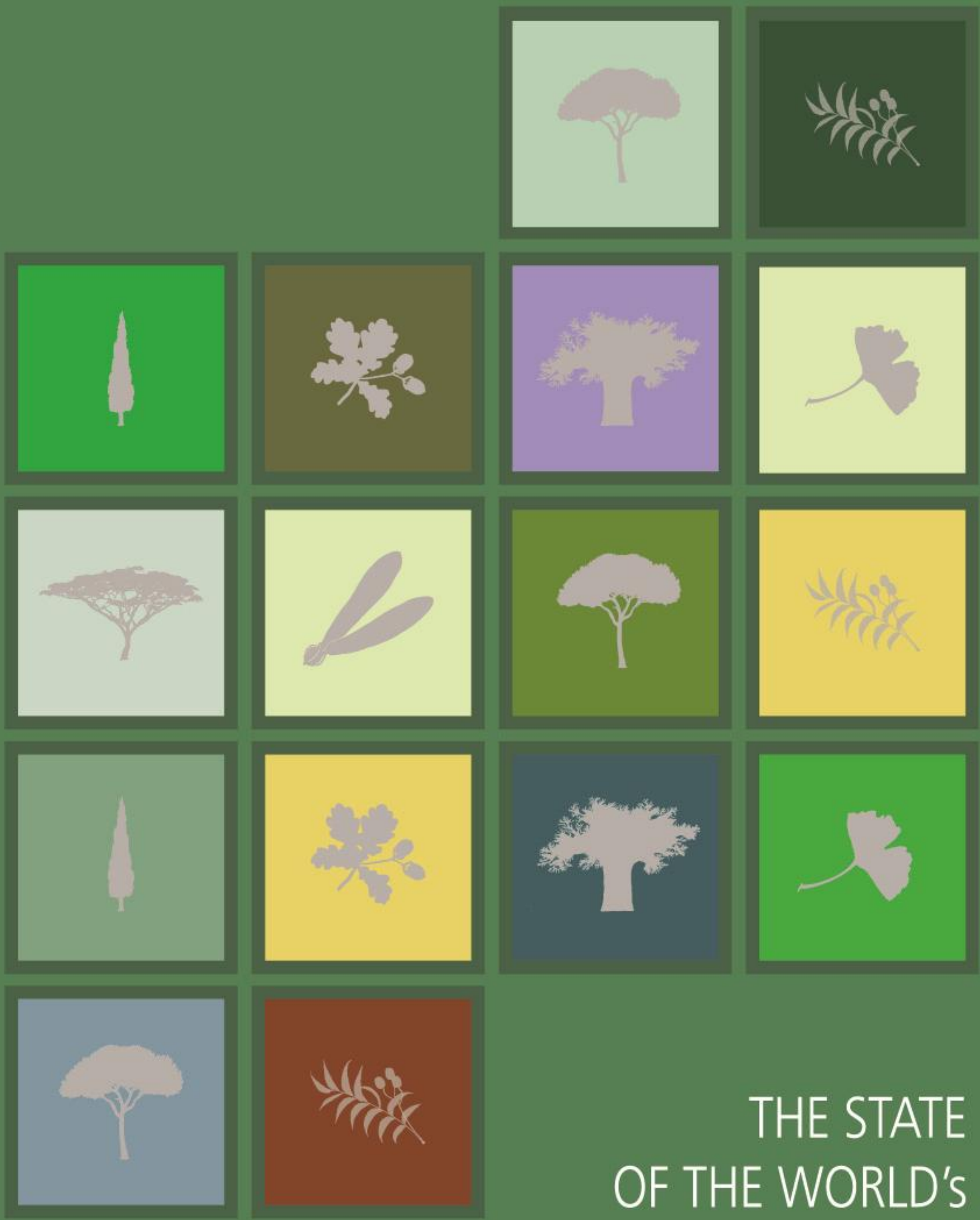

THE STATE
OF THE WORLD's
FOREST GENETIC RESOURCES

COUNTRY REPORT

POLAND

This country report is prepared as a contribution to the FAO publication, The Report on the State of the World's Forest Genetic Resources. The content and the structure are in accordance with the recommendations and guidelines given by FAO in the document Guidelines for Preparation of Country Reports for the State of the World's Forest Genetic Resources (2010). These guidelines set out recommendations for the objective, scope and structure of the country reports. Countries were requested to consider the current state of knowledge of forest genetic diversity, including:

- Between and within species diversity
- List of priority species; their roles and values and importance
- List of threatened/endangered species
- Threats, opportunities and challenges for the conservation, use and development of forest genetic resources

These reports were submitted to FAO as official government documents. The report is presented on www. fao.org/documents as supportive and contextual information to be used in conjunction with other documentation on world forest genetic resources.

THE NATIONAL REPORT ON FOREST GENETIC RESOURCES

POLAND

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December 2011

THE NATIONAL REPORT
ON FOREST GENETIC RESOURCES

POLAND

CONTENTS

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
BNL	Forest Reproductive Material Office (FRMO)
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)
BULiGL	Forest Management and Geodesy Bureau (FMGB)
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
Db	pedunculate oak
DD	parent trees
DGLP	Directorate General of the State Forests (GDSF)
DNA	deoxyribonucleic acid
DNA-RAPD	random amplified polymorphic DNA
DSRK	Long-Term National Development Strategy (LNDS)
EC	European Commission
EEA	European Environment Agency
EN	Endangered
ENSCONET	European Native Seed Conservation Network
EPPO	European and Mediterranean Plant Protection Organization (EMPPO)
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
FOŚiGW	Fund for Environmental Protection and Water Management (FEPWM)
FRA 2010	Global Forest Resources Assessment 2010. FAO Main Report
FSC	Forest Stewardship Council
F_{ST}	haplotype fixation index
GDOŚ	Directorate General of Environmental Protection (GDEP)
GIOŚ	Chief Inspectorate of Environment Protection (CIEP)
G_{ST}	genetic variation rate
GTD	production forest type
GUS	Central Statistical Office (CSO)
H_S	mitochondrial DNA polymorphism markers
ID PAN	Institute of Dendrology, Polish Academy of Science in Kórnik
IBL	Forest Research Institute in Warsaw (FRI)
ICP	International Co-operative Programme on Assessment and Monitoring of air pollution effects on forests.
IMGW	Institute of Meteorology and Water Management in Warsaw (IMWM)
ISTA	International Seed Testing Association
IUCN	International Union for 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)
KPZL	National Programme for the Augmentation of Forest Cover (NPAFC)

KRLMP	National Register of Forest Basic Material (NRFBM)
KSOCH	National Network of Protected Areas (NNPA)
LBG	Kostrzyca Forest Gene Bank (Kostrzyca FGB)
LG	Mountain broadleaved forest (forest habitat type)
LKP	Promotional Forest Complex (PFC)
LKP „PB"	The "Białowieża Primeval Forest" Promotional Forest Complex
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)
LP	The State Forests
LZD	Forest Experimental Station
LZG	Forest Genetic Resources (FGR)
MCPFE	Ministerial Conference on the Protection of Forests in Europe
OECD	Organisation for Economic Co-operation and Development
OHZ	Game Breeding Centre (GBC)
Ol	alder forest (forest habitat type)
OlJ	ash-alder forest (forest habitat type)
op	bulk precipitation
OSO	Special Protection Area for birds (SPA)
OZW	Sites of Community Importance (SCI)
PCR	polymerase chain reaction
PGL LP	The State Forests National Forest Holding (The State Forests)
PEFC	Programme for Endorsement of Forest Certification Schemes
pk	undercrown precipitation (up)
PKB	Gross Domestic Product (GDP)
PN	National Park
RAPD	random amplification of polymorphic DNA
RDLP	Regional Directorate of the State Forests (RDSF)
RDOŚ	Regional Directorate of Environmental Protection (RDEP)
RFLP	restriction fragment length polymorphism
RLMP LP	Register of the Forest Basic Material of the State Forests (RFBMSF)
RoSL 2010	Reports on the Condition of Forests in Poland, 2010
SGGW	Warsaw University of Life Sciences-SGGW
So	Scots pine
SoEF	State of Europe's Forests
SPO	Forest Monitoring System (FMS)
SSR	Simple Sequence Repeats
STS	Sequence Tagged Site
Św	Norway spruce
Traktat ateński	Treaty of Accession to the European Union
UE	European Union
UKW	Kazimierz Wielki University in Bydgoszcz
UNECE	United Nations Economic Commission for Europe
UP	Poznań University of Life Sciences
UR	H. Kołłątaj Agricultural University of Cracow
WDN	Selected seed stand
WISL	Large-Scale Inventory
WRB	World Reference Base for Soil Resources
VU	Vulnerable

ZHL	Principles of Silviculture
ha	hectare
m^3	cu. 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 play a vital role in implementing this policy and Large-Scale Forest Inventory is one of the tools used to support it. The role of the Ministry of the Environment is to maintain competitiveness of forestry, 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 within which it implements the ecological and forest policy of the state and creates 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 the environmental balance, life continuity and environmental diversity and reduce pollution which causes environmental degradation. The preservation of forest genetic resources is necessary for the reduction of soil erosion, preservation of water resources, regulation of water relations and protection of the landscape. Forests, as a form of land use, ensure biological production which has a market value, and are a public good that has an effect on the quality of human life (RoSL, 2011).

The period 1945-1989 was very difficult 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;
- need for carrying out forest management goals in different political and economic conditions.

The current state of forest management, conducted in accordance with the adopted principles of sustainable development of forests playing multiple functions, is satisfactory.

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

1. Forest ecosystems are the most valuable and best-represented components of natural sites placed under various forms of nature protection in Poland and account for over 37.3 percent of the country’s land area covered by legal protection. 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 those damaged by industry is 38.4 per cent. The Natura 2000 sites currently 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. Timber resources in the State Forests amount to 1.9 billion m^3 and their quality (according to the available data) surpasses that of the forests under other forms of ownership. This is reflected in the volume of growing stock amounting to 264 m^3/ha (compared to 215 m^3/ha in private forests), and in the average stand age of 57 years (compared to 46 years in private forests). The data show that, in recent years, the harvested volume in State Forests has not exceeded 55 per cent of its increment.
3. In 2000-2010, the average volume of harvested gross timber in Poland was approximately 32 million m^3 annually, and it is assumed that if the growth trend in timber resources continues, this volume will increase each year.
4. Although the area of the post-agricultural land and wasteland afforested in 2010 under the National Programme for the Augmentation of Forest Cover (which assumed an increase in the forest cover to 30 per cent by 2020 and to 33 per cent by 2050) slightly increased, there is danger that the assumed goals 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. Halting afforestation work in the Natura 2000 areas until the completion of planning of protection tasks for these areas is a serious limitation.
5. Poland’s forests are among the most threatened in Europe due to a 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 augment the vulnerability of forests to diseases.

a) Poland is in 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, roe deer, and locally by rodents (beavers and mice).

6. The species composition of Polish forests has been substantially re-built in recent centuries as a result of historical and economic processes. In consequence, in 19 per cent of Polish forests biocoenoses are not adjusted to the capabilities of the habitat. In order to improve this situation, stand conversion is being conducted in Poland on 10-12 thousand hectares annually, in line with the State Policy on Forests and the National Environmental Policy.
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 located in 83 regions of origin is registered in the Forest Reproductive Material Office at the Ministry of the Environment, and includes 35 140 objects (230 421 hectares). The need to select such a large and extensive seed base determines the way of forest renewal in the climatic and habitat conditions of Poland, where about 90 per cent of forests are restocked by planting or sowing (including afforestation of post-agricultural land).
9. Till now, there have been no comprehensive studies on the genetic variation of the main forest tree species. The scarce genetic studies conducted so far indicate that individual species are characterised by high intra-population genetic variation and a low one at the inter-population level.
10. The privately-owned forests are of concern regarding their protection, management and utilization status. They are fragmented and frequently incompetently managed, or simply neglected. A large proportion of privately-owned forests (56 per cent) still do not have management plans (Zaleski 2011). No appropriate conditions have been created for forest owners in Poland to participate, as beneficiaries, in the subsidy programme supporting forest management. Additionally, there are few registered objects of Forest Basic Material (FBM) on private land (81 objects, *i.e*. 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 implementing 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 reflected in national legislation. The Programme for the Preservation of Forest Genetic Resources and Selective Breeding of Forest Trees in Poland for 2011-2035 now being implemented in Poland encompasses only the area managed by the State Forests. There is a need for the implementation of a similar programme for the forest areas managed by other forest administrators and owners. It should be reflected in the upcoming Forest Strategy and in the Act on the Conservation of Forest Genetic Resources.

The most important challenge for Polish forestry in the future decade 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 conflicts that may arise between forestry, environmental organizations and the wood industry.

SECTION II. INTRODUCTION TO THE CHARACTERIZATION OF THE COUNTRY AND FORESTRY SECTOR

1. Location and climatic conditions

Poland is situated in Central Europe, with an area of 312 680 km^2. It borders Russia, Lithuania, Belarus, Ukraine, Slovakia, the Czech Republic and Germany. Poland's population is 38 167 thousand, of which the economically active population is estimated at 17 724 thousand people. The birth rate for the last two years shows a slight upward trend (+35 thousand in 2010).

Poland is a lowland country, with areas below 300 metres above sea level constituting 91.3 per cent of its territory (of which 0.2 per cent are depressions). The average height above sea level in Poland is 173 metres, which is almost half the average height for the European continent (330 metres). Rysy is the highest peak in the High Tatras – 2 499 metres a.s.l.; the lowest point is located west of the village Raczki Elbląskie – 1.8 metres b.s.l.; the inclination of the land surface in Poland is from south to north.

Four basic morphogenetic zones can be distinguished in Poland:

1) The Carpathian Mountains, the young mountains of Alpine orogeny, with foreland basins (Northern Podkarpacie);
2) The Sudeten Mountains, the old mountains of Hercynian orogeny;

These morphogenetic zones include a belt of uplands, like 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: the cape Rozewie in the north (54°50'N), the peak Opołonek in the Bieszczady Mountains in the south (49°00'N), the Oder river bed near Cedynia in the west (14°07'E), the Bug river near Strzyżowa in the east (24°09'E). The longitudinal distance is 5°50', *i.e*. 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, in the winter – on the contrary; during the year this difference is 2 hours and 12 minutes. A 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 parallel 52°).

Poland lies in the temperate climate zone with characteristics typical of transition climate, from marine in the west to continental in the east. Poland's climate features significant weather fluctuations and a high seasonal variation. Six seasons of the year are distinguished in Poland: winter, early spring, spring, summer, autumn and early winter. Mean annual temperatures range from 8.2^{o}C in the south-west (Wrocław) to 6.2^{o}C in the north-east (Suwałki). The average long-term annual precipitation in Poland in the period 2001-2010 amounted to 603.3 mm, and currently shows an upward trend (RoSL, 2011). The highest precipitation is in the summer months. There are large fluctuations in the thickness and persistence of the snow cover. In the lowlands, the snow cover usually does not exceed several centimetres; in the winter it appears and disappears several times. In the mountains, the snow cover lingers for about 150 days (depending on the elevation) and reaches about two-metres in thickness.

The majority of lakes in Poland are in the north and west-central part of the country. Their total number is about 9300. They cover a total area of 3200 km^2, which represents nearly 1 per cent of the country's land area. The largest lakes are: Śniardwy 11 487.5 hectares, Mamry 9851 hectares, Łebsko 7020 hectares (by A. Choiński). There are about 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 the highest in the winter and the lowest in the summer. The average wind velocity in 2010 ranged from 5.3 m/s in Warsaw, Hel, Cracow and Nowy Sącz to 6.2 m/s on Mt. Śnieżka.

As regards hydrographic conditions, 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 of the Oder river, and 11 per cent is the direct catchment basin of the Baltic Sea. The vegetation cover mostly represents the Central-European Province (mixed and broadleaved forests); with increasing continentality, the share of coniferous forests increases. Natural distribution limits of plants typical for different regions of Europe occur in Poland such as, *inter alia*, the north-eastern distribution limits of European beech and the northern limits of silver fir. Also the zonal distribution of soils is of transitional nature: 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 occurring in Poland are light and rather unfertile; to be used agriculturally, they need enrichment with large amounts of mineral and organic fertilizers.

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

Division I Litosols, Lithogenic soils:
Order: mineral, non-calcareous, poorly developed soils – occur mainly in the mountain regions and, *inter alia*, on artificial embankments and excavations; they occupy about 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) – occur, *inter alia*, on the loess soils of the Lublin Upland, the Świętokrzyskie Mountains, the Silesian Upland and the Kraków-Częstochowa Upland; they occupy about 1 per cent of the country's land area, are fertile but difficult for cultivation;

Section II. Autogenic soils:
Order: chernozem soils (type: chernozems) – occur, *inter alia*, on the loess fragments of the Lublin Upland and the Małopolska Upland; they occupy about 1 per cent of the country's land area, and are fertile;
Order: brown soils (types: typical brown, acid brown and lessive soils) – occur, *inter alia*, on 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) – occur mainly in the Polish Lowlands and the Sandomierska Valley, cover approximately 26 per cent of the country's land area, 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) – occur primarily in the Kujawy region, around Błonie, Sochaczew, Pyrzyce, Kętrzyn and Wrocław, one of the most fertile soils, they occupy approx. 3 per cent of the country's land area;
Order: gley soils (types: surface-water gley soils/ pseudogley soils and ground-water gley soils) – occur mainly in the Polish Lowlands and the Carpathian Mountains, occupy about 16 per cent of the country's land area, usually used as pastures, rarely for cultivation.

Section IV. Hydrogenic soils:
Order: bog soils (types: fluvic bog soils and peat soils) – 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 land area, they are typically grassland soils;
Order: Histosols – muck soils usually occur together with bog soils from which they develop, while mull soils soils develop as a result of humification of drained gleysols, typically of grassland soils;

Section V. Alluvial soils:
Order: alluvial soils: (types: river mud soils and marine soils) – e.g. alluvial soils at the Vistula estuary (Żuławy Wiślane) and deluvial soils, 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 profile, 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) recognized by the International Union of Soil Sciences – IUSS and the FAO.

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

2. Forestry sector in Poland

In our climatic and geographical zone, forests are the least disturbed natural formations. They are an indispensable element of ecological balance and, at the same time, a form of land use ensuring biological production, which has a market value. Forests are a public good enhancing the quality of human life.

Forests once covered almost the whole territory of Poland. As a result of historical socio-economic processes, where the economic goals related to the expansion of agriculture and increased demand for raw wood prevailed, forests in Poland underwent substantial transformations. While at the end of the 18^{th} century forests in Poland covered 40 per cent of the country's territory (within its borders at that time), by 1945 their area had decreased to just 20.8 per cent. Deforestation and the associated reduction of species composition in stands resulted in a decrease of biological diversity of forests, degradation of the landscape, soil erosion and the upsetting of water balance. The reversal of this process came about in the period of 1945–1970, when Poland's forest cover increased to 27.0 per cent as a result of 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). At present, the total forest cover in Poland is 29.2 per cent of the country's land area.

The assessment performed according to the internationally adopted standard, which takes into account the land associated with forest management, puts the forest area in Poland at 9.3 million hectares (of which 8.9 million hectares are forests established by way of artificial regeneration), which represents approximately 29.8 per cent of the country's land area. The forest area per capita is 0.24 hectare (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 features the lowest forest cover. The forest cover in the Łódzkie and Mazowieckie Provinces is 21.1 per cent and 22.7 per cent of their territories, 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.).

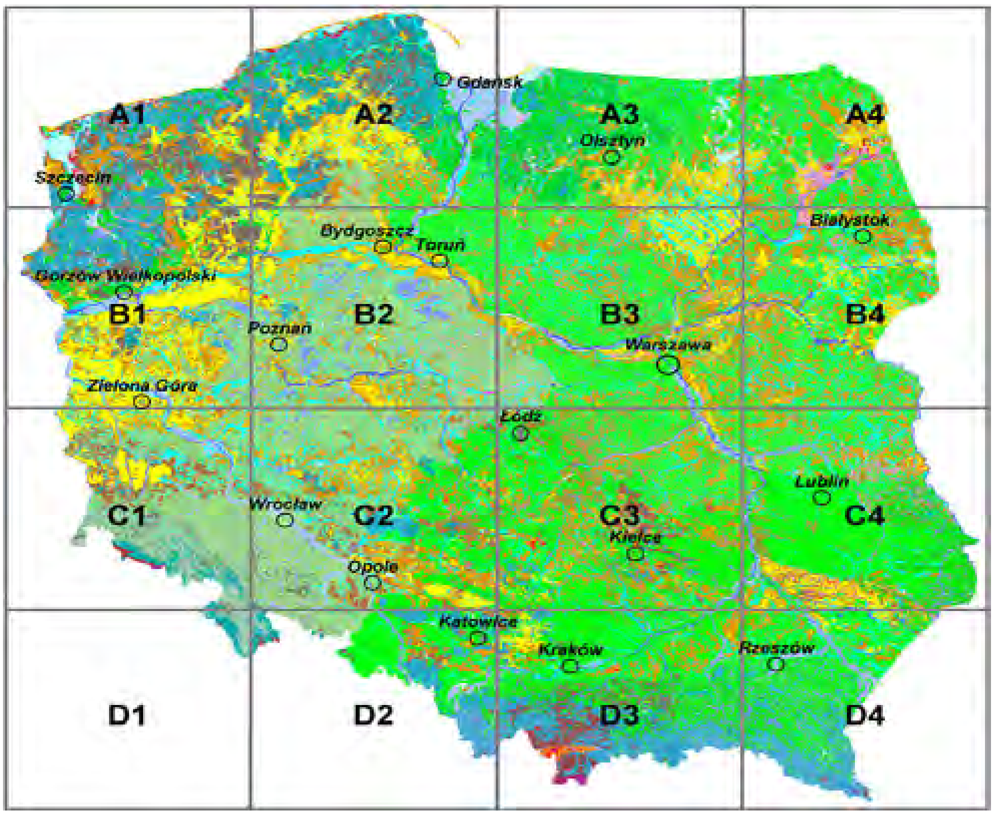


Fig. 1. A sectoral map of the potential natural vegetation in Poland

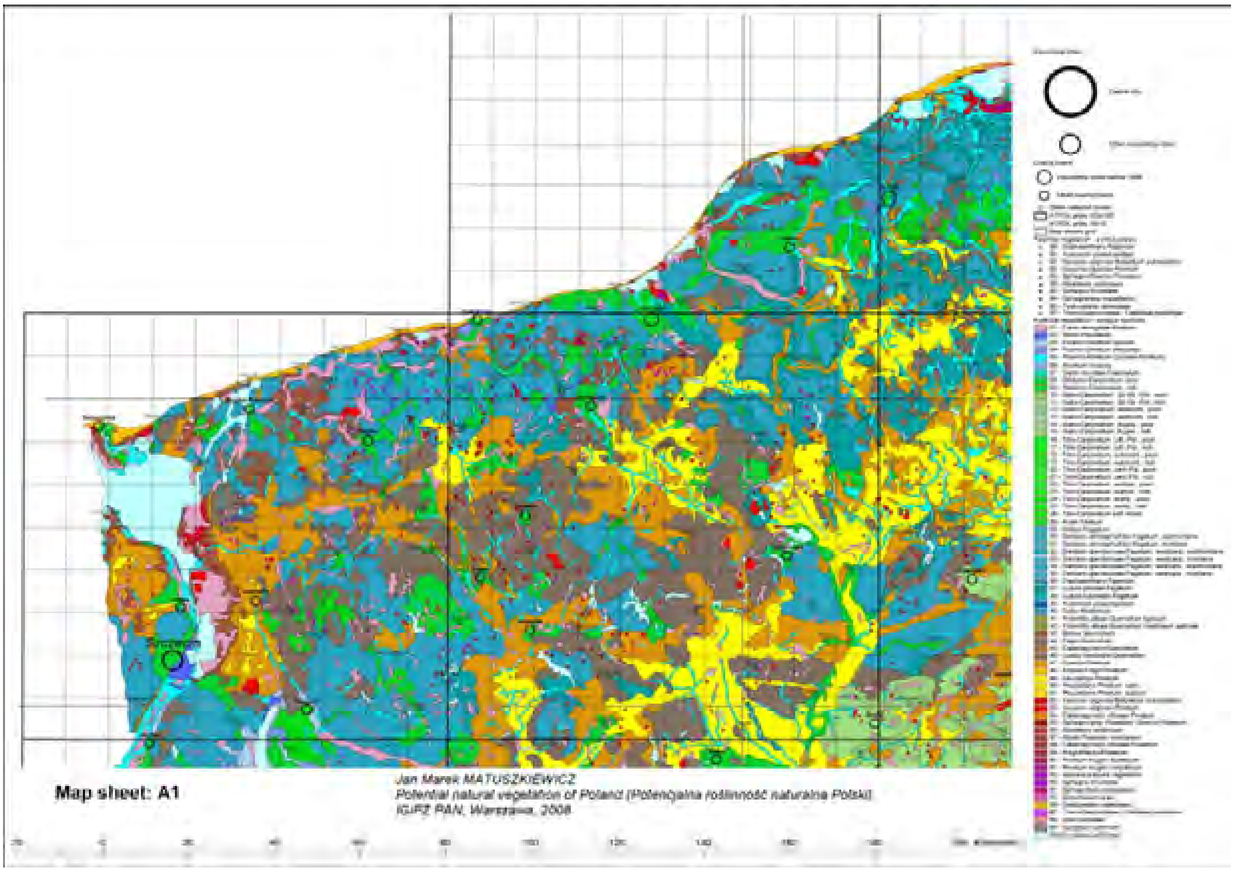


Fig. 2. A sample sector of the potential natural vegetation map (north-western Poland)

2.1. Changes in the forest area in Poland

According to the data of the Central Statistical Office, Poland's forest area increased by 33 thousand hectares in 2010, in comparison with the previous year, and by 365 thousand hectares in comparison with 1995 (according to land records).

The said increase in the forest area is the result of afforestation operations carried out on post-agricultural land and on wasteland. After 2001, areas forested by way of 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 had only a slight effect on the total area of forests (551 hectares in 2010).

The increase in the area of forests in the period 1990–2010 was not solely the result of afforestation. It was also the effect of updating the land records, by including plantations established, but not revealed in documents, in previous years. The areas forested by way of natural succession (209 hectares) only slightly contributed 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.

The National Programme for the Augmentation of Forest Cover, developed by the Forest Research Institute at the request of the Ministry of the Environment, Natural Resources and Forestry, is the basis for all afforestation operations undertaken in Poland. The Programme was adopted for implementation by the Council of Ministers on 23rd June 1995. The experience gained during its implementation revealed the need for necessary modifications, which 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, and the afforestation preferences were revised for each commune in Poland.

The Programme's main task is to increase the 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, as well as to set ecological and economic priorities and tools for their implementation. The afforestation of land under all ownership categories carried out in 2010 covered 5 864.9 hectares (Fig. 12).

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

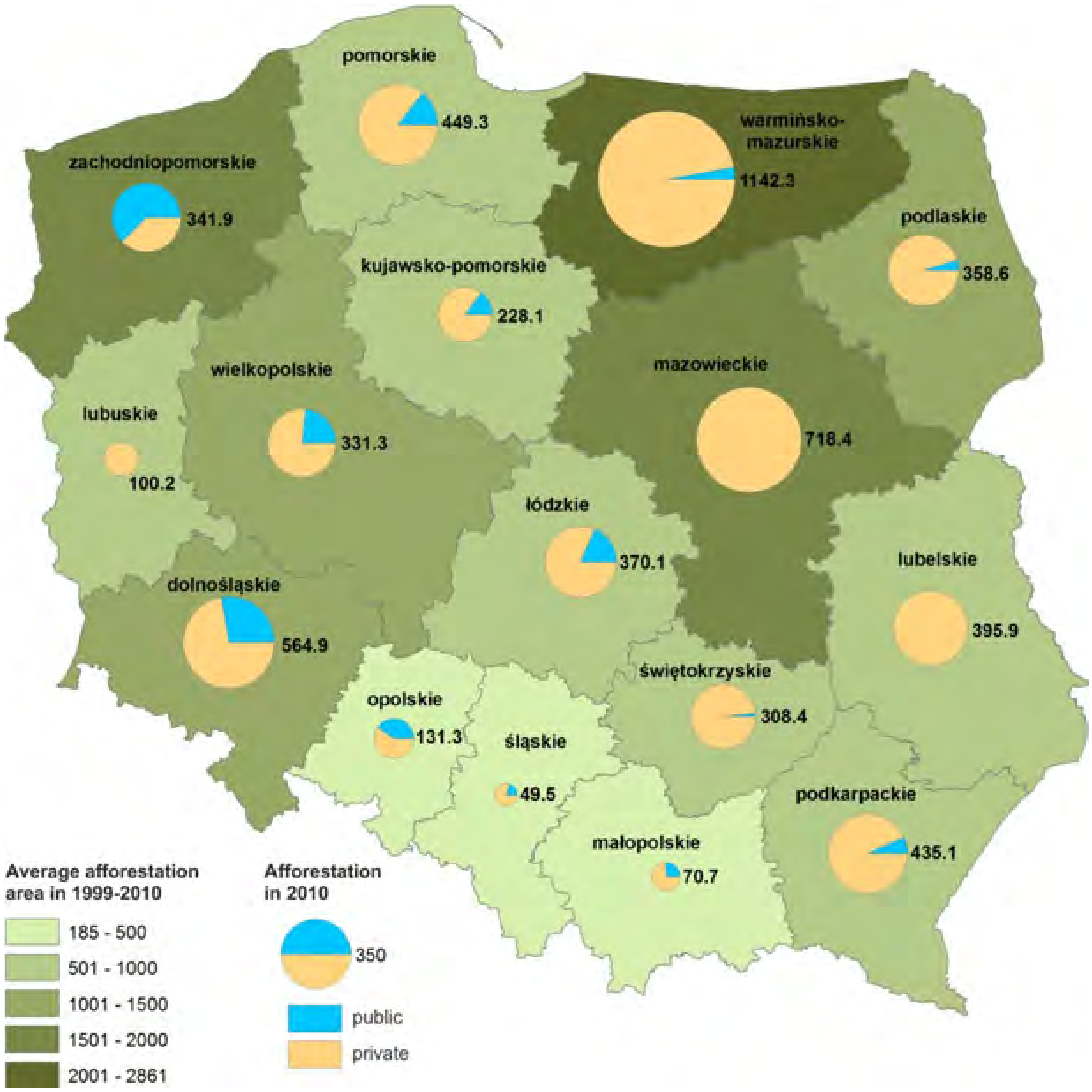


Fig. 4. Afforestation area in 2010 by Provinces against the average level afforestation area in 1999–2010 (Central Statistical Office, Forest Research Institute)

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 larger by about 1900 hectares, as compared to 2009. In recent decades, a steady decline in the afforestation area within the State Forests has been noted (as a consequence of the share of stands in younger age classes).

