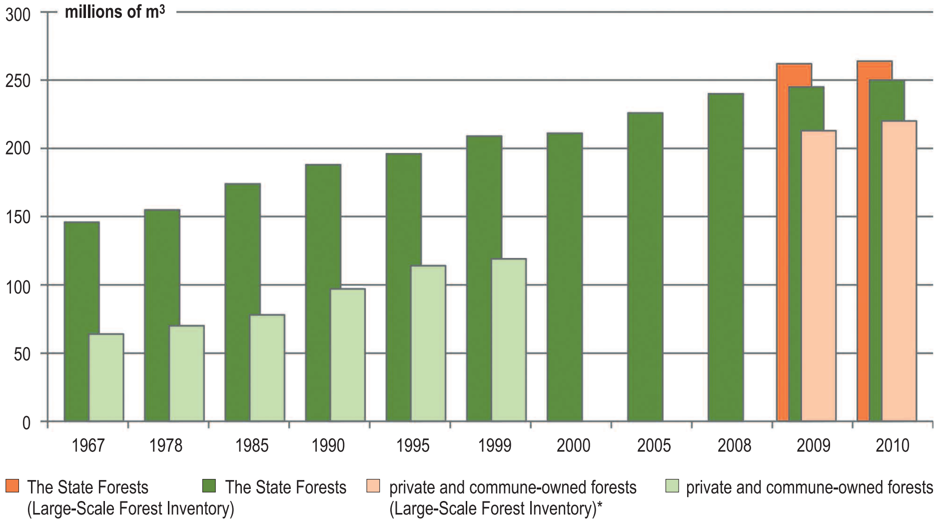


Fig. 18. Average standing volume in Poland's forests in 1967–2010 in m^3/ha of gross merchantable timber (Central Statistical Office, Forest Management and Geodesy Bureau, Large-Scale Forest Inventory)
* Large-Scale Forest Inventory data for 2005–2009 and 2006–2010

The harvest of merchantable timber at 55 per cent of current increment means that timber resources are also increasing and now amount to 2.049 billion m^3. The average standing volume for Poland amounts to 219 m^3/ha, which is one of the highest in Europe (FRA, 2010). In recent years, more than 32 million m^3 of timber has been harvested annually in Poland: 34.6 million m^3 of timber, including 32.7 million m^3 of merchantable timber (Central Statistical Office 2010).

The FRA 2010 assessments ceased to use uniform data (adoption of a threshold of 0 cm for resources) and used national definitions instead. In the case of Poland, the volume of timber resources refers to merchantable timber of over 7 cm in diameter.

2.2. Type and importance of timber production

The use of forests as a renewable raw material resource is not only driven by market demand, which ensures the economic conditions for forest management, but also by silvicultural needs and the principles regulating the structure of forest resources. Forest utilization is pursued at a level determined by the natural conditions of timber production and on the principle that forests should be sustainable and that their resources should increase. From January 1990 to January 2010, the increment in forests managed by the State Forests amounted to approximately 1072 million m^3 of gross merchantable timber. During that period, 586 million m^3 of merchantable timber was harvested, which means that 486 million m^3 of gross merchantable timber – 45 per cent of the total increment – remained to be added to timber resources (RoSL, 2011).

The volume of timber harvested in Poland in 2010 was 35 467 thousand m^3 of net merchantable timber, which included 1243 thousand m^3 from private forests and 201 thousand m^3 from stands in national parks.

In 2010, 8675 firms were registered as customers of wood produced by the State Forests. However, approximately one third of them purchased wood only occasionally for further processing, while the demand from some others was probably for resale. Approximately 90 per cent of the volume of wood sold in Poland is purchased by 700 buyers. It is estimated that approximately 60 per cent of the processed or unprocessed wood is exported to foreign markets.

The most important elements of the wood offer in Poland are large-sized wood (logs) from coniferous species at 10.3 million m^3 and medium-sized wood at 10.3 million m^3 (averages from 2000–2010; Central Statistical Office, 2010), which together account for nearly 60 per cent of harvested merchantable timber.

Large-sized wood from broadleaved species, including the European beech, is also becoming more popular. A significant increase has also been noted in the consump-

The Wilczków oaks in the Szczecinek Forest District (photo by K. Murat) tion of middle-sized hardwood, including in wood used by local communities as fuel and for heating needs. It is estimated that the demand for this wood has recently increased by 24 per cent to approximately 3.8 million m^3 annually (DGSF, 2011).

2.3. Exotic species in forests

Forest management in Poland is based on indigenous forest-forming tree species and a small number of exotic species. The total area covered by these species in Poland is estimated at 46 000 hectares, of which 39 000 hectares are covered by species that were until recently regarded by the environmentalists as invasive (SoEF Country Report, 2011)*. The following species are foreign to Polish forests: *Robinia pseudoacacia* L., *Quercus rubra* L., *Pseudotsuga menziesii* (Mirb.) Franco, *Larix kaempferi* (Lamb.) Carrière and *Larix x eurolepis* Henry, *Pinus nigra* J.F. Arnold, *Pinus strobus* L., *Acer negundo* L., *Prunus serotina* Ehrh. *and Salix acutifolia* Willd. Of these species, *Robinia pseudoacacia* L. (7 228 ha)**, *Quercus rubra* L. (5921 ha)**, *Pseudotsuga menziesii* (Mirb.) Franco (3217 ha)**, *Pinus nigra* J.F. Arnold (2956 ha)**,

A plus tree of Douglas-fir in the Warcino Forest District (photo by K. Murat)

Pinus strobus L. (1002 ha)**, *Larix kaempferi* (Lamb.) and Carrière and *Larix x eurolepis* Henry* occupy the largest area.

None of these species is considered invasive by the current Polish legislation (Ordinance of the Ministry of the Environment of 9 September 2011). Woody species that are potentially invasive are not included in the National Environmental Monitoring programme, though some are monitored to a certain degree by the Institute of Nature Conservation in Kraków (http://www.iop.krakow.pl). The presence of alien species is also recorded during the monitoring of species and habitats carried out by the Chief Inspectorate for Environmental Protection Monitoring.

* The SoEF Country Report of 2011 does not take into consideration the areas in the Polish forests occupied by *Larix kaempferi* (Lamb.) and Carrière and *Larix x eurolepis* Henry. There are 246 young stands of *Japanese larix* (*Larix kaempferi* (Lamb.) *Carrière*) and the hybrid (*Larix x eurolepis* Henry) in north-western Poland (the Gdańsk, Szczecinek, Piła, Poznań, Szczecin RDLPs) and 60 older stands located throughout Poland (the Wrocław, Katowice, Gdańsk, Piła, Szczecin, Lublin, Białystok, Poznań, Radom, Szczecinek, Olsztyn RDLPs) (Filipiak, 2008, 1993).

** Area by actual species – the areal share in individual stands by actual species was established as a multiplication of the percentage share in the species composition and the area of the given stand (Forest Management and Geodesy Bureau, 2008).

2.4. Environmentally important protected and endangered tree species growing in plantations

The biocoenotic indigenous species, which do not usually form forests but occur in stands individually or in clumps, are of high environmental value and demonstrate the high biological diversity of Polish forests (Table 6).

In Poland, the following tree and shrub species are considered endangered at species level (Ordinance of the Minister of the Environment of 9 July 2004):

- Common yew (*Taxus baccata* L.),
- Arolla pine (*Pinus cembra* L.),
- Ojców birch (*Betula x oycoviensis* Bess.),
- Shrub birch *(Betula humilis* Schrank),
- Dwarf birch *(Betula nana* L.),
- Swedish whitebeam (*Sorbus intermedia* (Ehrh.) Pers.),
- Wild service tree (*Sorbus torminalis* (L.) Crantz),
- Mountain pine (*Pinus mugo* Turra),
- Peat-bog pine (*Pinus uliginosa* Neum.),
- European dwarf cherry (*Prunus fruticosa* Pall.),
- Common sea-buckthorn (*Hippophaë rhamnoides* L.).

According to the IUCN categories, only some of them are on the Red List of Plants and Fungi in Poland or in the Polish Red Data Book of Plants (Zarzycki, 2006; Kaźmierczakowa, 1993).

The species *Betula nana* L., *Betula humilis* Schrank, *Quercus pubescens* Willd. and *Sorbus intermedia* (Ehrh.) Pers are in the Endangered (EN) category.

The species *Betula x oycoviensis* Bess. and *Juniperus sabina* L. are in the Vulnerable (VU) category.

Other tree species may also be considered locally endangered at the population level. These are species whose local populations have undergone genetic erosion as a result of the impact of anthropogenic and other damaging factors. These species include:

***Fraxinus excelsior* L.**

Populations of the European ash are endangered in its natural range across the country and, over the last decade, dieback of European ash has been witnessed. Research undertaken in Poland and other countries has detected the presence of sev-

The European ash (photo by K. Murat)

eral fungal pathogens of which *Chalara fraxinea,* which was described as a new species by prof. Tadeusz Kowalski, has proven to be the most dangerous. As ash dieback poses a serious threat to forests, parks and woodlands, the Secretariat of the European and Mediterranean Plant Protection Organization (EPPO) decided in 2007 to add *C. fraxinea* to Alert List 2011. In 2008, *C. fraxinea* was first considered to be an anamorph of *Hymenoscyphus albidus*, which had previously been described as a non-pathogenic, native and widespread species in Europe. The appearance of the new disease was, therefore, difficult to explain. However in 2011 a molecular analysis showed that *C. fraxinea* was indeed the anamorph of a new fungal species *Hymenoscyphus pseudoalbidus* (different from *H. albidus*). This fungus causes damage to the shoots in tree crowns, while pathogens of the genus *Phytophthora* – especially *P. plurivora* isolated from the fungi of the group *Oomycetes* – are responsible for root collar necrosis and fine root mortality.

Earlier studies had found that abiotic factors were the primary causes of diseases in ash trees and seedlings, while fungi such as *Discula fraxinea*, *Phyllactinia fraxini* (DC.) Homma, *Diplodia mutila, Nectria cinnabarina* (Tode) Fr. and *Nectria galligena* Bres, as well as insects such as *Stereonychus fraxini* De Geer and *Prays curtisellus* Don., were secondary disease-causing agents (Przybył, 2002).

Ash decline of varying levels of intensity has been observed in Polish forests for several years. The disease is now recorded in an area of 11.8 thousand hectares (3.4 thousand hectares fewer than in 2009). As in 2009, the majority (82 per cent) of areas with trees showing the symptoms of the disease are in mature stands (RoSL, 2011).

***Abies alba* Mill.**

Human activity in the 18th and 19th centuries and the ecological disaster that took place in the 1980s have resulted in a reduction in the proportion of silver fir in the Sudeten Mountains and Sudeten Foothills stands to 0.36 per cent. There are few remaining silver fir stand locations and those stands that have endured have a low number of trees. This has happened because for one-hundred years there has been no mating of individuals in this mountain range, which has eventually led to the genetic depletion of local populations (Barzdajn, 2000).

***Ulmus glabra* Huds., *Ulmus laevis* Pall., *Ulmus carpinifolia* Gled.**

None of these species has yet rebuilt its natural distribution potential after having been affected by what is popularly known as Dutch elm disease, which is caused by the fungi *Ophiostoma ulmi* (http://pl.wikipedia.org/wiki/Grzyby), *Ophiostoma himal-ulmi* (http://pl.wikipedia.org/wiki/Ophiostoma_ulmi) and their hybrid *Ophiostoma novo-ulmi Brasier* (Brasier, 1991) (*vide* Elm monograph, Kórnik).

Individual local populations or population groups of *Pinus sylvestris* L., *Picea abies* (L.) Karst., *Larix decidua* Mill. and other species in selected areas threatened by biotic, abiotic and anthropogenic factors – particularly the European larch (*Larix decidua* Mill.). Populations of this tree from northern and western Poland were significantly afflicted in the post-war period by genetic pollution from *Larix kaempferi* (Lamb.) Carrière (Filipiak 1993; Filipiak, 2008).

***Populus alba* L., *Populus nigra* L., *Populus x canescens* Sm.**
A few, residual populations, which typically occur in the riparian habitats of poplar in the valleys of large rivers, such as the Vistula, Oder and Warta, and occupy very narrow strips of land that for a variety of reasons are not used for agriculture (Danielewicz, 2008).

***Sorbus torminalis* (L.) Crantz.**
This species forms small insular populations on the north-eastern limits of its natural distribution in Poland. The insular occurrence of the populations, with only about 3600 adult individuals inventoried, the competition from other more expansive tree species, as well as the abandonment of active protection of the species in most of its locations may be the cause of the low gene transfer between populations, genetic drift, lack of seed cropping and withdrawal of the species from Polish forests (Bednorz, 2004; Bednorz, 2006; Bednorz, 2009).

2.5. The economic, environmental and social significance of forest tree species and wood products

The economic importance of individual tree species is primarily associated with their level of supply to the national and local markets. *Pinus sylvestris* L. has the greatest economic importance in Poland as it has the highest areal (60.4 per cent) and volume (62 per cent) share. Locally, though, other tree species such as *Picea abies* (L.) Karst. in the Sudetens and the Western Carpathians and *Abies alba* Mill. in the Central Carpathians and the Carpathian Foothills are also important. Deciduous species, such as *Fagus sylvatica* L. in northern and southern Poland and *Betula pendula* Roth., are also gaining economic importance all over the country as a source of firewood. All of the biocoenotic species are environmentally important, but especially the small-leaved lime, large-leaved lime, wild service tree, rowan, whitebeam, sycamore maple, Norway maple, field maple, common hornbeam, cherry, common pear, crab apple, field elm, wych elm and smooth-leaved elm.

2.6. Seed regionalization

Poland's location in a transitional climate zone between oceanic and continental influences has resulted in the high plasticity (adaptability) and tolerance shown by the majority of species to the growth conditions in Poland. The valuable forest tree populations that have been preserved open the way to 'improving' individual trees and entire stands and for using them in forest management. However, action needs to be taken to ensure their permanent conservation. The use of existing resources is possible thanks to generative reproduction by which seeds necessary for forest regeneration are produced (Fonder, 2007).

In accordance with the provisions of the OECD Regulations, EU Council Directive 1999/105/EC and the Polish Act on Forest Reproductive Material, the regions of origin cover areas:

- with sufficiently homogeneous ecological conditions,
- with stands or sources of seeds showing similar phenotypic or genotypic traits,
- selected out with account taken of differences in altitude,
- whose boundaries were set based on the boundaries of the country's administrative units.

The aim of the regionalization of forest reproductive material in Poland is to:

- select and preserve the genetic distinctiveness of the highest number of natural, autochthonous and indigenous (or potentially indigenous) populations of the main forest tree species,
- promote these populations in areas where the local base of seed stands is insufficient,
- reduce the uncontrolled movement of reproductive material and to establish clear rules and objectives for its transfer so that forest sustainability can be maintained,
- establish a system for the permanent recording and monitoring of the origin of reproductive material.

The regions of origin in Poland were distinguished based on:

- the ecological and genetic diversity of the nine species covered by regionalization in accordance with the provisions of the Act of 7 June 2001 on Forest Reproductive Material (Kocięcki, 1990; Matras, 1991, 1996),
- Poland's climatic, geomorphological and natural diversity,
- the international macro-division of Europe into provinces, sub-provinces, and physio-geographical regions (Kondracki, 1998),
- the division of Poland into Natural-Forest Regions and sub-regions (Trampler *et al.*, 1990).

There are 82 regions of origin of the basic material in Poland (Fig. 19).

Fig. 19. Regions of origin of forest basic material in Poland, 2011 (Forest Research Institute, 2011)

The aggregation of stands as a seed base was the most important criterion for delineating regions of origin. Regions of origin were designed to preserve the genetic distinctiveness of natural, indigenous or potentially indigenous tree populations in areas with relatively uniform ecological conditions. These regions are home to the most valuable Polish populations of forest tree species, which are subject to the statutory requirement of regionalization for their outstanding quality and growth. The seed base (basic material) is composed of stands distributed across large areas that have similar genotypic or phenotypic traits.

2.7. Priority actions for forest management

2.7.1. Stand conversion

The State Policy on Forests adopted by the Council of Ministers in April 1997 stipulated that forest resources shall be increased through the restitution and rehabilitation of forest ecosystems, which is to be achieved mainly by the replacement of monocultures by mixed stands on appropriate sites (State Policy on Forests, 1997). This requirement can also be found in art. 13, para. 1, point 4 of the Forest Act, which imposes the obligation "to convert and rebuild stands where these are not in a condition to ensure the achievement of the forest-management objectives set out in the Forest Management Plan and Simplified Forest Management Plan" (Forest Act, 1991). The respective provisions governing activities related to stand conversion in Poland can also be found in The National Strategy for the Conservation and Sustainable Use of Biological Diversity (2007) and in the National Environmental Policy (2008). These initiatives apply in particular to single-species stands in mixed coniferous and mixed broadleaved forest habitats.

It should be noted that the structure of the stands in the State Forests reflects a series of unforeseen events and the social and economic conditions that prevailed during the 20th century. In large part, Polish forests are replacement communities that are made up of pine or spruce monocultures, which have been established artificially to replace naturally developed ecosystems. Coniferous trees predominate on 70.8 per cent of the country's land area as a result of disturbances in the species composition of forests in Poland caused by forest management conducted in accordance with the 'normal forest' criteria. This approach favoured fast-growing conifer species, mainly *Pinus sylvestris* L., *Picea abies* (L.) Karst. and, in some regions, *Larix decidua* Mill. However, the natural share of coniferous forests (pine, spruce and fir) in the habitat structure of forests was only a little above fifty per cent (52.1 per cent) (RoSL, 2011). In accordance with the State Policy on Forests mentioned above, the stand conversion process taking place in Polish forests is aimed mainly at increasing the share of deciduous trees (in some regions this is the silver fir *Abies alba* Mill.) as well as at diversifying the age and species structure of stands.

Pinus sylvestris L. has, over the centuries, appeared as a substitute species where agricultural production was abandoned or where forest communities were introduced as a result of planned afforestation. In north-western Poland, large areas of monospecific and even-aged pine stands were established by planting an area of a few hundred thousand hectares following the disastrous outbreak of primary pests (especially pine beauty moth) in the years 1922–1924. After World War II, more than two million hectares of post-agricultural land and wasteland in Poland were afforested with species not always adapted to the habitat conditions – usu-

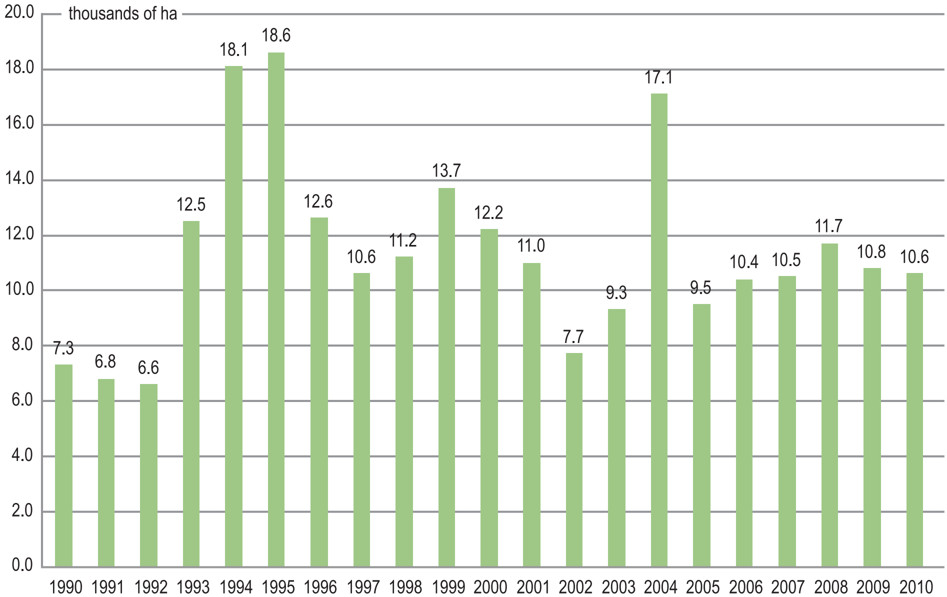


Fig. 20. Stand conversion in the State Forests in 1990–2010 in thousands of hectares (DGSF, 2011)

ally with pine or spruce and, additionally, with self-seeded expansive pioneer species (birch, gray alder, aspen) that supplemented existing plantations or formed new ones. In typical forest habitats moreover, as a result of insufficient recognition of their production potential (lack of soil and habitat analysis), species were introduced with lower edaphic requirements than would be correct with respect to the real fertility of the site. As a consequence, the species composition of only 41 per cent of stands administered by the State Forests can be regarded as suitable, while 40 per cent can be regarded as partially suitable and 19 per cent (approximately 1.3 million hectares) as unsuitable for the production forest habitat type (PFT) (GDSF, 2011).

Many stands unsuitable for the PFT need to be converted in the next 50 years. Over the past 20 years, the average area of annual cut in final felling and thinning associated with stand conversion on the territory of the State Forests was 10 000–12 000 hectares. In 2011, it was 10 640 hectares (GDSF, 2011) (Fig. 20).

2.7.2. Restitution of the silver fir (*Abies alba* Mill.) in the Sudetens

One of the major tasks of forest management in south-western Poland is to reconstruct the distorted phytocenoses in the Sudetens. Economic history records massive deforestations in the Sudetens, which began in the 14th century. They were caused by the demand for charcoal from glass works and metallurgy, and for potash from the textile and glass-making industry. Until the middle of the 18th century, there had been continuing deforestation and conversion of forests to mountain pastures. But metallurgy destroyed the forests almost completely and the middle years of the 18th century also saw the collapse of herding. The introduction of forest management to the Sudetens is associated with the annexation of Silesia by Prussia in 1742, but it was only in 1777 that Frederick II Hohenzollern passed a law enforcing the measurement and description of the Silesian forests as well as the method to be employed for stipulating the annual cut (Broda, 1965). From that moment the species composition of the Sudeten forests could be determined based on relatively accurate estimates. The law introduced by Frederick II Hohenzollern slowed the deforestation process and imposed a requirement for land afforestation. It was Norway spruce seeds that were the first to be used for this (Zoll, 1963).

Spruce has for centuries generated a much higher short-term income for forest owners than other tree species. The choice of a species for reforestation and afforestation has therefore been simple. In 1826, Hundeshagen published a theory of '*the normal state of sustainable forest management*', which is known today as '*the theory of the normal forest*'. It had and continues to have a huge impact on the theory of forestry and, right from the beginning, has also concerned the Sudeten forests. According to this theory, forest management requires the forest to be divided into even-aged stands, or so-called age classes. In practice, this means the use of clear cuts (rather than shelterwood felling) and artificial (rather than natural) regeneration. Today this is called the clear-cut system of forest management. Under the influence of this theory, large landowners introduced a clear-cut system where felled areas were restocked by spruce. This system survived in the Sudetens until 1914 (Zoll, 1963). Its consequences for the species composition of the Sudeten forests have persisted until today, so that two important forest species, the European beech and the silver fir, have been almost completely eliminated from the Sudetens. The number and area of locations of silver fir in this region have fallen drastically to 0.36 per cent and the number of locations with 6–10 individuals is now estimated at 2575.

Analyses of genetic structure based on enzyme variation have shown the genetic distinctiveness of the silver fir from the Sudetens when compared with the silver fir from the Carpathian Mountains (Mejnartowicz, 1979, 2004; Lewandowski, Filipiak, Burczyk, 2001). Bergmann (1995) suggests that the fir from the Polish Sudetens is genetically similar to the fir from the Harz Mountains (Saxony) and that it can be used for the reproduction of the species in that area. In managed forests, the introduction of foreign populations is permitted, however this may cause a loss of genetic distinctiveness in local stands. This has prevented effective management of the genetic resources of this species and it was for this reason that a restitution programme for fir in the Sudetens was introduced in the 1990s.

The restitution strategy

The reasons for adopting the restitution programme were based on the following assumptions:

1. The low proportion of silver fir in forests where the desired level is 20 per cent.
2. The very important role of the silver fir in stabilizing spruce forests.
3. The genetic distinctiveness of the Sudeten population compared to the populations from all other refugia of silver fir in Poland.
4. Scattered locations with a small number of silver fir trees, which do not guarantee natural regeneration but ensure the accumulation in the next generations of recessive alleles that cause a reduction of adaptive potential (due to self-pollination), further reduction in the number of silver fir trees and a decrease in genetic variation.
5. The very small local seed base of the silver fir.

The activities included taking an inventory of mature individuals in different regions of origin and altitudinal zones, the grafting of an appropriate amount of clones and the establishment of conservation orchards. A total of eight orchards in the territory of the State Forests and three conservation orchards in the Karkonosze National Park were established. The forest reproductive material to be collected from these plantations will be used to restore fir stands in an area of 38 000 hectares in the Sudetens so that the share of fir in the mountains can be increased to 20 per cent. At present, using the existing seed base, approximately 200 hectares of fir plantations are being established every year as a part of the stand conversion initiative (Barzdajn, Raj, 2008).

2.7.3. The protection and restitution of the common yew (*Taxus baccata* L.) in Poland

The common yew, *Taxus baccata* L., is one of the few tree species in Poland that forms natural associations or groups of trees. It is subject to strict species protection and is also included in the Polish Red Data Book of Plants.

As has been shown by long-term observations, it is no longer possible to preserve the genetic resources of the common yew by relying solely on natural processes. The passive conservation of the common yew often leads to it being ousted by other tree and shrub species, which leaves the species in poor health and gradual decline.

In spite of the problems with the restoration of the common yew in natural locations, many individuals produce large quantities of seeds and, because of the wide ecological range of the species, a research initiative has been launched to examine the possibilities for its restitution.

The Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., in Poland, which began to be developed in 2006 and has been im-

The Common yew (photo by K. Murat)

plemented by the organizational units of the State Forests, is an important element in the tree's restoration. Based on the Forest Research Institute data and on other publications, 36 locations of the common yew with FBM potential have been identified.

The development and implementation of the programme is part of the National Strategy for the Conservation and Sustainable Use of Biological Diversity, which concerns the development and implementation of programmes for the *in situ* and *ex situ* protection of species that are disappearing or that are the most endangered.

The assumptions, objectives and executors of the programme

The programme was based on the inventory of the common yew (its natural and artificial locations) carried out in 1999 by the Forest Research Institute. The inventory helped to identify about 500 common yew locations (of which approximately 280 were probably natural ones) and to select the 36 populations referred to above (Fig. 21).

The primary objectives of the Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., in Poland are to protect its biological diversity, population and individual variation, as well as to reinstate and reintroduce

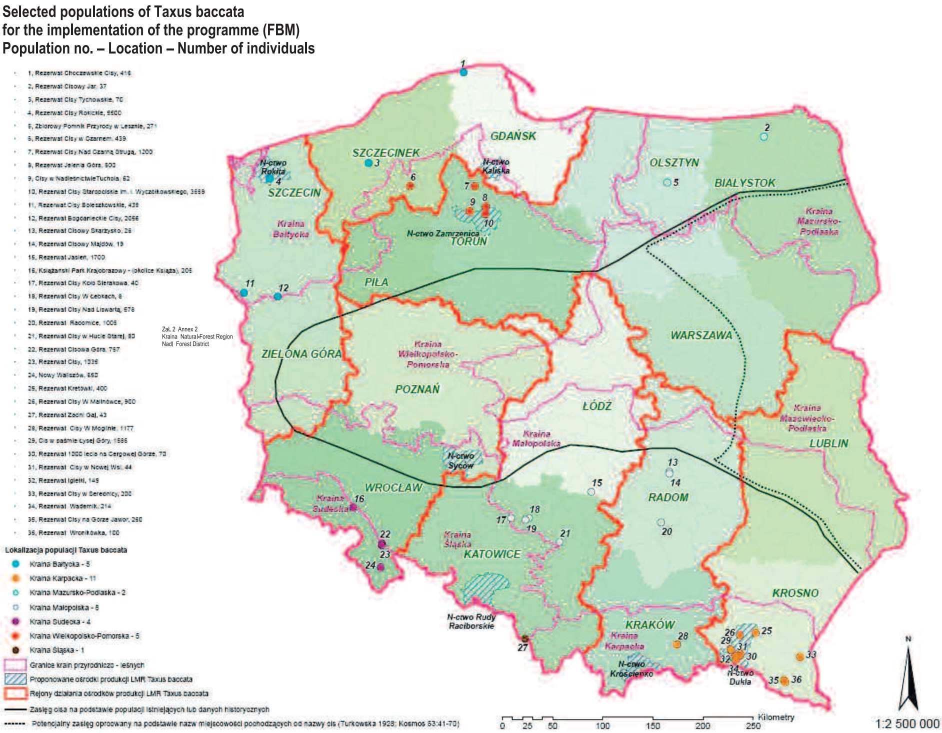


Fig. 21. The Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., in Poland

the species. Natural processes appear unequal to the task and active protection is therefore being used to conserve its genetic resources.

The common yew which occurs in natural habitats is, in managed forests, regarded as a biocoenotic and admixture species. The silvicultural and protection treatments applied are aimed at improving the conditions for development and health of the entire population, as well as at increasing the tree's fruiting by restoring the light conditions appropriate for the species. As the activities undertaken so far have produced desirable results, the participants in the programme are actively involved in developing proposals for protection tasks for the nature reserves that harbour populations of yew. The organizational units of the State Forests, the national parks and interested non-governmental organizations are also engaged in the implementation of the programme.

Implementation of the programme

In 2007, the Kostrzyca FGB used the data obtained from the organizational units of the State Forests to update the common yew inventory carried out by the Forest Research Institute in 1999 (Table F).

Table F. The number of common yew trees on the territory of individual RDSFs (Kostrzyca FGB, 2007)

RDSF	Total [number of yew trees]	In nature reserves [number of yew trees]	In private forests [number of yew trees]
Białystok	193	36	
Gdańsk	709	186	
Katowice	2 816	2 299	
Kraków	3 230	1 242	1 400
Krosno	5 204	3 228	984
Łódź	80		
Olsztyn	202		
Piła	816		
Poznań	269		
Radom	1 214	737	
Szczecin	20 196	6 163	
Szczecinek	1 113	498	
Toruń	10 748	6 792	
Warsaw	138		
Wrocław	4 024	2 387	
Zielona Góra	1 330		
Total:	**52 382**	**23 568**	**2 382**

The Selection of Genotypes and Populations of the Common Yew for the Protection of Genetic Variation (research in support of the Programme for the Restitution of the Common Yew in Poland) research project commissioned by the Directorate General of the State Forests and developed by the Institute of Dendrology, PAS, in Kórnik has been underway since 2008.

The project is designed to examine the level of genetic variation within and among each of the 36 selected populations of common yew in Poland. This will facilitate the estimation of their genetic diversity in the country, which will allow proper seed management under the Programme for the Restitution and Reintroduction of the Common Yew.

In addition, common yew seeds are being collected and seedlings are being produced for the establishment of seed orchards and under-canopy regeneration. The long seedling production cycle associated with the need for seed stratification and the slow growth typical of this species at any stage of its development is a limitation to the programme.

Projects implemented within the framework of the programme

Projects implemented in Poland:

1. The Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., at the Gdańsk RDSF including seven Forest Districts: Choczewo, Elbląg, Gdańsk, Kaliska, Lębork, Lipusz and Wejherowo – with the Kaliska Forest District as the leading unit.
2. The Regional Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., at the Katowice RDSF in 2007–2014 in the following Forest Districts: Gidle, Herby, Lubliniec, Namysłów, Olkusz, Rudy Raciborskie, Rybnik, Siewierz, Tułowice, Turawa, Wisła, Ustroń and Złoty Potok.
3. The Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., implemented at the Kraków RDSF in 2010–2014 in the following Forest Districts: Gorlice, Krościenko, Łosie, Myślenice, Nawojowa and Stary.
4. The Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., at the Krosno RDSF in 2007–2016 in the following Forest Districts: Baligród, Brzozów, Dukla, Kołaczyce, Oleszyce and Ustrzyki Dolne.
5. The Regional Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., at the Piła RDSF in 2007–2016 implemented in six Forest Districts: Jastrowie, Kaczory, Krucz, Lipka, Okonek and Złotów.
6. The Regional Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., at the Poznań RDSF in the following Forest Districts: Antonin, Góra Śląska, Przedborów and Syców.
7. The Regional Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., at the Szczecinek RDSF in the following Forest Districts: Czarne and Tychowo.
8. The Regional Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., at the Szczecinek RDSF.
9. The Regional Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., at the Toruń RDSF in 2007–2016 in seventeen Forest Districts.
10. The Regional Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., at the Wrocław RDSF.
11. The Regional Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., at the Zielona Góra RDSF in the following Forest Districts: Cybinka, Lubsko and Nowa Sól.
12. The conservation of the Common Yew Gene Pool in the Leon Wyczółkowski 'Cisy Staropolskie' Reserve in the Zamrzenica Forest District.
13. The establishment of a Clonal Archive of the Common Yew tree, *Taxus baccata* L., recognized as natural monuments at the Kostrzyca FGB.

Detailed tasks planned within the framework of the above projects:

1. Taking an inventory of, and assessing, yew locations in the area of project execution, verification of potential locations for the introduction of the common yew.
2. Selection of sites for planting (gene conservation plantations).
3. Recognizing the demand for planting stock.
4. Seed collection.
5. The production of planting stock.
6. The establishment of gene conservation plantations on selected sites.
7. Tending the established plantations.
8. The modernisation of the nursery and educational infrastructure.
9. Preparing reports on project execution and monitoring its effects.

Table G. The production of seedlings and the establishment of plantations by organizational units of the State Forests under the Programme for the Protection and Restitution of the Common Yew, *Taxus baccata* L., in Poland as of 30 November 2011

Number of common yew seedlings produced [in thousands of seedlings]	109.1
Gene conservation plantations established [ha / thousand seedlings]	40.39 / 93.68
Regeneration of gaps [ha / thousand seedlings]	7.22 / 9.26

The expected effects of the programme

The tasks carried out under the programme will largely depend on the results of the aforementioned research project conducted by the Institute of Dendrology, PAS, in Kórnik, whose completion is scheduled for the end of 2012. They will be of great importance for forestry practice in determining the potential for the transfer of reproductive material. This will help to exclude populations with low levels of genetic variation, as well as those composed of individuals of foreign origin and hybrids (with *T. cuspidata* and *T. x media*), from the restitution programme.

There are also plans to establish seed orchards, which will increase the quantity of harvested seeds, intensify the production of planting stock and, in the future, reduce the harvest of seeds in protected areas. At the same time, the established plantations will serve as living gene banks known as clonal archives.

It is anticipated that implementing the specific tasks under the programme will lead to an increase in the area, population and individual variability of the common yew.

2.7.4. The restitution of the wild service tree (*Sorbus torminalis* (L.) Crantz)

The wild service tree, *Sorbus torminalis* (L.) Crantz, requires urgent protective and restitutive measures comparable to those applied in the case of the common yew.

The wild service tree is under greater threat from genetic drift than the common yew for the following reasons:

- lack of the active protection that should be applied to *Sorbus torminalis* as a species that demands light (silvicultural treatments and the removal of competing species),
- the few scattered populations in the natural range of this species and the scarcity of the individuals in these populations,
- problems with pollinators and with the cross pollination of dispersed individuals,
- the rapid disappearance of the wild natural habitats of the tree's populations (Bednorz, 2004).

So far, there has been no national programme for the protection and restitution of this species in Poland, although some organizational units of the State Forests have undertaken active protective and restitution measures in this respect.

Projects implemented in Poland within the framework of the programme:

1. The ex *situ* conservation of genetic resources in selected locations of the wild service tree, *Sorbus torminalis (L.)* Crantz, in the Kostrzyca Forest Gene Bank (Kostrzyca FGB) planned for implementation in 2010–2012.
   The tasks within the programme include:
   - monitoring the flowering and fruiting of wild service trees in 37 locations,
   - collecting fruits and seeds and establishing a genetic resource base representing 37 populations.

   As of 30 November 2011, genetic resources representing 30 wild service tree populations were stored in the Kostrzyca FGB.
2. The Regional Programme for the Protection and Restitution of the Wild Service Tree, *Sorbus torminalis* (L.) Crantz, at the Piła RDSF in 2010–2013: inventory, seed collection and production of wild service tree planting stock.
   Activity planned until 2013: the establishment of a gene conservation plantation (16.68 ha / 33.65 thousand seedlings).
3. The Conservation and Restitution of the Wild Service Tree at the Wrocław RDSF: the introduction of 10.7 thousand seedlings into the natural environment.
4. The Restitution of the Wild Service Tree in the Nowa Sól Forest District (Zielona Góra RDSF).
5. The Restitution of the Wild Service Tree in the Jamy Forest District (Toruń RDSF): seedling production: 9.85 thousand seedlings; gene conservation plantations: 1.71 hectares.
6. The Protection of the Wild Service Tree at the Gdańsk RDSF:

- inventory of the species in the territory of the Gdańsk RDSF (93 individuals),
- planting 20.2 thousand seedlings in plantations,
- agrotechnical treatments for the establishment of a clonal archive; preparation of reproductive material from 53 individuals for the archive.

3. Factors affecting the state of forest genetic resources in Poland

The most important factors affecting the state of the forest genetic resources in Poland include all of the stress factors that impact the forest environment, that is, biotic, abiotic and anthropogenic factors.

Stress factors may, depending on their type and severity, cause the following effects:

- damage or disappearance (extinction) of individual organisms,
- disturbances in the natural composition and structure of forest ecosystems and depletion of biological diversity at all levels of natural organization: genetic, species, ecosystem and landscape,
- damage to the entire forest ecosystem, permanent reduction of site productivity and tree growth, including a reduction of forest resources and non-productive forest functions (protective, social),
- total dieback of stands and synanthropization of the entire plant community.

The effect of stress factors on the forest environment is a derivative of these factors and of forest ecosystem resistance.

3.1. Abiotic threats

In the period from October 2009 to September 2010, damage caused by abiotic factors to forests managed by the State Forests was reported on 164.4 thousand hectares with stands older than 20 years. Over 38 thousand hectares of forest stands were damaged by wind, nearly 68 thousand hectares by groundwater level fluctuations, 54 thousand hectares by snowfall, 2.3 thousand hectares by emissions and 644 hectares by low and high temperatures.

In 2010, the largest area (52.7 thousand hectares) of damage to forests caused by abiotic factors was reported in the Katowice RDSF. As regards the volume of wind-broken and wind-thrown timber, the greatest damage to stands occurred at the Katowice RDSF (1 045 thousand m^3), the Wrocław RDSF (939 thousand m^3) and the Krosno RDSF (378 thousand m^3).

The area of wind-damaged stands decreased in comparison with 2009 by approximately 3.7 thousand hectares (9 per cent). The forests in the Olsztyn and Białystok RDSFs, where the area of damage was 11.3 thousand hectares and 8.5 thousand hectares respectively, were most affected.

In Fig. 23 we can see the areas of distribution of damage to forests caused by abiotic factors in 2006–2010. The data in the table show that forests are exposed to constant pressure from extremely adverse thermal conditions and fluctuations in the groundwater level (in spite of a significant decrease in the area of stands damaged by this factor in 2007–2009), as well as from the random occurrence of other factors.

The year 2010 in Poland was particularly abundant in weather anomalies, which often had disastrous consequences. The heavy snowfall in the winter months caused losses in stands (snowbreaks), while excessive rainfall in the spring and summer brought about four flood events.

The moisture conditions during the growing season of 2010 were extreme compared with the preceding ten years as the season saw an average total rainfall for the country of 576.2 mm, which was 160.5 mm higher than the long-term average and the highest recorded in the 21st century. Heavy rainfall, which was at its most intense in May, July and August, had disastrous consequences. In May, for example, the weather stations in Kraków and Opole recorded 302 mm and 234 mm of rainfall respectively, which was 411 per cent and 390 per cent above the norm, while the rainfall in Katowice, Lublin, Łódź and Mława was three times greater than normal. Rainfall across the country was also above the norm in August, when the heaviest falls were recorded in Szczecin (324 per cent above the norm), Chojnice, Jelenia Góra, Koszalin, Poznań, Toruń and Warsaw (250–280 per cent above the norm). October was the only month in the growing season with a significant moisture deficit, while the lowest rainfalls (those below 10 mm) were recorded at weather stations in southern, eastern and central Poland, such as Wrocław (2.6 mm), Lublin (7.3 mm), Łódź (6.8 mm) and Warsaw (2.8 mm).

The mean value of the sum of annual precipitation (803.1 mm) was, as in the case of seasonal precipitation, the highest in the last 10 years and far higher (by 137.8 mm) than the amount of precipitation in 2009 and the long-term average (by 213 mm) (Fig. 24). The level of precipitation above the long-term norm in the past four years has shown an upward trend for both the amount of rainfall during the growing season and for the sum of annual precipitation.

The average temperature in the growing season of 2010 was 13.6°C, which was (as in 2004) the lowest in the past decade. It exceeded the value for the long-term average by only 0.4°C, which was the effect of the cold weather prevailing in May, September and October. The average annual temperature in 2010 (7.4°C) was the lowest in this decade and fell for the first time below the long-term average of 7.8°C (Fig. 25).

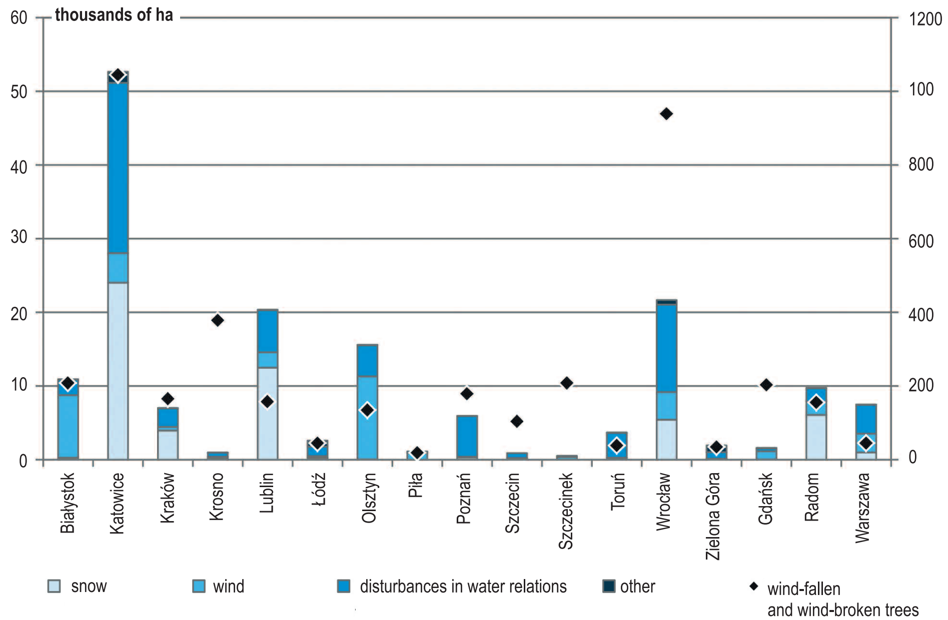


Fig. 22. Area of distribution of damage to forests caused by abiotic factors* and the volume of wind-broken and wind-fallen timber in stands aged 20+ in 2010 by RDSF
* hail, emissions, low and high temperatures, fire

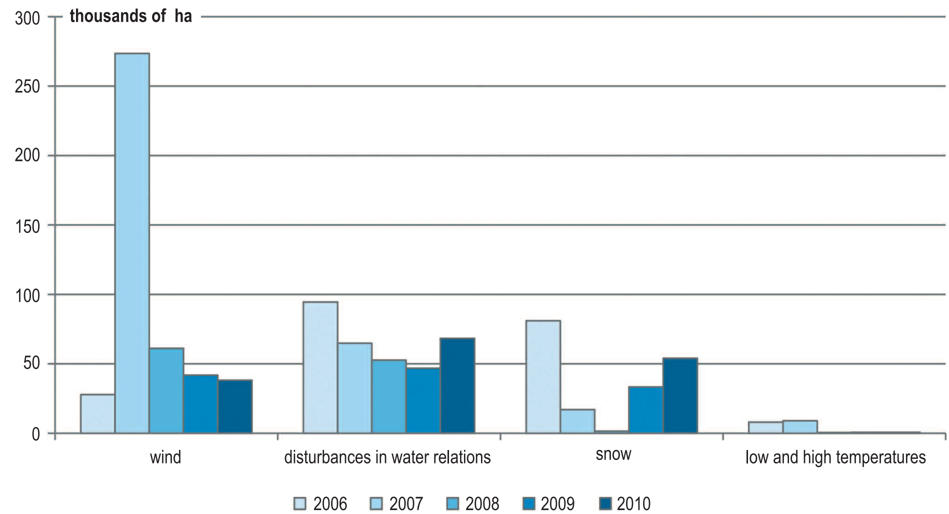


Fig. 23. Area of occurrence of damage caused by abiotic factors to the forests administered by the State Forests in 2006–2010

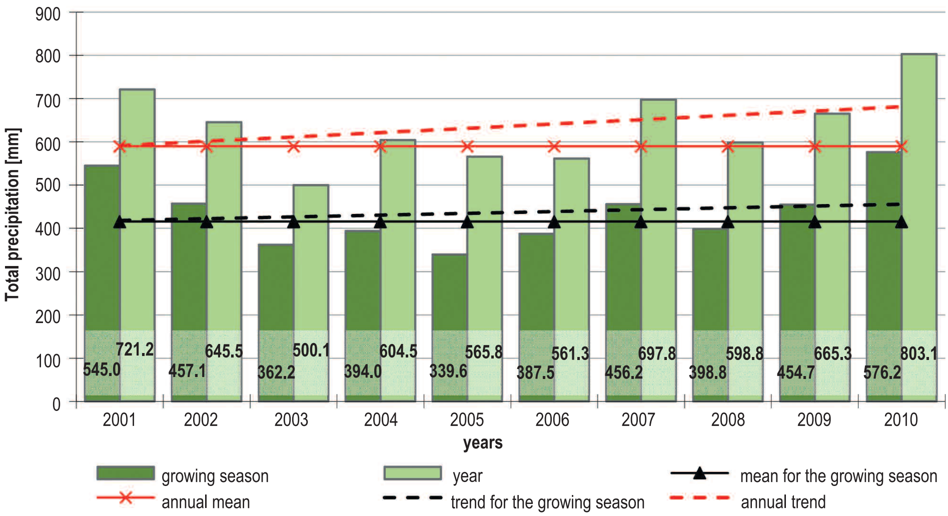


Fig. 24. The sum of atmospheric precipitation in 2001–2010 and the general trend

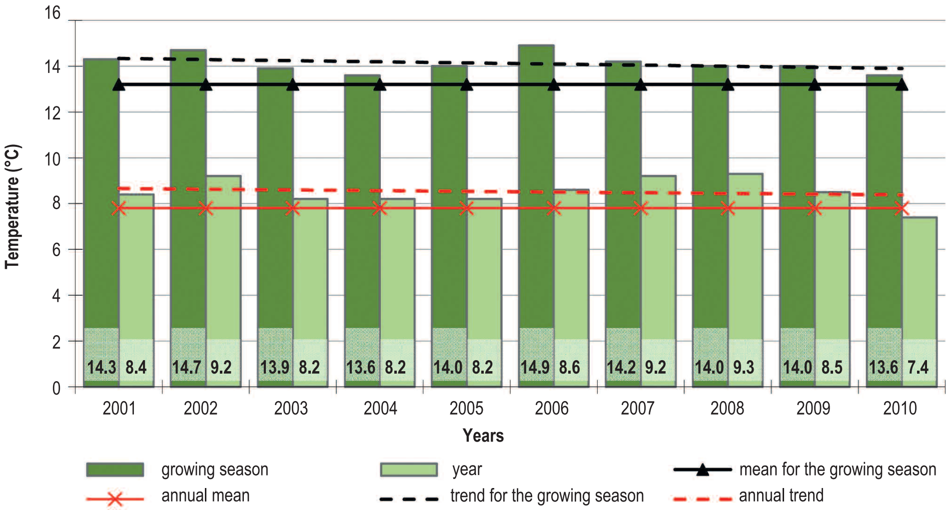


Fig. 25. Average air temperature in 2001–2010 and the general trend

This was as a consequence of the frosty winter months of January, February and December and of the cold weather in May, September and October. The trend for average annual temperatures and for growing seasons beginning from 2001 has therefore fallen slightly.

The average value of the hydrothermal coefficient was higher than the long-term average in the different regions of the country monitored by weather stations (Fig. 26).

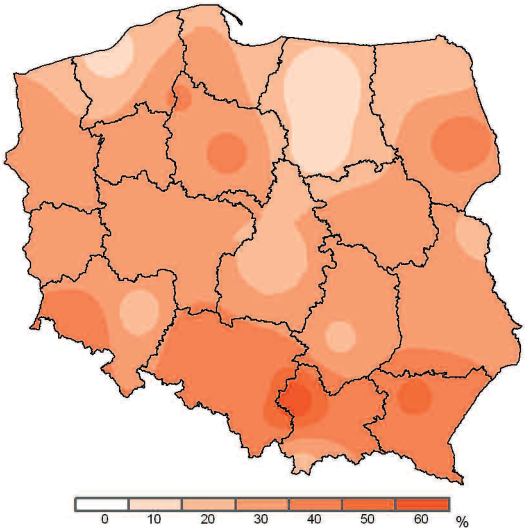


Fig. 26. Geographical differences in hydrothermal coefficient values for the growing season 2010 in terms of in plus deviations from long-term average values (%)

The largest differences were in the south-eastern region, where the precipitation level was the highest. The thermal and moisture conditions that deviated least *in plus* from the norm were recorded in the north-eastern region and, locally, in the coastal region (Koszalin) of Poland.

The meteorological section was prepared based on the monthly bulletins of the Institute of Meteorology and Water Management (IMWM).

3.2. Biotic threats

Poland belongs to a group of countries in which unfavourable phenomena in forests occur with high diversity and intensity and can lead to mass outbreaks of insect pests and pathogenic fungal diseases. In effect, the impact of a number of stress factors over the past decades has given rise to unfavourable phenomena affecting the forest environment, such as:

- the activation of new, poorly recognised insect and fungal species which so far have not done serious damage to forests,
- the shortening of the intervals between outbreaks of the most dangerous insect pests,
- the appearance of new outbreak centres and the expansion of old ones, which has increased their area of mass incidence,
- deterioration in the health condition of broadleaved tree species, which so far have been considered the most resistant to industrial pollution.

3.2.1. Threats to forests posed by insect pests

In each decade of the 1961–1990 period there was an increase in the number of insect species endangering stands and in the area of stands being treated protectively. While in 1961–1970, 38 insect pest species appeared *en masse* of which 20 required protective treatment on a combined area of 600 thousand ha, in 1981–1990, 56 insect pest species appeared *en masse*, of which 46 required treatment over a combined area of 7 million ha. At that time about 70 million m^3 of pest-infested conifer and broadleaf timber was removed from the forests. In the 1990s the risk to pine stands from the nun moth and to spruce stands from secondary pests was similar though not on such a large scale.

The leaf-eating insects of pine stands, especially the nun moth *Lymantria monacha* L., pine sawflies, *Diprionidae*, pine-tree lappet moth, pine looper, *Bupalus piniarius* L., pine beauty moth, *Panolis flammea* Den. et Schiff. and the pine webworm, *Acantholyda nemoralis* L. were the ones whose numbers increased most in Poland. A cyclicity in insect outbreaks was observed. The largest outbreaks of primary insect pests occurred in 1979–1984 and in 1992–1994, and of secondary pests in 1981–1985 and 1993–1994. Insects whose occurrence was once marginal have now gained economic significance. So it was that the areas in which action needed to be taken to reduce the number of pests in plantations and thickets increased fivefold and exceeded 50 thousand hectares in 1975–1994.

In recent years, the greatest threats to forests have been associated with:

- the outbreak of nun moth in 1997–2006 on a total of 1 487 thousand hectares, which required control treatments in an area of 363 thousand hectares,
- the outbreak of pine beauty moth in 1997–2002, which required control treatments in an area of over 153 thousand hectares,
- the mass occurrence of pine sawflies in 1991–1995, which required control treatments in an area of 620 thousand hectares and, in 2005, in an area of 50 thousand hectares,
- increased incidence of pine lappet moth in the 1990s, which required control treatments in an area of approximately 160 thousand hectares,
- increased activity of pine webworm, which required control treatments in an area of several thousand hectares per year (on nine thousand hectares in 1994, for example),
- the permanent activity of tortrix moth and other leaf-eating species of broadleaves, which were subject to control treatments in an area of 2.3–5.8 thousand hectares annually, and in 2004–2006 in a total area of more than 46.6 thousand hectares,
- the increased activity of cockchafers, which required control treatments in 1994–2006 in a total area of 71 thousand hectares,
- the increased incidence of diseases of oak, beech and birch stands.

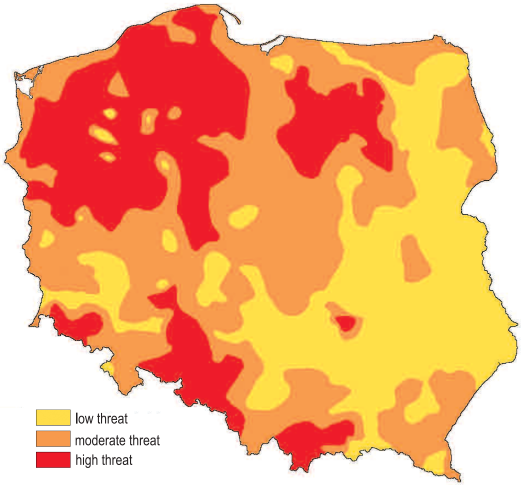


Fig. 27. Zones of threat to Poland's forests from primary and secondary insect pests (combined) according to the Forest Research Institute

The geographical distribution of damage to forest stands by insect pests (Fig. 27) shows that the most threatened stands are in the northern region (western part of the Mazury Lake District), in the north-western region (the Pomerania and Wielkopolskie Lake Districts) and in three southern regions of Poland (the Sudeten Mountains, Śląsk Opolski and the Beskid Wysoki Mountains). The severe threat to forests in southern Poland is almost solely attributed to secondary pests, while in other regions of the country it is attributed to primary pests (chiefly the nun moth). It is also possible to distinguish zones with a low and moderate threat. These extend in an arc from the Silesian Lowlands in western Poland *via* the Kraków-Częstochowa and Małopolska Uplands (excluding the Świętokrzyskie Mountains) and the Lubelska Uplands as far east as the Mazowiecka Lowlands and the Mazury Lake District.

The activity of insect pests in 2010 decreased by nearly 10 per cent in comparison with the previous year. Control treatments aimed at reducing the population of about 45 insect species covered an overall area of almost 12.8 thousand hectares, that is, approximately 4.3 thousand hectares less than in 2009. The reduction in the area of stands affected by insect pests was due to a decline in the population of sawflies (*Diprionidae* spp.), of the pine beauty moth (*Panolis flammea* Den. *et* Schiff.) and of imagines *Melolontha* spp.

1. Chemical treatments against leaf-eating insects were applied on 439 thousand hectares of pine stands, which was a decrease of approximately 3.5 thousand hectares compared with 2009.
2. Chemical controls against leaf-eating insects covered nearly 2.4 thousand hectares of broadleaved stands, which was an increase of approximately 300 compared with 2009.

3. The total area of pine plantations and young stands subjected to pest control treatments was 8.3 thousand hectares, which was a decrease of approximately 2.4 thousand hectares compared with 2009.
4. The total area of spruce and larch stands subjected to control treatments against insect pests was 2.3 thousand hectares and was four times greater than in 2009.
5. Salvation measures taken against the root pests of forest trees and shrubs were applied to plantations and nurseries over a total area of 993 hectares.
6. Of the major leaf-eating pests, cockchafer imagines were controlled in the largest area (1346 hectares) followed by oak tortrix moth (911 hectares), pine sawflies (295 hectares) and pine webworm (*Acantholyda nemoralis* L.; 128 hectares) (Fig. 28).

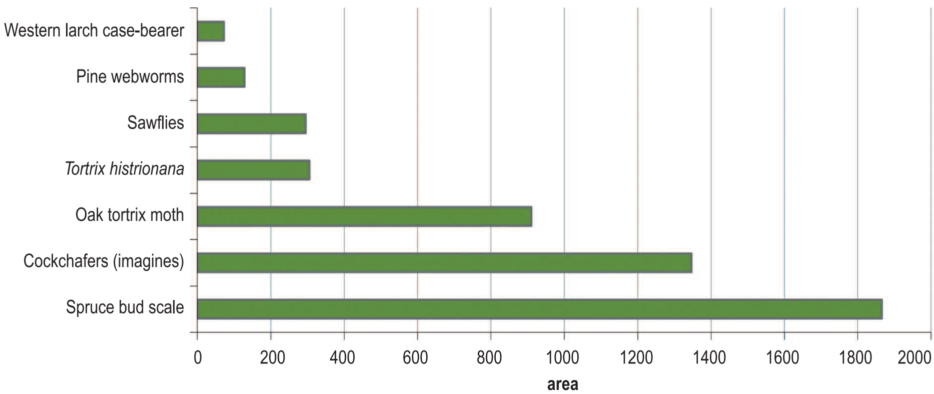


Fig. 28. Area of stands covered by protective treatments against major leaf-eating insect pests in 2010

In 2010, the largest areas in which treatments were applied to insect populations were in the Białystok RDSF (3.3 thousand hectares), the Toruń RDSF (2.0 thousand hectares), the Piła RDSF (1.7 thousand hectares) and the Szczecin RDSF (1.6 thousand hectares), while the smallest areas of insect control were in the Kraków RDSF (108 hectares), the Warsaw RDSF (131 hectares) and the Zielona Góra RDSF (150 hectares) (Figs. 29 and 34).

The leaf-eating insects of older pine stands, especially the nun moth (*Lymantria monacha* L.), pine sawflies *(Diprionidae)*, pine-tree lappet moth, pine looper (*Bupalus piniarius* L.), pine beauty moth (*Panolis flammea* Den. *et* Schiff.) and the pine webworm (*Acantholyda nemoralis* L.) were the ones with the highest rate of growth in Poland. At the same time, a cyclicity in insect outbreaks was observed.

The common cockchafer (*Melolontha melolontha* L.) and the chestnut cockchafer (*M. hippocastani* Fabr.) have in recent years become one of the most dangerous insect pests in forestry. Cockchafer larvae (grubs) feed on the roots of trees and

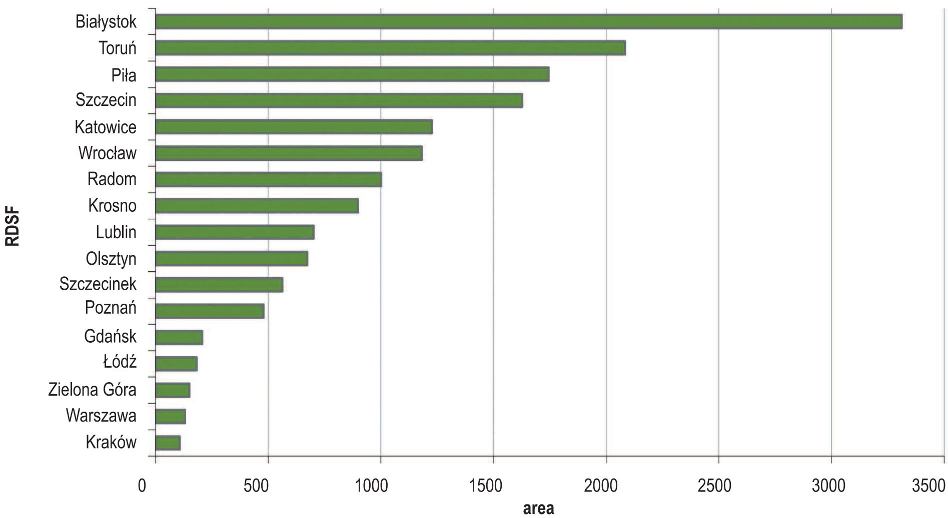


Fig. 29. Reduction in the population of forest insect pests in 2010 by RDSF (Forest Research Institute)

shrubs, often leading to their complete destruction – especially in forest nurseries and plantations. During the mating season, cockchafer adults additionally feed in the crowns of broadleaved trees, leaving them totally stripped of leaves. Reports of an increased threat to forests from cockchafers have been appearing since the early 1990s. The appearance of several cockchafer populations in Poland has resulted in strong fluctuations in cockchafer populations in subsequent years. There were swarms of a particularly dangerous population of cockchafers in the years 1995, 1999, 2003 and 2007 (Fig. 30). These appeared every four years across large areas administered by the Łódź RDSF, as well as in smaller areas throughout the country.