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).

A continuous decrease in the area of the youngest stands (age classes I and II) in Polish forests must arouse concern; this phenomenon may pose a threat to the sustainability of forests (to the optimal age-class structure) in the future. The reasons for this trend should be sought, *inter alia*, in the significant reduction of afforestations, limited final felling (reduced area of renewals) in favour of intermediate felling necessitated by the condition of forests, and reduction (e.g. for environmental reasons) of the area of clear-cuttings. An increase in the area of older forest stands is the consequence of limited final harvest; the long retained mature sawtimber stands causes timber depreciation (RoSL, 2011).

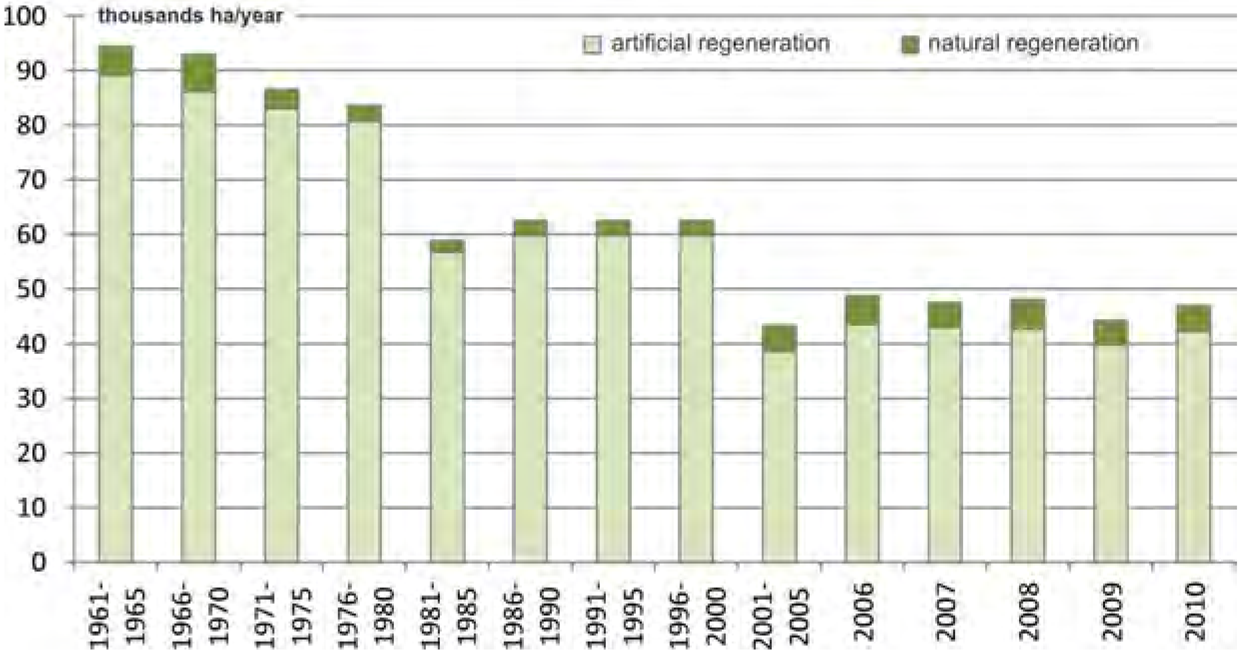


Fig. 5. The scale of afforestation in Poland in the years 1961-2010 (Central Statistical Office)

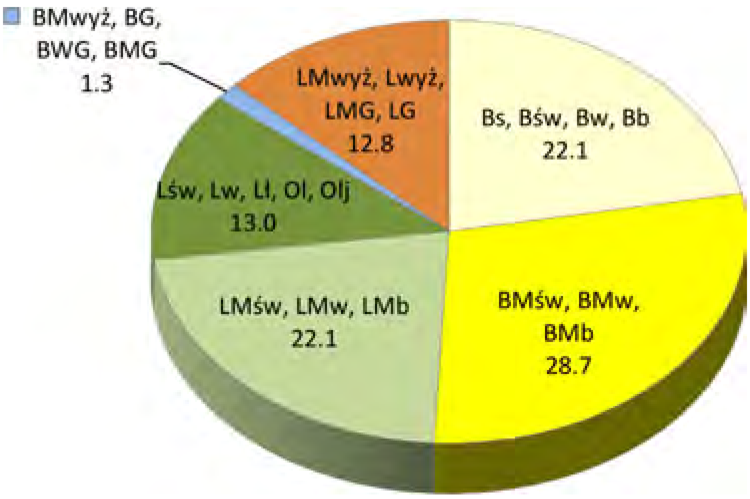
2.2. Habitat structure

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.

Fig. 6. Geographical distribution of forests (Forest Research Institute)

Poland has retained forests mostly on poorest soils, which is reflected in the structure of forest habitat types (Fig. 7). Coniferous forest habitats predominate, representing 52.1 per cent of the total forest area, while broadleaved forest habitats account for 47.9 per cent. In both groups, upland habitats occupy 5.5 per cent of the forest area and mountain habitats – 8.7 per cent.

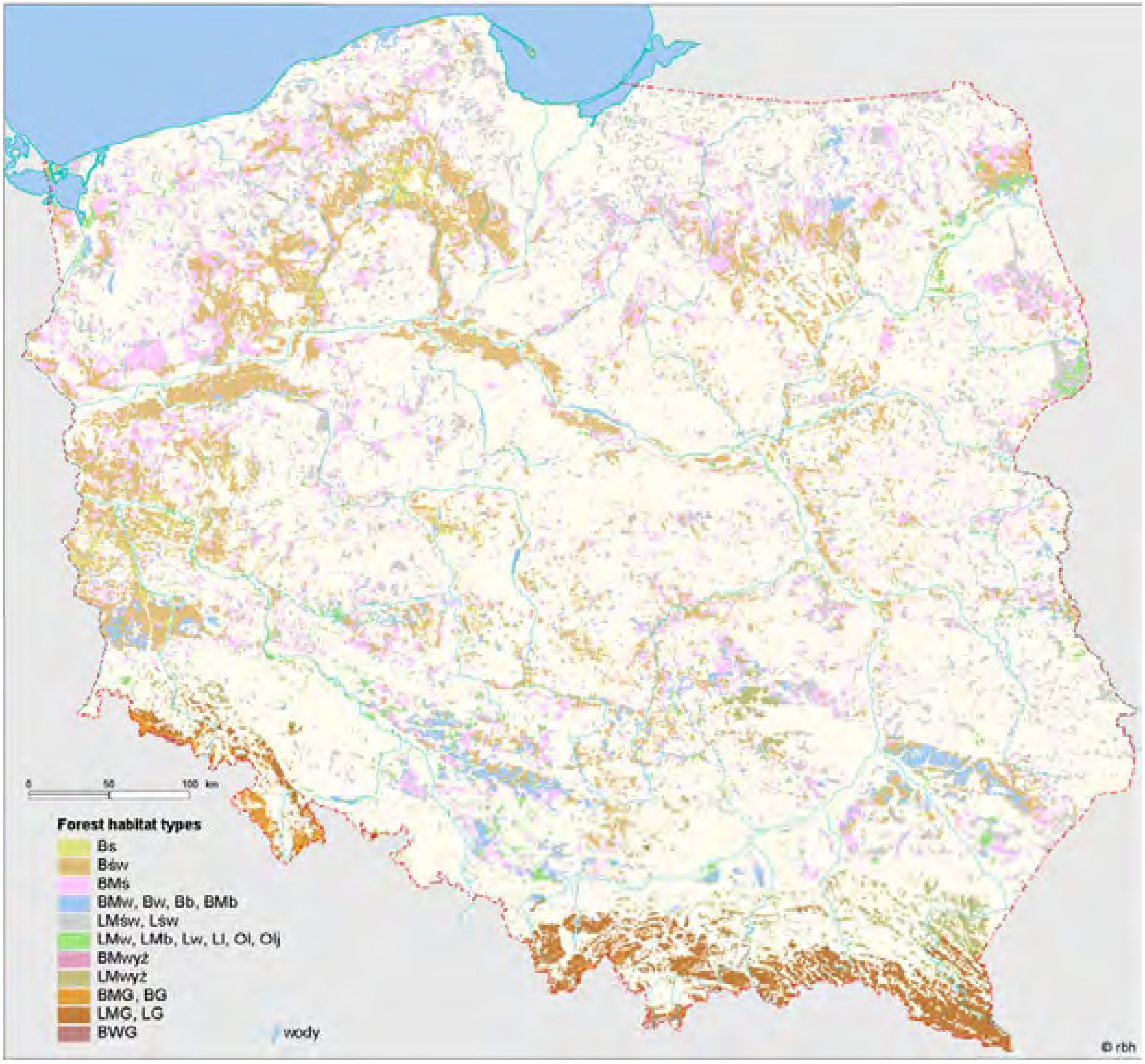
Mountain forests in the Tatras, photo by K. Murat



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)

In the geographical distribution of forest habitat types, the largest concentration of wetland habitats is, in addition to those in the mountains and uplands of southern Poland, 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.



Bs – dry coniferous forest
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BMb – mixed coniferous bog forest
LMśw – fresh mixed broadleaved forest
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LMw – moist mixed broadleaved forest
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
BWG – high mountain coniferous forest
wody – waters

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

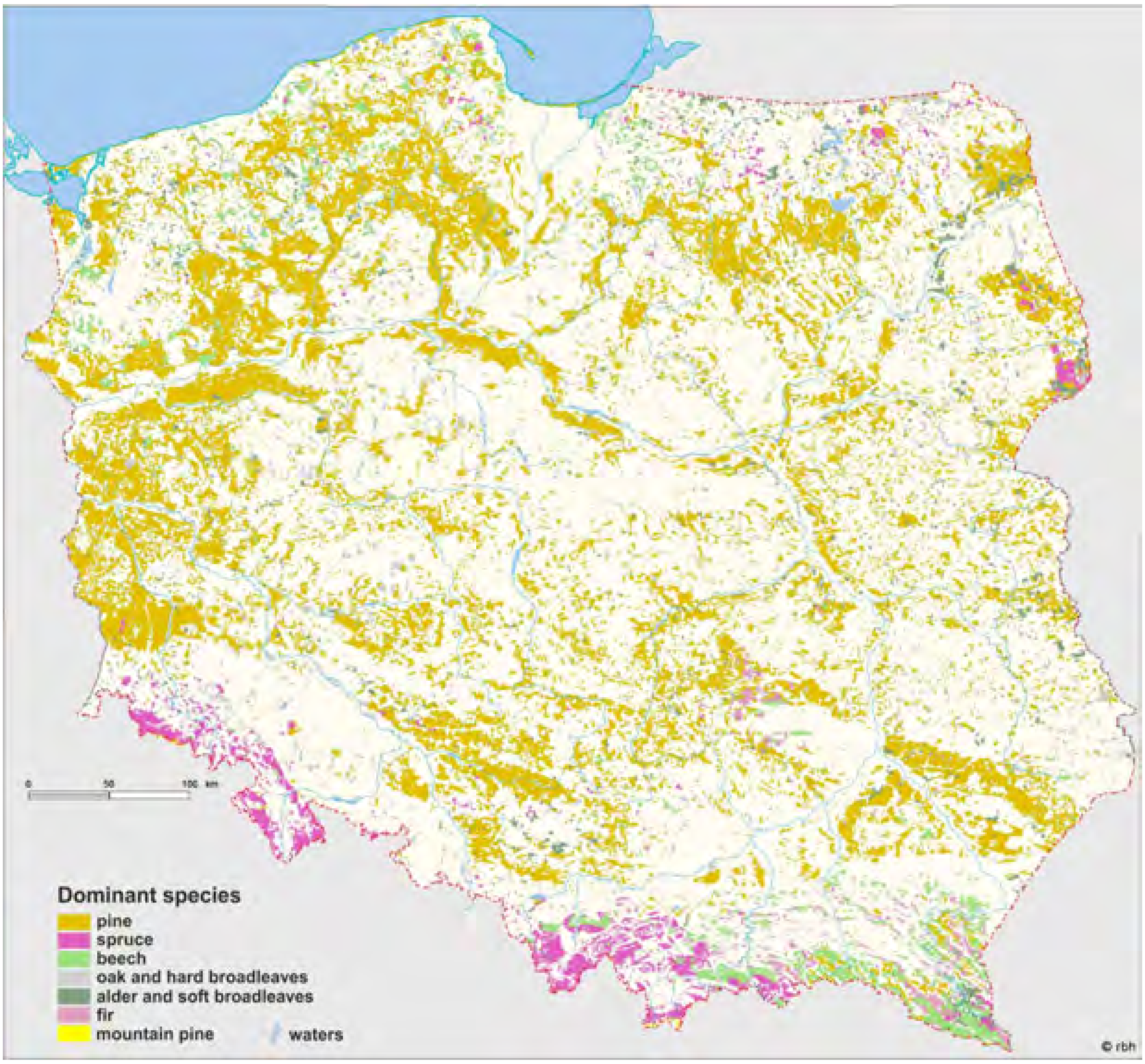


Fig. 9. Geographical distribution of forest stands by dominant species (RoSL, 2011)

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

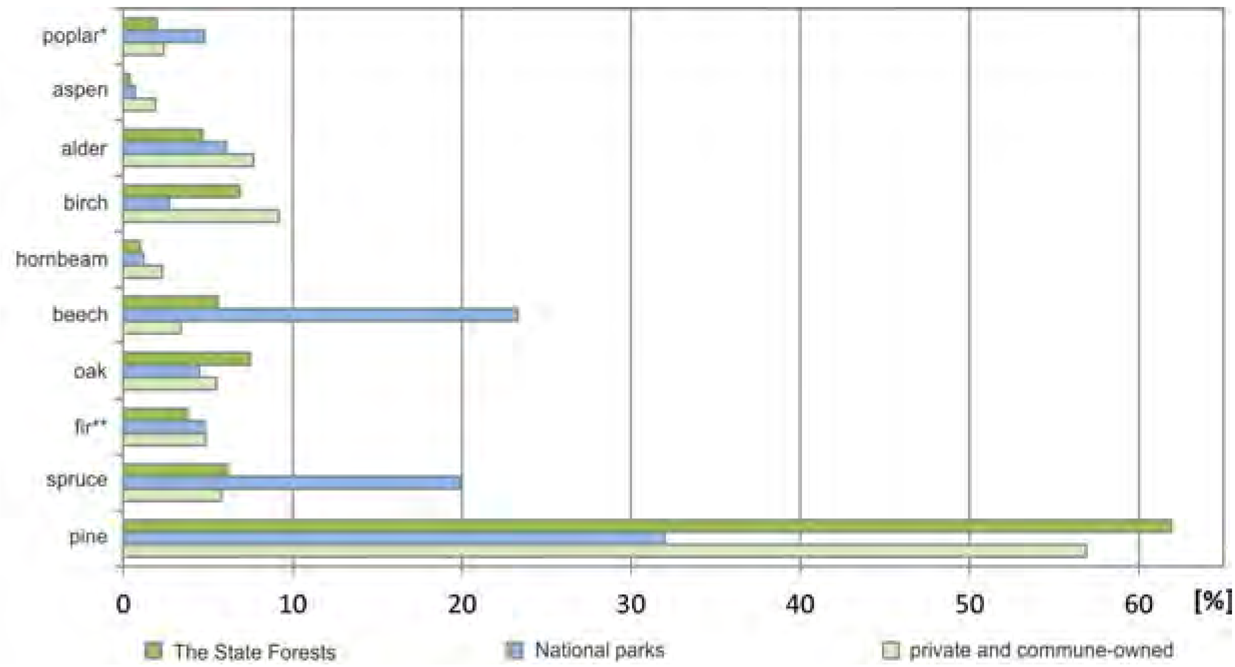


Fig. 10. Percentage area of dominant species in all ownership categories within the State Forests and private forests (Large-Scale Forest Inventory), including:
*** with other broadleaves, ** with other conifers**

In the period 1945-2009, the species structure of forests in Poland underwent substantial changes resulting, among other things, in an increase in the share of stands with the prevalence of broadleaved species. In the territory of the State Forests, where these changes are depicted in the annual updates on the forest area and timber resources, the increase in the area of broadleaved species was from 13 per cent to 23.2 per cent. In spite of the increased area of broadleaved stands, their proportion is still below their potential resulting from the structure of forest habitats (Figs. 9 and 10) (RoSL, 2011).

2.3. The age structure of forests in Poland

Stands aged 41-80, representing age classes III and IV prevail in the age structure of forests under all ownership categories, covering 27.1 per cent and 18.3 per cent of the forest area, respectively, while in private forests stands aged 41-80 occupy nearly 40 per cent of the forest area. Stands older than 100 years, including stands in the restocking class (KO), stands in the class for restocking (KDO) and stands with selection forest structure (BP) under the management of the State Forests account for 11.4 per cent of the forest area, while in private forests – 2.1 per cent. The share of non-forested land in privately-owned forests accounts for nearly 6.7 per cent, while in the State Forests, for 2.9 per cent (Fig. 11).

The reported steady increase in the share of stands older than 80 years from about 0.9 million hectares in 1945 to nearly 1.89 million hectares in 2006-2010 (excluding the KO and KDO classes) is an indicator of changes in the age structure of forests. 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.

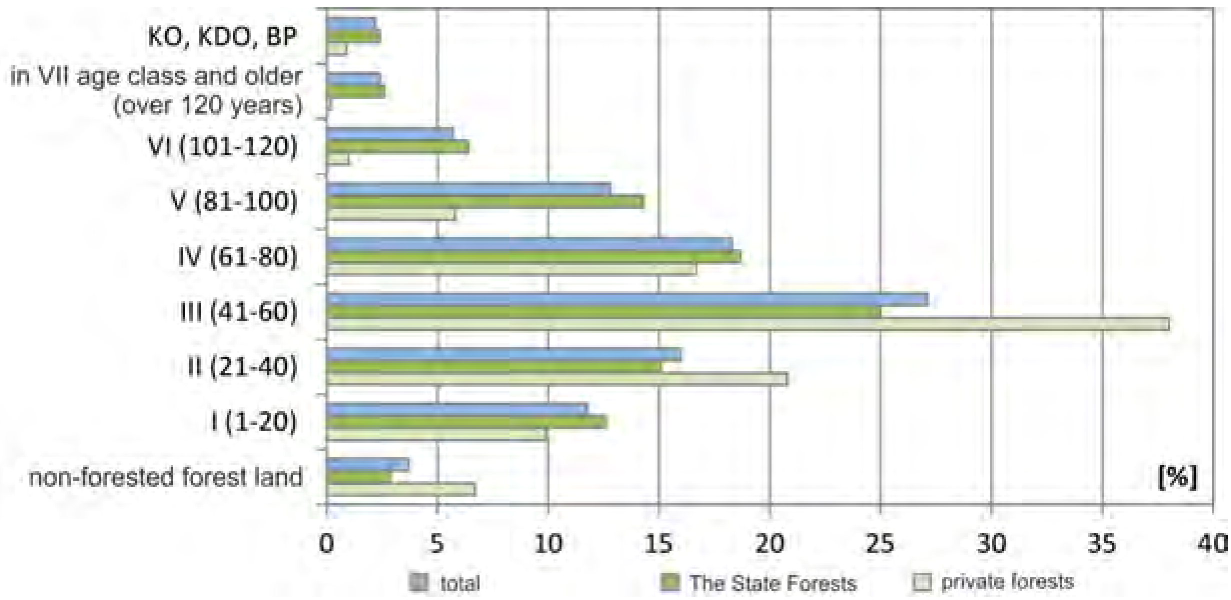


Fig. 11. Percentage area of stands under all forms of ownership in the State Forests and private forests by age class (Large-Scale Forest Inventory)

2.4. Plantations of fast-growing trees and monocultures

In Poland, semi-natural silvicultural management is pursued in accordance with the principles of sustainable development based on the knowledge and potential of forest habitats. As a result of changes in the principles of forest management adopted in 1991, monoculture plantations are practically no longer established (Forest Act, 1991, ZHL Principles of Silviculture 2003). To ensure additional production of woody biomass, medium-rotation plantations of fast-growing tree species, mostly monospecific, have been established on a small scale in Poland since the 1970s. The area of fast-growing tree plantations in Poland is given in Table 39 (the numeration of tables from 39 to 48 is a continuation of the tables placed at the end of the book).

Other monospecific plantations which were established in Polish forests in addition to the fast-growing tree plantations, such as experimental plantations or progeny plantations, are of marginal importance.

Table 39. 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 about 90 per cent of the currently established forest plantations in Poland come from planting or sowing, Polish forests should not be regarded as plantation forests for the following reasons:

- species composition of plantations is being adjusted to habitat;
- the seedlings and seeds used for afforestation and reforestation come from the seed lots of the registered seed base in a given region of origin. In view of the fact that seeds are collected from local populations and from a large number of trees (usually not less than 100 individuals), these forest plantations seem to reflect all the genetic variation of the initial source population. Preservation of the genetic resources and genetic diversity will be considered genetically justified when the collected material contains all or almost all the genes of the populations to be preserved and when 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 the 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) are developed in accordance with the EU Directive 1999/105/EC and the Act on Forest Reproductive Material (FRM). Forest Basic Material (FBM), which is the main forest seed base in Poland, is registered at the Forest Reproductive Material Office directly reporting 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 the organizational units of the State Forests, whose production amounts to about **828.8 million** plants annually (data as of 2010) (GDSF, 2011). The above-mentioned Act also sets the rules governing the use of FRM outside the regions of origin.

Table 40. 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

Forests provide employment for nearly 49.8 thousand people, of which 24.8 thousand are in the administration of the State Forests, and the rest - in the private sector. The wood processing industry (timber, paper and furniture) employs 129.9 thousand people representing 10.6 per cent of the overall employment in industry. In total, around 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 of forest services is largely fragmented. In 2009, there were as many as 8999 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 the internal and external markets

The importance of forests in the preservation of the country's ecological safety, including in particular carbon sequestration, protection of forest habitats, genetic resources of plants and animals, etc. is vital. No less important is the role which forests play in Poland in providing large amounts of timber harvested under sustainable forest management for the domestic and foreign markets. Of all the 17 Regional Directorates of the State Forests 16 have FSC certification (Forest Stewardship Council), and 5 have PEFC certification (Programme for Endorsement of Forest Certification Schemes). Private forests are not subject to certification (DGSF, 2011).

Forests are part of the national property which, as any property, should bring benefits (Płotkowski, 1998). Forest economy, as any other kind of business, is somewhat focused on generating revenue. However, unlike other businesses, here the money is put in long-term investment, locked up for many years. The income earned from the investment in forests typically reaches only about 2 per cent (Płotkowski, 1999; after Parzych, 2007).

All sectors of the national economy benefit to varying degrees from forest products and services (Table 41). The largest demand for forest products is from the processing industry sector. In 2010, it amounted to PLN 2 564 452 million (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, compared to 2000. The wood, as well as the pulp and paper industries are the major customers of forest products. A large part of forest-derived products are used for own needs of forest economy (24.4 per cent) and for the needs of households (15.6 per cent).

Table 41. The demand of 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 (in thousands of PLN)	Share (%)
1	2	3
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**

To conduct business, the forestry sector also needs products from other segments of the national economy (Table 42). The forestry sector itself is the largest supplier – 24.4 per cent. Polish forestry is a production sector of the economy in which the share of material costs (intermediate consumption) in total production is about 50 per cent. Also value added represents a significant share of about 40 per cent, including 28.5 per cent of labour costs, and 8.6 per cent of gross profit.

Table 42. The demand of 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 (in thousands of PLN)	Share (%)
1	2	3
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**

It is noteworthy that most of the revenues derived from the products made of wood go to the 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). Consequently, the share of forestry in the Gross Domestic Product (GDP) is insignificant, and amounts to about 0.3 per cent.

The majority of large-sized and stacked wood goes to the domestic market for further processing, while most of the final products made of the wood processed to varying degrees (60 per cent) go to foreign markets. In 2009, the share of the entire manufacturing industry in the production sold was 9.6 per cent, of which the wood processing industry without furniture was 6.02 per cent. In the same year, the share of the wood processing industry in total Polish exports amounted to 10.93 per cent. The value of the production sold in the entire timber sector in 2010 amounted to 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, and amounted to 2.29:1 for the year 2009.

Forests provide many other non-wood products mainly for the needs of the local communities engaged in collecting forest floor products whose share in exports is also significant. Forests supply annually around 11 834 tonnes of blueberries, 4 186 tonnes of fungi, and 7 304 tonnes of other forest fruits. In spite of the ever increasing share of private plantations of Christmas trees, forests still provide a significant number of Christmas trees – 49 000 (FRA 2010). With few restrictions on public access to forests for collecting non-wood products (restrictions under the Forest Act and Nature Conservation Act), forests have become a source of income for local people. They are also engaged in providing services for forest and timber economy. Forests therefore play a significant role in the reduction of poverty and unemployment in the agriculturally and industrially underdeveloped regions of Poland. Also the cultivation of hunting traditions is important for local communities. Hunters who have acquired the rights to hunt in Poland, harvest annually about 450 thousand big game, 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 from agriculture.

2.8. 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. As concerns public ownership, the increase in the forest area in national parks from 1.9 per cent in 1995 to 2.0 per cent in 2010 was mainly due to the establishment of four new parks.

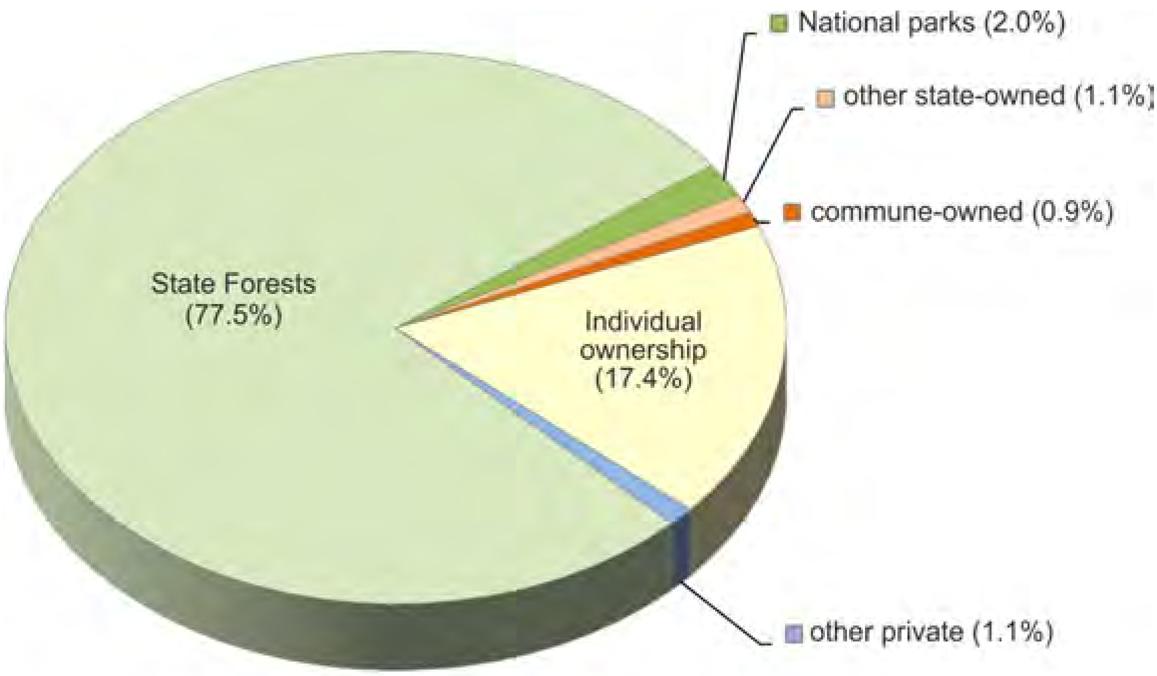


Fig. 12. Ownership structure of forests in Poland (Central Statistical Office, 2010)

The State Forests comprise the following organizational units:

- Directorate General of State Forests (GDSF) headed by the Director General;
- 17 Regional Directorates of State Forests (RDSFs) in Białystok, Gdańsk, Katowice, Kraków, Krosno, Lublin, Łódź, Olsztyn, Piła, Poznań, Radom, Szczecin, Szczecinek, Toruń, Warszawa, Wrocław and Zielona Góra;
- 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 State Forests, the Environmental Project Coordination Centre;
- 17 service units of the State Forests of regional scope.

RDSFs are established, merged, divided and canceled by virtue of a Regulation from the Minister relevant in matters of the environment, at the request of the Director General, while Forest Districts and organizational units of nationwide scope are established, merged, divided and canceled by the Director General of the State Forests. As concerns Forest Districts, a request of a Director at a RDSF is required. Organizational units of regional scope are established, merged, divided and canceled by the Director of a RDSF upon consent of the Director General.

The State Forests are headed by the Director General, with the assistance of Directors at the RDSFs; the Director General is appointed and dismissed by the Minister relevant in matters of the environment.

The College of State Forests 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 representatives of science, associations and social and professional organizations acting for the benefit of nature conservation, as well as from among 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. District Forest managers pursue autonomous forest management in their Forest Districts and are responsible for the state of forests in their area of operation (Forest Act, 1991; Fonder, Szabla, 2011).

2.9. Private forests

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

According to the Agricultural Census 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 with a forest area exceeding five hectares. The average area of forest per holding is 1.3 hectares (Gołos, 2007), and 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. Recently, a Union of Forest Associations has been called into being.

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

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

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 supervision over the remaining area the Governor's Offices have entrusted to the State Forests (1 233 thousand hectares) (RoSL, 2011).

All the main forest-forming tree species are represented in the privately-owned forests in Poland. About 70 per cent of the forest areas are coniferous species, and about 30 per cent are broadleaved forests.

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

Fig. 13. Share of private forests in the total forest area by Province (Central Statistical Office)

The environment-shaping role of private forests is significant in some regions of Poland, 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 characteristic of forest stands and organization of the economic activity in such forests. Private forests and forest estates have never been the main or a significant source of income for the inhabitants of rural areas. 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 the forests managed by the State Forests was even lower, and amounted to 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 the forests managed by the State Forests. This indicates a huge untapped potential as concerns acquisition of additional quantities of timber in the privately-owned forests, which would allow to satisfy wood shortages in the market. If we assume (very briefly) the same intensity of timber harvest in privately-owned forests as in those managed by the State Forests, the volume of harvested timber in privately-owned forests should amount to 6-7 million m^3 (Zaleski, 2011).

The harvest of timber from woodlots, located mainly on privately-owned land, to some extent makes up for the shortages of wood on the local market. In 2009, 851.6 thousand m^3 of timber from woodlots was harvested (Central Statistical Office, 2010).

After 2001, private landowners significantly contributed to the increase of the country's forest cover. In the years 1995-2010, 126.9 thousand 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,** favourable impact on the shaping of the climate both locally and globally, the regulation of the water cycle in nature, the prevention of floods, avalanches and landslides, the protection of soil against erosion and landscape against becoming a steppe;
- **Productive (economic) functions,** primarily the production of renewable biomass, including timber and non-timber products;
- **Social functions,** providing health-improving and recreational conditions for society and 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.

The forest cover, mostly composed of woody vegetation, has a positive influence on the local and global climate. Forest ecosystems, one 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 plus their high retention capacities slow down the melting of snow and the outflow of rainwater, thus alleviating flood hazard.

Forests in the mountain areas, where shallow soils are exposed not only to eolic erosion, but first of all to water erosion, become especially important. Moreover, forests largely stabilize the snow cover, thus reducing the danger of avalanches. The genetic diversity of forests is essential for the sustainable development and moderate use of forest ecosystems. It determines adaptability to changing environmental conditions and global climate change.

Taking into consideration the ecological and social functions of forests in forest management, frequently referred to as non-productive functions, has resulted in the establishment of protective forests, beginning from 1957. The total area of protective forests managed by the State Forests as of 31 December 2010 amounted to 3292 thousand hectares, which represents 46.6 per cent, and together with nature reserves – 48.3 per cent of the total forest area. In the category of protective forests, water-protecting forests occupy the largest area – 1414 thousand hectares, around cities – 637 thousand hectares, damaged by industry – 531 thousand hectares and soil-protecting forests – 344 thousand hectares (Fig. 14). The majority of protective forests are located 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 (about 36 per cent).

Depending on their predominant function, protective forests are subject to modified procedures including limits on clear-cutting, increase of rotation age, adjustment of species composition to the functions served, or recreational management (RoSL, 2011).

In comparison with other European countries, 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).

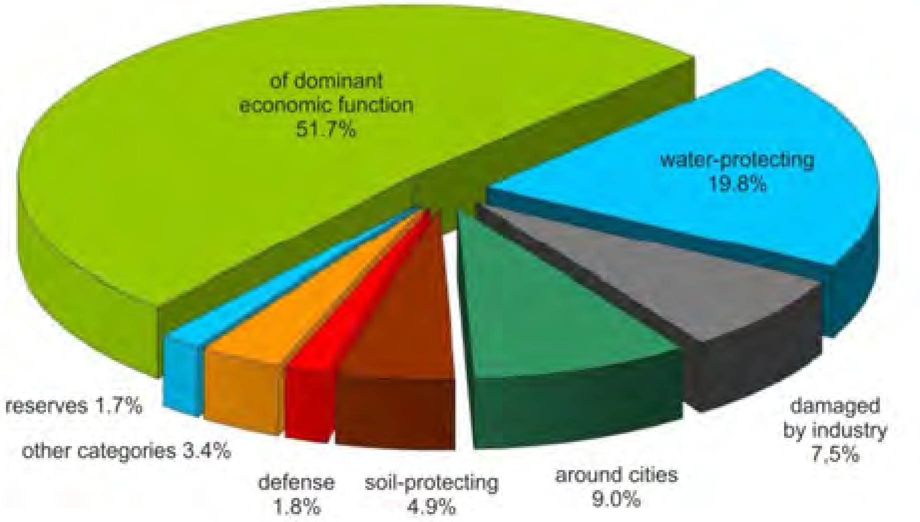


Fig. 14. Share of protective forest in the State Forests in 2010 (DGSF)

The social functions of forests

People find forests an attractive place for recreation and leisure. They are particularly appreciated by the inhabitants of large urban agglomerations. Forests are a popular destination for tourists, mainly schoolchildren and youth wishing to enjoy direct contact with nature. A trip to the forest is an excellent opportunity for achieving forest education objectives.

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 abilities of forests, such as hornbeam, oakwoods, mixed coniferous, pine and dry coniferous and even poplar and willow riparian forests, are known to stimulate cardio-respiratory systems. Moreover, forests contribute to the cleaning of the air of heavy metals and dusts, and help reduce the noise level, therefore have a beneficial effect on the microclimate of urban areas.

Forests also provide employment for nearly 50 thousand people directly involved in their protection and management. They also stimulate industrial production and support many jobs in other sectors of the economy, such as 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, which are used by many industries and trades, and which contribute to traditions and cultures.

The use of forests as a renewable resource of raw material is driven not only by market demand, which provides economic conditions for forest management, but also by silvicultural needs and the principles by which the structure of forest resources is regulated. Forest utilization takes place at the level determined by the natural conditions of timber production, silvicultural and protection needs, but first of all by the principle of the persistence of forests and augmentation of their resources. The average annual volume of timber harvested in Poland on the basis of these criteria in the period 2000-2010 amounted to 31 951 thousand m^3 (Table 25).

The volume of timber harvested in Poland in 2010 amounted to 33 568 thousand m^3 of net merchantable timber, including 1243 thousand 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 amount to about 40 million m^3 in the State Forests, and 1.5 million m^3 in private forests (DGSF, 2011).

The significance of the productive functions of forests in protected areas

The past decade saw a reorientation in sustainable forest management from the dominant productive function towards the protective function of forests. Despite the year-to-year increase in the volume of harvested timber, resulting from the need for felling the aging stands and for applying tending treatments mainly in the stands aged 41-80 years, increasingly more forest land is being excluded from timber production, or else such production is largely limited because of the growing importance of the ecological functions of forests (Natura 2000 sites, areas around national parks, *etc*.).

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

2.11. Transformations in the forestry sector and the factors determining these changes

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

In the period 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, covering 37 335 hectares of which 35 161 hectares were forest area (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 9363 thousand hectares, and the process of drawing up protection plans for these sites was started (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 increasing the harvested volume of merchantable timber by 9 million m^3 (RoSL 2011).
7. The harvest of seeds of the main forest tree species from outside the registered seed base was forbidden.
8. The *ex situ* collection of genetic resources of forest trees and shrubs in the Kostrzyca Forest Gene Bank was reported to increase 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, Cracow, Wrocław, Olsztyn, Katowice and Zielona Góra were registered in the EUFORGEN database, thus increasing 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).

With regard to legislation:

12. In addition to the above-mentioned legislation, the following acts and their executory provisions were implemented:
    a) The Environmental protection law of 27 April 2001 (consolidated text Dz. U. 2008, No. 25, item 150, with subsequent amendments);
    b) The Act of 13th April 2007 on the Prevention and Repair of Environmental Damage (Dz. U. 2007, No. 75, item 493, with subsequent amendments);
    c) The Act of 3rd October 2008 on Sharing Information about the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessment (Dz. U. 2008, No. 199, item 1227, with subsequent amendments);
    d) The Act of 7th June 2001 on Forest Reproductive Material (Dz.U. 2001, No. 73, item 761, with subsequent amendments);
    e) The Act of 18th December 2003 on Plant Protection (consolidated text Dz.U. 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 and the transition from the timber production model towards the multifunctional model of forest management.

However, the productive function of forests in Poland still plays a vital role. In comparison with 2000, timber harvest in Poland has increased by about 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 stood at more or less the same level while the general demand for timber increased significantly. Despite the ever-growing timber harvest in Poland, the demand for timber continues to be high. The annual timber deficit, with a maximum market demand for this raw material, is estimated at 1-2 million m^3 (GDSF, 2011).

In connection with the adoption of the climate package by Poland, there is growing pressure for supply of wood biomass for the energy market. The Ministry of the Environment in its forestry strategy, still being developed, does not foresee 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, forests in Poland should provide the power industry with about 4.5 million m^3 of timber per year from stump wood and slash (DGSF, 2011).

The insufficient supply of timber to the market may, in the near future, lead to conflicts between forestry, the wood and power industries, and ecological organizations. Non-governmental organizations increasingly more often and more effectively seek to change the role of the forest as a renewable source of timber and to emphasize the importance of non-productive forest functions, such as ecological and protective.

2.12. The anticipated directions in forest management in the upcoming decade

The most important goals of the forest economy in the upcoming decade are related to the continuation of sustainable forest management in accordance with the principles of sustainable development and permanence of forests expressed, *inter alia,* in the State Policy on Forests (1997) and the Forest Act (1991) 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) restitution and rehabilitation of forest ecosystems mainly through the replacement of monocultures by mixed stands on appropriate sites;
e) regeneration of devastated and neglected stands in private forests followed by their ecological rehabilitation;
f) changing the proportion of broadleaved species in the forest;
g) increasing the area of plantations established by way of natural regeneration;
h) limits on clear-cuts in favour of complex felling with a long regeneration period;
i) actions to enhance water retention in forest communities in the mountains and lowlands;
j) retaining larger amounts of deadwood in forests until their natural decay;
k) use of the FRM of known silvicultural value, including the material with increased adaptability for artificial regeneration;
l) active *in situ* and *ex situ* conservation of forest genetic resources from valuable stands located in the forest areas under different management and ownership also in protected areas.

2.13. Limitations on sustainable forest management, including forest productivity

Changes in the way of conducting forest management in valuable natural areas, specifically in the Natura 2000 areas and, to a lesser extent, setting the new or expanding the existing protected areas (national parks, nature reserves), whose main purpose is to protect forest communities, are factors limiting forest productivity or utilization of timber resources.

Climate changes and the associated weather anomalies, as well as the biotic and anthropogenic factors harmful to the forest environment (Table 43) are largely responsible for the reduction of timber production (RoSL, 2011).

Table 43. Stress factors affecting 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 Earth surface** ∗ mining **4. Forest fires** **5. Activities harmful to forest** ∗ poaching and theft ∗ excessive recreation ∗ mass mushroom picking **6. Incorrect forest management** ∗ schematic procedure ∗ excessive utilization ∗ abandonment of tending

In the Treaty of Athens of 16 April, 2003, Poland committed itself to designate in its territory areas for the Natura 2000 network. The EU rules, which form the basis for the creation of the Natura 2000 network, were incorporated into the Polish legislation system with the publication of the Nature Conservation Act of 16 April 2004.

However, many mistakes were committed in the process of building the Natura 2000 network, allowing excessive formalism and bureaucracy, neglecting the vitally interested parties in the arrangements and excessively favouring the selected NGOs, especially those developing “shadow lists”. The implementation of the Natura 2000 programme, the establishment of the principles and methods of protection, and a clear division of responsibilities between the nature protection bodies (Directorate General for Environmental Protection DGEP, Regional Directorate for Environmental Protection RDEP) and the administrator of the protected areas (the State Forests) – all these issues are included in the afore-mentioned strategy for the development of forestry and forest management of the State Forests (Fonder, Sword 2011) .

The scale of the anticipated restrictions concerning the productive functions of forests in areas of the Natura 2000 network is unknown at the moment. Due to the fact that 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 and other forest managers and forest owners, and may have adverse consequences for 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 in areas of the Natura 2000 network, taking into account only those restrictions which are contained in EU directives, such as: Habitats Directive 92/43/EEC and Birds Directive 79/409/EEC.

Due to the steadily growing demand for timber and the increasing area of protected sites, plantations of fast-growing trees from the proven and selected families and clones of the tree species outside the protected forest habitats should be established on a larger scale, and actions 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 give about 50 per cent of the 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.

In areas with damaging biotic and abiotic factors of high frequency and intensity, the FRM characterized by high plasticity and increased tolerance to these factors should be used.

2.14. The role to be played by forest genetic resources in Poland in the next decade with respect to forest goods and services

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

Expectations from the forest sector in the next decade will continue to grow, so Polish forests will face many difficult challenges such as:

- the growing demand for wood, due to the steadily increasing consumption of this raw material in Poland and other European countries, including energy needs;
- the growing public demand for access to forests, including 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 snowfall, hoarfrost, drought and resultant forest fires;
- the effects of deteriorating health condition of forest stands manifested by outbreaks of insects, as well as fungal and bacterial diseases;
- tendencies to limit the productive functions of forests in favour of protective ones by creating new or expanding the existing national parks, nature reserves, Natura 2000 sites and other protected areas;
- a steady increase in the costs of forest management, including the costs 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 up to 2016 formulated in the Forest Strategy of the Ministry of the Environment, pending enactment, assume continuation of the efforts towards the rational use of forest resources by shaping their desirable species and age structure, while maintaining their biological diversity in accordance with the principle of sustainable and multifunctional forest management.

The directions of operation for the years 2009-2012 were also identified. The most important ones are:

- 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 species composition of stands to habitat conditions and increase in the genetic and species diversity of forest biocoenoses, including the implementation of the Programme for the Restitution of Fir in the Sudetes and the Programme for the Protection and Restitution of Yew in Poland;
- increase of the role of forest gene banks;
- introduction of 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

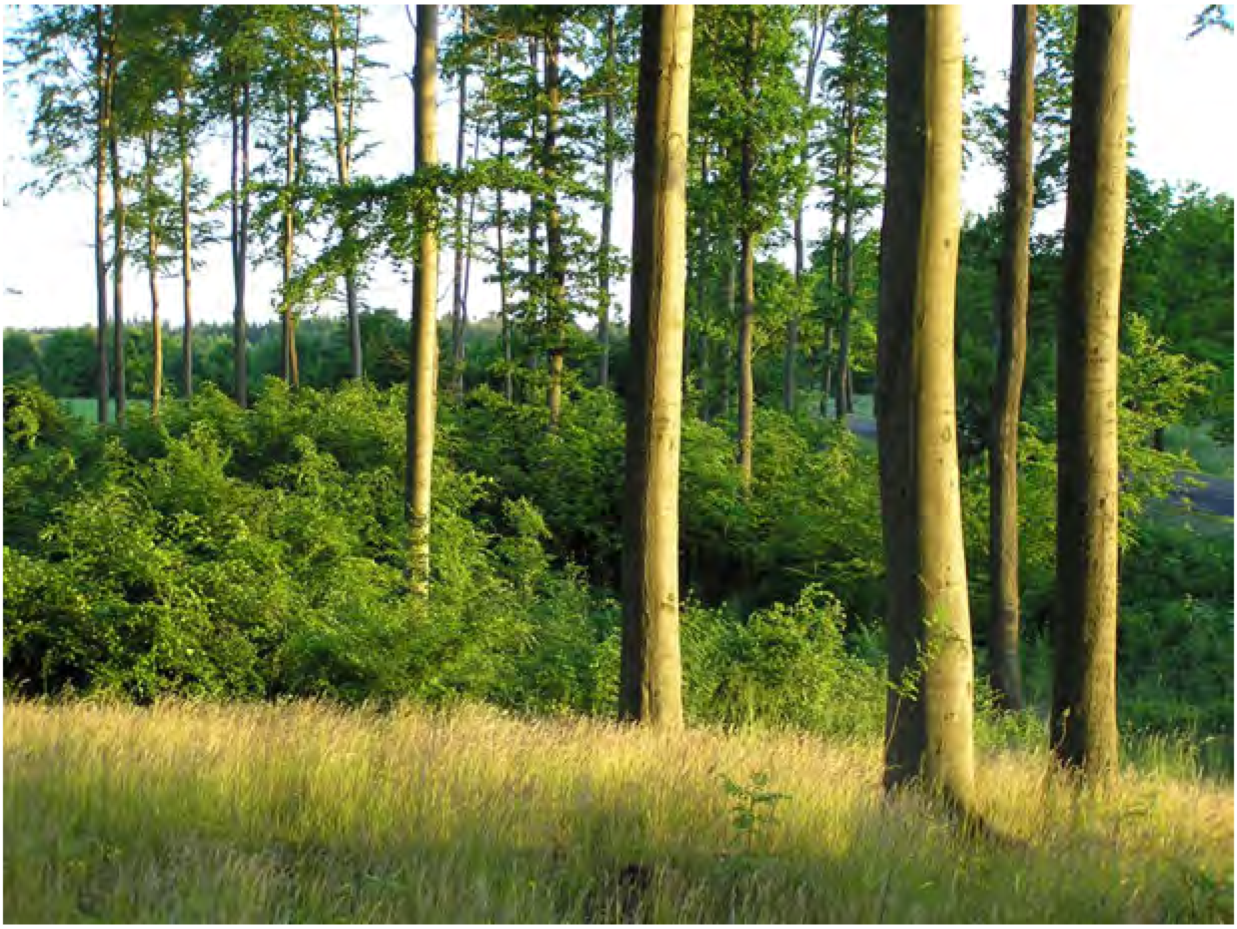
According to the FRA 2000 classification, forest communities in Poland fall into three ecological zones: transition zone forests with oceanic influences, transition zone forests with continental influences, and mountain forests. Poland lies in two bio-geographic regions distinguished for the needs of nature conservation management: Continental (over 90 per cent of the country's land area) and Alpine (Polish part of the Carpathian Mountains) (Source – 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* (Mattuschka) 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, adjusted for centuries to our climate and soils in the process of natural selection. Habitats of outstanding natural values and a high degree of naturalness account for 33 per cent of all areas subject to legal protection, *i.e*. national parks, nature reserves, landscape parks, or 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). The Natura 2000 network in Poland covers 20 per cent of land area, of which 38 per cent are in the forests managed by the State Forests and 18 per cent in private forests (Pigan, Błasiak 2010; Referowska-Chodak, 2010).

In Europe, forest ecosystems constitute 51 per cent of the Natura 2000 sites. 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 high requirements set by Polish experts for the indicators characterising habitat structure and function (Czerepko, 2010). The amount of deadwood in the forest is an indicator which may serve as an example. The deadwood indicator, which in most forest habitats should exceed 10 per cent of stand volume, allows classifying a given habitat to the appropriate conservation status.

Table 26 shows forest habitats whose condition is significantly influenced by the forest management procedures.



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

1.1. Genetic variation in the main forest tree species estimated on the basis of molecular analysis

There have, so far, been no comprehensive studies on the genetic variation and diversity of the main forest tree species in Poland. Actually, this type of research has been done for many years by different research institutions, *inter alia*, the Institute of Dendrology, Polish Academy of Sciences in Kórnik, Forest Research Institute in Warsaw, and Kazimierz Wielki University in Bydgoszcz, but the amount of the tested genetic material and the use of markers have always been limited, depending on the available funds.

The picture of genetic variation in forest trees that emerges from these scarce studies carried out so far in Poland does not differ essentially from that in Europe. 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 percent of the total genetic variation in the species. The high level of genetic variation in forest tree species determined by factors such as wide distribution range, dominant cross-mating system, long period of generations, a relatively large refuge area where species had survived the ice age allowed the populations which colonized Europe after the gradual climate warming to maintain a high genetic polymorphism. There is no doubt that the short time which has elapsed since the last ice age and the possibility of transfer and exchange of 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 mother stands themselves. The obtained results indicate that both examined natural and artificial regenerations are a good copy of mother stands, although, in some cases, a 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 studies also included the genetic variation in pine in the Gniewkowo clonal seed orchard. The analyzed seed orchard represented a high level of genetic variation, comparable to that observed in other seed orchards and in natural forests. This indicates a significant genetic potential of the orchard and high usefulness of the studied population as a seed base. The level of inbreeding in the parental population (seeds) is not a problem here, and a certain excess of heterozygosity may have positive effects (Burczyk *at al.,* 2000).

In the period 2002-2010, the Forest Research Institute examined 42 Scots pine stands representing a seed base according to the forest seed regionalization principles adopted by the State Forests (Zaleski, 2005) for the genetic structure of their DNA. Of those forest stands 30 were tested using nuclear DNA markers (RAPD and microsatellite) and 42 – using mitochondrial DNA markers (STS). The investigated stands were located 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 population), Silesia (2 populations) and Małopolska (11 populations).

The obtained results show that the tested Polish populations of Scots pine are characterized by 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 a high similarity of genetic variation in stands. Low levels of F_{ST} were also reported for other pine species analyzed using SSR markers, that is F_{ST} = 0.092 for *P. pinaster* and F_{ST} = 0.0054 for *P. strobus*.

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

Using microsatellite DNA markers, which are a more precise technique in detecting genome polymorphisms, 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). Other seed zones with provenances showing genetic similarity, *i.e.* 105, 107, 306, 352, 504, 607, 404 and 602, are located 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, least related to the genotypes of other populations.

Because of a high frequency of the rare mitochondrial haplotype *nad*1 and the largest intrapopulation variation in the Silesian and Wielkopolska-Pomerania Natural-Forest Regions in comparison with 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 observed higher genetic diversity 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 establishing the origin of spruce populations in Poland from different refugia. Due to the fact that 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 allowed proving that spruce in Poland came from two separate refugia. The study was conducted with 1352 trees from 58 populations representing the whole natural range of spruce in Poland and from the, so called, "*spruceless zone*". The majority of the examined trees in north-eastern Poland originated from the Russian refugium, while all those in southern regions came from the Carpathian range of distribution. Spruce from both the refugia occurred in the spruceless zone. This area should therefore be regarded as a place of natural crossing of the two distribution ranges. Spruce from the Białowieża Primeval Forest region was also shown to be a mixture of the two origins, although until now the Białowieża spruce had been classified to the north-eastern origin (Dering, Lewandowski, 2009; Dering *at al.,* 2011).

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

Based on the results of research on 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), compared to the spruceless zone of the Polish Lowland and Central Carpathian Depression (F_{ST} = 0.039). These values do 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 shows 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 reveal 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 - is 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* (Mattuschka) Liebl.)

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

Pedunculate oak, photo by K. Murat

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

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. Most of the trees were found to originate from the Balkan line (71.4 per cent), followed by the Apennine line (23.2 per cent), and the least number of trees (5.4 per cent) from the Iberian line. Finding the Iberian haplotype among the old, 400-700-year old trees proves natural spread of the individuals from that line in the Polish territory (Dering *et al*., 2008).

Europan beech (*Fagus sylvatica* L.)

The genetic variation in beech populations was tested, among others, on the basis of an analysis of microsatellite chloroplast DNA. Thirty populations of European beech selected on the basis of phytosociological characteristics of forest communities were studied.

Most variable genetically were stands from northern and south-eastern Poland (Kwidzyn, h = 0.505 and Tomaszów Lubelski, h = 0.417). The mountain populations from Suchedniów and Zdroje were characterized by an average level of genetic variation, 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 variable. The genetic variation in all the tested populations together was low (G_{ST} = 0.267), 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 Gryfino, Łosie and Zdroje populations showed the highest, while the Kartuzy and Miechów populations – the lowest share of polymorphic *loci.* The value of heterozygosity ranged from h = 0.268 in the Kartuzy population to h = 0.334 in the Gryfino population. There was a slight decline in the genetic diversity of the tested beech populations from south to north of Poland.

This trend, however, was not clearly marked and indicated rather 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 the European ash (*Fraxinus excelsior* L.) from the Bartoszyce, Elblag, 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 (Elblag, h = 0.156) and southern regions of Poland (Złoty Potok, h = 0.169) had a larger number of polymorphic alleles, in comparison with the Bartoszyce population (with the lowest number of alleles, h = 0.138) located in the north-eastern region of the country. In addition, the chloroplast DNA analysis confirmed the distinctiveness of the populations from the Szczecinek and Choszczno Forest Districts (north-western Poland), showing genetic similarity to the populations from the North-Carpathian refugium, from the stands of Alpine provenance in the Jawor and Jamy Forest Districts.

The examined stands 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 Polish ash populations was low (G_{ST} = 0.198 using RAPD markers and F_{ST} = 0.027 using microsatellite DNA markers), lower than the values obtained for other ash populations from Central Europe (G_{ST} = 0.799).

Common yew (*Taxus baccata* L.)

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

The genetic structure of yew from the Wierzchlas Reserve was examined using isozyme markers. A very high level of genetic variation in the species was detected, thus, the opinion about the alleged low level of genetic variation in yew indirectly contributing to the dieback of old trees and lack of natural regeneration in the Reserve was not confirmed. The research proved this population to be a valuable genetic base for the needs of protection and restoration of common yew (Lewandowski *at al*., 1995).

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

The results of the research on Douglas fir aroused interest, particularly in Western Europe. They 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).

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 examined populations was found to be relatively high. It was however lower than in the populations of other forest tree species investigated so far. The Sudeten populations of silver fir show significant genetic differences, compared to the Carpathian populations. The results clearly indicate a different origin of these two population groups (Mejnartowicz ,1979, 2004; Lewandowski, Filipiak, Burczyk, 2001).

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

On the basis of polymorphism of five of the studied 15 *loci,* Longauer (1994) includes the Sudeten fir with 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) designated three regions in Poland in which fir differs in the content of monoterpenes in needles. They are: 1) Sudetes and western Carpathians, 2) central and eastern Carpathians and 3) Roztocze. Thus the genetic separateness of the Sudeten fir is basically proven.

Svoboda (1953) classified it into the climatype Lusatian fir (*Abies alba lusatica*).

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

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

In examining five populations of Polish larch from the area of the Świętokrzyskie Mountains, several populations of the European larch from Europe and the Siberian larch from Russia using isozyme markers, these populations were found to have a high level of genetic variation and a low level of interpopulation 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 at the most, a subspecies of the European larch. Nor was it a hybrid taxon between the European larch and the Siberian larch, as many researchers believed (Lewandowski, 1997).

The genetic structure and the mating system of the old, over 200-year-old Polish larch trees in Ciechostowice were also tested using isozyme markers. It was shown that the population had a high level of genetic variation, and that about 94 per cent of viable seeds were the result of cross-fertilization. Thus, concerns about the high proportion of selfed seeds among the viable seeds of the species were 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, probably due to reduced availability of pollen of other clones. The detected similarity in cross-fertilization between grafts of the same clones may indicate a genetic control of self-fertilization (Burczyk *at al.,* 1991).

1.2. Genetic diversity in forest tree populations in Poland

Natural selection taking place in the population permanently present in a changing environment is an ongoing process modifying, from generation to generation, the frequency and set of genotypes and, consequently, the frequency and proportion of genes in the population; the selection made by foresters for the needs of timber production has a similar effect. 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; they only accelerate this 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 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 about 53 per cent reduction in the number of alleles. At the same time, a reduction in the number of individuals only minimally affects the level of heterozygosity, reducing 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 reduction in the overall number of alleles by 25 per cent. Interestingly, no losses were detected in the group of high-frequency alleles in the populations. Perhaps, then, with such a reduced pool of alleles, the population eliminates, in the first place, the recessive and defective alleles representing the so-called genetic load and thus not affecting significantly the population adaptability.

"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 right breeding procedure complying with the requirement to maintain genetic diversity of the species. So, 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. Population and progeny variation of breeding traits in the main forest tree species

Both natural selection and selective breeding lead primarily to quantitative changes, causing 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 the level of genetic variation similar to their parents'. Concluding, 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 next generations.

The ongoing changes in genetic diversity should not overwhelm the forest manager and paralyze his actions, but should rather encourage him to recognize and understand the genetic processes occurring in forest tree populations. The knowledge of these processes, extended through research, should support breeding decisions. A rational compromise is required between the need for intensive production of high-quality wood and conservation of the gene resources of forest trees. The current state of knowledge on forest tree genetics gives many arguments in favour of such a compromise. It is expected that intensified research on molecular genetics of trees will provide further useful information and guidelines for silvicultural management. Forest renewal is another important issue in tree breeding designed to preserve genetic diversity. As stated above, maintaining the appropriate range of genetic variation in future forests and their sustainable productivity also depends on the production and selection of genetically diverse planting stock and on silvicultural treatments at the establishement and thicket stage.

It seems that modern selective breeding will increasingly require development of control mechanisms of genetic variation in breeding populations proposed for use in forest management for various reasons. In addition, constant enrichment of these populations with different highly plastic genotypes will also be required. Such valuable genotypes can be found in populations at various experimental sites (e.g. provenance and provenance-progeny trials). Hence, their increasing importance and need for conducting systematic research on these sites, 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 (e.g. seed orchards) for regeneration, or about the genetic effects of different tending treatments. Behind these concerns is the risk of mistakes whose negative effects might be seen in the future generations of forests, hence the need for new research and deepened knowledge of the genetic processes taking place in trees and transfer of this knowledge to silvicultural practice. Forest trees have a stable genetic structure able to restore its original state, so there is no 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 way of 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, etc.) played an important role in genetic research in Poland. They showed, among others, that environmental pollution eliminated, in the first place, trees with lower levels of genetic variation.

The synthetic studies on genetic variation in some important forest species based on the results of international provenance trials were important for forest geneticists in Europe. They included research on the population variation in Scots pine covering a large area of land stretching from Poland to the Pacific coast.

The decades-long provenance trials allowed developing 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 Norway spruce.

Forest seed science is, indisputably, the leading European and global research section. Its results enabled the establishment in Poland of a modern Forest Gene Bank and a network of modern seed stores, and ranked the Polish seed science among the European leaders.