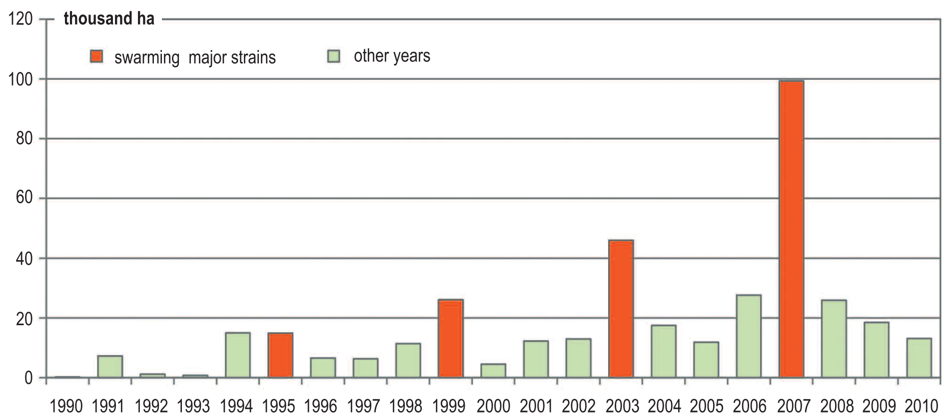


Fig. 30. Area of occurrence of cockchafers in 1990–2010

In 2010 pests of the root system were observed over an area of 35 810 ha, of which over 35 728 ha were damaged by cockchafer grubs. There has been a consistently high level of risk to nurseries and plantations from cockchafers in recent years (Fig. 31).

In recent years, the nun moth population has remained at a low level. In 2009, this pest was reported in an area of approximately 20 thousand hectares, which in 2010 had increased to 31.3 thousand hectares. The most threatened stands were in the Toruń and Gdańsk RDLPs (Fig. 32). The nun moth is able to increase its population in a short time.

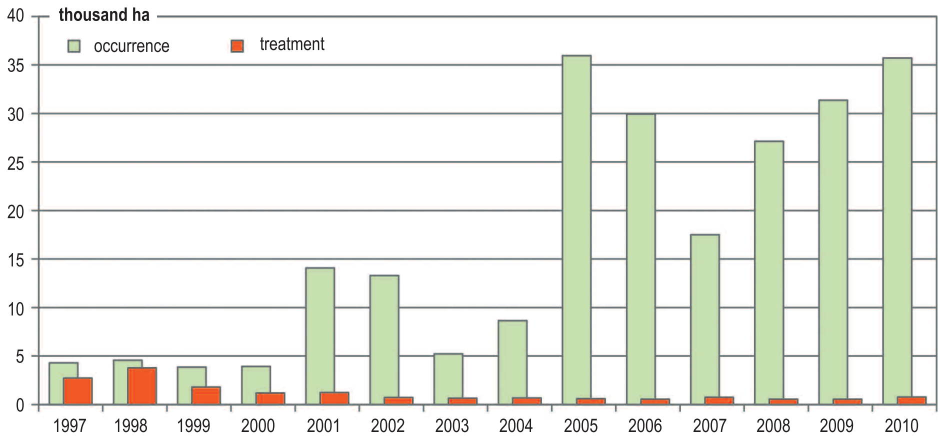


Fig. 31. The area of occurrence and control of cockchafer grubs in 1997–2010

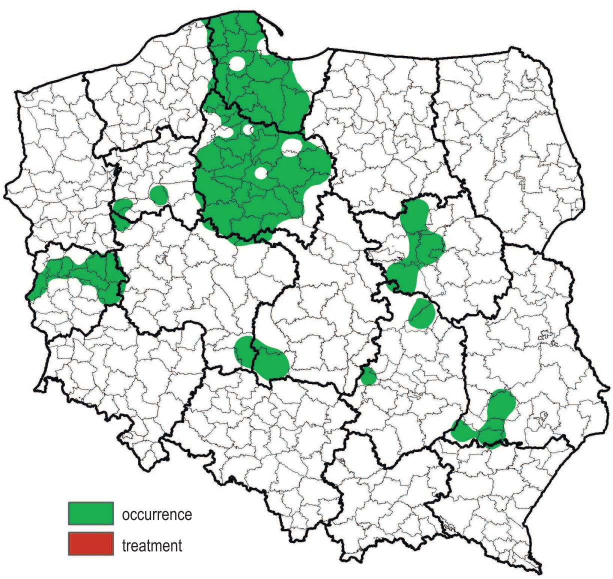


Fig. 32. The occurrence and control of the nun moth in 2010

The area of pine stands threatened by pine sawflies has oscillated in recent years between 20 thousand hectares and 25 thousand hectares. In 2010, damage caused by this group of insects affected 12.3 thousand hectares, which was half the area affected in the previous year. Control treatments were applied over an area of 295 hectares. The threat occurred mainly in the north-west of the country and the most threatened stands were in the Toruń and Gdańsk RDSFs (Fig. 33).

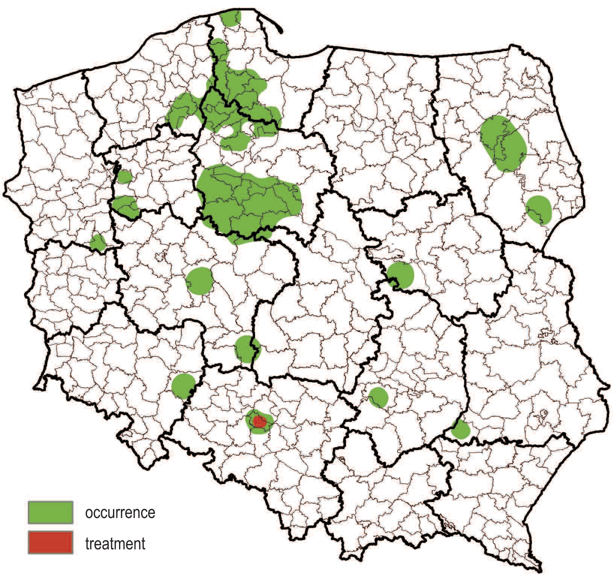


Fig. 33. The occurrence and control of pine sawflies in 2010

In 2010, the area of threatened plantations, thickets and poletimber stands was reduced by approximately 7.6 thousand hectares to 18.4 thousand hectares. Control treatments were applied to 8.3 thousand hectares. These were carried out in the largest areas of damage caused by such species as weevils (*Hylobius* spp.) (6.5 thousand hectares), the banded pine weevil (*Pissodes notatus* F.) (931 hectares) and the *Pissodes* weevil (*Pissodes piniphilus* Herbst.) (664 thousand hectares).

The greatest threat to forests caused by secondary pests occurred between 1 October 2008 and 30 September 2009. These were *Phaenops cynaea,* weevils and pine-shoot beetles in pine stands, European spruce bark beetles in spruce stands, and two-spotted oak borer and *Chrysobothris* spp. in oak stands. The threat was associated with the weakening of stands induced by abiotic factors, such as wind, changes in the groundwater level, snowfall and low and high temperatures.

The volume of harvested timber in coniferous stands in sanitation cuts from 1 October 2009 to 30 September 2010 amounted to 4598 thousand m^3, which included 3151 thousand m^3 (68.5 per cent) of wind-fallen and wind-broken timber.

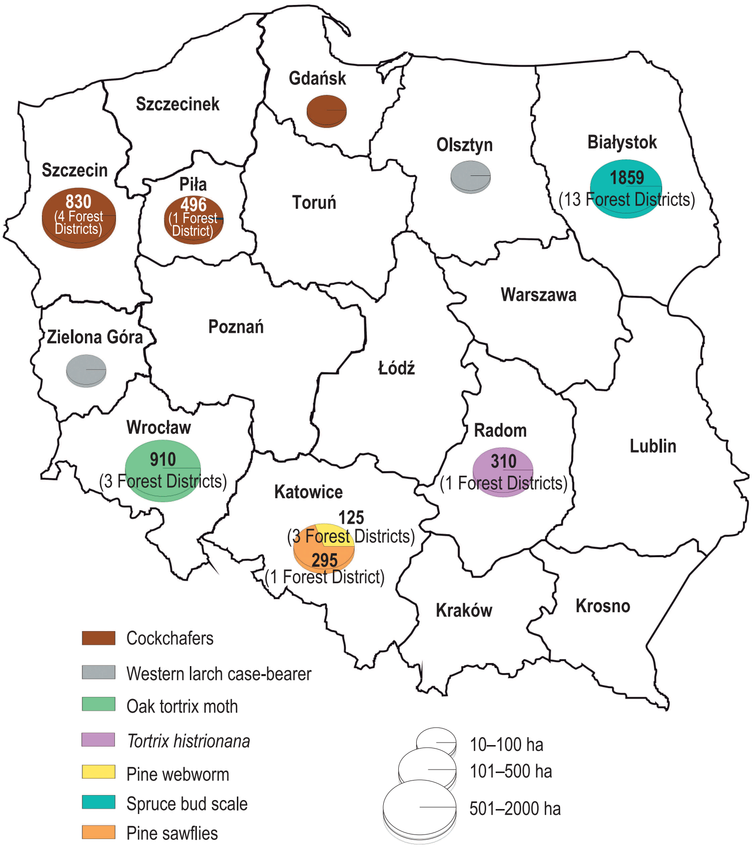


Fig. 34. Reduction in the number of major leaf-eating pests at individual RDSFs in 2010

In comparison with the previous reporting period, the volume of harvested timber had increased by 12.1 per cent. The largest harvest of softwood was in the Katowice and Wrocław RDSFs.

The volume of pine wood harvested in sanitation cuts from 1 October 2009 to 30 September 2010 amounted to 3 077 thousand m^3, which included 2484 thousand m^3 (80.75 per cent) of wind-fallen and wind-broken timber. In comparison with the previous reporting period, the volume of harvested timber had increased by 44.3 per cent. The largest volume of pine wood was harvested in the Katowice (26.46 per cent) and Wrocław (22.89 per cent) RDSFs.

The most common secondary pests of pine were the steelblue jewel beetle (*Phaenops cyanea* F.), the pine weevil (*P. pini* L.), the *Pissodes* weevil (*P. piniphilus* Herbst.), the larger pine shoot beetle (*Tomicus piniperda* L.), the striped ambrosia beetle (pinhole borer) (*Trypodendron lineatum* Oliv.), the two-toothed pine beetle (*Pityogenes bidentatus* Herbst.), bark beetles *Hylastes* spp. and, in low numbers, the beetles of the family Cerambycidae (longhorn beetles *Tetropium* spp. and *Rhagium* spp.).

The volume of spruce wood harvested in sanitation cuts from 1 October 2009 to 30 September 2010 amounted to 1342 thousand m^3, including 517 thousand m^3 (38.53 per cent) of wind-fallen and wind-broken timber. In comparison with the previous reporting period, the volume of harvested timber had decreased by 27.34 per cent. The largest volume of spruce wood was harvested in the territory of the Katowice (41.93 per cent), Białystok (12.18 per cent), Wrocław (11.17 per cent) and Gdańsk (10.2 per cent) RDSFs.

In the previous reporting period, the damage to spruce stands was mainly from European spruce bark beetles (*Ips typographus* L.), smaller eight-toothed spruce bark beetles (*I. amitinus* Eichh.), northern bark beetles (*I. duplicatus* CR Sahlberg), striped ambrosia beetles (*T. lineatum* Oliv.), six-toothed spruce bark beetles (*Pityogenes chalcographus* L.), the small spruce bark beetle (*Polygraphus poligraphus* L.) and *Tetropium* spp. (mainly the brown spruce longhorn beetle (*Tetropium fuscum* F.).

The volume of hardwood timber harvested in sanitation cuts from 1 October 2009 to 30 September 2010 amounted to 1222 thousand m^3, which is approximately 27 thousand m^3 (c. 2.16 per cent) less than in the previous reporting period. Incidental felling represented 74.75 per cent of sanitation cuts. The largest volume of hardwood timber was harvested in the Wrocław (182 thousand m^3), Krosno (165 thousand m^3) and Katowice (119 thousand m^3) RDSFs.

The volume of oak wood harvested in sanitation cuts in the period from 1 October 2009 to 30 September 2010 amounted to 335 thousand m^3 and was lower by 6 thousand m^3 (1.8 per cent) compared to the previous reporting period. At the same time, the harvest of wind-fallen and wind-broken timber was 212 thousand m^3 and had increased by 210 per cent compared to 2009. There was an increase of over 10 per cent in the harvest of oak wood in the Wrocław and Poznań RDSFs (27.59 per cent and 14.49 per cent respectively). In nine RDSFs (Wrocław, Krosno, Gdańsk, Radom, Kraków, Warsaw, Lublin, Szczecinek and Katowice) the share of wind-fallen and wind-broken timber exceeded 50 per cent of the timber harvested in sanitation cuts, while in four RDSFs (Wrocław, Krosno, Gdańsk and Radom) the share of wind-fallen and wind-broken timber harvested in sanitation cuts exceeded 75 per cent.

The factors influencing the natural thinning of oak stands in the period analysed were the lowering of the groundwater level and attacks of secondary pests – the majority made by the two-spotted oak borer. However, oak decline was less intense due to a considerable reduction in the population of this pest. The exceptions were the forests managed by the Poznań, Piła and Toruń RDSFs, where intensified feeding of two-spotted oak borers resulted in a larger number of standing dead oak trees. Other common cambio- and xylophagous oak stand pests included longhorn beetles *Plagionotus* spp., *Leiopus* spp., tanbark borer (*Phymatodes testaceus* L.), *Xyloterus* spp. and the European oak bark beetle (*Scolytus intricatus* Ratz.).

The volume of birch wood harvested in sanitation cuts in the period from 1 October 2009 to 30 September 2010 was 326 thousand m^3 and was higher by 59 thousand m^3 (22 per cent) than in the previous reporting period. At the same time, the harvest of wind-fallen and wind-broken timber was 286 thousand m^3 and was higher by 41.6 per cent compared to 2009. Damage to birch stands in 2010 was primarily caused by snow-packing and wind action, which broke trees or caused them to fall. In birch stands and mixed stands with birch, the damage was caused primarily by the birch bark beetle (*Scolytus ratzeburgi* Jans.), *Xyloterus spp.* and the large timberworm (*Hylecoetus dermestoides L.*). Generally, these pests fed in stands that had been weakened by attacks from primary pests.

The volume of ash wood harvested in sanitation cuts in the period from 1 October 2009 to 30 September 2010 was 118 thousand m^3, which was 33.5 per cent lower compared to the previous reporting period. At the same time, the harvest of wind-fallen and wind-broken timber was 30 thousand m^3, which was an increase of 2 per cent compared to 2009. Fewer standing dead ash trees were reported in 2010, which may be mainly due to the halting of the tree's decline and the regular removal of trees colonized by secondary pests. The major threat of this kind still comes from cambiophages in the shape of the ash bark beetle (*Leperisimus fraxini* Panz.) and the larch elm bark beetle (*Hylesinus crenatus* F.). The most important of the abiotic factors that had an impact on the health status of the ash were changing water relations.

Insect outbreaks mainly affect large tracts of pure coniferous forests, which are more sensitive to biotic factors due to their lower capacity to adapt to local habitat conditions.

3.2.2. Threats to forests posed by infectious fungal diseases

In 2010, infectious diseases were reported over a total area of 384 thousand hectares of stands, which meant a decrease in area of nearly 27.5 thousand hectares (or 7 per cent) compared with 2009. This was due to a three-fold decrease in the areas afflicted by Lophodermium needlecast of pine. In turn, varying degrees of increase in the area affected by other diseases of the assimilatory apparatus were noted. These concerned pine shoot disease and pine twisting rust (630 hectares and 310 hectares respectively), and oak mildew and needle and leaf rust (7 per cent and 13 per cent respectively). The dieback of all broadleaved tree species (oak, beech, birch, ash) was less severe (23 per cent, 28 per cent, 25 per cent and 23 per cent respectively). The area of stands showing symptoms of alder dieback was reported to have decreased by 1800 hectares and the area of stands showing symptoms of fungal diseases in poplars (cankers, decline, bark rot and tree dieback) had (taken together) fallen by 48 per cent. A slight decrease was also noted in the area of forests affected by pine gall rust and stem and trunk diseases (14 per cent and 4 per cent respectively). The

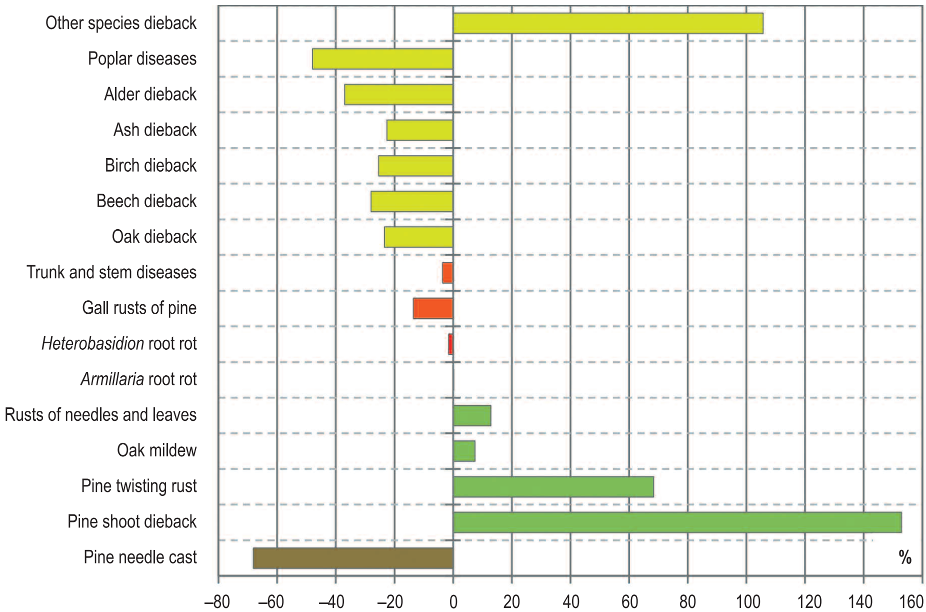


Fig. 35. Percentage changes in the area affected by infectious diseases in 2010 compared with 2009

occurrence of root-rot diseases was reported in an area of less than 2.2 thousand hectares, the area of stands affected by *Heterobasidion* root rot fell by 2 per cent and the occurrence of *Armillaria* root rot remained at the same level (Fig. 35).

A comparison of the health condition of stands in individual RDSFs with the 2009 data showed that the health of forests had either improved or stabilised (Fig. 36). The area of stands under threat was reported to have increased only in the Łódź RDSF (by 34.6 per cent), while in the remaining RDSFs it had fallen by between about six per cent and fifteen per cent or had remained at the 2009 level (Katowice, Szczecinek and Toruń RDSFs). With regard to the Łódź RDSF, the increase in the total area of stands affected by diseases was mainly due to the more than five-fold increase in the area affected by oak decline when compared with 2009.

An analysis of the areal share of occurrence of fungal diseases in the total forest area of individual RDSFs showed that, as in 2009, the area affected by diseases in two RDSFs (Toruń 11.6 per cent) and Warsaw (10.6 per cent) exceeded 10 per cent, while in the other RDSFs it varied between 0.7 per cent and 9.8 per cent of forest area. The same nine RDSFs as in 2009 had threats from infectious diseases in less than 5 per cent of the forest area. These were Kraków, Krosno, Lublin, Piła, Poznań, Radom, Szczecin, Szczecinek and Zielona Góra. The assessment of the threat to forest areas in individual RDSFs expressed as a share in the total area of occurrence of infectious diseases, showed that the greatest potential threat (over 10

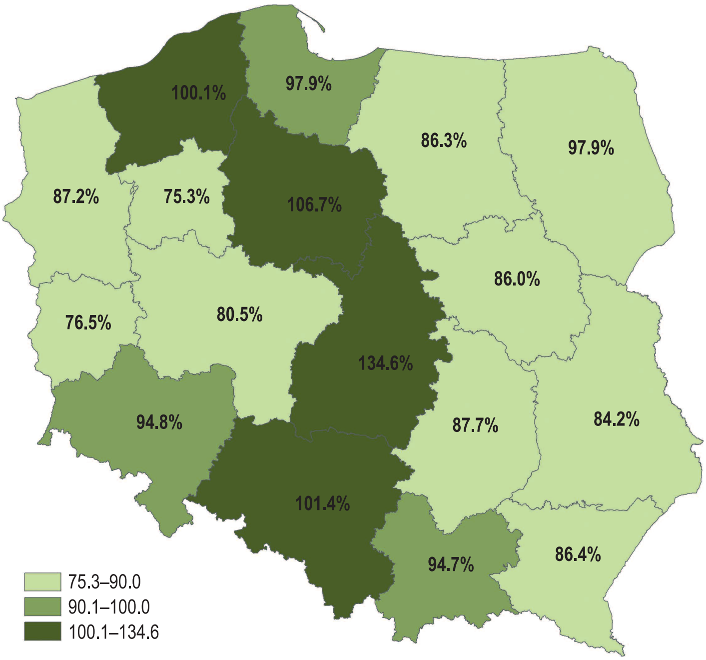


Fig. 36. Changes in the area of occurrence of infectious diseases in 2010 as a percentage of the area under threat in 2009

per cent of the total area of disease occurrence) was in the Olsztyn, Toruń and Wrocław RDSFs. In other RDSFs, stands showing symptoms of fungal diseases did not exceed 8.6 per cent of the total affected area, while the lowest levels of fungal infection – at close to 1 per cent of the total area of disease occurrence – were reported only in the Kraków and Zielona Góra RDSFs. In the nurseries, the area affected by fungal diseases increased in 2010 by 20 hectares when compared with 2009.

In 2010 the area of occurrence of diseases in stands up to 20 years of age fell by 23 per cent (13 500 hectares) compared to 2009. The area of stands affected by *Lophodermium* needlecast (approximately 30 per cent of the 2009 level) markedly decreased, while the area of stands affected by oak mildew, pine gall rust, root diseases, as well as the area of oak and ash stands affected by dieback, also decreased – but to a lesser degree. An increase was noted in the areas of occurrence of other diseases of the assimilatory apparatus: pine shoot disease (160 per cent) and pine twisting rust (by 80 per cent). A slight increase was also recorded in the area of occurrence of rust fungi on needles and leaves and in the area of beech decline.

The area of mature stands affected by foliage diseases was larger by nearly one third as a result of a significant increase in the threat to the stands caused by oak mildew. A slight reduction in the area of forests affected by pine gall rust and stem and trunk diseases was also reported (14 per cent and 4 per cent respectively). The spread of *Armillaria* root rot diseases increased by 2 per cent, while the area of dieback of broadleaved stands, which were affected to varying degrees by *Heterobasidion* root rot, pine gall rusts and stem and trunk diseases, decreased.

Root diseases, which have for many years been first among the general threats to forests from infectious diseases, affected a combined total of 262.1 thousand hectares (68 per cent of the total disease occurrence area) in 2010. The combined area of occurrence of pine gall rust and stem and trunk diseases was 54.3 thousand hectares, while that of the dieback of broadleaved trees was 40.4 thousand hectares. In 2010, diseases of the assimilatory apparatus were detected on a total of 24.1 thousand hectares.

When comparing this year's figures (2010) with those of last year there was a similar degree of improvement in the health condition of forests with broadleaved species. So it was that the area of infested oak, birch and ash stands was reported to have fallen by nearly one fourth compared to 2009. The area affected by alder decline was 37 per cent smaller and poplar diseases were recorded in an area of 91 hectares, which was more than half the area of damage reported in 2009. In 2010, observations of the state of health of other tree species (pine, fir, sycamore, larch) revealed a two-fold increase in the area of stands showing dieback symptoms (1997 hectares). It was estimated that multifactor disturbances in stands occurred in a total area of 40.45 thousand hectares, which was 11.7 thousand hectares (22 per cent) fewer when compared to the figure of 52.1 thousand hectares recorded in 2009.

The area of oak stands showing disease symptoms was 20.4 thousand hectares (6.2 thousand hectares fewer than in 2009). The area most affected was the Łódź RDSF, which recorded a figure five times greater than in the previous year (6.3 thousand hectares). Of this area, 5.5 thousand hectares was accounted for by the Kolumna Forest District. Oak decline occurred in areas exceeding one thousand hectares in four RDSFs: Białystok (4971 ha), Szczecin (2365 ha), Lublin (1347 ha) and Wrocław (1065 ha). In five RDSFs, the disease afflicted areas of over 500 hectares, while in the remaining seven RDSFs areas below 400 hectares were involved. No symptoms of disease were observed in the Kraków and Zielona Góra RDSFs.

The area of threatened beech stands was reduced by 654 thousand hectares to 1682 hectares. Beech decline was at its most intense in the Szczecin RDSF (620 hectares; the extent of the damage remained at the previous year's level) followed by the Szczecinek RDSF (260 hectares; the extent of the damage was similar to that in 2009) and the Lublin and Wrocław RDSFs, where damage was recorded on 205 and 174 hectares respectively, which was a fall of approximately 50 per cent on the previous year. The decline affected areas no larger than 80 hectares at the remaining RDSFs.

The symptoms of all poplar diseases (canker, decline, bark rot, tree dieback) were recorded on 90.7 hectares, which was a fall of approximately fifty per cent compared to the previous year. The largest areas of damage were in the Poznań (38 ha), Łódź (14 ha) and Szczecin (11 ha) RDSFs. Damage was either absent or below 10 hectares in the remaining RDSFs.

In birch stands, the area of tree decline was 1 465 hectares compared to 1 965 hectares in 2009, which was a fall of 25 per cent on the preceding year. Dieback was most severe in the forests of the Łódź RDSFs (520 ha). In four RDSFs (Katowice, Lublin, Poznań and Warsaw), damage to birch stands was reported in an area ranging from 100 to 200 hectares, while tree dieback symptoms did not exceed 70 hectares in the remaining RDSFs.

Ash decline in Poland has been observed in forest stands mixed with this species for a dozen or so years and has alternately gained or lost strength. The disease is now recorded in an area of 11.8 thousand hectares (3.4 thousand hectares fewer than in 2009). Ash decline occurred in all of the RDSFs but with a considerable range of severity: Zielona Góra (100 hectares), Olsztyn, Poznań and Toruń (1.0 thousand hectares to 1.7 thousand hectares), Białystok (nearly 2.0 thousand hectares). In other parts of the country the disease was observed in areas ranging from 140 hectares to 900 hectares. As in 2009, the majority (82 per cent) of areas with trees showing symptoms of decline were in mature stands. The greatest damage to mature stands occurred in the Białystok (1827 ha) and Poznań (1081 ha) RDSFs. In the remaining RDSFs, the area of damage ranged from 0.1 thousand hectares to 1.0 thousand hectares. It was only in the territory of the Zielona Góra RDSF that the decline affected an area smaller than 100 hectares. A good deal of damage (yet still 22 per cent less than in the previous year) was also recorded in younger stands (2099 ha), which were mostly in the Poznań RDSF (635 ha) and in two Krosno and Toruń RDSFs (over 200 hectares). Ash decline was observed in an area of less than 160 hectares in the remaining RDSFs.

Like ash dieback, alder dieback has been recorded since the beginning of this century in Poland. In this period (2000–2010) alder dieback has extended with varying intensity over an area exceeding three thousand hectares. The greatest damage was reported in 2006 on more than 5.8 thousand hectares, while in 2010 damage was recorded on a total of three thousand hectares. The dieback of alder in stands was less intense in 2010 than in the preceding five years. The largest area of damage to alder stands was reported in the Białystok (609.5 ha) and Toruń (593 ha) RDSFs. The disease was also detected in alder stands in the Krosno, Lublin, Olsztyn and Wrocław RDSFs and covered an area of between 200 hectares and 400 hectares. The pathogen *Phytophthora alni*, from the group *Oomycetes*, which causes damage to alder trees regardless of their age, plays a significant role in the dieback process. It damages fine roots and the base of the stem in seedlings and causes rot in fine roots, the root collar, the base of the trunk or the whole tree trunk. The symptoms of the disease include dark discoloration on the bark and, often, the exudation of sap. In addition, the leaves of the infested tree become abnormally small, sparse and yellowish. Affected trees suffer for many years from the disease (phytophthorosis) before dying.

3.2.3. Game animals

The analysis of damage to forest regeneration was based on data obtained from the RDSFs. Damage to forest ecosystems caused by forest animals in the 2009–2010 season affected 170 thousand hectares, including 76 thousand hectares of plantations, 62 thousand hectares of young stands and 22 thousand hectares of stands from older age classes. The area of stands damaged by deer browsing or bark stripping increased by 14 thousand hectares in comparison with 2009.

Damage below 20 per cent of the forest regeneration area affected 49 thousand hectares of plantations, 51.3 thousand hectares of thickets and 14 thousand hectares of older stands. The total area of forest stands damaged in this way amounted to 114.3 thousand hectares and was 7 thousand hectares higher (39 per cent) compared to 2009.

Damage of the order of 21 per cent to 50 per cent of the forest regeneration area affected a total of 40.7 thousand hectares of stands, including 21.6 thousand hectares of plantations, 17.4 thousand hectares of thickets and 1.7 thousand hectares of older stands. The total area of forest stands damaged in this way was 5.1 thousand hectares lower (13 per cent) than in 2009.

Damage in excess of 50 per cent of the area of renewals affected 5.8 thousand hectares of plantations, 3.1 thousand hectares of thickets and 5.8 thousand hectares of older stands. The total area of forest stands damaged in this way was 14.7 thousand hectares, which was 1.4 thousand hectares higher (11 per cent) than in 2009.

An eight-year inventory of damage to forest plantations caused by deer showed that, after a slow but steady decline in the impact of deer, this trend was reversed in 2009 and 2010. An increase has been seen in the area of damage to both younger and older generations of forest.

Data on the population dynamics of major damage-causing animals (deer) have shown a clear and steady upward trend despite a relatively higher harvest level than in 2009. In the 2009–2010 hunting season the population of elk was estimated at 8 387, of red deer at 180 thousand, of fallow deer at 23 thousand and of roe deer at 822 thousand. At the same time, the harvest of game animals amounted to 49 thousand red deer, 4.5 thousand fallow deer and 167 thousand roe deer. No elks were harvested in the 2009–2010 hunting season as a result of a hunting moratorium imposed on the species in 2000.

3.3. Anthropogenic threats

3.3.1. Forest fires

There were 4680 forest fires in 2010 compared to 9161 in 2009. The affected area covered 2126 hectares of forest, which was a 52 per cent decrease compared to the previous year. The largest number of fire events occurred in the Mazowieckie Province (23 per cent of the total number), while the lowest number was recorded in the Opolskie and Podlaskie Provinces (Fig. 37).

In 2010, the number of forest fires within the State Forests amounted to 1740 (37 per cent of the total number of fires in Poland) and covered an area of 380 hectares (18 per cent of the total). The largest number of forest fires occurred within the Zielona Góra (236), Szczecin (230) and Katowice (222) RDSFs. The largest affected area (108 hectares, or 28 per cent of all the fire area within the State Forests) was reported in the Katowice RDSF. There were no large fires (those covering more than 10 hectares) in the territory of the State Forests, which contrasted with the rest of the country where there were 14 large fire events. Eight fires, with a total affected area of 412 hectares, were reported in former military training grounds which compared with 3 fires in 2009 covering 54 hectares.

The average area of a single fire in forests under all ownership categories decreased by 0.03 hectares compared to 2009 and was 0.45 hectares (the smallest av-

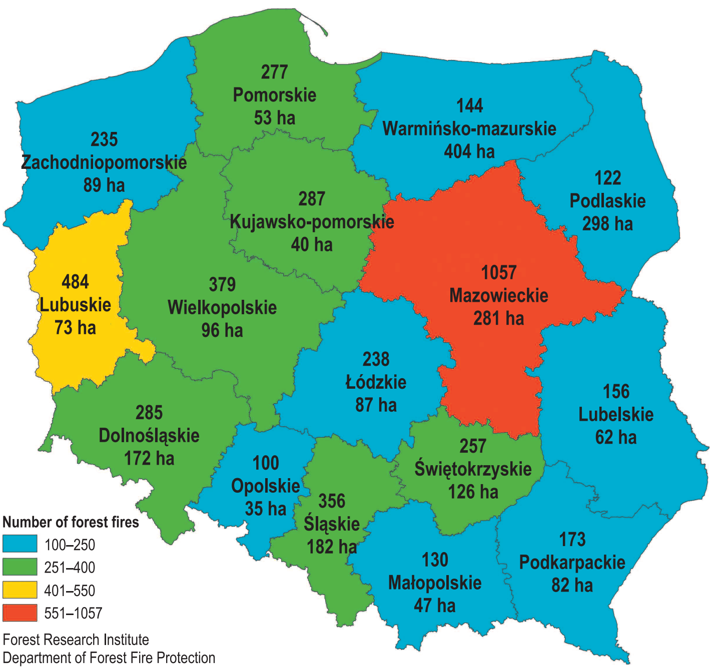


Fig. 37. The number of fires and the affected area in 2010 by Province

erage fire area of 0.32 hectares was recorded in 2008). In the State Forests the average area of a single fire in 2010 was 0.22 hectares, while the average in the same year for forests in other forms of ownership was 0.59 hectares.

The most frequent causes of fires within the State Forests were arson (43 per cent) and careless adults (25 per cent). Nearly 4 per cent of fires spread from areas other than forests (4.3 per cent of burnt forest area). The number of fires of unknown origin (22 per cent of all fires and 22 per cent of burnt forest area) remains high. The corresponding figures for forests under all ownership categories were arson (43 per cent), careless adults (33 per cent) and unknown cause (17 per cent).

The largest number of fires (1807 fires, or 39 per cent of all fires) occurred in July, followed by 29 per cent in April and 12 per cent in June. The months with the smallest proportion of recorded fires were September (1 per cent), May (3 per cent) and August (4 per cent).

The seasonality of forest fires is closely connected with weather conditions. The volume of atmospheric precipitation in the burning season of 2010 was varied – both in terms of occurrence over time and distribution across the country. In April, there was atmospheric precipitation every day and for six days the average

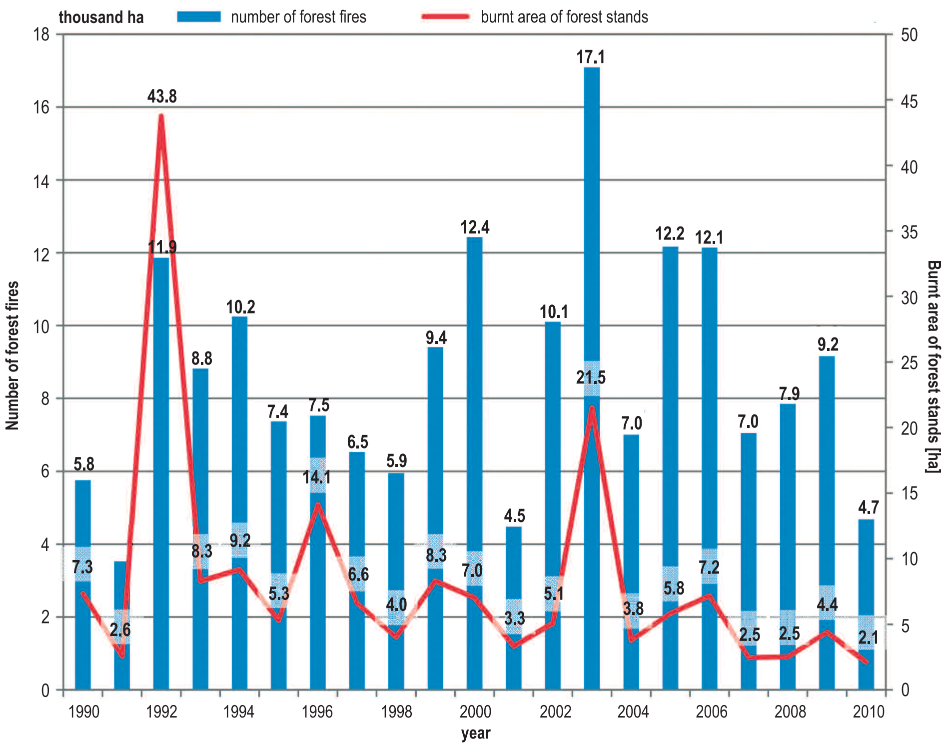


Fig. 38. Total number of forest fires and the burnt area of forests in Poland in 1990–2010

rainfall exceeded 2.0 mm. The average daily rainfall in April (1.3 mm) was significantly different from that in May (4.8 mm). In June, rainfall decreased to 2 mm per day and for 18 days rainfall was less than 2 mm. There was only one day without rainfall in July and 16 days with rainfall of less than 2 mm. There were seven days with heavy rainfall at the end of the month. Finally, there was heavy rainfall every day in August and September.

3.3.2. Air pollution

There are two main groups of sources for global emissions of air pollutants: natural and anthropogenic. The natural sources include volcanic eruptions, biomass distribution, lightning and fires. The anthropogenic sources are emissions from the combustion of solid and liquid fuels used for energy production on macroeconomic and local scales, industrial production, transportation, refineries, energy and fuel transmission, agriculture, waste dumping and incineration, and the treatment of waste water. If they originate from direct emission sources these atmospheric pollutants are referred to as primary. They undergo a variety of chemical and photochemical transformations that generate so-called secondary pollutants, which are an additional but no less dangerous source of air contamination. The ozone occurring in the lower layers of the atmosphere is an excellent example: its presence is associated with the prevailing climate conditions and concentrations of nitrogen oxides and other substances in the air.

The role played by forests in the circulation of air pollution is both that of the releaser (source) and absorber of substances transported in air masses from the atmosphere – often from long distances. Extensive research into the mechanisms of forest decline has found that a number of stress agents, which occur with varying intensity depending on the region, combine to make an impact. The effects of the individual components of industrial emissions can be individual or may be combined with those of other stress factors. The latter, synergic, outcome is more common. The decline in forests caused by acid rain associated with the presence of sulphur, nitrogen oxides, ammonia and ozone in the atmosphere is a well-known phenomenon. The acidifying substances – in the form of gaseous pollutants or acid rain – damage the assimilation apparatus of trees, reduce the number of needle age classes, cause shoot decline and, as a consequence, lead to a progressive reduction in the growth of forest stands. It has also been proven that the indirect effects resulting from changes in soil chemistry and gradual soil acidification have a number of negative consequences in the rhizosphere. One example is an increase in the concentration of nitrogen compounds, whose release from nitrogen-saturated forest ecosystems threatens the purity of groundwaters.

According to the Central Statistical Office, the total emissions of major air pollutants in Poland are among the highest (in absolute values) in EU countries. In

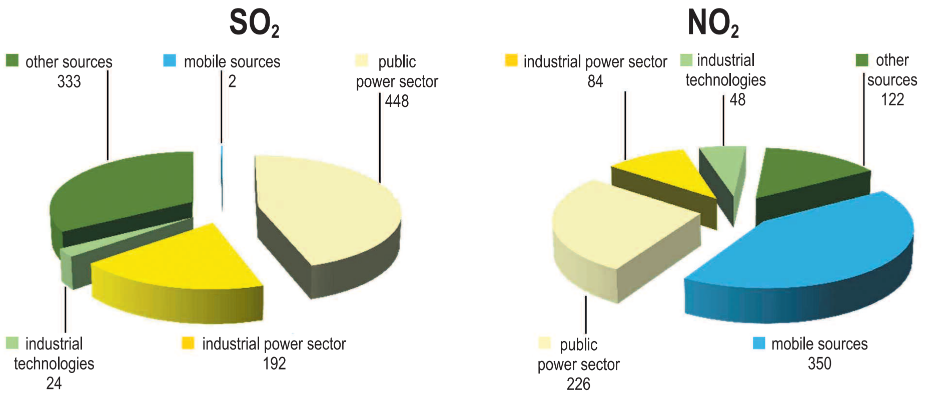


Fig. 39. Total emissions of sulphur dioxide and nitrogen oxides in 2008 by pollution source, in thousands of tonnes (Central Statistical Office)

2008, total emissions of sulphur oxide in Poland (Fig. 39) amounted to 999 thousand tonnes, while the figure for nitrogen oxides calculated as NO_2 was 831 thousand tonnes and that for ammonia was 285 thousand tonnes.

There has been a consistent decrease in SO_2 emissions in Poland since the late 1980s. Except for local incidents, these emissions are probably not the main cause of the current deterioration in the health of the country's forests. Emissions of nitrogen oxides in the past decade have remained fundamentally stable with some fluctuations (Fig. 40). It is, however, difficult to predict the future trend in an era of road transport, which is the main source of these emissions in the air. With the threat of habitat eutrophication, the inflow of nitrogen compounds into forest areas is still at the centre of research.

Forest monitoring provides information on the concentrations of major pollutants in the forest environment in different regions of Poland. The collection of data on gaseous pollutants of sulphur and nitrogen oxides, ammonia and ozone is based on annually-averaged monthly measurements using the passive method. The scope of research includes the flow of elements in atmospheric precipitation in the total precipitation transported to forest ecosystems, as well as the undercrown deposition reaching the forest floor.

The Intensive Monitoring Network consists of 12 Permanent Observation Plots (POPs), five of which are in pine forests in the Chojnów (Warsaw RDSF), Strzałowo (Olsztyn RDSF), Białowieża (Białystok RDSF), Krucz (Piła RDSF) and Zawadzkie (Katowice RDSF) Forest Districts. There are three POPs in spruce stands in the Suwałki (Białystok RDSF), Bielsko (Katowice RDSF) and Szklarska Poręba (Wrocław RDSF) Forest Districts, while there are two in oak stands in the Łąck (Łódź RDSF) and Krotoszyn (Poznań RDSF) Forest Districts and a further

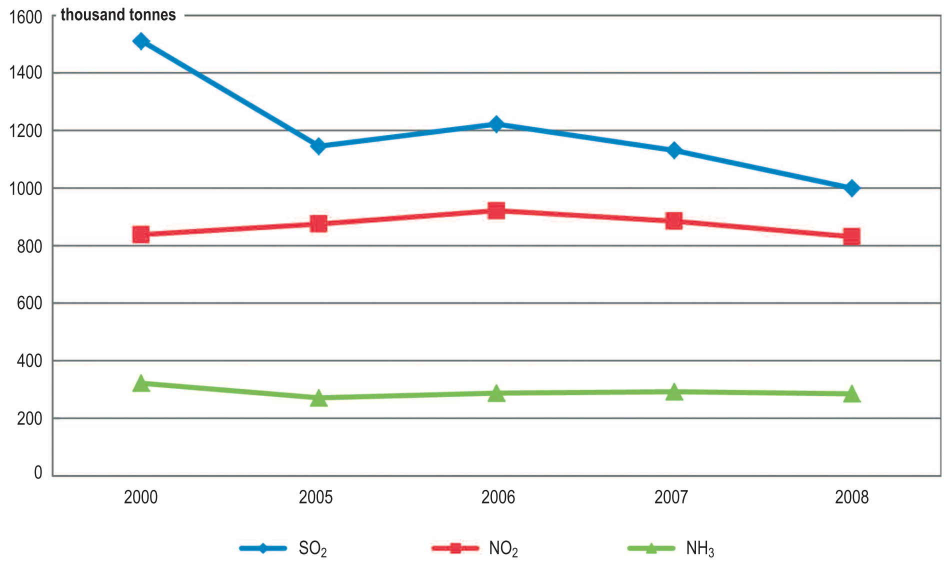


Fig. 40. Total emissions of SO_2, NO_2 and NH_3 in Poland in 2000–2008, in thousands of tonnes (Central Statistical Office)

two in beech stands in the Gdańsk (Gdańsk RDSF) and Bircza (Krosno RDSF) Forest Districts.

The ozone level was measured during the growing season from April to October, when its concentrations are usually high due to conditions conducive to ozone formation in the troposphere (high temperatures, strong insolation). The monthly ozone concentrations ranged from 36.6 $\mu g \cdot m^{-3} \cdot m\text{-}c^{-1}$ to 149 $\mu g \cdot m^{-3} \cdot m\text{-}c^{-1}$ with the value at its maximum in April. With lower temperatures and weaker insolation at the end of the measurement period in September and October, the concentrations of ozone in the air were significantly reduced. The lowest average concentrations throughout the study period were recorded in the Białowieża and Chojnów Forest Districts, while particularly high O_3 concentrations were reported in the mountain and foothill regions, that is, in the Bielsko, Szklarska Poręba and Bircza Forest Districts (Fig. 41).

The average annual concentrations of pollutants on the POPs analysed varied between 1.1 $\mu g \cdot m^{-3}$ and 1.6 $\mu g \cdot m^{-3}$ for SO_2, 2.4 $\mu g \cdot m^{-3}$ and 9.0 $\mu g \cdot m^{-3}$ for NO_2 and 2.0 $\mu g \cdot m^{-3}$ and 3.7 $\mu g \cdot m^{-3}$ for NH_3 (Fig. 42). Compared to other regions, a lower deposition of gaseous sulphur was recorded in northern and eastern Poland (in the Strzałowo, Gdańsk, Suwałki and Białowieża Forest Districts). Higher concentrations were found to occur in southern and central Poland – especially in the Łąck, Szklarska Poręba, Krotoszyn, Bielsko and Zawadzkie Forest Districts. The seasonal variability of pollution was distinct, so that during the heating season of January,

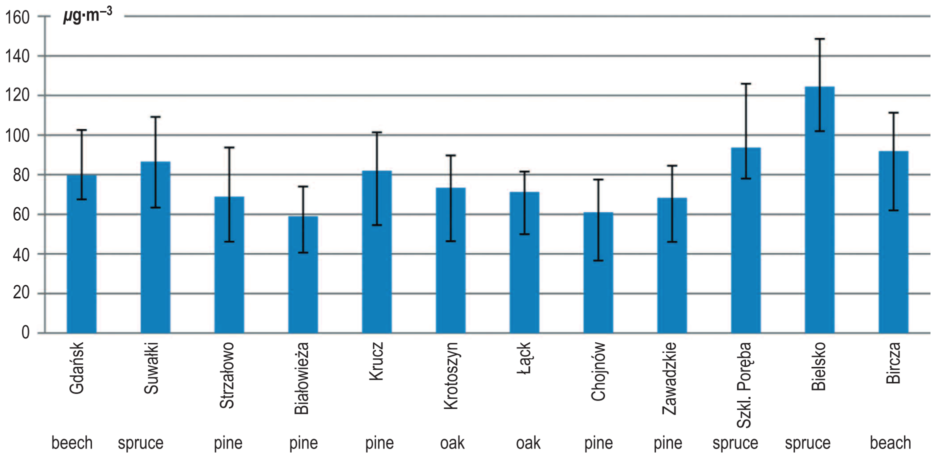


Fig. 41. Average ozone concentrations in the air measured by the intensive monitoring network of POPs in 2010 – error bars represent the monthly minima and maxima

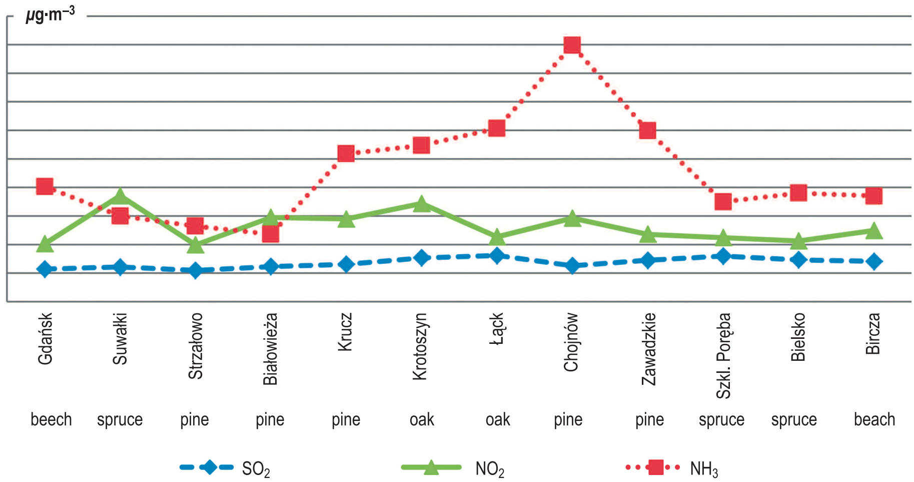


Fig. 42. Average values for sulphur dioxides, ammonia, and nitrogen dioxide concentrations in the air measured by the intensive monitoring network of POPs in 2010

February, November and December, SO_2 and NO_2 concentrations were at their highest (Fig. 43).

The highest concentrations of nitrogen dioxide were recorded in central Poland in the Chojnów, Łąck, Zawadzkie, Krotoszyn and Krucz Forest Districts. Significantly lower concentrations occurred in northern and eastern Poland (Białowieża, Strzałowo and Suwałki Forest Districts) and in the foothill and mountain regions (Szklarska Poręba, Bircza and Bielsko Forest Districts). There are a number of rea-

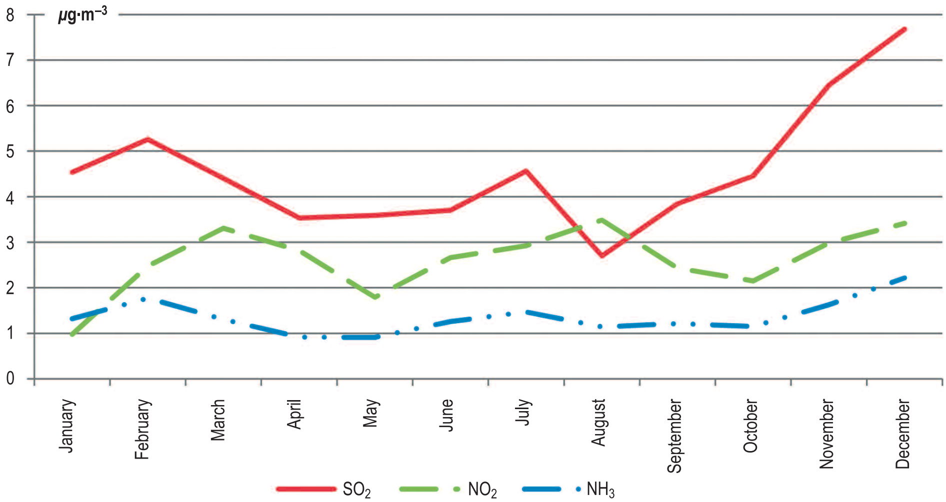


Fig. 43. Changes in the values of concentrations of sulphur dioxides, ammonia and nitrogen dioxide in the air measured by the intensive monitoring network of POPs in 2010

sons for this, such as the number of inhabitants in the surrounding areas and large population concentrations, which entail increased road traffic.

In making provision for nature protection, the Ordinance of the Minister of the Environment of 3 March 2008 on the level of selected pollutants in the atmosphere (Journal of Laws 2008, No. 47, Item 281) sets the admissible level of sulphur dioxide at 20 $\mu g \cdot m^{-3}$ for the calendar year and winter season and the admissible level of nitrogen oxides at 30 $\mu g \cdot m^{-3}$ for the calendar year.

The average annual SO_2 concentrations and the average SO_2 concentrations for the winter season recorded on the POPs of the Intensive Monitoring System were not greater than 2 $\mu g \cdot m^{-3}$, meaning that they were at least ten times lower than the admissible limit. Furthermore, the average concentrations of NO_2 for 2010 were below the levels permitted by the Ordinance of 3 March 2008.

Precipitation (rainfall, drizzle, snow, mist) is the main medium by which acidifying compounds in the atmosphere reach the forest ecosystem. The sulphate and nitrate ions, as well as the protons contained in the precipitation, have a direct effect on the tissues of foliage and are generally less damaging to the environment than the gaseous depositions. However, the influx of these elements into the soil environment usually has long-term consequences for the ecosystems.

Acid precipitation includes snowfall, hail or rainfall with a pH value of less than 5.6. More than half of the monthly precipitation recorded on the POPs of the Intensive Monitoring System in 2010 had a pH of below 5.5. Precipitation acidity is generally at its highest at the beginning of the year, in January and February. The most acidic precipitation occurred on the majority of the POPs in February,

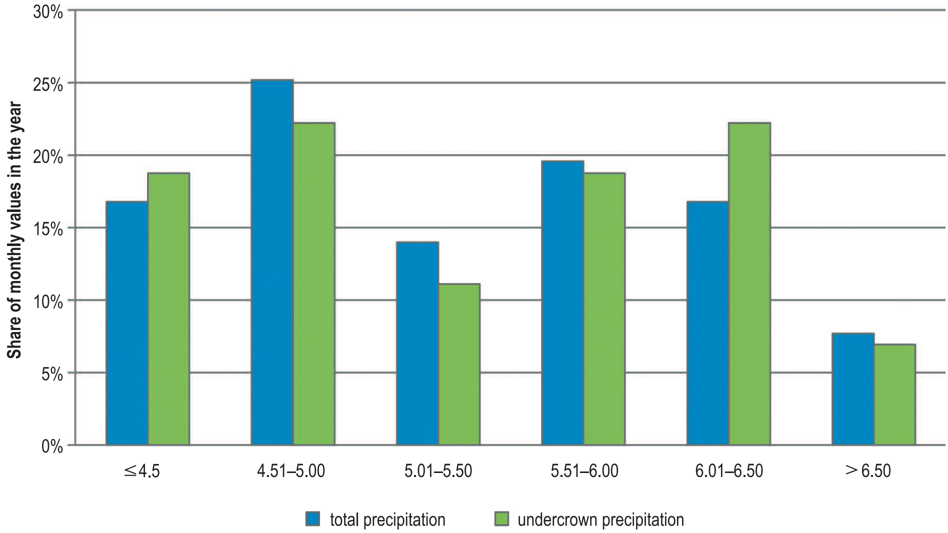


Fig. 44. Frequency of average monthly pH levels in the total and undercanopy precipitation within diverse value ranges on the POPs of the Intensive Monitoring System in 2010

while the highest concentrations of undercrown deposition were recorded on the POPs in the Szklarska Poręba and Bielsko Forest Districts. Low pH values for annual precipitation were recorded in pine stands on less fertile soils in the Chojnów, Krucz and Zawadzkie Forest Districts.

Significant differences in the pH value were found between the summer and winter seasons in the beech forests of the Bircza and Gdańsk Forest Districts and in the oak forests of the Krotoszyn and Łąck Forest Districts, which indicates that the assimilatory apparatus has a large impact on the chemistry of the rain water that passes through the crowns. A similar situation (a high pH value for the summer half-year precipitation) was found in the coniferous forests of the Suwałki, Strzałowo and Białowieża Forest Districts, where the soils are relatively fertile and have a pH close to neutral.

The annual ion deposition transferred with precipitation to forest areas oscillated between 28 $kg{\cdot}ha^{-1}$ and 55 $kg{\cdot}ha^{-1}$. The lowest ion deposition was recorded in the Białowieża, Krotoszyn and Chojnów Forest Districts, while the highest ion deposition was recorded in the mountain regions of the Bielsko and Szklarska Poręba Forest Districts, which also had the highest precipitation level.

The deposition of elements in the undercrown precipitation was greater than in the total deposition reaching the forest floor. The annual undercrown deposition in 2010 ranged from 37 $kg{\cdot}ha^{-1}$ to 87 $kg{\cdot}ha^{-1}$ (Fig. 45). The volume of annual deposition was largely attributed to the amount of precipitation during the year. The highest concentrations of undercrown deposition were recorded on the POPs

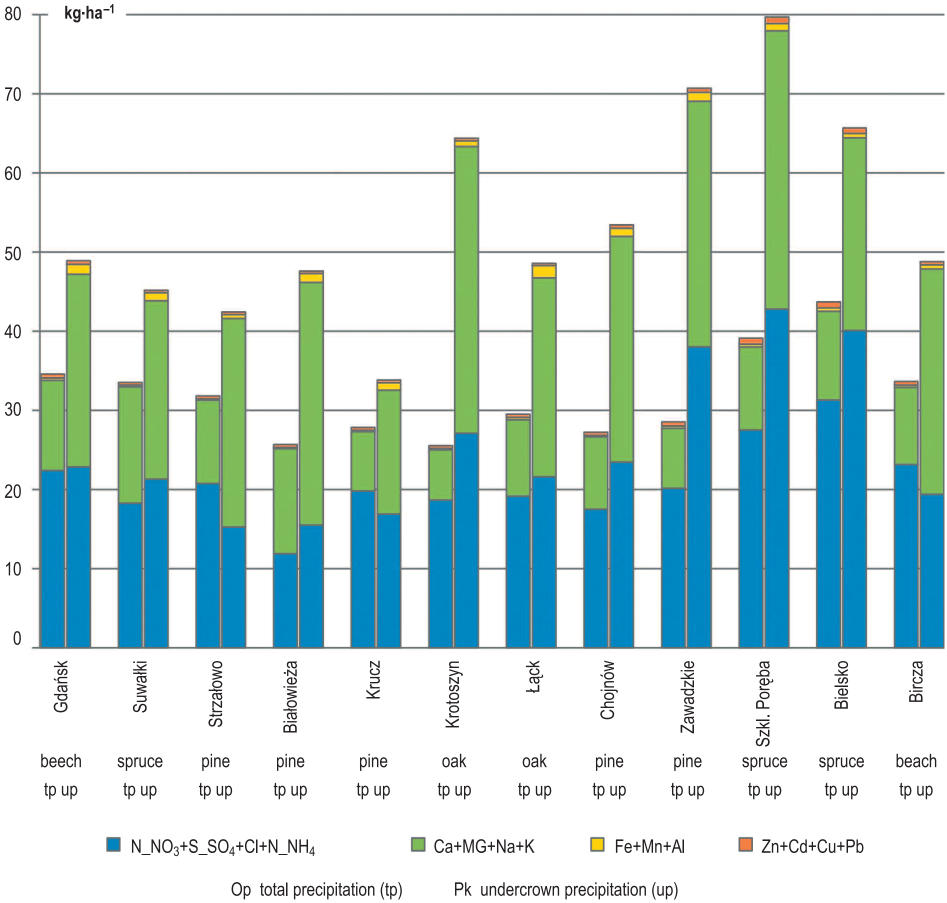


Fig. 45. Deposition of elements (kg·ha^{-1}) from total precipitation (tp) and undercrown precipitation (up) on the POPs of the Intensive Monitoring System in 2010

in the Szklarska Poręba (spruce), Zawadzkie (pine), Bielsko (spruce) and Krotoszyn (oak) Forest Districts, while the lowest concentrations of undercrown deposition were recorded in the Krucz (pine) Forest District. In the case of the beech POPs, (Gdańsk and Bircza Forest Districts), where a part of the deposit is transported in the stemfall to a greater extent than in other forest stands, the total deposit may have been underestimated by at least 5 per cent to 10 per cent.

An important characteristic of precipitation in terms of its impact on the environment is its acid-base balance, which is expressed as the molar ratio of the acidifying ions (Cl^-, $S\text{-}SO_4^{2-}$, $N\text{-}NO_3^{2-}$ $N\text{-}NH_4^+$) to the alkaline ion deposition (Ca, K, Mg, Na) (Fig. 46).