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 on the silvicultural value of the Polish provenances of Scots pine carried out 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 trials were established by the Department jointly with other research units: the Warsaw University of Life Sciences-SGGW, the University of Agriculture in Cracow, the University of Life Sciences in Poznań, using the same initial material and a similar methodology. Moreover, in the framework of joint experiments, the following sites were established: 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. In 1994, progeny trials on the mechanisms of intrapopulation variation were started. The research focused on the population of the Taborska pine. In the same year an experimental site in the Nowe Ramuki Forest District, and in the following year a comparative experimental site in the Kutno Forest District were established. Another series of provenance-progeny trials was started by the Department in 2004, embracing the open-pollinated progeny of trees from the 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 are observed on 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 40 years of growth, the Rychtal, Gubin, Bolewice, Tabórz, Wyszków, Dłużek and Lipowa populations exhibit the fastest growth on most of the experimental sites. They may be used on a larger scale than previously, but only in lowlands. The pines from Nowy Targ, Józefów, Łącka and Rozpuda are characterized by poor growth and should not be used on a larger scale. After 20 years of growth of different European provenances of Scots pine in the IUFRO 1982 experiment, the Central European populations (including Polish populations) are characterized by the best growth and adaptation to the environmental conditions. Among the Polish populations of pine those from Rychtal, Spała and Bolewice exhibit the best growth traits. The diversity in the progeny of the Taborska pine populations is very high. Already after the initial period of growth, it is possible to choose the fastest growing progenies and to include this reproductive material to the category "*tested*". The best progeny of mother trees are those described by the FRI symbols 2157, 2226, 335, and the worst by 2141, 2162 and 2112.

A pine stand, the Warcino Forest District, photo by K. Murat

The University of Agriculture in Cracow carries out studies mainly on the experimental site in Polany near Grybów. The studies confirm the possibility of using the forest basic material from the northern range of Scots pine as a nurse crop and for the afforestation of post-agricultural land in the foothill and mountain areas of the Beskid Niski Mountains. These are mainly the Scots pine provenances representing the climatic zone where the growing season lasts for 205-215 days (Sabor, 1993). Finlay-Wilkinson's method allowed distinguishing groups of fast-growing provenances showing the greatest dynamics, while being stable in terms of their adaptive potential. 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.

The choice of selected trees allows developing an individual selection programme for pine in the Carpathian Foothills. When establishing nurse crop plantations in the foothill and mountain areas of the Carpathian Mountains this programme should take into account the selected provenances of pine, including the Mazury provenances. Analysis of the terpene compounds in the bark of selected trees and their vegetatively-propagated progeny allows the development of efficient genetic markers for the forest reproductive material. Delta-3-carene and beta-phellandrene are significant terpene compounds used as markers of pine.

Based on the available information on the variation of Scots pine in Poland, 25 maternal seed zones have been distinguished. They include populations which, in the provenance trials, demonstrated a very good growth, plasticity and quality. These are, among others, 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), Parczew pine (404) (Matras, 1989) and the populations with above-average breeding values, occurring in areas where pine is of very poor quality, e.g. the Łochów pine (403), Goleniów pine (101), and Bytów pine (105).

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

In Poland, interest in the genetic variation of spruce is high. Even before World War II, due to the activity of Professor S. Tyszkiewicz, provenances from our country became part of the progeny collection from the first IUFRO 1938 experiment (Białowieża, Istebna, Garbatka-Radom, Stolpce, Vilnius and Dolina). Regretfully, this experiment did not survive the WW II operations in our country.

In 1968, on the initiative of Professor T. Krzysik, Professor S. Bałut established the IUFRO 1964/68 experimental series in Krynica using 1096 provenances, of which 91 were from Poland. It was a milestone in expanding our knowledge of genetic variation in Norway spruce.

The IUFRO 1964/68 series is 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). Results of these experiments are the basis for determining population variability and the genetic and breeding value of spruce in its natural range in Poland (Kocięcki 1968, 1977).

Species monographs by many authors, *inter alia*, Tjoelker, Boratyński or Bugała (eds.) 2007), and materials from numerous scientific conferences on Norway spruce summarize the research findings on the population variation of this species in Poland. A broader presentation of genetic variation in Polish provenances, based on provenance trials, can be found in several collective studies, such as the Conference Materials Concerning Research on Norway Spruce in Poland 1967 (Institute of Dendrology, PAS in Kórnik), Population Studies on the Norway Spruce in Poland 1968 (Forest Research Institute), spruce monographs 1977 and 1998, and in the IPTNS-IUFRO 1964/68 experiment results under the project Assessment of the Seed Base for the Main Forest Tree Species in the Carpathian and Sudeten Forests in Relation to Selective Joice of the Best Provenances (Bałut, Sabor 2001, 2002). The materials and conclusions from the national conferences on the mountain spruce (in the Carpathians and Sudetes) and lowland spruce (from the north-eastern range) populations, held in Poland in in the years 1994-1998, complement these studies. The results confirm the high genetic and breeding value of Polish Norway spruce populations.

The provenance experiments are complemented by numerous physiological and biochemical studies. The major ones include research projects on Norway spruce conducted for many years at the Institute of Dendrology, PAS in Kórnik, e.g. by Chmura (2006) on the phenology of Norway spruce populations in the Beskidy Mountains, by Rudawska, Leski, Trocha, 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, or 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, and by Misiorny and Chałupki (2006) on the variation and phenology of flowering and cone bearing of *Picea abies* grafts in second-generation seed orchards, and by Szczygieł, Hazubska, Bojarczuk (2007) on the somatic embryogenesis of selected coniferous tree species, as well as by Finer, Helmissari, Lõhmus, Maj di, Brunner, Borja, Eldhuset, Goodbold, Grebenc, Konopka, Kraigher, Mòttònen, Ohashi, Oleksyn, Ostonen, Uri, Vanguelova (2007) on the variation in fine root biomass.

The ongoing research on the establishment of plantations for gene conservation of endangered spruce populations and genetic evaluation of the seed orchards established from clones representing geographically distant provenances (Chałupka, Mejnartowicz, Lewandowski, 2008; Chałupka, Misiorny, Rożkowski, 2008) are important for the genetic resource conservation programmes. The studies of Nowakowski (2004), Prus-Glowacki *et al*., (2007) may be an example of advanced research on the genetic structure of spruce stands in Poland.

Under the impact of many biotic and abiotic factors, spruce has become one of the most endangered species. A decline of spruce populations has been observed, especially in recent years, throughout their natural range in Poland, which is due to the *"spiral disease"* (forest decay), *i.e.* the process of rapid self-thinning of trees, poor growth, reduction of the assimilation apparatus and, finally, the death of trees. The causes of this situation are sought in environmental pollution, droughts, attacks by pathogenic fungi and insect pests, as well as winds and global warming. The spiral disease leads to the death of whole stands, and even 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 Sudetes (Jizera and Karkonosze Mountains), and recently in the Beskid Śląski and Żywiecki Moutains (Sierota, 2001) are an example of the decline of spruce forests on a massive scale. Spruce decline affects the most valuable selected stands, which are recognized in the world as a genetic population having, like the population of Istebna spruce, the most valuable breeding traits. Only in 2008, as a result of an ecological disaster, a reduction in the area of seed stands of this population was estimated at 16 per cent, and of plus trees at over 35 per cent (Urbaczka, 2008). This indicates the need for developing effective programmes to protect the genetic resources of this species.

The results of studies conducted, *inter alia*, at the University of Agriculture in Vienna can be helpful in developing forecasts of climate change in Poland. According to the analysis by Kromp-Kolb (2002), climate change in Europe is both global and local and varies in time and space. Temperature and precipitation trend analysis has a significant impact on the accuracy of predictions of climate change in the next 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 1 to 4 per cent in the winter and by 2 per cent in the summer; rainfall is expected to decrease by 5 per cent in the south. Moreover, stronger winds and increased frequency of storms are predicted. It is also anticipated that the period of persistent snow cover at an elevation of 600-1400 m a.s.l. will be shorter as a result of global warming by 1°C during snow melt.

Many other research institutes conduct studies on variation in the populations and progenies of 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 co-operating units, and thirty sites established under the IUFRO 1972 experimental series. The research embraced 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 experimental series, Poland additionally established an experimental site with 1100 spruce populations. The populations from the north-eastern range are more homogeneous in terms of growth traits than the southern populations. The differences in growth traits in the populations up to 30 years of growth on the experimental sites were found to be not significant statistically. The Bukowiec Istebna population is by far the best in terms of all the analyzed traits, and the southern populations are definitely better than the populations from the north-eastern distribution range.

The population growth of spruce on the 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 (data for all experimental sites) is very high (6.0491 standard deviation units) throughout the experiment, ranging from +2.6262 to -3.4229, while for individual populations – from +1.9181 to -2.756 for Kartuzy, and from 1.437 to -0.755 for Rycerka Zwardoń. By classifying the populations in classes by 0.5 standard deviations, five main groups are created.

Group I – the best, includes populations from Istebna Bukowiec and Zwierzyniec Lubelski. These populations can be regarded as exceptionally valuable in the entire area where the evaluation was performed. Group II includes the populations from Wisła, Istebna Zapowiedź, Zwierzyniec Białowieski 2, Rycerka Praszywka 700 m, Rycerka Zwardoń, Tarnawa and Bliżyn, which are valuable, but do not guarantee, in every conditions, appropriate economic effects. 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, therefore they should not be used on a lager scale without detailed studies. The Witów population should under no conditions be grown in lowland regions.

The latest genetic evaluation of Polish spruce was made by Giertych in the monograph “Biology of Norway Spruce” (1998). Based on provenance experiments results, 13 seed zones of spruce were distinguished in the framework of seed regionalization: 4 Beskidy seed zones in the Western Carpathians (801, 802, 805, 808), 3 Sudeten seed zones (701, 702, 703), 1 seed zone (807) in the Eastern and Southern Carpathians, and 5 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 Polish lowlands, mainly from its north-eastern range, reveal high value of the Mazury-Podlasie provenances from the Knyszyn Primeval Forest and the Augustów Primeval Forest, and of the Baltic provenances from the Rominta Primeval Forest. It should be noted that the lowland spruce populations in IUFRO 1964/68 and IUFRO 1972 tests involve native stands within the natural range as well as stands established by artificial regeneration (Sabor, 1999). The analysis conducted by Giertych (1999) indicates a relatively poor quality of the Białowieża populations, disqualifying them from wider use. However, as shown in some provenance tests (IUFRO 1972), single Białowieża populations from the managed part of the Białowieża Primeval Forest (Zwierzyniec Forest District) display high plasticity and fast growth. On the basis of the plasticity tests for spruce from the Knyszyn, Augustów, Rominta, Borki and Pisz Primeval Forests these populations can be recommended for use abroad, and to a smaller extent, and rather locally, in Poland. Their growth in Scandinavia and western Canada is related to good performance in these countries (Giertych 1977,1999). Also, a comparative study conducted by the Forest Research Institute, mainly based on the results of the IUFRO 1972 experiments (Matras, 2006 a, b) confirm the generally poorer quality of lowland spruce forests from the north-eastern range, in comparison with the Carpathian spruce forests. However spruce provenances from Zwierzyniec reveal 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, compared to 7.6 per cent of the country’s land area (Sabor, 1995). The analysis of mature spruce stands reveals a significant site quality variation in these populations under the homogeneous site conditions of the Carpathian Mountains, and a 0.4 higher average site-index class of spruce forests in this region, compared to the national average. It also shows a much lower quality of the mature Sudeten stands (by one class), compared to the Carpathian spruce stands. Owing to the comparable stand age and homogeneity of site conditions, this variation can be considered genetic.

The evaluation of results of provenance trials showed a generally high genetic quality of most stands of the Istebna population from the Beskid Śląski and Beskid Żywiecki Mountains. This concerned all the main Polish provenance tests, including IUFRO 1972, but above all the IUFRO 1964/68 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 constitute a true “elite” (Sabor, 1996). In the Programme for the Selection and Conservation of Forest Genetic Resources, the role of the Istebna spruce is emphasized. Its seeds are recommended for use in 50 Forest Districts in the country, and its reproductive material (seeds, grafts) has for years been the object of international studies and exported. The assessment of intrapopulation variation of Istebna spruce and the degree of autochthony of its subpopulations is at the core of the current studies. Equally important is the *in situ/ex situ* evaluation of the progeny of selected trees and protection of the genetic resources of yjr 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 part of the Carpathian Mountains and across the Carpathian Foothills. In the provenance experiments, this population was found to improve its growth dynamics and showed high plasticity, nevertheless its widespread use in Carpathian conditions is not yet scientifically justified (Sabor, Kulej, 1997).

The test results of the Bieszczady spruce population are not clear. In the IUFRO 1964/68 experiment, spruce from Tarnawa shows 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, the Tarnawa spruce is ranked among rather good provenances (Matras, 1997). Despite divergent assessments, this population should be regarded as valuable and needing urgent protection because its distribution range continues to shrink. The provenance experiments point to suitability for supplementary planting of the Ukrainian populations from Jasina and Dolina as well as of Romanian provenances (Sabor, 1998a).

The Sudeten population

In provenance trials, the Sudeten spruce is classified as the 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) shows poor quality of the spruce from the Kłodzka Valley and high plasticity of the provenances from the Izera, Karkonosze and Kaczawskie Mountains in the Western Sudetes and from Jesioniki in the Eastern Sudetes. These populations can be recommended for the introduction into the lowlands of western Poland, and the Karkonosze populations – for planting in the mountains. The Szczytna Śląska provenance tested in the IUFRO 64/68 experiment is regarded as valuable.

In the framework of seed regionalization, 12 maternal seed zones of spruce are distinguished in Poland. 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.. Therefore, it is difficult to establish seed zones in areas of sparse occurrence of Norway spruce. The largest number of maternal seed zones (seven) are in the Western Carpathians and the Sudetes: 4 in Beskidy (801, 802, 805, 808), 2 Sudeten (701, 702), and only one in the Eastern and Southern Carpathians (807). The remaining five seed zones of spruce (202, 203, 204, 208, 605) are located in north-eastern Poland.

European larch (*Larix decidua* Mill.)

Research on population and progeny variation in breeding traits of selected origins of larch (*Larix decidua* Mill.) was carried out on 4 population and 4 progeny experimental sites of the Silviculture Department of the Forest Research Institute, as well as on 3 provenance sites of cooperating units. 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 embraced by the research. The many years of studies on the genetic and breeding value of larch trees growing on the population and progeny sites indicate considerable, statistically significant differences in the tested provenances and families. This applies not only to the basic growth traits (height, dbh, diameter, volume), but also to the quality of stems and health condition. The diversity of these traits is primarily determined by genotypes of the analyzed populations. As the interpopulation and progeny diversity in larch may show up only in its later period of development, after the culmination of average volume increment, long-term studies ensure more reliable results than those covering only the juvenile phase of growth.

Because of a 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, perhaps except for regions of occurrence of the Polish and Sudeten larch. For this reason, the selection of larch populations should be conducted primarily at the stand level.

European larch, photo K. Murat

Polish and Sudeten larch provenances growing in the lowlands (experimental sites in Sękocin and Rogów) showed no clear differences in growth traits. Both in the Sudeten (Kłodzko) and Polish (Skarżysko) populations of larch there were some showing fast and slow growth. The Czerniejewo population of larch from areas of its scattered occurrence in north-western Poland, tested on these sites, 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 of their scattered occurrence.
Polish larch clearly predominates on the experimental site (Bliżyn) in the Świetokrzyskie Mountains, both in terms of quantitative and qualitative traits. Also populations from areas of scattered occurrence are definitely inferior to the local populations of Polish larch. However, not all populations of this variety are valuable. Those from the 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 from Szczytna Śląska, Prószków and Kłodzko are characterized by highest growth. Those from the Świętokrzyskie Mountains (Skarżysko and Moskorzew) exhibit only a slightly slower growth. Attention should also be given to the northern provenances of larch from Myślibórz-Północ, from the "Płonne" and "Tomkowo" Reserves in Konstancjewo and from Czerniejewo, from the hitherto poorly recognized and untested locations, whose growth intensity increases with age. The Krościenko and Marcule provenances definitely proved to be the worst in mountain conditions. The quality of stems in the analyzed populations of larch in the mountains significantly improves with age. At the present stage of research, geographically, the best larches are from Czerniejewo, the "Płonne" Reserve in Konstancjewo, Myślibórz and from the selected locations (Bliżyn) in the Świętokrzyskie Mountains. Larch provenances from Grójec, Rawa and Pilica showed stem deformation. The greatest diversity in 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. In lowland conditions, of the analyzed populations only larch from Grójec did not show the symptoms of disease caused by this pathogen. Generally, Polish larch populations were much less susceptible to the disease than the Sudeten populations, while larch from Pelplin and Hołubla were characterized by extremely high susceptibility. The share of infested trees in Polish larch populations did not exceed a few per cent, while in the Sudeten larch it was several times higher. The Polish larch populations from Grójec, Skarżysko and Moskorzew showed the highest resistance to canker also in the mountains.

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 a base material for finding clones for timber production in short and medium rotations.

For the purposes of seed regionalization, 4 maternal seed zones are distinguished in two main areas of larch occurrence in Poland: 3 zones for the Sudeten larch (701, 702, 503) and one seed zone for the Polish larch ssp.(604). A large number of selected seed stands and most of the fast growing, good quality populations, as shown in provenance experiments, are located in these zones (Kocięcki, 1987).

Silver fir (*Abies alba* Mill.)

Because of the regional occurrence of silver fir populations, most study results on the variation of this species come from the University of Agriculture in Cracow. On the initiative of the University, the largest experiment with fir was set up. On six comparative sites 99 populations of this species from throughout its distribution range in Poland are analyzed. These studies were initiated by Professor Stanislaw Bałut. The traits of the tested fir progenies are 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), which constitute the current seed base of this species. The genetic evaluation of silver fir in the Jd PL 86/90 experiment also includes the progeny of the Powroźnik stand, 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 86/90 experimental sites were established in the mountain (Baligród and Stary Sącz), upland (Łagów and Zwierzyniec) and lowland habitats (Bielsk Podlaski and Nowe Ramuki).

The 20-years research showed 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 the 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 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 seven regions with high plasticity, responding 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 indicates stability of its adaptive traits, and very high selection values of the Roztocze populations. The index value for the Roztocze fir was high on all the Jd PL 86/90 experimental sites. The Sądeckie and Świętokrzyskie firs should be included in the group of well-performing populations. However, after being transplanted into the Bieszczady conditions, the Świętokrzyskie fir shows negative adaptive values. The Bieszczady fir had the poorest genetic and breeding quality. In the FBM of maternal regions, three provenances of the Roztocze fir, *i.e.* Ułów, Hedwiżyn and Rybnica, with very high selection values, were classified as the elite populations. Also four provenances of the Sądeckie fir: Berest, Kudłoń, Łomnica and Powroźnik confirmed their superior breeding value. Of the Świętokrzyska fir populations, the Jastrzębia fir was the best.

On the basis of recent research findings, seven maternal seed zones of fir are distinguished: 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, were tested on four experimental sites set up in 1999, while growth and development of eight provenances of this species, represented by 180 families, were 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, however, exhibited low 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 were characterized by best, while the Sienawa and Opole provenances by worst qualitative traits.

Individual provenances were characterized by a similar time of beginning and ending growth on each experimental site, regardless of climatic conditions. 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 provenances were small, however, a trend was noted toward early termination of growth by the provenances beginning spring growth earlier, and a longer autumn growth of the provenances beginning spring growth later.

Studies on genetic variation in pedunculate oak and the adaptability of the lowland provenance progeny to the foothill conditions in southern Poland were carried out in three experimental plantations located in the Carpathian Natural-Forest Region and on its northern boundary. The results of the analysis conducted after 1996 indicate a high adaptive potential of some of the progenies, including those from the Krotoszyn Plateau and from the selected stands in the north of the country (e.g. Zaporowo). On one of the plantations, the progenies of the populations from the Massif Central in central France also exhibit a relatively high adaptability. The detected very high survival rate of oaks in the juvenile phase of development, and the lack of a marked effect of the genotype (of provenance and families within provenance) on the variation in this trait indicates a positive adaptive response of the progeny of the tested subpopulations to changes in the environmental conditions. In terms of physiology (beginning and termination of growth), oak provenances from northern Poland are better adapted to the foothill environment, since their progenies are less vulnerable to damage caused by late (spring) and early (autumn) frosts. In spite of the very fast growth of the progenies of the populations from the south-western range of the species, their quality is slightly worse, because of a large proportion of oaks with proleptic shoots and poorly-shaped crowns (bushy or fork-shaped). Generally, research findings indicate positive result of using reproductive material of pedunculate oak from other regions of origin than the current seed regionalization rules permit. In terms of growth, a wide diversity and a significant effect of the genotype (provenance), as well as an increasing effect of families within the provenance can be observed. In addition, the high provenance and progeny heritability suggests the possibility of effective selection already in the juvenile phase of oak development. The assessment of selection values also shows a large diversity in the analyzed subpopulations, as in each provenance it was possible to select progenies with a high index value. Therefore, genetic gain will be higher as a result of the selection of trees in the stand, compared to the selection of stands.

Based on the research results and the location of the most valuable seed base of oak, seven maternal zones are distinguished in Poland, including the 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.)

Most of the studies on the genetic variation in European beech were carried out in Poland as late as in the past two decades. A few earlier experiments established with a small number of populations provide information of little use for forest practice. The main experiment was set up in 1996, consisting of Polish sites with beech progeny mostly representing selected stands and two international sites with the European populations of beech. The purpose of the nationwide provenance experiment with European beech was to investigate the genetic variation in beech, its adaptability to different environmental conditions, as well as their suitability for use in other geographical regions and seed zones in Poland. By establishing a series of comparative sites (with identical populations, a similar site design, types of observations and measurements), it was possible to determine genotype x environment interactions for individual populations and to identify populations useful in certain edaphic and climatic conditions and those with high plasticity. Two experimental sites with European populations, including Polish ones, were tested for their genetic variation, thus allowing a more general assessment of the breeding value of Polish beech populations in comparison with European provenances.

Fruiting of the European beech, photo by K. Murat

The research findings demonstrated 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 analyzed Polish populations of European beech throughout the experiment. The genotype was also shown to interact with the environment for survival and spring growth of the populations. The beech populations from Kwidzyń, Wipsowa, Gryfin, Kartuzy and Lipusz exhibited the best growth before reaching 15 years of age. Most of them came from northern Poland. Among 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 exhibiting slow growth. A high variation of European beech was also observed over a relatively small area. Of the three populations from the Bieszczady National Park, only those from the Bieszczady National Park demonstrated fast growth. The performance of European beech from the Kwidzyn populations was very interesting. Initially, these populations, represented by three beech stands, were superior in height growth and breast height diameter. However, the other Kwidzyń populations, though still remaining in the group of fast-growing trees, do not show such intensive growth. There were also statistically significant differences in the survival of Polish populations on comparative sites. A fairly high survival was observed on the Bystrzyca sites, a relatively high survival on the Choczewo, Brzeziny and Łobez sites, and an average survival 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 Kwidzyń beech, definitely showed the highest survival, although, some of the lowland populations – low survival (Krucz, Lipinki, Szczecinek). Populations with a relatively high survival rate were found in three regions of origin: the Gdańsk region, the Lublin region and the mountain region. Regions with beech populations exhibiting poor survival are located primarily in the Bieszczady Mountains and in north-western Poland.

Based on an analysis of variation in beech populations and their traits, the environment (experimental site conditions) has undoubtedly the highest impact on population growth and development. The findings from six research sites show that location is, like genotype, an important factor influencing the growth and development of beech populations. There is, in fact, no population growing fast enough and being sufficiently plastic in the experiment 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, Kwidzyń, Bierzwnik, Lipusz, the Bieszczady National Park, Ustronie and Szczecinek can be regarded as highly plastic and therefore promising. The populations from Krucz, Łagów, Milicz, the Bieszczady National Park, Grodzisk, Tomaszów and Karnieszewice should, due to their low plasticity, be used on a limited scale and rather not recommended for spreading beyond their current area of occurrence.

The current assessment should be regarded as approximate only. Changes in the growth of individual populations on experimental sites are so prominent that none of the populations can be considered to have stable growth. In general, there is a variation (fluctuation) in the analyzed traits, causing changes in population ranks in the subsequent measurement periods, although directional changes in the ranking were also observed, reflecting a systematic increase in the case of positive changes and a decline in the case of negative changes in the analyzed traits. The observed changes indicate that the assessment of the breeding values of the studied populations is burdened with a serious error and must be verified when their traits are fully developed. An analysis of the dynamics of spring development shows that the population diversity is typical for a region. First the mountain populations and then the lowland populations in the west of Poland start to develop significantly earlier than the populations from the eastern range of beech. Therefore, the mountain populations are not recommended for use on a commercial scale in the lowlands, nor should we allow long-distant transfer of the lowland beech from west to east.

In Pomerania, six maternal see3d zones of European beech are established, including the valuable Gryfińska (102) and Drawieńska (301) populations. In the upland area, two seed zones of European beech are established with the valuable Kielce (604) and Roztocze (605) populations. In the mountains, six seed zones of European beech are established: two for the Bieszczady (804 and 806), one for the Beskidy (801) and two for the Sudeten Mountain (701 and 702) populations. The area of selected seed stands in the latter three regions is not as large as those mentioned earlier. The stands should, however, be used, to the largest degree, as 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.)

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

The aim of the studies discussed in this Report was to obtain information allowing establishment of the FBM regions of silver birch, as well as setting rules for admission and transfer of the material to other regions. The collected data on the 30-year-period of growth of birch provenances and families from the experimental site set up in the Nidzica Forest District in 1978, and on the 10-year-period of growth of birch from the six comparative sites set up in the Kutno, Wichrowo and Kwidzyń Forest Districts in 1998-1999 were 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, Białowieza 500CD and Augustów Bal.111b. The Siedlce provenance was the best, in this respect, with the volume of a single tree about 60 per cent higher compared to the least productive Łomża provenance. The birch provenances of the Second (II) Mazury-Podlasie Natural-Forest Region are characterized by the highest quality. They have straighter trunks, thinner branches, although often arising from the trunk at a more acute angle, compared to the average from other regions, and thinner bark. The provenances of silver birch from the experimental site in Nidzica are 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 are the best, both in terms of productivity and trunk shape. The Siedlce and Grodziec provenances, though very good in terms of growth, are inferior in trunk straightness. The same birch families as in Nidzica were also tested on five comparative sites in Lower Saxony. The published data from these sites concern height and trunk straightness of individual provenances aged 21. The ranking of these provenances by average height in conjunction with trunk straightness showed that six best of them 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 the 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 results of the to-date studies indicate a high intraspecific variation in silver birch in Poland. Populations of silver birch with good growth and qualitative traits can be found across the country's lowlands. This gives an opportunity to find, in each region, valuable stands and plus trees whose progeny should be used as forest reproductive material. In North-eastern Poland (Mazury-Podlasie Natural-Forest Region), primarily the Augustów Primeval Forest, is the area of the highest concentration of birch populations valued for their growth and qualitative traits. Therefore, birch populations in this region should serve as the forest basic material for individual selection, mainly for the needs of birch plantations.

Although research focused on silver birch, there are also provenances or families of downy birch on some 10-year-comparative sites. Silver birch was found to grow on the soils derived from loose sand, loamy sand or sandy loam, with ground water below the rhizosphere, with much larger breast height diameters and heights compared to the downy birch growing in the same habitat conditions. Downy birch trees, however, usually have straighter trunks than most of the silver birch provenances.

Bird cherry *Prunus avium* (L.) L.

The bird cherry is considered one of the most valuable forest tree species in Europe. This fast-growing tree is cultivated for its valuable wood in plantations in many countries. Bird cherry plantations are usually established from selected clones of this species. In 2003, the

Forest Research Institute undertook to assess the distribution and timber resources of bird cherry in Poland.

The forest survey data obtained from the database of the Forest Management and Geodesy Bureau show that within State Forests this species occurred in different forest layers and in different proportions in 9141 sub-compartments with a total area of 48 375 hectares. The presence of bird cherry in the species composition of the main stand was found in 819 sub-compartments, covering 3309 hectares. In the remaining area, there were forest stands with individual trees, groups of trees or reserved old-age trees of bird cherry. The total standing volume of bird cherry in the State Forests was estimated at 80 721 m^3. The largest forest resources of bird cherry are in the south of Poland, within the limits of its range widely recognized as natural, where its four main distribution centres are distinguished: the Lublin-Lvov Upland, the Central Beskidy Foothills, the Western Beskidy Mountains and the Sudeten Foothills. In northern and western Poland, bird cherry is less abundant, but occurs in many isolated groups, which seems to confirm the opinion that this species was planted there. The bird cherry usually occurs and grows well in Poland in the fresh broadleaved, upland broadleaved and montane forests, as well as in the moist and mixed moist broadleaved forests.

The State Forests has a fairly large reproductive material base for selective breeding of birch cherry, because the area of stands with bird cherry trees aged 50-plus was 1624 hectares by the end of 2002. To prevent the depletion of the genetic resources of the indigenous bird cherry, it is essential to urgently develop a comprehensive programme for its conservation and genetic improvement.

Wych elm (*Ulmus glabra* Huds.)

The studies on wytch elm are still at an early stage of development. They focus on testing progeny of nine trees in seven experimental plantations. The study results indicate a significant diversity in the analyzed traits, both in nurseries and in conservation plantations. There is a significant variation into two leaf morphotypes (ssp. *glabra* and *montana)*, which depends mainly on the genotype, while heritability of this trait is very high 0.810. Thus, the reported variability of wytch elm from the few other European experiments is confirmed.

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

Many years of research on the genetic and breeding value of the giant fir in the habitat conditions of the Beskid Sądecki Mountains indicate 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 needles and branches. The variability of these traits is largely determined by genotype. The diversity in the survival percentage between provenances is of clinal nature, and depends on the location of the parent stands: height above sea level and latitude. According to Muller division of the range, giant fir from the first natural range shows a higher growth rate compared to the second range. Growth of giant fir trees can be predicted with high likelihood from the observations of giant fir trees aged 8-14 years. The Salmon River provenances of the giant fir from British Columbia, Canada, well performing 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 the introduction and adaptation to the mountain forest conditions in Poland.

A few experimental sites were also established for other forest tree species, like the European ash, the black alder, or Douglas fir, however, due to a limited range of tests with these species, their variation is difficult to characterize.

2. The importance of forest genetic resources

2.1. Poland's timber resources and forest tree species of highest economic importance

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 downy 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. As of 1 January 2010 (the latest update), the estimated timber resources in the forests managed by the State Forests amounted to 1748 million m^3 of gross merchantable timber. According to the Forest Management and Geodesy Bureau, the timber resources (as of 1 January 1999) in private and commune-owned forests stood at 188.6 million m^3 of gross merchantable timber. Recent data on Poland's timber resources (Central Statistical Office) come from 1997. The estimate of timber resources under the management of the State Forests and under other forms of ownership in Poland (estimates by experts), as of 1 January 2008, is 1914 million m^3 of gross merchantable timber.

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

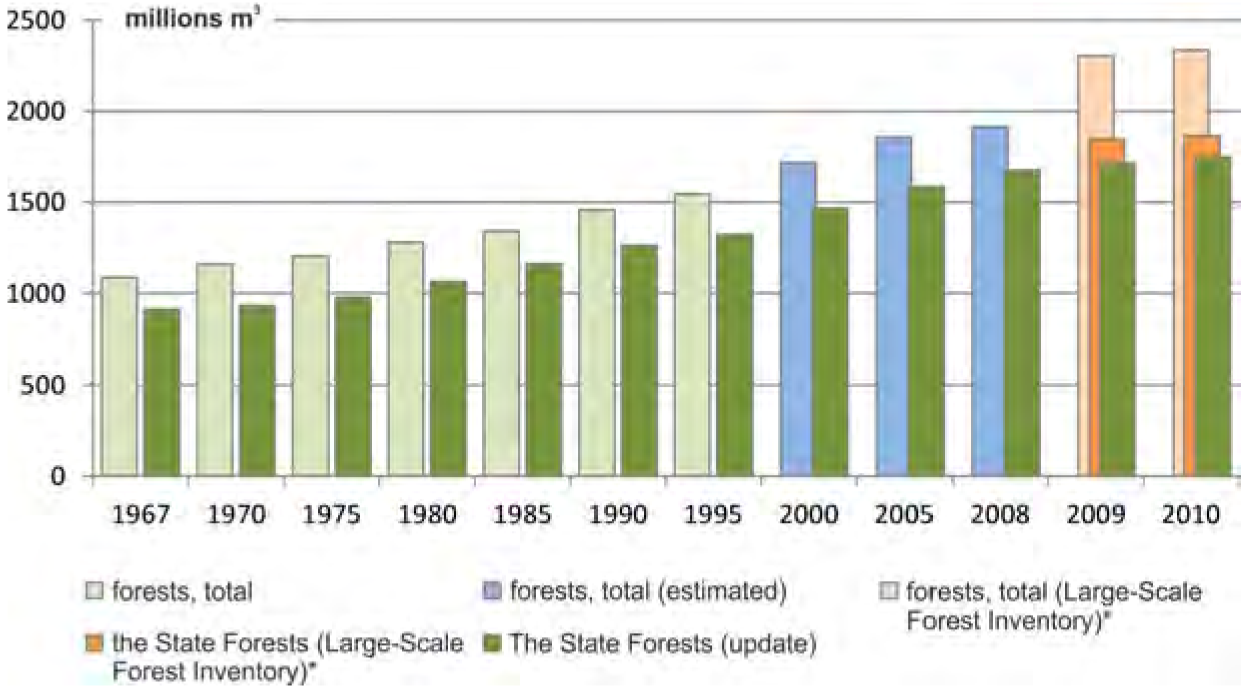


Fig. 15. Forest timber resources in Poland in the years 1967–2010, in millions m^3 of gross merchantable timber (Central Statistical Office, Forest Management and Geodesy Bureau, Large-Scale Forest Inventory)
*** data of Large-Scale Forest Inventories 2005–2009 and 2006–2010**

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 in privately-owned forests (Fig. 17).

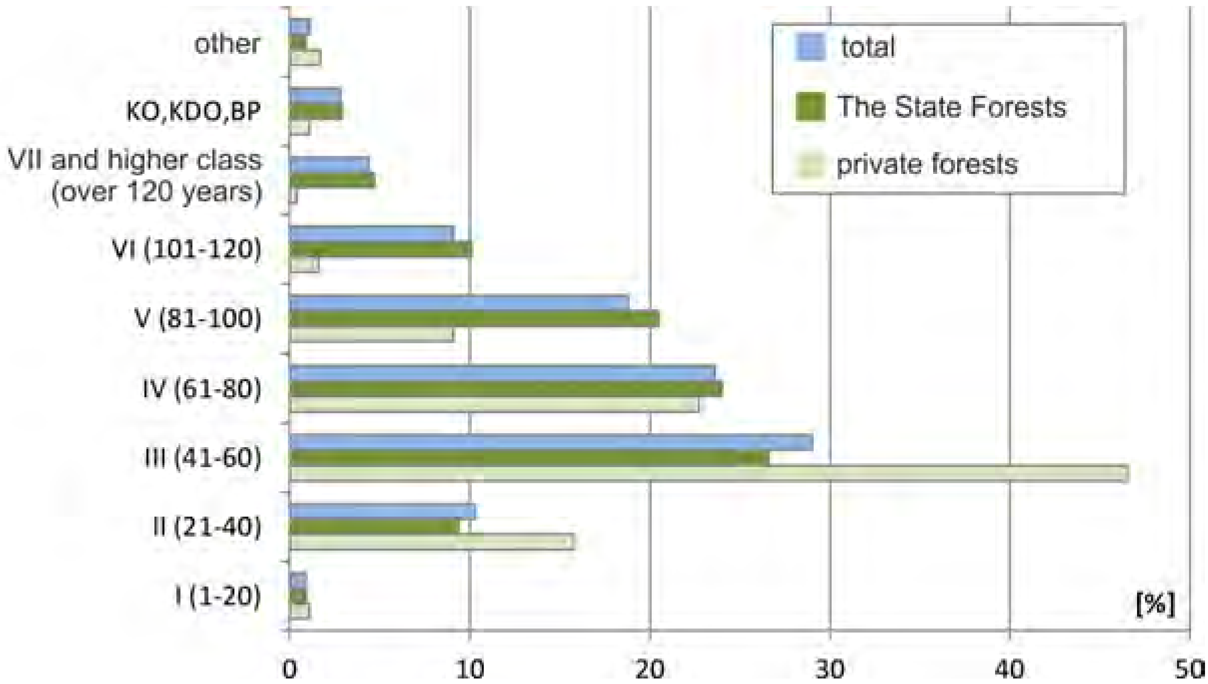


Fig. 16. Volume structure of timber resources under all forms of ownership in the State Forests and in private forests by age class (Large-Scale Forest Inventory)

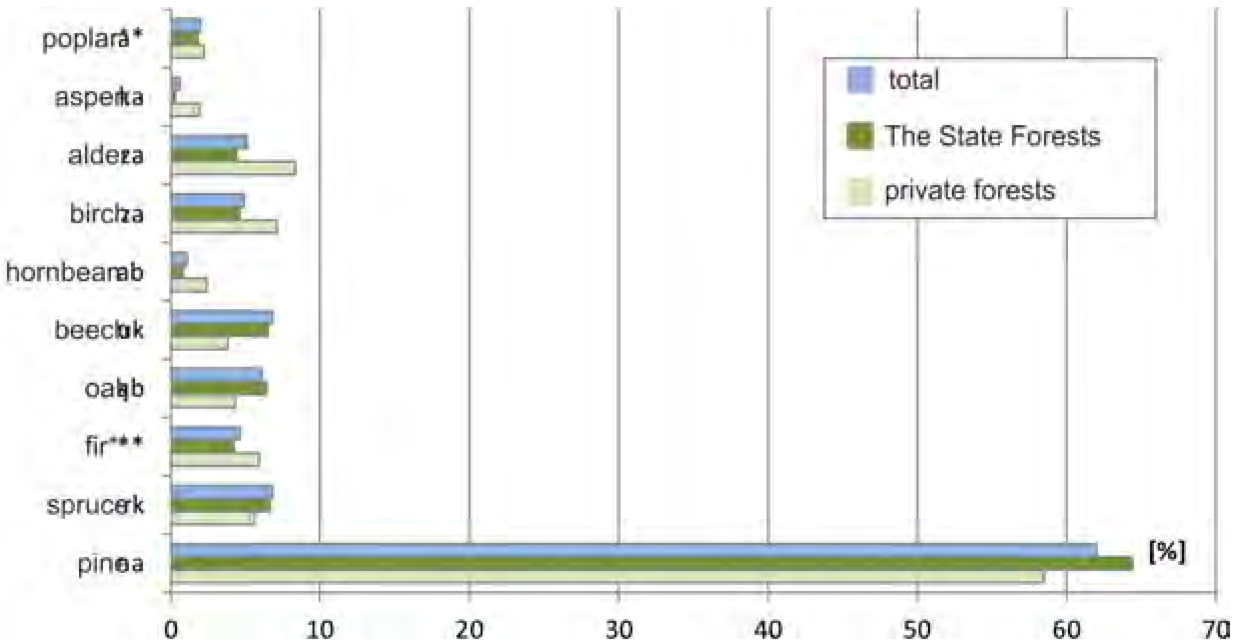


Fig. 17. Volume share of dominant tree species in the forests under all forms of ownership in the State Forests and in private forests (Large-Scale Forest Inventory)
***with other broadleaves, **with other conifers**

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 in private and commune-owned forests the latest available figure (1 January 1999) puts it at 119 m^3/ha (Fig. 18). The Large-Scale Forest Inventory shows 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.

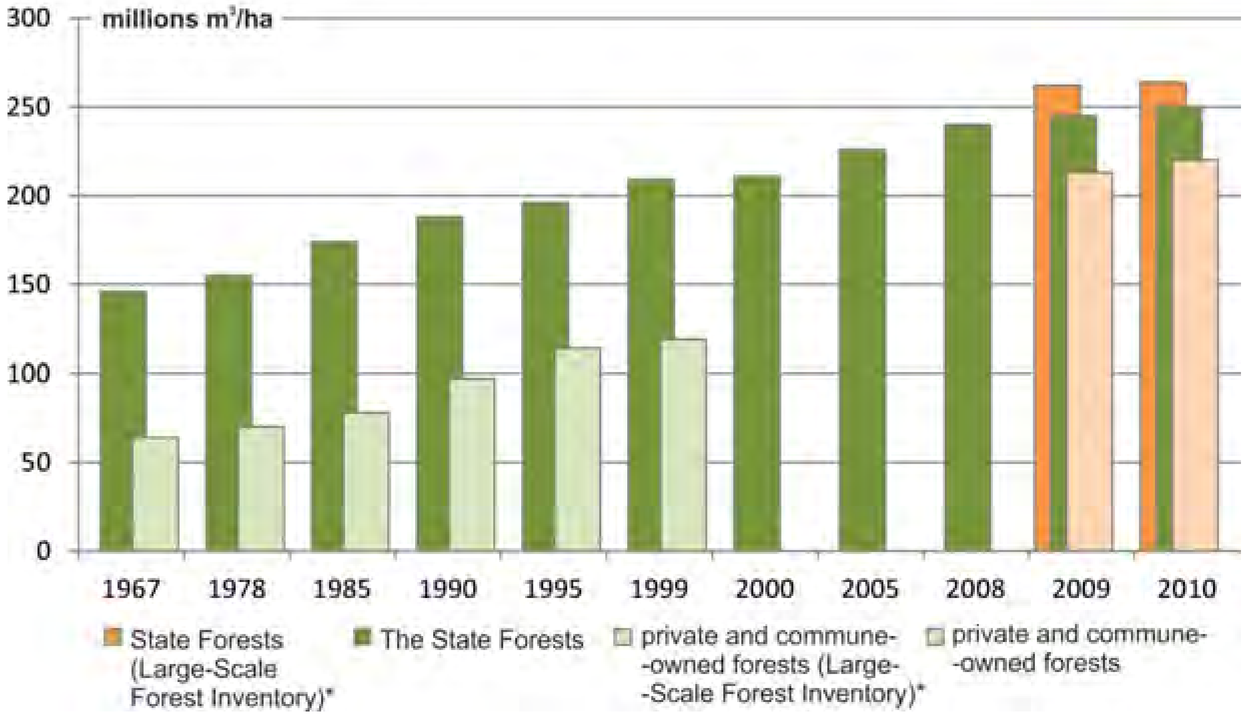


Fig. 18. Average standing volume in Poland's forests in 1967-2010 in m^3/ha of gross merchantable timber (Central Statistical Office, Forest Management and Geodesy Bureau, Large-Scale Forest Inventory)
***Large-Scale Forest Inventory data for 2005–2009 and 2006–2010**

The harvest of merchantable timber representing 55 per cent of current increment augments timber resources, currently amounting to 2.049 billion m^3. The average standing volume for Poland amounts to 219 m^3/ha and is one of the highest in European (FRA 2010). In recent years, more than 32 million m^3 of timber is harvested annually in Poland (34.6 million m^3 of timber, including 32.7 million m^3 of merchantable timber in 2010) (Central Statistical Office 2010).

According to FRA 2010, national definitions were used – the standardization of data (adoption of the threshold of 0 cm for resources) was abandoned. In the case of Poland, the volume of timber resources refers to merchantable timber (over 7 cm in diameter).

2.2. Type and importance of timber production

The use of forests as a renewable resource of raw material is driven, not only by market demand, which ensures economic conditions for forest management, but also by silvicultural needs and the principles by which the structure of forest resources is regulated. Forest utilization is pursued at a level determined by the natural conditions of timber production, in accordance with the principle of the persistence of forests and augmentation of their resources. From January 1990 to January 2010, the increment in forests managed by the State Forests amounted to about 1 072 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, representing 45 per cent of total increment, remained to augment the timber resources (RoSL, 2011).

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

In 2010, 8675 firms buying wood from the State Forests were registered. However, approximately one third of them purchased wood occasionally for further processing, and some probably for resale. About 90 per cent of the volume of wood sold in Poland is purchased by about 700 buyers. It is estimated that approximately 60 per cent of the processed or unprocessed wood is exported to foreign markets.

The Wilczków oaks, the Sczecinek Forest District, photo by K. Murat

The most important wood assortments in Poland are: the large-sized wood of coniferous species (logs) – 10.3 million m^3, and medium-sized wood – 10.3 million m^3 (averages from 2000-2010, Central Statistical Office, 2010), representing a total of nearly 60 per cent of harvested merchantable timber.

The large-sized wood of broadleaved species, including European beech, also becomes more popular. A significant increase is noted in the consumption of middle-sized hardwood, including the wood used by local communities as fuel and for heating needs. It is estimated that the demand for these assortments has recently increased by 24 per cent to around 3.8 million m^3 annually (DGSF, 2011).

2.3. Exotic species in forests

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

Forest management in Poland is based on indigenous forest-forming tree species with a small share of exotic species. The total areal cover by these species in Poland is estimated at 46 000 hectares, of which 39 000 hectares are species considered, until recently, invasive (SoEF – Country Report, 2011)*. The species foreign to Polish forests are: *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.*, 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)**, *Pinus strobus* L. (1002 ha)** and *Larix kaempferi* (Lamb.) Carrière & *Larix x eurolepis* Henry* occupy the largest area.

In the current Polish legislation, none of these species is considered invasive (Ordinance of the Ministry of the Environment dated 9 September 2011). Potentially invasive woody species are not included in the National Environmental Monitoring programme. Some of them are, to a certain extent, monitored by the Institute of Nature Conservation in Cracow (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 Report (SoEF – Country Report 2011) does not take into consideration the areas in the Polish forests occupied by Larix kaempferi (Lamb.) 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 (Gdańsk, Szczecinek, Piła, Poznań, Szczecin RDLPs) and 60 older stands located across Poland (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 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 usually do not form forests, but occur in stands individually or in clumps are of high environmental value indicating 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 category Endangered (EN).

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

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 damage-causing factors. These species include:

Fraxinus excelsior **L**. – populations of the European ash are endangered in its natural range across the country. In the last decade, European ash dieback is observed. Research undertaken in Poland and other countries have showed the presence of several fungal pathogens of which *Chalara fraxinea* described as a new species proved to be the most dangerous. Due to the fact that the phenomenon of 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 the Alert List 2011. In 2008, *C. fraxinea* was first considered to be an anamorph of *Hymenoscyphus albidus*, previously 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, the molecular analysis showed that *C. fraxinea* was, in fact, 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 the root collar necrosis and fine root mortality.

The previous studies showed 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., *Nectria galligena* Bres. and insects such as *Stereonychus fraxini* De Geer and *Prays curtisellus* Don*.* were the secondary disease-causing agents (Przybył, 2002).

The phenomenon of ash decline of alternating intensity has been observed in Polish forests for several years. Currently, the disease is recorded in an area of 11.8 thousand hectares (3.4 thousand hectares less than in 2009). Like in 2009, the majority (82 per cent) of areas with trees showing the symptoms of the disease are in mature stands (RoSL, 2011).

European ash, photo by K. Murat

***Abies alba* Mill.** The 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 stands in the Sudeten Mountains and the Sudeten Foothills to 0.36 per cent. Few locations of stands with silver fir and a low number of fir trees in the stands in the Sudeten Mountains have caused the century-long lack of mating of individuals in this mountain range, which eventually have led to the genetic depletion of local populations (Barzdajn, 2000).

***Ulmus glabra* Huds., *Ulmus laevis* Pall., *Ulmus carpinifolia* Gled.** All these species have not yet rebuilt their natural distribution potential after having been affected by the, so-called, Dutch elm disease, 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 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 like the Vistula, Oder and Warta, occupying very narrow strips of land not agriculturally utilized for various reasons. (Danielewicz, 2008).

***Sorbus torminalis* (L.) Crantz.** The 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. 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 silvestris* L. has the greatest economic importance in Poland, which is due to the fact that it has the highest areal (60.4 per cent) and volume (62 per cent) share, though locally, other tree species such as *Picea abies* (L.) Karst. in the Sudetes and the Western Carpathians, as well as *Abies alba* Mill. in the Central Carpathians and the Carpathian Foothills are also important. Deciduous species, e.g. *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 biocoenotic species are environmentally important, primarily the small-leaved lime, large-leaved lime, wild service tree, rowan, whitebeam, sycamore maple, Norway maple, field maple, common hornbeam, bird cherry, common pear, crab apple, field elm, wych elm, or the smooth leaved elm.

2.6. Seed regionalization

Poland's location in the transition climate zone, between the oceanic and continental influences, has resulted in a high plasticity (adaptability) and tolerance of the majority of species to the growth conditions in Poland. The preserved valuable forest tree populations provide the possibility of "improving" individual trees and entire stands, and using them in forest management. However, actions need to be taken to ensure their permanent conservation. The use of the 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, the 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 on the basis of the boundaries of the country's administrative units.

Regionalization of the forest reproductive material in Poland is aimed to:

- select and preserve the genetic distinctiveness of the highest number of natural, autochthonous and indigenous or possibly 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 set clear rules and directions of its transfer in order to preserve forest sustainability,
- establish a system for permanent recording and monitoring of the origin of reproductive material.

The regions of origin in Poland are distinguished on the basis of:

- ecological and genetic diversity of nine species covered by regionalization in accordance with the provisions of the Act of 7th June 2001 on Forest Reproductive Material (Kocięcki, 1990; Matras, 1991, 1996),
- Poland's climatic, geomorphological and natural diversity,
- 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).

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 likely indigenous tree populations in areas with relatively uniform ecological conditions. These regions are home to the most valuable Polish populations of forest tree species subject to the statutory requirement of regionalization for their outstanding quality and growth. **Seed base** (basic material) are stands over large areas having similar genotypic or phenotypic traits.

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

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, provided, among other things, that forest resources shall be increased through restitution and rehabilitation of forest ecosystems mainly through the replacement of monocultures by mixed stands on the appropriate sites (State Policy on Forests, 1997). Such an obligation can also be found in art. 13, para 1, point 4 of the Forest Act, commanding "to convert and rebuild stands, where these are not in a condition to ensure achievement of the objectives of forest management set out in the Forest Management Plan, 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). In particular, this activity applies to single-species stands in mixed coniferous and mixed broadleaved forest habitats.

It should be noted that the structure of stands in the State Forests reflects random events and the social and economic conditions during the 20th century. In large part, Polish forests are replacement communities that are made up of pine or spruce monocultures, established artificially, in place of the naturally developed ecosystems. Coniferous trees predominate on 70.8 percent of the country's land area as a result of disturbances in the species compositions of forests in Poland caused, in the past, by forest management conducted in accordance with the criteria of normal forest and favouring 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 only slightly exceeded fifty percent (52.1 per cent) (RoSL, 2011). According to the above-mentioned State Policy on Forests, the stand conversion process taking place in Polish forests is aimed at increasing the share of mainly deciduous trees (in some regions it is silver fir *Abies alba* Mill.), as well as at diversifying the age and species structure of stands.

Pinus sylvestris L. appeared, through centuries, 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 several hundred thousand hectares after 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, usually with pine or spruce, and additionally, with self-seeded expansive pioneer species (birch, gray alder, aspen) complementing the existing plantations or forming new ones. Moreover, in typical forest habitats, as a result of insufficient recognition of their production potential (lack of soil and habitat analysis), species with lower edaphic requirements than would be proper from the actual site fertility were introduced. Consequently, species composition of only 41 per cent of stands administered by the State Forests can be regarded as suitable, 40 per cent 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 in the territory of the State Forests was 10-12 thousand hectares. In 2011, it was 10 640 hectares (GDSF, 2011) (Fig. 20).

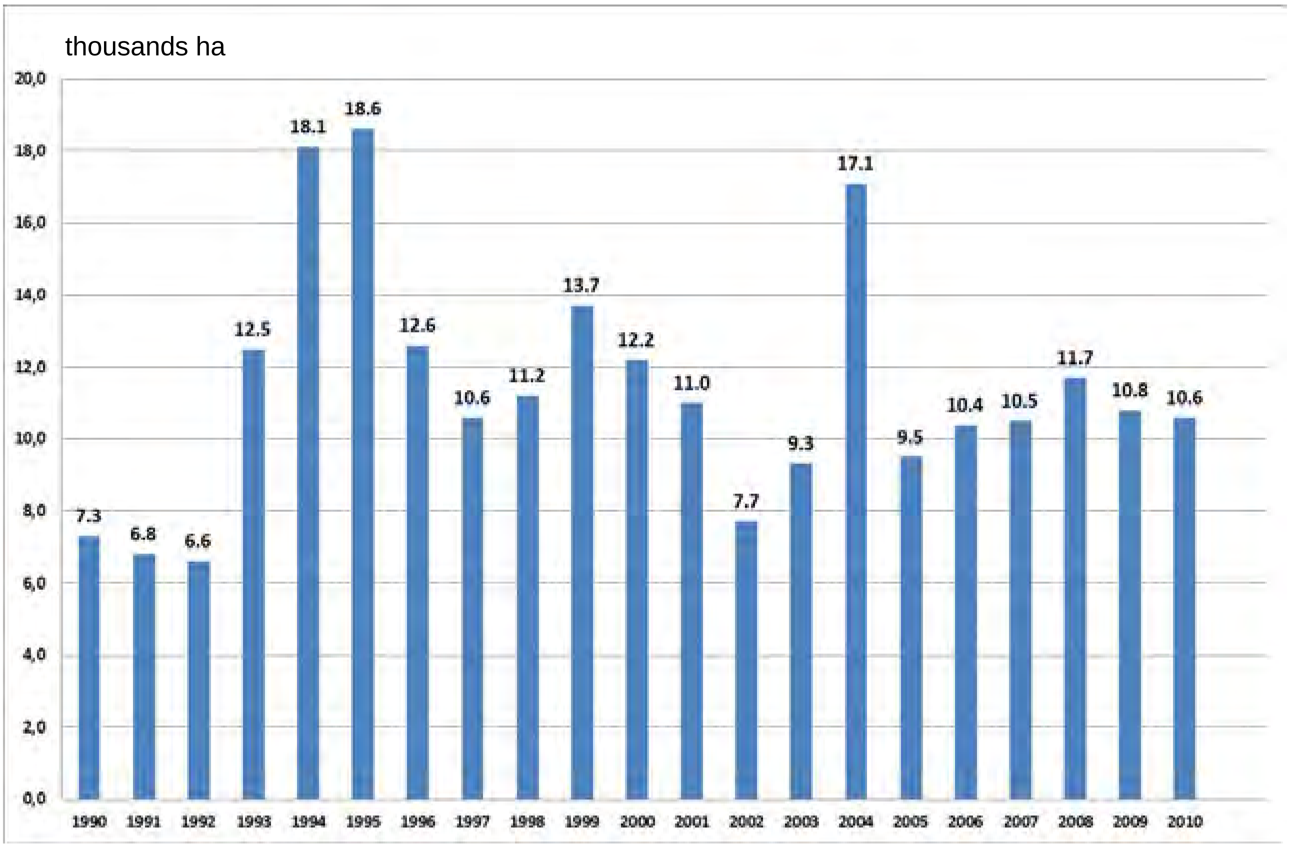


Fig. 20. Stand conversion in the State Forests in 1990-2010 in thousands of hectares (DGSF, 2011)

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

One of the major tasks of forest management in south-western Poland is to reconstruct the distorted phytocenoses in the Sudetes. Economic history records massive deforestations in the Sudetes, beginning from the 14th century. They were caused by the demand for charcoal by the glass works and metallurgy, and for potash from the textile and glass-making industry. Until mid-eighteenth century, there had been continuing deforestation and conversion of forests to mountain pastures. Metallurgy destroyed forests almost completely; the mid-eighteenth century also saw a collapse of herding. The introduction of forest management to the Sudetes is associated with the annexation of Silesia by Prussia in 1742, but it was only in 1777 that Frederick II Hohenzollern passed a law following which the Silesian forests were measured and described. It also regulated the method of prescribing the annual cut (Broda, 1965). From that moment on the species composition of the Sudeten forests could be determined on the basis of relatively accurate estimates. That law of Frederick II Hohenzollern slowed the deforestation process and commanded land afforestation. Initially, Norway spruce seeds were used for afforestation (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 on "*the normal state of sustainable forest management*", called today "*the theory of the normal forest*". It had and continues to have a huge impact on the theory of forestry; from the beginning it has also concerned the Sudeten forests. According to this theory, forest management requires dividing the forest 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 had survived in the Sudetes until 1914 (Zoll 1963). The consequences thereof for the species composition of the Sudeten forests have remained till today. Two important forest species have been almost completely eliminated from the Sudetes – the European beech and the silver fir. The number and area of locations of silver fir in this region have drastically dropped to 0.36 per cent. The number of locations with 6-10 individuals is estimated at 2575.

Analysis of genetic structure based on enzyme variation shows genetic distinctiveness of the silver fir from the Sudetes in comparison with the silver fir from the Carpathian Mountains (Mejnartowicz, 1979, 2004; Lewandowski, Filipiak, Burczyk, 2001). Bergmann (1995) suggests that the fir from the Polish Sudetes 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 genetic resources of this species, and therefore in the 1990s, a restitution programme for fir in the Sudetes was commenced.

The restitution strategy

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

1. Small participation of silver fir in forests where its desired proportion is 20 per cent.
2. Huge role of silver fir in stabilizing spruce forests.
3. 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, not guaranteeing natural regeneration, but ensuring accumulation, in the next generations, of recessive alleles causing 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. Very small local seed base of silver fir.

The activities consisted of an inventory of mature individuals in different regions of origin and altitudinal zones, grafting of an appropriate amount of clones, and establishment of conservation plantations. A total of 8 plantations in the territory of the State Forests and 3 conservation plantations in the Karkonosze National Park were established. The forest reproductive material to be collected from the above mentioned plantations will be used to restore fir stands in an area of 38 000 hectares in the Sudetes in order to increase the share of fir in the mountains to 20 per cent. At present, using the existing seed base, about 200 hectares of fir plantations are established every year in the framework of stand conversion (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 forming natural associations or groups of trees. It is subject to strict species protection. It is also included in the Polish Red Data Book of Plants.

As shown by years-long observations, the preservation of the genetic resources of common yew relying solely on natural processes is no longer possible. Passive conservation of common yew often leads to the ousting of this species by other tree and shrub species, resulting in a poor health condition and a gradual decline of yew trees.

In spite of problems with the restoration of common yew in natural locations, many individuals produce large quantities of seeds. Because of the wide ecological range of the species, its restitution possibilities have become the object of research.

The Programme for the Protection and Restitution of Common Yew (*Taxus baccata* L.) in Poland developed in 2006 and implemented by the organizational units of the State Forests is an important element of the restoration of common yew. Based on the Forest Research Institute data and other publications, 36 locations of common yew being a potential FBM 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 concerning the development and implementation of the programmes for *in situ* and *ex situ* protection of the disappearing or most endangered species.