Throughout 2010, acidifying ions represented nearly half to over three quarters of the total deposition of molar ions, while precipitation in open areas was char-

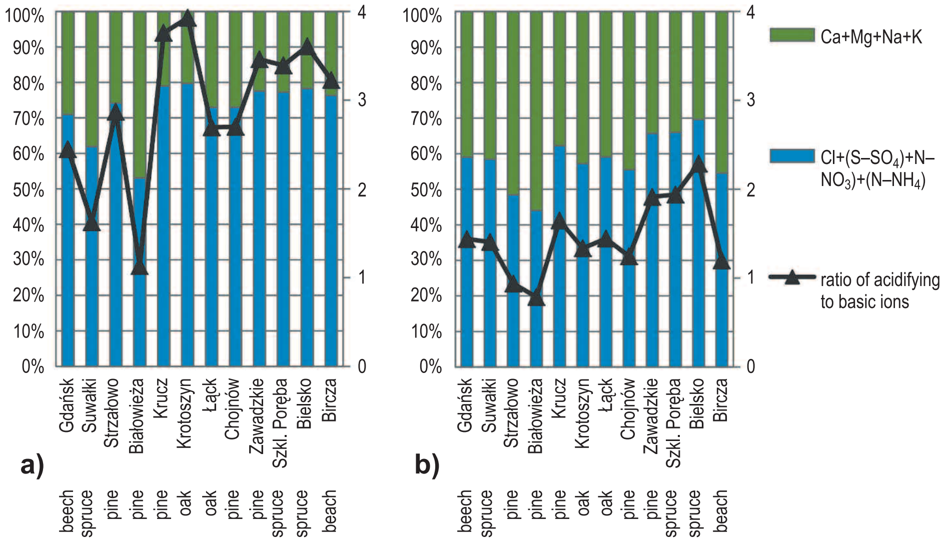


Fig. 46. Share of acidifying and basic ions in total precipitation (tp) and undercrown precipitation (up) on the POPs of the Intensive Monitoring System in 2010

acterized by a higher share of acidifying ion deposition than undercanopy precipitation (Fig. 46). This means that the deposition of acidifying ions prevailed in forest areas, but the tree crowns acted as a filter that to some extent neutralised the acidic precipitation reaching the forest soil. The smallest acidifying ion deposition was recorded in north-eastern and northern Poland in the stands of the Białowieża, Suwałki, Gdańsk and Strzałowo Forest Districts. A particularly high proportion of acidifying ions was found in the areas in southern Poland in the Bielsko, Zawadzkie, Szklarska Poręba and Bircza Forest Districts.

The imbalance between the deposition of acidifying and alkalizing ions increased in the winter months, when the share of acidifying ions deposited in the crown and in the soil under the stand canopy significantly increased compared to the summer half-year in all of the stands investigated. This phenomenon may be associated with the increased physiological activity of vegetation during the growing season, which results in an intense ion exchange in the tree crowns and increased leaching of alkaline cations from the crown area in the summer months.

The deposition of heavy metals, that is, zinc, copper, cadmium and lead (with zinc contributing the highest quantities) ranged from 300 $g \cdot ha^{-1} \cdot year^{-1}$ to 800 $g \cdot ha^{-1} \cdot year^{-1}$. A significantly higher content of heavy metals was recorded on the two mountain POPs in the Szklarska Poręba and Bielsko Forest Districts, which is associated with the high total deposition in these regions compared to the rest of the country. Furthermore, the emissions of heavy metals in these areas are likely to increase, since the two Forest Districts mentioned above and the Zawadzkie Forest District were found to have an increased share of trace elements in the total deposition compared with stands from other regions of Poland.

The data collected within the framework of the Intensive Monitoring Programme clearly show areas where the individual air pollutants contribute to the overall environmental stress. Forest stands in the mountain regions growing on acid soils that have low buffering capacity and are susceptible to acidification are exposed to high levels of ozone and sulphur oxides, high deposition of acidic ions and heavy metals and precipitation with a lower pH value compared to the overall, national figures. It is possible that the high concentrations of nitrogen oxides in central Poland may become a cause of habitat eutrophication. On the other hand, even small amounts of acidifying, eutrophying compounds and gaseous pollutants can upset the natural balance in the habitats of north-eastern Poland, which has been confirmed by studies of rainwater and soil solutions. The threats to the health of forests from air pollution should be considered in relation to the physiographic, climatic and soil conditions, as well as in relation to other stress factors that determine or modify the susceptibility of forest stands to damage.

3.4. Threats to forest sustainability

The impact of stress factors on forests whose ecosystems are already less resistant, for example where the species composition is not adjusted to habitat conditions and ecotypes of trees of foreign origin have been introduced, may in extreme cases lead to their total decline. This occurred in 1980–1991 in the Sudeten Mountains where, due to the weakening of stands caused by industrial emissions, long-lasting droughts and the mass occurrence of secondary insect pests, the stands in the territory of the State Forests were completely removed in sanitation felling from an area of 15 thousand hectares and over 4 million m^3 of deadwood was harvested. This decline affected all forests at higher than 800 metres above sea level. The State Forests carried out afforestation work to protect the deforested areas from soil erosion and degradation, which was frequently accompanied by control treatments against secondary pests. In this way 14 thousand hectares of land was restocked in 1981–1996.

One of the outcomes of the ecological disaster in the Sudeten Mountains was the establishment of an institution for the conservation of endangered ecosystems in Poland. The operational guidelines for the institution were developed by the representatives of the State Forests in cooperation with the Institute of Dendrology, PAS, in Kórnik. In December 1995, the Kostrzyca Forest Gene Bank was established in Miłków in the foothills of the Karkonosze Mountains which, like the Jizera Mountains, were severely hit by ecological disaster in the late 1970s and early 1980s.

The Kostrzyca FGB works to conserve the genetic diversity of forest plant communities. Communities with a high genetic variation adapt to the constantly changing environment more easily, as they are less vulnerable to the adverse effects of biotic and abiotic factors. The Kostrzyca FGB is responsible for a number of nationwide strategic programmes, including those that address the impact of biotic and abiotic factors:

– the Programme for the Preservation of Forest Genetic Resources and the Selective Breeding of Forest Tree Species for the Years 1991–2010 and its continuation beyond 2010,
– the Programme for the Progeny Testing of Selected Seed Stands, Plus Trees, Seed Orchards and Seedling Seed Orchards,
– the Programme for the Conservation and Restitution of the Common Yew (*Taxus baccata* L.) in Poland,
– the Programme for the Restitution of the Silver Fir in the Sudeten Mountains,
– the Programme for the *ex-situ* Conservation of Endangered and Protected Wild Plants in western Poland.

The Kostrzyca FGB was established in response to the emerging threat to the sustainability of forests from various abiotic, biotic and anthropogenic factors. Regrettably, these threats remain and it is left to foresters to take the initiative in acting to minimize their effects.

The development by the Katowice RDSF of a number of preventive measures to halt forest decline in the Beskid Śląski and Beskid Żywiecki forests was one of these initiatives. In the past 30 years, work has been done to reduce the proportion of spruce in the structure of the stands. This achieved a reduction in the share of spruce in the composition of stands in the Sucha, Jeleśnia and Ustroń Forest Districts of approximately 20 per cent.

In 2003, the Programme for the Beskidy Mountains was developed and implemented as part of the Regional Operational Programme of the National Policy on Forests. The document set out a strategy for the protection and management of the Beskidy forests, which has resulted in the conversion of nearly 3000 hectares of spruce stands. The implementation costs over the period 2003–2006 were close to PLN 61 million.

Despite the wide range of preventive measures, increased tree dieback has been observed in the Beskidy forests in the past four years, which has led to forest decline. As in the case of the Sudeten Mountains, there are a number of causes. For example, industrial emissions have changed the chemistry of forest soils and made them unfavourable for tree growth, so that there has been an increase in acidity (pH below 3) and aluminium content and a decrease in the level of calcium and magnesium. Adverse weather conditions, such as frost and droughts in spring 2003, catastrophic wind storms in 2004 and 2007, and high temperatures and low rainfall during the growing season of 2006, have had a significant impact on tree dieback. An increase in the area of stands affected by *Armillaria* root rot disease in the Beskidy Mountains was reported from the beginning of the 1960s. The deteriorating health of the Beskidy stands favoured the appearance of secondary pests and especially the European spruce bark beetle. In 2006, the volume harvested in sanitation felling in the Beskid Śląski and Beskid Żywiecki forests (within the State Forests) amounted to 0.8 million m^3 of wood. The situation is even worse in that private forest owners, who have a significant share of forests in the region, are reluctant to carry out sanitation treatments at the required level. However, the favourable weather conditions in the growing season of 2009 contributed to an improvement in the health of the Beskidy forests and a reduction in the rate of decline of spruce stands.

There are a number of stress factors thought to be causing the increasing decline of broadleaved trees that has been observed in recent years. The cyclic recurrences of oak decline processes observed since the 1970s have been attributed to extreme climate conditions, such as extremely high or low temperatures, long-lasting droughts and changes in the groundwater level. Recent scientific reports have pointed to the significant role of fungi of the genus *Phytophthora* in the decline of broadleaved stands. In 2010, when it was reported on 20.4 thousand hectares, oak decline was at its lowest point of intensity since 2000 (Fig. 47).

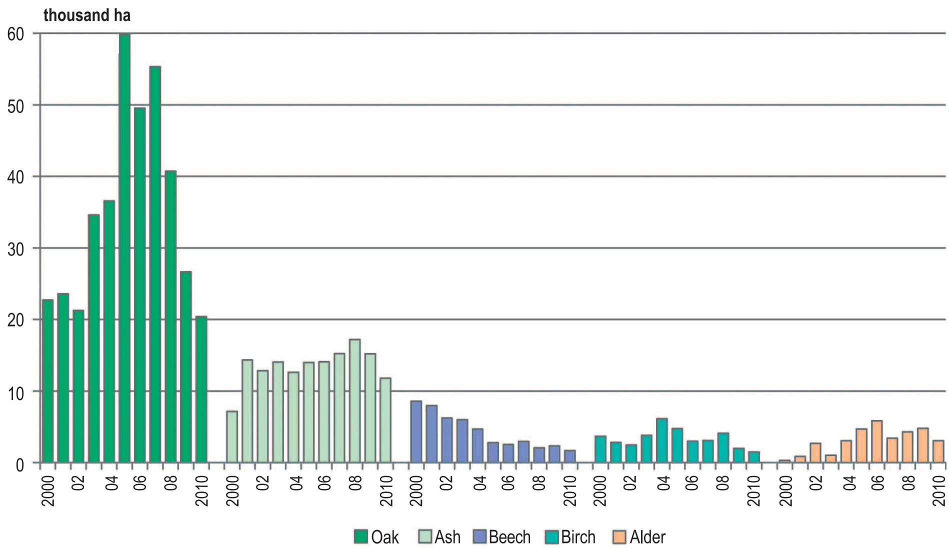


Fig. 47. Area of dieback of selected broadleaved tree species within the State Forests in 2000–2010

Ash decline has been observed in Poland for more than a decade. In 1999, the affected area amounted to approximately 2.3 thousand hectares and, since 2001, ash decline has been recorded each year in an area of 13 thousand hectares to 14 thousand hectares. The disease affects older stands, seedlings in forest nurseries, plantations and thickets. The research conducted by the Institute of Forest Research has shown that fungal pathogens are not the main cause of ash decline. The research has brought results in the form of silvicultural guidelines to prevent the dieback of this species, including the intensive tending of stands with large, well developed tree crowns (the element most strongly correlated with the health of the trees examined). In 2007, the area of dying ash stands exceeded 15 thousand hectares for the first time and 2008 saw further deterioration when symptoms of disease were observed in an area of 17.2 thousand hectares. In 2009, the area of ash decline was similar to that in 2007, while in 2010 the area of decline, 11.8 thousand hectares, was the lowest since 2001.

Recent years have seen a steady improvement in the situation of beech stands. In 2000, beech decline was recorded in an area of 8.6 thousand hectares, while in 2010 on only 1.7 thousand hectares. The decline of alder was reported for the first time in 1999 and affected an area of 31 thousand hectares. The area in which alder stands are now threatened is 3.0 thousand hectares. It is the stands aged 20 years and above that are most affected. In total, tree dieback in 2010 was observed on 40.4 thousand hectares, which was a decrease of approximately 22 per cent compared with the previous year.

3.5. The level of damage to forests

The level of damage to forests in Poland has been assessed every year since 1989 as part of the forest monitoring programme, which is one of the elements of the National Environment Monitoring System.

In 2006–2009, Forest Monitoring was integrated with the Large-Scale Forest Inventory. A network of Level I POPs, with a grid density 16 km x 16 km, was established in accordance with the methodologies recommended by the International Co-operative Programme (ICP-Forests). In 2009, the grid density was increased to 8 km x 8 km. The forests under all forms of ownership and protection were assessed under the Forest Monitoring Programme. The assessment was carried out in stands aged 20 years and above located on the POPs. Sample trees of all woody species located on the plots were selected for assessment.

The location of the Level II POPs has not changed. The scope of measurements and observations on these plots is a continuation of the Monitoring Programme from previous years.

In 2010, an assessment of the loss to assimilatory apparatus took place with regard to 39 080 trees aged 20 years and above in stands located on 1954 Level I POPs (20 trees per plot).

Of the trees assessed, 21.0 per cent showed no defoliation (defoliation class 0 indicates healthy trees), including 18.8 per cent of conifers and 25.2 per cent of broadleaves. The largest share of coniferous trees without defoliation was reported for fir (32.8 per cent) and the lowest for pine (17.6 per cent). The largest share of healthy broadleaved trees was reported for beech (47.3 per cent) and the lowest for oak (12.8 per cent) (Fig. 48).

The share of all damaged trees with defoliation over 25 per cent (in defoliation classes 2–4) was 20.7 per cent, while for the particular species the shares were conifers (20.2 per cent) and broadleaves (21.5 per cent). Of the coniferous species, spruce had the highest share of damaged trees (24.0 per cent of trees with defoliation over 25 per cent), while for the broadleaves oak had the highest share of damaged trees (34.2 per cent). The lowest share of damaged trees among the conifers was for the fir (14.6 per cent) and among the broadleaves for the beech (7.5 per cent) (Fig. 48).

The order of species from the healthiest to the most damaged (determined based on average defoliation and the share of healthy and damaged trees) was as follows: beech, fir, other conifers, other broadleaves, alder, pine, birch, spruce and oak.

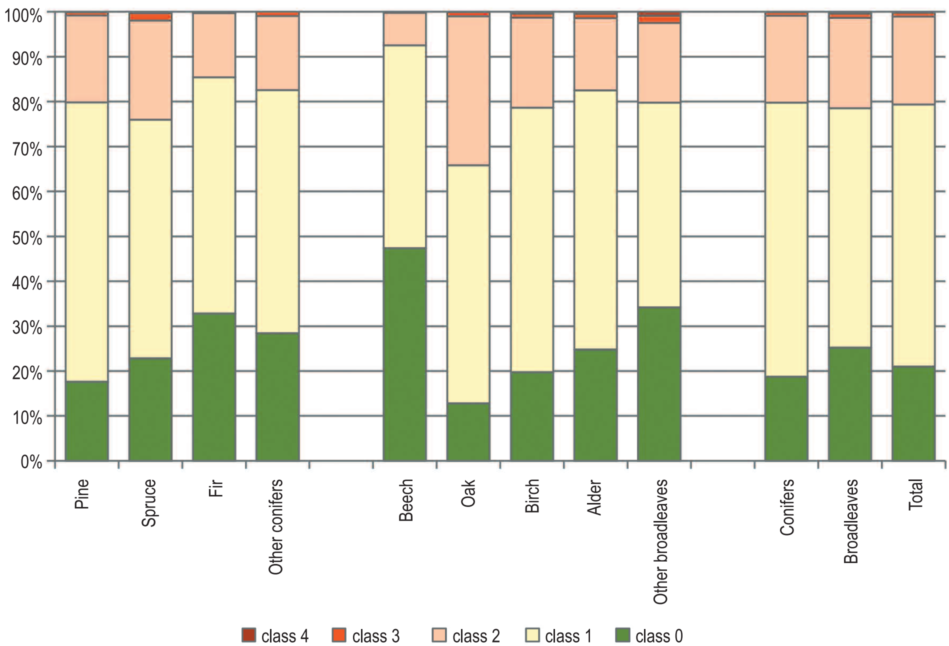


Fig. 48. Share of monitored tree species in defoliation classes on Level I POPs (Forest Monitoring) in 2010: stands aged 20 + under all forms of ownership (Forest Research Institute)

The share of healthy trees (defoliation class 0) in the stands managed by the State Forests was 21.3 per cent, while the share of damaged trees (in defoliation classes 2–4) was 19.3 per cent. Forests owned by individuals had a lower share of healthy trees (19.1 per cent) and a significantly higher share of damaged trees (24.5 per cent). In national parks, the share of healthy and damaged trees was identical at 20.5 per cent.

A comparison of the level of damage to forests in the territory of the Regional Directories of the State Forests has shown that the healthiest stands were in the territory of the Szczecin RDSF (45.7 per cent of trees in class 0; 8 per cent of trees in classes 2–4; average defoliation of 15.0 per cent). The stands in the Zielona Góra and Krosno RDSFs also showed good health (above 32 per cent of healthy trees; 9.6 per cent and 20.4 per cent of damaged trees; average defoliation at 19.5 per cent). Low defoliation levels in stands were reported in the Piła, Szczecinek and Poznań RDSFs (19.8 per cent, 19.8 per cent and 20.0 per cent respectively). However in these stands, along with the low share of damaged trees (15.2 per cent, 14.9 per cent and 13.1 per cent respectively) there was a concurrent low share of healthy trees (17.3 per cent, 20.0 per cent and 12.6 per cent respectively). In the Kraków, Wrocław and Radom RDSFs there were a large number of healthy trees (26.0 per cent, 24.1 per cent and 20.4 per cent respectively), along with a higher average defoliation level (20.1 per cent, 21.2 per cent and 22.0 per cent respectively) and a high share of damaged trees. The highest proportion of damaged stands was reported in the Gdańsk and Warsaw RDSFs (average defoliation level 24.3 per cent and 24.6 per cent, share of healthy trees 8.3 per cent and 2.1 per cent, share of damaged trees 30.9 per cent and 28.5 per cent respectively).

The health of forests in 2007–2009 did not change substantially, while 2010 saw a slight deterioration. The combined average defoliation of species in 2007, 2008, 2009 and 2010 was 19.8 per cent, 19.9 per cent, 19.8 per cent and 20.9 per cent respectively (Fig. 50). For the same years, the share of healthy trees was 25.1 per cent, 24.5 per cent, 24.2 per cent and 21.0 per cent and the share of damaged trees was 19.57 per cent, 18.0 per cent, 17.7 per cent and 20.7 per cent.

The greatest damage to trees in the past four years was reported for oak (below 16 per cent of healthy trees; over 28 per cent of damaged trees; average defoliation of 22 per cent). Spruce had a high share of damaged trees (below 28 per cent of healthy trees; over 24 per cent of damaged trees; average defoliation at above 21 per cent). Beech had the lowest share of damaged trees (over 41 per cent of healthy trees; below 14 per cent of damaged trees; average defoliation at 17 per cent). Alder was found to be in good health (over 24 per cent of healthy trees; below 18 per cent of damaged trees; average defoliation at below 20 per cent) (Fig. 51).

In the past four years the share of healthy beech trees has increased from 41.7 per cent to 47.3 per cent, the share of damaged beech trees has decreased from

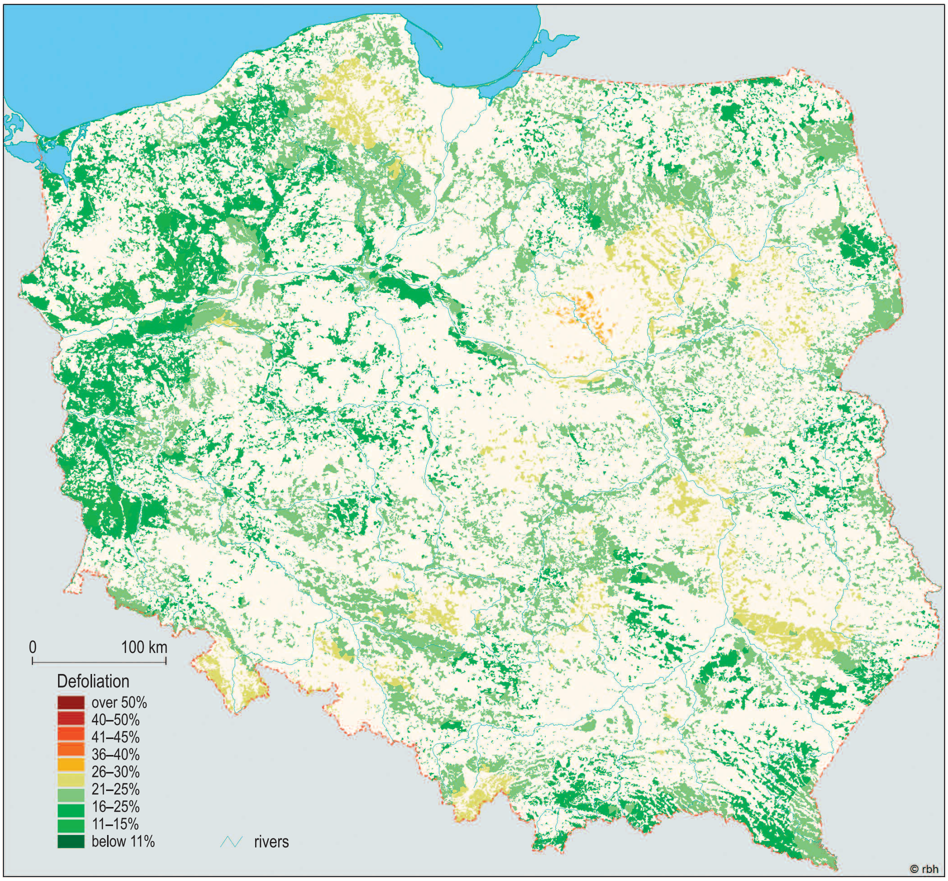


Fig. 49. Level of damage to forests based on the defoliation on Level I POPs (Forest Monitoring), assessed according to 5 per cent defoliation intervals in 2010 (Forest Research Institute)

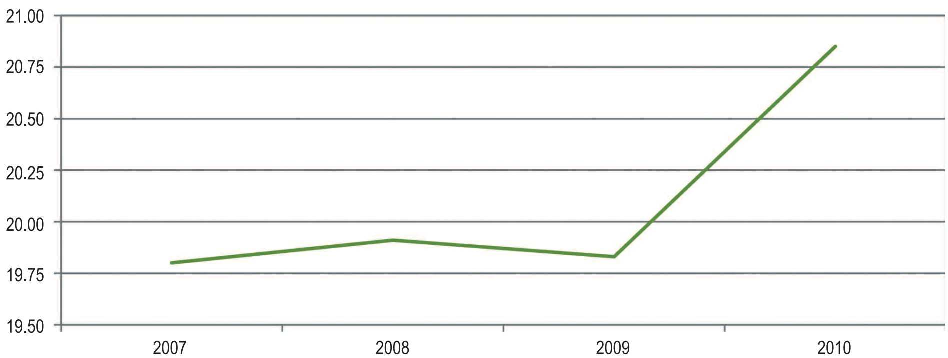


Fig. 50. Average percentage defoliation of trees on Level I POPs (Forest Monitoring) in 2007–2010: stands aged 20 years and above (Forest Research Institute)

13.7 per cent to 7.5 per cent and average defoliation in the beech has fallen from 16.1 per cent to 14.5 per cent, which indicates a gradual improvement in health (Fig. 51).

The health of alder and oak has been reported as deteriorating over the past four years. The share of healthy trees has fallen from 38.7 per cent to 24.8 per cent and from 15.4 per cent to 12.8 per cent respectively and the share of damaged trees has increased from 11.9 per cent to 17.5 per cent and from 30.4 per cent to 34.2 per cent respectively, while average defoliation has increased from 16.4 per cent to 20.0 per cent and from 23.0 per cent to 24.6 per cent respectively (Fig. 51).

For the health of the pine, the period 2007–2009 was one of stabilization, however 2010 saw a deterioration. The health of the spruce in 2007–2009 deteriorated slightly and improved in 2010. The health of the birch and fir varied: in 2008 it deteriorated by comparison with 2007, in 2009 it improved and in 2010 it deteriorated once more (Fig. 51).

A comparison of the level of damage to forests in different regions of the country shows that in the past four years the stands of the Szczecin RDSF were the healthiest (8 per cent of damaged trees). The stands administered by the Piła, Szczecinek and Poznań RDSFs were also found to be in good health (10–18 per cent of damaged trees), while damaged stands (over 23 per cent) were reported in the Katowice, Radom and Warsaw RDSFs. The distribution of damage to forests

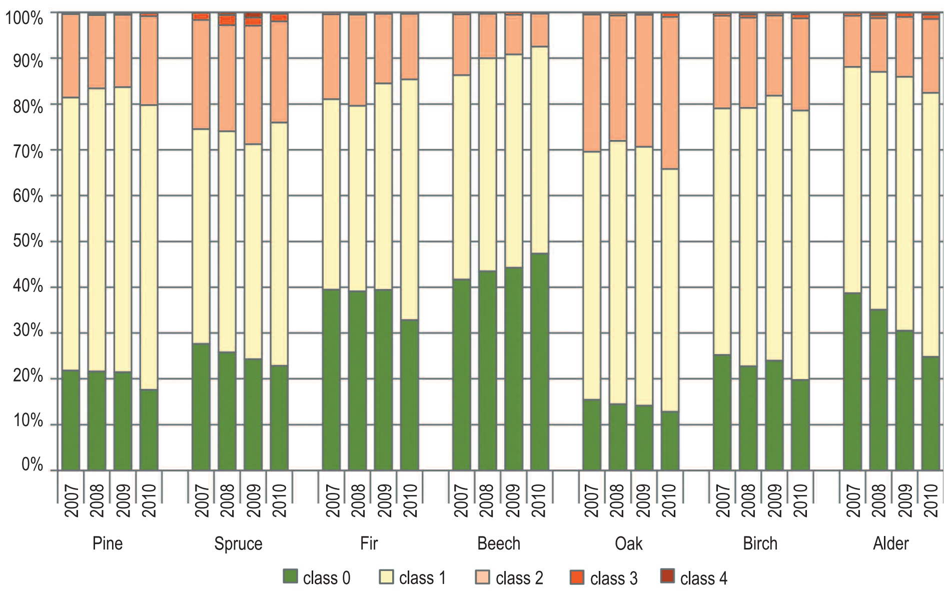


Fig. 51. Share of monitored tree species in defoliation classes on Level I POPs (Forest Monitoring) in 2007–2009: stands aged 20 years and above (Forest Research Institute)

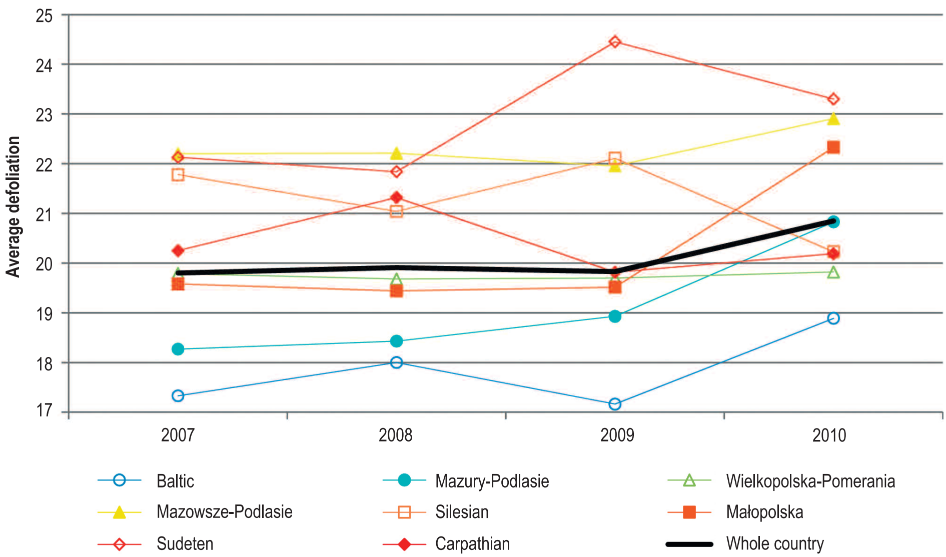


Fig. 52. Share of trees in defoliation classes 2–4 on Level I POPs (Forest Monitoring) in the Natural-Forest Regions and in the country (on average) in 2007–2010: stands aged 20 years and above (Forest Research Institute)

in Natural-Forest Regions found that the healthiest stands were in the Baltic Natural-Forest Region and that there were healthy stands in the Mazury-Podlasie and Wielkopolska-Pomerania Natural-Forest Regions. There were heavily damaged stands, however, in the Sudeten, Mazowsze-Podlasie, Carpathian and Silesian Natural-Forest Regions (Fig. 52).

An improvement in the health of forest stands in the past four years (based on a comparison of the shares of damaged trees) was reported in the Toruń, Kraków, Krosno and Zielona Góra RDSFs, while their deterioration was observed in the Białystok, Lublin, Olsztyn and Łódź RDSFs. Significant increases and decreases were recorded for damage to stands in the Wrocław and Gdańsk RDSFs over the years in question. With regard to the Natural-Forest Regions, an improvement in the health of forest stands was reported in the Baltic and the Poznań-Pomerania Natural-Forest Regions and a deterioration in the Mazury-Podlasie, Małopolska and Sudeten Natural-Forest Regions (Fig. 52).

Weather conditions in the growing season of 2010 were favourable in most regions of the country. The average total rainfall for the country calculated based on the measurement results from 22 synoptic stations of the Institute of Meteorology and Water Management was 601 mm, which corresponds to 151 per cent of the long-term norm. Particularly heavy and sudden precipitation (storms) occurred in May and brought floods to many regions of the country.

The comparison of the level of damage to forests in Poland with other European countries is based on the report, The Condition of Forests in Europe in 2011: ICP Forests Technical Report (UNECE, Hamburg, 2011).

A comparison of the levels of damage to forests in European countries in 2010 arranged in order of increasing share of trees in defoliation classes 2–4 for all species combined ranked Poland as a country with a moderate share of damage (20.7 per cent). A high level of damage (over 35 per cent of trees in defoliation classes 2–4) was reported in the Czech Republic (54.2 per cent), Great Britain (48.5 per cent) and Slovakia (38.6 per cent). The forest stands in Russia, Ukraine, Belarus, Estonia and Denmark had the lowest share of damaged trees at below 10 per cent of trees in defoliation classes 2–4.

4. The importance of main forest tree species in recent years

The last twenty years, and particularly the last decade, have seen changes in the importance of the major forest tree species. The current major focus of forest management is the drive to obtain stable forest communities that are best adjusted to habitat conditions and that are highly capable of adapting to the changing environmental conditions associated with anthropopressure and climate change. The significance and share of broadleaved species in Polish forests has increased considerably. Furthermore, the area of stands established by natural regeneration has increased by almost 100 per cent compared to 10.1 per cent in the previous decade (RoSL, 2011). The size of the clear-cut areas is being reduced constantly and complex felling is assuming an ever greater role. Forest regeneration periods are being extended more and more frequently, which aids the development of forest communities that are more resistant to the impact of damage-causing factors because they have varied age, species and spatial structures.

5. Forest monitoring and the assessment of the level of genetic erosion of forest genetic resources

The genetic erosion of forest genetic resources is not monitored in Poland. The environmental monitoring carried out by the Chief Inspectorate for Environmental Protection (CIEP) within the framework of National Environmental Monitoring applies to selected natural habitats, plants and animals. In 2006–2008, 1580 natural habitats, including forests, were being monitored, which allowed threats to be identified and protective measures to be determined (Table 26). The list of monitored plant species, which includes 16 species from 122 habitats (CIEP, 2010) does not include woody species. Tree species considered potentially invasive, such as *Robinia pseudoacacia* L. and *Prunus serotina* Ehrh., are not monitored either.

The State Forests, in collaboration with the Forest Research Institute, continuously monitor the environment and health status of forest stands. This is an integral part of National Environmental Monitoring and also functions alongside the International Cooperative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP-Forest). The purpose of the monitoring is to identify the geographical distribution of damage to stands, analyse the cause-effect relationships between the health status of forests and environmental factors, identify the main symptoms and causes of damage to trees, determine the trend of changes in stand damage over time and forecast the short-term health of forests.

Forest monitoring in Poland has been carried out every year since 1989 but the form it took changed significantly in 2006. It was then that the Forest Monitoring POPs were integrated with the observation plots of the Large-Scale Inventory of the condition of forests. The integration of these plots improved the systems used to collect information about the forest and made them more compatible.

The Forest Monitoring System is based on a network of POPs, which includes Level I POPs with a grid density 8 km x 8 km and permanent Level II POPs, which represent stands of pine, spruce, oak and beech. The system has no capacity for monitoring the genetic erosion of selected forest tree species.

The State Forests do, though, take indirect action to limit the negative effects of the genetic erosion of species, for example by identifying and protecting populations within species to preserve their breeding and genetic value and to restore populations in danger of extinction. Population diversity is protected mainly by adopting legal regulations to govern the transfer of FRM, which forbid its introduction from other mother populations.

The restoration of endangered populations involves the reproduction of surviving stands and individuals and the establishment of gene conservation plantations of an appropriate size and species composition. At the species level, the focus is on *Taxus baccata* L. and *Sorbus torminalis* (L.) Crantz, while at the population level it is on the Noteć, Milicz-Kubryk and Nowogród populations of pine, the Tarnawa, Wigry, Śląsk, Roztocze, Klonowskie and Nowe-Ramuki populations of spruce, the Młynary population of larch and the Sudeten fir.

The action to be taken should include permanent monitoring involving cyclical genetic studies of within-species genetic erosion. These should concentrate especially on protected forest tree species and on selected populations influenced by genetic drift.

6. Needs and priorities for the future

The priority tasks in Poland of the Ministry of the Environment, the State Forests, the Forest Research Institute and other institutions are to study forest genetic resources, to thoroughly investigate the genetic diversity of forest tree species and to monitor changes in the genetic diversity within species and between existing populations. These tasks are included in the Programme for the Preservation of Forest Genetic Resources and the Breeding of Trees in Poland for the years 2011–2035. However, the programme only covers forest genetic resources managed by the State Forests.

6.1. Priorities for a better understanding of the importance of forest genetic resources

One of the objectives of the National Environmental Policy for the protection of nature is to maintain biological diversity at the genetic and species levels. If individual tree species and their populations are to be properly protected it is necessary to gather knowledge of the initial state of their genetic diversity. To satisfy the need for comprehensive and standardized genetic studies on the variability of forest trees in Poland, a Scientific Consortium (Genetics of Forest Trees; *DENDROGEN)* was established in 2010 at the Institute of Dendrology, PAS, in Kórnik. It represents major scientific bodies involved in genetic studies of forest trees, such as the Institute of Dendrology, PAS, in Kórnik, the University of Bydgoszcz, the Forest Research Institute in Warsaw, the Poznań University of Life Sciences, the University of Agriculture in Kraków, the Warsaw University of Life Sciences (SGGW) and the Adam Mickiewicz University in Poznań. The Kostrzyca Forest Gene Bank also joined the consortium as a non-associate member. The consortium unites several dozen researchers involved in forest tree genetics, whose joint projects and scientific publications will contribute to a better assessment of the genetic variation of Polish forests. The implementation of research findings into forest practice should help improve the adaptability, resistance, and qualitative and productive attributes of forest stands.

If the significance of forest genetic resources is to be better understood, it is extremely important to provide high-quality public education at all levels of the education system from primary school to university. In addition to the ecological aspect, the educational process should also highlight the productive role that forest genetic resources play in the management of sustainable and multifunctional forests. Education programmes are therefore being established in all territorial units of the State Forests, as well as in national and landscape parks. Their focus is on the role and significance of genetic diversity in the development and stabilization of forest ecosystems and on the potential to pursue sustainable development and be more conservative in their use.

The task of environmental education also falls to academic institutions, which include the University of Warsaw (the Warsaw Botanical Garden), the Forest Research Institute, the Centre for Nature-Forest Education in Rogów, which is affiliated to the Warsaw University of Life Sciences (SGGW), the Institute of Dendrology (the Kórnik Arboretum) and the University of Wrocław (the Botanical Garden in Wrocław and the Arboretum in Wojsławice) (RoSL, 2011).

It is very important in this endeavour to raise ecological awareness and promote the right approach and attitude to forests and their resources. This will entail developing extensive networks for partnership with nature conservation organizations and environmental associations that will deliver carefully considered outcomes.

Fig. 53. Promotional Forest Complexes in Poland in 2009 (Forest Research Institute)

The Promotional Forest Complexes (PFCs), whose principles of operation are set out in the Forest Act (1991) and the State Policy on Forests (1997), may also be regarded as areas of particular scientific significance where interdisciplinary studies can be pursued (Fig. 53). Their results will make it possible to improve forest management methods and to set admissible limits to economic interference in forest ecosystems. The PFCs are, moreover, a pleasant alternative to the crowded national parks where tourist traffic is regulated by rigorous and strict rules.

The promotion of ecological forest management pursued by the State Forests has made it possible to locate PFCs (there are 19 in total) in each of the 17 RDSFs. Their total area is nearly 1 million hectares, of which 979 thousand hectares represents land managed by the State Forests. PFCs therefore account for approximately 14% of the entire territory of the State Forests.

The issues associated with the genetic diversity of Polish forests have been taken up by the Kostrzyca FGB as elements of environmental education. Their specialist courses, which attract 3140 people each year, are designed for forests and forestry professionals, forest management staff, natural history students, young people and children (Kostrzyca FGB data for 2006–2010).

6.2. The level of public ecological awareness

Although educational and training initiatives are up and running, the level of ecological awareness in Poland is still unsatisfactory. This is reflected in people's carelessness and in the harm they do to forests. The major threats to forest communities resulting from a low level of ecological awareness are arson, timber theft, the destruction and excessive use of forest floor products, poaching, littering, the illegal extraction of gravel and sand and illegally driving motor vehicles.

6.2.1. Harm to forests

Irrespective of the form of ownership, incidents of unlawful logging and theft of timber, illegal use of forest products, damage and poaching are still frequent in Poland's forests. Approximately 55 thousand cases of these kinds are reported each year in the forests managed by the State Forests, while the value of the related financial losses is estimated at approximately PLN 6 million (GDSF, 2011).

6.2.2. Leaving litter in forests

The Forest Service is continually patrolling forests and pursuing people who leave litter. Despite this, the State Forests incur cleaning costs of approximately PLN 11 million per annum.

6.3. The need to legislate for the effective protection of forest genetic resources

There is an urgent need for legislation to govern the protection of Forest Genetic Resources (FGR) in Poland and the implementation of the Programme of PFCs for the Preservation of Forest Genetic Resources in forests under all forms of ownership – rather than in the State Forests alone. These regulations should also be included in the forthcoming Forest Strategy and in the National Forest Programme.

Chapter 2:

The state of the *in situ* conservation of genetic resources

1. The role of forests in the conservation of genetic resources

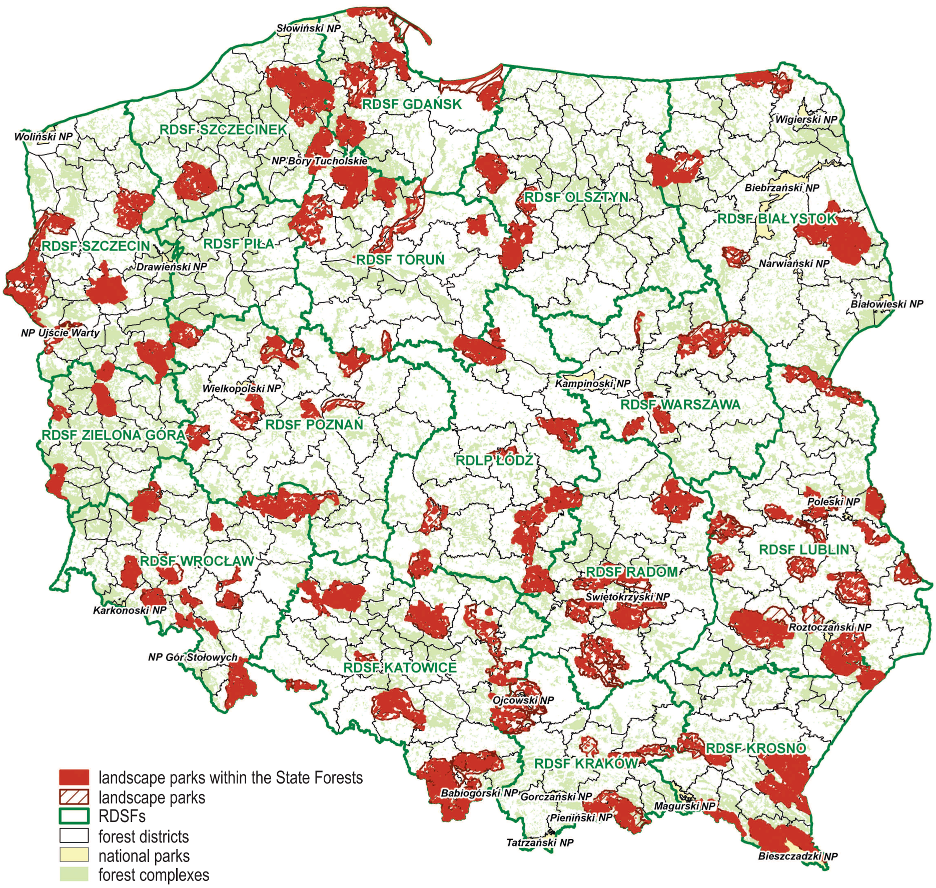
The conservation of biological diversity has been carried out in Poland since the 1920s. Its initial aims were to protect and conserve valuable natural objects in the form of individual trees or nature reserves (usually to protect populations of forest trees) and to establish national parks. The national parks were created to preserve biodiversity, resources, elements of inanimate nature and landscape values and to restore the resources and elements of nature to their proper condition. They were also intended to rehabilitate the degraded natural environment and the habitats of plants, animals and fungi.

There are now 23 national parks covering 314 474 thousand hectares, which is 1 per cent of the country's land area (Fig. 54). The total area of nature reserves is 194 992 hectares, of which 54 059 hectares are under strict protection (Table 28).

The conservation of the genetic resources of forest trees in national parks is included in the protection plan developed for parks or in their protection tasks. The forest ecosystems are placed under strict, active or landscape protection. The areas under strict protection are those with a high degree of naturalness of vegetation cover. The most important goal is to protect the processes involved in the functioning of natural and semi-natural ecosystems. Active protection involves restoring these ecosystems to a closer-to-natural state through the introduction of tree species suitable for a given habitat (reconstruction), while landscape protection is intended to maintain the characteristics of the landscape. It is permitted to collect seeds from trees of native origin growing in parks. The seeds are collected from individual trees at the age prescribed for the given species provided their health and quality suggest they are adapted to local conditions (Ministry of the Environment, 2011).

According to Central Statistical Office data from 2010, there are additionally in Poland:

a) 1463 nature reserves with an area of 164.2 thousand hectares, including 99.2 thousand hectares of forest area (of which 42.1 thousand hectares are in non-forest reserves),



The source materials for landscape parks come from the DGSF

Forest Management and Geoinformation Section of the DGSF

Fig. 54. National and landscape parks in Poland (GDSF)

b) 121 landscape parks with an area of 2.608 million hectares, including 1.309 million hectares of forest area (50.2 per cent),
c) 386 areas of protected landscape totalling 7.076 million hectares, including 2.228 million hectares of forests.

The total area of national and landscape parks, and of protected landscape areas, increased in the period 1980–2010 by almost 30 per cent (from 3.2 per cent to 32.0 per cent of the administrative area of the country). The increase was even greater in the case of forest area, which increased from 5.5 per cent to 40.9 per cent of the area of the national and landscape parks and protected landscape areas.

All of the above forms of forest management and protection are aimed at ensuring the stability and biological resistance of forests while also serving the *in situ* conservation of forest genetic resources.

The Bartek Oak in the Zagańsk Forest District (photo by K. Murat)

1.1. The Natura 2000 network

The main goal of the European network of protected areas, Natura 2000, is to prevent the extinction of endangered plant and animal species and to protect biological diversity in Europe. All member states are obliged to establish special protection areas to be included in the Natura 2000 network. Two EU directives, the Birds Directive and the Habitats Directive, form the legal foundation for the implementation of the Natura 2000 programme. Both were incorporated into Polish legislation by the Act on Nature Protection of 16 April 2004.

The Natura 2000 network is composed of two types of protection areas (Fig. 55):
- Special Protection Areas (SPAs) for the conservation of populations of wild birds,
- Sites of Community Importance (SCIs) for the protection of natural habitats and rare flora and fauna.

By the end of 2010, 144 Special Protection Areas and 823 Sites of Community Importance covering 5.571 million and 3.792 million hectares respectively, had

Fig. 55. Natura 2000 sites in Poland (GDSF)

been established (General Directorate of Nature Protection). These areas cover nearly 20 per cent of Poland's land area.

The Białowieża Primeval Forest, which is unique in Europe, is the main area of Poland in which natural forests are preserved. Please see:
http://pl.wikipedia.org/wiki/Puszcza and, for Białowieża National Park,
http://pl.wikipedia.org/wiki/ Bia%C5%82owieski.

1.2. The biological diversity of the Białowieża Primeval Forest

The Białowieża Primeval Forest is one of the largest tracts of forest in the Central European Plain and has stands representing all of the types of lowland forest typical of the boreal-nemoral zone. It is a mixture of broadleaved forests that shed leaves in winter and evergreen coniferous forests. Their phytosociological and ecological diversity corresponds to the habitat diversity typical of denudation plains in the eastern parts of the postglacial North European Plain. The dominant forest types include the meso-eutrophic oak-hornbeam-lime forests, meso-oligotrophic oak-spruce-pine forests and oligotrophic pine forests. The share of spruce forests is small, though important (Faliński). In spite of its location near the geometric centre of the European sub-continent, the Białowieża Primeval Forest is in the transition zone between the Continental and Atlantic climates and on the south-western edge of the geobotanical northern division. This has an effect on its natural attributes.

The Białowieża Primeval Forest has a high degree of naturalness, a high density and a vast area, as well as large tracts of virgin, old-growth stands, in which many trees are classified as natural monuments. It has a special position among natural sites in Europe because of the favourable condition of most of the components of the geographical environment, the biological diversity, the high degree of naturalness and variety of the ecosystems and its location in the transitional zone of Europe in terms of biogeographic, climatic and hydrographic conditions. Many of the forest biocoenoses of the Białowieża Primeval Forest are composed of natural forest with a complex multi-layer, multi-species and multi-age structure.

There are 26 tree species in the forest communities of the Białowieża Primeval Forest. The current structure of the dominant species in the stands of the Białowieża Forest Districts is the result of the mosaic structure of habitats and of human activity. Pine is the dominant species in the coniferous mixed forest habitats and, partly, in the mixed forest habitats. Spruce is the second most common species in the medium-fertile coniferous and mixed stands of the Białowieża forests, which are those most suited to its growth. It can be found in nearly all types of forests and plays a special role in shaping the structure and dynamics of forest communities (Paczoski, 1930; Matuszkiewicz, 1952; Faliński, 1986; Sokołowski, 1966). In the most fertile hornbeam-oak forests, where oak is predominant, large areas are occupied by birch, hornbeam and aspen and some spruce and pine are found. Beech, large-leaved lime, sycamore and field maple are absent in the flora of the Białowieża Primeval Forest. Sessile oak and fir occur on the edge of their geographical range and do not play a major role in the structure of forest communities. Oak and hornbeam have a large share in the composition of the Białowieża forest communities.

All types of forest communities typical of the given geographical location can be found in the Białowieża Primeval Forest. They occupy over 95 per cent of its territory and in some places co-occur with bushy plant communities. Phytosociological studies have documented 5 classes of 25 associations and 11 sub-associations. In addition to the dominant forest communities, there are natural or semi-natural water, bog and shrub communities, which contribute to the biological diversity of the Białowieża Primeval Forest.

The Białowieża Primeval Forest is regarded as a relic of the original forest landscapes of the old glacial moraine plateaus prevailing in the past in the central and northern lowlands of Poland. This type of lowland forest is characteristic of the boreal-nemoral zone. In comparison with other forest areas of Poland and Europe, the primeval and relict character of the Białowieża forests is due to its significant share of forest stands of natural origin that are over 100-years-old, which have a multi-layer structure. Approximately 80 per cent of the area is occupied by the forest habitat types listed in Appendix I to the Habitats Directive. Patches of non-forest habitats from Appendix I are also identified. The total number of habitat types listed in Appendix I is 12 (Table H).

Table H. A list of natural habitats on the Natura 2000 'Puszcza Białowieska' site (PLC200004).

Natural habitat	Estimated area	% of coverage	General assessment
3150 Old river-beds and natural, eutrophic water bodies	12.62	0.02	C
6230 Mountain and lowland species-rich Nardus grasslands	132.61	0.21	C
6410 *Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)	6.31	0.01	
6510 Lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*) and 6520 mountain hay meadows	524.12	0.83	C
7120 Degraded raised bogs still capable of natural regeneration	6.31	0.01	
7140 Transition mires and quaking bogs	18.94	0.03	C
7230 Alkaline fens of *Caricion davallianae* with mostly low-growing sedge, rush communities and helophilous mosses	157.87	0.25	C
9170 *Galio-Carpinetum* oak-hornbeam forests	39 814.58	63.05	A
91D0 Bog woodlands	2 746.92	4.35	A
91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)*	12.62	0.02	A
91F0 Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along great rivers (*Ulmenion minoris*)	63.15	0.10	A
91IO Euro-Siberian steppe woods with *Quercus* spp.	6.31	0.01	C
Total	**43 502.36**	**68.89**	

* priority habitats.

The high proportion of old trees and deadwood favours the development of rich invertebrate fauna and especially of saproxylic insects, many of which are rare in Europe. For some invertebrates, such as the *Boros schneideri* beetle, goldstreifiger, the false darkling beetle, *Pytho kolwensis*, *Rhysodes sulcatus* and Desmoulin's whorl snail, the Białowieża Primeval Forest is either the only site in Poland where the species has been confirmed or one of the only confirmed sites. Species such as the great capricorn beetle, the hermit beetle and the fairly numerous *Cucujus haematodes* beetle are also worth noting.

According to the Natura 2000 Standard Data Form for the 'Puszcza Białowieska' site (PLC200004), 39 species of the animals listed in Appendix II to the Habitats Directive are found in the Białowieża Primeval Forest: 6 mammal species, 2 amphibian species, 1 species of reptile, 4 fish species and 26 invertebrate species.

The mammalian fauna, which includes a total of 58 species (72 per cent of the fauna of lowland Poland), is very well represented. The Białowieża Primeval Forest is of great importance for the conservation of large carnivores in the form of the wolf and the lynx and Poland's most important bison refuge is also to be found there. The latest catalogue of the primeval fauna in the forest includes nearly 11 000 species, of which 40 per cent are native to Poland. The insect fauna is particularly rich with 9300 species represented. There are in addition 12 species of amphibians and 7 species of reptiles that are also worthy of attention.

Approximately 240 bird species have been identified in the Białowieża Primeval Forest. The majority are nesting forest species that migrate for the winter. There are few migratory birds that stop here to feed and few birds associated with anthropogenic habitats. The Białowieża Primeval Forest is also host to 15 species of diurnal birds of prey, 6 species of owl, 8 species of woodpeckers and 18 species of warblers. At least 45 of the bird species listed in Appendix I to the Birds Directive and 12 species from the Polish Red Data Book have been identified there. During the breeding season, the area is inhabited by the collared flycatcher, booted eagle, white-backed woodpecker, nightjar, pygmy owl, three-toed woodpecker, red-breasted flycatcher, middle spotted woodpecker, honey buzzard, black stork, lesser spotted eagle, Tengmalm's owl, northern harrier, short-toed eagle, great snipe, black woodpecker, grey-headed woodpecker, spotted crake, eagle owl, green sandpiper, woodcock and short-eared owl.

Vascular species are among the best recognized of the Białowieża Primeval Forest flora. According to the Natura 2000 Standard Data Form there are nearly 1020 species on the 'Puszcza Białowieska' site (PLC20004), which represent half of the vascular plant species of lowland Poland. Three of these, toadflax, the American pasqueflower and hairy agrimony, are listed in Appendix II to the Habitats Directive. The locations of a dozen or so orchids and other endangered plant species have also been identified. What is more, the Białowieża Primeval Forest is home to

325 species of lichens, approximately 260 species of moss and 1200 species of macrofungi.

According to A. W. Sokołowski (1995), the vascular plant flora of the Białowieża Primeval Forest (including synanthropic species) includes 1017 plant species of 428 genera and 93 families. In all, 44 per cent of the most numerous families, and 55 per cent of the most numerous species, of Polish flora are represented in the Białowieża forests. That it is possible to find 152 species of aerophytic algae, 3500 species of fungi (including 430 cup fungi), 162 species of lichens, 41 species of liverworts, 105 species of mosses, 18 species of ferns and 287 species of seed plants in a single forest area testifies to the richness of the flora.

The very rich European lowland flora and fauna that make up the greatly varied forest communities includes a wide range of mammalian species (bison, roe deer, red deer, elk, wild boar, wolf, lynx, badger, beaver, otter) that live in the natural conditions of the Białowieża forests.

Because of its geographical location, the health of the forest and the protection of its ecosystems have been afforded, the Białowieża Primeval Forest is a unique wildlife habitat.

The 'Białowieża Primeval Forest' Promotional Forest Complex, along with other nature protection entities within the Podlaskie Province, forms a part of the National System of Protected Areas (NSPA) that are connected *via* ecological corridors. According to art. 5 para. 2 of the Act on Nature Conservation of 16 April 2004, an ecological corridor is an area that makes it possible for plants, animals and fungi to migrate.

The closest protected areas to the Białowieża Primeval Forest are the Bug River Valley, the Narew River Valley and, to the north of the Narew River Valley, the Knyszyn Primeval Forest. To some extent the areas lying between the Białowieża Primeval Forest and the Knyszyn Primeval Forest play the role of ecological corridors. This is a region whose extensive forests, shrub thickets, landscape afforestations, rivers, streams and wetlands, which include the valley of the Supraśl river and the Siemianówka water reservoir, facilitate the migration of animals and plants. Packs of wolves, lynx, bison and other animals use these corridors as their migration routes between the Białowieża Primeval Forest and the Knyszyn Primeval Forest. The Narew River Valley, which links contiguous tracts of forests and extensive marshes, is also an excellent ecological corridor for animal migration. It should be noted that the area between the Białowieża Primeval Forest and the Bug River Valley has the potential to play the role of an ecological corridor.

The Białowieża Primeval Forest is afforded special protection as a result of its unique natural qualities. A number of measures are employed, which depend on the legal forms of the natural and landscape protection. They include protected landscape areas, model promotional forest complexes, Natura 2000 sites, reserves, nat-

Table I. Summary table of the current forms of nature protection in the Białowieża Primeval Forest outside the Białowieża National Park.

No.	Nature protection category	Forest District			Białowieża Primeval Forest PFC
		Białowieża	Browsk	Hajnówka	
1.	Nature reserves [ha]	4 305.24	1 979.15	5 770.12	12 054.51
2.	Protection zones for rare bird refuges [ha]	303.35	508.95	949.42	1 761.72
3.	Protection zones for lichen refuges [ha]	–	198.26	56.08	254.34
4.	Natural monuments [no.]	515.00	82.00	552	1 149.00
5.	Ecological utility areas [ha]	80.71	47.88	609.89	738.48
6.	Areas of protected landscape [ha]	12 592.61	20 379.29	19 656.80	52 628.70
7.	Natura 2000 sites [ha]	12 594.47	17 860.50	19 195.00	49 649.97

ural monuments, ecological areas, and protected plant and animal species (Table I). A further protection measure, which awaits legal confirmation, was added in 2005 when the entire Białowieża Primeval Forest was declared a biosphere reserve.

The most valuable areas of the Białowieża Primeval Forest are protected in 21 nature reserves, whose total area is 12 055.38 hectares.

1.3. The conservation of the genetic diversity of forests

1.3.1. The *in situ* conservation of forest genetic resources

The preservation of forest genetic diversity is essential to ensure the continuity of key ecological processes, the sustainability of forests, the use of ecological systems, the restoration of degraded forest habitats, the enhancement of the natural resistance of stands and plant communities and the preservation of genetic diversity for future generations. In many cases passive protection does not produce the desired effects, as it often leads to the replacement of valuable elements of the natural ecosystem by other, more dynamic ones. It is therefore necessary to develop programmes for the active protection and restoration of certain plant species, including – in the appropriate locations – forest-forming, admixture and rare species.

It is further necessary to establish a formal and legal foundation for the use of the genetic resources of forest tree populations in protected areas, such as nature reserves or national parks, so that progeny plantations can be established in their surroundings within the State Forests. On the one hand this will enable the rational use of genetic variation in natural populations, which is in accord with one of the protection objectives, and on the other this will provide a buffer zone around the protected areas. The genetic variation in this zone is comparable to that of the protected areas and will therefore constitute a more effective means of isolating protected areas from the populations under intensive forest management.

A plus tree of European beech in the Szczecinek Forest District (photo by K. Murat)

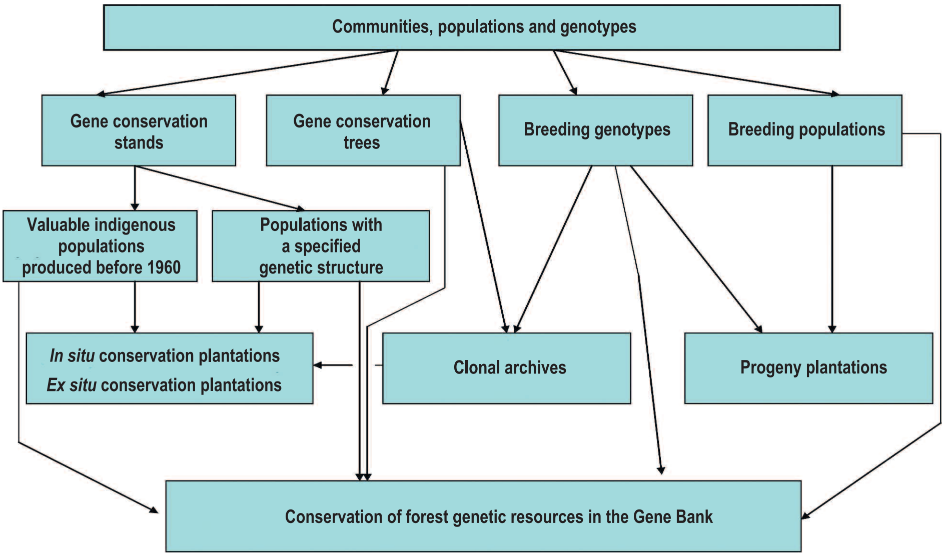


Fig 56. A flow-diagram of forest genetic resource conservation within the framework of the new Preservation Programme for 2011–2035

Seed orchard of European beech in the Warcino Forest District (photo by K. Murat)

With regard to the protection and conservation of genetic resources, the main focus of the State Forests is on forest tree species of economic importance. Many populations of these species show low stability or are in decline due to the intensified action of biotic factors, which are in this case secondary to abiotic and anthropogenic factors.

A general flow-diagram for the implementation of the Programme for the Preservation of the Genetic Diversity of Forest Tree Species is shown in Fig. 56.

1.3.2. The implementation of the forest genetic resources conservation programme

The biodiversity conservation strategy included in the Convention on Biological Diversity is related to four levels of nature organisation. These are species diversity, landscape diversity, ecosystem diversity and diversity of genetic resources. The State Forests implement cyclically developed programmes for the conservation of forest genetic resources and selective breeding. The current Programme of Forest Genetic Resources Conservation and Selective Breeding of Trees in Poland covers the period 2011–2035 (Chałupka, 2009).

The programme includes the following categories:
a) stands (populations of trees),
b) parents of families: plus (mother) trees and conservation trees (genotypes),
c) other endangered components of the forest.

Within these categories the following require conservation:
- populations valuable to forestry for their superior phenotypic traits (designed for the production of FRM in the 'selected' category),
- individuals with valuable genotypes of economic importance to forestry that have been identified as a result of intentional selection (designed for the production of FRM in the 'qualified' category),
- indigenous populations and individuals of coniferous and broadleaved species initiated before 1860.

In addition, the programme emphasizes the need to preserve the genetic resources of other stands and trees valued for their adaptive ability (conservation stands and trees):
- populations and individuals with genotypes considered valuable based on genetic studies,
- populations and individuals of admixture trees and other plant species which, due to their scattered distribution and lack of active protection, may disappear from forest ecosystems or become extinct.