Common yew, photo by K. Murat

The assumptions, objectives and executors of the Programme

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

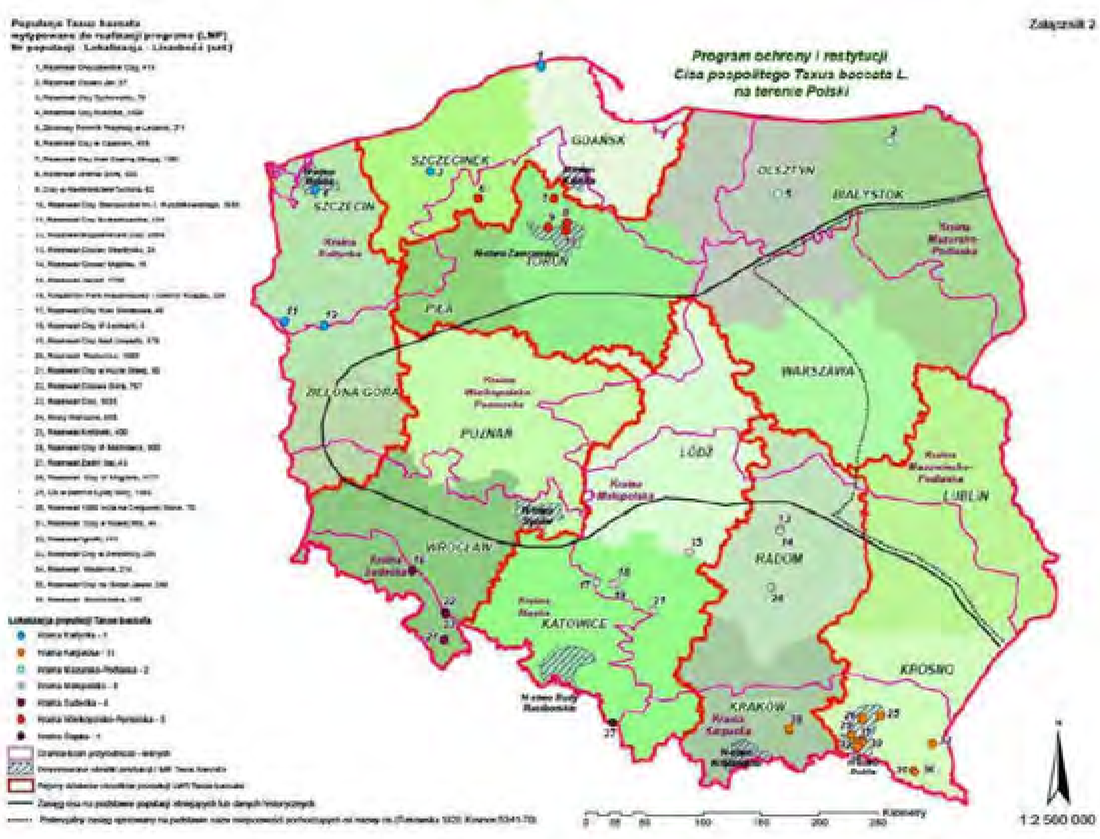


Fig. 21. Appendix to the Programme for the Protection and Restitution of Common Yew *Taxus baccata* L. in Poland

The primary objective of the Programme for the Protection and Restitution of Common Yew (*Taxus baccata* L.) in Poland is to protect the biological diversity of common yew, its population and individual variation, as well as to reinstate and reintroduce this species. The natural processes seem to be inadequate in this respect, therefore active protection has been 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 applied silvicultural and protection treatments are aimed at improving the development and health conditions of the entire population, as well as at increasing its fruiting through the restoration of the species-appropriate light conditions. As the activities undertaken, so far, have produced the desirable results, the participants in the Programme are actively involved in developing proposals of protection tasks for the nature reserves protecting yew populations. 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 44).

Table 44. The number of common yew trees in 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	
Warszawa	138		
Wrocław	4 024	2 387	
Zielona Góra	1 330		
Total	**52 382**	**23 568**	**2 382**

The research project 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 Common Yew in Poland), commissioned by the Directorate General of the State Forests and developed by the Institute of Dendrology, PAS in Kórnik has been implemented since 2008.

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

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

Projects implemented in the framework of the Programme

Projects implemented in Poland:

1. The Programme for the Protection and Restitution of the Common Yew *Taxus baccata* L. in the Territory of the Gdańsk RDSF – seven Forest Districts (Choczewo, Elbląg, Gdańsk, Kaliska, Lębork, Lipusz and Wejherowo) with the Kaliska Forest District as a leading unit.
2. The Regional Programme for the Protection and Restitution of the Common Yew *Taxus baccata* L. in the Territory of the Katowice RDSF in the years 2007–2014 – 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 in the Territory of the Kraków RDSF in the years 2010-2014 – Forest Districts: Gorlice, Krościenko, Łosie, Myślenice, Nawojowa and Stary.
4. The Programme for the Protection and Restitution of the of Common Yew *Taxus baccata* L. in the Territory of the Krosno RDSF in the years 2007-2016 – 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. in the Territory of the Piła RDSF in the years 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. in the Territory of the Poznań RDSF – Forest Districts: Antonin, Góra Śląska, Przedborów and Syców.
7. The Regional Programme for the Protection and Restitution of Common Yew *Taxus baccata* L. in the Territory of the Szczecinek RDSF – Forest Districts: Czarne and Tychowo.
8. The Regional Programme for the Protection and Restitution of the Common Yew *Taxus baccata* L. in the Territory of the Szczecinek RDSF.
9. The Regional Programme for the Protection and Restitution of the Common Yew *Taxus baccata* L. in the Territory of the Toruń RDSF in the years 2007–2016 – in seventeen Forest Districts.
10. The Regional Programme for the Protection and Restitution of the Common Yew *Taxus baccata* L. in the Territory of the Wrocław RDSF.
11. The Regional Programme for the Protection and Restitution of the Common Yew *Taxus baccata* L. in the Territory of the Zielona Góra RDSF – in the Cybinka, Lubsko and Nowa Sól Forest Districts.
12. Conservation of the Common Yew Gene Pool in the Leon Wyczółkowski “Cisy Staropolskie” Reserve, in the Zamrzenica Forest District.
13. Establishment of a Clonal Archive of the Common Yew trees *Taxus baccata* L. recognized as natural monuments – Kostrzyca FGB.

Specification of detailed tasks planned in the framework of the aforementioned Projects:
1. Inventory and assessment of yew locations in the area of project execution. Verification of potential locations for the introduction of common yew.
2. Selection of sites for planting (gene conservation plantations).
3. Recognizing the demand for planting stock.
4. Seed collection.
5. Production of planting stock.
6. Establishment of gene conservation plantations on selected sites.
7. Tending the established plantations.
8. Modernization of nursery and educational infrastructure.
9. Preparing reports on project execution. Monitoring the effects of project execution.

Table 45. Production of seedlings and establishment of plantations by organizational units of 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 produced common yew seedlings [in thousand seedlings]	109.1
Established gene conservation plantations [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 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 due to the determination of the possibilities of reproductive material transfer . This will help to exclude from the restitution programme the populations with low levels of genetic variation, as well as those comprising individuals of foreign origin and hybrids (with *T. cuspidata* and *T. x media*).

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

An increase in the area of common yew, as well as in its population and individual variability will be the anticipated effect of implementation of the specific tasks under the Programme.

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

The wild service tree *Sorbus torminalis* (L.) Crantz requires urgent protective measures and restitution activities like those applied for common yew. Wild service tree is more threatened by genetic drift than common yew, because of:

– lack of active protection that should be applied to *Sorbus torminalis* as a light-demanding species (necessary silvicultural treatments and removal of competing species),
– few scattered populations in the natural range of this species and the scarcity of individuals of in these populations,
– problems with pollinators and cross pollination of dispersed individuals,
– a rapid pace of disappearance of the natural habitats for wild service tree 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 undertake active protective and restitution measures in this respect.

<u>Projects implemented in Poland in the framework of the Programme:</u>

1. The ex *situ* conservation of genetic resources in selected locations of wild service tree *Sorbus torminalis (L.)* Crantz – in the Kostrzyca Forest Gene Bank (Kostrzyca FGB) planned for implementation in the years 2010-2012.
   The tasks under the Project include:
   - monitoring the flowering and fruiting of wild service trees in 37 locations,
   - collection of fruits and seeds and establishment of 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 Wild Service Tree *Sorbus torminalis* (L.) Crantz in the Territory of the Piła RDSF in 2010-2013. Tasks:
   inventory, seed collection and production of wild service tree planting stock.
   Planned activity till 2013 – the establishment of a gene conservation plantation (16.68 ha/33.65 thousand seedlings).
3. Conservation and Restitution of Wild Service Tree in the Territory of the Wrocław RDSF – introduction of 10.7 thousand seedlings into the natural environment.
4. Restitution of Wild Service Tree in the Territory of the Nowa Sól Forest District (Zielona Góra RDSF).
5. Restitution of Wild Service Tree in the Territory of the Jamy Forest District (Toruń RDSF):
   seedling production – 9.85 thousand seedlings, gene conservation plantations – 1.71 hectares.
6. Protection of Wild Service Tree in the Territory of 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 the forest genetic resources in Poland

The most important factors affecting the state of the forest genetic resources in Poland include all the stress factors having an impact on the forest environment, *i.e*. biotic, abiotic and anthropogenic.

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 nature 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 October 2009 – 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 in the territory of the Katowice RDSF (1 045 thousand m^3), Wrocław RDSF (939 thousand m^3) and Krosno (378 thousand m^3) RDSF.

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

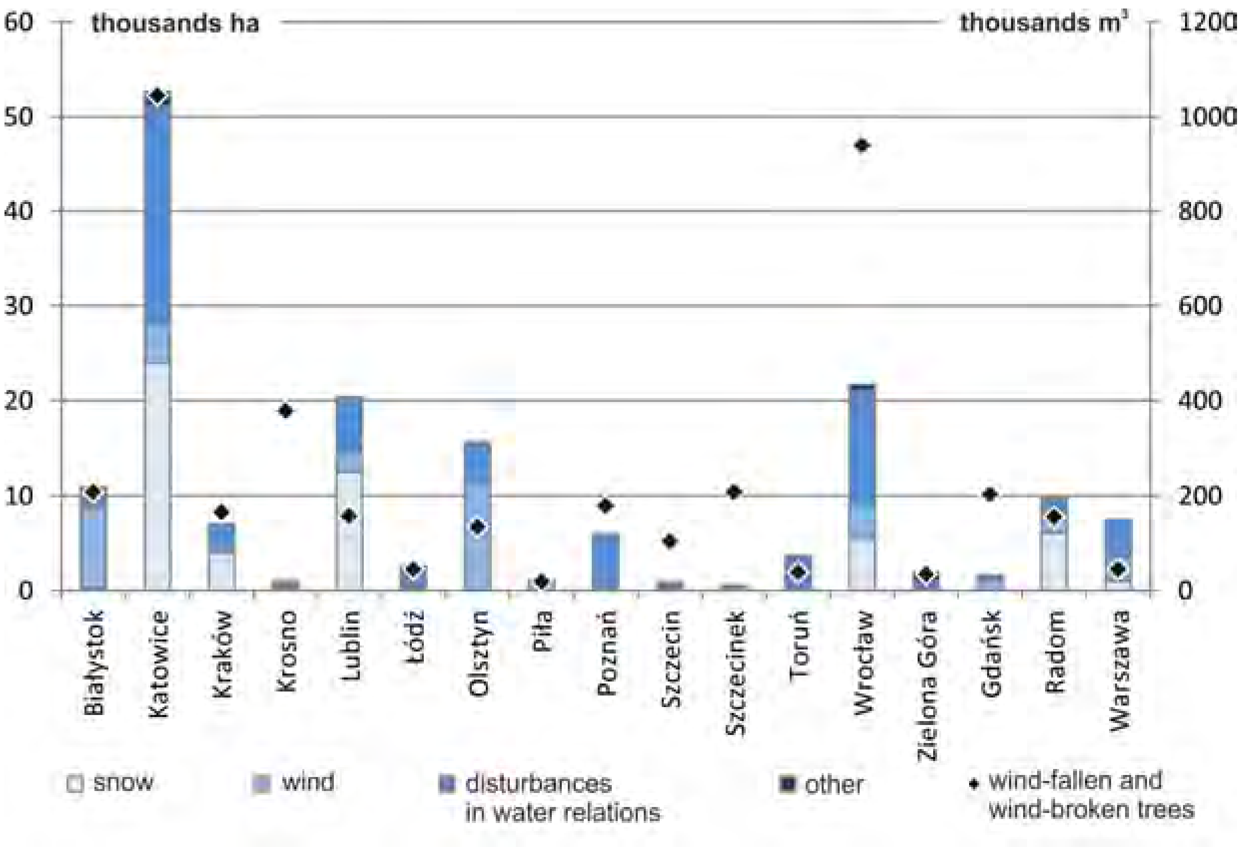


Fig. 22. Area of distribution of damage to forests caused by abiotic factors and the volume of wind-broken and wind-fallen timber in stands aged 20+ in 2010, by RDSF
*** hail, emissions, low and high temperature, fire**

Fig. 23 illustrates the area of distribution of damage to forests caused by abiotic factors in 2006–2010. The data in the table show that forests are exposed to a 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 a random occurrence of other factors.

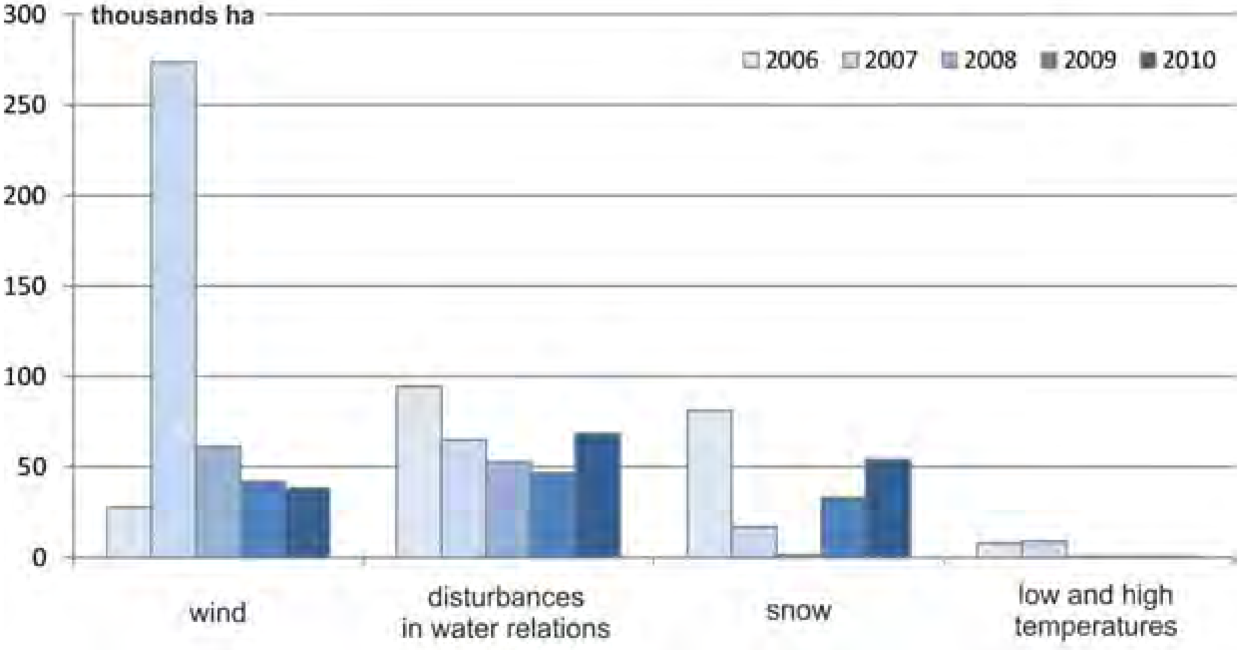


Fig. 23. Area of occurrence of damage caused by abiotic factors to the forests administered by the State Forests in 2006–2010

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

Moisture conditions during the growing season of 2010 were extreme, compared with the past decade. The average total rainfall for the country during the growing season was 576.2 mm; it was higher by 160.5 mm from the long-term average and the highest ever recorded in the 21st century. Heavy rainfalls whose intensity was the highest in May, July and August had disastrous consequences. For example, in May, 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 above normal. In August, rainfalls across the country were also above the norm – the heaviest rainfalls were recorded in Szczecin (324 per cent above the norm) and Chojnice, Jelenia Góra, Koszalinie, Poznań, Toruń and Warszawa (250–280 per cent above the norm). October was the only month in the growing season with significant moisture deficit, the lowest rainfalls not exceeding 10 mm were recorded at the weather stations in southern, eastern and central Poland, for example in Wrocław – 2.6 mm, Lublin – 7.3 mm, Łódź – 6.8 mm, Warsaw – 2.8 mm.

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

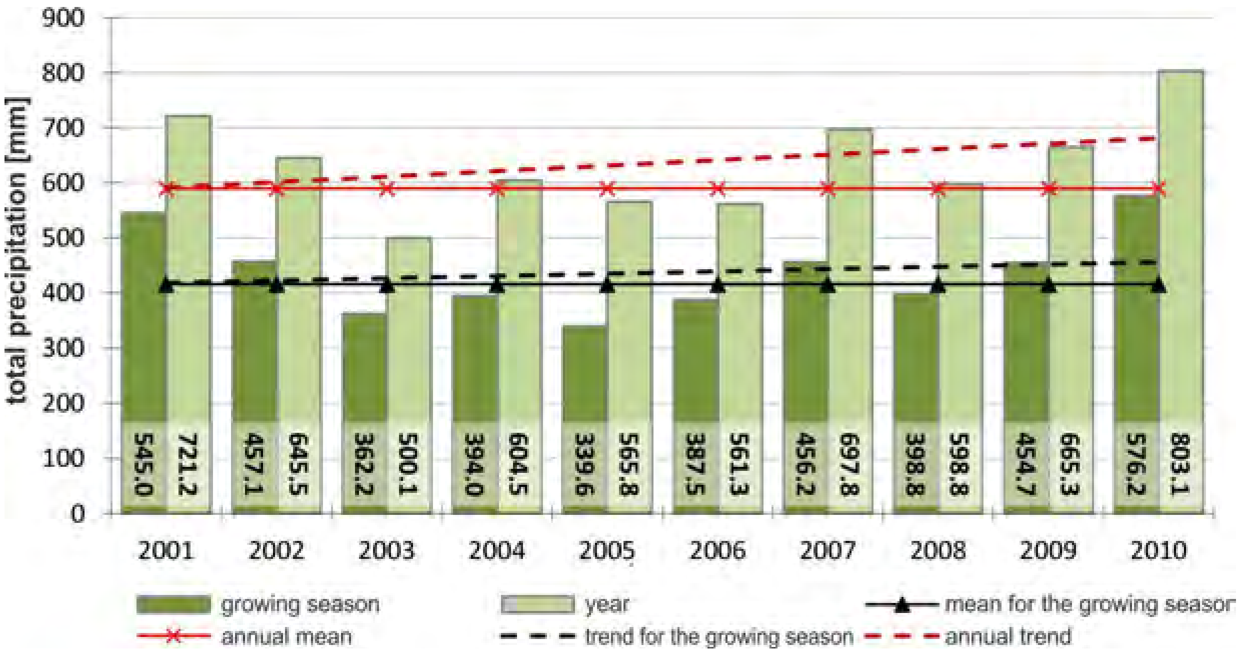


Fig. 24. The sum of atmospheric precipitation in 2001–2010 and the general trend

The average temperature in the growing season 2010 was 13.6°C, and was (like in 2004) the lowest in the past decade. It exceeded the value of the long-term average only by 0.4°C, which was the effect of cold weather prevailing in May, September and October. The average annual temperature in 2010 (7.4°C) was the lowest in this decade going down, for the first time, below the long-term average of 7.8°C, (Fig. 25). This was the consequence of the frosty winter months (January, February and December) and the cold May, September and October. Therefore, the trend for average temperatures in the year and in the growing season beginning from 2001 went slightly down.

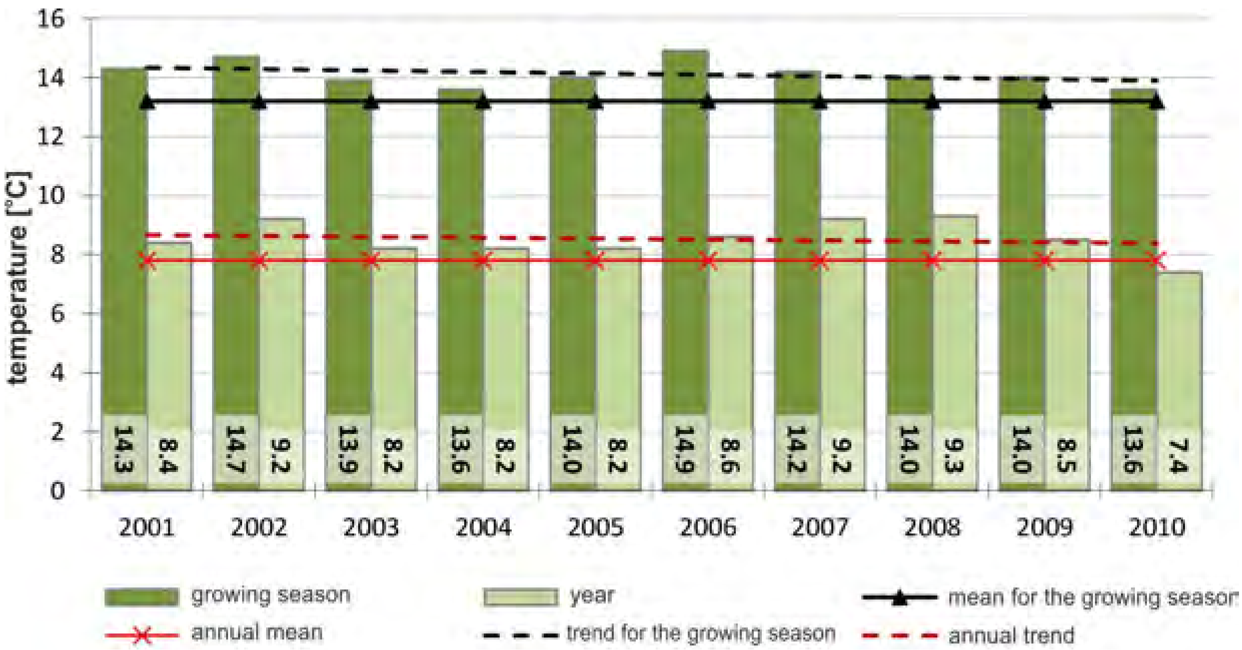


Fig. 25. Average air temperature in 2001–2010 and the general trend

The average value of the hydrothermal coefficient was higher than the long-term average in different regions of the country monitored by weather stations (Fig. 26). The largest differences were in the south-eastern region where precipitation level was the highest. The thermal and moisture conditions least deviating *in plus* from the norm were recorded in the north-eastern region, and locally in the coastal region (Koszalin) of Poland.

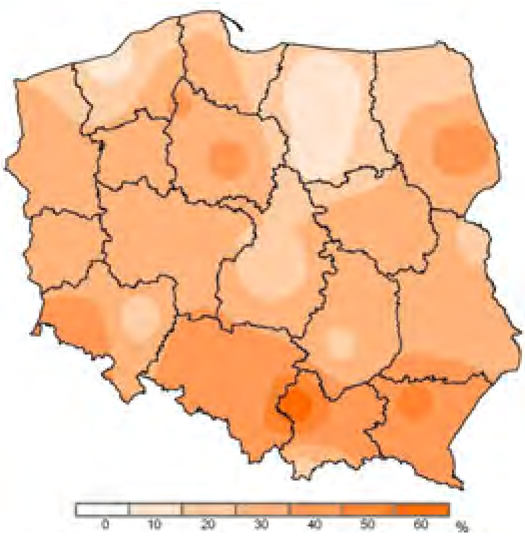


Fig. 26. Geographical differences in hydrothermal coefficient values for the growing season 2010 in terms of the *in plus* deviations from the long-term average values (%)

(The meteorological part was prepared on the basis of monthly Bulletins of the National Hydrological and Meteorological Service, Institute of Meteorology and Water Management – IMiGW).

3.2. Biotic threats

Poland is in the group of countries in which unfavourable phenomena in forests occur with high diversity and intensity, capable of leading to mass outbreaks of insect pest 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 forest environment such as:

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

3.2.1. Threats to forests posed by insect pests

In consecutive decades of the 1961-1990 period there was an increase in the number of insect species endangering stands and the area of stands that were treated protectively. And so while in the years 1961-1970 38 insect species was observed to occur massively (of which 20 were treated against) and the protective treatments were conducted on a joint area of 600 thousand ha, in the years 1981-1990 there were massive attacks of 56 insect pest species of which 46 were treated against over a joint area of 7 m ha. At that time about 70 m m3 of pest infested conifer and broadleaf timber was removed from the forests. In the nineties similar though not on such a great scale was the risk to pine stands from the nun moth and to spruce stands from secondary pests.

The leafeating 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 pine webworm *Acantholyda nemoralis* L. show the highest dynamics in Poland. At the same time, a cyclicity of insect outbreaks is observed. The largest outbreaks of primary insect pests occurred in 1979-1984 and in 1992-1994, and of secondary pests in 1981-1985 and in 1993-1994. Insects whose occurrence was marginal have now gained economic significance, e.g. the area, where the number of pests in plantations and thickets was reduced, increased fivefold, exceeding 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 1487 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;
– mass occurrence of pine sawflies in 1991-1995 – control treatments were carried out 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 – control treatments were carried out in an area of approximately 160 thousand hectares;
– increased activity of pine webworm – control treatments were carried out in an area of several thousand hectares per year (in 1994 on nine thousand hectares);
– permanent activity of tortrix moth and other leafeating 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;
– increased activity of cockchafers – control treatments were carried out in 1994-2006 in a total area of 71 thousand hectares;
– increased incidence of diseases of oak, beech and birch stands.

The geographical distribution of damage to forest stands by insect pests (Fig. 27) shows that most threatened are the stands 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 – to primary pests (chiefly the nun moth). It is also possible to distinguish zones with a low and moderate threat, extending in an arc from the Silesian Lowland in western Poland *via* the Krakowsko-Częstochowska and Małopolska Uplands (excluding the Świętokrzyskie Mountains) and the Lubelska Upland, as far east as the Mazowiecka Lowland and the Mazury Lake District.

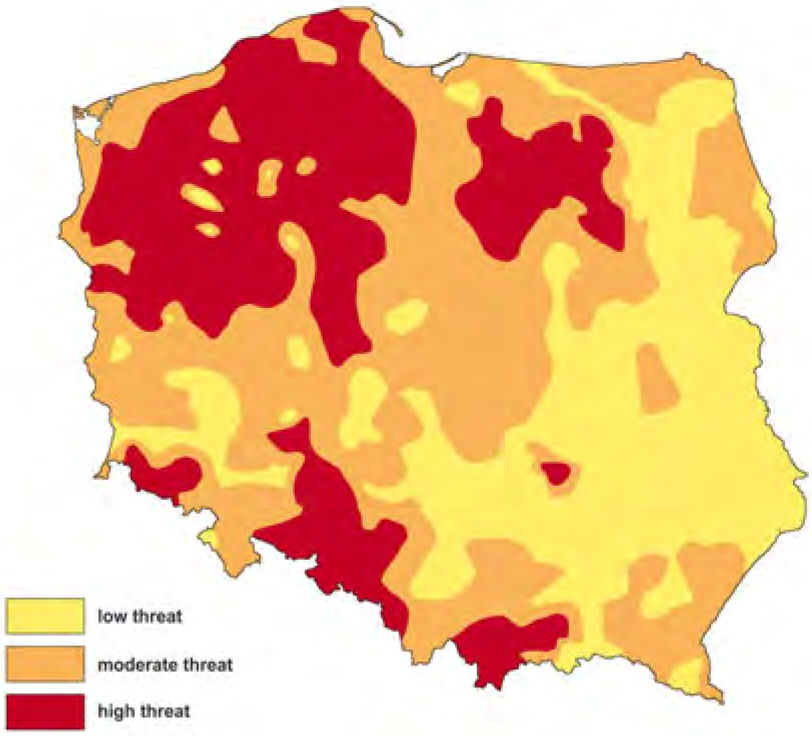


Fig. 27. Zones with threat to Poland's forests posed by insect pests (primary and secondary pests taken together) according to the Forest Research Institute

The activity of insects pests in 2010 decreased by nearly 10 per cent in comparison with the previous year. The control treatments aimed to reduce the population of about 45 insect species covered an overall area of almost 12.8 thousand hectares, that is about 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.), the pine beauty moth (*Panolis flammea* Den. *et* Schiff.) and imagines of *Melolontha* spp.

1. Chemical treatments against leafeating insects were carried out on 439 thousand hectares of pine stands, a decrease by about 3.5 thousand hectares in comparison with 2009.
2. Chemical control against leafeating insects covered nearly 2.4 hectares of broadleaved stands, an increase by about 300 hectares in comparison with 2009.
3. The total area of pine plantations and young stands subjected to pest control treatments was 8.3 thousand hectares, a decrease by about 2.4 thousand hectares in comparison with 2009.
4. The total area of spruce and larch stands subjected to control treatments against pest insects was 2.3 thousand hectares and was four-fold smaller in comparison with 2009.
5. Salvation measures taken against root pests of forest trees and shrubs were applied to plantations and nurseries over a total area of 993 hectares.
6. Of the major leafeating pests, cockchafer imagines were controlled in the largest area of 1346 hectares, oak tortrix moth – on 911 hectares, pine sawflies on 295 hectares and pine webworm (Acantholyda nemoralis L.) on 128 hectares (Fig. 28).
7. Chemical treatments against leafeating insects were carried out on 439 thousand hectares of pine stands, a decrease by about 3.5 thousand hectares in comparison with 2009.
8. Chemical control against leafeating insects covered nearly 2.4 hectares of broadleaved stands, an increase by about 300 hectares in comparison with 2009.
9. The total area of pine plantations and young stands subjected to pest control treatments was 8.3 thousand hectares, a decrease by about 2.4 thousand hectares in comparison with 2009.
10. The total area of spruce and larch stands subjected to control treatments against pest insects was 2.3 thousand hectares and was four-fold smaller in comparison with 2009.
11. Treatments taken against root pests of forest trees and shrubs were applied to plantations and nurseries in a total area of 993 hectares.
12. Of the major leafeating pests, cockchafer imagines were controlled in the largest area of 1346 hectares, oak tortrix moth – on 911 hectares, pine sawflies on 295 hectares and pine webworm (*Acantholyda nemoralis* L.) on 128 hectares (Fig. 28).

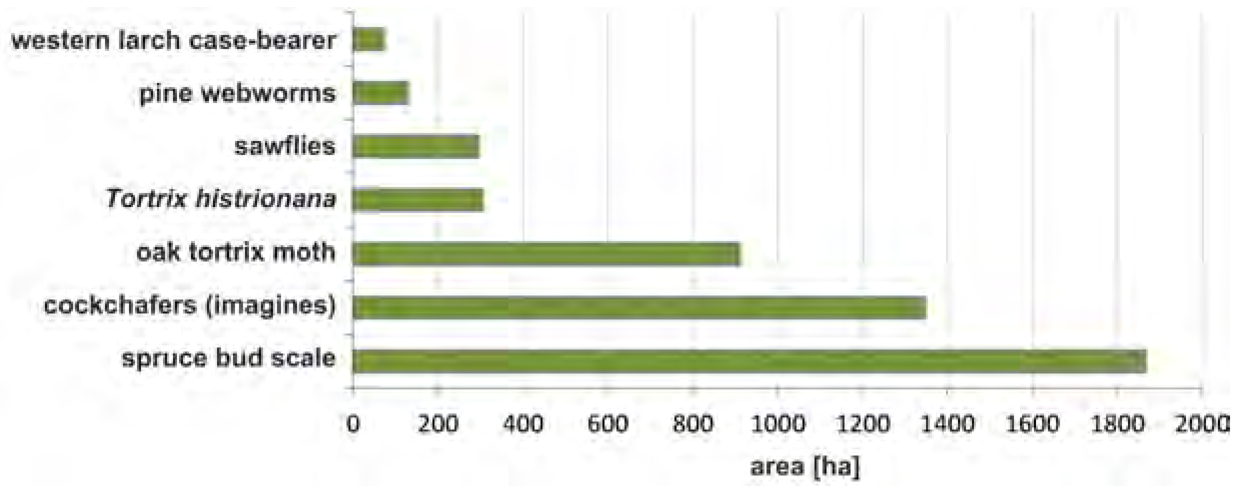


Fig. 28. Area of stands covered by protective treatments against major leafeating insect pests in 2010

In 2010, the largest areas where insect populations were controlled were in the Białystok RDSF – 3.3 thousand hectares, Toruń RDSF – 2.0 thousand hectares, Piła RDSF – 1.7 thousand hectares and Szczecin RDSF – 1.6 thousand hectares, while the smallest in the Cracow RDSF – 108 hectares, Warsaw RDSF – 131 hectares and Zielona Góra RDSF – 150 hectares (Figs 29 and 34).

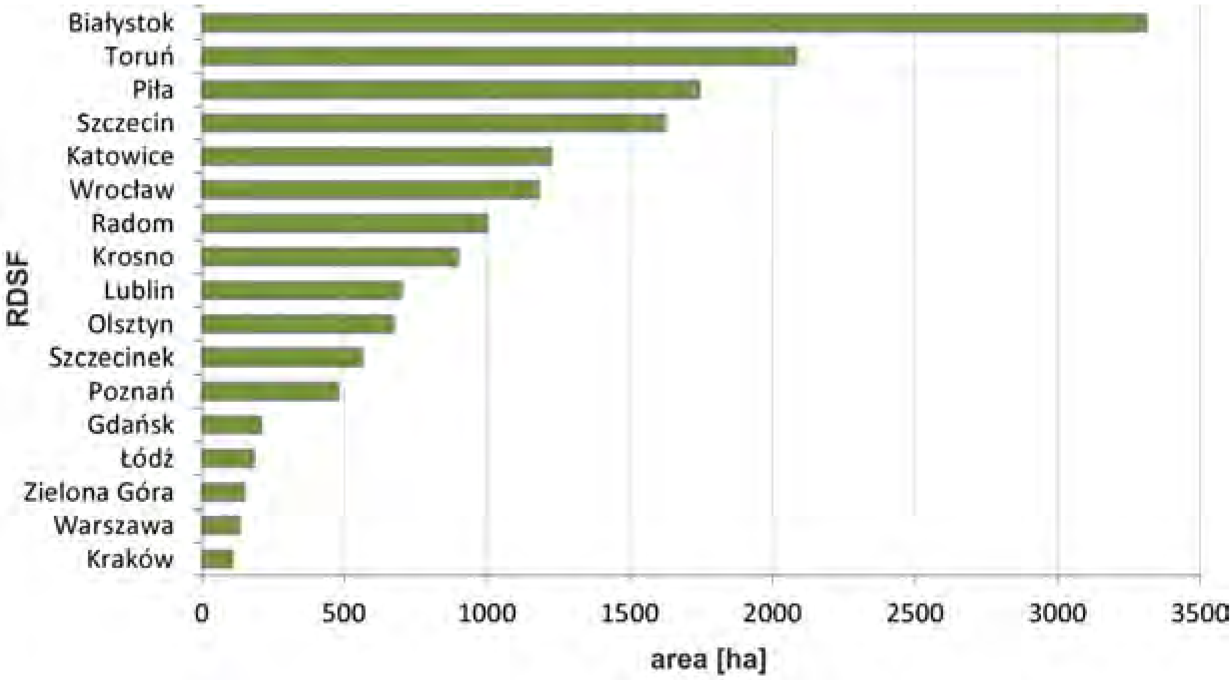


Fig. 29. Reduction in the population of forest insect pests in 2010 by RDSF (according to the Forest Research Institute)

The leafeating 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 pine webworm *Acantholyda nemoralis* L. show the highest dynamics in Poland. At the same time, a cyclicity of insect outbreaks is 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 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. Since the early 1990s, an increased threat to forests caused by cockchafers has been reported. The appearance of several cockchafer populations in Poland resulted in strong fluctuations in cockchafer populations in subsequent years. A particularly dangerous population of cockchafers swarmed in the years 1995, 1999, 2003 and 2007 (Fig. 30). It appeared every four years across large areas administered by the Łódź RDSF and in smaller areas throughout the country.

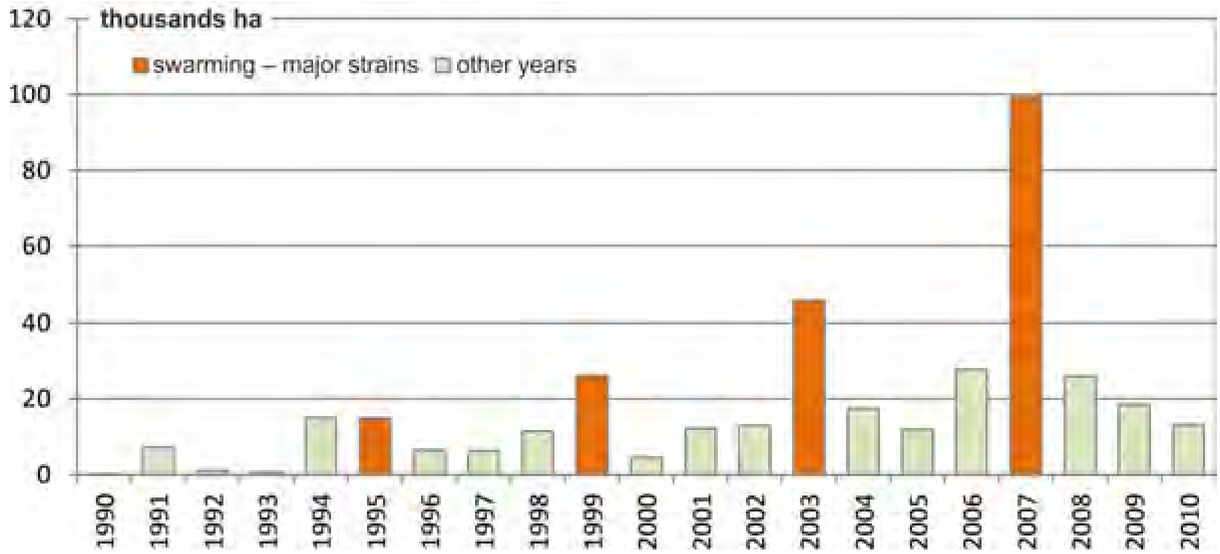


Fig. 30. Area of occurrence of cockchafers in the period 1990-2010

In 2010 pests of the root system have been observed over an area of 35 810 ha, out of which the damage done by cockchafer grubs was over 35 728 ha. The nurseries and plantations are very much endangered by the cockchafers in the recent years (Fig. 31).

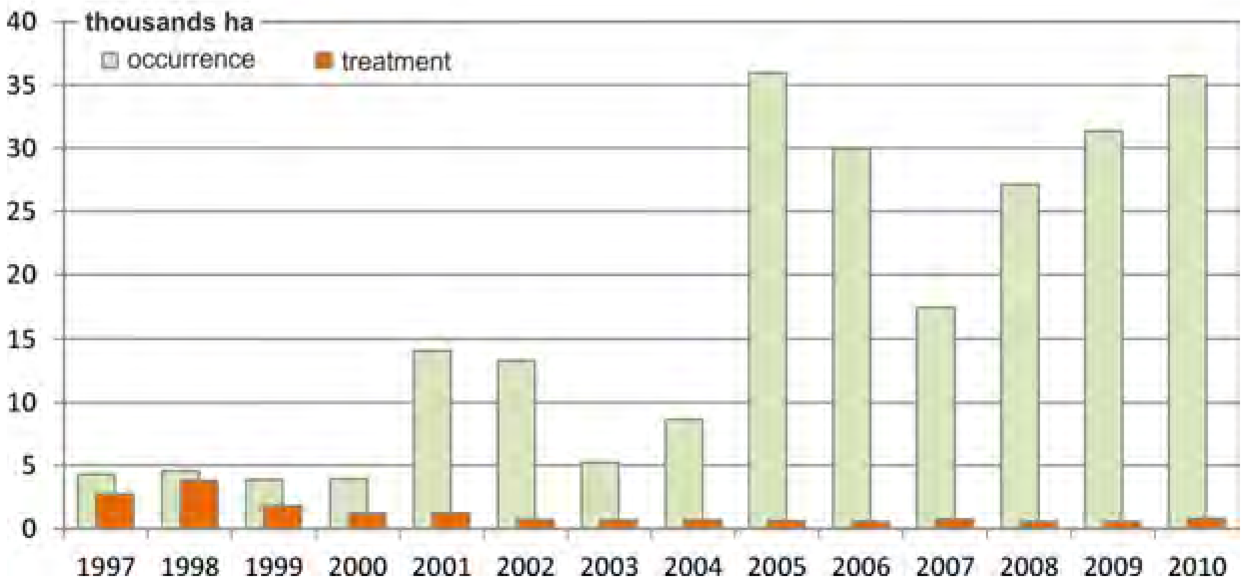


Fig. 31. Area of occurrence and control of cockchafer grubs in the period 1997-2010

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

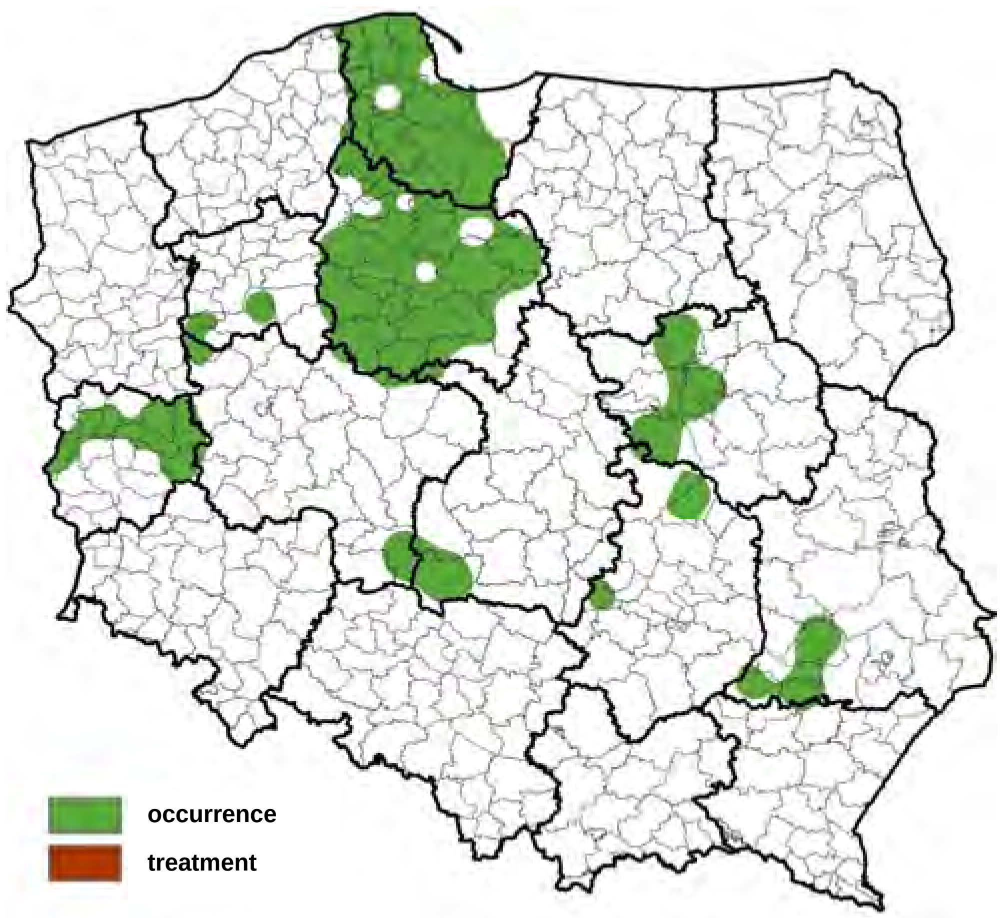


Fig. 32. The occurrence and control of nun moth in 2010

The area of pine stands threatened by pine sawflies has oscillated in recent years between 20 thousand and 25 thousand hectares. In 2010, damage caused by this group of insects affected 12.3 thousand hectares, half the area of 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 territory of the Toruń and Gdańsk RDSFs (Fig. 33).

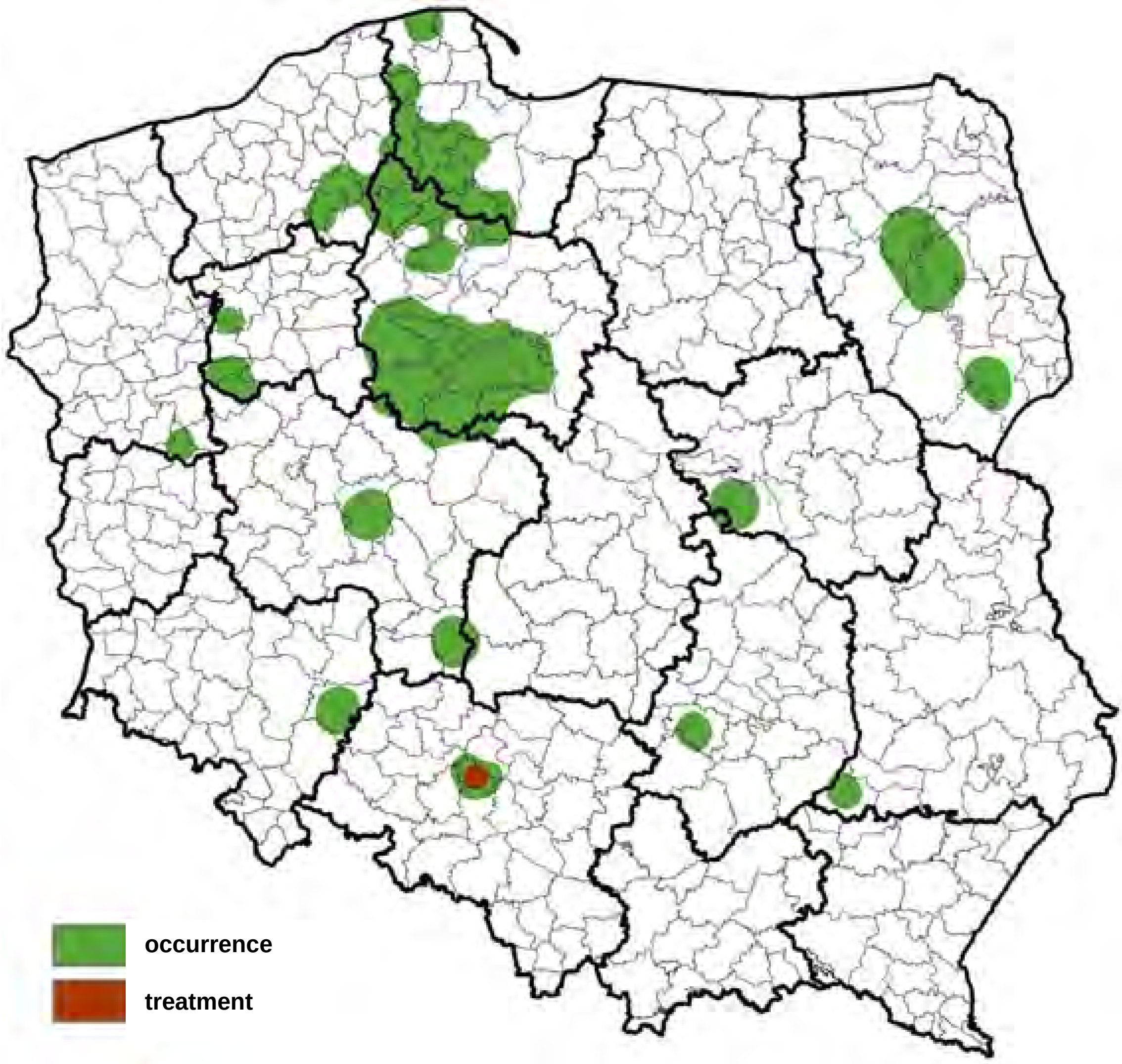


Fig. 33. The occurrence and control of pine sawflies in 2010

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

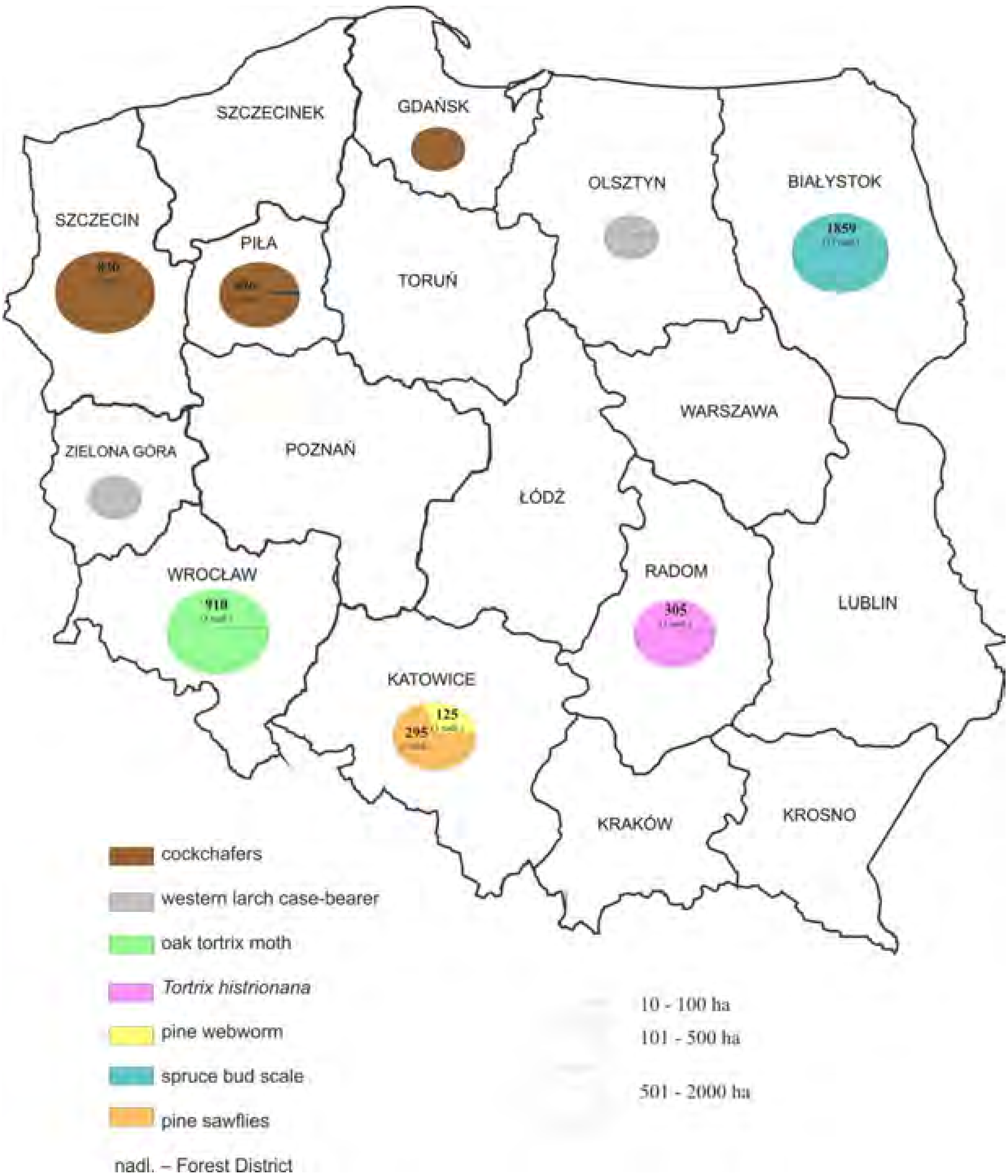


Fig. 34. Reduction in the number of the major leafeating pests in the territory of individual RDSF in 2010

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, two-spotted oak borer and *Chrysobothris* spp*.* in oak stands. It was associated with the weakening of stands induced by abiotic factors, like wind, changes in the groundwater level, snowfall or 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, including 3151 thousand m^3 (68.5 per cent) of wind-fallen and wind-broken timber. In comparison with the previous reporting period, the volume of harvested timber increased by 12.1 per cent. The largest harvest of softwood was in the territory of the Katowice and Wrocław RDSFs.

The volume of pine wood harvested in sanitation cuts from 1 October 2009 to 30 September 2010 amounted to 3077 thousand m^3, including 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 increased by 44.3 per cent. The largest volume of pine wood was harvested in the territory of 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 the beetles of the family Cerambycidae – longhorn beetles *Tetropium* spp. and *Rhagium* spp. (in low numbers).

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 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, 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., 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 about 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 territory of 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 increased by 210 per cent, compared to 2009. A higher (over 10 per cent) harvest of oak wood was in the Wrocław and Poznań RDSFs, *i.e.* 27.59 per cent and 14.49 per cent, respectively. In nine RDSFs (Wrocław, Krosno, Gdańsk, Radom, Cracow, 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; in four RDSFs (Wrocław, Krosno, Gdańsk and Radom), its share exceeded 75 per cent.

In the analyzed period, the factors influencing the natural thinning of oak stands were: the lowering of the groundwater level and attacks of secondary pests, mainly the two-spotted oak borer. However, oak decline was less intense due to considerable reduction in the population of this pest, except in 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 pests of oak stands were: longhorn beetles *Plagionotus* spp., *Leiopus* spp., tanbark borer *Phymatodes testaceus* L., *Xyloterus* spp. and 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 amounted to 326 thousand m^3 and was higher by 59 thousand m^3 (22 per cent), compared to 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 due to snow-packing and wind action breaking and falling trees. 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, they fed in stands weakened by the attacks of primary pests.

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

Insect outbreaks mainly affect large tracts of pure coniferous forests, which are more sensitive to biotic factors due to their lower adaptability to the 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, a decrease in area by 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* needle cast of pine. In turn, a varying degree of increase was noted in the areas of occurrence of other diseases of the assimilatory apparatus: pine shoot disease, pine twisting rust (630 hectares and 310 hectares, respectively), as well as oak mildew and needle and leaf rust (by 7 per cent and 13 per cent, respectively). The dieback of all broadleaved tree species: oak, beech, birch and ash was less severe (by 23 per cent, 28 per cent, 25 per cent and 23 per cent, respectively). The area of stands showing the symptoms of alder dieback was reported to decrease by 1800 hectares and of fungal diseases in poplars (cankers, decline, bark rot and tree dieback) taken together – 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 occurrence of root-rot diseases was reported in an area of less than 2.2 thousand hectares. The area of stands affected by the *Heterobasidion* root rot decreased by 2 per cent, while the occurrence of the *Armillaria* root rot remained at the same level (Fig. 35).

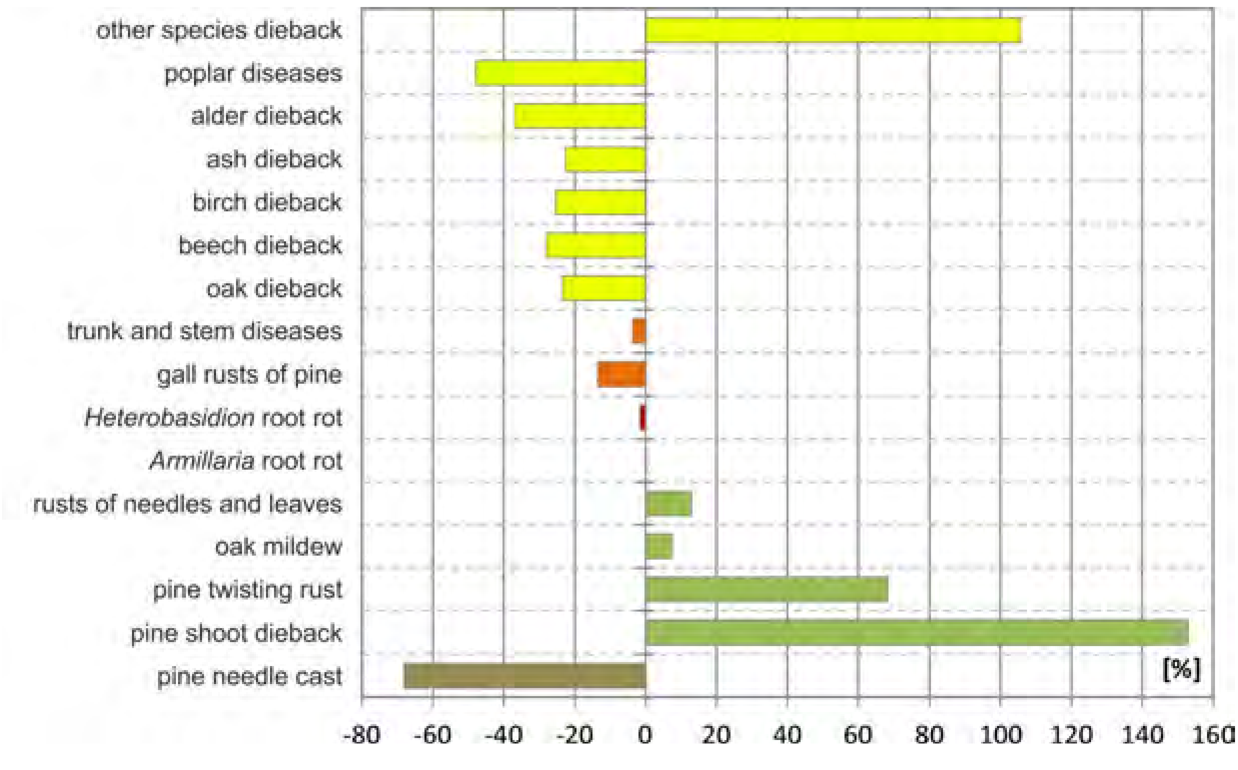


Fig. 35. Changes in the area affected by infectious diseases in 2010, in comparison with 2009 (%)

The comparison of the health condition of stands in individual RDSFs with the 2009 data shows improvement or stabilisation of the health condition of forests (Fig. 36). The area of stands under threat was reported to increase only in the Łódź RDSF by 34.6 per cent, while in the remaining RDSFs it decreased by several to dozen or so per cent or remained at the level of 2009 (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 more than a five-fold increase in the area affected by oak decline in comparison with 2009.

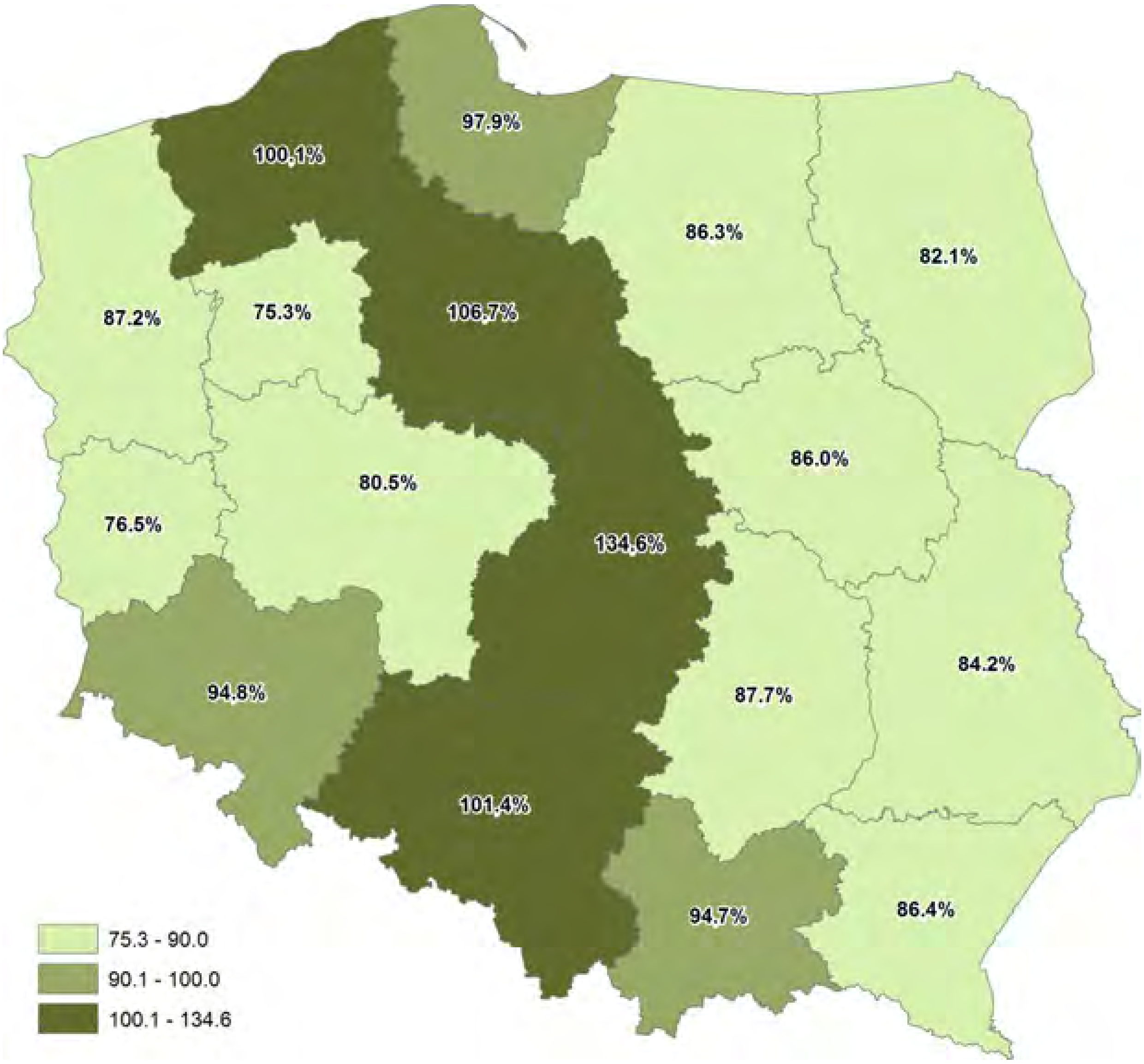


Fig. 36. Changes in the area of occurrence of infectious diseases in 2010 expressed as a percentage of the area under threat in the previous year

The analysis of the areal share of occurrence of fungal diseases in the total forest area of individual RDSFs shows that, like in 2009, the area affected by the diseases in two RDSFs exceeds 10 per cent: in the Toruń RDSF (11.6 per cent) and Warsaw RDSF (10.6 per cent), while in other RDSFs it oscillates between 0.7 and 9.8 per cent of forest area. The threat to forests from infectious diseases below 5 per cent of the forest area occurs in the same nine RDSFs as in 2009: Cracow, 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, shows that the greatest potential threat (over 10 per cent of the total area of disease occurrence) is located in the Olsztyn, Toruń and Wrocław RDSFs. In other RDSFs, stands showing the symptoms of fungal diseases did not exceed 8.6 per cent of the total affected area, the lowest fungal infection (close to 1 per cent of the total area of disease occurrence) being reported only in the Cracow and Zielona Góra RDSFs.