The following are the main activities planned under this programme:
a) as regards legislation:
   - action to pass a law sanctioning the implementation of the active protection of genetic diversity on land managed by the State Forests,
   - an amendment to the current law (the Nature Conservation Act and the Forest Act) that will permit and regulate active protection measures for genetic diversity, including in legally protected areas (national parks, nature reserves, Natura 2000 sites and others).
b) as regards fieldwork:
   - the management of conservation stands selected under the previous programme and the selection of new ones for this category,
   - the production of progeny generations from conservation stands (*in situ* conservation areas),
   - the establishment and management of *ex situ* conservation areas based on existing conservation stands and other conservation entities,
   - the establishment of progeny plantations of breeding populations,
   - the establishment and management of conservation and breeding seed orchards, seedling seed orchards and clonal archives (*ex situ* conservation of individual genotypes),

- the gathering of reproductive material (seeds, parts of plants, pollen) in gene conservation stands, breeding populations and individual genotypes for long-term storage in the Kostrzyca FGB,
- the selection and protection of species, populations and genotypes of indigenous woody vegetation (other than the main forest tree species) and the development and implementation of restitution programmes in defined areas,
- complementary selection (based on genetic trials) of other populations of genotypes with specific genetic traits so that the range of genetic diversity previously protected in gene conservation stands and breeding populations can be extended.

c) as regards projects implemented by the Kostrzyca FGB:
   - the collection of gene resources of categories II, III and IV in the National Register of Forest Basic Material from conservation entities,
   - the long-term storage of seeds, pollen and parts of plants; the extension of the use of cryogenic methods to other species,
   - the genetic characterization (DNA, isozymes and other markers) of populations and genotypes selected for the conservation of forest genetic resources,
   - the monitoring of changes in the genetic diversity of forests – with a particular emphasis on areas under anthropogenic pressure,
   - the systematic collection of silvicultural and genetic information on the breeding and conservation populations.

The main tasks faced by the organizational units of the State Forests in conserving genetic diversity lie in the management of new objects valuable for conservation (populations and genotypes) that have already been approved and selected, as well as in the establishment of conservation plantations (for populations) and clonal archives (for single genotypes) for selected entities. The State Forests have not until now drawn on stands located in the national parks when establishing conservation areas. This should change so that the State Forests can expand their seed base by including these exceptionally valuable objects.

Research needs

The long-term preservation of genetic diversity – particularly that of the gene pool of valuable stands and genotypes – should be determined by the findings of studies of the genetic diversity of forest tree species. There is a need for:

a) studies of genetic variation and diversity based on quantitative traits and molecular analyses:
   - the development and standardization of research methodology,
   - studies of populations selected for the conservation of genetic resources (seed stands, gene conservation stands and plus trees) within the State Forests; comparative studies and the identification of valuable populations,

- studies of populations in legally protected areas (nature reserves, national parks, Natura 2000 sites); the identification of valuable populations aimed at establishing gene conservation areas within the State Forests,
- an assessment of the level of autochthony of the population; the identification of non-autochthonous populations,
- a revision of seed regionalization based on studies of genetic variation and seed regionalization in individual tree species,
- linking of studies of genetic variation to the progeny-testing programme,
- linking the variation in quantitative traits with variation at the molecular level.

b) studies of the changes in genetic diversity in the selection, breeding and long-term storage of seeds,
c) an assessment of the effects of forest management on genetic variation in forest trees in Poland,
d) studies of mechanisms for preserving genetic diversity and an assessment of the potential for using natural regeneration in the protection of genetic resources,
e) the formulation of detailed criteria for the establishment and management of gene conservation plantations,
f) an assessment of the potential for species restitution based on an analysis of variation in genetic diversity,
g) studies of hybridizing species, including the development of methods for identifying and distinguishing species and their hybrids.

2. Support measures, obstacles and priorities for the future

2.1. Measures to improve the inventorisation and study of forest genetic resources

Two registers of forest basic material have been established in Poland:

1. The National Register of Forest Basic Material (NRFBM) includes forest tree species and categories of items listed in the Act on Forest Reproductive Material. The register is kept by FROM (Forest Reproductive Material Office), which is a state body reporting to the Ministry of the Environment.
2. The Register of Forest Basic Material of the State Forests (RFBMSF), which is managed by the State Forests IT Department and includes data on tree species and other categories, such as stands, trees, conservation plantations and clonal archives not covered by the act.

The objects registered in the NRFBM and in the RFBMSF serve the *in situ* conservation of forest genetic diversity in forests under all ownership categories.

Table J. Seed base objects registered in the NRFBM (FROM, 2011).

Administered by	Number of objects						Area [ha]			
	seed source	forest stand Part I	forest stand Part II	plus tree	seed orchard	clone	seed source	forest stand Part I	forest stand Part II	seed orchard
The State Forests	2 568	22 671	1 077	8 219	268	9	7 971.24	202 376.55	15 649.06	1 836.28
National parks	37	132	10	68	0	0	82.27	2 147.82	120.20	0.00
Other	20	23	4	34	0	0	30.34	160.69	46.84	0.00
Total	**2 625**	**22 826**	**1 091**	**8 321**	**268**	**9**	**8 083.85**	**204 685.06**	**15 816.10**	**1 836.28**

In addition to plus trees, there are 33 628 registered natural monuments in Poland (some of them outside the forest areas) subject to individual *in situ* conservation (Central Statistical Office, 2011). To monitor changes in the genetic diversity of forest tree species at the European level, Poland has submitted data on a few hundred items to the Bioversity International database. Eighty-seven of these, representing 17 species of trees evenly distributed across the country, are included in EUFGIS (EUFORGEN) (SoEF, 2011; FGB, 2011). Examples of the distribution of gene conservation units are shown in Figures 57–63.

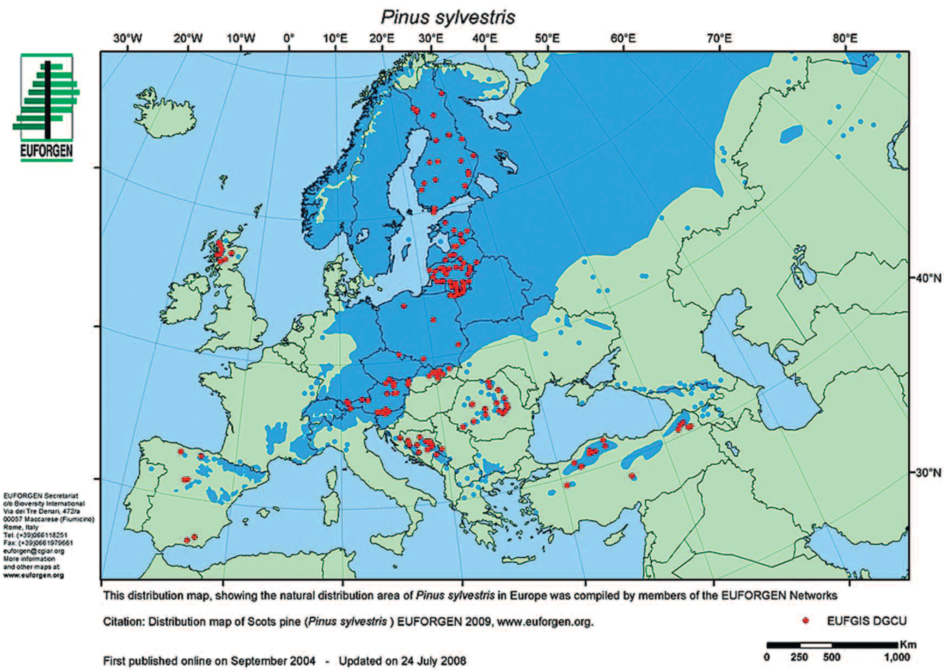


Fig. 57. Distribution of the gene conservation units (GCUs) of *Pinus sylvestris* L. in Europe

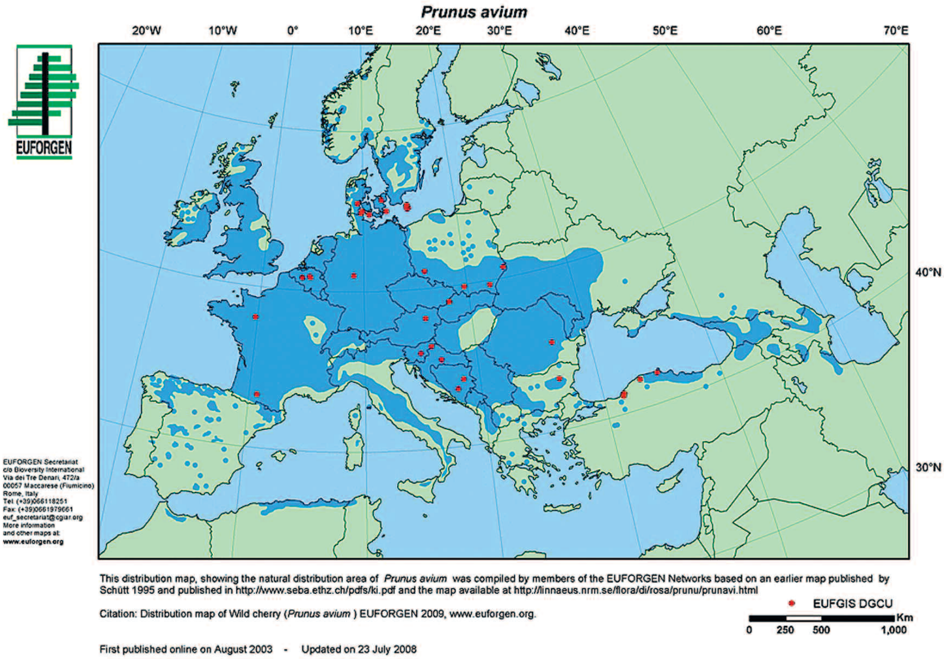


Fig. 58. Distribution of the gene conservation units (GCUs) of *Prunus avium* in Europe

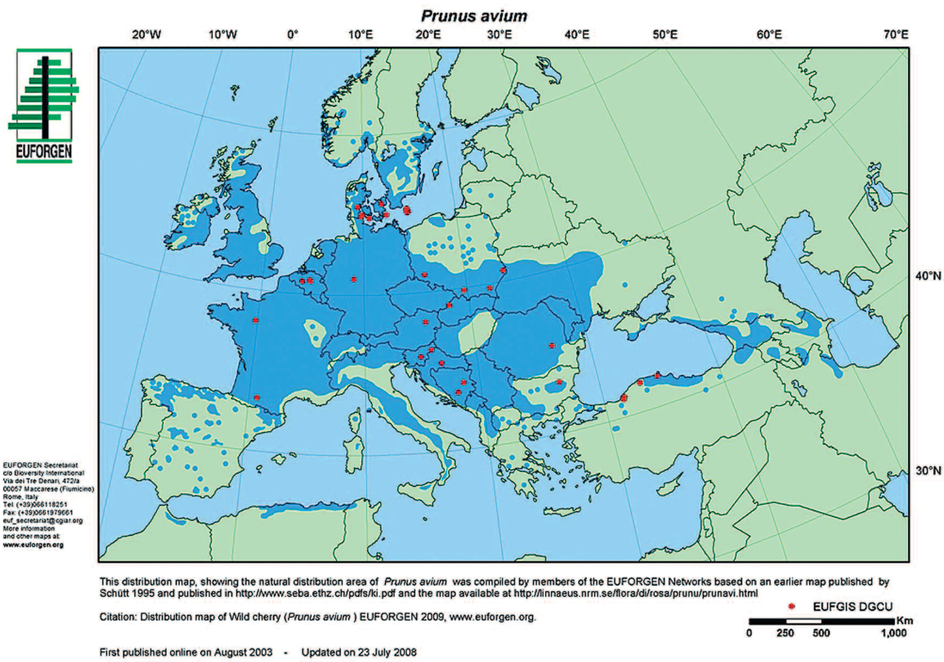


Fig. 59. Distribution of the gene conservation units (GCU) of *Albies alba* Mill. in Europe

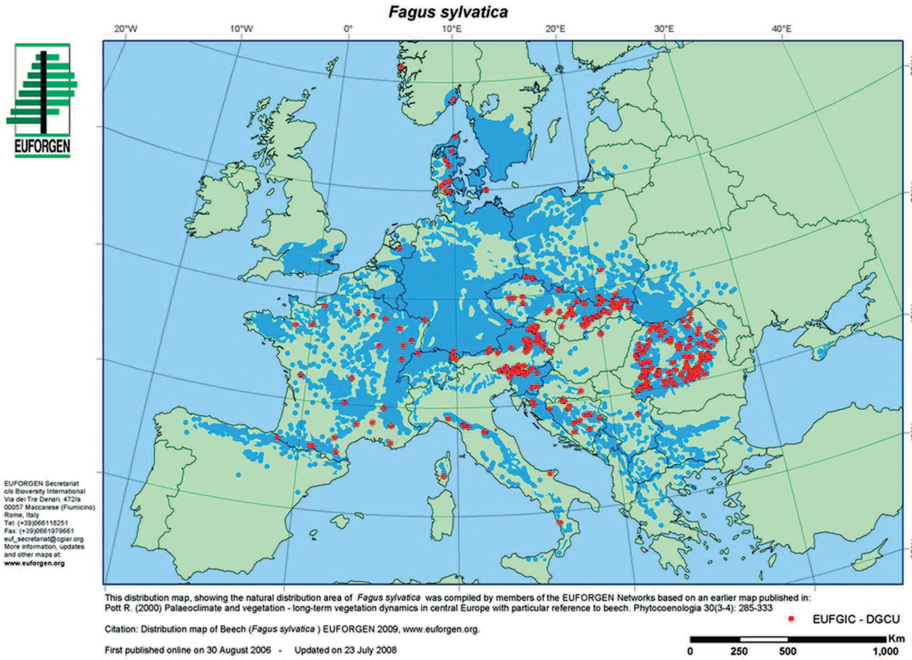


Fig. 60. Distribution of the gene conservation units (GCUs) of *Fagus sylvatica* L. in Europe

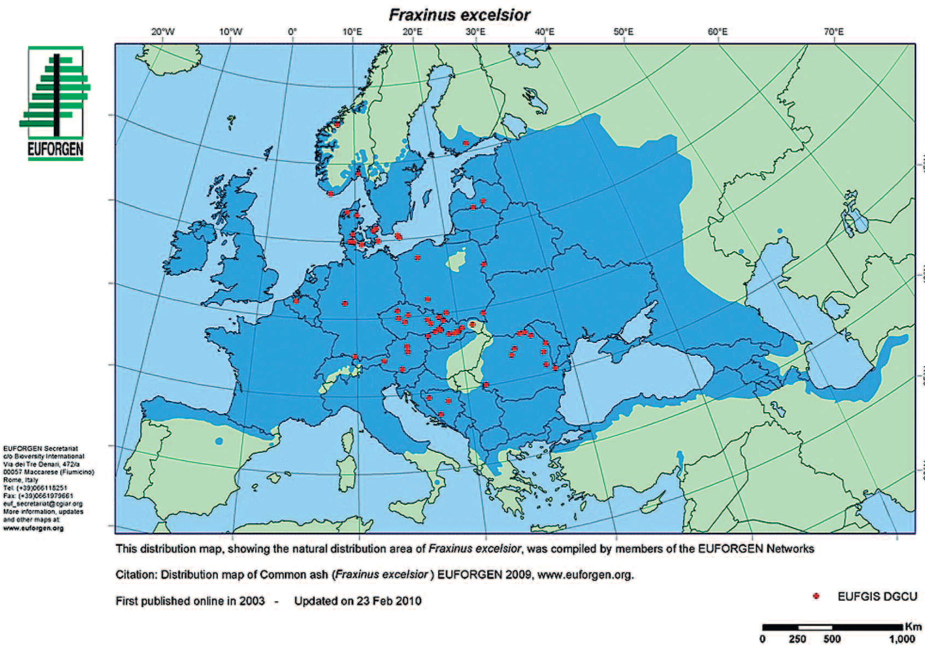


Fig. 61. Distribution of the gene conservation units (GCUs) of *Fraxinus excelsior* L. in Europe

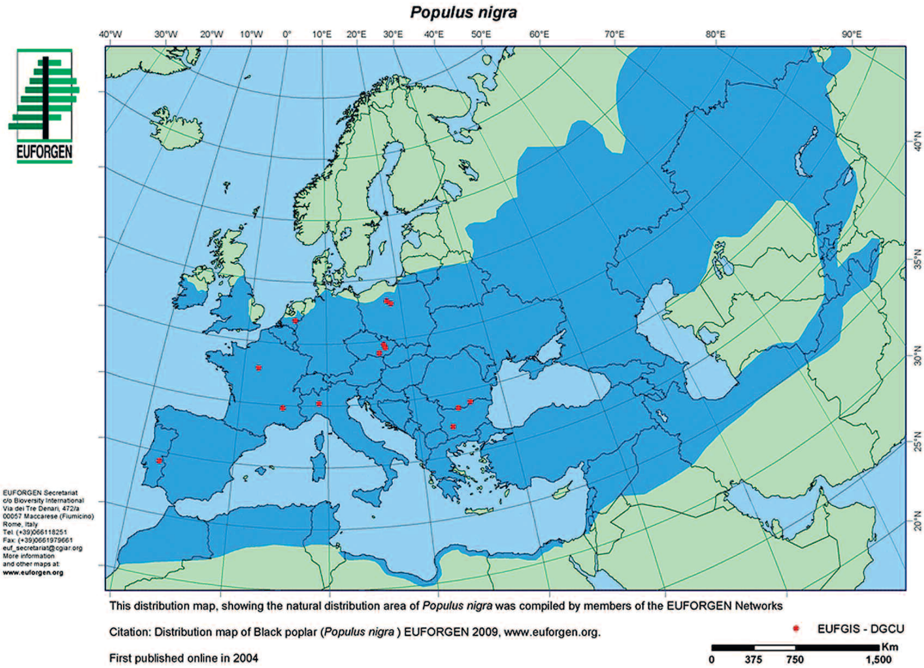


Fig. 62. Distribution of the gene conservation units (GCUs) of *Populus nigra* L. in Europe

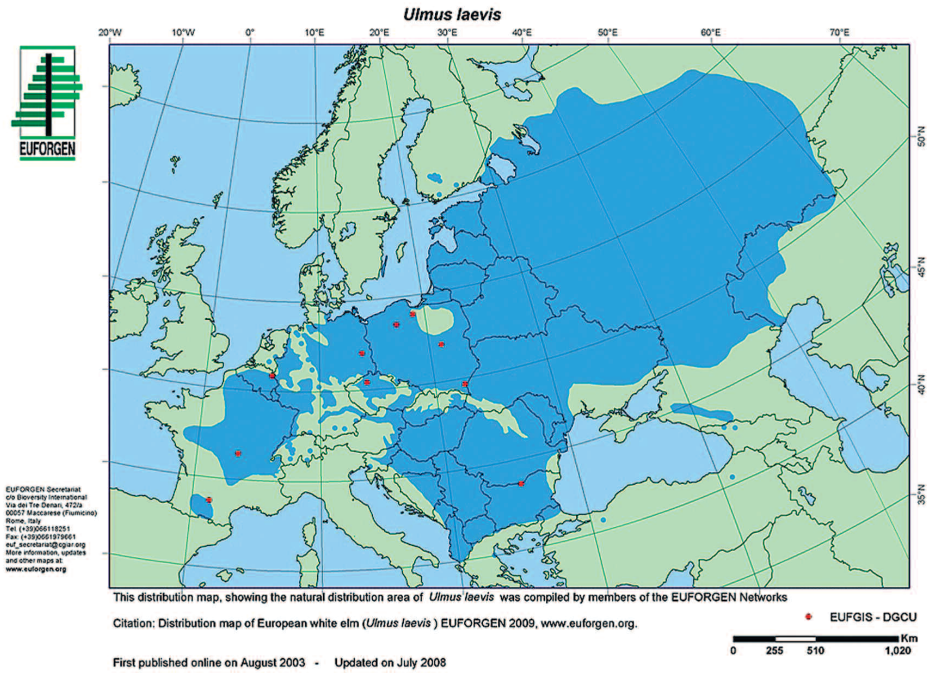


Fig. 63. Distribution of the gene conservation units (GCUs) of *Ulmus laevis* Pall. in Europe

2.2. Measures to promote the *in situ* conservation of forest genetic resources

Support for the *in situ* conservation of forest genetic resources involves promoting natural regeneration, which is achieved mainly in stands valuable for gene conservation and in selected maternal stands in seed zones. Artificial regeneration by underplanting or sowing is applied in the area occupied by the stand in the special cases where it is difficult to attain natural regeneration.

2.3. Obstacles and threats to the *in situ* protection and conservation of genetic resources

A major threat to the *in situ* conservation of forest resources is presented by external conditions that prevent the survival of the progeny generation in plantation. These include heavy weed growth, high groundwater level, game animals and irregular seed production in older stands. There is also a problem with initiating reforestation in gene conservation stands, national parks and nature reserves – especially in areas under strict protection, where it is difficult to take action to conserve populations that have been selected to have their genetic diversity protected.

2.4. Priorities for the *in situ* conservation of genetic resources in the future

The priority for the near future is to develop and implement the National Programme for the Preservation of Forest Genetic Resources, which includes forests in all ownership categories. It is also necessary to develop criteria for selecting conservation objects based on genetic information. The starting point in implementing a long-term programme for the conservation of genetic resources is to establish a system for monitoring changes in genetic diversity. The information obtained from such monitoring will form a base for determining the scope and urgency of conservation tasks, for developing conservation programmes and for taking immediate action to preserve individual populations exposed to damage-causing factors.

Chapter 3:

The status of the *ex situ* conservation of forest genetic resources

1. The status of the *ex situ* conservation of forest genetic resources

Depending on the level of threat, action to preserve genetic diversity should be taken both *in situ* through active promotion in the forest environment and *ex situ*. In the case of protected plants on the territory of the State Forests, appropriate steps towards the active protection of their genetic resources should be subject to agreement between the organizational units of the State Forests, the Directorate General and the Regional Directorates for Environmental Protection. The agreed recommendations should then be incorporated into the programmes for the protection of forest reserves, forest management plans and protection plans for Natura 2000 sites.

Ex situ conservation is designed to reduce the risk arising from unforeseen phenomena in the natural and forest environment that may lead to losing valuable stands, such as climate change, fires, floods, insect outbreaks, the activity of viral and fungal pathogens, the impact of wildlife and successional changes in forest communities. The e*x situ* conservation of genetic diversity is carried out by establishing gene conservation plantations, progeny plantations, seed orchards, seedling seed orchards and *in vivo* clonal archives. The collection and long-term storage of genetic material in gene banks in the form of seeds or of parts of plants are further important elements of the e*x situ* conservation of genetic diversity.

Long-term action associated with the restitution and reintroduction of protected plant species and endangered populations should be taken within the framework of the Preservation Programme for 2011–2035. No specific tasks for this activity were set out in the programme.

1.1. The role of gene banks

The Kostrzyca FGB, which is participating in the implementation of the Preservation Programme for 2011–2035, carries out the conservation of genetic resources through the long-term *ex situ* storage of seeds, pollen and other parts of plants. It also draws up guidelines for the collection of genetic resources to preserve the highest variation in the selected objects, monitors their quality, ensures their timely withdrawal from further storage and establishes *ex situ* conservation plantations from seeds after storage. The Kostrzyca Forest Gene Bank is also responsible for supervising the collection of material and determining its genetic identity. In addition, it develops and implements new methods and technologies for seed storage and stratification and monitors the status of genetic resources in other regional gene banks. Together with the Forest Research Institute and other research centres involved in the implementation of the Programme for Progeny Testing of the Selected Seed Stands, Plus Trees, Seed Orchards and Seedling Seed Orchards, it maintains a nationwide register of the DNA data of the genetic resources that are collected and studied, as well as a register of the experimental sites involved in the selection and conservation of forest tree genetic resources in Poland.

The directors of the RDSFs are responsible for establishing regional gene banks within their territories. These must meet the appropriate requirements, which first of all means having the necessary technical infrastructure and skilled staff. Direct supervision of the regional gene banks is exercised by the local District Forest Manager and general supervision by the Director of the relevant RDSF. The Kostrzyca FGB is the national coordinator for the collection and storage of genetic resources in regional gene banks and it ensures that this is conducted in accordance with the current guidelines. The genetic resources of the regional gene banks are first of all designed to restore endangered and lost populations, and single individuals, of economic importance on the territory of the RDSF in question. The seeds collected as a gene resource by the organizational units of the State Forests are first delivered to the Kostrzyca FGB. Any information on the genetic resources stored in the regional gene banks is entered in the National FRM Register.

The *ex situ* conservation of genetic resources in Poland is primarily designed to complement the *in situ* conservation of genetic resources. Table 11 lists the species that are included in the programme for the *ex situ* conservation of forest genetic resources. *Ex situ* conservation is carried out in the form of:

– *in vivo* plantations (progeny plantations, conservation plantations, seed orchards, clonal archives, progeny trials),
– conservation through the long-term storage of seeds, pollen and parts of plants at the Kostrzyca FGB.

A list of *ex situ* protected species and of the quantities of seeds and other parts of plants stored in the Kostrzyca FGB is given in Table 11. The material so far gathered in the Kostrzyca FGB is made up of 7327 genetic resources, which includes

7263 genetic resources of populations and individuals (plus trees, conservation trees and natural monuments).

Where the *ex situ* conservation of genetic resources is concerned, the establishment of progeny plantations and gene conservation plantations is specific to Polish forestry (Table 11a). A total of 68 850 hectares of these plantations had been established in Poland by the end of 2010.

1.2. Infrastructure for the preservation of the genetic resources of forest trees in Poland

Due to the geographical and climatic conditions, to the species composition of the forests (in which coniferous species dominate and determine the way they are regenerated) and to the low share of natural regeneration (10.1 per cent), it was necessary to both designate and register a sizeable seed base of various forest-forming tree species and to build nurseries and an adequate seed extraction and storage infrastructure (Fonder *et al.*, 2007; Suszka, 2000).

Over the past two decades these activities have facilitated the full implementation by the State Forests of the tasks arising from: 1) the Forest Act, 2) the Act on Forest Reproductive Material and 3) from the long-term programmes for the conservation of forest genetic resources and the selective breeding of trees in Poland, which were adopted in collaboration with research centres.

Without the technical infrastructure it is impossible to perform the basic tasks involved in the *ex situ* conservation of genetic resources, such as seed extraction from cones, seed storage, seed stratification and seed assessment. If these tasks cannot be performed it is impossible to supply fixed quantities of seeds of known origin, quality and high breeding value to forest nurseries for the production of the planting stock needed to establish gene conservation and progeny plantations – or to supply the market. On average, the reserves established to cover the annual demand of Forest Districts amount to 12–15 tonnes of coniferous species seeds alone, and to several thousand tonnes of broadleaved species seeds.

The organizational structure of the State Forests includes a nationwide network that produces seeds. There are 9 Seed Testing Stations, 5 Seed Quality Control Stations (Fig. 65) and 24 Seed Extraction Plants and Storage Units (Fig. 64). They have the processing capacity to provide services to all of the organizational units of the State Forests. The network of seed testing stations and seed quality control stations operating within the State Forests makes it possible to collect data on the quality of seeds and cones from regions of origin across the country systematically. The data collection system makes it possible to monitor the seed crop and the quality of seeds and to prepare annual announcements of the expected level of seed crops from the major tree and shrub species. The seeds are evaluated using advanced laboratory techniques that involve X-rays, chemical analysis and germination tests.

The seeds are extracted and stored using modern technologies. Cold stores with controlled air humidity and temperature make it possible to store seeds for several decades. Special production lines are used for seed extraction and each operation in the seed extraction process is performed by a separate machine. At all of the extraction plants in Poland, the seeds are removed from cones using the thermal method, which involves the gradual drying of cones with dry and hot air in a cabinet dryer. In the next step, extraction drums are used to separate seeds from open cones and screens are used to remove impurities and fractions, for which tasks seed de-wingers, gravity separators and PREVAC vacuum separators are also employed. The seeds from the fruits of broadleaved trees are extracted using macerators and special sieves. Boilers with extensions or modern cabinets are used for seed flotation tests and thermotherapy. Seeds are kept in cold stores at fixed minus temperatures depending on the species. The storage capacities of the organizational units of the State Forests are shown in Table 29.

Poland is one of the few countries in Europe to have a forest gene bank of national reach. This institution, in the form of the Kostrzyca FGB, conducts the majority of activities related to the *ex situ* conservation of the gene pool of forest species. In addition to this, its technical infrastructure allows it to conserve endangered and protected wild plants in Poland. The cubic space at Kostrzyca's disposal is sufficient to store reproductive material from all of the strategically important seed sources in Poland and, when it comes to processing and storage, it is equipped with a seed extraction unit, a seed store, a seed stratification unit, seed assessment stations and traditional cold stores with temperatures of -30°C, -100°C and -200°C. In addition, there is a cryo-preservation laboratory where genetic resources, mainly of recalcitrant species, are stored in liquid nitrogen at ultra-low temperatures. This is not always in the form of whole seeds, but often as separated apical meristems or plumulas, which significantly reduces the space occupied. Furthermore, the Kostrzyca FGB has been furnished with a laboratory for DNA analysis to test whether the genetic material delivered for *ex situ* conservation at the gene bank corresponds to its region of origin.

The construction and modernisation of the infrastructure facilities that serve seed science require considerable organizational and logistical efforts, as well as huge financial resources. The changes in seed science, as well as in the techniques and technologies applied in forestry, can be regarded as a giant forward leap. In effect, the State Forests have created optimal conditions for the preservation of genetic resources and the storage and conditioning of seeds.

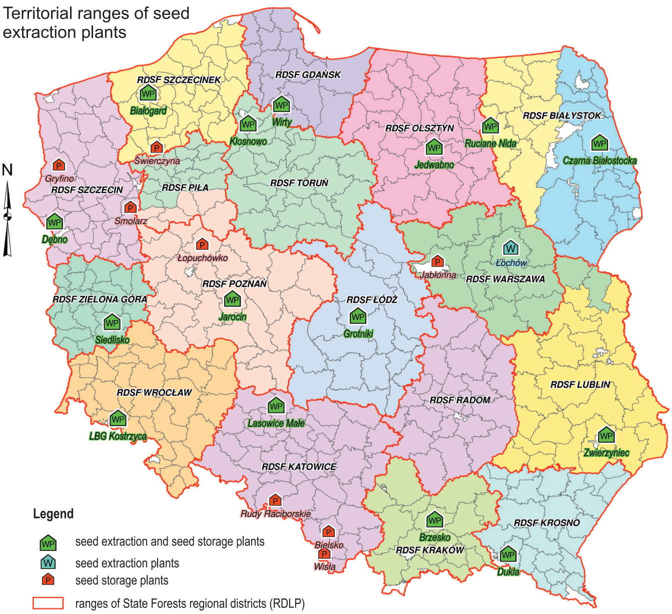


Fig. 64. The distribution of seed extraction plants and seed stores in Poland

Fig. 65. The distribution of seed testing and seed control stations in Poland

1.3. The role and importance of botanical gardens and arboreta in Poland with particular reference to woody species

In view of the irreversible changes in the natural environment, *ex situ* conservation has become a particularly important issue, hence the increasing role of botanical gardens as places designated by law to protect endangered species. The Nature Conservation Act of 16 April 2004 obliges these institutions to grow endangered plant species for their *ex situ* conservation, to introduce specimens of these species into the natural environment and to participate in research into the protection of wild species in danger of extinction. These tasks are performed by botanical gardens by creating and maintaining collections of protected and endangered plants that are brought directly from their natural habitats or are propagated from seeds collected *in situ*.

These kinds of activities are carried out in the majority of botanical gardens and arboreta, such as the Botanical Garden of the Jagiellonian University in Kraków, the Botanical Garden of the University of Wrocław, the Botanical Garden of the University of Warsaw, the Botanical Garden of the Adam Mickiewicz University in Poznań, the Forest Arboretum in the Experimental Station of the Poznań University of Life Sciences in Zielonka, the Botanical Garden of the Maria Curie-Skłodowska University in Lublin, the Botanical Garden Laboratory of the Kazimierz Wielki University in Bydgoszcz, the Dendrology Garden of the Poznań University of Life Sciences, the Arboretum of the Warsaw University of Life Sciences (SGGW) in Rogów, the Garden of Medicinal Plants of the Medical University of Gdańsk, the Mountain Botanical Garden of the Institute of Nature Conservation, the Botanical Garden of Zabrze City, the Polish Academy of Sciences Botanical Garden and Centre for the Conservation of Biological Diversity in Powsin, Warsaw, the Dendrology Garden in Przelewice, Gołubieński Botanical Garden, the Botanical Garden in Łódź, the Arboretum and Institute of Physiography in Bolestraszyce, the Professor S. Białobok Forest Arboretum in Syców, the Glinna Dendrology Garden, the Dendrology Garden and Nurseries in Wirty and the Forest Arboretum of Warmia and Mazury. These institutions have collections of approximately 200 species of protected plants.

Attention should be given to the role of botanical gardens in the conservation of the biological diversity of grown plants – especially forest trees, fruit trees and ornamental plants. There are, for example, collections of old varieties of fruit trees in the Polish Academy of Sciences Botanical Garden and Centre for the Conservation of Biological Diversity in Powsin, Warsaw, in the Arboretum in Bolestraszyce near Przemyśl and in the Silesian Botanical Garden in Mikołów.

In addition, the botanical gardens are involved in *ex situ* nature conservation in the following ways: through plant propagation and the preparation of genetic material, by participating in programmes for the introduction and reintroduction of plants into natural or substitute habitats and by creating a bank of genetic resources in which genetic material is stored in the form of seeds, pollen and tissues. In Poland, this seed bank is run by the Polish Academy of Sciences Botanical Garden and Centre for the Conservation of Biological Diversity in Powsin, Warsaw.

The collections assembled in the dendrology gardens and forest arboreta are exceptionally valuable for the preservation of the FGR of indigenous and non-indigenous tree and shrub species of both native and foreign origin. The oldest of the gardens and arboreta are the Kórnik Arboretum of the Institute of Dendrology, PAS, in Kórnik, the Arboretum of the Warsaw University of Life Sciences (SGGW) in Rogów, the Arboretum of the University of Wrocław in Wojsławice, the Glinna Dendrology Garden in the Gryfino Forest District and the Dendrology Garden and Nurseries in the Kaliska Forest District.

The Professor S. Białobok Forest Arboretum in the Syców Forest District is especially important for the conservation of the FGR of Polish forests and foreign flora. In addition to dendrological collections, it has seed orchards and an archive of plus trees from western Poland for gene conservation. The Arboretum boasts 26 genera of conifers and the national collection of 60 species and varieties of pine.

By studying rare and endangered species the botanical gardens play a very important role in implementing the provisions of the Nature Conservation Act (Table 30).

2. The transfer of FRM and the associated documentation

2.1. The principles for the transfer of forest reproductive material between regions of origin

Knowledge of the possibilities offered by the use of certain populations and their seed base in diverse ecological conditions is of practical importance in that it lays a foundation for successful seed management and is decisive in achieving positive breeding results. The recognition of the intra-population and inter-population diversity of forest-forming species within their natural ranges helps determine the geographical distribution of individual populations. This information is useful in establishing seed bases and in developing programmes for the protection of genetic diversity.

Forestry practitioners have been aware of the need to erect barriers against the free disposal and transfer of seeds and the plants grown from them for a long time.

The first move was made by the Scandinavian countries in the 1920s when they introduced regulations for seed and seedling transfer and specified the range of seed movement, which was mainly from north to south and south to north. As knowledge of the genetic diversity of individual species within their natural ranges grew, the regulations became more detailed and led to the development of the idea of region of origin.

According to the O.E.C.D. rules and to Council Directive 1999/105/EC, the region of origin of a species, subspecies or variety is an area, or group of areas, that has sufficiently uniform ecological conditions and in which there are trees and stands with similar phenotypic or genetic characteristics.

From the genetic point of view, the region of origin is the zone or area of occurrence of a population characterized by a specific genetic structure (different to that of adjacent populations) formed under the impact of the external conditions (of natural selection) specific to the region.

It is the law that only material from the registered seed bases in different regions of origin may be admitted into the forest and placed on the market.

General guidelines for the transfer of seeds and seedlings have been introduced along with specific rules for pine, spruce, fir, European larch, Polish larch, sessile oak, pedunculate oak, European beech, black alder and silver birch. These rules are intended to prevent the unrestricted transfer of reproductive material to physical-geographical and natural conditions different from those in which it was produced.

According to the general guidelines, the seeds and the plants grown from them can be distributed without limitation only within the same region of origin, while in the mountains they must remain in the same altitudinal zones. Where seeds of valuable provenance are absent or scarce in their own region, the use of reproductive material from other provenance regions located within the same Natural-Forest Region, or within its physico-geographical sub-province, is permitted unless otherwise stated in the regulations. The seeds and seedlings of the species that are not covered by specific rules may, where appropriate, be brought from other Natural-Forest Regions or sub-provinces, subject to the following general principles:

- no crossing of boundaries of physico-geographical regions and provinces,
- where any species lacks a seed base, to adopt the principle of transferring seeds and the seedlings grown from them from physico-geographical regions with more severe climatic conditions (East-European Depression and Carpathian Sub-Region) into other parts of the country with milder climatic conditions.

Detailed rules governing the movement of forest reproductive material between regions have been developed in accordance with these general principles, which marks a departure from the statutory rules demanding its use only in its region of origin. These rules take precedence over the general guidelines and may be periodically reviewed as information from provenance tests is gathered.

The management of reproductive material in mountain areas is subject to additional rules that require reproductive material to remain within altitudinal zones (Act on FRM, 2001).

2.2. The documentation used in trading FRM

The approved seed base is entered in the FBM Register of the State Forests (Table 37) and in the National FBM Register (Table J). The use of the seed base for FRM production in Poland is presented in Table 38 by species and seed base type.

2.3. The documentation of genetic resources stored in the Kostrzyca FGB and in other seed stores in Poland

All of the established and stored gene resources (regardless of their place and conditions of storage) have a documented source of origin.

The delivery of FRM to a store is confirmed by a protocol. The delivered seed lots are provided with certificates of origin of forest reproductive material derived from seeds or stands, which are issued by the Forest Reproductive Material Office in accordance with the requirements of Directive 1999/105/EC. The certificates include information about the species, the type and category of FRM and the type and number of entry in the National FBM Register. They also contain data on the year of ripening of seed units, on the quantity of forest reproductive material and on the supplier.

During the technological process (seed extraction from cones, cleaning, de-winging and separation), the forest reproductive material is labelled with the most important information about its origin: unit, category and seed lot.

When seeds have been dried and proper moisture content for storage at -10°C has been obtained, they are packed in aluminium tins or in three-layer aluminium foil.

The seed deposits in seed stores are mainly designed for short-term storage (usually 3–6 years) to secure nursery production for the needs of the organizational units of the State Forests and for private companies.

In addition to the short-term storage of seeds for the planned nursery production, the Kostrzyca FGB also stores genetic material of strategic importance to the country's long-term ecological security (30–50 years). These are the genetic resources of the main forest tree species and endangered plant species that grow in the wild in Poland.

The Kostrzyca Forest Gene Bank

All of the technological processes related to seed production and the weight of seeds obtained are listed in the Seed Lot Handling Specification and in the Protocol of Transfer to the Packing Room. Detailed information about the structure and location of gene resources in the cold store is given in the Resource Storage Protocol or Deposition Protocol. This states the type of resource or deposit (basic, test samples, accompanying samples, supplementary resource) and gives the weight of the seeds in the different packages.

Releases of seed material (for evaluation, sowing, stratification or research) from seed stores and from the Kostrzyca FGB are recorded as a matter of routine. Each release is confirmed by a Genetic Material Release Protocol stating its weight, the purpose of the release and the recipient.

The seed material is evaluated during the course of the technological processes (Kostrzyca FGB) and also checked during storage. The frequency of evaluation of all deposits and genetic resources in Poland is two to three years. The history of all of the evaluations is recorded in the initial evaluation sheets. When seed testing is complete, a Simplified Evaluation Certificate is issued.

In accordance with the Ordinance of 28 November 2007 issued by the Minister of Agriculture and Rural Development on detailed procedures for combatting and preventing the spread of *Giberella circinata* Nirenberg & O'Donell, the seeds of selected forest tree species (pine, Douglas fir) are subject to phytosanitary and organoleptic evaluation by the relevant Regional Inspectorate for Plant and Seed Protection. Pathogen-free seed lots are then issued with plant passports.

The processed seeds are labelled in one of four colours depending on the category of FRM. Yellow for FRM in the 'source-identified' category, green for FRM in the 'selected' category, pink for FRM in the 'qualified' category and blue for FRM in the 'tested' category. Planting stock (FRM) to be placed on the market is labelled and given a copy of the certificate of origin. Information about the origin of the material used for establishing a forest plantation is included in the forest management plan of the relevant Forest District. These procedures are governed by the Act on FRM and its executive regulations.

3. *Ex situ* conservation

3.1. Measures to protect existing ex situ collections

Ex situ field collections are kept under the special care and supervision of the organizational units of the State Forests and the Forest Research Institute. They are registered, marked out on the ground, usually enclosed for protection from wild animals and properly managed in accordance with the internal regulations of the State Forests (Ordinance No. 7a, DGSF).

The Kostrzyca FGB cooperates with the research centres in perfecting new technologies and methods for storing seeds of species in the 'intermediate' and 'recalcitrant' categories, which will make it possible to store seeds or their parts for much longer periods using cryogenic techniques.

The tests suggested that cryogenic storage in liquid nitrogen at a temperature of -196°C would be possible for the genetic resources of the oak species (*Quercus robur* L.) and (*Quercus petraea* Liebl.), as well as for the common beech (*Fagus sylvatica* L.), the silver fir (*Abies alba* Mill.) and the European yew (*Taxus baccata* L.).

Oak seeds are sensitive to drying, low temperatures and prolonged storage and for these reasons it is not possible to preserve oak genetic resources in gene banks in the form of whole seeds. Suitable cryopreservation and drying treatments will, however, make the plumulas or apical meristems of embryos isolated from acorns tolerate the temperature of liquid nitrogen at a level of approximately 60 per cent and restore complete plants from thawed meristems in the *in vitro* cultures at the Kostrzyca FGB.

In the case of large seeds, such as those of the beech, cryogenic storage is limited because of the relatively small capacity of dewars filled with liquid nitrogen.

The Kostrzyca FGB has made attempts to develop liquid nitrogen storage methods for embryonic axes isolated from nuts, which are smaller than seeds and from which whole plants can be produced using the *in vitro* technique.

The cryopreservation methods for fir and yew seeds involve drying seeds to their permissible level of moisture content and then freezing them in liquid nitrogen. The survival rate of seeds after being stored at cryogenic temperatures is approximately 80 per cent.

As a result of the Kostrzyca FGB's collaboration with the Institute of Dendrology, PAS, in Kórnik, the Forest Research Institute in Warsaw, the PAS Botanical Garden and Centre for the Conservation of Biological Diversity in Powsin, Warsaw, the Millennium Seed Bank, the Royal Botanical Gardens at Kew and with many other research centres in Europe within the framework of the ENSCONET consortium, liquid nitrogen seed storage methodologies are also applied to the trees and shrubs of biocoenotic species such as *Prunus avium, Ulmus gabra, Tilia cordata* and *Carpinus betulus*, as well as to many species of herbaceous plants.

A permissible humidity content (SHC) has been calculated for storing the seeds of forest trees and other plant species at cryogenic temperatures (Chmielarz, 2007).

Species with dormant seeds:

Carpinus betulus L.	- common hornbeam (SHC 16.5%–3.2%)
Fraxinus excelsior L.	- European ash (SHC 19.5%–7.2%)
Prunus avium L.	- cherry (SHC 16.9%–9.0%)
Tilia cordata Mill.	- small-leaved lime (SHC 20.1%–5.2%)

Species with non-dormant seeds:

Alnus glutinosa L. Gaertn.	- black alder (SHC 19.2%–2.7%)
Betula pendula Roth.	- silver birch (SHC 23.2%–2.0%)
Ulmus glabra Huds.	- wych elm (SHC 17.7%–3.2%)

3.2. Support measures for *ex situ* conservation

The State Forests, with the participation of the Forest Research Institute, are organizing regular training courses and conferences on the protection and conservation of forest genetic resources to promote the idea of the *ex situ* conservation of genetic resources. They are being held in conjunction with the Programme for the Preservation of Forest Genetic Resources and the Selective Breeding of Forest Trees, in conjunction with the introduction by the Director General of the State Forests of new regulations on issues connected with forest seed science, selection, genetics and nursery production and in conjunction with the introduction of new legislation in this area.

3.3. Limitations and obstacles to improving the *ex situ* conservation of forest genetic resources

The following are the major limitations to *ex situ* conservation under the Preservation Programme for 2011–2035 in Poland:

- lack of methods for the long-term storage of certain forest tree and shrub species,
- lack of comprehensive genetic information on material selected for conservation in field plantations (*in vivo*) and storage; the impact of long-term storage on that material's genetic structure,
- unsatisfactory methods for reproducing material stored at cryogenic temperatures,
- limited availability of FRM from conservation stands that are outside the areas administered by the State Forests,
- the Preservation Programme for 2011–2035 does not include forests under national park management and non state-owned forests,
- lack of monitoring of the loss of genetic variation in genetic material during its long-term storage.

3.4. Priorities for the *ex situ* conservation of genetic resources

1. Because of the unsatisfactory condition of the present genetic resources in the legally protected areas, they will require effective ex situ conservation resulting from the functions these areas serve (passive protection).
2. It is important that the Preservation Programme for 2011–2035 implemented in the State Forests is included in the plans for protective tasks being developed for the Natura 2000 sites.
3. Progeny plantations, conservation plantations and clonal archives should continue to be established.
4. Research into the storage and assessment of seed quality should continue and its results should be integrated into forest practice.

Chapter 4:

The use and sustainable management of forest genetic resources

Forest management in Poland is regulated by the Forest Act.

1. “Sustainable forest management proceeds in accordance with a Forest Management Plan or a simplified Forest Management Plan, with particular account being taken of the following objectives:
   1) the preservation of forests and their favourable influence on climate, air, water, soil, the conditions for human life and health and the natural balance;
   2) the protection of forests (especially those that, along with their ecosystems, are native natural areas) that are particularly valuable in terms of:
      a) the preservation of natural diversity,
      b) the preservation of forest genetic resources,
      c) landscape features,
      d) the needs of science;
   3) the protection of soils and areas particularly vulnerable to pollution or damage, as well as soils and areas of special social significance;
   4) the protection of surface and underground water; drainage-basin retention – particularly in water divide areas and in areas of supply for underground bodies of water;
   5) the production, based on rational management, of wood, raw materials and the by-products of forest utilisation.
2. Forest management in forests that are Nature Reserves or that are included within National Parks shall take account of the rules laid down in the nature conservation regulations.
3. Forest management in forests included in the Register of Monuments, as well as in forests on land that supports archaeological monuments entered in this register, will be conducted in agreement with the Voivodship Conservator of Monuments, with account also being taken of the regulations on the protection and care of monuments.

Forest management is conducted in accordance with the principles of:
1) the universal protection of forests,
2) long-term forest maintenance,
3) the continuity and sustainable use of all forest functions,
4) the augmentation of forest resources.”

1. Breeding programmes and their implementation

The State Forests is carrying out a parallel tree improvement and selection programme for all the main forest tree species and for selected biocoenotic and exotic species as part of the Preservation Programme for 2011–2035.

1.1. The selective breeding of forest trees

The term ‘selective breeding’ refers to the field of science that deals with the genetic improvement of desired traits in trees, as well as to practical measures aimed at producing more productive varieties of a higher quality that are more resistant to biotic and abiotic threats than are wild populations or recent varieties. The main tasks of forest tree improvement resulting from public expectations are as follows:
a) the identification and protection of genetic variation, taking into account the preservation and restoration of endangered resources,
b) the rational use of genetic resources for the needs of society.

The identification and conservation of genetic diversity in trees is the starting point for tree breeding. Genetic diversity is essential to successful selection. It is for this reason that the breeding process begins with the recognition, use and artificial increase of natural variation.

The public demand for quality wood is increasing. With this in mind, the variety of methods applied in the selective breeding of forest trees ensures the efficiency, cost-effectiveness, improvement and stability of the productive and non-productive functions of forests.

Unlike natural selection, artificial selection is under the control of the forest tree breeder and is conducted under properly selected environmental conditions. The best effects are obtained when selection is for a single trait only. When the object of selection is the entire population we are dealing with population selection, but when the objects of selection are single trees within (and outside) the population we are engaged in individual selection. Different selection methods are employed in each case.

Population selection is based on the selection of superior populations (breeding purpose) with respect to the selection objectives and on maintaining their phenotypic variation which, indirectly, also preserves their genetic diversity. This ensures that forest stands have a high level of genetic variability and are adapted to local conditions. There are limits to how far breeding traits can be improved (by a maximum of 10%–15%) and it can only be done in relation to the traits by which stands are selected.

Individual selection is based on the principle of survival of the fittest, that is, on the selection of single trees in stands for defined traits and on the improvement of these traits to the degree determined by the tree breeder. The methods of individual selection are more effective in improving the traits selected by the breeder, but the improvement of traits is achieved at the expense of reduced genetic variation in the progeny population.

To strengthen the positive effects of selection in progeny, it is necessary for mating to be restricted to selected individuals and for the selected varieties to be effectively isolated from the influence of unselected individuals from the same species.

These effects can be achieved by implementing, in a series of programmes, the long-term breeding strategies included in the selective tree breeding programmes for each forest tree species and through selection for special purposes.

1.1.1. The long-term breeding strategy in the Preservation Programme for 2011–2035

The long-term breeding strategy implemented in the successive stages of the Preservation Programme for 2011–2035 is based on the following general assumptions:

- for the long-term breeding strategy, breeding populations with a defined number of selected genotypes are established for individual tree species;
- the number of breeding populations in each cycle of selection is similar;
- in successive selection cycles, the breeding population is produced through selection within the progeny derived from the open pollination or controlled crossing of the genotypes selected in the previous cycle;
- the selection criteria are quantitative and qualitative traits, as well as plasticity to ensure the sustainability of forest production;
- the intensity of selection in the successive cycles should be similar for individual traits.

The plans adopted set out in detail the action necessary to implement the long-term breeding strategy in the State Forests:

- breeding populations will be established in the regions of origin where the seed base most valuable for the State Forests is located and where the number of selected genotypes is the highest. The Programme for the Progeny Testing of Selected Seed Stands, Plus Trees, Seed Orchards and Seedling Seed Orchards will enable the selection of the genotypes in the progeny so that the first breeding populations can be created. Further work will be performed mostly in these regions;

- in each selection cycle, breeding populations for the region of origin and species will consist of 50 different genotypes selected in the tests. Where breeding effects are unsatisfactory or where the genetic variation in the breeding populations is too limited, it should be possible to extend or exchange some genotypes within the population;
- the number of breeding populations for the species should be equal to the number of regions of origin (however, not less than five);
- one full selection cycle should be performed in each successive selective breeding programme. Programmes should therefore be developed for periods not shorter than the breeding cycles, that is, for 25 years.

A flow-diagram showing the implementation of the long-term selective breeding strategy in the State Forests is presented in Fig. 66.

1.1.2. Selective breeding for special purposes

Selective breeding programmes for special purposes are proposed to supplement the main breeding selection. They will concern small populations (50 progenies)

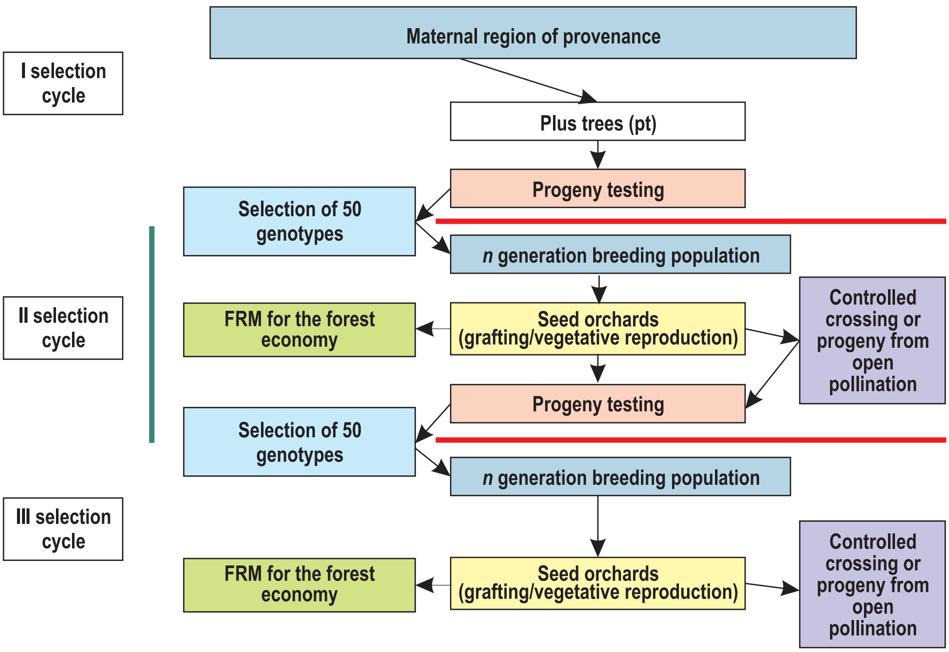


Fig. 66. A flow-diagram of the long-term selective breeding strategy of the State Forests

selected based on the traits defined below. It is permitted and recommended in these programmes to use controlled crossing and other available techniques, including molecular ones. If there is to be a high genetic gain, no more than two traits should be selected simultaneously in a single population. The selection tasks planned for individual species are shown in Table K.

Table K. Planned selection tasks for individual tree species.

<table>
<tr><th>Species</th><th>Selection tasks</th></tr>
<tr><td>Silver birch and black alder</td><td>Biomass production, wood quality, wood chemical properties</td></tr>
<tr><td>European larch</td><td rowspan="2">Biomass production, wood quality</td></tr>
<tr><td>Douglas fir</td></tr>
<tr><td>Pedunculate oak and sessile oak</td><td>Wood quality (valuable categories)</td></tr>
<tr><td>Norway spruce</td><td rowspan="3">Resistance to biotic and abiotic factors</td></tr>
<tr><td>European ash</td></tr>
<tr><td>Elms (European white elm, smooth-leaved elm and wych elm)</td></tr>
</table>

Silver birch

Scope and methods of work

The work will be conducted primarily in north-eastern Poland in regions of origin 202, 203, 204, 252, 253, 207 and 208 where, according to the provenance trials that have been conducted so far, the most valuable birch populations are to be found. In the first selection cycle, the testing will be based on the generative reproduction of genotypes that have been selected for the breeding program. In the choice of the introductory material use should also be made of the existing plus trees and progeny trials. Control crossings will be made during selection. The 50 full-sib progenies obtained from each breeding population will be used to establish test sites and evaluation of the genetic effect of selection will be possible after 10 years. Vegetative reproduction and clone testing should be employed in the successive selection cycles (Fig. 67).

Anticipated effects

The production seed orchards will yield a progeny that will be characterized by genetic gain of the order of 15 per cent to 20 per cent after the first stage of selection relative to the stands selected. The progeny will be used to establish special-purpose tree plantations and it will also be possible to produce clones with desirable traits.

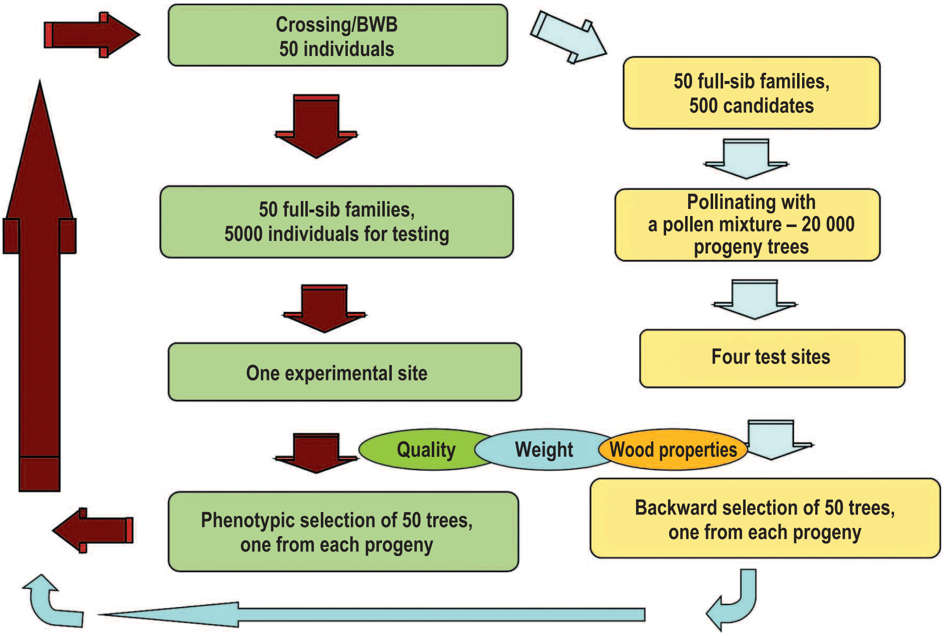


Fig. 67. A flow-diagram of the selective breeding of silver birch for improving its wood quality traits, its chemical properties and its volume increment

European larch and Douglas fir

Scope and methods of work

The plan is to create a breeding population of European larch in the Sudeten and Świętokrzyskie Mountains. The existing plus trees and progeny trials should be used in the selection of the initial material. International cooperation in selective breeding, including, among others, with the Czech Republic and France, is recommended.

The initial selection should primarily involve Douglas fir trees selected from populations adapted to Polish conditions. The selection of larch and Douglas fir will be based on generative propagation. The breeding populations should consist of a minimum of 50 families. After 15 years, the best families will be selected based on the available information on tree growth in test plantations.

Anticipated effects

After 15 years, the genetic gain should be 20 per cent to 25 per cent of the managed stands in a given region. Second-generation seed orchards will be established to produce seeds for forestry needs.

Norway spruce, elm and ash

Scope and methods of work

The initial material will include individuals selected from the populations of forest trees for their resistance to fungal pathogens, insect pests and drought. Generative propagation and cloning will be used in selection. The breeding populations should be composed of 50 families. After 20 years, the best individuals will be selected based on the available information on the resistance and growth of trees in the progeny trials.

Anticipated effects

After 20 years, the genetic gain should be 15 per cent to 20 per cent of the managed stands in a given region. Second-generation seed orchards will be created to produce seeds for forestry needs and clonal archives will be established that can serve as conservation seed orchards.

Pedunculate oak and sessile oak

Scope and methods of work

The source material will include individuals chosen from selected stands. The initial selection will involve the existing plus trees and progeny trials. Selection will mainly involve generative propagation. The breeding populations should consist of at least 50 families and the testing should take into account genetic and ecotypic variation. After 30 years, the best families will be selected based on the available information from progeny trials and the correlation between juvenile wood characteristics and wood properties at rotation age.

Anticipated effects

After 30 years, the genetic gain will be 15 per cent to 20 per cent of the managed stands in a given region. Second-generation seed orchards will be established to produce seeds for forestry needs.

A list of species in the Preservation Programme for 2011–2035 and their breeding objectives is presented in Table 13 and a list of species for which progenies of populations, plus trees, seed orchards and clonal seed orchards are tested is given in Table 14 (Preservation Programme for 2011–2035).

1.1.3. Clonal archives

The State Forests protect the genetic resources of particularly valuable genotypes in clonal archives. There are four categories of specimens in the archives: plus trees, conservation trees, natural monuments in forests and valuable local genotypes selected by local managers. Archives with clones of individual forest tree species are established for the needs of individual RDSFs or groups of RDSFs. Clonal archives are now being established in western Poland in the Syców Forest District for the Szczecin, Szczecinek, Piła, Poznań, Zielona Góra, Wrocław and Katowice RDSFs, as well as in north-eastern Poland in the Łomża Forest District for the Gdańsk, Olsztyn, Białystok, Warsaw and Lublin RDSFs. Other RDSFs have also begun organizing individual clonal archives. The first clonal archive of the common yew (*Taxus baccata* L.) in Poland was established in the Kostrzyca FGB. Data on the number of genotypes of trees so far planted in the clonal archives are given in Table 14.

1.2. Promoting the use of FRM from categories I, II, III and IV

In Poland, information on the breeding value of each population is published with little delay. The main sources are regular scientific conferences and reports on the scientific achievements of the Forest Research Institute.

The Preservation Programme for 2011–2035 permits the use of larger quantities of seeds from seed orchards than hitherto (40 per cent) and also permits reproductive material from category IV (tested). In 2005, the State Forests launched a large-scale Programme for the Progeny Testing of Selected Seed Stands, Plus Trees, Seed Orchards and Seedling Seed Orchards to test 1160 populations of main forest tree species, 10 000 plus trees, 200 seed orchards, and 100 seedling seed orchards. After testing, the approved material will be registered in category IV. It is assumed that by 2035 at least 10 per cent of FRM will come from category IV (tested).

1.3. IT systems supporting breeding programmes

The State Forests have implemented a computer application (ZASOBY_WWW) to support the circulation of forest reproductive material in seed extraction plants and stores in Poland. The application operates in all organizational units of the State Forests and its online access and user-friendly interface ensure the rapid transfer of data between the many units. It allows seed owners to browse information on the collected seeds, on the successive stages of the technological processes at seed extraction facilities and on the seed assessments at Seed Testing Stations. A module has also been created for the registration of FBM objects and reporting. The data collected from throughout Poland forms a unique database which aids the analysis of FBM.

The Forest Research Institute, as the coordinator of the progeny testing programme, collects information about test sites, test objects and the results of measurements and observations on the established sites. Working with the collaborating research institutions, the Forest Research Institute processes test results and evaluates the tested stands for their suitability for FRM category IV (tested).

The Kostrzyca FGB is developing a computer programme that will collect data on the selection and genetics of trees at all forest experimental sites.

1.4. Supply and dislocation systems and the availability of FRM

The rules for FRM transfer are contained in the Act on FRM. The forest seed base in Poland is large and generally available commercially to all FRM suppliers registered in the FRMO if arrangements are made with the manager or owner of the database.

Some restrictions may only be introduced by District Forest Managers, which occurs where there are shortages of seeds in stores or of seedlings in nurseries in periods of poor seed harvests. The species involved are mainly broadleaved and include the seeds of *Fagus sylvatica* L., *Quercus robur* L. and *Quercus petraea* Liebl. The import of seeds from abroad is reduced to a minimum and is incidental.

FRM providers other than the organizational units of the State Forests may:

- collect seeds from the registered seed base indicated by a District Forest Manager, who also determines the optimum time of seed harvest; after the harvest, the producer may apply to the Minister of the Environment for a certificate of origin for the FRM,
- buy seeds from a registered seed base kept in a State Forest store or at the Kostrzyca FGB,
- buy plants for direct use or further distribution from the State Forest nurseries.

The procedures concerning the circulation of relevant documents must be observed in all cases. The Act on FRM does not apply to seeds and plants that are not included in Appendix I for tree species and their hybrids or to FRM sent to countries outside the EU.

Table 12 shows the average annual movement of seeds and seedlings from the State Forests in international trade in 2005–2010 (Forest Reproductive Material Office, 2011). It is estimated that the quantity of seedlings and seeds exported privately, which is not monitored by the FRMO, could be several times greater. The official import of FRM for forestry purposes has been reduced almost to zero by the regulations contained in the Ordinances of the Minister of the Environment on Forest Seed Regionalization.

An analysis of the documents on FRM movement found that the State Forests mostly sell material produced before 2004. By contrast, most of the material that is imported to Poland in the form of seeds goes to Polish nurseries only to raise plants and returns in the form of seedlings to the country from which it was imported (mainly Germany and Denmark).

1.5. Categories of forest reproductive material

Directive 1999/105/EC places reproductive material used for forestry purposes in three categories: 1) source-identified, which is material derived from a source of seeds and stands of known origin, 2) selected, which is material derived from selected seed stands and 3) qualified, which is material derived from plus trees, seed orchards and seedling seed orchards. Category IV (tested) is being established.

1.6. Varieties of tree species registered in Poland

Forest management in Poland is based on the cultivation of tree varieties to only a small degree. Only nine varieties of poplars from the Brzeg Forest District, which originate from the United States, Canada, Germany and France and which are used to establish plantations of fast-growing trees, are registered in the Forest Reproductive Material Office.

Populus maximowiczii x trichocarpa – 'Androscoggin' and *'Hybrida 275'* varieties
Populus maximowiczii x berlinensis – 'Geneva' and *'Oxford'* varieties
Populus 'Italica' x laurifolia – 'Berolinensis' variety
Populus x euramericana – 'Blanc du Poitou', 'Löns' and *'Robusta Gostynin'* varieties
Populus trichocarpa – 'Fritzi Pauley' variety

So far, 14 200 parts of plants (cuttings) have been taken from these varieties.

Chapter 5:

The status of national programmes, research, education, training and legislation

1. Legislation and national programmes

The Constitution of the Republic of Poland of 2 April 1997 (Constitution 1997), which is considered the most environmentally friendly constitution in Europe, is the supreme law in Poland indirectly relating to forest genetic resources (Radecki, 2005). Article 5 provides, inter alia, that the Republic of Poland shall "safeguard the national heritage and ensure the protection of the environment based on the principle of sustainable development". Following the Rio conference in 1992, sustainable development became the fundamental principle of global forestry (Geszprych, 2007), yet the introduction of the Forest Act in Poland in 1991 preceded the Rio declaration by one year.

The conservation of forest genetic resources is carried out in Poland by the State Forests based on international agreements ratified by Poland. This especially concerns the Convention on Biological Diversity (CBD) from Rio de Janeiro (1992) and the resolutions of the Ministerial Conference on the Protection of Forests in Europe (MCPFE) – in particular those resolutions concerning the protection and conservation of forest genetic resources, such as the Strasbourg S2 resolution of 1990, the Helsinki H2 resolution of 1993 and Vienna resolution 4 of 2003 (Table 31).

Following accession to the European Union in 2005, Poland undertook to develop and introduce the provisions of a number of binding strategic documents. Unfortunately, no forestry development strategy was on the list of priorities. The State Policy on Forests of 1997, which requires an urgent update, set out a vision of forestry for the late twentieth century and introduced a number of concepts related to the ecologization of forest management and the importance of forests in carbon sequestration. The many provisions common to both the Forest Act and the State Policy on Forests concentrated on the promotion of multifunctional forestry based on ecological principles. Both the Forest Act of 1991 and the State Policy on Forests of 1997 led to the development of the Strategy for the State Forests: Vision, Purpose and Concept, which was drawn up under the leadership of Waldemar Sieradzki (Sieradzki, 1997) but was never formally adopted (Zaleski, 2011). Meanwhile, Bogdan Łonkiewicz's study of 1996, The Conservation and Sustainable Use of Forests in Poland, which could have underpinned the development of a strategy, has so far not been implemented. In 2003, the Polish Parliament adopted the National Environmental Policy 2003–2006, which included prospects for 2007–2010. This document was followed up in 2008 – with a time horizon extending to 2016. The chapters on nature conservation and on the protection and sustainable development of forests raise issues concerning the protection of natural habitats in the Natura 2000 network, the augmentation of forest cover in Poland, educating society about forests and the natural world, water retention in forests and the reconstruction of stands. The latter point was also taken up within the framework of the Programme for the Protection and Restoration of the Common Yew (*Taxus baccata*) in Poland and the Programme for the Restitution of Fir in the Sudeten Mountains. The National Environmental Policy also highlights the role of forest gene banks in the preservation of forest biological diversity. Poland has not yet implemented the National Forest Programme, whose functions are to some extent fulfilled by the State Policy on Forests.

The issue of the conservation of forest genetic resources is quite strongly emphasized in the National Strategy for the Sustainable Use of Biodiversity and in the Action Programme for 2007–2013 (Council of Ministers, 2007) that were adopted in Poland in 2007. Of the eight objectives of the Strategy, two refer specifically to forest genetic resources:

1. The preservation of biological diversity and the monitoring of existing and potential threats.
2. The preservation and/or enhancement of existing components of biological diversity and the restoration of those that are lost.

These objectives are to be implemented, *inter alia*, through:

- the preservation and enhancement of the existing within-species, between-species and above-species biological diversity,
- the restitution of the most valuable genetic resources and species and the restoration or reconstruction of damaged ecosystems by rebuilding man-made forest stands and especially coniferous stands,
- shaping the desired biological diversity in areas (including urban areas) that have been heavily depleted by human activity and by various other factors of degradation,
- the preservation of the genetic resources of wild plants and animals threatened by extinction that are important for scientific research and breeding in *ex situ* collections and gene banks,
- the development of scientific research and analysis aimed at integrating different aspects of biological diversity.

Other Polish legal documents concerning the protection and conservation of forest genetic resources:

- Act of 3 February 1995 on the Protection of Agricultural and Forest Land (consolidated text, Journal of Laws 2004, No. 121, item 1266 with subsequent amendments),
- Act of 13 April 2007 on the Prevention and Repair of Environmental Damage (Journal of Laws 2007, No. 75, item 493 with subsequent amendments),
- Act of 8 June 2001 on the Allocation of Agricultural Land for Afforestation (Journal of Laws 2001, No. 73, item 764 with subsequent amendments),
- Act of 16 April 2004 on Nature Conservation (consolidated text, Journal of Laws 2009, No. 151, item 1220 with subsequent amendments),
- Act of 27 April 2001 on Environmental Protection (consolidated text, Journal of Laws 2008, No. 25, item 150 with subsequent amendments),
- Act of 13 October 1995 on Hunting (consolidated text, Journal of Laws 2005, No. 127, item 1066 with subsequent amendments),
- Act of 7 June 2001 on Forest Reproductive Material (Journal of Laws 2001, No. 73, item 761 with subsequent amendments),
- Act of 3 October 2008 on the Provision of Information on the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessments (Journal of Laws 2008, No. 199, item 1227 with subsequent amendments),
- Act of 18 December 2003 on Plant Protection (consolidated text, Journal of Laws 2008, No. 133, item 849 with subsequent amendments).

2. Scientific research

Scientific research in the field of forestry is carried out mainly by the Forest Research Institute in Warsaw, the Institute of Dendrology, PAS, in Kórnik and the universities (Table 17).

The Forest Research Institute

The Forest Research Institute was established in 1930 as the State Forests Experimental Station. In 1934, the Station was transformed into the State Forests Research Institute. Since 1945 it has operated under the new name of the Forest Research Institute and is now under the supervision of the Minister of the Environment.

The governing bodies of the Institute are the Director and the Scientific Council. The Scientific Council is the decision-making, initiating and opinion-giving body of the Institute. It is authorised to confer doctoral and postdoctoral degrees and to apply for permission to confer the title of professor.

The Forest Research Institute carries out extensive scientific research and developmental studies for the needs of forests, forest management and forestry in areas related to afforestation and restocking, forest tending, utilisation and protection, ecology and genetics, and economics and forest policy. The Institute's research findings, study results and expert analyses help support the forest sciences, the forest economy and government institutions.

The Institute participates in drawing up legal acts and other documents for the state authorities, including those arising from international conventions and agreements and the National Policy on Forests.

It is the organizer or co-organizer of many international and national gatherings, seminars, workshops and conferences and also provides education on forests and the natural world for children and young people at the Forest Education Centre. The Institute's library has been collecting forest literature for 75 years and its resources are now the largest in this part of Europe.

The institute's staff play a number of different roles in international organizations, such as the International Union of Forestry Research Organizations (IUFRO) (http://iufro.boku.ac.at/) and the European Forest Institute (EFI) (http://www.efi.int/). They lend their expert knowledge to international scientific boards, programmes, associations, teams and working groups. The Institute's annual budget is PLN 31.5 million, of which PLN 18.3 million comes from contracts and subsidies from the State Forests.

The Institute of Dendrology of the Polish Academy of Sciences in Kórnik

This is a research unit of the Polish Academy of Sciences whose major statutory task is to carry out biological and forest studies of woody plants and to disseminate the findings. Its areas of specialisation in this field are as follows:

- systematics and chorology,
- physiology and ecophysiology,
- molecular biology,
- seed biology,
- genetics,
- proteomics,
- ecology,
- bioindcation,
- phytoremediation,
- mycology and mycorrhizas,
- selection, silviculture and reproduction,
- phytopatology,

- entomology,
- the introduction and acclimation of alien species,
- the physiology of thermal and radiation stress.

The Institute's annual budget for the activities related to forest gene resources amounts to PLN 5.5 million, of which one million comes from contracts with the State Forests.

Chapter 6:

The status of general and international cooperation

1. International networks

IUFRO

The International Union of Forest Research Organizations is an independent, non-governmental international network of forest scientists. It promotes global scientific cooperation in forestry and the development of forest research.

Polish members of the IUFRO:

- Faculty of Forestry, Warsaw University of Life Sciences (SGGW),
- Faculty of Forestry, Poznań University of Life Sciences,
- Faculty of Forestry, H. Kołłątaj Agricultural University of Kraków,
- Wood Technology Institute in Poznań,
- Forest Research Institute in Warsaw,
- Institute of Dendrology of the Polish Academy of Sciences in Kórnik.

Professor Władysław Chałupka (D. Sc. Habil.) from the Institute of Dendrology, PAS, in Kórnik is the member of the IUFRO International Council representing Poland (mailto:idkornik@man.poznan.pl).

Poland has personal membership of the International Seed Testing Association (ISTA) on its Forest Tree and Shrub Seed Committee (FTSSC), which is held by Czesław Kozioł from the Kostrzyca FGB (mailto:czeslaw.koziol@lbg.lasy.gov.pl).

The committee members deal with issues of seed quality assessment, seed storage, seed stratification and seed diseases.

2. International Programmes

EUFORGEN

Poland is a member of the European Forest Genetic Programme (EUFOGEN) (Bioversity International) which promotes the conservation and sustainable use of forest genetic resources. EUFORGEN serves as a platform for pan-European collaboration in this area, bringing together scientists, managers, policy-makers and other stakeholders.

EUFORGEN facilitates the development of science-based strategies, methods and recommendations for policy-makers and managers to improve the management of the genetic resources of forest trees in Europe. It also contributes to various initiatives and projects whose purpose is to improve the quality of information on forest resources in Europe and to disseminate it. EUFORGEN was established in 1994 as an implementation mechanism of the Strasbourg S2 Resolution (Conservation of Forest Genetic Resources) adopted at the first Ministerial Conference on the Protection of Forests in Europe (MCPFE) held in France in 1990. Dr Jan Matras of the Forest Research Institute in Warsaw is the programme's National Coordinator. The EUFGIS (Establishment of a European Information System on Forest Genetic Resources) project involves the development of an IT system to support EUFORGEN. EUFGIS offers support to European countries in their efforts to implement and document the dynamic gene conservation of the FGR of forest trees. Czesław Kozioł of the Kostrzyca FGB is the liaison for EUFGIS in Poland.

Polish scientific institutions are also involved in international research into tree breeding and forest tree genetics, whose findings are used to perform tasks involved in FGR conservation, including Treebreedex, Evoltree Trees4Future, ECONET and ESBRI.

Poland's most effective contribution to the protection and conservation of FGR and to cognitive studies of forest tree genetics is made in its participation in the IUFRO, Treebreedex and EUFORGEN programmes.

If international cooperation on FGR conservation is to be strengthened, studies of seed quality assessment and storage should be developed and at least one of the Polish forest research institutes should be a full participant in the ISTA programme. As it is an independent research unit with a well-developed and well-equipped seed testing station and considerable research experience, the Forest Research Institute would seem most suited for this function.

In view of the increasing impact of climate change, the *ex situ* conservation of valuable populations and genotypes in gene banks now appears a necessity. With time, the *ex situ* conservation being carried out in the various European countries should coalesce in the establishment of a pan-European network of forest gene banks storing the genetic resources of forest trees.

The following projects should be developed and implemented within the framework of international collaboration on FGR protection, conservation and research:

– periodic training for FGB managers, policy-makers and stakeholders highlighting the need to monitor FGB studies and *ex situ* conservation,

- further development of pan-European projects and programmes involving studies of the genetic variation of forest tree species on a national scale and on a European scale not confined to the EU member states,
- intensified training in forestry and FGR conservation at various levels of public education, addressed particularly to policy-makers and stakeholders, to help raise public awareness of what is at stake and of the action necessary to preserve genetically undepleted FGR,
- the establishment of a pan-European system to monitor genetic changes occurring within forest tree species and to develop plans to counteract the potential genetic drift that could be included in the national programmes.

3. International agreements

The agreements are presented in Tables 32–36.

Chapter 7:

The availability of forest genetic resources

In Poland, forests that are Treasury property are open to the public and it is only in very exceptional cases that the right to enter a forest is limited. There is a ban on access to forests where there are plantations up to 4 metres in height, experimental areas, seed stands, refugia designated for animals, spring areas of rivers and streams and areas threatened by erosion.

The Forest Act 1991 states, "District Forest Managers shall enjoy the right to introduce temporary bans on entry into forests constituting Treasury Property, where a major fire risk or natural disasters have arisen that may endanger the safety of people, such as storms, and where management measures are in progress in connection with silviculture, forest protection or timber harvesting." The obligation to introduce temporary bans on entry and to put up 'No Entry' signs also applies to forests under other forms of ownership. The Act continues, "Traffic comprising motor vehicles or animal-drawn vehicles is not permitted in forests on public roads unless these roads are marked with signs stating that such traffic is allowed. Horse riding in a forest is only permitted via forest roads designated for the purpose by the District Forest Officer. Forests that are Treasury property are available for the gathering and picking of forest-floor produce. The gathering and picking of forest-floor produce for industrial purposes requires an agreement to be concluded with the relevant Forest District. An owner of a forest that is not Treasury property may prohibit entry into that forest by marking it with a board that bears the appropriate inscription."

The Forest Act of 1991 further forbids the following in forests:

1) "to pollute soil and water,
2) to leave litter,
3) to dig up ground,
4) to destroy fungi or fungal mycelia,
5) to destroy or damage trees, shrubs or other plants,
6) to destroy installations and other elements associated with management and tourism, as well as technical installations, signs and boards,

7) to gather and pick the produce of the forest floor where this activity is marked as prohibited,
8) to disturb or collect leaf litter,
9) to graze livestock,
10) to bivouac away from places designated for the purpose by a forest owner or a District Forest Officer,
11) to collect eggs or the nestlings of birds, to destroy their breeding grounds or nests, to destroy the holes, dens, lairs and setts of animals, to destroy anthills,
12) to scare, chase, catch, trap and/or kill wild animals,
13) to let dogs off the leash,
14) except in cases where there is a need for the alarm to be raised, to make noise or use sound signals."

The provisions of paragraph 1, points 3 and 5, do not apply to forest management activities, while points 12–14 do not apply to hunting.

Forests, areas of land within forests and areas up to 100 metres from the forest edge are subject to proscriptions on activities capable of giving rise to danger. These are:

a) the starting of fires away from places designated for the purpose by the forest owner or District Forest Officer,
b) the use of a naked flame,
c) the burning of surface soil layers or of the remnants of vegetation.

Provided that they do not pose a fire threat, the provisions of paragraph 3 do not apply to forest management activities.

The Nature Conservation Act of 2004 forbids the following in national parks and nature reserves:

1) to construct or expand buildings and technical facilities, with the exception of those serving the purposes of national parks or nature reserves;
2) to capture or kill wild animals, collect or destroy eggs or the juvenile forms and developmental forms of animals, deliberately disturb vertebrate animals, collect antlers and destroy burrows, nests, dens, and other shelters of animals and their breeding sites;
3) to hunt, except in areas designated for this purpose in the protection plan or in the protection tasks set for nature reserves;
4) to collect, destroy or intentionally damage plants and fungi;
5) to use, destroy, intentionally damage, leave litter in or make changes to natural objects, areas and resources, including natural formations and elements;
6) unless they serve nature protection, to introduce changes in water relations and the regulation of rivers and streams;
7) to collect rocks, including peat, to collect fossils, such as the fossil remains of plants and animals, to collect minerals and amber;

8) to cause soil disturbance or changes in land designation and use;
9) to light fires and tobacco products, to use light sources with a naked flame in national parks except in the areas designated by the director of a national park and, in nature reserves, by a decision of the relevant regional director for environmental protection;
10) to perform manufacturing, trade and agricultural activities, except in areas specified in the conservation plan;
11) to use chemical and biological plant protection agents and fertilizers;
12) to collect wild plants and fungi and the parts thereof, except in areas designated by the director of a national park and by the relevant regional director for environmental protection in a nature reserve;
13) to catch fish and other aquatic organisms, except in areas specified in the protection plan or protection tasks;
14) to walk, ride a bicycle, ski and ride a horse, except for trails and ski slopes designated by the director of a national park or by the relevant regional director for environmental protection in a nature reserve;
15) to let dogs into areas under strict and active protection, except into areas designated for the purpose in the protection plan and, where the protection plan or protective tasks allow grazing, to let herding dogs into areas covered by active protection;
16) to climb, explore caves or water reservoirs, except in areas designated for the purpose by the director of a national park and, in a nature reserve, by the relevant regional director for environmental protection;
17) to drive vehicles off public roads and off roads located on a property that is under the permanent management of a national park as designated by the director of a national park and, in nature reserves, by the relevant regional director for environmental protection;
18) to erect, or otherwise put into position, billboards, signs, advertising boards and other signs not relating to nature protection, access to nature reserves and environmental education – except for road signs and other signs relating to public security and the protection of public order;
19) to disturb the silence;
20) to use motor boats and other motor vehicles, to play water sports, swim and sail yachts – with the exception of water or trails designated by the director of a national park and, in a nature reserve, by the relevant regional director for environmental protection;
21) to construct earthworks causing permanent deformation of the topography;
22) to camp, except in places designated by the director of a national park and, in a nature reserve, by the relevant regional director for environmental protection;

23) to conduct research in a national park without the permission of the director of the park and, in a nature reserve, without the permission of the relevant regional director for environmental protection;
24) to introduce species of plants, animals and fungi without the consent of the Minister competent in matters of the environment;
25) to introduce genetically modified organisms;
26) to organize recreational and sports events in a national park without the permission of a park director or in a nature reserve without the permission of the relevant regional director for environmental protection.

These bans in national parks do not apply to:

1) the performance of tasks arising from the protection plan or protection tasks,
2) carrying out rescue operations and activities related to general safety,
3) the performance of national defence tasks in the case of a threat to state security,
4) areas of protected landscape during their economic use by organizational units, legal entities or individuals exercising ownership rights in accordance with the provisions of the Civil Code.

The relevant prohibitions also apply to landscape parks.

There are no fully-elaborated methods and agreements in place in Poland for sharing benefits from the use of FGR. If action were to be taken to draw up a legal act regulating the sharing of these benefits, attention should be given to ensuring that provisions relevant to foreign buyers of LMR and private owners of FBM are included in it.

LITERATURE

Alert List 2011. European and Mediterranean Plant Protection Organization. Paris.

Andrzejczyk T., Twaróg J. 1997. Inicjowanie naturalnego odnowienia sosny. Las Polski, 5: 4–5.

Andrzejewski K., Kowalkowski W., Rzeźnik Z. 1994. Variability of growth and qualitative features of 10-year-old Scots pine (*Pinus sylvestris* L.) of European provenances. IUFRO Symposium Kaunas, pp. 24–28, figs, tables, bibliography, 10 items.

Andrzejewski R., Weigle A. 2003. Różnorodność biologiczna Polski. Narodowa Fundacja Ochrony Środowiska. Warszawa.

Bałut S. 1989. Zróżnicowanie wysokości w wieku 20 lat europejskich pochodzeń świerka pospolitego (*Picea abies* (L.) Karst.) doświadczenia IPTNS-IUFRO 1964–1968 na powierzchni doświadczalnej w Krynicy. Sylwan, 133, 11–12: 19–30.

Bałut S., Kulej M., Sabor J., Skrzyszewska K. 1987. Obecny stan bazy nasiennej buka zwyczajnego (*Fagus sylvatica* L.) w górskich terenach Polski. Sylwan, 7: 35–47.

Bałut S., Sabor J. 2001. Inventory provenance test of Norway Spruce (*Picea abies* (L.) Karst.) IPTNS-IUFRO 1964–1968 in Krynica. Part I. Description of the experimental area. Test material. IUFRO Working Party S 2.02.11 Norway Spruce Provenances and Breeding. Kraków.

Bałut S., Sabor J. 2002. Inventory provenance test of Norway Spruce (*Picea abies* (L.) Karst.) IPTNS-IUFRO 1964–1968 in Krynica. Part II. Test results of 1968–1984. Geographical variability of traits in the whole range of the species. IUFRO Working Party S 2.02.11 Norway Spruce Provenances and Breeding. Kraków.

Banach J. 2002. Zmienność wewnątrzgatunkowa dębu szypułkowego testowanego na powierzchni doświadczalnej w Leśnictwie Chrostowa. Zeszyty Naukowe Akademii Rolniczej w Krakowie, ser. Sesja Naukowa, 86: 131–147.

Banach J. 2003. Zmienność wybranych cech niżowych pochodzeń dębu szypułkowego (*Quercus robur* L.) na proweniencyjno-rodowych powierzchniach doświadczalnych w Nadleśnictwie Brzesko. Zeszyty Naukowe Akademii Rolniczej w Krakowie, ser. Sesja Naukowa, 88: 67–74.

Banach J. 2006. Variation of stem form of pedunculate oak (*Quercus robur* L.) tested on experimental plots located in Carpathian foothills. Beskydy, 19: 205–212.

Banach J. 2007. Adaptacja potomstwa dębu szypułkowego (*Quercus robur* L.) pochodzeń niżowych na uprawach doświadczalnych w Nadleśnictwie Brzesko. [In:] Hodowla dębów w Polsce. Wybrane zagadnienia. Opracowanie zbiorcze pod red. P. Rutkowskiego. Idee ekologiczne, 16: 35–44. Sorus. Poznań.

Banach J. 2007. Leaf retention of young pedunculate oak (*Quercus robur* L.) of some provenances tested on two experimental plots located in foothills of the western Beskids (Southern Poland). Beskydy, 20: 259–266.

Banach J. 2010. Adaptation of selected provenances of pedunculate oak (*Quercus robur* L.) under conditions of the Carpathian submontane zone in Southern Poland. Annals of Warsaw University of Life Science, Forestry and Wood Technology, 73: 83–96.

Banach J. 2011. Przeżywalność i wysokość dębu szypułkowego (*Quercus robur* L.) testowanego na powierzchni doświadczalnej „Chrostowa I" w Nadleśnictwie Brzesko. Leśne Prace Badawcze, 72, 1: 5–15.

Banach J., Barzdajn W., Fober H., Markiewicz P. (main author), **Matras J.** (main author). 2006. Badania porównawcze populacyjnej i rodowej zmienności cech hodowlanych wybranych pochodzeń dębu szypułkowego (*Quercus robur* L.). Sprawozdanie Naukowe IBL: 1–116.

Banach J., Lenowiecki K. 2011. The occurrence of insect pests on pedunculate oak tested on the Chrostowa II experimental plot. Journal of Forest Science, 57, 9: 384-393.

Banach J., Sabor J. 2001. Proweniencyjno-rodowa powierzchnia doświadczalna z dębem szypułkowym w Leśnictwie Chrostowa. Prace Instytutu Badawczego Leśnictwa, Ser. A, 4, 925: 47–59.

Barzdajn W., Buraczyk W., Kowalczyk J., Markiewicz P., Matras J. (main author),
Szeligowski H., Żybura H. 2006. Badania porównawcze populacyjnej i rodowej zmienności cech hodowlanych wybranych pochodzeń świerka pospolitego (*Picea abies* Karst.). Sprawozdanie Naukowe IBL: 1–128.

Barzdajn W., Kulej M., Kowalczyk J., Markiewicz P., Matras J. (main author),
Szeligowski H., Żybura H. 2006. Badania porównawcze populacyjnej i rodowej zmienności cech hodowlanych wybranych pochodzeń modrzewia europejskiego (*Larix decidua* Mill.).Sprawozdanie Naukowe IBL: (1–105).

Barzdajn W. 1982. Przyrostowa i morfologiczna charakterystyka krajowych populacji świerka pospolitego (*Picea abies* (L.) Karst.) na uprawie porównawczej w Nadleśnictwie Doświadczalnym Laski. Roczniki AR w Poznaniu, 140: 17–49.

Barzdajn W. 1994. Dwudziestoletnie doświadczenie proweniencyjne ze świerkiem (*Picea abies* (L.) Karsten) serii IUFRO 1972 w Leśnym Zakładzie Doświadczalnym Siemianice. I. Cechy wzrostowe. Sylwan, 138, 11: 25–36.

Barzdajn W. 1995. Dwudziestoletnie doświadczenie proweniencyjne ze świerkiem (*Picea abies* (L.) Karsten) serii IUFRO 1972 w Leśnym Zakładzie Doświadczalnym Siemianice. II. Cechy morfologiczne. Sylwan, 139, 6: 43–54.

Barzdajn W. 1995. Dwudziestoletnie doświadczenie proweniencyjne ze świerkiem (*Picea abies* (L.) Karsten) serii IUFRO 1972 w Leśnym Zakładzie Doświadczalnym Siemianice. III. Cechy fenologiczne. Sylwan, 139, 7: 33–49.

Barzdajn W. 1996. Dwudziestoletnie doświadczenie proweniencyjne ze świerkiem (*Picea abies* (L.) Karsten) serii IUFRO 1972 w Leśnym Zakładzie Doświadczalnym Siemianice. IV. Odporność drzew. Sylwan, 140, 6: 15–21.

Barzdajn W. 1996. Dwudziestoletnie doświadczenie proweniencyjne ze świerkiem (*Picea abies* (L.) Karsten) serii IUFRO 1972 w Leśnym Zakładzie Doświadczalnym Siemianice. V. Próba syntezy. Sylwan, 140, 8: 11–17.

Barzdajn W. 1996. Ocena wartości diagnostycznej morfologicznych cech szyszek świerka pospolitego (*Picea abies* (L.) Karst.) dla wyróżnienia jego proweniencji. Sylwan, 140, 9: 61–75.

Barzdajn W. 1997. Zmienność świerka pospolitego (*Picea abies* (L.) Karst.) polskich proweniencji w 25-letnim doświadczeniu w LZD Siemianice. Sylwan, 141, 10: 73–82.

Barzdajn W. 2000. Doświadczenie proweniencyjne z modrzewiami polskich pochodzeń w Leśnym Zakładzie Doświadczalnym w Siemianicach. Seminarium „Modrzew – gospodarcze i ekologiczne znaczenie w ekosystemach leśnych". Leśny Bank Genów Kostrzyca, 25–26 października 2000.

Barzdajn W. 2000. Doświadczenie proweniencyjne nad zmiennością sosny zwyczajnej (*Pinus sylvestris* L.) serii IUFRO 1982 w Nadleśnictwie Supraśl. Sylwan, 144, 6: 41––52.

Barzdajn W. 2000.Strategia restytucji jodły pospolitej (*Abies alba* Mill.) w Sudetach. Sylwan 144, 2: 63–77

Barzdajn W. 2002. Gatunkowe i proweniencyjne zróżnicowanie dębów (*Quercus robur* L. i *Q. petraea* Liebl.) w doświadczeniu proweniencyjnym z 1993 r. Zeszyty Naukowe Akademii Rolniczej im. Hugona Kołłątaja w Krakowie, 394: 189–198.

Barzdajn W. 2002. The variability of dimensions of *Quercus robur* L. and *Q. petraea* Liebl. acorns in Poland. Dendrobiology, 47: 21–24.

Barzdajn W. 2002. Proweniencyjna zmienność buka zwyczajnego (*Fagus sylvatica* L.) w Polsce w świetle wyników doświadczenia proweniencyjnego serii 1992/1995. Sylwan, 146, 2: 5–34.

Barzdajn W. 2003. Świerk pospolity (*Picea abies* (L.) Karst.) w 30-letnim doświadczeniu proweniencyjnym serii IUFRO 1972 w Nadleśnictwie Doświadczalnym Siemianice. Sylwan, 147, 7: 30–36.

Barzdajn W. 2006. Zmienność cech taksacyjnych sosny zwyczajnej (*Pinus sylvestris* L.) polskich pochodzeń w doświadczeniu proweniencyjnym z 1985 roku w Nadleśnictwie Zielonka. Sylwan, 150, 1: 8–19.

Barzdajn W. 2007. Porównanie odziedziczalności proweniencyjnej, rodowej i indywidualnej dębów szypułkowych (*Quercus robur* L.) w doświadczeniu rodowo-proweniencyjnym w Nadleśnictwie Bolesławiec. [In:] Hodowla dębów w Polsce: wybrane zagadnienia. Idee ekologiczne. Sorus. Poznań, 16: 45–50.

Barzdajn W. 2008.Porównanie odziedziczalności proweniencyjnej, rodowej i indywidualnej cech wzrostowych dębów szypułkowych (*Quercus robur* L.) w doświadczeniu rodowo-proweniencyjnym w Nadleśnictwie Milicz. Sylwan, 152, 5: 52–59.

Barzdajn W. 2008.Wyniki 24-letniego doświadczenia proweniencyjnego z sosną w Nadleśnictwie Supraśl. Sylwan, 152, 4: 21–29.

Barzdajn W. 2009. Adaptacja różnych pochodzeń jodły pospolitej (*Abies alba* Mill.) do warunków Sudetów. Leśne Prace Badawcze (*Forest Research Papers*), 70, 1: 49–58.

Barzdajn W. 2009. Adaptacja i początkowy wzrost potomstwa drzewostanów nasiennych buka zwyczajnego (*Fagus sylvatica* L.) na uprawach porównawczych w nadleśnictwach Złotoryja i Lądek Zdrój. Leśne Prace Badawcze (*Forest Research Papers*), 70, 2: 101–111.

Barzdajn W. 2009. Wzrost dębu szypułkowego (*Quercus robur* L.) i dębu bezszypułkowego (*Q. petraea* Liebl.) w doświadczeniu proweniencyjnym z 1994 r. w Nadleśnictwie Milicz. Leśne Prace Badawcze (*Forest Research Papers*) 70, 3: 241–252.

Barzdajn W. 2010. Provenance and family variation of silver fir (*Abies alba* Mill.) in the experiment established in the Siemianice Forest Experimental Station in 1996. Ann. Warsaw Univ. of Life Sci. (SGGW), For. and Wood Technol., 73: 51–64.

Barzdajn W., Ceitel J., Modrzyński J. 2003. Świerk w lasach polskich: historia, stan, perspektywy. [In:] Drzewostany świerkowe. Stan, problemy, perspektywy rozwojowe, 5––22.
Barzdajn W., Kowalkowski W. 2007. Kolekcja klonów jodły pospolitej (*Abies alba* Mill.) w Nadleśnictwie Międzylesie. Nauka Przyroda Technologie, 1, 1: 1–5.
Barzdajn W., Kowalkowski W., Rzeźnik Z. 2002. Doświadczenie proweniencyjne nad zmiennością buka zwyczajnego (*Fagus sylvatica* L.) serii 1993/1995 w Polsce. Roczniki AR w Poznaniu 345, Leśn., 40: 3–18.
Barzdajn W., Raj A., 2008.Jodła pospolita w Karkonoskim Parku Narodowym. Karkonoski Park Narodowy. Jelenia Góra.
Barzdajn W., Rzeźnik Z. 2002. Proweniencyjna zmienność buka zwyczajnego (*Fagus sylvatica* L.) polskich pochodzeń w doświadczeniu serii 1992/1993/1995 na powierzchni w Nadleśnictwie Łopuchówko. Sylwan, 146, 2: 139–147.
Barzdajn W., Urbański K., Wesoły W. 1990. Wzrost polskich pochodzeń świerka pospolitego (*Picea abies* (L.) Karst.) w doświadczeniu proweniencyjnym z 1972 r. w Nadleśnictwie Doświadczalnym Laski, w latach 1982–1986. Sylwan, 134, 2: 33–44.
Bednarek T. 2003. Zmienność osobnicza jodły pospolitej (*Abies alba* Mill.) w Sudetach Zachodnich w nasiennej plantacji zachowawczej w Nadleśnictwie Kamienna Góra. Doctoral thesis performed in the Dept. of Silviculture of the Poznań Agricultural Academy.
Bednorz L. 2004. Rozmieszczenie i zasoby *Sorbus torminalis* (*Rosaceae: Maloidae*) w Polsce. Fragmenta Floristica et Geobotanica Polonica, 11: 105–121. Kraków.
Bednorz L. 2009. Jak chronić jarząb brekinię (*Sorbus torminalis* (L.) Crantz) w polskich lasach? Sylwan, 153, 5: 354–360.
Bednorz L., Myczko Ł., Kosiński P. 2006.Genetic variability and structure of the wild service tree (*Sorbus torminalis* (L.) Crantz) in Poland. Silvae Genetica, 55, 4/5: 197–202.
Bergmann F. 1995. Genetische Charakterisierung der erfassten Restvorkommen mittels Isoenzym-Genmarkern. [In:] Genetik und Waldbau der Weisstanne, Teil 2. Schriften der Sächsischen Landesanstalt für Forsten, 5: 65–78.
Bernadzki E. 1971. Planowanie hodowlane w rębni gniazdowej przerębowej na przykładzie obiektu położonego w Puszczy Białowieskiej. Sylwan, 115, 1: 79–85.
Bernadzki E. 1995. Półnaturalna hodowla lasu. Ochrona różnorodności biologicznej w zrównoważonej gospodarce leśnej, 45–51. Warszawa.
Bernadzki E. 2006. Lasy i leśnictwo krajów europejskich i ich organizacja. CILP. Warszawa.
Brincken J. 1828. Mémoire Descriptif sur la Forêt Impériale de Białowieża en Lithuanie. Varsovie; fragments translated by J.J. Karpiński [In:] „Białowieża". Warszawa, 1947. „O żubrze litewskim i polowaniu na niego". (translator D.W.), Sylwan, 1828, 1–3. „O Puszczy Białowieskiej" (translator D.W.), Dziennik Warszawski, 11, 1826, Sylwan 1827, 3.
Broda J. 1965.Puszcze karpackie i sudeckie. [In:] Polskie Towarzystwo Leśne, Stowarzyszenie Inżynierów i Techników Leśnictwa i Drzewnictwa 1965. Dzieje lasów leśnictwa i drzewnictwa w Polsce. PWRiL. Warszawa.
Burczyk J., Dzialuk A., Lewandowski A. 2000. Zmienność genetyczna sosny zwyczajnej (*Pinus sylvestris* L.) na klonowej plantacji nasiennej w Gniewkowie. Sylwan, 144, 7: 65––74.

Burczyk J., Kosiński G., Lewandowski A. 1991. Mating pattern and empty seed formation in relation to crown level of *Larix decidua* (Mill.) clones. Silva Fennica, 25: 201–205.

Chałupka W. 2006. Czy możliwe jest zachowanie różnorodności genetycznej w hodowli selekcyjnej drzew leśnych? Postępy Techniki w Leśnictwie, 95: 46–50.

Chałupka W. 2006. Procesy rozmnażania generatywnego a ochrona zasobów genowych w chronionych populacjach drzew leśnych. [In:] Elementy genetyki i hodowli selekcyjnej drzew leśnych. J. Sabor (ed.), 597–617. CILP. Warszawa.

Chałupka W., Mejnartowicz L., Lewandowski A. 2008. Reconstitution of a lost forest tree population: a case study of Norway spruce (*Picea abies* (L.) Karst.). For. Ecol. Manage., 255, 1: 2103–2108.

Chałupka W., Misiorny A., Rożkowski R. 2009. Provenance contributions to genetic composition of progeny from out-breeding seed orchard of Norway spruce (*Picea abies* (L.) Karst.). Dendrobiology, 61, supl.: 105–109.

Chałupka W. 2010. Genetyka drzew leśnych – zarys aktualnych problemów. [In:] Postęp badań w zakresie genetyki populacyjnej i biochemicznej drzew leśnych. Prace Komisji Nauk Rolniczych, Leśnych i Weterynaryjnych PAU, 13: 85–92.

Chałupka W., Mejnartowicz L., Lewandowski A. 2008. Reconstitution of a lost forest tree population: a case study of Norway spruce(*Picea abies* (L.) Karst.). For. Ecol. Manage., 255, 1: 2103–2108.

Chałupka W., Misiorny A., Rożkowski R. 2008.Provenance contributions to genetic composition of progeny from out-breeding seed orchard of Norway spruce (*Picea abies* (L.) Karst.). Dendrobiology (accepted for publication).

Chandelier A., Delhaye N., Helson M. 2011. First report of the ash dieback pathogen (anamorph *Chalara fraxinea*) on *Fraxinus excelsior* in Belgium. Plant Disease, 95, 2: 220.

Charakterystyka siedlisk dla Nadleśnictw Białowieża, Browsk, Hajnówka, 1998. RDLP w Białymstoku. (typescript).Białystok

Chmura D.J. 2002. Bud burst phenology of Polish provenances of pedunculate (*Quercus robur* L.) and sessile (*Q. petraea* Liebl.) oaks (in Polish with English summary). Sylwan, 146, 4: 97–103.

Chmura D.J. 2000. Analysis of results from a 59-year-old provenance experiment with Scots pine (*Pinus sylvestris* L.) in Lubień, Poland. Denrobiology, 45: 23–29.

Chmura D.J. 2000. Results of 84-year-old Scots pine (*Pinus sylvestris* L.) experiment in Puławy (in Polish with English summary). Sylwan, 144, 1: 19–25.

Chmura D.J., Giertych M., Rożkowski R. 2003.Early height growth of Scots pine (*Pinus sylvestris* L.) from Polish clonal seed orchards. Dendrobiology, 49: 15–23.

Chmura D.J., Rożkowski R. 2002. Diversity of European larch (*Larix decidua* Mill.) in provenance experiment in Poland. Proceedings of the Larix 2002 International. Symposium 'Improvement of larch (*Larix* sp.) for better growth, stem form and wood quality.' 16-21/09, 76–83. France.

Chmura D.J. 2006. Phenology differs among Norway spruce populations in relation to local variation in altitude of maternal stands in Beskidy Mountains. New Forests, 32: 21–31.

Chmura D.J., Rożkowski R. 2002.Variability of beech provenances in spring and autumn phenology. Silvae Genetica, 51, 2–3: 123–127.

Chmielarz P. 2007. Kriogeniczne przechowywanie nasion leśnych drzew liściastych z kategorii orthodox I suborthodox (intermediate). Bogucki Wydawnictwo Naukowe. Poznań.

Chrempińska Z. 2010. Perspektywy zmian powierzchni leśnej Polski w XXI wieku. Konferencja Naukowa, 34–37. SGGW. Warszawa.

Choiński A. 2006. Katalog jezior Polski,234, 416, 575. Wydawnictwo Naukowe UAM. Poznań.

Cieśliński S., Tobolewski Z. 1988. Porosty (Lichenes) Puszczy Białowieskiej i jej zachodniego przedpola. Phytocenosis, Supplementum Cartogr. Geobot. 1988, 1: 216.

Convention on biological diversity 1992. United Nations.

Csaikl U.M., Glaz I., Baliuckas V., Petit R.J., Jensen J.S. 2002. Chloroplast DNA variation of white oak in the Baltic countries and Poland. For. Ecol. Mgmt., 156: 211–222.

Czemko B. 2011.Gospodarcze i społeczne znaczenie drewna jako materiału. Polska Izba Gospodarcza Przemysłu Drzewnego (PIGPD). Conference, Puszczykowo, 27, 28 April 2011 r.

Czerepko J. 2010. Zakres i stan ochrony siedlisk leśnych. [In:] Problemy ochrony przyrody w lasach. Materiały II Sesji Zimowej Szkoły Leśnej przy IBL, Sękocin Stary, 16th-19th March 2010 r., 314–325. Instytut Badawczy Leśnictwa. Sękocin Stary.

Czerwiński A. 1978. Zbiorowiska leśne północno-wschodniej Polski. Zeszyty Nauk. Polit. Białostockiej, 27: 1–326.

Czerwiński A. 2002. Rola drzewostanów przejściowych w przemianach fitocenoz leśnych. 2000. [In:] Materials for the Conference: Postępowanie z drzewostanami „przejściowymi" w nadleśnictwach Leśnego Kompleksu Promocyjnego „Lasy Puszczy Białowieskiej". (typescripts). Białowieża.

Danielewicz W. 2008. Ekologiczne uwarunkowania zasięgów drzew i krzewów na aluwialnych obszarach doliny Odry. Wydawnictwo Uniwersytetu Przyrodniczego w Poznaniu. Poznań.

Dawidziuk J., Gątkowicz T., Kutrzeba M., Michaluk L., Zbrożek P. 1993. Strategia gospodarki leśnej w Puszczy Białowieskiej. (typescripts). Warszawa.

Decyzja nr 23 Ministra Ochrony Środowiska, Zasobów Naturalnych i Leśnictwa z dnia 8.11.1994 r. w sprawie ochrony i zagospodarowania Puszczy Białowieskiej z uzasadnieniem i załącznikiem „Zasady postępowania ochronnego i hodowlanego w Puszczy Białowieskiej". (typescripts). Warszawa.

Decyzja nr 24 Dyrektora Generalnego Lasów Państwowych z dnia 5 lipca 1995 roku w sprawie wprowadzenia nadzwyczajnej ochrony starych o charakterze pomnikowym – żywych i obumarłych oraz rzadkich gatunków w Puszczy Białowieskiej (ZO-73-64/96). (typescripts). Warszawa.

Decyzja nr 48 Dyrektora Generalnego Lasów Państwowych z dnia 6 lipca 1998 roku w sprawie wstrzymania wyrębu ponad 100 letnich: – pojedynczych drzew, – drzewostanów o charakterze naturalnym na terenie nadleśnictw w Puszczy Białowieskiej (ZO-732-19/98). (typescripts). Warszawa.

Dederko B. 1958. Handel „towarem leśnym" w Polsce w XVIII wieku. Sylwan, 102, 8.

Dederko B. 1926. Polityka leśna Litwy za Zygmunta Augusta. Las Polski, 12.

Dering M., Lewandowski A., Ufnalski K., Kędzierska A. 2008. How far to the east was the migration of white oaks from the Iberian refugium? Silva Fennica, 42: 327–335.

Dering M., Lewandowski A. 2009. Finding the meeting zone: Where have the northern and southern ranges of Norway spruce overlapped? Forest Ecology and Management, 259: 229–235.

Dering M., Misiorny A., Lewandowski A., Korczyk A. 2011. Genetic and historical studies on the origin of Norway spruce in Białowieża primeval forest in Poland. Eur. J. Forest Res DOI.1007/s10342-011-0510-8.

Dyrektywa Rady 1999/105/WE z dnia 22 grudnia 1999 r. w sprawie obrotu leśnym materiałem rozmnożeniowym. 2000. Dziennik Urzędowy Wspólnot Europejskich L11/17.

Dyrektywa Rady 92/43/EWG z dnia 21 maja 1992 r. w sprawie ochrony siedlisk przyrodniczych oraz dzikiej fauny i flory. 1992. Dziennik Urzędowy Wspólnot Europejskich L206/7.

Dyrektywa Rady 79/409/EEC z dnia 2 kwietnia 1979 r. w sprawie ochrony dzikiego ptactwa. 1979. Dziennik Urzędowy Wspólnot Europejskich L 103/1.

Encyklopedia PWN. 2010.

Faber A. Sabor J., Grzebelus D. 2007. Zróżnicowanie genetyczne wybranych drzewostanów świerka pospolitego (*Picea abies* L. Karst.) na przykładzie rasy istebniańskiej przy wykorzystaniu markerów RAPD. Zeszyty Problemowe Postępu Nauk Rolniczych, 517: 277–283.

Faliński J.B. 1966. Antropogeniczna roślinność Puszczy Białowieskiej jako wynik synantropizacji naturalnego kompleksu leśnego. Rozprawy Uniwersytetu Warszawskiego, 13: 1–256.

Faliński J.B. (ed.) 1968. Park Narodowy w Puszczy Białowieskiej. PWRiL, Warszawa.

Faliński J.B. 1980. Rozmieszczenie kurhanów na tle zróżnicowania środowisk leśnych Puszczy Białowieskiej. Zabytek Archeologiczny i Środowisko, 7: 97–42.

Faliński J.B. 1986. Vegetation dynamics in temperete forests. Ecological Studies in Białowieska Forest. Junk. Dordrecht.

Filipiak M. 1993. Wskazówki dotyczące uprawy modrzewia japońskiego w lasach północno-zachodniej Polski. Dyrekcja Generalna Lasów Państwowych.

Filipiak M. 1993: Wskazówki dotyczące uprawy modrzewia japońskiego w północno-zachodniej Polsce. Dyrekcja Generalna Lasów Państwowych.

Filipiak M., Napierała-Filipiak A. 2008. Relation between the height of *Larix kaempferi* and some characteristics in Poland. Dendrobiology, 60: 11–17.

Finer L., Helmissari H.S., Lohmus K., Majdi H., Brunner L, Borja I., Eldhuset T.D., Goodbold D.L., Grebenc T., Konopka B., Kraigher H., Môttônen M-R., Ohashi M., Oleksyn J., Ostonen I., Uri V., Vanguelova E. 2007. Variation in fine root biomass of three European tree species: Beech (*Fagus syhatica* L.), Norway spruce (*Picea abies* L. Karst.), and Scots pine (*Pinus sylvestris* L.). Plant Biosystems, 141: 406–425.

Fober H. 1998. Provenance experiment with pedunculate (*Quercus robur* L.) and sessile (*Q. petraea* /Matt./Liebl.) oaks established in 1968, 43: 67–78. Arboretum Kórnickie.

Fober H. 1999. Wewnątrzgatunkowa zmienność dębu szypułkowego (*Quercus robur* L.) w doświadczeniu proweniencyjno-rodowym, 44: 59–72. Arboretum Kórnickie.

Fober H., Rożkowski R. 2006. Ocena polskich ras dębu szypułkowego (*Quercus robur* L.) i bezszypułkowego (*Q. petraea* Liebl.) testowanych w doświadczeniu proweniencyjnym w Kórniku. Sylwan,150, 11:3–13.

Fonder W., Matras J., Załęski A. 2007. Leśna baza nasienna w Polsce. CILP. Warszawa.
Fonder W., Szabla K. 2011. Miejsce i rola rozwoju lasów i gospodarki leśnej z perspektywy Regionalnej Dyrekcji Lasów Państwowych. [In:] Strategia rozwoju lasów i leśnictwa w Polsce do roku 2030. Materiały III Sesji Zimowej Szkoły Leśnej przy IBL, Sękocin Stary, 15th–17th March 2011 r., 43–62. Instytut Badawczy Leśnictwa.
Forest Condition in Europe: 2011 Technical Report of ICP Forests (UNECE, Hamburg, 2011).
Geszprych M. 2007. Koncepcja prawa leśnego w Polsce – stan obecny. Sierota Z. (ed.), Quo vadis, forestry? Materiały Międzynarodowej Konferencji, Sękocin Stary, 29 and 30 June 2006, 94–104
Giertych M. 1977.Genetyka. [In:] Świerk pospolity. *Picea abies* (L.) Karst. Nasze drzewa leśne, 287–331. PWN. Warszawa–Poznań.
Giertych M. 1978.Plastyczność polskich ras świerka (*Picea abies* (L.) Karst.) w świetle doświadczenia IUFRO z lat 1964–1968, 23: 185–206. Arboretum Kórnickie.
Giertych M. 1979. Summary of results on Scots pine (*Pinus sylvestris* L.) height growth in IUFRO provenance experiments. Silvae Genetica, 28, 4: 136–152.
Giertych M. 1979. Summary of results on European larch (*Larix decidua* Mill.) height growth in the IUFRO 1944 provenance experiment. Silvae Genetica, 28, 5–6: 244–256.
Giertych M.1980. Polskie rasy sosny, świerka i modrzewia w międzynarodowych doświadczeniach proweniencyjnych, 25: 135–160. Arboretum Kórnickie.
Giertych M. 1993. Breeding Norway spruce in Poland: from provenance test to seed orchards. Norway spruce and breeding, Proceeding of IUFRO (S2.2–11). Symposium. Latvia.
Giertych M. 1998.Genetyka. Zmienność proweniencyjna i dziedziczna. [In:] Biologia świerka pospolitego. Bogucki,213–239. Wydawnictwo Naukowe. Poznań.
Giertych M. 1999. Wartość genetyczna świerka z północno-wschodniej Polski. [In:] Materials from the conference Genetyczna i hodowlana wartość polskich populacji świerka z zasięgu północno-wschodniego, 39–60.
Giertych M. 1999. The impact of selection practices on the biological diversity of production forests in Poland. [In:] Evaluation of the Impact of Forest Management Practices on Biological Diversity in Central Europe (eds. K. Rykowski, G. Matuszewski, E. Lenart), 59–78. Forest Research Institute. Warsaw.
Giertych M. 2002. Troska o bioróżnorodność. Sesja naukowa pt. „Zagospodarowanie oraz wartość genetyczna populacji drzew gatunków domieszkowych i introdukowanych w aspekcie stabilizacji ekosystemów leśnych Karpat". Zeszyty Naukowe Akademii Rolniczej w Krakowie, 394: 289–301.
Giertych M., Oleksyn J. 1981. Summary of results on Scots pine (*Pinus sylvestris* L.) volume production in Ogievskij's pre-revolutionary Russian provenance experiments. Silvae Genetica, 30, 2–3: 56–74.
Ginszt T. 2010. Znaczenie rezerwatów faunistycznych Puszczy Białowieskiej dla utrzymania różnorodności gatunkowej motyli dziennych (*Lepidoptera*: *Papilionoidea*, *Hesperioidea*). Doctoral thesis. Szkoła Główna Gospodarstwa Wiejskiego w Warszawie.
Glaz I. 2000. Genetic cartography of oaks in Poland using PCR-RFLP markers of the chloroplast DNA. Glas. Šum. Pokuse, 37: 481–487.

Global Forest Resources Assessment 2010.Main report, 2010. Food and Agriculture Organization of the United Nations. Rome.

Global Forest Resources Assessment. 2010. Country Report Poland, FRA 2010/166. Rome.

Głowaciński Z. (ed.). 2001. Polska czerwona księga zwierząt. Kręgowce. PWRiL. Warszawa.

Głowaciński Z., Nowacki J. (ed.). 2004. Polska czerwona księga zwierząt. Bezkręgowce. Instytut Ochrony Przyrody PAN in Kraków and Akademia Rolnicza in Poznań.

Gołos P. 2007. Lasy prywatne w Polsce: stan obecny oraz kierunki zmian. [In:] Quo vadis, forestry? Sierota Z. (ed.) Materiały Międzynarodowej Konferencji, Sękocin Stary, 29–30 June 2006 r., Poland. Sękocin Stary: 149–153.

Górska J. 1973. Najdawniejsze ślady człowieka w Puszczy Białowieskiej. Z otchłani wieków, 39, 4: 270–273.

Gutowski J.M., Kubisz D. 1995. Entomofauna drzewostanów pohuraganowych w Puszczy Białowieskiej. Prace. Instytut Badawczy Leśnictwa A, 788: 92–129.

Gutowski J.M., Sućko K., Bohdan A., Zieliński S. 2010. Inwentaryzacja chrząszczy saproksylicznych w Puszczy Białowieskiej, ujętych w Dyrektywie Siedliskowej. Białowieża.

Halmschlager E., Kirisits T. 2008. First report of the ash dieback pathogen *Chalara fraxinea* on *Fraxinus excelsior*in Austria. New Disease Reports. Volume 17. February 2008–July 2008.

Hartman W. 1938. Puszcza Białowieska, a dawny handel drzewny w świetle dokumentów. Las Polski, 6.

Hartman W. 1939. Wypalanie potażu, bartnictwo i łowiectwo w dawnej Puszczy Białowieskiej. Echa Leśne, 7, 9.

Hedemann O. 1939. Dzieje Puszczy Białowieskiej w Polsce przedrozbiorowej (w okresie do 1798 roku). Warszawa.

Heuertz M. 2003. Population genetic structure in European ash: a focus on south-eastern European genetic resources. Doctoral thesis. Free University of Brussels, Belgium and the Gabriel Lippmann Public Research Centre.Luxembourg.

Instrukcja wyróżniania i kartowania siedlisk leśnych – Załącznik do Zarządzenia nr 43 Dyrektora Generalnego Lasów Państwowych z dnia 18 kwietnia 2003 r. Państwowe Gospodarstwo Leśne Lasy Państwowe. Warszawa.

Ioos R., Kowalski T., Husson C., Holdenrieder O. 2009. Rapid in planta detection of *Chalara fraxinea* by a real-time PCR assay using a dual-labelled probe. European Journal of Plant *Pathology* (in press).

Jabłoński M., Kalinowski M. 2011. State of Forests and Sustainable Forest Management in Europe:National Data Reporting Forms on MCPFE Indicators for Sustainable Forest Management.

Jankovský L., Holdenrieder O. 2009.*Chalara fraxinea* ash dieback in the Czech Republic. Plant Protection Science, 45, 2: 74–78.

Jędrzejewska B., Jędrzejewski W. 2001. Ekologia zwierząt drapieżnych Puszczy Białowieskiej. PWN. Warszawa.

Karcow G. 1903. Białowieżskaja Puszcza. S. Petersburg.

Karpiński J.J. 1939. Puszcza Białowieska i Park Narodowy w Białowieży. Kraków.

Karpiński J.J. 1972. Puszcza Białowieska. Warszawa.
Kaźmierczakowa R., Zarzycki K. 2001.Polska Czerwona Księga Roślin, paprotniki i rośliny kwiatowe – Polish Red Data Book of pteridophytes and flowering plants. Instytut Botaniki im. W. Szafera. Polska Akademia Nauk. Kraków.
Kempf M. Sabor J. 2009.Aktualne wyniki oceny zmienności cech adaptacyjnych jodły pospolitej pochodzeń objętych ochroną na powierzchniach zachowawczych Karpackiego Banku Genów. Sylwan, 153, 10: 651–661.
Kempf M. Sabor J., Stanuch H. 2003.Ocena cech adaptacyjnych i morfologicznych potomstwa drzewostanów jodłowych objętych ochroną w Karpackim Banku Genów. Sylwan, 147, 10: 3–15.
Kempf M., Skrzyszewska K. 2006. Estimation of the genetic structure of silver fir (*Abies alba* Mill.) of selected provenances protected in the Carpathian Gene Bank using terpene markers. Beskydy, 19: 197–204.
Kirisits T., Matlakova M., Mottinger-Kroupa S., Halmschlager E., Lakatos F. 2010. *Chalara fraxinea* associated with dieback of narrow-leafed ash (*Fraxinusangustifolia*). Plant Pathology, 59, 2: 411.
Kocięcki S. 1968. Study on permanent areas with spruce in mature stands. [In:] Population studies of Norway spruce in Poland, 78–99. Instytut Badawczy Leśnictwa. Warszawa.
Kocięcki S. 1977. Zmienność. [In:] Świerk pospolity *Picea abies* (L.) Karst. Nasze drzewa leśne, 37–62. PWN. Warszawa–Poznań.
Kocięcki S. 1987. Badania nad wzrostem i formą modrzewia i przydatnością różnych pochodzeń. (typescript). Instytut Badawczy Leśnictwa. Warszawa.
Kocięcki S. 1990. Wykaz uznanych drzewostanów nasiennych. Dyrekcja Generalna Lasów Państwowych. Instytut Badawczy Leśnictwa. Warszawa.
Kondracki J. 1998. Geografia regionalna Polski. Wydawnictwo Naukowe PWN. Warszawa.
Konstytucja Rzeczypospolitej Polskiej z dnia 2 kwietnia 1997 r. Dz.U., NR 78 poz. 483.
Kontrakt dla Puszczy Białowieskiej,1999. Ministerstwo Ochrony Środowiska, Zasobów Naturalnych i Leśnictwa. Warszawa.
Kosińska J., Lewandowski A., Chałupka W. 2007. Genetic variability of Scots pine maternal populations and their progeny. Silva Fennica, 41: 5–12.
Kossak S. 1995. Liczebność zwierzyny w Puszczy Białowieskiej i proponowane sposoby prowadzenia gospodarki łowieckiej. Sylwan, 139, 8.
Kowalczyk R., Ławreszuk D., Wójcik J.M. 2010. Ochrona żubra w Puszczy Białowieskiej. Zakład Badania Ssaków PAN. Białowieża.
Kowalczyk J., Matras J., Barzdajn W., Korczyk A.F., W., Markiewicz P., Sabor J., Szeligowski H., Żybura H. 2006. Badania porównawcze populacyjnej i rodowej zmienności cech hodowlanych wybranych pochodzeń sosny zwyczajnej (*Pinus sylvestris* L.). Sprawozdanie Naukowe IBL: 1–245.
Kowalkowski W. 2001. Zmienność buka zwyczajnego (*Fagus sylvatica* L.) polskich pochodzeń w 30–letnim doświadczeniu proweniencyjnym. Rozprawy naukowe, zeszyt 318, Roczniki AR Poznań, 95 pages, figs., tables., bibliogr. 84 items.
Kowalkowski W., Rzeźnik Z. 1995. Comparision of 30-year old beech stands (*Fagus sylvatica* L.) of Polish provenances. International Union of Forest Research Organizations,

Ukrainian State University of Forestry and Wood Technology, Lviv, VI IUFRO Beech Symposium, October 1–8. Ukraine.

Kowalski T. 2006.*Chalara fraxinea* sp. nov. associated with dieback of ash (*Fraxinusexcelsior*) in Poland. Forest Pathology, 36, 4: 264–270.

Kowalski T., Holdenrieder O. 2008. Pathogenicity of *Chalara fraxinea*.*Forest Pathology*, 38, 6, 1–7.

Kowalski T., Holdenrieder O. 2009. The teleomorph of *Chalara fraxinea*, the causal agent of ash dieback. Forest Pathology (in press).

Kozioł C. 2007. National Policy on Forests in Poland and forest management in the Carpathians in First Meeting of the Carpathian Convention Working Group on SARD and Forestry 9–10 July 2007, VIC. Vienna. Austria.

Krajowa strategia ochrony i zrównoważonego użytkowania różnorodności biologicznej oraz Program działań na lata 2007–2013, Załącznik do uchwały nr 270/2007 Rady Ministrów z dnia 26.10.2007 r. Warszawa.

Krajowy Program Zwiększania Lesistości. Modyfikacja krajowego programu zwiększania lesistości wykonanej w latach 2000–2002 przez IBL 2003. Ministerstwo Środowiska. Warszawa.

Krajowy Raport Polska (Country Report Poland) 1995. Materiały Międzynarodowej Konferencji i Program Ochrony Zasobów Genowych (International Conference and Programmme for Plant Genetic Resources ICPPGR). Radzików.

Kromb-Kolb H. 2002. Climatic Change and impact Assessment on the European Scale. IUFRO Symposium Forest Research: Challenges and Concepts in a Changing World. BFM – IUFRO. Mariabrunn. Wienn.

Król A. 2011. Miejsce i rola lasów prywatnych w leśnictwie polskim. [In:] Strategia rozwoju lasów i leśnictwa w Polsce do roku 2030. Materiały III Sesji Zimowej Szkoły Leśnej przy IBL, Sękocin Stary, 15–17 March 2011 r., 83-100. Instytut Badawczy Leśnictwa.

Kulej M. 2004. A silvicultural quality of larch (*Larix decidua*) provenances from Poland growing under mountain conditions of the Beskid Sądecki Mts. Beskydy, 17: 81–94.

Kulej M. 2004. Adaptation of larch (*Larix decidua*) of Polish provenances under mountainous conditions of Beskid Sądecki (southern Poland), Journal of Forest Science, 50, 12: 559–565.

Kulej M. 2005. Variation of some morphological characteristics of foliage of grand fir (*Abies grandis* Lindl.) growing under different mountain conditions of Beskid Sądecki. Beskydy, 18: 135–144.

Kulej M. 2006. Adaptation of grand fir (*Abies grandis* Lindl.) of selected provenances under mountain conditions of Beskid Sądecki. Beskydy, 19: 189–196.

Kulej M. 2006. Resistance of larches of Polish provenances to larch crank (*Lachnellula willkommii* Hartig.) Dennis under mountain conditions of the Sącz Beskid. Electronic Journal of Polish Agricultural Universities, http://www.ejpau.media.pl.

Kulej M. 2007. Survival of grand fir (*Abies grandis* Lindl.) of various provenances under mountain conditions of the Beskid Sądecki exemplified area of the Forest Experimental Station in Krynica. Beskydy, 20: 233–242.

Kulej M. 2008. Dynamika wzrostu jodły olbrzymiej (*Abies grandis* Lindl.) różnych pochodzeń w warunkach górskich Beskidu Sądeckiego. Leśne Prace Badawcze, 69, 4: 299–307.

Kulej M. 2010. Wartość genetyczno-hodowlana wybranych pochodzeń jodły olbrzymiej (*Abies grandis* Lindl.) w warunkach Beskidu Sądeckiego, 71, 3: 249–256.

Kulej M., Skrzyszewska K. 1996. Wstępna ocena zmienności szyszek świerka istebniańskiego na przykładzie wybranych drzewostanów nasiennych Nadleśnictwa Wisła. Sylwan, 140, 5: 105–120.

Kulej M., Socha J. 2005. Productivity of selected provenances of grand fir in the provenance experiment in the Krynica experimental forest. Electronic Journal of Polish Agricultural Univesities, http://www.ejpau.media.pl.

Kulej M., Socha, J. 2008. Effect of provenance on the volume increment of grand fir (*Abies grandis* Lindl.) under mountain conditions of Poland. Journal of Forest Science, 54, 1: 1–8.

Kulej M., Socha, J. 2008. Effect of provenance on the volume increment of grand fir (*Abies grandis* Lindl.) under mountain conditions of Poland. Journal of Forest Science, 54, 1: 1–8.

Kutrzeba M. 1979. Drzewostany o niewłaściwym składzie gatunkowym w Puszczy Białowieskiej i propozycje ich przebudowy. Warszawa. Sylwan, 123, 11, 39–44.

Kwiatkowski W. 1994. Krajobrazy roślinne Puszczy Białowieskiej (mapa, skala 1:50000). Phytocoenosis, 6.

Lagercrantz U., Ryman N. 1990.Genetic structure of Norway spruce (*Picea abies*): concordance of morphological and allozymic variation. Evolution, 44: 38–53.

Larsen, A.B. 1996. Genetic structure of populations of beech (*Fagus sylvatica* L.) in Denmark. Scandinavian Journal of Forest Research, 11: 220–232.

Leśne kolejki wąskotorowe w północno-wschodniej Polsce. 1999. RDLP Białystok.

Lewandowski A., Burczyk J., Mejnartowicz L. 1991.Genetic structure and mating system in an old stand of Polish larch. Silvae Genetica, 40: 75–79.

Lewandowski A. 1997. Genetic relationships between European and Siberian larch [*Larix spp.* (*Pinaceae*)], studied by allozyme. Is the Polish larch a hybrid between these two species? Plant Systematics and Evolution, 204: 65–73.

Lewandowski A., Burczyk J., Mejnartowicz L. 1992. Inheritance and linkage of some allozymes in *Taxus baccata* L. Silvae Genetica, 41: 342–347.

Lewandowski A., Burczyk J., Mejnartowicz L. 1995.Genetic structure of English yew (*Taxus baccata* L.) in the Wierzchlas reserve: implications for genetic conservation. Forest Ecology and Management, 73: 221–227.

Lewandowski A., Burczyk J. 2002. Allozyme variation of *Picea abies* in Poland. Scandinavian Journal of Forest Research, 17: 487–494.

Lewandowski A., Filipiak M., Burczyk J. 2001. Genetic variation of *Abies alba* Mill. In Polish part of Sudety Mts. Acta Societatis Botanicorum Poloniae, 70: 215–219.

Lewandowski A., Mejnartowicz L. 1990. Inheritance of allozymes in *Larix decidua* Mill. Silvae Genetica, 39: 184–188.

Longauer R. 1994. Genetic differentiation and diversity of European silver fir in east part of its natural range. 7. IUFRO – Tannensymposium, Altensteig, 155–163.

Luksiene R. 2011.DNA polymorphism of European ash (*Fraxinus excelsior* L.) and the influence of ecological conditions *in vitro* on morphogenesis in isolated embryo culture. Doctoral thesis.Institute of Forestry. Lithuanian Research Centre for Agriculture and Forestry. Kowno. 2011.

Maćkowiak-Pandera J. 2011. Główne założenia aktualnych strategii rozwoju kraju. [In:] Strategia rozwoju lasów i leśnictwa w Polsce do roku 2030. Materiały III Sesji Zimowej Szkoły Leśnej przy IBL, Sękocin Stary, 15–17 March 2011 r., 13–17. Instytut Badawczy Leśnictwa.

Mały Rocznik Statystyczny Polski. 2011. Główny Urząd Statystyczny. Warszawa.

Mańka K. 2005. Fitopatologia Leśna. Wydanie VI zmienione i poprawione. PWRiL. Warszawa.

Marquardt P.E., Epperson B.K. 2004. Spatial and population genetic structure of microsatellites in white pine. Molecular Ecology, 13: 3305–3315.

Masternak K., Sabor J., Majerczyk K. 2009. Effect of provenance on the survival of *Picea abies* trees on the IPTNS-IUFRO 1964–68 site in Krynica (Poland). Dendrobiology, 61 (suppl.), 53–61.

Masternak K., Zielińska M., Sabor J. 2011. Polimorfizm izoenzymów i wzrost wybranych pochodzeń świerka pospolitego [*Picea abies* (L.) Karst] doświadczenia IPTNS-IUFRO 1964/68 w Krynicy. Prace Badawcze, 72, 1: 65–75.

Matras J. 1989. Zmienność sosny pospolitej i hodowlana wartość jej proweniencji. Sprawozdanie Naukowe. Warszawa.

Matras J. 1997.Wstępne wytyczne wykorzystania populacji świerka pospolitego na skalę gospodarczą. Dyrekcja Generalna Lasów Państwowych, Instytut Badawczy Leśnictwa. Warszawa.

Matras J. 1991. Rejestr drzew doborowych, plantacji i plantacyjnych upraw nasiennych. DGLP, Instytut Badaczy Leśnictwa. Warszawa.

Matras J. 1996. Rejestr bazy nasiennej w Polsce. DGLP, IBL, Warszawa.

Matras J. 2006. Wytyczne wykorzystania populacji świerka pospolitego na skale gospodarczą, 1–37 Instytut Badawczy Leśnictwa, Dyrekcja Generalna Lasów Państwowych.

Matras J. 2006. Badania porównawcze populacyjnej i rodowej zmienności cech hodowlanych wybranych pochodzeń świerka pospolitego (*Picea abies* Karst.). Instytut Badawczy Leśnictwa.

Matras J. 2006. Zmienność wewnątrzgatunkowa świerka w doświadczeniu IUFRO 1972 [In:]

Elementy genetyki i hodowli selekcyjnej drzew leśnych. Joint publication edited by J. Sabora, 159–170.

Matras J., Kowalczyk J. 1998. Świerk sudecki w badaniach IBL. Zeszyty Leśnego Banku Genów Kostrzyca. Zeszyt II, t. 1, 91–108.

Matras J., Barzdajn W., Chałupka R., Sabor J., Tarasiuk S., Szyp-Borowska I., Markiewicz P. 2005. Populacyjna zmienność buka pospolitego (*Fagus sylvatica* L.) w Polsce (wzrost i rozwój populacji w okresie młodnika). Sprawozdanie Naukowe IBL, 1–245.

Matuszkiewicz A.J. 2001. Zespoły Leśne Polski. PWN. Warszawa.

Matuszkiewicz A.J. 2009. Potential natural vegetation and geobotanical regionalisation of Poland (Potencjalna roślinność naturalna i geobotaniczna regionalizacja Polski). Uniwersytet Kazimierza Wielkiego. Bydgoszcz. Poland.

Matuszkiewicz A.J. 2008. Potential natural vegetation of Poland (Potencjalna roślinność naturalna Polski). IGiPZ PAN, Warszawa.

Matuszkiewicz W. 1952. Zespoły leśne Białowieskiego Parku Narodowego. Ann. Univ. MCS. Sec. C. Suppl. 6.

Mejnartowicz L. 1976. Genetic investigations on Douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco.] populations.Arboretum Kórnickie,21: 125–187.

Mejnartowicz L. 1979.Polymorphism at the LAP and GOT loci of *Abies alba* Mill. Populations. Bulletin de l'Académie Polonaise des Sciences. Biologiques, 27: 1063–1070.

Mejnartowicz L. 1983. Changes in genetic structure of Scots pine (*Pinus sylvestris* L.) population affected by industrial emission of fluoride and sulphur dioxide. Genetica Polonica, 24, 1: 41–50.

Mejnartowicz L. 2003. Genetic analysis of silverfir populations in the Beskides. Acta Societatis Botanicorum Poloniae, 72, 2: 115–119.

Mejnartowicz L. 2004. Genetic Analysis of Silver-fir Populations in the North Carpathian and Sudeten Mountains. Acta Societatis Botanicorum Poloniae, 73, 4: 285–292.

Mejnartowicz L. 2004. Genetic analysis of silver-fir populations in the north Carpathian and Sudeten mountains. Acta Societatis Botanicorum Poloniae, 73: 285–292.

Mejnartowicz L. 2004. Genetic Analysis of Silverfir Populations in the North Carpathian and Sudeten Mountains. Acta Societatis Botanicorum Poloniae, 73, 4: 285–292.

Mejnartowicz L., Bergmann F. 1985. Genetic differentiation among Scots pine populations from the lowlands and the mountains in Poland. Lecture Notes in Biomathematics, 60: 242–252. Springer Verlag Berlin N.Y. Tokyo.

Mejnartowicz L., Lewandowski A. 1994. Allozyme polymorphism in seeds collected from a IUFRO-68 Douglas-fir test-plantation. Silvae Genetica, 43, 4: 181–186.

Mirek Z., Zarzycki K., Wojewoda W., Szeląg Z. 2006.Red list of plants and fungi in Poland Czerwona lista roślin i grzybów Polski. Instytut Botaniki im. W. Szafera, Polska Akademia Nauk. Kraków.

Misiorny A. 2007. Występowanie obupłciowych kwiatów na świerku pospolitym. Sylwan, 151, 7.

Misiorny A., Chałupka W. 2006. Flowering and cone bearing of *Picea abies* grafts in second-generation seed orchards. Dendrobiology, 56: 51–59.

Müller-Starck G., Ziehe M. 1991.Genetic variation in populations of *Fagus sylvatica* L., *Quercus robur* L. and *Q. petraea* Liebl. in Germany. In: Müller-Starck, G. and Ziehe, M. (eds) Genetic Variation in European Populations of Forest Trees, 125–140. Sauerländer's Verlag. Frankfurt am Main.

Michalski J., Starzyk J.R., Kolk A., Grodzki W. 2004. Zagrożenie świerka przez kornika drukarza [*Ips typographus* (L.)] w drzewostanach Leśnego Kompleksu Promocyjnego „Puszcza Białowieska" w latach 2000–2002. Leśne Prace Badawcze, 3: 5–30.

Niedzielska B., Sabor J. 1990. Zróżnicowanie wybranych właściwości drewna sosny zwyczajnej z powierzchni proweniencyjnej w Polanach k. Grybowa. Acta Agraria et Silvestria, ser. Silvestris, 29: 75–82.

Niemczyk M. 2006.Struktura genetyczna jodły pospolitej (*Abies alba* Mill.) w Karkonoskim Parku Narodowym oraz wzrost szczepów jodły w klonowych archiwach genetycznych. Doctoral thesis in the Katedra Hodowli Lasu Akademii Rolniczej w Poznaniu.

Nowakowska J. 2004. Zmienność genetyczna świerka pospolitego w Polsce na podstawie markerów RAPD. Notatnik Naukowy IBL, 7, 67, 1–8.

Nowakowska J. 2004. Badanie zróżnicowania genetycznego u sosny zwyczajnej za pomocą markerów genetycznych (RAPD). Notatnik Naukowy IBL, 4, 64/2004(XII), 4 pages.

Nowakowska J. 2004. Genetic variation in Scots pine (*Pinus sylvestris* L.) populations at regional level revealed by random amplified polymorphic DNA analysis. Miškininkystė, 2, 56: 13-20.

Nowakowska J. 2004. Zmienność genetyczna świerka pospolitego w Polsce na podstawie markerów RAPD. Notatnik Naukowy IBL, 7, 67/2004(XII), 4 pages.

Nowakowska J. 2005. Microsatellite sequences in Scots pine as a new tool in forest-tree genetics. [In:] Analysis of microsatellite sequences in Scots pine. ed. J. Nowakowska, 9–24, FRI, PROFOREST Centre of Excellence.Warsaw.

Nowakowska J. 2007.Czy istnieją różnice między świerkiem pospolitym z północnego i południowego zasięgu występowania w Polsce na podstawie analiz DNA? Notatnik Naukowy IBL, 2, 76/2007(XV), 4 pages.

Nowakowska J. 2007.Zmienność genetyczna polskich wybranych populacji sosny zwyczajnej (*Pinus sylvestris* L.) na podstawie analiz polimorfizmu DNA. Habilitation thesis, Instytut Badawczy Leśnictwa. Warszawa.

Nowakowska J.A. 2010.Zmienność genetyczna sosny zwyczajnej i świerka pospolitego na podstawie markerów DNA jądrowego i mitochondrialnego. [In:] Postęp badań w zakresie genetyki populacyjnej i biochemicznej drzew leśnych. Polska Akademia Umiejętności, Prace Komisji Nauk Rolniczych, leśnych i weterynaryjnych PAN, 13: 37–53.

Nowakowska J., Szczygieł K., Szyp-Borowska I., Bieniek J. 2005.Populacyjna zmienność oraz identyfikacja wybranych pochodzeń sosny zwyczajnej i świerka pospolitego na podstawie analiz DNA. Grant DGLP BLP-219, 1.01.2001–31.12.2005. Dokumentacja naukowa Instytutu Badawczego Leśnictwa. 112 pages. Warszawa.

Nowakowska J., Bieniek J., Jabłonowski S. 2006. RAPD polymorphism of Norway spruce (*Picea bies* (L.) Karst.) populations in Poland. Folia Forestalia Polonica, 48: 27–44.

Nowakowska J.A. 2009. Mitochondrial and nuclear DNA differentiation of Norway spruce (*Picea abies* (L.) Karst.) populations in Poland. Dendrobiology, 61: 119–129.

Nowakowska J.A. 2010.Zmienność genetyczna sosny zwyczajnej i świerka pospolitego na podstawie markerów DNA jądrowego i mitochondrialnego. [In:] Postęp badań w zakresie genetyki populacyjnej i biochemicznej drzew leśnych. Polska Akademia Umiejętności. Prace Komisji Nauk Rolniczych, leśnych i weterynaryjnych PAN, 13: 37––53.

Nowakowska J., Jabłonowski S., Mockeliūnaitė R., Bieniek J. 2004.Comparison of genetic variability within and among Polish and Lithuanian populations of European ash (*Fraxinus excelsior* L.) based on RAPD analysis. Baltic Forestry, 10, 1: 57–64.

Nowakowska J.A., Oszako T., Bieniek J., Rakowski K. 2007.Charakterystyka genetyczna PCR-RFLP oraz ocena zdrowotności wybranych populacji dębu elbląskiego i krotoszyńskiego. Leśne Prace Badawcze, 3: 33–51.

OECD scheme for the control of forest reproductive material moving in international trade. 2001. Organization for Economic Cooperation and Development, 1–28. Paris 1974 (including 2001 amendment).

Ogris N., Hauptman T., Jurc D., Floreancig V., Marsich F., Montecchio L. 2010. First report of *Chalara fraxinea* on European ash in Italy. Plant Disease, 94, 1: 133.

Oleksyn J., Reich P.B., Chałupka W., Tjoelker M.G. 1999. Differential above- and below-ground biomass accumulation of European *Pinus sylvestris* populations in a 12-year-old provenance experiment. Scandinavian Journalof Forest Research, 14, 1: 7–17.

Oleksyn J., Reich P.B., Tjoelker M.G., Chałupka W. 2001. Biogeographic differences in shoot elongation pattern among European Scots pine populations. Forest Ecology and Management, 148: 207–220.

Oleksyn J., Reich P.B., Tjoelker M.G., Vaganov E.A., Modrzyński J. 2006. Interannual growth response of Norway spruce to climate along an altitudinal gradient in the Tatra Mountains, Poland. Trees, 20: 735–746.

Orzeł S., Kulej M. 1999. Bark thickness of larches of various Polish provenances in an experimental area of the Forest Experimental Station in Krynica. Folia Forestalia Polonica, Ser. A – Forestry, 41: 25–35.

Pierzgalski E. (ed.) 2000. Stosunki hydrologiczne Puszczy Białowieskiej. Instytut Badawczy Leśnictwa.

Plany urządzenia lasu Nadleśnictw Białowieża 2001.Browsk, Hajnówka for the period 01.01.2002–31.12.2011. (typescript). Białystok.

Paczoski J. 1930. Lasy Białowieży. Nakładem Państwowej Rady Ochrony Przyrody w Krakowie. Lubicz 45. Skład Główny w Księgarni Kasy im. Mianowskiego w Warszawie. Pałac Staszica. Poznań.

Parzych S. 2007. Produkcyjne funkcje lasów jako ważny element określający pozycję leśnictwa w gospodarce narodowej. [In:] Quo vadis, forestry? Sierota Z. (ed.) Materiały Międzynarodowej Konferencji, Sękocin Stary, 29–30 June 2006 r., Poland. Sękocin Stary, 149–153.

Pigan M. 2011. Kamienie węgielne strategii PGL Lasy Państwowe. [In:] Strategia rozwoju lasów i leśnictwa w Polsce do roku 2030. Materiały III Sesji Zimowej Szkoły Leśnej przy IBL, Sękocin Stary, 15–17 March 2011 r., 29–42. Instytut Badawczy Leśnictwa.

Pigan M., Błasiak J. 2010. Problemy ochrony przyrody w Lasach Państwowych. In: Problemy ochrony przyrody w lasach. Materiały II Sesji Zimowej Szkoły Leśnej przy IBL, Sękocin Stary, 16-19 March 2010 r., 24–26. Instytut Badawczy Leśnictwa.

Płotkowski L. 1998. Las jako majątek, miejsce pracy i źródło utrzymania. Sylwan, 3: 41––55.

Płotkowski L. 1999.Ekonomiczne aspekty gospodarki leśnej – stan i perspektywy. [In:] Publiczne funkcje lasów, 34–44. PTL. Gdańsk.

Podstawy strategii zarządzania Puszczą Białowieską. 2001. Joint publications: Członkowie GR Projektu DANCEE Puszcza Białowieska. Białowieża.

Polak-Berecka M. 1999. Określenie zmienności genetycznej drzew doborowych wybranych proweniencji świerka pospolitego [*Picea abies* (L.) Karst.] z terenu Karpat metodą markerów izoenzymowych. Zeszyty Naukowe Akademii Rolniczej w Krakowie, 362, ser. Leśnictwo, 28: 51–67.

Polak-Berecka M. 2003. Struktura genetyczna wybranych populacji świerka pospolitego z terenu Karpat określona metodą markerów izoenzymowych. Zeszyty Naukowe Akademii Rolniczej w Krakowie, 398, ser. Sesja Naukowa, 88: 99–106.

Polak-Berecka M., Perchlicka I. 2007. Polimorfizm izoenzymowy i zmienność genetyczna wybranych populacji cząstkowych świerka rasy istebniańskiej. Sylwan, 15, 1, 10: 47–53.

Polityka ekologiczna Państwa w latach 2009-2012 z perspektywą do roku 2016. 2008. Ministerstwo Ochrony Środowiska. Warszawa.

Polityka Leśna Państwa. 1997. Ministerstwo Ochrony Środowiska, Zasobów Naturalnych i Leśnictwa, Warszawa.

Postępowanie z drzewostanami „przejściowymi" w nadleśnictwach Leśnego Kompleksu Promocyjnego – Lasy Puszcza Białowieska 2000. Materials from a Conference. (typescirpt). Białowieża.

Program ochrony i restytucji cisa pospolitego (*Taxus baccata* L.) na terenie Polski. 2006. Dyrekcja Generalna Lasów Państwowych. Warszawa.

Program zachowania leśnych zasobów genowych i hodowli selekcyjnej drzew w Polsce na lata 2011-2035.2009. Dyrekcja Generalna Lasów Państwowych. Warszawa.

Program zarządzania ochroną obszaru specjalnej ochrony ptaków i specjalnego obszaru ochrony siedlisk Natura 2000 „Puszcza Białowieska" PLC 200004 2004. Joint publications.(typescript). Białowieża,.

Prus-Głowacki W., Bielewicz A., Modrzyński J. 2007. Struktura genetyczna populacji świerka (*Picea abies*) z dolnego i górnego regla Karpat i Sudetów. Zeszyty Naukowe Akademii Rolniczej w Krakowie. Sesja Naukowa 439, zeszyt 92. Ochrona i zachowanie leśnej bioróżnorodności w Karpackim Banku Genów. Rola świerka pospolitego i innych gatunków w zachowaniu ekosystemów leśnych Karpat, 29–41.

Przybylski T. *et al.* 1998. Ekspertyza „Zasady ochrony starych drzew z uwzględnieniem ciągłości pokoleń na terenie Leśnego Kompleksu Promocyjnego Puszcza Białowieska", Instytut Dendrologii PAN, Kórnik. (typescript).

Przybył K. 2002. Przyczyny zamierania drzew i drzewostanów jesionowych w Polsce. Projekt badawczy zlecony przez DGLP, Instytut Dendrologii PAN w Kórniku.

Przyczyny i ocena zagrożenia drzewostanów Puszczy Białowieskiej przez kornika drukarza w latach 2000–2001.2001. Materials from a seminar. (typescript). Białowieża.

Pugacewicz E. 1997. Ptaki lęgowe Puszczy Białowieskiej. PTOP. Białowieża.

Pugacewicz E. 2002. Stan populacji dzięcioła białogrzbietego *Dendrocopos leucotos* na Nizinie Północnopodlaskiej w latach 1984–2000. Chrońmy Przyrodę Ojczystą, 58, 1: 5–24.

Pugacewicz E. 2009. Wynik inwentaryzacji ptaków z Dyrektywy Ptasiej gniazdujących na polanach i w dolinach rzecznych Puszczy Białowieskiej w 2008 roku. Dubelt. Zeszyt I. Hajnówka.

Pugacewicz E. 2010. Zmiany liczebności szponiastych Falconiformes w Puszczy Białowieskiej między latami 1985–1994 i 2004–2008. Dubelt Zeszyt II, Hajnówka.

Queloz V., Grünig CR., Berndt R., Kowalski T., Sieber T.N., Holdenrieder O. 2011. Cryptic speciation in *Hymenoscyphus albidus.* Forest Pathology, 41, 2: 85–168.

Radecki W. 2005. Formy własności leśnej a problemy realizacji i finansowania publicznych funkcji lasu. Aura 2: 14–16.

Rakowski K., Kowalczyk J., Matras J., Nowakowska J., Załęski A. 2005.Weryfikacja zasobów genetycznych wybranych gatunków drzew leśnych i kategorii baz nasiennych w związku z wdrożeniem przepisów ustawy o leśnym materiale rozmnożeniowym ze szczególnym uwzględnieniem przynależności leśnego materiału podstawowego (LMP) do regionów pochodzenia. Projekt zespołowy: grant NFOŚiGW 12-U-31. Okres realizacji: 3.12.2003–20.11.2005. Dokumentacja naukowa Instytutu Badawczego Leśnictwa. Warszawa. 112 pages.

Raport o stanie lasów w Polsce 2010. 2011. Centrum Informacyjne Lasów Państwowych. Warszawa.

Referowska-Chodak E. 2010. Skala i intensywność ochrony przyrody w lasach. [In:] Problemy ochrony przyrody w lasach. Materiały II Sesji Zimowej Szkoły Leśnej przy IBL, Sękocin Stary, 16–19 marca 2010 r., 291–313. Instytut Badawczy Leśnictwa.

Reich, P.B., Oleksyn, J. 2008. Climate warming will reduce growth and survival of Scots pine except in the far north. Ecology Letters 11: 588–597.

Rezerwaty Biosfery w Polsce. 2009. Joint publ. (Ed. A. Breymeyer) Komitet Narodowy UNESCO-MAB przy Prezydium PAN, Warszawa, typescript.

Rocznik statystyczny Rzeczypospolitej Polskiej 2010. Główny Urząd Statystyczny. Warszawa.

Rozporządzenie Ministra Środowiska z dnia 3 marca 2008 r. w sprawie poziomów niektórych substancji w powietrzu. Dz.U. 47, Poz. 281 nr 2777.

Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 28 listopada 2007 r. w sprawie szczegółowych sposobów postępowania przy zwalczaniu i zapobieganiu rozprzestrzeniania się organizmu Gibberella circinata Nirenberg & O'Donnell. Dz.U. z dnia 14 grudnia 2007 r. Nr 233, poz. 1715.

Rozporządzenie Ministra Środowiska z dnia 9 września 2011 r. w sprawie listy roślin i zwierząt gatunków obcych, które w przypadku uwolnienia do środowiska przyrodniczego mogą zagrozić gatunkom rodzimym lub siedliskom przyrodniczym. Dz.U. z 2011 nr 210, poz. 1260.

Rozporządzenie Ministra Środowiska z dnia 9 lipca 2004 r. w sprawie gatunków dziko występujących grzybów objętych ochroną. Dz.U. z dnia 28 lipca 2004 nr 168, poz. 1764.

Rożkowski R. 1999. Analiza wyników 35-letniego doświadczenia proweniencyjnego z sosną zwyczajną (*Pinus sylvestris* L.). Arboretum Kórnickie, 44: 73–86.

Rożkowski R. 2000. Proweniencje modrzewia dla Polski. Sylwan, 1: 87–107.

Rożkowski R., Giertych M., Maj-Lewandowska A. 2001.A 23-year old spruce [*Picea abies* (L.) Karst] provenance trial of the IUFRO-1972 series in Kórnik. Folia Forestalia Polonica, ser. A , 43: 34–52.

Rożkowski R. 2004. Breeding value of Norway spruce (*Picea abies* (L.) Karst.) from the Kłodzko Forest District (SW Poland). Journal of Forest Science, 50, 1: 17–23.

Rożkowski R., Chałupka W., Misiorny A., Giertych M. 2007.Early evaluation of open pollinated offspring from Polish seedling seed orchards of *Pinus sylvestris* L. Dendrobiology, 57: 35–48.

Rudawska M., Leski T., Trocha L.K., Gornowicz R. 2006.Ectomycorrhizal status of Norway spruce seedlings from bare-root forest nurseries. Forest Ecology and Management, 236: 375–384.

Rzeźnik Z. 1972. Studies on Scotch Pine provenances and the results obtained in the Siemianice experimental area. (Badania nad proweniencją sosny zwyczajnej oraz dotychczasowe wyniki na powierzchni badawczej w Siemianicach). IUFRO, Division

2, Working Party, S 2.03.5., Symposium on Genetics of Scotch Pine, October 8–18, Warszawa- Kórnik. figs. tables.

Rzeźnik Z. 1976. Badania buka zwyczajnego (*Fagus silvatica* L.) polskich proweniencji. Roczniki Akademii Rolniczej w Poznaniu, z.72, 1–37, figs. tables. bibliogr. 60 items, summary, conclusions.

Rzeźnik Z. 1988. Miąższość i jakość 20-letnich drzewostanów bukowych krajowych proweniencji. Sylwan, 132, 8, 9–20, figs. tables. bibliogr. 17 items, conclusions, summary.

Rzeźnik Z. 1988. Ergebnisse der 20-jährigen Rotbuchenprovenienzuntersuchungen in Polen. 3IUFRO-Buchensymposium zusammengestelt von S. Korpel – L. Paule, Zvolen, 3–6.06.1988, figs. bibliogr. 10 items.

Rzeźnik Z. 1993. Studies on the progenies of red beech (*Fagus sylvatica* L.) of different provenances in Poland, The Scientific Basis for the Evaluation of Forest Genetic Resources of Beech, H.J. Muhs and G. von Wuehlisch (eds.) Proceedings of an EC Workshop, Ahrensburg 1993, Working document of the EC, DG, VI, Brussels, 217––227. bibliogr. 11 items.

Rzeźnik Z. 1995. Larch (*Larix decidua* Mill.) of Polish Provenances on Experimental Areas in Poland, Paper submitted for publication in the proceedings of the Symposium on Ecology and Management of Larix Forests: A Look Ahead, Whitefish, MT, USA. October 5–9 1992, United States Department of Agriculture Forest Service, Intermountain Research Station, May 1995, 438–446, figs. tables. bibliogr. 9 items.

Rzeźnik Z., Handl H. 1977. Niektóre cechy sosny zwyczajnej (*Pinus sylvestris* L.) różnych krajowych pochodzeń. Prace Komisji Nauk Rolniczych i Komisji Nauk Leśnych PTPN, vol.44, 149–155, tables. bibliogr. 17 items, summary.

Rzeźnik Z. 1978. Sosnowe powierzchnie porównawcze proweniencji krajowych w LZD Murowana Goślina i Siemianice. Sympozjum pt. Stan prac nad proweniencjami sosny, świerka i modrzewia w Polsce oraz perspektywy badań populacyjnych tych gatunków. Kórnik, 5–6 June 1978, 3.

Rzeźnik Z. 1980. Zmiany w jakości drzew sosny zwyczajnej po cięciu pielęgnacyjnym na powierzchni proweniencyjnej w LZD Siemianice. Roczniki Akademii Rolniczej w Poznaniu, vol.123, 141-152, tables. bibliogr. 13 items, summary, conclusions.

Rzeźnik Z. 1981. Porównanie wielkości aparatu asymilacyjnego u drzew sosny zwyczajnej (*Pinus sylvestris* L.) krajowych proweniencji na uprawie w Leśnym Zakładzie Doświadczalnym Siemianice. Roczniki Akademii Rolniczej w Poznaniu, vol. 132, 145––151, tables. bibliogr. 13 items, summary. conclusions.

Sabor J. 1991. Wstępna ocena biochemicznego polimorfizmu polskich pochodzeń sosny zwyczajnej na podstawie analizy zawartości monoterpenów w korze drzew. Sylwan, 135, 10: 37–42.

Sabor J. 1993. Conditions of oak selection in Poland. Annales des Sciences Forestieres, 50, 452–455.

Sabor J. 1995. Zasady selekcji drzew i drzewostanów w terenach górskich. Prace IBL ser. A.783, 5–28.

Sabor J. 1996. Możliwości zachowania i metody selekcji drzewostanów świerkowych rasy istebniańskiej. Sylwan, 3, 61–81.

Sabor J. 1997. Ocena zróżnicowania genetycznego świerka rasy istebniańskiej pochodzeń Inwentaryzacyjnego Doświadczenia Proweniencyjnego Świerka Pospolitego IPTNS--IUFRO 1964/68 markerami terpenowymi. [In]: Zachowanie leśnych zasobów genowych i hodowla selekcyjna świerka pospolitego w Nadleśnictwie Wisła. (typescript). RDLP Katowice. Zakład Nasiennictwa, Szkółkarstwa i Selekcji Drzew Leśnych Akademii Rolniczej w Krakowie.

Sabor J. 1998a. Charakterystyka świerka bieszczadzkiego w doświadczeniu IPTNS-IUFRO 1964–1968. Sylwan, 10, 77–87.

Sabor J. 1998b. Świerk pochodzeń sudeckich w doświadczeniu proweniencyjnym serii IUFRO 1964–1968 w LZD Krynica. Zeszyty Leśnego Banku Genów Kostrzyca. Z. 11, 11, 60–75.

Sabor J. 1998c. Ocena wartości genetycznej świerka rasy istebniańskiej. cechy adaptacyjne potomstwa drzewostanów nasiennych i drzew doborowych „Regionalnego banku genów RDLP Katowice". Rok 1998. [In:] Zachowanie leśnych zasobów genowych i hodowla selekcyjna świerka pospolitego w Nadleśnictwie Wisła. Opracowanie na zlecenie RDLP w Katowicach. (typescript). Zakład Nasiennictwa, Szkółkarstwa i Selekcji Drzew Leśnych Akademii Rolniczej w Krakowie.

Sabor J. 1999. Aktualny stan badań nad zmiennością genetyczną polskich ras świerka pospolitego. [In:] Materiały z konferencji: Genetyczna i hodowlana wartość polskich populacji świerka z zasięgu północno-wschodniego, 5–38.

Sabor J. 2000. Wartość genetyczna buka karpackiego. Zeszyty Naukowe Akademii Rolniczej w Krakowie, 358, ser. Sesja Naukowa, 69: 139–152.

Sabor J. 2002. Doświadczenie proweniencyjne modrzewia w Kolanowie pod Bochnią. Zeszyty Naukowe Akademii Rolniczej w Krakowie, 394, ser. Sesja Naukowa, 86: 399––406.

Sabor J. 2004. Potential for genetic conversion of Norway spruce (*Picea abies* (L.) Karst.) stands and methods for preserving gene resources of Istebna race in Silesian Beskid Mts. Dendrobiology, 51 (suppl): 91–93.

Sabor J. 2009. Research on the variability of *Picea abies* in Poland: genetic and breeding value of spruce populations in the Polish range of the species. Dendrobiology, 61 (suppl.): 7––13.

Sabor J., Bałut S., Skrzyszewska K., Kulej M., Baran S., Banach J., 1996. Ocena zróżnicowania i wartości hodowlanej polskich pochodzeń jodły pospolitej w ramach Ogólnopolskiego Doświadczenia Proweniencyjnego Jd PL 1986–1990. Zeszyty Naukowe Akademii Rolniczej w Krakowie. Leśnictwo. Zeszyt 24. Kraków.

Sabor J., Chwistek K. 1993. Miąższość drzew i zasobność sosny zwyczajnej różnych pochodzeń na powierzchni doświadczalnej w Polanach k. Grybowa. Acta Agraria et Silvestria, ser. Silvestris, 31: 31–38.

Sabor J., Janeczko Z. 2007. Czy świerk Istebniański jest świerkiem rodzimym? Cienkowarstwowa analiza porównawcza wybranych fenoli świerka pospolitego (*Picea excelsa*), pochodzenia polskiego i alpejskiego. Materials from the conference:Rola i znaczenie ektomikoryz dla optymalnego wzrostu i rozwoju drzew leśnych – 10 lat realizacji programu wdrożenia polskiej technologii mikoryzacji sadzonek drzew leśnych w Lasach Państwowych.

Sabor J., Janeczko J. 2007. Wpływ genotypu na efekt wzrostowy mikoryzowanych jednolatek świerka – markery fenolowe. [In:] Ektomikoryzy. Nowe biotechnologie w polskim szkółkarstwie leśnym. ed. S. Kowalski, 176–187 CILP. Warszawa.
Sabor J., Janeczko J. 2009. Ocena metabolizmu związków fenolowych u sadzonek mikoryzowanych i niemikoryzowanych świerka pospolitego pochodzeń istebniańskich. Sylwan, 153, 2: 125–133.
Sabor J., Kulej M. 1997. Zagospodarowanie selekcyjne oraz wartość hodowlana populacji świerka orawskiego. Sylwan, 5, 75–84.
Sabor J., Skrzyszewska K. 2002. Rola genetycznych markerów terpenowych w selekcji i taksonomii drzew. II. Studia struktury genetycznej populacji drzew leśnych. Sylwan, 146, 8: 49–60.
Sabor J., Skrzyszewska K. 2002. Rola genetycznych markerów terpenowych w selekcji i taksonomii drzew. I. Chemizm i synteza. Zakres zastosowań. Sylwan, 146, 8: 41–48.
Sabor J., Skrzyszewska K. 2002. Rola genetycznych markerów terpenowych w selekcji i taksonomii drzew. II. Studia struktury genetycznej populacji drzew leśnych. Sylwan, 146, 8: 49–60.
Sabor J., Stachnik E. 1990. Przeżywalność i wzrost różnych pochodzeń sosny pospolitej w warunkach siedliskowych Beskidu Sądeckiego na przykładzie powierzchni porównawczej w Polanach k. Grybowa. Sylwan, 134, 1: 11–26.
Sabor J., Stanuch H. 2007. Ocena zmienności cech adaptacyjnych oraz określenie wartości genetyczno-hodowlanej pochodzeń objętych ochroną w Regionalnym Banku Genów buka zwyczajnego RDLP w Katowicach. Sylwan, 160, 10: 25–37.
Sabor J., Stanuch H. 2009. Assessment of the height growth of *Picea abies* as related to the geographical regions of Krutzsch (IPTNS-IUFRO 1964–1968, years 1969–1988). Dendrobiology, 61 (suppl.): 39–52.
Sabor J., Stanuch H. 2009. Genetyczna reaktywność buka zwyczajnego na warunki glebowe. Sylwan, 153, 8: 507–518.
Sabor J., Żuchowska J. 2002. Wstępne wyniki badań nad proweniencyjną zmiennością buka zwyczajnego (*Fagus sylvatica* L.) na powierzchni porównawczej doświadczenia serii GC 2234 1992–1995 w Krynicy. Sylwan, 146, 2: 43–72.
Samojlik T. 2005. Ochrona i Łowy Puszcza Białowieska w czasach królewskich. Zakład Badania Ssaków PAN Białowieża.
Schumacher J., Wulf A., Leonhard S. 2007. [First record of *Chalara fraxinea* T. Kowalski sp. nov. in Germany: a new agent of ash decline.] *Nachrichtenblatt des Deutschen Pflanzenchutzdienstes*, 59, 6: 121–123.
Shutyaev A.M., Giertych M. 2000. Genetic subdivisions of the range of Scots pine (*Pinus sylvestris* L.) based on a transcontinental provenance experiment. Silvae Genetica, 49, 3: 137–151.
Shutyayev A.M., Giertych M. 2003. Scots pine (*Pinus sylvestris* L.) in Eurasia – map album of provenance site interaction, 266. Institute of Dendrology. Kórnik.
Sierota Z. 2001. Choroby lasu. Centrum Informacyjne Lasów Państwowych. Warszawa.
Skrzyszewska K. 1999. Ocena struktury genetycznej jodły pospolitej markerami monoterpenowymi na powierzchni porównawczej Jd PL 1986–1990 w Nadleśnictwie Baligród. Zeszyty Naukowe Akademii Rolniczej w Krakowie, 339, ser. Sesja Naukowa, 61: 67––86.

Skrzyszewska K. 2002. Możliwości oceny struktury genetycznej jodły pospolitej markerami monoterpenowymi. Sylwan, 146, 5: 23–31.

Skrzyszewska K. 2002. Wstępna ocena wartości genetycznej bazy nasiennej jesionu wyniosłego, klonu jaworu i lip w Krainie Karpackiej. Zeszyty Naukowe Akademii Rolniczej w Krakowie, 394, ser. Sesja Naukowa, 86: 117–129.

Skrzyszewska K. 2002. Wartość genetyczno-hodowlana jodły w wieku 15 lat określona na podstawie oceny indeksowej. Raport do tematu 7/00. (typescript). Katedra Nasiennictwa, Szkółkarstwa i Selekcji Drzew Leśnych. Wydział Leśny. Kraków.

Skrzyszewska K. 2003. Zmienność jodły pospolitej (*Abies alba* Mill.) w doświadczeniu proweniencyjnym Jd PL 86/90. Zeszyty Naukowe Akademii Rolniczej w Krakowie, 398, ser. Sesja Naukowa, 88: 121–128.

Skrzyszewska K. 2004. Wartość genetyczno-hodowlana jodły pospolitej dla XIV regionów pochodzeniowych w polskim zasięgu występowania gatunku określona na podstawie doświadczenia JdPL 1986–1990. Raport do tematu 7/00 za okres badawczy 2000–2004. (Typescript). Katedra Nasiennictwa, szkółkarstwa i Selekcji Drzew Leśnych. Wydział Leśny. Kraków.

Skrzyszewska K. 2007. Genetic structure of silver fir (*Abies alba* Mill.) in Beskid Sądecki. Beskydy, 20: 243–250.

Skrzyszewska K., Chłanda J. 2009. A study on the variation of morphological characteristics of silver fir (*Abies alba* Mill.) seeds and their internal structure determined by X-ray radiography in the Beskid Sądecki and Beskid Niski mountain ranges of the Carpathians (southern Poland). Journal of Forest Science, 55: 403–414.

Skrzyszewska K., Sabor J. 2007. The genetic value of Polish Carpathian provenances of silver fir (*Abies alba* Mill.) in the experiment Jd PL 1986–1990. Beskydy, 20: 251–258.

Skrzyszewski J., Skrzyszewska K. 2004. Species conversion of spruce stands in the Wisła Forest District. Dendrobiology, 51 (suppl): 95–99.

Socha J., Kulej M. 2005. Provenance-dependent viability of *Abies grandis* stem form under mountain conditions of Beskid Sądecki (southern Poland). Canadian Journal of Forest Research, 35: 253–259.

Socha J., Kulej M. 2007. Variation of the tree form factor and taper in European larch of Polish provenances tested under conditions of the Beskid Sądecki mountain range (southern Poland). Journal of Forest Science, 53, 12: 538-547.

Sokołowski A.W. 1966. Fitosocjologiczna charakterystyka borów iglastych ze związku Dicrano-Pinion w Puszczy Białowieskiej. Prace IBL, 305: 71–105.

Sokołowski A.W. 1990. Badania dynamiki naturalnych zbiorowisk leśnych w obiektach rezerwatowych ze szczególnym uwzględnieniem odnowienia gatunków drzewiastych. IBL. Zakład Lasów Naturalnych w Białowieży. Białowieża.

Sokołowski A.W. 1990. Wpływ użytkowania rębnego na skład gatunkowy zbiorowisk leśnych w Puszczy Białowieskiej. Prace IBL, no 712.

Sokołowski A.W. 1991. Zmiany składu gatunkowego zbiorowisk leśnych w rezerwatach Puszczy Białowieskiej. Ochrona Przyrody, 49, part 2: 63–78.

Sokołowski A.W. 1991. Changes in species composition of a mixed Scots Pine-Norway Spruce Forest at the Augustów Forest during the period 1964–1987, Folia Forestalia Polonica, ser. A: Forestry, 33, 5–23.

Sokołowski A.W. 1991. Changes in species composition of forest associations in the nature reserves of the Białowieża Forest (Polish with English summary). Ochrona Przyrody, 49, 63–78.

Sokołowski A.W. 1995. Flora roślin naczyniowych Puszczy Białowieskiej. Białowieża.

Sokołowski A.W. 1996. Identyfikacja i charakterystyka lasów naturalnych na terenie Puszczy Białowieskiej. IBL Zakład Lasów Naturalnych Białowieży.

Sokołowski A.W. 1998. Charakterystyka oraz inwentaryzacja lasów naturalnych na terenie Nadleśnictw Białowieża i Browsk. IBL Zakład Lasów Naturalnych. Białowieża.

Sokołowski A.W., Wołkowycki M. 2000. Uzupełnienie do flory roślin naczyniowych Puszczy Białowieskiej. Parki Narodowe i Rezerwaty Przyrody, 19, 4: 71–75.

Sokołowski A.W. 2004. Lasy Puszczy Białowieskiej. Centrum Informacyjne Lasów Państwowych. Warszawa.

Souvannavong O. 2011.Better information for sustainable forest management, Forestry Department, FAO (Food and Agriculture Organisation of the United Nations) [In:] Samara, The International Newsletter of the Partners of the Millenium Seed Bank Partnership, 21: 1–2.

State of Europe's Forests 2011, Status & Trends in Sustainable Forest Management in Europe. 2011. The Ministerial Conference on the Protection of Forests in Europe, Oslo.

Strategia Państwowego Gospodarstwa Leśnego Lasy Państwowe 1997. Wizja, Założenia i Koncepcja Strategii. Projekt opracowany pod kierunkiem Waldemara Sieradzkiego.

Sulkowska M., Charkot S. 2010.Genetic foundations of ecotype differentiation of European beech (*Fagus sylvatica* L.) in Poland. Annales of Warsaw university of Life Sciences SGGW, Forestry and Wood Technology, 73: 15–23.

Sułkowska M., Kowalczyk J., Przybylski P. 2008.Zmienność genetyczna i ekotypowa buka zwyczajnego (*Fagus sylvatica* L.) w Polsce. Leśne Prace Badawcze, vol. 69, 2: 133–142. English summary: Genetic and ecotype diversity of European beech (*Fagus sylvatica* L.) in Poland.

Sułkowska M., Nowakowska J. 2011.Genetic structure of European beech of mother and progeny stands in Poland on the basis of DNA chloroplast markers. Forestry Ideas 2011, vol. 18, 1, in print.

Suszka B., Muller C., Bonnet-Masimbert M. 1994.Nasiona leśnych drzew liściastych od zbioru do siewu. PWN. Warszawa–Poznań.

Systematyka gleb Polski, Roczniki Gleboznawcze.1989. Polskie Towarzystwo Gleboznawcze, vol. 40, 3/4.Warszawa.

Szczygieł K., Hazubska T., Bojarczuk K. 2007. Somatic embryogenesis of selected coniferous tree species of the genera *Picea*, *Abies* and *Larix.* Acta Societatis Botanicorum Poloniae, 76, 1: 7–17.

Szczygieł K, Zajączkowski K, Wojda T. 2010. Selekcja i wegetatywne rozmnażanie *in vitro* wybranych genotypów brzozy brodawkowatej i czereśni ptasiej do plantacyjnej uprawy. Sprawozdanie Naukowe IBL.

Szmit Z. 1923. Zarys geologiczny i przyczynek do badań archeologicznych Puszczy Białowieskiej, 2: 7–27. Białowieża.

Szujecki A. 1992. Raport o stanie Puszczy Białowieskiej. (typescript). Warszawa.

Szujecki A. (ed.) 2001. Próba szacunkowej waloryzacji lasów Puszczy Białowieskiej metodą zooindykacyjną. SGGW. Warszawa.

Ścibor J. 1958. Bobry w Puszczy Białowieskiej. Las Polski, 19.

Śliwiński J. 2007. Puszcze wielkoksiążęce na północnym Podlasiu i zachodniej Grodzieńszczyźnie w XV-XVI wieku. Wyd. Uniwersytetu Warmińsko-Mazurskiego. Olsztyn.

Traktat między Królestwem Belgii, Królestwem Danii, Republiką Federalną Niemiec, Republiką Grecką, Królestwem Hiszpanii, Republiką Francuską, Irlandią, Republiką Włoską, Wielkim Księstwem Luksemburga, Królestwem Niderlandów, Republiką Austrii, Republiką Portugalską, Republiką Finlandii, Królestwem Szwecji, Zjednoczonym Królestwem Wielkiej Brytanii i Irlandii Północnej (Państwami członkowskimi Unii Europejskiej) a Republiką Czeską, Republiką Estońską, Republiką Cypryjską, Republiką Łotewską, Republiką Litewską, Republiką Węgierską, Republiką Malty, Rzeczpospolitą Polską, Republiką Słowenii, Republiką Słowacką dotyczący przystąpienia Republiki Czeskiej, Republiki Estońskiej, Republiki Cypryjskiej, Republiki Łotewskiej, Republiki Litewskiej, Republiki Węgierskiej, Republiki Malty, Rzeczypospolitej Polskiej, Republiki Słowenii, Republiki Słowackiej do Unii Europejskiej. Dz.U. z dnia 23 września 2003 r. L 236.

Trampler T., Kliczkowska A., Dmyterko E., Sierpińska A. 1990. Regionalizacja przyrodniczo-leśna na podstawach ekologiczno-fizjograficznych. PWRiL. Warszawa.

Tjoelker M.G., Boratyński A., Bugała W. (eds.). 2007. Biology and Ecology of Norway Spruce Forestry Sciences, vol. 78, 97–106.Springer. Dordrecht. Netherlands.

Tracz M. 2010.Zmienność genetyczna i dziedziczenie cech ilościowych jodły pospolitej (*Abies alba* Mill.) w Sudetach Środkowych. Praca doktorska wykonana w Katedrze Hodowli Lasu Akademii Rolniczej w Poznaniu.

Trocha L.K., Rudawska M., Leski T., Dabert M. 2006.Genetic diversity of naturally established ectomycorrhizal fungi on Norway spruce seedlings under nursery conditions. Microbial Ecology, 236: 375–384.

Tyszkiewicz S. 1969. Population studies of Norway spruce in Poland. Instytut Badawczy Leśnictwa. Warszawa.

Urbaczka M. 2008.Analiza zmienności świerka istebniańskiego oraz realizacja programu ochrony zasobów genowych Stacji Wyrchczadeczka KBG w Nadleśnictwie Wisła. (typescript of masters thesis). Katedra Nasiennictwa, Szkółkarstwa i Selekcji Drzew Leśnych. Wydział Leśny Uniwersytetu Rolniczego. Kraków.

Ustawa z dnia 28 września 1991r. o lasach. (Dz. U. z 2005 r. Nr 45, poz. 435 z późn. zm.).

Ustawa z dnia 3 lutego 1995 r. o ochronie gruntów rolnych i leśnych. (Dz. U. z 2004 r. Nr 121, poz. 1266, z późn. zm.).

Ustawa z dnia 27 kwietnia 2001 r. Prawo ochrony środowiska. (Tekst jednolity Dz. U. 2008, Nr 25, poz. 150 z późn. zm.).

Ustawa z dnia 7 czerwca 2001 r. o leśnym materiale rozmnożeniowym. (Dz. U. 2001, Nr 73, poz. 761).

Ustawa z dnia 18 grudnia 2003 r. o ochronie roślin. (Tekst jednolity Dz. U. 2008, Nr 133, poz. 849 z późn. zm.).

Ustawa z dnia 16 kwietnia 2004 r. o ochronie przyrody. (Tekst jednolity Dz. U. 2009, Nr 151, poz. 1220 z późn. zm.).

Ustawa z dnia 13 kwietnia 2007 r. o zapobieganiu szkodom w środowisku i ich naprawie. (Dz. U. z dnia 26 kwietnia 2007 r. Nr 75, poz. 493 z późn. zm.).

Ustawa z dnia 3 października 2008 r. o udostępnianiu informacji o środowisku i jego ochronie, udziale społeczeństwa w ochronie środowiska oraz ocenach oddziaływania na środowisko. (Dz. U. z dnia 7 listopada 2008 r. Nr 199, poz. 1227 z późn. zm.).

Ustawa z dnia 8 czerwca 2001 r. o przeznaczeniu gruntów rolnych do zalesienia (Dz. U. 2001, Nr 73, poz. 764 z późn. zm.).

Ustawa z dnia 13 października 1995 r. prawo łowieckie. (Tekst jednolity Dz. U. 2005, Nr 127, poz. 1066 z późn. zm.).

Wachowski M. 1958. Przyczynek do historii handlu drzewnego na Litwie w końcu XVIII wieku. Sylwan, 10.

Walankiewicz W., Czeszczewik D., Mitrus C., Bida E., 2002. Znaczenie martwych drzew dla zespołu dzięciołów w lasach liściastych Puszczy Białowieskiej. Notatki Ornitologiczne, 43.

Walankiewicz W., Czeszczewik D., Rowiński P., Wereszczuk M., Tumie T., Stański T., Świętochowski P. 2010. Dzięcioł trójpalczasty (*Picoides tridactylus*) na obszarze Puszczy Białowieskiej. Akademia Podlaska. Siedlce.

Więcko E. 1984. Puszcza Białowieska. Warszawa.

Wielkoobszarowa Inwentaryzacja Stanu Lasów, 2006–2010 (WISL). Biuro Urządzania Lasu i Geodezji Leśnej.

World reference base for soil resources 1998. 84 World Soil Resources Reports. International Society of Soil Science, International Soil Reference and Information Centre, Rome.

Zając A., Zając M. 2001. Atlas rozmieszczenia roślin naczyniowych Polski. Uniwersytet Jagielloński. Kraków.

Zajączkowski J. 1997. Odnowienie lasu naturalnego na przykładzie powierzchni badawczej w Białowieskim Parku Narodowym. Sylwan, 5–14.

Zajączkowski J. ***et al.*** 1999. Naturalna różnorodność składu gatunkowego, budowy i struktury drzewostanów w Polsce na tle zmian środowiskowych. Dokumentacja końcowa. Instytut Badawczy Leśnictwa. Warszawa. (typescript).

Zaleski J. 2011. Strategia leśna w polityce Ministerstwa Środowiska. [In:] Strategia rozwoju lasów i leśnictwa w Polsce do roku 2030. Materiały III Sesji Zimowej Szkoły Leśnej przy IBL, Sękocin Stary, 15–17 marca 2011 r., 18–28. Instytut Badawczy Leśnictwa.

Załęski A., Zajączkowska B., Matras J., Sabor J. 2000. Leśna regionalizacja dla nasion i sadzonek w Polsce. IBL Warszawa.

Zaręba R. 1958. Ślady działalności ludzkiej w drzewostanach Białowieskiego Parku Narodowego. Sylwan, 102, 8.

Zaręba R. 1962. „Ogrody do polowania" w Puszczy Białowieskiej w czasach Stanisława Augusta Poniatowskiego. Sylwan, 106, 2.

Zarządzenie Nr 5 Dyrektora Generalnego Lasów Państwowych z dnia 24.01.2001r. (Zn. Sp.: ZO-01-1/4/01) w sprawie Leśnych Kompleksów Promocyjnych.

Zarządzenie nr 7A Dyrektora Generalnego Lasów Państwowych z dnia 7 kwietnia 2006 r. (Zn. sp. ZG-7130-7/06) w sprawie ochrony leśnych zasobów genowych na potrzeby nasiennictwa i hodowli drzew leśnych.

Zarządzenie Nr 11A Dyrektora Generalnego Lasów Państwowych z dnia 11 maja 1999 r. (Zn. sp. ZG-7120-2/99) zmieniające Zarządzenie Nr 11 Dyrektora Generalnego Lasów Państwowych z dnia 14 lutego 1995 roku w sprawie doskonalenia gospodarki leśnej na podstawach ekologicznych (zn. sp. ZZ-710-13/95).

Zarządzeniem Nr 68 Dyrektora Generalnego Lasów Państwowych z dnia 30 września 2008 r. (Zn. sp.: ZP-732-1-15/2008) w sprawie powołania zespołu zadaniowego do opracowania programu działań ochronnych w nadleśnictwach Puszczy Białowieskiej.

Zasady Hodowli Lasu obowiązujące w Państwowym Gospodarstwie Leśnym Lasy Państwowe 2002. Dyrekcja Generalna Lasów Państwowych. Warszawa.

Zasady postępowania hodowlanego i ochronnego w ekosystemach Leśnego Kompleksu Promocyjnego Puszcza Białowieska. 1997. (typescript). Białystok.

Zasady postępowania w drzewostanach gospodarczych i ochronnych Puszczy Białowieskiej zagrożonych przez korniki.2008. Materiały z seminarium. (typescript). Białowieża.

Zielony R., Majer A. 1994. Stan aktualny i tendencje rozwojowe chronionych ekosystemów leśnych Puszczy Białowieskiej. Katedra Urządzania Lasu i Geodezji Leśnej SGGW. Białowieża, Warszawa.

Zoll T. 1963. Analiza stanu lasów w Sudetach. Zeszyty Problemowe Postępów Nauk Rolniczych, 37: 123–144.

Żółciak A., **Oszako T., Sabor J.** 2009. Evaluation of the health status of *Picea abies* provenances growing on the IUFRO 1964–68 experimental plots. Dendrobiology, 61 (suppl.): 63–68.

10 messages for 2010: Biodiversity. 2010. European Environment Agency. Kopenhaga.

10 messages for 2010: Forest ecosystems. 2010. European Environment Agency. Kopenhaga.

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Table 1. Characteristics and area of forests (FRA)

Main forest characteristics	Area (ha)[1]
Primary forests	54 000
Naturally regenerated forests	394 000
Planted forests	8 889 000
Reforestation	451 300*
Afforestation	146 000*

[1] data for 2010 (Country Report of the State Forests in Poland)
* aggregated data for 2001–2010 (FRA data for 2001–2007, supplemented with data for 2008–2010)

Table 2. Forest ownership category and area (FRA)

Forest ownership category	Area (ha)	%
Public	7 495 800	80.6%
Private	1 720 500	18.5%
Other	83 700	0.9%

Table 3. Major forest types and the main tree species drawn from the categories used in Poland or from the list (Forest Types and Ecological Zone Breakdown used in FRA, 2000)

Major Forest Types	Area covered by forest type	Main species for each forest type	
		Trees	Other species if applicable
Temperate oceanic forest	45.3%	Pine, Spruce, Oak, Beech, Larch, Fir, Birch	
Temperate continental forest	46.0%	Pine, Spruce, Oak, Beech, Larch, Fir	
Temperate mountain forest	8.7%	Spruce, Fir, Beech, Larch	

Table 4. Priority species (scientific names)

Priority species		Reasons for priority	
Scientific name	Tree (T) or other (O)	Native (N) or exotic (E)	
1	2	3	4
Abies alba Mill.	T	N	Economic – 4
Acer campestre L	T	N	Threatened – 3
Acer platanoides L.	T	N	Economic – 2
Acer pseudoplatanus L.	T	N	Economic – 3
Alnus glutinosa Gaertn.	T	N	Economic – 3
Alnus viridis DC	T	N	Threatened – 5
Betula pendula Roth.	T	N	Economic – 4

1	2	3	4
Betula pubescens Ehrh.	T	N	Threatened – 4
Betula humilis	O	N	Threatened – 5
Betula nana	O	N	Threatened – 5
Betula oycoviensis	O	N	Threatened – 5
Carpinus betulus L.	T	N	Economic – 3
Fagus sylvatica L.	T	N	Economic – 5
Fraxinus excelsior L.	T	N	Threatened – 5
Larix decidua Mill.	T	N	Economic – 4
Malus silvestris Mill.	T	N	Threatened – 4
Picea abies Karst.	T	N	Economic – 5
Pinus cembra L.	T	N	Threatened – 5
Pinus nigra Arnold	T	E	Economic – 1
Pinus sylvestris L.	T	N	Economic – 5
Pinus x rhaetica	T	N	Threatened – 5
Populus alba	T	N	Threatened – 4
Populus nigra	T	N	Threatened – 5
Populus x canascens	T	N	Threatened – 3
Populus tremula	T	N	Economic – 2
Prunus avium L.	T	N	Economic – 4
Pseudotsuga menziesii Franco	T	E	Economic – 3
Pyrus communis L.	T	N	Threatened – 3
Quercus petraea Liebl.	T	N	Economic – 4
Quercus pubescens Willd.	T	N	Threatened – 5
Quercus robur L.	T	N	Economic – 5
Robinia pseudoacacia L.	T	E	Economic – 2
Salix alba L.	T	N	Other – 1
Sorbus aria Crantz.	T	N	Threatened – 4
Sorbus aucuparia L.	T	N	Other – 1
Sorbus torminalis Crantz.	T	N	Threatened – 5
Sorbus intermedia	T	N	Threatened – 5
Taxus baccata L.	T	N	Threatened – 5
Tilia cordata Mill.	T	N	Economic – 3
Tilia platyphyllos Scop.	T	N	Economic – 2
Ulmus glabra Huds.	T	N	Threatened – 5
Ulmus Laevis Pall.	T	N	Threatened – 5
Ulmus carpinifolia Gleditsch.	T	N	Threatened – 5

Examples of reasons for priority: Economic, social or cultural importance; Threatened; Invasive (priority for removal)
Scale of priority: 1 – low; 5 – high
** Threatened – concerns legally protected and also environmentally endangered species*

Table 5. Native (N) and exotic (E) forest species currently used in Poland

Species (Scientific name)	Native (N) or Exotic (E)	Current uses* (code)	If managed, type of management system (e.g. natural forest, plantation, agroforestry)	Area managed if known (ha)
1	2	3	4	5
Abies alba Mill.	N	1,2,3	N, P	266 100
Acer campestre L	N	4,5	N	
Acer platanoides L.	N	3,4,5	N, P	
Acer pseudoplatanus L.	N	1	N, P	
Alnus glutinosa Gaertn.	N	1	N, P	332 700
Alnus incana Moench.	N	3,4	N	
Alnus viridis DC	N	4	N	
Betula pendula Roth.	N	1,2,3,	N, P	485 700
Betula pubescens Ehrh.	N	4	N	
Betula humilis Schrank	N	6 – vulnerable	N, P	
Betula nana L.	N	6 – vulnerable	N, P	
Betula oycoviensis Bess.	N	6 – endemic	N, P	
Carpinus betulus L.	N	3,4	N	68 300
Fagus sylvatica L.	N	1,2,3	N, P	395 300
Fraxinus exelsior L.	N	1	N, P	
Larix decidua Mill.	N	1	N, P	
Malus silvestris Mill.	N	4	N	
Picea abies Karst.	N	1,2,3	N, P	440 800
Pinus cembra L.	N	4	N	
Pinus nigra Arnold	E	1	P	
Pinus sylvestris L.	N	1,2,3	N, P	4 380 600
Populus tremula L.	N	2,3	N,P	171 600
Populus alba L.	N	2,3	N	
Populus nigra L.	N	2,3	N	
Populus x canascens	N	2,3	N	
Prunus avium L.	N	1	N, P	
Pseudotsuga menziesii Franco	E	1	P	
Pyrus communis L.	N	4	N	
Quercus petraea Liebl.	N	1	N, P	227 000
Quercus pubescens Willd.	N	4	N	
Quercus robur L.	N	1	N, P	300 000
Robinia pseudoacacia L.	E	1	P	
Salix alba L.	N	1,2,3	N	

1	2	3	4	5
Sorbus aria Crantz.	N	4	N	
Sorbus aucuparia L.	N	4	N	
Sorbus intermedia	N	4	N	
Taxus baccata L.	N	4	N	
Tilia cordata Mill.	N	1	N,P	
Tilia platyphyllos Scop.	N	4	P	
Ulmus glabra Huds.	N	1	N	
Ulmus Laevis Pall.	N	1	N	
Ulmus carpinifolia Gleditsch.	N	4	N	

N – naturally regenerated
P – planted

*** Current use:**
Solid wood products (1)
Pulp and paper (2)
Energy (fuel) (3)
Non-wood forest products (such as food, fodder, medicine) (4)
Used in agroforestry systems (5)
Other (6)

Table 6. Main tree and other woody forest species that provide environmental services or social value: native (N) or exotic (E)

Species (scientific name)	Native (N) or Exotic (E)	Environmental service or social value (code)
1	2	3
Abies alba Mill.	N	1,3,5
Acer campestre L.	N	1,3
Acer platanoides L.	N	1,3
Acer pseudoplatanus L.	N	1,3
Alnus glutinosa Gaertn.	N	1
Alnus viridis DC	N	3
Betula pendula Roth.	N	1,3
Betula pubescens Ehrh.	N	1,3
Betula humilis Schrank	N	3
Betula nana L.	N	3
Betula oycoviensis Bess.	N	3
Carpinus betulus L.	N	3
Fagus sylvatica L.	N	1
Fraxinus exelsior L.	N	1,3
Larix decidua Mill.	N	1,4
Malus silvestris Mill.	N	3
Picea abies Karst.	N	1

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1	2	3
Pinus cembra L.	N	3
Pinus nigra Arnold	E	5
Pinus sylvestris L.	N	1
Populus alba L.	N	3
Populus nigra L.	N	3
Populus x canascens	N	3
Populus tremula L.	N	1
Prunus avium L.	N	3
Pseudotsuga menziesii Franco	E	1
Pyrus communis L.	N	3
Quercus petraea Liebl.	N	3,4
Quercus pubescens Willd.	N	3
Quercus robur L.	N	3,4
Robinia pseudoacacia L.	E	7 (bee-keeping)
Salix alba L.	N	1
Sorbus aria Crantz.	N	3
Sorbus aucuparia L.	N	1,2
Sorbus torminalis Cranz.	N	3,5
Sorbus intermedia	N	3,5
Taxus baccata L.	N	3,4,5
Tilia cordata Mill.	N	3,6
Tilia platyphyllos Scop.	N	3,6
Ulmus glabra Huds.	N	3
Ulmus laevis Pall.	N	3
Ulmus carpinifolia Gleditsch.	N	3

Services and value include:
1. Soil and water protection, including watershed management
2. Soil fertility
3. Biodiversity conservation
4. Cultural value
5. Aesthetic value
6. Religious value
7. Other

Table 7. List of tree and other woody forest species in Poland considered to be threatened in all or part of their ranges from the point of view of genetic conservation

Species (scientific name)	*Area (ha) of species' natural distribution	Average number of trees per hectare, if known	**Proportion of species' natural distribution (%)	Threat category*** Distribution in the country: wide spread (W), rare (R) or local (L)	Type of threat (Code)	High	Medium	Low
1	2	3	4	5	6	7	8	9
Abies alba Mill.	262 000			W	2, 4,10,11		X	
Acer campestre L.				R	4,7		X	
Acer platanoides L.				W				X
Acer pseudoplatanus L.				W				X
Alnus glutinosa Gaertn.	480 000			W				X
Alnus viridis DC				R	2,4,7	X		
Betula pendula Roth.	667 000			W				X
Betula pubescens Ehrh.				L	2,4,7,13	X		
Betula humilis Schrank				R	2,7	X		
Betula Nana L.				R	2,7	X		
Betula oycoviensis Bess.				R	2,7	X		
Carpinus betulus L.	108 000			W				X
Fagus sylvatica L.	503 000			W				X
Fraxinus excelsior L.				R	2,4,7,11,13	X		
Larix decidua Mill.				W				X
Malus silvestris Mill.				R	2,4,7,11	X		
Picea abies Karst.	583 000			W	9,10,11,13		X	
Pinus cembra L.				R	2,7	X		
Pinus nigra Arnold				**				
Pinus sylvestris L.	5 479 000			W				X
Populus tremula L.	66 000			L	2,4,5,7	X		
Populus alba L.					1,2,6,7,8	X		
Populus nigra L.					1,2,6,7,8	X		
Populus x canascens					1,2,6,7,8	X		
Prunus avium L.				L	2,4,7,10		X	
Pseudotsuga menziesii Franco				**				
Pyrus communis L.				R	2,4,5,7	X		

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1	2	3	4	5	6	7	8	9
Quercus petraea Liebl.	625 000*			W	11,13		X	
Quercus pubescens Willd.				R	2,4,5,7	X		
Quercus robur L.				W	11,13		X	
Robinia pseudoacacia L.				**				
Salix alba L.				L				X
Sorbus aria Crantz.				R	2,4,7,	X		
Sorbus aucuparia L.				W				X
Sorbus torminalis Cranz.				R	2,4,7	X		
Sorbus intermedia				R	2,4,7	X		
Taxus baccata L.				R	2,4,7,	X		
Tilia cordata Mill.				W				X
Tilia platyphyllos Scop.				L				x
Ulmus glabra Huds.				R	2,4,7,11	X		
Ulmus laevis Pall.				R	2,4,7,11	X		
Ulmus carpinifolia Gleditsch.				R	2,4,7,11	X		

* *Quercus petraea* and *Quercus robur*
** *exotic species*

Table 8a. Annual quantity of seeds produced and current state of identification of forest reproductive material of the main forest tree and other woody species in Poland

Species		Total quantity of seeds used (kg)	Quantity of seeds from documented sources (provenance/ delimited seed zones)	Quantity of seeds from tested provenances (provenance trials established and evaluated)	Quantity that is genetically improved (from seed orchards)
Scientific name	Native (N) or Exotic (E)				
1	2	3	4	5	6
Abies alba Mill.	N	3955*	83%	17.0%	0.0%
Acer platanoides L.	N	403	100%	0.0%	0.0%
Acer pseudoplatanus L.	N	518	100%	0.0%	0.0%
Alnus glutinosa Gaertn.	N	985	85.4%	3.6%	10.0%
Betula pendula Roth.	N	1553	94%	3.0%	1.0%
Fagus sylvatica L.	N	23521	91%	9.0%	0.0%
Fraxinus excelsior L.	N	38	100%	0.0%	0.0%
Larix decidua Mill.	N	771	27%	10.0%	63.0%
Picea abies Karst.	N	775	80%	19.0%	1.0%
Pinus sylvestris L.	N	6639	81%	11.0%	8.0%

1	2	3	4	5	6
Quercus petraea Liebl.	N	8511	99%	1.0%	0.0%
Quercus robur L.	N	87248	91%	9.0%	0.0%
Tilia cordata Mill.	N	729	83.6%	1.4%	15.0%
Other coniferous	N	677**	100%	0.0%	0.0%
Other deciduous	N	3 412	100%	0.0%	0.0%

** all data for 2010*
*** kg of cones*

Table 8b. Annual number of seedlings (or vegetative propagules) planted and the state of identification of the reproductive material used for the main forest tree and other woody species in Poland

Species		Total quantity of seedlings planted**	Quantity of seeds from documented sources (provenance/ delimited seed zones)	Quantity of seedlings from tested provenances (provenance trials established and evaluated)	Quantity of vegetative repro-ductive material used	Quantity of seedlings that are genetically improved
Scientific name	Native (N) or Exotic (E)					
1	2	3	4	5	6	7
Abies alba Mill.	N	38 581 000	*	*	0	*
Acer platanoides L.	N	3 699 000			0	
Acer pseudoplatanus L.	N	7 001 000			0	
Alnus glutinosa Gaertn.	N	22 743 000			0	
Betula pendula Roth.	N	33 982 000			0	
Fagus sylvatica L.	N	116 990 000			0	
Fraxinus excelsior L.	N	421 000			0	
Larix decidua Mill.	N	12 689 000			0	
Picea abies Karst.	N	47 392 000			0	
Pinus sylvestris L.	N	215 493 000			0	
Quercus petraea Liebl.	N	68 794 000			0	
Quercus robur L.	N	154 566 000			0	
Tilia cordata Mill.	N	9 739 000			0	
Other coniferous	N	4 938			0	
Other deciduous	N	16 995			0	

** proportion of plants of different category as in table 8a; data for 2010*
*** data show the quantity of seedlings produced (not planted), but the difference is not significant*

Table 9. A list of forest species for which genetic variability has been evaluated

Species		Morphological traits	Adaptive and productive characters assessed	Molecular characterization
Scientific name	Native (N) or Exotic (E)			
Abies alba Mill.	N	+	+	+
Acer campestre L.	N	–	–	–
Acer platanoides L.	N	+	–	–
Acer pseudoplatanus L.	N	+	–	–
Alnus glutinosa Gaertn.	N	+	+	
Alnus incana Moench.	N	–	–	–
Alnus viridis DC	N	–	–	–
Betula pendula Roth.	N	+	+	–
Betula pubescens Ehrh.	N	–	–	–
Carpinus betulus L.	N	–	–	–
Fagus sylvatica L.	N	+	+	+
Fraxinus excelsior L.	N	–	–	–
Larix decidua Mill.	N	+	+	+
Malus silvestris Mill.	N	–	–	–
Picea abies Karst.	N	+	+	+
Pinus cembra L.	N	+	–	–
Pinus nigra Arnold	E	+	+	–
Pinus sylvestris L.	N	+	+	+
Populus spp. alba, nigra, canescens, tremula	N	+	–	–
Prunus avium L.	N	+	+	+
Pseudotsuga menziesii Franco	E	+	+	+
Pyrus communis L.	N	–	–	–
Quercus petraea Liebl.	N	+	+	+
Quercus pubescens Willd.	N	–	–	–
Quercus robur L.	N	+	+	+
Robinia pseudoacacia L.	E	+	–	–
Salix alba L.	N	–	–	–
Sorbus aria Crantz.	N	–	–	–
Sorbus aucuparia L.	N	–	–	–
Sorbus torminalis Cranz.	N	+	–	+
Taxus baccata L.	N	+	–	+
Tilia cordata Mill.	N	+	–	–
Tilia platyphyllos Scop.	N	–	–	–
Ulmus glabra Huds.	N	–	–	–
Ulmus laevis Pall.	N	–	–	–
Ulmus carpinifolia Gleditsch.	N	–	–	–

Table 10. Target forest species included within *in situ* conservation programmes/units

Species (scientific name)	Purpose for establishing conservation unit	Number of populations or stands conserved	Total area (ha)**
Abies alba Mill.	1,2,3*	106	2213
Acer pseudoplatanus L.	2	3	18
Alnus glutinosa Gaertn.	2,3	67	593
Betula pendula Roth.	2,3	27	221
Carpinus betulus L.	2	1	11
Fagus sylvatica L.	2,3	156	2873
Fraxinus exelsior L.	1,2,3	15	94
Larix decidua Mill.	2,3	90	512
Picea abies Karst.	1,2,3	129	3316
Pinus cembra L.	2	1	17
Pinus sylvestris L.	2,3	267	8895
Quercus petraea Liebl.	1,2,3	68	1572
Quercus robur L.	1,2,3	112	1892
Tilia cordata Mill.	2,3	11	156

* *1 – threatened species*
2 – for conservation of genetic variability
3 – for breeding purposes
** *total surface area of gene reserve stands and selected seed stands (data for 2009)*

Table 11. *Ex situ* conservation

Species		Field collections*				Germplasm bank			
Scientific name	Native (N) or Exotic (E)	Collections, provenance or progeny tests, arboreta or conservation stands		Clone banks		*In vitro* (including cryo conservation)		Seed banks	
		No. stands	No. acc.	No. banks	No. clones	No. banks	No. acc.	No. Banks	No. acc
1	2	3	4	5	6	7	8	9	10
Alnus glutinosa Gaertn.	N							1	178
Betula nana L.						1	1	1	1
Betula pendula Roth.	N							1	99
Cornus alba L.								1	1
Crateagus monogyna								1	2
Fagus sylvatica L.	N					1	11	1	53
Fraxinus excelsior L.	N							1	6
Juniperus communis L.								1	1

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1	2	3	4	5	6	7	8	9	10
Larix decidua Mill.	N							1	660
Lonicera periclymenum L.								1	1
Malus silvestris Mill.	N							1	1
Myrica gale L.								1	1
Picea abies Karst.	N							1	836
Picea sitchensis								1	1
Pinus mugo Turra								1	1
Pinus nigra Arnold	E							1	140
Pinus rigida Mill.								1	1
Pinus x rhaetica Brugger								1	5
Pinus strobus L.								1	32
Pinus sylvestris L.	N							1	4764
Pinus uliginosa								1	1
Prunus avium L.	N					1	3	1	22
Prunus divaricata (Prunus cerasifera Ehrh.)								1	1
Pseudotsuga menziesii Franco	E							1	365
Pyrus communis L.	N							1	2
Quercus petraea Liebl.	N					1	7		
Quercus robur L.	N					1	28		
Rosa rugosa Thunb.								1	2
Salix lapponum L.						1	1	1	3
Staphleya pinnata								1	1
Taxus baccata L.	N							1	5
Tilia cordata Mill.	N							1	22
Viburnum opulus L.								1	2
Wild herbaceous plants	N					1	13	1	53
Total							**64**		**7 263**

Table 11a. The area* of established progeny and conservation plantations

Scientific name	Native (N) or exotic (E)	Collections, provenance or progeny tests, arboreta or conservation stands	
		Area of progeny plantations for breeding purposes (ha)	Area of progeny plantations for gene conservation purposes (ha)
Abies alba Mill.	N	2 762	19
Alnus glutinosa Gaertn.	N	1 187	
Betula pendula Roth.	N	1 150	
Fagus sylvatica L.	N	5 177	72
Larix decidua Mill.	N	2 450	81
Picea abies Karst.	N	2 253	439
Pinus sylvestris L.	N	45 653	757
Quercus petraea Liebl.	N	2 347	17
Quercus robur L.	N	3 703	88
Tilia cordata Mill.	N	165	
Other coniferous	N/E	948	
Other deciduous	N/E	81	
Total		**67 876**	**1 473**

** Data for 2010*

Table 12. Seed and vegetative propagules transferred internationally per annum (average of last 5 years)

Species	Quantity of seed (kg)		Quantity of seed per annum (kg)		Number of vegetative propagules		Number of seedlings		Number of seedlings per annum		Purpose
	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	
1	2	3	4	5	6	7	8	9	10	11	12
Abies alba Mill.	5.00	0	1.00	0.00	0	0	100	363565	20	72713	for forestry purpose
Abies grandis.	2.50	0	0.50	0.00	0	0	800	17500	160	3500	for forestry purpose
Acer platanoides L.	15.00	1007	3.00	201.40	0	0	0	224019	0	44803,8	for forestry purpose
Acer pseudoplatanus L.	155.00	0	31.00	0.00	0	0	0	28470	0	5694	for forestry purpose
Alnus glutinosa Gaertn.	36.10	40	7.22	8.00	0	0	0	413500	0	82700	for forestry purpose
Betula pendula Roth.	26.25	9	5.25	1.80	0	0	0	1557375	0	311475	for forestry purpose
Betula pubescens Ehrh.	1.00	0	0.20	0.00	0	0	0	5000	0	1000	for forestry purpose
Carpinus betulus L.	40.00	493	8.00	98.60	0	0	0	12271	0	2454.2	for forestry purpose
Cedrus atlantica Carr.	1.30	0	0.26	0.00	0	0	0	0	0	0	for forestry purpose
Fagus sylvatica L.	9178.60	3340	1835.72	668.00	0	0	0	738599	0	147719.8	for forestry purpose
Fraxinus angustifolia Vahl.	0.50	0	0.10	0.00	0	0	0	0	0	0	for forestry purpose
Fraxinus excelsior L.	7.00	0	1.40	0.00	0	0	0	15525	0	3105	for forestry purpose
Larix decidua Mill.	7.00	0	1.40	0.00	0	0	1000	238900	200	47780	for forestry purpose
Larix eurolepis Henry.	6.90	0	1.38	0.00	0	0	0	370025	0	74005	for forestry purpose
Larix kaempferi Carr.	2.50	0	0.50	0.00	0	0	0	16900	0	3380	for forestry purpose
Larix leptolepis sibirica Ledeb	0.30	0	0.06	0.00	0	0	0	0	0	0	for forestry purpose
Picea abies Karst.	59.73	1706.8	11.95	341.36	0	0	306200	6147230	61240	1229446	for forestry purpose
Picea sitchensis Carr.	1.88	0	0.38	0.00	0	0	0	41990	0	8398	for forestry purpose

1	2	3	4	5	6	7	8	9	10	11	12
Pinus cembra L.	95.00	0	19.00	0.00	0	0	1250	0	250	0	for forestry purpose
Pinus contorta Loud.	0.10	0	0.02	0.00	0	0	0	0	0	0	for forestry purpose
Pinus nigra Arnold.	14.50	0	2.90	0.00	0	0	1000	0	200	0	for forestry purpose
Pinus sylvestris L.	7.75	1	1.55	0.20	0	0	0	53325	0	10665	for forestry purpose
Pinus strobus L.	0.00	0	0.00	0.00	0	0	0	100	0	20	for forestry purpose
Prunus avium L.	8.00	0	1.60	0.00	0	0	0	930	0	186	for forestry purpose
Pseudotsuga menziesii Franco	46.68	0	9.34	0.00	0	0	27750	136800	5550	27360	for forestry purpose
Quercus petraea Liebl.	28841.00	3 000	5768.20	600.00	0	0	191000	1125110	38200	225022	for forestry purpose
Quercus robur L.	7844.88	0	1568.98	0.00	0	0	111000	1590900	22200	318180	for forestry purpose
Quercus rubra L.	513.00	0	102.60	0.00	0	0	0	0	0	0	for forestry purpose
Populus Albelo	0.00	0	0.00	0.00	0	0	550	0	110	0	for forestry purpose
Populus canescens	0.00	0	0.00	0.00	0	0	500	0	100	0	for forestry purpose
Populus Degrosso	0.00	0	0.00	0.00	0	0	550	0	110	0	for forestry purpose
Populus Koster	0.00	0	0.00	0.00	0	0	550	0	110	0	for forestry purpose
Populus Polargo	0.00	0	0.00	0.00	0	0	550	0	110	0	for forestry purpose
Populus x euramericana	0.00	0	0.00	0.00	0	0	3000	0	600	0	for forestry purpose
Tilia cordata Mill.	0.00	990	0.00	198.00	0	0	200	479085	40	95817	for forestry purpose
Robinia pseudoacacia L.	0.00	0	0.00	0.00	0	0	500	0	100	0	for forestry purpose
Tilia platyphyllos Scop.	0.00	77	0.00	15.40	0	0	0	0	0	0	for forestry purpose

Table 13. Forest improvement programmes: species\improvement programme objectives

Scientific name	Native (N) or Exotic (E)	Timber	Pulpwood	Energy	MP*	NWFP**	Other
Abies alba Mill.	N	X	X		X		
Acer campestre L	N					X	
Acer platanoides L.	N	X					X
Acer pseudoplatanus L.	N	X		X	X		
Alnus glutinosa Gaertn.	N	X		X	X		
Alnus incana Moench.	N					X	
Alnus viridis DC	N					X	
Betula pendula Roth.	N	X	X	X	X		
Betula pubescens Ehrh.	N	X				X	
Carpinus betulus L.	N	X					
Fagus sylvatica L.	N	X	X	X	X		
Fraxinus excelsior L.	N	X			X		
Larix decidua Mill.	N	X			X		
Malus silvestris Mill.	N					X	
Picea abies Karst.	N	X	X	X	X		
Pinus cembra L.	N					X	
Pinus nigra Arnold		X		X	X		
Pinus sylvestris L.	N	X	X	X	X		
Populus spp. *alba, nigra, canescens, tremula*	N		X	X			
Prunus avium L.	N	X			X		
Pseudotsuga menziesii Franco		X			X		
Pyrus communis L.	N					X	
Quercus petraea Liebl.	N	X			X		
Quercus pubescens Willd.	N						
Quercus robur L.	N	X			X		
Robinia pseudoacacia L.		X					
Salix alba L.	N		X	X			
Sorbus aria Crantz.	N					X	
Sorbus aucuparia L.	N					X	
Sorbus torminalis Crantz.	N					X	
Taxus baccata L.	N					X	
Tilia cordata Mill.	N			X	X		
Tilia platyphyllos Scop.	N					X	
Ulmus glabra Huds.	N	X					
Ulmus laevis Pall.	N	X					
Ulmus carpinifolia Gleditsch.	N					X	

** MP: Multipurpose tree improvement programme*
*** NWFP: Non-wood forest product*

Table 14. Tree improvement trials

Species		Plus trees*	Provenance trials		Progeny trials***		Clonal testing and development**			
Scientific name	Native (N) or Exotic (E)	Number	No. of trials	No. of prov.	No. of trials	No. of families	No. of tests	No. of clones tested	No. of clones selected	No. of clones used
Abies alba Mill.	N	486	36	260	3	104	11	1761		
Acer platanoides L.	N	3								
Acer pseudoplatanus L.	N	39			1	30				
Alnus glutinosa Gaertn.	N	584	1	11			1	49		
Betula pendula Roth.	N	284			2	67				
Betula pubescens Ehrh.	N	1								
Fagus sylvatica L.	N	562	51	263	20	490	1	128		
Fraxinus excelsior L.	N	108					1	24		
Larix decidua Mill.	N	902	8	83	32	882	3	360		
Malus silvestris Mill.	N									
Picea abies Karst.	N	753	17	907	23	1750	9	646		
Pinus cembra L.	N	37			1	43				
Pinus nigra Arnold	E	213			23	198	1	73		
Pinus strobus L.	E				1	32				
Pinus sylvestris L.	N	3226	46	371	65	2669	6	1319		
Populus spp. *alba, nigra, canescens, tremula*	N	56					1	30		
Prunus avium L.	N	246			4	68				
Pseudotsuga menziesii Franco	E	503	1	100	5	202	2	311		
Quercus petraea Liebl.	N	329	5	34	4	124				
Quercus robur L.	N	540	3	75	20	356				
Robinia pseudoacacia L.	E	34								
Taxus baccata L.	N						1	125		
Tilia cordata Mill.	N	161								
Ulmus glabra Huds.	N	60					8	56		
Ulmus laevis Pall.	N	41					1	37		

** number of plus trees after the first generation seed orchards have been established under the programme*
*** data for clonal archives, which are not tested*
**** the list of progeny trials also includes seedling seed orchards which are used for the genetic evaluation of plus trees*

Table 15. Seed orchards

Species (scientific name)	Seed orchards*		
	Number	**Generation	Area (ha)
Abies alba Mill.	12	1 generation	79
Acer pseudoplatanus L.	0	1 generation	0
Alnus incana Moench.	11	1 generation	62
Betula pendula Roth.	9	1 generation	48
Fagus sylvatica L.	7	1 generation	48
Fraxinus excelsior L.	2		10
Larix decidua Mill.	38	1 generation	247
Picea abies Karst.	13	1 generation	76
Pinus cembra L.	1	1 generation	5
Pinus nigra Arnold	8	1 generation	25
Pinus sylvestris L.	50	1 generation	418
Pinus Weymouta	1	1 generation	3
Prunus avium L.	3	1 generation	12
Pseudotsuga menziesii Franco	8	1 generation	38
Quercus petraea Liebl.	9	1 generation	53
Quercus robur L.	6	1 generation	32
Robinia pseudoacacia L.	1	1 generation	6
Sorbus aucuparia L.	1	1 generation	1
Taxus baccata L.	1		1
Tilia cordata Mill.	19	1 generation	97

** Seed orchards are plantations specifically planted and managed for seed production and are not natural seed stands.*
*** Generation refers to first, second, third etc. breeding cycle.*

Table 15a. A list of seedling seed orchards

Species (scientific name)	Seedling seed orchards*		
	Number	**Generation	Area (ha)
1	2	3	4
Abies alba Mill.	13	1 generation	15
Acer pseudoplatanus L.	1	1 generation	5
Alnus incana Moench.	11	1 generation	62
Betula pendula Roth.	2	1 generation	13
Fagus sylvatica L.	2	1 generation	11
Fraxinus excelsior L.	2		10
Larix decidua Mill.	24	1 generation	172
Picea abies Karst.	12	1 generation	11
Pinus cembra L.	1	1 generation	10
Pinus nigra Arnold	23	1 generation	111

1	2	3	4
Pinus sylvestris L.	33	1 generation	277
Pinus Weymouta	1	1 generation	4
Prunus avium L.	3	1 generation	12
Pseudotsuga menziesii Franco	5	1 generation	33
Quercus petraea Liebl.	2	1 generation	11
Quercus robur L.	4	1 generation	23
Robinia pseudoacacia L.	1	1 generation	6
Sorbus aucuparia L.	1	1 generation	1
Taxus baccata L.	1		1
Tilia cordata Mill.	19	1 generation	97

Table 16. Type of reproductive material available

Species (scientific name)	Type of material	Available for national requests		Available for international requests	
		Commercial	Research	Commercial	Research
1	2	3	4	5	6
Abies alba Mill.		S	S, Sc	S	S, Sc
Acer campestre L			S, Sc		
Acer platanoides L.			S, Sc		S, Sc
Acer pseudoplatanus L.		S	S, Sc	S	S, Sc
Alnus glutinosa Gaertn.		S	S, Sc	S	S, Sc
Alnus viridis DC			S, Sc		
Betula pendula Roth.		S	S, Sc	S	S, Sc
Betula pubescens Ehrh.			S, Sc		S, Sc
Fagus sylvatica L.		S	S, Sc	S	S, Sc
Fraxinus excelsior L.			S, Sc		S, Sc
Larix decidua Mill.		S	S, Sc	S	S, Sc
Picea abies Karst.		S	S, Sc	S	S, Sc
Pinus cembra L.			S, Sc		
Pinus nigra Arnold		S	S, Sc	S	S, Sc
Pinus sylvestris L.		S	S, Sc	S	S, Sc
Pinus Weymouta			S, Sc		
Populus spp. Alba, nigra, canescens, tremula			S, Sc		S, Sc
Prunus avium L.			S, Sc		S, Sc
Pseudotsuga menziesii Franco			S, Sc		S, Sc
Pyrus communis L.			S, Sc		
Quercus petraea Liebl.		S	S, Sc	S	S, Sc
Quercus pubescens Willd.					

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1	2	3	4	5	6
Quercus robur L.		S	S, Sc	S	S, Sc
Taxus baccata L.			S, Sc		
Tilia cordata Mill.		S	S, Sc	S	S, Sc
Tilia platyphyllos Scop.			S, Sc		S, Sc
Ulmus glabra Huds.			S, Sc		S, Sc
Ulmus laevis Pall.			S, Sc		S, Sc

C – commercial
S – scientific

Table 17. Institutions involved in the conservation and use of forest genetic resources

Name of Institution	Type of Institution	Activities or Programmes	Contact Data
1	2	3	4
430 territorial units of the State Forests	Forest Districts of the State Forests (governmental units)	*Ex situ* field plantations and in situ stands and single trees; seed stores	www.lasy.gov.pl sekretariat@lasy.gov.pl
Kostrzyca FGB	The State Forests, The State Forests NFH – governmental unit	*Ex situ* field plantations; ex situ collections in the gene bank; laboratories; scientific research	www.lbg.jgora.pl lbg@lbg.lasy.gov.pl
Forest Research Institute in Warsaw	Governmental unit	Specialist supervision over implementation of the Programme for the Preservation … 2011–2035 and the Programme for Progeny Testing …; field research plots; scientific research	www.ibles.pl ibl@ibles.waw.pl
Poznań University of Life Sciences (Forest Faculty)	University	Scientific research; field research plots	www.wles.up.poznan.pl dziekles@up.poznan.pl
University of Agriculture in Kraków (Forest Faculty)	University	Scientific research; field research plots	www.wl.ur.krakow.pl wles@ar.krakow.pl
Warsaw University of Life Sciences – SGGW (Forest Faculty)	University	Scientific research; field research plots	www.wl.sggw.pl dwl@sggw.pl
Institute of Dendrology (PAS) in Kórnik	Scientific-research Institution	Scientific research; field research plots	www.idpan.poznan.pl idkornik@man.poznan.pl
Kazimierz Wielki University in Bydgoszcz (Faculty of Natural Sciences)	University	Scientific research	www.ukw.edu.pl/jednostka /wydzial_przyrodniczy

1	2	3	4
Adam Mickiewicz University in Poznań (Faculty of Biology)	University	Scientific research	www.biologia.amu.edu.pl
International Paper – Kwidzyń S.A.	Industrial plant	Experimental sites	www.internationalpaper.com/POLAND/PL/Company/Facilities/Kwidzyn.html

Table 18. Requirements for developing legislation for forest genetic resources

Needs	Priority level			
	Not applicable	Low	Moderate	High
Improve forest genetic resource legislation	X			
Improve reporting requirements	X			
Consider sanctions for non-compliance	X			
Create forest genetic resources targeted regulations				X
Improve effectiveness of forest genetic resources regulations	X			
Enhance cooperation between forest genetic resources national authorities				X
Create a permanent national commission for conservation and management of forest genetic resources				X

Table 19. Awareness raising needs

Needs	Priority level			
	Not applicable	Low	Moderate	High
Prepare targeted forest genetic resources information				X
Prepare targeted forest genetic resources communication strategy			X	
Improve access to forest genetic resources information				X
Enhance forest genetic resources training and education			X	
Improve understanding of benefits and values of forest genetic resources				X
Other	X			

Table 20. Overview of the main activities carried out through networks and their outputs

Network name	Activities*	Genus/species involved (scientific names)
IUFRO	Information exchanges Development of technical guidelines Development of shared databases Ectomycorrhizal community structure determination	*Pinus sylvestris, P. mugo, P. nigra, Picea abies, Larix decidua, Abies alba, Quercus sp., Fagus sylvatica, Populus sp., Aesculus hippocastanus*

Table 21. Awareness raising needs / needs for international collaboration and networking

Needs	Level of priority			
	Not applicable	Low	Medium	High
Understanding the state of diversity	X			
Enhancing *in situ* management and conservation		X		
Enhancing *ex situ* management and conservation		X		
Enhancing the use of forest genetic resources	X			
Enhancing research				X
Enhancing education and training				X
Enhancing legislation			X	
Enhancing information management and early warning systems for forest genetic resources			X	
Enhancing public awareness		X		

Table 22. A list of tree and other woody species that are important for food security or livelihoods in Poland

Use for poverty reduction			
Species		Use for food security	Use for poverty reduction
Scientific name	Native (N) or exotic (E)		

Does not concern

Table 23. Types and sub-types of forest soils (State Forests Information Centre, 2003)

No.	Soil type	Soil sub-type	Current symbol
1	2	3	4
1	Lithic Leptosols		**lS**
2	Haplic Regosols		**lR**
3	Rankers/Leptosols/ Regosols		**RN**
		Leptic Regosols	**RNw**
		Folic Regosols	**RNbt**
		Albic Regosols	**RNb**
		Leptic Cambisols	**RNbr**
4	Arenosols		**AR**
		Protic Arenosols	**ARi**
		Haplic Arenosols	**ARw**
		Albic Arenosols	**ARb**

1	2	3	4
5	Pelosols		**PE**
6	Rendzic Leptosols/Regosols		**R**
		Rendzic Leptosols	**Risk**
		Hiperskeletic Rendzic Leptosols	**Rir**
		Folic Rendzic Leptosols	**Rbt**
		Mollic Rendzic Regosols	**Rp**
		Haplic Rendzic Leptosols	**Rw**
		Mollic Rendzic Regosols	**Rc**
		Cambic Rendzic Regosols	**Rbr**
		Chromic Rendzic Leptosols	**Rcz**
7	Pararendzinas Calcaric Regosols		**PR**
		Calcaric Regosols	**PRi**
		Haplic Regosols	**PRw**
		Brunic Regosols	**PRbr**
8	Chernozems		**C**
		Luvic Chernozems	**Cwyw**
		Haplic Phaeozems	**Cwybr**
		Stagnic Phaeozems	**Cwyog**
		Luvic Phaeozems	**Csz**
9	Mollic Gleysols		**CZ**
		Histic Gleysols	**CZms**
		Haplic Gleysols	**CZw**
		Luvic Gleysols	**CZwy**
		Gleyic Cambisols	**CZbr**
10	Cambisols		**BR**
		Haplic Cambisols	**BRw**
		Mollic Cambisols	**BRs**
		Dystric Cambisols	**BRwy**
		Dystric Cambisols	**BRk**
		Albic Cambisols	**BRb**
11	Luvisols		**P**
		Haplic Luvisols	**Pw**
		Haplic Luvisols	**Pbr**
		Albic Luvisols	**Pb**
		Stagnic Luvisols	**Pog**

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1	2	3	4
12	Brunic Arenosols		**RD**
		Haplic Brunic Arenosols	**RDw**
		Brunic Arenosols	**RDbr**
		Albic Arenosols	**RDb**
13	Chromic Arenosols		**OC**
14	Podzols		**B**
		Haplic Podzols	**Bw**
		Rustic Podzols	**Blw**
		Gleyic Podzols	**Bgw**
		Histic Gleyic Podzols	**Bgms**
		Histic Gleyic Podzols	**Bgts**
		Gleyic Podzols	**Blgw**
15	Gleysols		**G**
		Haplic Gleysols	**Gw**
		Mollic Gleysols	**Gp**
		Haplic Gleysols	**Grd**
		Histic Gleysols	**Gt**
		Histic Gleysols	**Gts**
		Histic Gleysols	**Gm**
		Umbric Gleysols	**Gms**
		Fluvic Gleysols	**Gmł**
16	Stagnosols		**OG**
		Haplic Stagnosols	**OGw**
		Albic Stagnosols	**OGb**
		Haplic Stagnosols	**OGSw**
		Histic Stagnosls	**OGSt**
		Histic Stagnosols	**OGSts**
		Endogleyic Stagnosols	**OGam**
17	Fluvic Gleysols		**MŁ**
		Fluvic Gleysols	**MŁw**
		Fluvic Histic Gleysols	**MŁt**
		Limnic Histosols	**MŁgy**
18	Histosols		**T**
		Rheic Sapric Histosols	**Tn**
		Hemic Histosols	**Tp**
		Ombric Fibric Histosols	**Tw**

1	2	3	4
19	Histosols		**M**
		Sapric Histosols	**Mt**
		Fluvic Gleyic Histosols	**Mmł**
		Limnic Histosols	**Mgy**
		Fluvic Histosols	**Mn**
20	Gleysols		**MR**
		Histic Gleysols	**MRm**
		Umbric Gleysols	**MRw**
		Umbric Gleysols	**MRms**
21	Fluvisols		**MD**
		Haplic Fluvisols	**MDi**
		Haplic Fluvisols	**MDw**
		Mollic Fluvisols	**MDp**
		Fluvic Cambisols	**MDbr**
22	Fluvisols		**MDM**
23	Fluvisols		**D**
		Haplic Fluvisols	**Di**
		Haplic Fluvisols	**Dw**
		Mollic Fluvisols	**Dp**
		Fluvic Cambisols	**Dbr**
24	Anthrosols		**AK**
		Terric Anthrosols	**AKrs**
		Hortic Anthrosols	**AKhs**
		Terric Anthrosols	**AKl**
		Histic Anthrosols	**AKb**
25	Technosols		**AU**
		Urbic Technosols	**AUi**
		Urbic Technosols	**AUp**
		Calcaric Technosols	**AUpr**
		Salic Technosols	**AUsł**

Table 24. Spatial characteristics of the natural general potential vegetation map of Poland, legend units

Community groups			Description of potential natural vegetation cartographic unit			Total unit area [sq km]	Unit share of country area [%]	Number of point marks on the map
I	II	III	code	English name of potential community type	latin name (associations and other units)			
1	2	3	4	5	6	7	8	9
Hygrophilous deciduous forests	Lowland alder and/or birch swamp or peat forests		1	Middle-European alder fen forest	*Carici elongatae-Alnetum (= Ribeso nigri-Alnetum + Sphagno squarrosi-Alnetum)*	6 474.0	2.069	
	Deciduous alluvial forests, as well as hygrophilous broadleaved and forb-rich forests on the ground-water soils	Lowland riparian forests	2	Lowland willow-poplar floodplain forest; regularly flooded	*Salici-Populetum (= Salicetum albo-fragilis + Populetum albae)*	4 395.3	1.405	
			3	Lowland ash-elm floodplain forest; occasionally flooded	*Ficario-Ulmetum typicum*	6 978.3	2.231	
			4	Lowland eutrophic forb-rich elm-oak forests on the ground-water soils out of floodplains	*Ficario-Ulmetum chrysosplenietosum*	4 401.6	1.407	
			5	Lowland alder and ash-alder forest on the periodically swamped ground-water soils	*Fraxino-Alnetum (= Circaeo-Alnetum)*	31 389.9	10.034	
		Submontane\ montane riparian forests	6	Submontane/montane grey alder floodplain forest	*Alnetum incanae*	1 570.9	0.502	
			7	Submontane forb-rich ash forests along streams and little rivers	*Carici remotae-Fraxinetum*	711.8	0.228	
		Total riparian forests				**49 447.8**	**15.806**	
	Total hygrophilous deciduous forests					**55 921.8**	**17.875**	

1	2	3	4	5	6	7	8	9
Hygrophilous deciduous forests	**Lowland/submontane mesophilous broad-leaved forests, with oak and hornbeam predominant**	**Sub-Atlantic beech-oak-hornbeam forests**	8	Sub-Atlantic beech-oak-hornbeam forest; Pomerania-vicariant, mesotrophic ('poor") Communities	*Stellario-Carpinetum*	6 521.9	2.085	
			9	Sub-Atlantic beech-oak-hornbeam forest; Pomerania-vicariant, eutrophic ('rich") Communities	*Stellario-Carpinetum*	4 521.9	1.445	
		Middle European oak-hornbeam forests	10	Middle European lowland oak-hornbeam forest; Silesia/Wielkopolska-vicariant, mesotrophic ('poor') communities	*Galio-Carpinetum*	13 965.8	4.464	
			11	Middle European lowland oak-hornbeam forest; Silesia/Wielkopolska-vicariant, eutrophic ('rich') communities	*Galio-Carpinetum*	15 443.1	4.936	
			12	Middle European submontane oak-hornbeam forest; Silesia/Wielkopolska vicariant, mesotrophic ('poor') communities	*Galio-Carpinetum*	2 124.1	0.679	
			13	Middle European submontane oak-hornbeam forest; Silesia/Wielkopolska-vicariant, eutrophic ('rich') communities	*Galio-Carpinetum*	1 395.2	0.446	
			14	Middle European lowland oak-hornbeam forest; Kujawy-vicariant, mesotrophic ('poor') communities	*Galio-Carpinetum*	3 313.8	1.059	
			15	Middle European lowland oak-hornbeam forest; Kujawy-vicariant, eutrophic ('rich') communities	*Galio-Carpinetum*	2 182.8	0.698	
		Subcontinental lime-oak-hornbeam forests	16	Subcontinental colline lime-oak-hornbeam forest; Małopolska-vicariant with beech and fir, mesotrophic ('poor') communities	*Tilio-Carpinetum*	17 554.9	5.611	
			17	Subcontinental colline lime-oak-hornbeam forest; Małopolska-vicariant with beech and fir, eutrophic ('rich') communities	*Tilio-Carpinetum*	15 055.0	4.812	

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1	2	3	4	5	6	7	8	9
Hygrophilous deciduous forests	**Lowland/submontane mesophilous broad-leaved forests, with oak and hornbeam predominant**	**Subcontinental lime-oak-hornbeam forests**	18	Subcontinental submontane lime-oak-hornbeam forest; Małopolska-vicariant with beech, fir and spruce, mesotrophic (‘poor’) communities	*Tilio-Carpinetum*	1 004.3	0.321	
			19	Subcontinental submontane lime-oak-hornbeam forest; Małopolska-vicariant with beech, fir and spruce, eutrophicb (‘rich’) communities	*Tilio-Carpinetum*	6 223.6	1.989	
			20	Subcontinental lowland lime-oak-hornbeam forest; Central-Poland-vicariant mesotrophic (‘poor’) communities	*Tilio-Carpinetum*	23 337.1	7.460	
			21	Subcontinental lowland lime-oak-hornbeam forest; Central-Poland-vicariant eutrophic (‘rich’) communities	*Tilio-Carpinetum*	7 180.9	2.295	
			22	Subcontinental lowland lime-oak-hornbeam forest; subboreal vicariant with spruce, mesotrophic (‘poor’) communities	*Tilio-Carpinetum*	6 838.4	2.186	
			23	Subcontinental lowland lime-oak-hornbeam forest; subboreal vicariant with spruce, eutrophic (‘rich’) communities	*Tilio-Carpinetum*	4 676.5	1.495	
			24	Subcontinental colline lime-oak-hornbeam forest; Wolhynia-vicariant without beech, with many thermophilous species, mesotrophic (‘poor’) communities	*Tilio-Carpinetum*	466.1	0.149	
			25	Subcontinental colline lime-oak-hornbeam forest; Wolhynia-vicariant without beech, with many thermophilous species, eutrophic (‘rich’) communities	*Tilio-Carpinetum*	2 259.7	0.722	
			26	Lowland/colline forb-rich fir forest with hornbeam and oak, so-called ‘black wood’	*Tilio-Carpinetum (?)*	1 678.9	0.537	
		Total oak-hornbeam forests				**135 743.9**	**43.390**	

1	2	3	4	5	6	7	8	9
Hygrophilous deciduous forests	**Lowland to montane beech and fir-beech forests**	**Forb-rich beech and fir-beech forests (typical)**	29	Lowland forb-rich beech forest	*Galio odorati-Fagetum (=Melico-Fagetum)*	9 566.1	3.058	
			30	Submontane forb-rich Sudeten beech forest	*Dentario enneaphyllidis- Fagetum*	1 066.4	0.341	
			31	Montane forb-rich Sudeten beech forest	*Dentario enneaphyllidis-Fagetum*	246.6	0.079	
			32	Submontane forb-rich Carpathian fir-beech forest; West-Carpathian vicariant	*Dentario glandulosae-Fagetum*	463.7	0.148	
			33	Montane forb-rich Carpathian fir-beech forest; West-Carpathian vicariant	*Dentario glandulosae-Fagetum*	2 163.6	0.692	
			34	Submontane forb-rich Carpathian fir-beech forest; East-Carpathian vicariant	*Dentario glandulosae-Fagetum*	689.9	0.221	
			35	montane forb-rich Carpathian fir-beech forest; East-Carpathian vicariant	*Dentario glandulosae-Fagetum*	2 293.4	0.733	
		Orchid beech forests	36	Calciphilous and subthermophilous beech forests with many orchid species in undergrowth	*Cephalanthero-Fagenion*	37.5	0.012	1
		Acidophilous beech forests	37	Lowland acidophilous beech forest with graminoids and/or dwarf-shrubs in undergrowth	*Luzulo pilosae-Fagetum*	3 800.6	1.215	
			38	Montane/submontane acidophilous beech forest with graminoids and/or dwarf shrubs in undergrowth	*Luzulo luzuloidis-Fagetum*	1 173.3	0.375	
		Fir forests	40	Montane/submontane eutrophic and forb-rich fir forests	*Galio-Abietenion*	1 781.7	0.570	
		Total beech and fir-beech forests				**23 282.9**	**7.442**	**1**

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1	2	3	4	5	6	7	8	9
Hygrophilous deciduous forests	**Maple-lime-sycamore forests**		28	Submontane maple-lime forest on the rocky slopes	*Aceri platanoidis-Tilietum platyphylli*	8.6	0.003	
			39	Montane sycamore forest with tall forbs in undergrowth	*Acerenion pseudoplatani*	14.3	0.005	33
		Total maple-lime-sycamore forests				**22.9**	**0.007**	33
	Thermophilous oak forests		41	Subxero-thermophilous sarmatian oak and pine-oak forests	*Potentillo albae-Quercetum typicum*	6 672.9	2.133	
			42	Thermophilous oak forest of upland-type	*Potentillo albae-Quercetum rosetosum gallicae*	1 319.0	0.422	
		Total thermophilous oak forests				**7 991.8**	**2.555**	
	Total eutrophic deciduous forests					**167 041.6**	**53.394**	34
Acidophilous oak and beech-oak mixed forests			43	Sub-Atlantic moist acidophilous birch-oak forest	*Betulo-Quercetum roboris*	5 34.0	0.171	
			44	Sub-Atlantic acidophilous beech-oak forest; Pomerania-vicariant	*Fago-Quercetum petraeae*	7 868.1	2.515	
			45	Middle-European lowland acidophilous oak forest	*Calamagrostio arundinaceae-Quercetum*	4 489.2	1.435	
			46	Submontane Middle-European acidophilous oak forests	*Luzulo luzuloidis-Quercetum*	1 419.0	0.454	
Total acidophilous mixed forests						**14 310.4**	**4.574**	
Coniferous forests	**Oligotrophic acidophilous pine forests (exceptionally birch and oak forests)**		47	Continental mesotrophic oak-pine mixed Forest	*Pino-Quercetum (=Querco-Pinetum + Serratulo -Pinetum)*	42 672.9	13.640	
			48	South-Baltic coastal pine forest	*Empetro nigri-Pinetum*	333.0	0.106	
			49	Suboceanic Middle-European pine forest	*Leucobryo-Pinetum*	17 403.4	5.563	
			50	Continental East-European pine forest; Sarmatian-vicariant with subxerophilous species	*Peucedano-Pinetum*	3 808.4	1.217	

1	2	3	4	5	6	7	8	9
Coniferous forests	**Oligotrophic acidophilous pine forests (exceptionally birch and oak forests)**		51	Continental East-European pine forest; subboreal-vicariant with spruce	*Peucedano-Pinetum*	3 439.5	1.099	
			52	Sub-Atlantic swamp birch forest	*Vaccinio uliginosi-Betuletum pubescentis*	104.4	0.033	5
			53	Continental swamp/bog pine forest	*Vaccinio uliginosi-Pinetum*	414.4	0.132	914
		Total pine forests				**68 176.0**	**21.792**	**919**
	Acidophilous spruce and fir forests		54	Submontane moist spruce-pine forest	*Calamagrostio villosae-Pinetum*	425.9	0.136	
			55	Lowland subboreal spruce forests	*Sphagno girgensohnii-Piceetum, Querco-Piceetum*	155.7	0.050	68
			56	Colline/submontane mesotrophic fir forest	*Abietetum polonicum*	844.5	0.270	12
			57	Lower-montane spruce forests (in rare cases fir-spruce)	*Abieti-Piceetum, Galio-Piceetum*	1 345.0	0.430	
			58	Sudeten higher-montane spruce forest	*Calamagrostio villosae-Piceetum (=Piceetum hercynicum)*	136.6	0.044	
			59	West-Carpathian higher-montane spruce Forests	*Plagiothecio-Piceetum, Polysticho-Piceetum*	134.9	0.043	
		Total spruce and fir forests				**3 042.5**	**0.973**	**80**
	Total coniferous forests					**71 218.5**	**22.765**	**999**
Non-forest special habitat communities	**Subalpine/alpine vegetation complexes**		60	Sudeten subalpine 'Krummholz" thicket	*Pinetum mughi sudeticum*	20.4	0.007	
			61	Carpathian subalpine 'Krummholz" thicket	*Pinetum mughi carpaticum*	41.5	0.013	
			62	Alpine/subalpine grassland, forbs- and dwarf-shrub formations, as well as subalpine deciduous shrubland or thicket	*Caricetalia curvulae, Betulo-Adenostyletea, Elyno-Seslerietea*	61.4	0.020	
		Total subalpine/alpine communities				**123.4**	**0.039**	

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1	2	3	4	5	6	7	8	9
Non-forest special habitat communities	**Mossy bog vegetation with dwarf shrubs**		63	Atlantic wet dwarf-scrub (heaths)	*Sphagno-Ericetalia*	16.9	0.005	19
			64	Raised bog complexes	*Sphagnetalia magellanici*	96.1	0.031	476
			65	Subboreal mesotrophic non-raised bogs with mosses and sedges	*Caricetalia fuscae*	33.5	0.011	
		Total bog communities				**146.4**	**0.047**	**495**
	Extrazonal and azonal vegetation of special habitats		66	Natural and semi-natural xero- and calciphilous grassland – the so-called steppe-like communities	*Festucetalia valesiacae*	1.9	0.001	818
			67	Coastal and inland salt marshes and similar formations	*Thero-Salicornietea, Cakiletea maritimae, Asteretea tripolium*	20.7	0.007	71
			68	Pioneer communities on the coastal 'white" dunes	*Ammophiletea*	12.5	0.004	
	Total non-forest special habitat communities					**304.8**	**0.097**	**1384**
Other cartographic units			69	Devastated environment vegetation, succession unknown; also areas without vegetation	Without phytosociological characteristics	283.3	0.091	
			0	Rivers, lakes		3 768.4	1.205	

Table 25. Removals in 2000–2010

Assortments[a]	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	in dam^3										
TOTAL	**27 659**	**26 671**	**28 951**	**30 836**	**32 725**	**31 945**	**32 384**	**35 935**	**34 261**	**34 629**	**35 467**
Of which timber	**26 025**	**25 017**	**27 137**	**28 737**	**30 426**	**29 725**	**30 228**	**34 146**	**32 407**	**32 701**	**33 568**
Coniferous	19 540	18 047	19 828	20 838	22 059	21 919	22 326	26 375	24 511	24 529	25 579
of which:											
large-size wood	9 470	8 227	8 527	9 168	9 706	9 953	10 445	12 871	11 143	11 570	11 691
medium-size wood for industrial uses	8 507	8 256	9 458	9 685	10 253	10 249	10 120	11 525	11 415	11 570	11 982
Fuelwood	730	743	1 105	1 276	1 350	1 015	1 080	1 231	1 176	1 379	1 364
Non-coniferous	6 485	6 970	7 309	7 899	8 367	7 806	7 902	7 771	7 896	8 172	7 989
of which:											
large-size wood	2 484	2 503	2 397	2 597	2 738	2 762	2 697	2 600	2 572	2 547	2 629
medium-size wood for industrial uses	3 193	3 568	3 876	4 238	4 473	3 959	4 004	3 809	4 103	4 238	4 008
Fuelwood	806	898	1 036	1 064	1 126	1 085	1 201	1 125	1 221	1 387	1 352

[a] Based on *the quality-size classification defined by Polish Norms*

Table 26. Reported impacts and threats, including forest management, on the condition of natural habitats (Monitoring of forest habitats in 2006-2008; Chief Inspectorate of Environmental Protection, www.gios.gov.pl**)**

Code	Type of natural (forest) habitat	Protection Recommendations
1	2	3
2140	Decalcified fixed dunes with *Empetrum nigrum*	**Major threats:** afforestation of dunes, technical protection of coasts, mechanical damage related to recreational activity. **Protection recommendations**: the best form of protection is passive protection or lack of any human interference. The intensive development of tourism and construction of summer houses is a serious threat to these small-area communities. Close cooperation with the Maritime Office and, primarily, the exclusion of these areas from planned afforestation are necessary to protect and preserve the habitats.
4070	Bushes with *Pinus mugo* and *Rhododendron hirsutum* (*Mugo-Rhododendretum hirsuti*)	**Major threats:** expansion of ski infrastructure, inappropriate use of the existing infrastructure (the use of land outside ski routes, incorrect setting out of ski routes), trampling (limited to the immediate neighbourhood of tourist trails), mechanical destruction of mountain pine shoots. **Protection recommendations:** the existing recreational infrastructure should not be expanded and must be used with the utmost care to preserve the natural habitat.

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1	2	3
9180	*Tilio-Acerion* forests of slopes, screes and ravines (*Tilio platyphyllis-Acerion pseudoplatani*)	**Major threats:** pressure from tourists on hiking trails, tourism and road traffic, hazards associated with planned construction of buffer reservoirs on steep slopes of river valleys and (rarely) from forest management. **Protection recommendations:** the most appropriate form of protection is passive protection. Protective regimes prevailing in nature reserves and national parks (as well as in the territory of some Forest Districts) will maintain the favourable conservation status of the habitat. Due to its small area and high natural value, the habitat should be strictly protected and excluded from forest management.
91D0	Bog woodland	**Major threats:** disturbances in water relations, intensification of logging, enrichment of species composition (introduction of undergrowths and understory species), bark beetle outbreaks. **Protection recommendations:** if natural water conditions are preserved, the most appropriate passive protection for forests and bog woodland is the exclusion of final felling or, exceptionally, the admission of selection felling. Otherwise, active protection such as damming water using gates and filling ditches. Protective forests and swamp forests should be seen as part of the comprehensive protection of peat bogs where forests and woodlands occur. The 91D0 habitat itself can and should be subject to protection, but there are also situations where the purpose of protection of bog ecosystems will be to inhibit forest expansion and increase the area of open bogs at the expense of swamp forests. The planning of the protection of coniferous and swamp forests should be comprehensive and always carried out for the whole complex of hydrogenic habitats. Especially when planning the protection of small habitat patches, the impact of the surrounding non-bog environment must be taken into account, that is, avoid disturbances in the immediate vicinity of the protected habitat, such as the use of clear-cuts at a distance of about two stand heights from the bog forest patches. General rules for the protection of coniferous and swamp forests in individual objects may be modified, for example in relation to the needs of conservation of valuable species (such as black grouse, wood grouse, white-tailed eagle) or plants (e.g. cloudberry).
91E0	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)	**Major threats** regulation of river beds, construction of hydro-engineering facilities, maintenance of flood embankments, the invasion of alien species of herbaceous plants. **Protection recommendations:** maintain the natural rhythm of flooding, limit timber harvesting, if necessary reconstruct stands (remove alien species in the stand), remove invasive alien species in the undergrowth, in some cases, reconstruct the existing hydro-engineering structures. The protection of riparian forests should rely on maintaining or restoring natural water regimes and be the basis for a reasonable compromise between the optimum passive protection for the ecosystem and forest management needs. Such a compromise can be achieved by excluding part of the riparian forests from use and „leaving them to nature”. The following principles are recommended for use: • The specimen examples of the most valuable and best preserved natural habitats should be excluded from use and protected as ‘reference areas’ or given the status of nature reserves so that the specimens of „riparian forest growing in a natural way” measuring at least 30–50 hectares are ultimately present in each Forest District.

1	2	3
91E0	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*)	• Prohibit the use of clear-cuts (I). • Complex felling can be applied to the remaining patches, but with much attention given to the preservation and restoration of decaying wood resources and the preservation of intact fragments of old-growth stands. As a consequence to retain 5 per cent of stands for the next generation in each clear-cut area but not less than 0.5 hectare in the form of compact fragments. Leave the dying and dead trees, so that the decaying wood resources constitute at least 10 per cent of mature stand volume. Not to remove old birch, aspen, alder and hornbeam trees (hollow-nesting species). • While planning the final harvest, care should be taken that it does not worsen 'the structure of the protection status' of riparian forest stands on a Forest District scale and does not reduce the share of stands over 100 years-old. • If there are ash, elm and oak trees in the stand, the proportion of these species should also be retained in the renewals. • Eliminate species of foreign origin (e.g. Canadian poplar, also shrubs). • Tolerate local natural bog development, tolerate the activity of beavers. • In the case of fluviogenic swamp forests, they should be excluded from use. Also, clear-cuts should be prohibited in adjacent stands at a distance of two stand heights from the edge of the swamp forest. The need for the preservation of swamp forests must be included in flood protection plans. Natural disturbances (flood damage, river erosion, beaver activity), even if leading to the local destruction of trees and phytocoenoses, should not be regarded as negative in terms of the conservation status of swamp forests and, usually, they do not require intervention.
91I0	Euro-Siberian steppic woods with *Quercus* spp. (*Quercetalia pubescentis-petraeae*)	**Major threats:** Poorly-regenerating oak stands, excessive undergrowth canopy closure, emergence of neophytes, withdrawal of thermophilous species, transformation towards oak-hornbeam stands. **Protection recommendations:** regular cuts to reduce the shading of the forest floor, removal of non-native species from stands. This requires active protection, removal of undergrowths and understory which shade the forest floor, sometimes the stand canopy needs thinning to ensure the conditions of growth for the thermophilous species that decide the nature of the ecosystem.
91P0	Świętokrzyski fir forest (*Abietetum polonicum*)	**Major threats:** the expansion of invasive alien species (both in the herb layer and forest stand) is a minor threat. The excessive domination of blackberries and the lack, in some cases, of the natural regeneration of fir do not pose a threat to this habitat in the wild. In addition, the status of this habitat is fairly stable, and the management conducted in state-owned forests is conducive to promoting the species composition typical of *Abietetum polonicum*. In the case of habitats located on private land a certain threat arises from the overexploitation of stands in older age classes. **Protection recommendations:** maintain the current management, retain deadwood in the forest, supervise harvests in private forests. The prospects for the preservation of the habitat seem positive. The current forest management assumes the promotion of fir as a forest-forming species; its natural regeneration is found in most monitored locations. In Roztocze, some threats to fir forests adjacent to beech patches derive from the expansion of the Carpathian beech, whose abundant undergrowth is competition for fir trees.

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1	2	3
91P0	Świętokrzyski fir forest (*Abietetum polonicum*)	A list of threats and potential conflicts between human activity and preservation of the habitat condition mainly consists of those types of human activity that are associated with forest management – mainly the removal of dead trees. The threats from tourism and plant collection appear less severe.
91Q0	Relic Western Carpathian calcicolous *Pinus sylvestris* forests	**Major threats:** Potential, mechanical damage by trampling. **Protection recommendations:** the current passive protection should be continued. Habitat resources are located in national parks, mainly in the strict protection zone where forest management is permitted. Passive, and preferably strict protection, are the appropriate forms of protection for this habitat. No protective measures have been carried out so far in this type of habitat.
91T0	White cushion moss pine forests belong to the habitat type 'Central European lichen pine forests"	**Major threats:** Eutrophication leads to the disappearance of the moss-lichen layer, changing the age structure of the stand, mechanical damage to lichens. **Protection recommendations:** active protection is recommended, such as the removal of all slash and wood residue after management treatment and the removal of pine and oak regeneration. Reports appear to confirm the disappearance of the habitat. This phenomenon is more intense in the south rather than in the north of Poland. Moss pine forests in central Poland have either completely disappeared, or are highly degraded and there is no chance for their reinstatement, whereas the habitat in the north of the country is in the initial stage of degradation which can be reversed by active protection. As a result of monitoring, a method of active protection of the habitat has been developed based on the ancient traditions of people living in heavily wooded areas. It is known that raking of litter and collection of wood from the forest contributes to the depletion of forest floor vegetation in pine forests, thus establishing favourable conditions for the development of lichen cover. In areas not covered by protection, where fragments of the moss pine forest have been preserved, in order to protect this habitat it is recommended to remove all the wood that has remained after silvicultural treatments. This means that if early or late thinning has been performed, all the slash and coarse wood should be taken away from the area. Otherwise, in about two years, the habitat will be completely degraded. These simple treatments, combined with the removal of the natural regeneration of pine and oak, will successfully support the active protection of this natural habitat in the future.

Table 27. Promotional Forest Complexes (PFCs)

Item	PFC	Location of PFC		Area (ha)
		RDSF	Forest District	
1.	The Lubuskie Primeval Forests PFC	Zielona Góra	Lubsko	32 135
2.	The Tuchola Forests PFC	Toruń	Tuchola, Osie, Dąbrowa, Woziwoda, Trzebciny	84 140
3.	The Beskid Sądecki Forests PFC	Kraków	Piwniczna, Forest Experimental Station in Krynica (University of Agriculture in Kraków)	19 650
4.	The Beskid Śląski Forests PFC	Katowice	Bielsko, Ustroń, Wisła, Węgierska Górka	39 883
5.	The Birczańskie Forests PFC	Krosno	Bircza	29 578
6.	The Gostynin-Włocławek Forests PFC	Łódź, Toruń	Gostynin, Łąck, Włocławek	53 093
7.	The Janów Forests PFC	Lublin	Janów Lubelski	31 620
8.	The Mazury Forests PFC	Olsztyn Białystok	Strzałowo, Spychowo, Mrągowo, Pisz, Maskulińskie, Research Station for Ecological Agriculture and Preservation of Native Breeds (PAS) at Popielno	118 216
9.	The Oliwa-Darżlubskie Forests PFC	Gdańsk	Gdańsk, Wejherowo	40 907
10.	The Rychtal Forests PFC	Poznań	Antonin, Syców, Forest Experimental Station in Siemianice, Poznań University of Life Sciences	47 992
11.	The Spała-Rogów Forests PFC	Łódź	Brzeziny, Spała, Rogów Forest Experimental Station (Warsaw University of Life Sciences – SGGW)	34 950
12.	The Warcińsko-Polanowskie Forests PFC	Szczecinek	Warcino, Polanów	37 335
13.	The Białowieża Primeval Forest PFC	Białystok	Białowieża, Browsk, Hajnówka	52 637
14.	The Kozienice Primeval Forest PFC	Radom	Kozienice, Zwoleń, Radom	30 435
15.	The Noteć Primeval Forest PFC	Piła, Poznań, Szczecin	Potrzebowice, Wronki, Krucz, Sieraków, Oborniki, Karwin, Międzychód	137 273
16.	The Szczecin Primeval Forests PFC	Szczecin	Kliniska, Gryfino, Trzebież, Szczecińskie Primeval Forests	61 070
17.	The Świętokrzyskie Primeval Forest PFC	Radom	Kielce, Łagów, Suchedniów, Zagnańsk, Skarżysko	76 885
18.	The Western Sudety Forests PFC	Wrocław	Szklarska Poręba, Świeradów	22 866
19.	The Warszawa Forests PFC	Warsaw	Celestynów, Chojnów, Drewnica, Jabłonna	48 572
Total area of PFCs				**999 237**

Table 28. National Parks in Poland

YEARS NATIONAL PARKS	Year of Category Foundation	Category according to IUCN	Area in hectares			
			total	of which forests	total under strict protection	
					total	of which forests
2000	X	X	306 494.1	190 893.4	64 321.9	50 400.6
TOTAL 2005	X	X	317 233.8	193 710.9	67 294.8	52 414.7
2008	X	X	314 477.4	195 056.1	67 660.8	53 692.2
2009	**X**	**X**	**314 483.6**	**195 044.4**	**68 001.2**	**54 058.7**
Biebrza	1993	–	59 223.0	15 682.9	4 472.2	3 757.3
Kampinos	1959	II	38 548.5	28 258.8	4 636.0	4 130.2
Bieszczady	1973	II	29 195.1	24 719.1	18 553.6	16 871.2
Słowiński	1967	II	21 572.9*d*	6 181.5	5 928.9	2 630.1
Tatra	(1947) *a,* 1954	II	2 1197.3	16 290.0	12 449.1	7 956.8
Magurski	1995	–	19 437.9	18 571.7	2 407.7	2 407.7
Wigry	1989	V	14 987.9	9 410.7	623.2	283.0
Drawa	1990	II	11 342.0	9 548.0	569.0	443.3
Białowieża	(1932) *b,* 1947	II	10 517.3	9 974.0	5 726.1	5 531.0
Polesie	1990	II	9 764.4	4 784.8	116.0	115.1
Roztocze	1974	II	8 482.8	8 101.3	805.9	805.9
Wolin	1960	II	8 133.1	4 641.9	500.2	418.8
Warta Mouth	2001	–	8 074.0	81.7	681.9	–
Świętokrzyskie	1950	II	7 626.4	7 221.7	1 715.2	1 696.6
Wielkopolska	1957	II	7 583.9	4 729.8	259.7	114.5
Narew	1996	–	7 350.0	93.0	–	–
Gorce	1981	II	7 030.8	6 591.5	3 610.8	3 596.0
Góry Stołowe	1993	–	6 340.4	5 778.2	771.0	771.0
Karkonosze	1959	II	5 580.5	4 021.8	1 726.1	294.1
Tuchola Forests	1996	–	4 613.0	3 935.7	324.3	278.4
Babiagóra	1954	II	3 390.5	3 232.3	1 124.5	1 023.8
Pieniny	(1932) *c,* 1954	II	2 346.2	1 665.2	748.9	683.0
Ojców	1956	V	2 145.7	1 528.8	250.9	250.9

Table 29. Storage of seed material in organizational units of the State Forests

Item	Forest District – store	RDSF	Conifers – maximum weight of stored seeds [kg]	Broad-leaves – maximum weight of stored seeds [kg]	Notes	Number of cold store rooms	Temperature range in the cold store
1	2	3	4	5	6	7	8
1.	Czarna Białostocka	Białystok	6 000.00	0.00	small quantities of seeds of deciduous trees for own needs	2	a) 1st room +6°C b) 2nd room -10°C
2.	Maskulińskie	Białystok	12 000.00				cold store with constant temperature 4-5°C
3.	Kaliska	Gdańsk	3 900.00	0.00	cannot store seeds of deciduous species	2	from -5°C to +5°C
4.	Kluczbork	Katowice	10 000.00	27 600.00		5	a) four rooms -10°C; b) one room from -2°C to -3°C
5.	Brzesko	Kraków	12.5 m^3	0.00	cannot store seeds of deciduous species	2	a) 1 room from 0 to -6°C b) 1 room from 0 to -6°C
6.	Dukla	Krosno	500.00	29 500.00		6	a) two rooms -10°C b) two stratification rooms +3°C c) one room -3°C d) one room in the laboratory for germination tests +3°C
7.	Zwierzyniec	Lublin	1 500.00	5 000.00		2	a) one room -4°C b) second room -10°C
8.	Grotniki	Łódź	3 500.00	2 500.00		7	a) 5 cooling cabinets from +25°C to -30°C b) 2 cooling cabinets from +5°C to -20°C
9.	Jedwabno	Olsztyn	5 000.00	15 000.00		3	a) one room to -10°C. b) one room to -20°C. c) one stratification room to -5°C.

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1	2	3	4	5	6	7	8
10.	Jarocin	Poznań	12 000.00	30 000.00		4	a) one room from 0 to -10°C. b) three rooms from 0 to -10°C
11.	Dębno	Szczecin	8 000.00	7 000.00		2	+10 : -10°C
12.	Smolarz	Szczecin	0.00	22 000.00		2	to -3°C
13.	Białogard	Szczecinek	6 000.00	29 300.00		5	a) two rooms to -10°C b) one room to -3°C c) two rooms +3°C
14.	Świerczyna	Szczecinek	0.00	16 000.00		2	+3 : -20°C
15.	Rytel	Toruń	3 000.00	2 500.00		2	a) one room to -3°C b) one room to -9°C
16.	Jabłonna	Warsaw	400.00	15 000.00		3	a) two rooms from -3°C to +3°C b) one stratification room from -3°C to +25°C
17.	Kostrzyca FGB	Wrocław	10 000.00	15 000.00		11	a) two rooms +3°C b) four stratification rooms +15°C: 20°C c) one room -3°C d) three rooms to -10°C e) one room -20°C
18.	Nowa Sól	Zielona Góra	3 000.00	6 960.00		5	a) two rooms +3°C b) one room -3°C c) one room -5°C d) one room -7°C

Table 30. List of Botanical Gardens and Arboreta in Poland

Item	Name	Contact dat	Area [ha]	Activities
1	2	3	4	5
1.	**The Brama Morawska Arboretum**	ul. Markowicka 17 47-400 Racibórz e-mail: arboretum.raciborz@interia.pl tel. (32) 415 44 05 Director: mgr inż. Hubert Kretek	162	Protection of habitats from excessive exploitation; Multiplication/augmentation of natural resources under controlled conditions; Protection of endangered species where they occur naturally. The arboretum has a collection of rhododendrons, lilacs, junipers, clematises, barberries, hostas, dogwoods, ferns, and aquatic and wetland plants. The arboretum includes a stand of 180-year-old trees.

1	2	3	4	5
				The arboretum vegetation consists mostly of common plants that are widespread in the lowlands, with a number of rare species occurring in Poland. These species are field maple, rice cutgrass, snowdrop, Siberian squill, hacquetia, field garlic and autumn crocus.
2.	**The Bishop Jan Chrapek Arboretum in Marcule – Marcule Forest District**	27-100 Iłża tel. (48) 695 390 254; (48) 616 00 77 Manager: inż. Radosław Koniarz e-mail: radoslaw.koniarz@op.pl	6.5	The arboretum boasts a collection of nearly 600 species and varieties of trees, shrubs and perennials typical of the entire temperate climate zone. The most numerous are maple trees (30 species) and magnolia trees (26 species) The arboretum also has a small rock garden with a collection of mountain plants. The arboretum has the following sections: Native Flora, Foreign Flora, Rock Garden, Heather Plants, Maples, Magnolias.
3.	**The Arboretum and Institute of Physiography in Bolestraszyce**	Bolestraszyce-Zamek 37-700 Przemyśl e-mail: arboretum@poczta.onet.pl tel. (16) 671 64 25 Director: Dr Narcyz Piórecki	25	Number of taxa: trees and shrubs – 2200, herbaceous plants – 1200, including: native plants – about 600 greenhouse plants – 180.
4.	**The Kórnik Arboretum of the Institute of Dendrology (PAS)* in Kórnik**	ul. Parkowa 5 62-035 Kórnik e-mail: idkornik@rose.man.poznan.pl tel. (61) 817 00 33 Manager: Dr Kinga Nowak-Dyjeta	> 40	The arboretum has a collection of about 3 500 species and varieties of trees and shrubs It has a rich collection of trees and shrubs native to the temperate zone in the northern hemisphere. Representatives of the woody flora of East Asia (Japan, Korea, China) and North America are particularly numerous. The collections also include trees and shrubs from the mountain regions of Central Asia and the Caucasus.
5.	**The Prof. S. Białobok Forest Arboretum in Syców**	56-506 Stradomia GRN e-mail: sycow@poznan.lasy.gov.pl tel. (62) 785-13-25 Manager: Stanisław Sęktas	150	Approximately **1500 taxa of trees and shrubs**. The arboretum includes dendrological collections, an alpinarium (rock garden) with a collection of aquatic and protected plants, a nursery, seed orchards, clonal archives of valuable species and a ‘green school’. The genetic resources/germplasm collected in the arboretum come from western Poland. Conifers are represented by 26 genera. The most numerous are pine (more than 60 species and varieties). These include dwarf varieties of European black pine (*Pinus nigra*), spruce, fir, larch, juniper, false cypresses and cedars. Among the deciduous trees and shrubs, species and varieties of maple, birch, magnolia and beech make up the largest collections. The rhododendron collection – about 300 taxa.

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1	2	3	4	5
6.	**The Arboretum of the Warsaw University of Life Sciences (SGGW) in Rogów**	96-135 Rogów e-mail: arbor@wp.pl tel. (46) 874 81 36 Manager: mgr Piotr Banaszczak	53.76	Collections of woody plants: Number of taxa: 2837 Number of provenances: 5667 Number of specimens: 35 750 The arboretum specializes particularly in several groups of woody plants: coniferous trees and shrubs – botanical taxa genus *Acer* L. – the National Collection dendroflora of China genus *Stewartia* L. – the National Collection Araliaceae family and, in particular, the genus *Eleutherococcus* Maxim. genus *Sorbus* L. – the National Collection The alpinarium occupies an area of approximately 1.4 hectares, of which the rock area occupies 15 ares. The alpinarium contains more than 700 species and varieties of plants from mountains around the world. A small area in the alpinarium is occupied by collections of **Polish flora** made up of protected, endangered and rare plants. In this section, as well as throughout the arboretum, there are more than 80 plant species that are endangered and legally protected in Poland. **The collections of herbaceous plants** are mainly in the alpinarium and the surrounding area. These include mountain vegetation, as well as aquatic, wetland and floodplain species. The collection now has over 640 species and varieties (806 provenances, 6650 individuals). **The forest experimental sites** are small areas with alien species set up for experimental purposes. The planted trees are tested and observed to check the growth, health condition and productivity of individual species for forest management needs. The arboretum is made up of about 130 plots with an average area of 0.1 hectares (0.05–0.5 ha). They occupy an area of over 18 hectares.
7.	**The Arboretum of the University of Wrocław in Wojsławice**	58-230 Niemcza e-mail: obuwr@biol.uni.wroc.pl tel. (71) 322 59 57 Acting Director: mgr inż. Hanna Grzeszczak-Nowak	11	There are around 2000 species and varieties, including 1500 trees and shrubs. genus *Rhododendron* – 470 species; the National Collection includes 60 individuals of the genus *Rhododendron, Lusatian* race.

1	2	3	4	5
8.	**The Arboretum of the University of Human and Life Sciences in Sandomierz**	ul. Krakowska 26 27-600 Sandomierz e-mail: wshp@wshp.sandomierz.pl tel. (15) 832 22 84 Manager: Dr Barbara Woytowicz	1.5	The arboretum is divided into two main sections: the southern section with cultivars and tree and shrub varieties and the northern section, which is elevated and dominated by botanical species from Asia, Europe and America.
9.	**The Forest Arboretum of Warmia and Mazury – Kudypy Forest District**	Kudypy 4 11-036 Gietrzwałd e-mail: kudypy@olsztyn.lasy.gov.pl tel. (89) 527 90 90 Manager: inż. Witold Szumarski e-mail: w.szumarski@olsztyn.lasy.gov.pl	15.69	The arboretum is a forest park with elements of landscape topography, thinned areas in the stands of trees, bodies of water, paths, roads, footbridges, bridges and open-sided roofed shelters. **There are about 1000 species** and **varieties** of trees and shrubs growing in the arboretum**.** Sections: • **Polish Flora**. The collection of approximately 300 species and varieties of trees and shrubs is one of the finest and largest collections of the native species that occur in Poland. • **The Arboretum Collection**. A collection of more than 700 species and varieties of trees and shrubs. The most numerous of the plants are the maples (more than 30 species), the cotoneaster plants (29 species) and the wild-growing honeysuckles and roses. The collections of juniper, spruce, fir and other coniferous species are also worth mentioning. • **The Natural Forest**. This is a part of the ancient natural forest with monument trees.
10.	**The Glinna Dendrology Garden – Gryfino Forest District**	ul. 1 Maja 4 74-100 Gryfino e-mail: gryfino@szczecin.lasy.gov.pl tel. (91) 416 34 42 District Forest Manager mgr inż. Robert Wójcik	6	The garden is home to a collection of over 700 species and varieties of trees and shrubs, of which 25% are species originating from Asia and North America and 18% are from Europe. The conifers include nearly 100 taxa from 25 genera. Maple, magnolia, holly, dogwood, birch and viburnum are among the best- represented deciduous plant genera.
11.	**The Dendrology Garden and Nurseries in Wirty – Kaliska Forest District**	ul. Długa 64 83-260 Kaliska e-mail: kaliska@gdansk.lasy.gov.pl tel. (58) 588 98 18 District Forest Manager mgr inż. Krzysztof Frydel	33.6	The most interesting taxa are: – Sawara cypress var. needled, – Hiba arborvitae, – European beech var white-margined, – Walnut, – Tulip tree var. aureomarginatum. The stand of 110-year-old oak trees covering an area of 1.01 ha serves today as a selected seed stand.

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1	2	3	4	5
12.	**The Dendrology Garden of the Poznań University of Life Sciences**	ul. Wojska Polskiego 71 D 60-625 Poznań e-mail: ogrdend@ up.poznan.pl tel. (61) 848 77 46 Manager: dr inż. Tomasz Maliński e-mail: ogrdend@up. poznan.pl e-mail: tomekm@up. poznan.pl tel. (61) 848 76 46 Scientific Manager: dr hab. inż. Władysław Danielewicz	4.17	Collection of 900 taxa of woody plants. The most important include fir, spruce, pine, alder, oak, shadbushes, euonymus, maple, dogwood and species of the families *Caprifoliaceae*, *Cupressaceae*, *Juglandaceae*, *Ulmaceae*, *Berberidaceae*, *Rosaceae*, *Fabaceae* and *Rutaceae* occurring in Poland in the wild. There are also a large number of species of foreign origin – mostly Asian and North American. Some of these taxa are rare, endangered or little known. The special collection of Polish blackberries contains more than 80 taxa.
13.	**The Dendrology Garden in Przelewice**	74-210 Przelewice gm. Pyrzyce woj. Zachodniopomorskie tel. (91) 564 30 80 Director: mgr inż. Maria Syczewska e-mail: msyczewska@ ogrodprzelewice.pl	45	The dendrology garden boasts almost all the tree species protected in Poland, including 1200 species and varieties of trees and shrubs, such as wild service (*Sorbus torminalis*) and flowering specimens of common ivy (*Hedera helix*) creeping up the old trees. Specimens of the protected, rare and endangered herbaceous species recorded in the Polish Red Data Book of Plants, as well as protected alien species recorded in the World Red Data Book, are well-represented in the garden. The garden includes natural locations of protected plants such as broad-leaved helleborine (*Epipactis helleborine*) or common ivy (*Hedera helix*).
14.	**The Forest Culture Centre in Gołuchów – Arboretum in Gołuchów**	ul. Działyńskich 2 63-322 Gołuchów e-mail: okl@okl.lasy. gov.pl tel. (62) 761 50 45 Director: mgr inż. Benedykt Roźmiarek	158.05	The centre was founded in 1853 by Jan Działyński. It has the following sections: – The Old Park with the hornbeam-lime alley, lime alley and specimens of nootka cypress, Western red cedar and the maidenhair tree, – The New Park with a collection of beech and oak trees, – The Wild Promenade with *Potentilla* spp., spruce, lilacs and *Spirea* spp., – The Sunny Promenade with red oaks, pin oaks and Eastern hemlock, – The Animal Show Farm with bison, the Polish horse, wild boar and fallow deer the ‘Oficyna’ Museum of Forestry and the ‘Powozownia and Owczarnia’ complex.

1	2	3	4	5
15.	**The Forest Arboretum at the Experimental Station of the Poznań University of Life Sciences in Zielonka**	Zielonka 6 62-095 Murowana Goślina e-mail: arboretum@au.poznan.pl tel. (61) 811 38 16 Director: inż. Marian Grodzki	83	Research (using dedicated experimental plots) has been in progress at the arboretum since 1870. Its purpose is to determine the suitability of alien species of trees for forest management. The arboretum has two sections: Observation and Research. The arboretum has over 800 species and varieties of trees and shrubs of both native and foreign origin. There is an emphasis on protected species. The scope of the research includes acclimation and the suitability of various species for forest purposes, the preservation of forest genetic resources, collecting rare and endangered taxa, and the testing and selection of varieties.
16.	**The Arboretum of Kartuzy Forests – Kartuzy Forest District**	Forest District Kartuzy Kartuzy Burchardztwo 181 e-mail: kartuzy@gdansk.lasy.gov.pl tel. (58) 685 29 30	4.03	The arboretum was founded by Jan Duda in the Kartuzy Forest District in 2011. The idea was to preserve the diversity of dendroflora. In all, 23 species of trees grow in the arboretum.
17.	**The Golubie Botanical Garden**	ul. Botaniczna 21 83-316 Gołubie tel. (58) 684 36 08, 600 872 501 Director: mgr Zbigniew Butowski e-mail: zbutowski@poczta.wp.pl	2.12	The botanical garden is known for its collection of about 4000 taxa of vascular plants from different regions of the Earth, including about 150 protected species. These include plants listed in the Polish Red Data Book of Plants (50 taxa). The plant collection is divided into five sections: Ecological, Medicinal Plants, Ornamental Plants, Arboretum and Woodlands. The plants are grouped according to natural communities. The Garden keeps full documentation of the sources of origin, place and date of planting and tending treatments. The plants are labelled with the name of the family, and scientific (Latin) and Polish names. There are plans to deploy the plants in various quarters of the botanical garden (systematic inventory). Phenological observations and assessment of the degree of acclimation of plant species of foreign origin outside their areas of occurrence are conducted in the garden.
18.	**The Mountain Botanical Garden of the Institute of Nature Conservation (PAS)**	ul. Antałówka 7 34-500 Zakopane (18) 201 26 51 Manager: Dr Paweł Olejniczak e-mail: olejniczak@iop.krakow.pl	0.3	The botanical garden has a collection of more than 600 species of 290 genera and 72 families with almost all endemic and subendemic plants from the Western Carpathians, Carpathians and Tatras, such as *Cochlearia tatrae*, *Saxifraga wahlenbergii, Delphinium oxysepalum and Oxytropis carpatica*.

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1	2	3	4	5
				The collection of plants protected by law is made up of about 70 species under strict or partial protection that represent 18 per cent of all the protected plants in Poland. These include *Crocus scepusiensis, Cypripedium calceolus, Gentiana verna and Lilium martagon*.
19.	**The Botanical Garden of the City of Zabrze**	ul. Piłsudskiego 60 41-800 Zabrze tel. (32) 271 30 33; (32) 276 39 10 Director: mgr inż. Danuta Tarkowska e-mail: dyrektor@mob-zabrze.pl	6.5	There are 800 taxa. • The Park Section – about 5000 specimens of trees and shrubs (260 taxa), • The Collection of Perennial Herbaceous Plants (over 200 taxa), • The Rosarium – 2500 specimen of roses, different types in 64 varieties (large-flower, multiflorous, park, ground cover, miniature plants and creepers), • Annual Plants: salvia, ageratum houstonianum, marigold, dahlia, canna and many others, • Greenhouses with more than 340 taxa of plants from different climatic zones of the world.
20	**The Botanical Garden and Institute of Plant Culture and Acclimation in Bydgoszcz**	ul. Jeździecka 5 85-687 Bydgoszcz tel. (52) 381 31 93 Manager: dr inż. Włodzimierz Majtkowski e-mail: w.majtkowski@interia.pl	5.5	The collections of plants are used for scientific research coordinated by the Institute of Plant Breeding and Acclimation (IHAR) in Radzikowo near Warsaw. The research focuses mainly on collecting and assessing the gene resources of grasses.
21.	**The 'Myślęcinek' Botanical Garden in the Forest Park of Culture and Leisure**	ul. Gdańska 173-175 85-674 Bydgoszcz e-mail: bcee@bcee.bydgoszcz.pl, lpkiw@bydgoszcz.com tel. (52) 328 00 09; (52) 328 00 23 tel./fax. 328-00-24 Manager: mgr inż. Karol Dąbrowski	60	Of 820 plant species, 460 are wild-growing plants. Sections: • Plant Communities of Poland – the plant species are displayed in the communities and habitats in which they occur in the wild. Of those grown in the garden, the most interesting are the forest communities (oak-hornbeam forests, floodplain forests, sycamore maple forests), aquatic and reed bed vegetation, meadows and grasslands; • The Arboretum – forests of North America, euxine forests, broad-leaved forests, tundra vegetation, trees and bushes from arid areas, sclerophyllous vegetation. Many collections and displays, including of beech, maple, rose, heather spp., plants under legal protection and evergreen plants. A spring garden will be added to the botanical resources of the garden;

1	2	3	4	5
				• The Garden of Conifers – this is a composition in the shape of an amphitheatre in which shrub species are arranged in strips from the lowest towards the upper end where there are groups of high trees. There are many species and varieties of fir, spruce, juniper, false cypress, Douglas fir, microbiota and ginkgo here; • The Alpinarium Collections of Plant Genera – collections of pines, rhododendrons and lilacs, a cherry and apple blossom garden, magnolias, spireas and dogwoods; • Thematic Displays; • The Agrobotanical Garden; • The Botanical Trail for the blind and partially sighted.
22.	**The Botanical Garden of the Adam Mickiewicz University in Poznań**	ul. Dąbrowskiego 165 60-594 Poznań e-mail: obuam@amu.edu.pl, wiland@amu.edu.pl tel. (61) 829 2013 Director: Dr Justyna Wiland-Szymańska	22	Tropical flora, mountain species, endangered species, ornamental perennials, the National Collection of Cotoneasters.
23.	**The Botanical Garden of the Maria Curie-Skłodowska University in Lublin**	ul. Sławinkowska 3 20-810 Lublin e-mail: botanik@ hektor.umcs.lublin.pl tel. (81) 743 49 00; (81) 742 67 00 Director: Dr Grażyna Szymczak	21.25	There are a total of 6 700 taxa. Plant collections used for didactic and educational purposes, as well as for research conducted by the staff and students of the Lublin universities. Sections: – Bulb and tuber Section, – Dendrology Section (Arboretum), – South and South-Eastern Europe Plants Section, – Bible Plant Section, – Polish Flora Section, – Protected Plant Section, – Mountain Plant Section (Alpinarium), – Ornamental Plant Section, – ‘Pałacówka’ and ‘Wąwóz Ozdobny’ Section, – ‘Nad Stawami’ Ornamental Plant Section, – Perennial Collection Section, – Rosarium Section, – Plant Taxonomy Section, – Tropical and Subtropical Section, – Utility Plant Section, – Aquatic and Bog Plant Section, – *Index Plantarum* Section.

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1	2	3	4	5
24.	**The Botanical Garden of the Jagiellonian University in Kraków**	ul. Kopernika 28 31-501 Kraków tel. (12) 421 26 20; (12) 663 36 35; (12) 663 36 30 Director: prof. dr hab. Bogdan Zemanek e-mail: bogdan. zemanek@uj.edu.pl	9.6	There are about 5 000 taxa in the collection, including cycads, orchids, carnivore plants, succulents, epiphytes, tropical utility plants and palms. Scope of activity: • Studies of rare and endangered species are conducted in southern Poland, mainly in the Carpathians, • Studies of the flora of southern Poland, especially in the Carpathians. In the last two decades most of the studies have been conducted in the Polish Carpathians (Bieszczady Niskie, the Bieszczady National Park, the Magurski National Park), • The history of botany with particular emphasis on botanical studies at the Jagiellonian University, botany during the Renaissance, botany in the nineteenth century, the history of herbaria and the history of Polish names of plants, • Ecological and taxonomic studies of various groups of vascular plants.
25.	**The Botanical Garden of the University of Warsaw**	Al. Ujazdowskie 4 00-478 Warszawa e-mail: ogrod@biol. uw.edu.pl tel. (22) 55 30 511 Director: Dr Hanna Werblan-Jakubiec	22	Collections of over 5000 species. The purpose is to preserve the biodiversity of both wild-growing plants and cultivars. Twenty years of researching and monitoring a population of almost 50 species of plants in north-eastern Poland, including rare species like Jacob's ladder (*Polemonium caeruleum*) and cloudberry (*Rubus chamaemorus*). Several years ago, the first collection of endangered native varieties of ornamental trees and shrubs in Poland began to be built. So far, almost 20 old cultivars have been saved from disappearing. These include *Acer pseudoplatanus 'Foliis Atropurpureis Argenteovariegatis', Alnus glutinosa 'Pyramidalis', Alnus incana 'Foliis Aureomarginatis' and Robinia pseudoacacia 'Rozynskiana'.* The garden carries out taxonomic research using the methods of molecular biology and takes a particular interest in the plants of the *Apiaceae* family.
26.	**The Botanical Garden of the University of Wroclaw**	ul. Sienkiewicza 23 50-335 Wrocław e-mail: obuwr@biol.uni. wroc.pl tel. (71) 322 59 57 Director: dr hab. Tomasz Nowa	7.4	Number of taxa: about 12 000 • The Plant Taxonomy Section is located in the central part of the garden and arranged according to the Adolf Engler system, • The Alpinarium – containing mountain and rock vegetation,

1	2	3	4	5
				• The Arboretum – its eastern part is an English-style park with trees and shrubs of the temperate zones of Europe, Asia and America, • The Educational Section with displays presenting various morphological, ecological and physiological aspects, plants protected by law, the ‘Green Class' pavilion, collections of vines and Polish varieties of ornamental plants, • The Aquatic and Wetland Plant Section includes vegetation of the semi-natural pond, a pool with a collection of water lily (Nymphaea), several smaller outdoor reservoirs and 29 tropical freshwater aquariums with a capacity of 1200 litres each, • Tropical and Subtropical Terrestrial Plants, including bromeliads (Bromeliaceae), aroids (Araceae), orchids (Orchidaceae), cacti and other succulents are grown in four exhibition greenhouses and several collection greenhouses.
27.	**The Botanical Garden in Łódź**	ul. Krzemieniecka 36/38 94-303 Łódź (42) 688 44 20 mail:sekretariat@botaniczny.lodz.pl Director: Dr Dorota Mańkowska	64	More than 3000 taxa are represented in the plant collections in the garden, including about 1000 greenhouse taxa, species of native flora and a large number of plants of foreign origin. • The Japanese Garden (2 ha) – the plants come from East Asia (mainly China and Japan). They include the dawn redwood (*Metasequoia glyptostroboides)*, asunaro (*Thujopsis dolabrata)* and varieties of Japanese Cherry (*Prunus serrulata*), • The Alpinarium – (4.5 ha) is set on four hills enclosed by granite, limestone and sandstone blocks sourced from quarries throughout Poland. The foot of the hills and their slopes are covered by trees and shrubs. The Serbian spruce, *Picea omorica*, Caucasian spruce *Picea orientalis* and a variety of White cedar with characteristic filamentous shoots, *Thuja occidentalis* ‘Filiformis”, are of special interest. In addition to trees and shrubs, perennials (mostly low-forming and cushion-forming species) can also be found in the Alpinarium, • The Arboretum – most of the species are under 30 years old. The most interesting are the bald cypress *Taxodium distichum* and the honey locust *Gleditsia triacanthos*,

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1	2	3	4	5
				• Polish Flora (9.6 ha) – post-nursery trees, monocultures of pedunculate oak (*Quercus robur*) that are over 50 years old, beech (*Fagus sylvatica*), gray alder (*Alnus incana*) and common hornbeam (*Carpinus betulus*). The collections of rare and endangered species are on separate sites. Many aquatic and reed bed plant species grow in ponds and depressions, such as the common water-crowfoot (*Batrachium aquatile*) and water fringe (*Limnanthemum nymphoides*), • The Green Section (8.75 ha) – the recreation area. The Tree Alley, which in the 1990s was recognized as a natural monument, is a great attraction in this part of the Garden. It is composed of lime trees aged around 100 years: small-leaved lime (*Tilia cordata*), large-leaved lime (*Tilia platyphyllos*) and silver lime (*Tilia tomentosa*). No less impressive are the flower beds which feature perennials covering 1600 m^2 and beech (*Fagus sylvatica*) hedges over 25 years old, • The Plant Biology Section (5 ha) – the collections illustrate various aspects of plant biology, such as the morphology and transformation of shoots and foliage, differences in the shape of trees and shrubs, ways of pollinating flowers and seed dispersal, • The Collection of Ornamental Plants (5.7 ha) – includes varietal collections of roses: large-flowered, floribundas, climbers and miniatures, as well as a collection of conifers and heathers and multi-varietal rhododendron groups, • The Medicinal and Industrial Plant Section – plants used in herbal medicine are exhibited in this section. The herbs are planted in groups according to their therapeutic use. In addition to the common representatives of native flora, such as the stinging nettle (*Urtica dioica*) and the German chamomile (*Matricaria chamomilla*), species of foreign origin also grow well here, such as borage (*Borago officinalis*), common thyme (*Thymus vulgaris*) and purple coneflower (*Echinacea purpurea*).

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28.	**The Garden of Medicinal Plants at the Medical University of Gdańsk**	Katedra i Zakład Farmakognozji ul. Gen. J. Hallera 107 80-416 Gdańsk tel. (58) 349 33 11 Manager: dr hab. Mirosława Krauze-Baranowska e-mail: krauze@gumed.edu.pl	2.5	The Garden of Medicinal Plants (GUMed). The present collection consists of 1800 plant taxa in four sections: the Plant Taxonomy Section, the Medicinal Plant Section, the Ornamental Plant Section and the Arboretum.
29.	**The Medicinal Plant Garden of the Institute of Natural Fibres and Medicinal Plants**	ul. Kolejowa 2 62-064 Plewiska tel. (61) 84 55 800 Manager: Dr Waldemar Buchwald e-mail: wbuchwald@iripz.pl	3	There are approximately 1500 taxa in the garden, of which more than 400 have been the subject of detailed studies on acclimation, breeding, cultivation and phytochemistry, and have therefore laid the foundations for the production of herbal medications.
30.	**The Poznań Palm House**	ul. Matejki 18 60-767 Poznań e-mail: palmiarnia@interia.pl tel. (61) 865 89 07 Director: mgr inż. Zbigniew Wągrowski	0.46	This is one of the oldest gardens of its type in Europe. Its unique collection contains 17 000 thousand plants from 1100 species.
31.	**The Polish Academy of Sciences Botanical Garden and Centre for Biological Diversity Conservation in Powsin, Warsaw**	ul. Prawdziwka 2 02-973 Warszawa 76 Director: prof. dr hab. Jerzy Puchalski e-mail: bgpas@obpan.eu e-mail: ob.sekr@obpan.pl	40	More than 8600 taxa have been gathered in the garden so far. They are thematically grouped into sections: the Arboretum, the Collection of Polish Flora and Ornamental, Utility and Exotic Plants.
32.	**The 'Botanical Garden' at the Laboratory of the Kazimierz Wielki University in Bydgoszcz**	ul. Chodkiewicza 30 80-064 Bydgoszcz e-mail: ogrodb@ukw.edu.pl tel. (52) 34 19 293 Manager: Dr Barbara Wilbrandt	2.33	The garden now has over 300 species and taxa of lower order trees, shrubs, broadleaves and conifers of native and foreign origin, including unique and relict species. The phytogeographically alien species come mainly from Asia and North America. There are a small number of trees and shrubs from the Mediterranean, including North Africa. Half of them are plants from their natural range in Europe. The 15 species of trees and shrubs growing in the garden are under legal protection. They include shrubby birch, dwarf birch, mezereon, Swiss pine, dwarf cherry and bladdernut.

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1	2	3	4	5
33.	**The Silesian Botanical Garden – Union of Associations**	ul. Sosnowa 5 43-195 Mikołów Mokre Director: Dr Paweł Kojs e-mail: pkojs@op.pl	78	The mission of the Silesian Botanical Garden is to act to conserve biological diversity, including through ecological and natural education, and to foster attitudes conducive to the realization of sustainable development. The Laboratories of the Ornamental Plants Collection, the Scientific Research and Conservation Collection and the Habitat Collection are tasked with meeting the statutory objectives of the Silesian Botanical Garden. These, in accordance with the Permit to Operate as a Botanical Garden issued by the Minister of the Environment on 7 February 2006, are to grow plants of the selected species and to conserve biological diversity.
34.	**The Orle Arboretum**	83-420 Liniewo Orle 35 Tel. (58) 687 94 15 Maria and Klaudiusz Buzalski e-mail: mariabuzalska@wp.pl		
35.	**The Podlaski Botanical Garden**	Koryciny 73 B, 17-315 Grodzisk e-mail: biuro@darynatury.pl tel. (85) 656 86 68; (85) 656 86 62; 502 646 947 mgr Mirosław Angielczyk		The garden holds a collection of 700 species of plants. It has collected almost all of the utility plant species occurring in Poland, as well as a good number of those occurring in a large part of Europe. The garden conducts scientific studies on the preservation of the natural habitats of medicinal plants. The collection includes American purple coneflowers (Echinacea), Asian ginseng, Manchurian aralia, and many other herbs with local names, such as sage, mint and burdock.
36.	**The Department of Biology and Pharmaceutical Botany** at the **Medical University in Wrocław**	Al. Jana Kochanowskiego 10 51-61 Wrocław e-mail: bbsekret@biol.am.wroc.pl tel. (71) 348 29 42 Acting Manager: Dr Adam Matkowski		

***** PAS (Polish Academy of Sciences)

Table 31. Declarations and resolutions adopted at ministerial conferences for the protection of forests in Europe (MCPFE)

Location of ministerial conference	Date	Declarations	Resolutions
I MCPFE Strasbourg, France	18 December 1990	Strasbourg Declaration	• Resolution S1 The Monitoring of Forest Ecosystems • Resolution S2 Genetic Resources • Resolution S3 Data Bank on Forest Fires • Resolution S4 Adapting the Management of Mountain Forests • Resolution S5 Research on Tree Physiology • Resolution S6 Research into Forest Ecosystems
II MCPFE Helsinki, Finland	16–17 June 1993	Helsinki Declaration	• Resolution H1 General Guidelines for the Sustainable Management of Forests • Resolution H2 General Guidelines for the Conservation of Biodiversity • Resolution H3 Cooperation with Transition Economies • Resolution H4 Adaptation of Forests in Europe to Climate Change
III MCPFE Lisbon, Portugal	2–4 June 1998	Lisbon Declaration	• Resolution L1 Socio-economic Aspects of Sustainable Forest Management • Resolution L2 Pan-European Criteria: Indicators and PEOLG for Sustainable Forest Management
IV MCPFE Vienna, Austria	28–30 April 2003	Vienna Living Forest Summit Declaration	• Resolution V1 Cross-sectoral Cooperation and NFPs • Resolution V2 The Economic Viability of SFM • Resolution V3 The Social and Cultural Dimensions of SFM • Resolution V4 The Biological Diversity of Forests • Resolution V5 Climate Change and Sustainable Forest Management in Europe
V MCPFE Warsaw, Poland	5–7 November 2007	Warsaw Declaration	• Resolution W1 Forests, Wood and Energy • Resolution W2 Forests and Water

Table 32. Agreements with countries outside the EU

Country	Date	Status	Agreements and memoranda
1	2	3	4
Australia	17.03.2006	In force	Joint Declaration of Intent between the Minister of the Environment of the Republic of Poland and the Minister of Industry, Tourism and Resources of Australia on technological, scientific and investment cooperation in the field of environment and climate protection.
People's Republic of China	02.12.1996	In force	Environmental Cooperation Agreement between the Ministry of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the National Environmental Protection Agency of the People's Republic of China on environmental cooperation.

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1	2	3	4
Iran	10.10.2002	In force	Memorandum between the Minister of the Environment of the Republic of Poland and the Environmental Protection Bureau of the Islamic Republic of Iran on cooperation in the field of environmental protection.
Canada	12.09.1994	In force	Memorandum between the Minister of the Environment of the Republic of Poland (former Minister of Environmental Protection, Natural Resources and Forestry) and the Departments of Environment and Industry of Canada on cooperation in the field of environmental protection (with an Annex of June 2000 on joint implementation projects, extended with amendments to 2014).
	15.06.2000	In force	Memorandum between the Minister of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the Departments of Environment and Industry of Canada on cooperation in the field of environmental protection.
	09.2004	In force	Verbal Note concerning amendments to the Memorandum between the Minister of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the Departments of Environment and Industry of Canada on cooperation in the field of environmental protection.

Table 33. Agreements with European countries outside the EU

Country	Date of Agreement	Status	Agreements and memoranda
1	2	3	4
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 in case of Nuclear Accident and Cooperation in the field of Nuclear Safety and Radiological Protection.
	25.01.1996	In force	Memorandum between the Ministry of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the State Committee on Ecology of the Republic of Belarus on cooperation in the field of forestry.
Norway	13.02.1989	In force	Memorandum on cooperation in the field of environmental protection between the Ministry of the Environment of the Republic of Poland (former Minister of Environmental Protection, Natural Resources and Forestry) and the Minister of the Environment of Norway.
	15.11.1989	In force	Agreement between the Government of the Republic of Poland and the Government of the Kingdom of Norway on Early Notification of Nuclear Accidents and Cooperation in the Field of Nuclear Safety and Radiological Protection.
	14.10.2004	In force	Memorandum of Understanding on the implementation of the Norwegian Financial Mechanism 2004–2009 established in accordance with the Agreement of 14.10.2003 between the Kingdom of Norway and the European Community on a Norwegian Financial Mechanism for the period 2004–2009 between the Kingdom of Norway and the Republic of Poland (allocating part of the aid for environmental protection).

1	2	3	4
Norway	17.12.2007	In force	Memorandum on amendments to the Memorandum of Understanding on the implementation of the Norwegian Financial Mechanism 2004–2009 established in accordance with the Agreement of 14.10.2003 between the Kingdom of Norway and the European Community on a Norwegian Financial Mechanism for the period 2004–2009 between the Kingdom of Norway and the Republic of Poland (allocating part of the aid for environmental protection).
Republic of Moldova	22.10.2003	In force	Memorandum 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 the Management of Natural Resources.
Russia	22.05.1992	In force	Memorandum between the Government of the Republic of Poland and the Government of the Russian Federation (Commonwealth of Independent States) on cooperation between the north-eastern provinces of the Republic of Poland and the Kaliningrad Oblast of the Russian Federation.
	02.10.1992	In force	Memorandum between the Government of the Republic of Poland and the Government of the Russian Federation on cooperation between regions of the Republic of Poland and the St. 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 to prevent industrial accidents and natural disasters and to resolve 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 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 accidents, on the exchange of information on nuclear installations and on cooperation in the field of nuclear safety and radiological protection.
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 Programme to reduce economic and social disparities 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 the exchange of information on 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.
	24.01.1994	In force	Memorandum between the Ministry of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the Ministry of the Environment of Ukraine on the marketing of hazardous waste.
	10.10.1996	In force	Agreement between the Government of the Republic of Poland and the Government of Ukraine on cooperation to manage water in border areas.

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1	2	3	4
Ukraine	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 to prevent disasters, natural calamities and other extraordinary events and to remove their consequences.

Table 34. Bilateral agreements with EU countries

Country	Date of Agreement	Status	Agreements and memoranda
1	2	3	4
Austria	24.11.1988	In force	Agreement between the People's Republic of Poland and the Republic of Austria on cooperation in the field of environmental protection.
	15.12.1989	In force	Agreement between the People's Republic of Poland and the Republic of Austria on the exchange of information and cooperation in the field of nuclear safety and radiation protection.
Belgium	09.11.1989	In force	Agreement between the Minister of Environmental Protection of the Republic of Poland (former Minister of Environmental Protection, Natural Resources and Forestry) and the Minister of the Environment of the Flemish Province of the Kingdom of Belgium on cooperation in environmental protection.
	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 environmental protection.
	10.10.1996	In force	Cooperation Agreement between the Government of the Republic of Poland on the one hand and the Government of the French Community of Belgium and the Walloon Government on the other hand.
Bulgaria	26.11.1997	In force	Memorandum between the Minister of the Environment (formerly the Minister of Environmental Protection, Natural Resources and Forestry) of the Republic of Poland and the Ministry of the Environment and Water of the Republic of Bulgaria on cooperation in environmental protection.
The Czech Republic	07.07.1958	In force	Agreement between the Government of the People's Republic of Poland and the Republic of Czechoslovakia on cooperation to manage water in border areas.
	15.01.1998	In force	Agreement between the Government of the Republic of Poland and the Government of the Czech Republic on cooperation in environmental protection.
	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 accidents and the exchange of information on peaceful uses of nuclear energy, nuclear safety and radiation protection.
	19.08.2008	In force	Memorandum 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 region of the common border.

1	2	3	4
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	Memorandum between the Minister of the Environment of the Republic of Poland and the Minister of the Environment of the Kingdom of Denmark on the implementation of joint projects to reduce greenhouse gas emissions.
Estonia	28.06.1995	In force	Agreement between the Minister of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the Ministry of the Environment of the Republic of Estonia on cooperation in the field of environmental protection.
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 environmental protection.
	13.06.2000 Helsinki 15.06.2000 Warsaw	In force	Agreement between the Minister of the Environment of the Republic of Poland and the Minister of the Environment of Finland on the implementation of joint action projects in the field of climate protection.
France	14.06.1989	In force	Agreement between the Government of the People's Republic of Poland (PRL) and the Government of the Republic of France on cooperation in environmental protection.
	27.02.2002	In force	Memorandum on Cooperation in the Field of Water Management between the Polish Bureau of Water Management (currently the National Water Management Authority) and the International Office for Water of the Republic of France.
The Netherlands	25.09.1987	In force	Memorandum between the Minister of the Environment (formerly the Minister of Environmental Protection, Natural Resources and Forestry) of the Republic of Poland and the Minister of Housing, Spatial Planning and the Environment of the Kingdom of The Netherlands on cooperation in the field of environmental protection.
	22.02.1994	In force	Memorandum between the Minister of the Environment (formerly Minister of Environmental Protection, Natural Resources and Forestry) of the Republic of Poland and the Ministry of Agriculture, Nature Conservation and Fisheries of the Kingdom of The Netherlands on cooperation in the field of nature conservation and forestry.
	19.12.1997	In force	Memorandum between the Ministry of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the Ministry of Transport, Public Works and Water Management of the Kingdom of The Netherlands on cooperation in the field of water management.
Lithuania	24.01.1992	In force	Memorandum between the Ministry of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the Department of Environmental Protection of the Republic of Lithuania on cooperation in the field of environmental protection.

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1	2	3	4
Lithuania	13.12.1995	In force	Memorandum between the Ministry of Environmental 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 nuclear accidents and on cooperation in the field of nuclear safety and radiation 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 Environmental Impact Assessment in a Transborder 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 use and protection of border waters.
Latvia	12.10.1995	In force	Agreement between the Ministry of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the Ministry of Environmental Protection and Regional Development of the Republic of Latvia on cooperation in the field of environmental protection.
Germany	17.06.1991	In force	Memorandum between the Government of the Republic of Poland and the Government of the Federal Republic of Germany to establish a 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 to manage border waters.
	07.04.1994	In force	Agreement between the Republic of Poland and the Federal Republic of Germany on cooperation in the field of environmental protection.
	18.06.2001	In force	Memorandum between the Minister of the Environment of the Republic of Poland and the Federal Minister of the Environment, Nature Conservation and Nuclear Safety of the Federal Republic of Germany on the implementation of joint pilot projects in the field of environmental protection in the Republic of Poland in order to reduce transborder pollution.
	02.02.2005	In force	Memorandum between the Minister of Environment of the Republic of Poland and the Federal Minister of the Environment, Nature Conservation and Nuclear Safety of the Federal Republic of Germany on the implementation of joint projects in the field of environmental protection in the Republic of Poland (content of the Memorandum).
	24.04.2005	In force	Joint Statement by the Minister of the Environment of the Republic of Poland and the Bavarian Minister of the 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 on Environmental Impact Assessment in a Transborder Context of 25 February 1991.

1	2	3	4
Germany	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 nuclear accidents, the exchange of information and experience and on cooperation in the field of nuclear safety and radiological protection.
Slovakia	18.08.1994	In force	Agreement between the Government of the Republic of Poland and the Slovak Republic on cooperation in environmental protection.
	14.05.1997	In force	Agreement between the Government of the Republic of Poland and the Government of the Slovak Republic on the management of border waters.
	17.07.1997	In force	Agreement between the Ministry of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the Ministry of Agriculture of the Slovak Republic on cooperation in the field of forestry.
	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, exchange of information and cooperation in the field of nuclear safety and radiation protection.
Sweden	10.02.1989	In force	Agreement between the Government of the People's Republic of Poland and the Government of the Kingdom of Sweden on the delimitation of regions of responsibility and cooperation in combatting pollution in 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 for environment conversion.
	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 Programme.
Hungary	19.11.1990	In force	Memorandum between the Ministry of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the Ministry of Environment and Spatial Development of the Republic of Hungary on cooperation in environmental protection.
Italy	17.01.1974	In force	Memorandum on Economic, Industrial and Scientific Cooperation between the Government of the People's Republic of Poland (PRL) 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 the Environment of the Republic of Poland and the Minister of the Environment and Territorial Protection of Italy.

Table 35. International conventions

Dates: R – Ratification N – Notices E – Entry into force T – Termination	Status	Convention or memorandum	Unit responsible for supervision of implementation	More information at Websites
1	2	3	4	5
R – 06.01.1977 N – 29.03.1978 E – 22.03.1978	In force	Convention on Wetlands of International Importance Especially as Waterfowl Habitat, drawn up at Ramsar on 2 February 1971	Directorate General for Environmental Protection (Department of Nature Conservation, WOSCiK)	www.ramsar.org www.bagna.pl www.poleskipn.pl www.zb.eco.pl www.wigry.win.pl
R – 03.11.1989 N – 04.04.1991 E – 12.03.1990	In force	Convention on International Trade in Endangered Species of Wild Fauna and Flora drawn up at Washington on 3 March 1973	Ministry of the Environment (Department of Environmental Protection), National Council for Nature Conservation	www.mos.gov.pl www.cites.org cites.site50.net/ www.cites.info.pl
R – 13.12.1995 N – 10.01.2003 E – 01.05.1996	In force	Convention on the Conservation of Migratory Species of Wild Animals, drawn up at Bonn on 23 June 1979	Ministry of the Environment (Department of Environmental Protection)	www.mos.gov.pl www.cms.int
R – 04.12.1991 N – 03.12.1999 E – 10.05.1996	In force	Memorandum on the Conservation of Bats in Europe, signed in London on 4 December 1991 (EUROBATS)	Ministry of the Environment (Department of Environmental Protection)	www.mos.gov.pl www.eurobats.org
R – 17.03.1992 N – 03.12.1999 E – 18.02.1996	In force	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas, drawn up at New York on 17 March 1992 (ASCOBANS)	Ministry of the Environment (Department of Environmental Protection)	www.mos.gov.pl hel.univ.gda.pl www.ascobans.org
R – 13.12.1995 N – 06.11.2002 E – 19.12.1996	In force	Convention on Biological Diversity, signed in Rio de Janeiro on 5 September 1992	Ministry of the Environment (Department of Environmental Protection)	www.mos.gov.pl www.cbd.int
R – 10.12.2003 N – 04.10.2004 E – 09.03.2004	In force	The Cartagena Protocol on Biosafety to the Convention on on Biological Diversity		
R – 12.07.1995 N – 25.05.1996 E – 01.01.1996	In force	Convention for the Conservation of European Wildlife and Natural Habitats, signed in Berne on 19 September 1996	Ministry of the Environment (Department of Environmental Protection)	www.gdos.gov.pl www.mos.gov.pl

1	2	3	4	5
R – 24.06.2004 N – 29.01.2006 E – 01.01.2005	In force	The European Landscape Convention signed in Florence on 20 October 2000	Directorate General for Environmental Protection (Department of Nature Conservation, WOSCiK)	
R – 27.02.2006 N – 31.05.2007 E – 19.06.2006	In force	Framework Convention on the Protection and Sustainable Development of the Carpathians	Ministry of the Environment (Department of Environmental Protection)	www.mos.gov.pl www.zielonekarpaty.org.pl
R – 12.01.2009 N – 29.01.2009 E – 12.01.2009	In force	Convention on the European Forest Institute of 28 August 2003	Ministry of the Environment (Department of Forestry)	
R – 06.05.1976 N – 30.09.1976 E – 30.09.1976	In force	Convention on the Protection of World Cultural and Natural Heritage of 16 November 1972	Ministry of the Environment (Department of Environmental Protection)	ww.eko.org.pl www.unesco.pl
Not subject to ratification	In force	Memorandum on the Protection of the aquatic warbler.	Directorate General for Environmental Protection (Department of Nature Conservation, WOGiZ)	

Table 36: Other agreements

Dates: R – Ratification N – Notices E – Entry into force T – Termination	Status	Convention or memorandum	Unit responsible for supervision of implementation	More information at Websites
1	2	3	4	5
R – 12.06.1997 N – 30.04.1999 E – 10.09.1997	In force	Convention on Environmental Impact Assessment in a Transborder Context, signed in Espoo on 25 February 1991	Directorate General for Environmental Protection (Department of Environmental Impact Assessment)	www.unece.org
	Ratification pending	Protocol on Strategic Environmental Impact Assessment to the Convention on Environmental Impact Assessment in a Transborder Context (Espoo Convention) of 2003	Directorate General for Environmental Protection (Department of Environmental Impact Assessment)	

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1	2	3	4	5
Signed on: 15.12.1999	Ratification in progress	Convention on the Establishment of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) of 24 May 1983	Institute of Meteorology and Water Management	www.imgw.gov.pl
R – 31.10.2001 N – 03.12.2002 E – 04.12.2001	In force	Cooperation Agreement with the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)	Institute of Meteorology and Water Management	www.imgw.gov.pl
R – 31.12.2001 N – 09.05.2003 E – 16.05.2002	In force	Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, drawn up at Aarhus on 25 June 1998	Ministry of the Environment (Department of Environmental Education and Communication)	cpe.eko.org.pl/ aarhusclearinghouse.unece.org/ www.unece.org
	Ratification pending	Protocol on Pollutant Release and Transfer Registers to the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention) of 2003	Chief Inspectorate of Environmental Protection (Department of Inspection and Appeal)	
R – 30.09.2008 N – 29.01.2009 E – 21.01.2009	In force	Convention on Persistent Organic Pollutants (Stockholm Convention)	Ministry of Environment (Waste Management Department)	srodowisko.ekologia.pl
R – 08.09.2003 N – 06.07.2004 E – 07.12.2003	In force	Convention on the Transborder Effects of Industrial Accidents on March 17, 1992 (Emergency Convention)	Chief Inspectorate for Environmental Protection, Headquarters of the State Fire Service	www.unece.org www.ciop.pl

Table 37. Implementation of the Programme for the Preservation of Forest Genetic Resources and the Selective Breeding of Forest Trees in Poland for 1991–2010 (according to the National Register of Forest Basic Material; as of 31 December 2010, GDSF 2011)

Item	Specification	Unit of measure	Total	Species											
				Pine	Spruce	Fir	Larch	Other conifers	Sessile oak	Pedunculate oak	Beech	Alder	Birch	Lime	Other broadleaf
1.	Selected seed stand	ha	**15 811**	6 858	1 233	1 334	447	220	1 481	1 414	1 910	502	194	157	61
2.	Progeny plantations	ha	**67 876**	45 653	2 253	2 762	2 450	948	2 347	3 703	5 177	1 187	1 150	165	81
3.	Production seed stands	ha	**202 076**	127 195	10 387	6 159	1 693	408	5 662	17 432	18 937	6461	5 046	811	1 885
4.	Seed orchards	ha	**1 272**	415	94	77	241	69	57	34	47	61	47	90	40
5.	Seedling seed orchards	ha	**729**	269	12	15	165	144	14	26	48		14		22
6.	Gene conservation stands	ha	**3 165**	1 711	439	272	81		255	285	72				50
7.	Gene conservation plantations	ha	**973**	757	67	19	8		17	88	13				4
8.	Mother trees	no.	**8 384**	2 924	534	421	875	759	333	501	542	569	284	160	482

Table 38. Use of the seed base

Species	Populations of known origin	Selected stands	Seed orchards
Pine	86.6	7.2	6.2
Spruce	75.6	21.4	3.0
Larch	26.2	13.4	60.4
Fir	74.5	24.2	1.3
Other conifers	5.3	35.5	59.2
Birch	91.2	5.6	3.2
Beech	89.0	11.0	0.0
Pedunculate oak	95.0	5.0	0.0
Sessile oak	88.2	11.8	0.0
Black alder	91.6	7.3	1.1
Lime	93.5	2.4	4.1
Other broadleaf	100.0	0.0	0.0
Mean	**76.40**	**12.10**	**11.50**

Data for 2007