In nurseries, the area affected by fungal diseases increased in 2010 by 20 hectares in comparison with 2009.

The area of occurrence of diseases in the stands up to 20 years of age was in 2010 smaller by 23 per cent (by 13 500 hectares) in comparison with 2009. The area of stands affected by *Lophodermium* needlecast (approx. 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 oak and ash decreased to a smaller degree. In turn, an increase was noted in the areas of occurrence of other diseases of the assimilatory apparatus: pine shoot disease (by 160 per cent), 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 area of occurrence of *Armillaria* root-rot diseases increased by 2 per cent, while the area of dieback of stands with broadleaved species, affected, to a varying degree, by the *Heterobasidion* root rot, pine gall rusts and stem and trunk diseases, decreased.

For many years, root diseases posed the major threat to forests affecting a total of 262.1 thousand hectares (68 per cent of the total disease occurrence area). The occurrence of pine gall rust and stem and trunk diseases taken together were reported in an area of 54.3 thousand hectares, and the dieback of broadleaved trees in an area of 40.4 thousand hectares. In 2010, diseases of assimilatory apparatus occurred on a total of 24.1 thousand hectares.

A comparison of the current and last-year's situation shows a similar degree of improvement in the health condition of forests with broadleaved species; the area of infested stands with oak, birch and ash was reported to decrease by nearly one fourth compared to 2009. Alder decline occurred in a 37 per cent smaller area, and poplar diseases were recorded in an area of 91 hectares, representing 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 the symptoms of dieback (1997 hectares). It was estimated that the multifactor disturbances in stands occurred in a total area of 40.45 thousand hectares which was by 11.7 thousand hectares (22 per cent) less compared to the 52.1 thousand hectares in 2009.

The area of oak stands showing disease symptoms amounted to 20.4 thousand hectares (6.2 thousand hectares less than in 2009). The most affected area was in the territory of the Łódź RDSF, amounting to 6.3 thousand hectares (mostly in the Kolumna Forest District – 5.5 thousand hectares), which was five times larger than in the previous year. In four RDSFs (Białystok, Szczecin, Lublin and Wrocław), the phenomenon of oak decline occurred in areas exceeding one thousand hectares (4971 ha, 2365 ha, 1347 ha and 1065 ha, respectively). In five RDSFs, the disease afflicted the areas of over 500 hectares, while in the other seven RDSFs – the areas under 400 hectares, except for the Cracow and Zielona Góra RDSFs where disease symptoms were not observed.

The area of threatened beech stands was reduced by 654 thousand hectares to 1682 hectares. Beech decline occurred with the greatest intensity in the Szczecin RDSF – on 620 hectares (the extent of damage remained at the previous year's level), in the Szczecinek RDSF – on 260 hectares (the extent of damage was similar to that in 2009) and in the Lublin and Wrocław RDSFs – on 205 and 174 hectares, respectively (about 50 per cent less than in the previous year). In the remaining RDSFs, the decline affected areas no larger than 80 hectares.

The symptoms of all poplar diseases (canker, decline, bark rot, tree dieback, *etc.*) were recorded on 90.7 hectares, about half less than in 2009; the largest area of damage was in the Poznań (38 ha), Łódź (14 ha) and Szczecin (11 ha) RDSFs. In the remaining RDSFs they did not exceed 10 hectares, or did not occur at all.

In birch stands, the area of tree decline was 1465 hectares (compared to1965 hectares in 2009) and was by 25 per cent smaller than in the preceding year. The dieback was most servere 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, and in the remaining RDSFs tree dieback symptoms did not exceed 70 hectares.

The ash decline in Poland has been observed in forest stands mixed with this species for a dozen or so years; it gained strength and weakened alternately. Currently, the disease is recorded in an area of 11.8 thousand hectares (3.4 thousand hectares less than in 2009). Ash decline occurred in all the RDSFs, but its severity was very diverse, from 100 hectares in the Zielona Góra RDSF, to about 1.0-1.7 thousand hectares in the Olsztyn, Poznań and Toruń RDSFs, and to nearly 2.0 thousand hectares in the Białystok RDSF. In other parts of the country, the disease was observed in areas ranging from 140 to 900 hectares. Like in 2009, the majority (82 per cent) of areas with trees showing the 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 to 1.0 thousand hectares. Only in the territory of the Zielona Góra RDSF, the decline affected an area smaller than 100 hectares. Much damage (yet still by 22 per cent less than in the previous year) was also recorded in younger stands (2099 ha), mostly in the Poznań RDSF (635 ha), and in two Krosno and Toruń RDSFs (over 200 hectares). In the remaining RDSFs, ash decline was observed in an area of less than 160 hectares.

The alder dieback in Poland recorded since the beginning of the 21st century has, like in the case of ash dieback, occurred for the last ten years with varying intensity over an area exceeding three thousand hectares. The largest damage was reported in 2006 on more than 5.8 thousand hectares, and in 2010 on a total of three thousand hectares. The dieback of alder in stands was in 2010 less intense than in the past 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 the stands with alder in the Krosno, Lublin, Olsztyn and Wrocław RDSFs covering an area of 200 to 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 of fine roots, root collar, base of the trunk or the whole tree trunk. The disease symptoms include dark discoloration on the bark and often exudation of sap. Additionally, the leaves of the infested tree become abnormally small, sparce and yellowish. The tree suffers from the disease (phytophthorosis) for many years before it dies.

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 of older age classes. The area of stands damaged by deer browsing or bark stripping increased by 14 thousand hectares in comparison with 2009.

Damage which did not exceed 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 so damaged forest stands amounted to 114.3 thousand hectares, and was higher by 7 thousand hectares, or by 39 per cent compared to 2009.

Damage of the order of 21–50 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 so damaged forest stands was lower by 5.1 thousand hectares (by 13 per cent) compared to 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 so damaged forest stands amounted to 14.7 thousand hectares, and was higher by 1.4 thousand hectares, or 11 per cent, compared to 2009.

The eight-year inventory of damage to forest plantations caused by deer shows that, after a slow but steady decline of the impact of deer, this trend was reversed in 2009 and 2010. An increase is observed in the area of damage to both young and older generations of forest.

Data on population dynamics of major damage-causing animals (deer) clearly show a steady upward trend in spite of a relatively higher harvest level than in 2009. In the 2009/2010 hunting season, the population of elk was estimated at 8387, red deer at 180 thousand, fallow deer at 23 thousand and 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 binding hunting moratorium imposed on this species in 2000.

3.3. Anthropogenic threats

3.3.1. Forest fires

There were 4 680 forest fires in 2010 (compared to 9 161 in 2009). The burnt area covered 2 126 hectares of forests, which is a 52 per cent decrease compared to the previous year. The largest number of fire events took place in the Mazowieckie Province (23 per cent of the total number), the lowest – in the Opolskie and Podlaskie Provinces (Fig. 37).

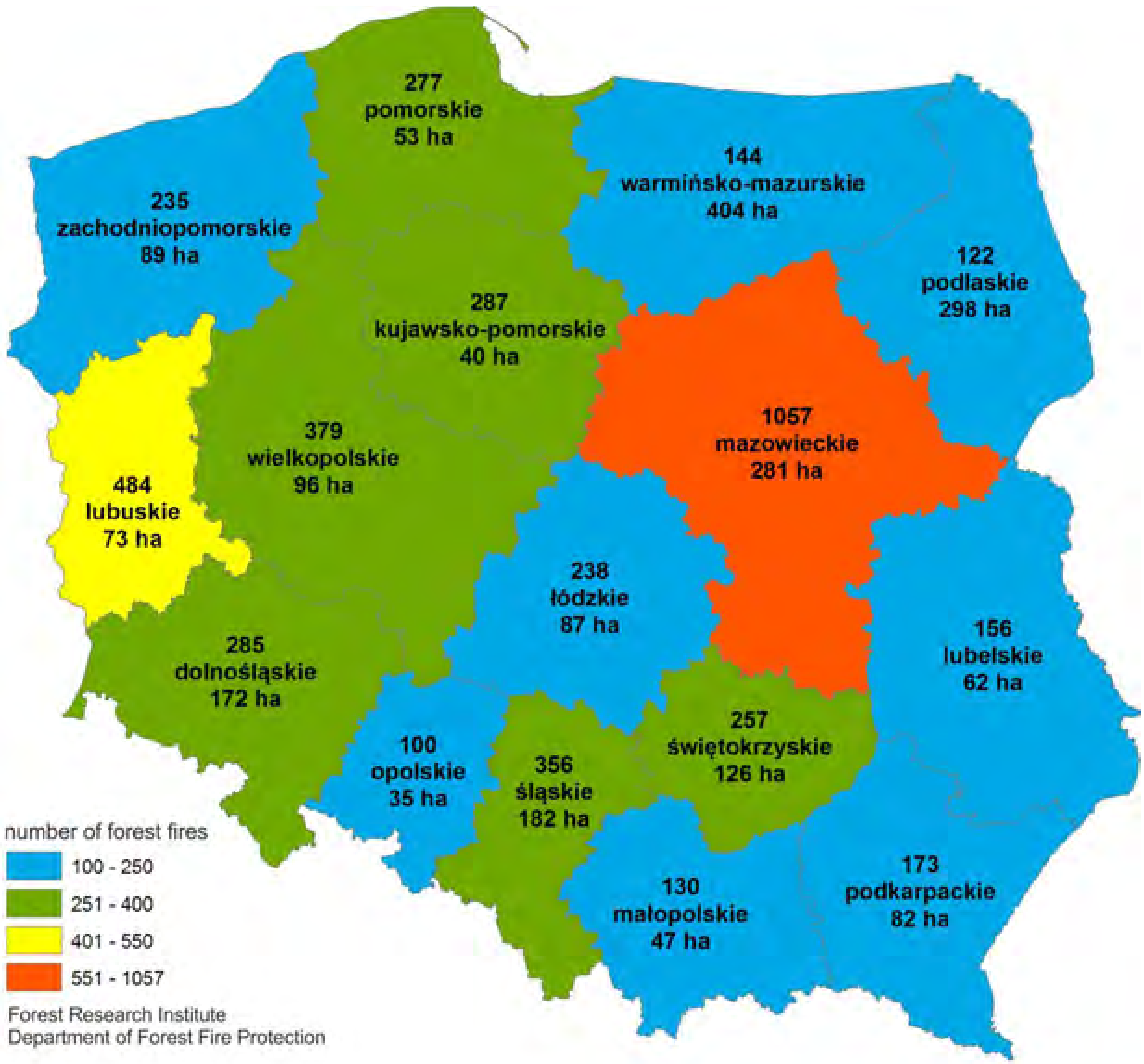


Fig. 37. Number of forest fires and the burnt area by Province in 2010

In 2010, the number of forest fires within the State Forests amounted to 1 740 (37 per cent of the total number of fires in Poland) covering 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 burnt area (108 hectares, or 28 per cent of all fire areas within the State Forests) was reported in the Katowice RDSF. There were no large fires (covering more than 10 hectares) in the territory of the State Forests in contrast with the rest of the country where 14 such fire events occurred. Eight fires were reported in the former military training grounds, with a total burnt area of 412 hectares (compared to 3 fires in 2009, covering 54 hectares).

The average area of a single fire in the forests under all ownership categories decreased by 0.03 hectare, compared to 2009, and was 0.45 hectare (the smallest average fire area of 0.32 hectare was recorded in 2008). These figures for the State Forests and for forests under other forms of ownership in 2010 were 0.22 hectare and 0.59 hectare respectively.

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) is still high. The corresponding figures for forests under all ownership categories were: 43 per cent fires caused by arson, 33 per cent caused by careless adults and 17 per cent of unknown causes.

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 number of recorded fires were September (1 per cent), May (3 per cent) and August (4 per cent).

Seasonality of forest fires is closely connected with weather conditions. The volume of atmospheric precipitation in the burning season of 2010 was different, both in terms of their occurrence over time, as well as their distribution across the country. In April, atmospheric precipitation occurred every day, and for six days the average rainfall exceeded 2.0 mm. The average daily rainfall in April (1.3 mm) significantly differed from the average daily rainfall in May (4.8 mm). In June, rainfall decreased to 2 mm per day, and for 18 days rainfall was less than 2 mm. In July, there was just one day without rainfall and 16 days with rainfall of less than 2 mm. At the end of the month, there were seven days with heavy rainfall. Heavy rainfall occurred every day throughout August and September.

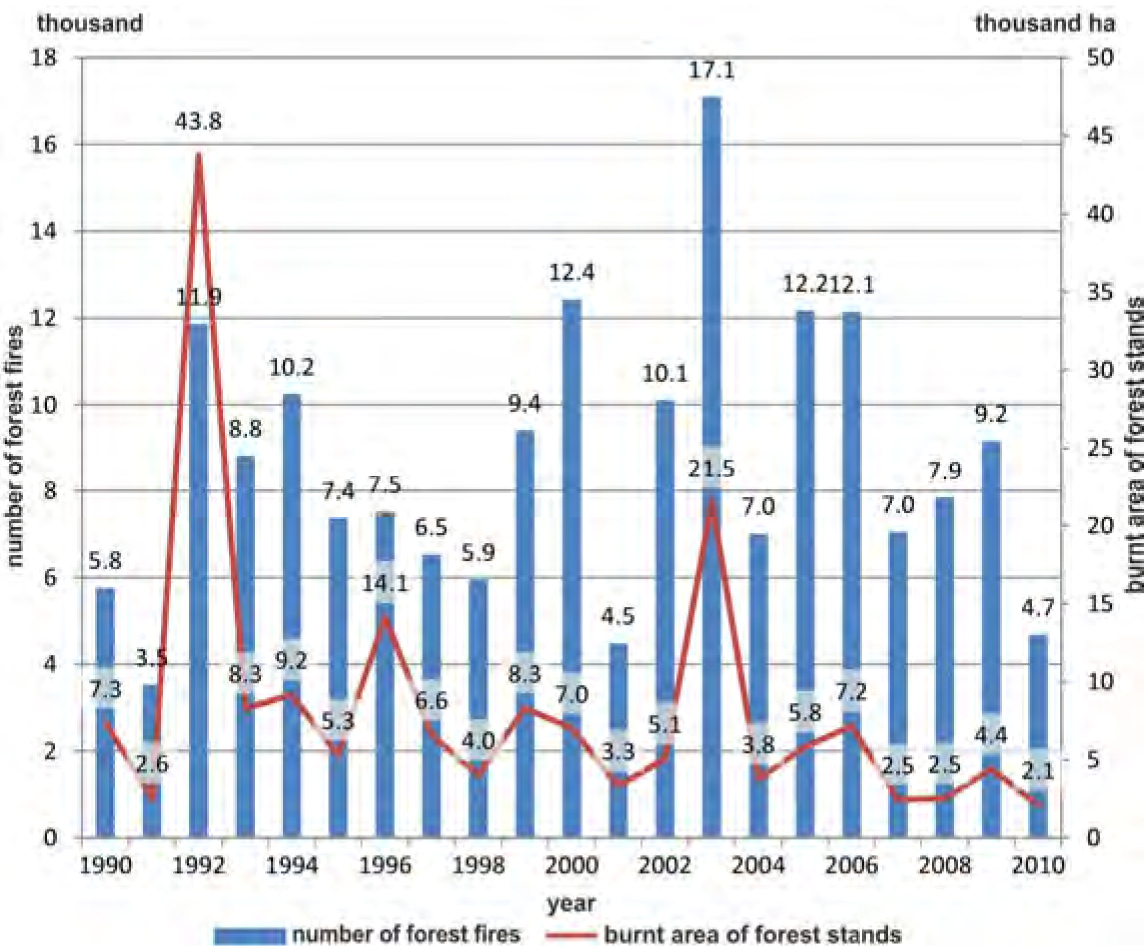


Fig. 38. The total number of forest fires and the burnt area of forests in Poland in 1990–2010

3.3.2. Air pollution

Global emissions of air pollutants have their origin in two main groups of sources: natural and anthropogenic. Their natural sources include, *inter alia*, volcanic eruptions, biomass distribution, lightning, or fires. Anthropogenic influences are manifested in the form of emissions from the combustion of solid and liquid fuels for energy production on macroeconomic and local scales, industrial production, transportation, refineries, energy and fuel transmission and other human activities, such as agriculture, waste dumping and incineration, or waste water treatment. Originating from direct sources of emissions, these atmospheric pollutants are referred to as primary. They undergo different chemical and photochemical transformations, generating 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.

In the air pollution circulation, forests play the role of both the releaser (source) and absorber of substances transported in air masses from the atmosphere, often from long distances. Extensive research on the mechanism of forest decline has shown a combined impact of a number of stress agents, occurring with varying intensity, depending on the region. The impact of individual components of industrial emissions can be individual or combined with other stress factors – which is more common – being frequently synergic. The forest decline caused by acid rains associated with the presence of sulphur and nitrogen oxides, ammonia and ozone in the atmosphere is a well known phenomenon. The acidifying substances in the form of gaseous pollutants or acid rains are damaging to the assimilation apparatus of trees, reducing the number of needle age classes, causing shoot decline, and consequently, a progressive reduction in the growth of forest stands. Their indirect effect resulting from the changes in soil chemistry and gradual soil acidification, causing a number of negative consequences in the rhizosphere, has also been proven. An increase in the concentration of e.g. nitrogen compounds released from the nitrogen-saturated forest ecosystems is a threat to 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 2008, the total emissions of sulphur oxide in Poland (Fig. 39) amounted to 999 thousand tonnes, nitrogen oxides calculated as NO_2 – to 831 thousand tonnes, and ammonia – to 285 thousand tonnes.

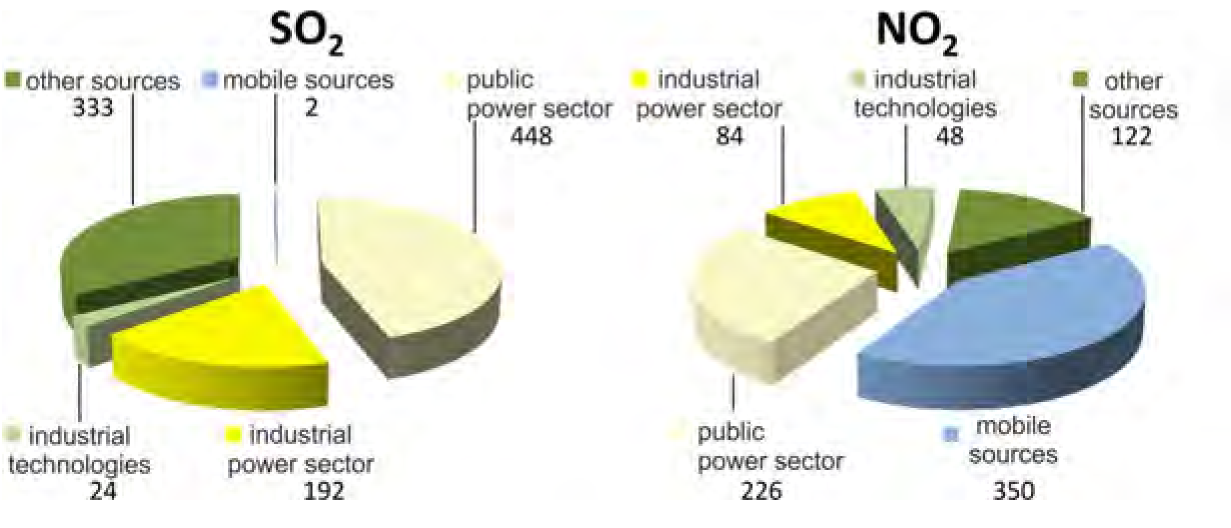


Fig. 39. Total emissions of sulphur dioxide and nitrogen oxides in 2008 by pollution source, in thousands tonnes (Central Statistical Office)

Since the late 1980s, a constant decrease of SO_2 emissions has been noted in Poland. Except for local incidents, they probably are not the main cause of the current deterioration of the health condition of Poland's forests. Emissions of nitrogen oxides in the past decade remained on a basically stable level, with fluctuations in successive years (Fig.

40). However in the era of road transport, being the main source of these emissions in the air, the future trend is difficult to predict. With the threat of habitat eutrophication, the inflow of nitrogen compounds into forest areas is still at the centre of research.

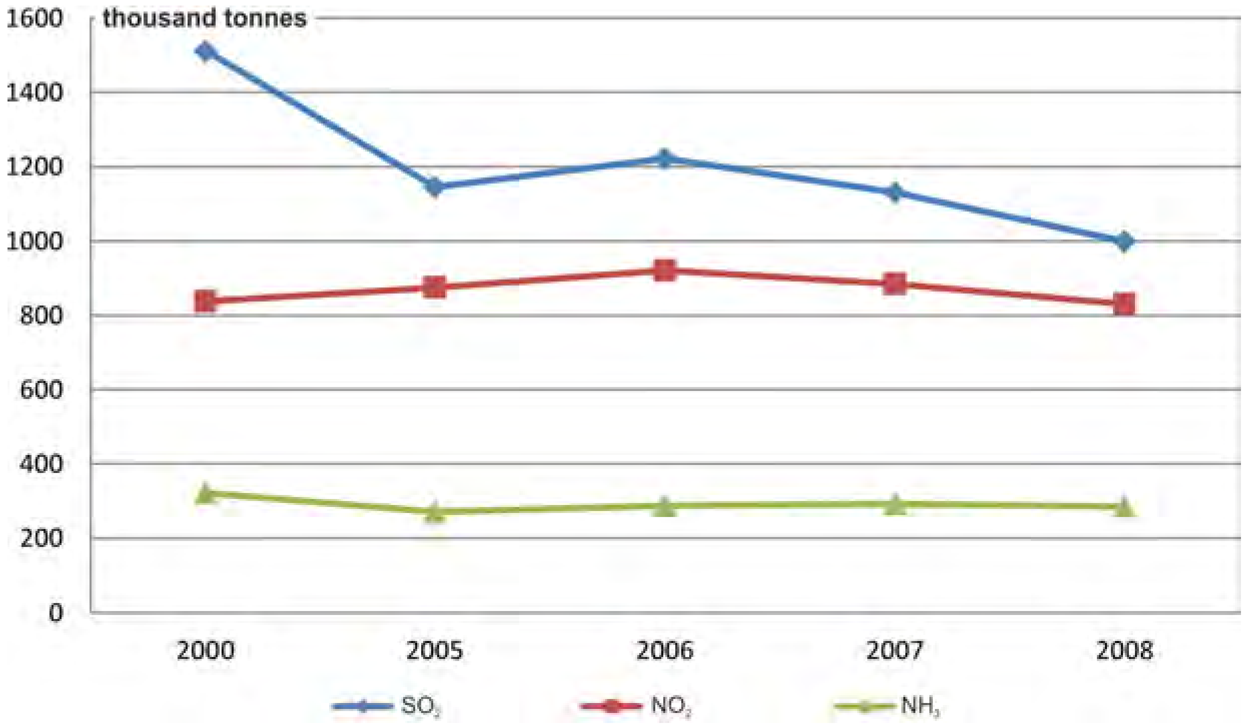


Fig. 40. Total emissions of SO_2, NO_2 and NH_3 in Poland in 2000–2008, in thousands tonnes (Central Statistical Office)

Forest monitoring provides information on the concentrations of major pollutants in the forest environment in different regions of Poland. Data collection on gaseous pollutants of sulphur and nitrogen oxides, ammonia and ozone is based on the annually averaged monthly measurements using the passive method. The scope of research includes the flow of elements in the atmospheric precipitation that is 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 located in pine forests in Forest Districts: Chojnów (Warszawa RDSF), Strzałowo (Olsztyn RDSF), Białowieża (Białystok RDSF), Krucz (Piła RDSF) and Zawadzkie (Katowice RDSF). Three POPs are located in spruce stands in Forest Districts: Suwałki (Białystok RDSF), Bielsko (Katowice RDSF) and Szklarska Poręba (Wrocław RDSF), two – in the oak stands in Forest Districts: Łąck (Łódź RDSF) and Krotoszyn (Poznań RDSF) and another two – in the beech stands in Forest Districts: Gdańsk (Gdańsk RDSF) and Bircza (Krosno RDSF).

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 to 149 $\mu g \cdot m^{-3} \cdot m\text{-}c^{-1}$ with the maximum value in April. With lower temperatures and poorer 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, in the Bielsko, Szklarska Poręba and Bircza Forest Districts (Fig. 41).

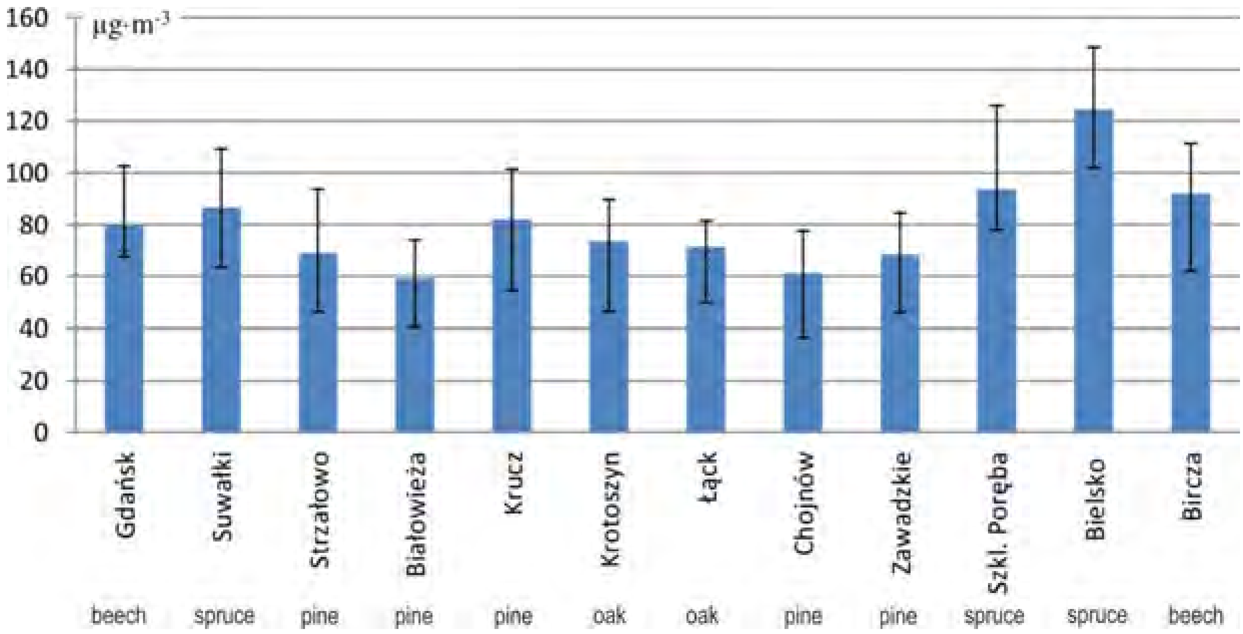


Fig. 41. Average ozone concentrations in the air measured on the POPs of Intensive Monitoring in 2010. Error bars represent the monthly minima and maxima

The average annual concentrations of pollutants on the analysed POPs oscillated between 1.1 and 1.6 µg·m^{-3} for SO_2, 2.4 and 9.0 µg·m^{-3} for NO_2 and 2.0 and 3.7 µg·m^{-3} for NH_3 (Fig. 42). A lower deposition of gaseous sulphur was recorded in northern and eastern Poland (in the Strzałowo, Gdańsk, Suwałki and Białowieża Forest Districts) in comparison with other regions. Higher concentrations occurred in southern and central Poland, especially in the Łąck, Szklarska Poręba, Krotoszyn, Bielsko and Zawadzkie Forest Districts. The seasonal variability of pollution was distinct; during the heating season, particularly in January, February, November and December, SO_2 and NO_2 concentrations were the highest (Fig. 43).

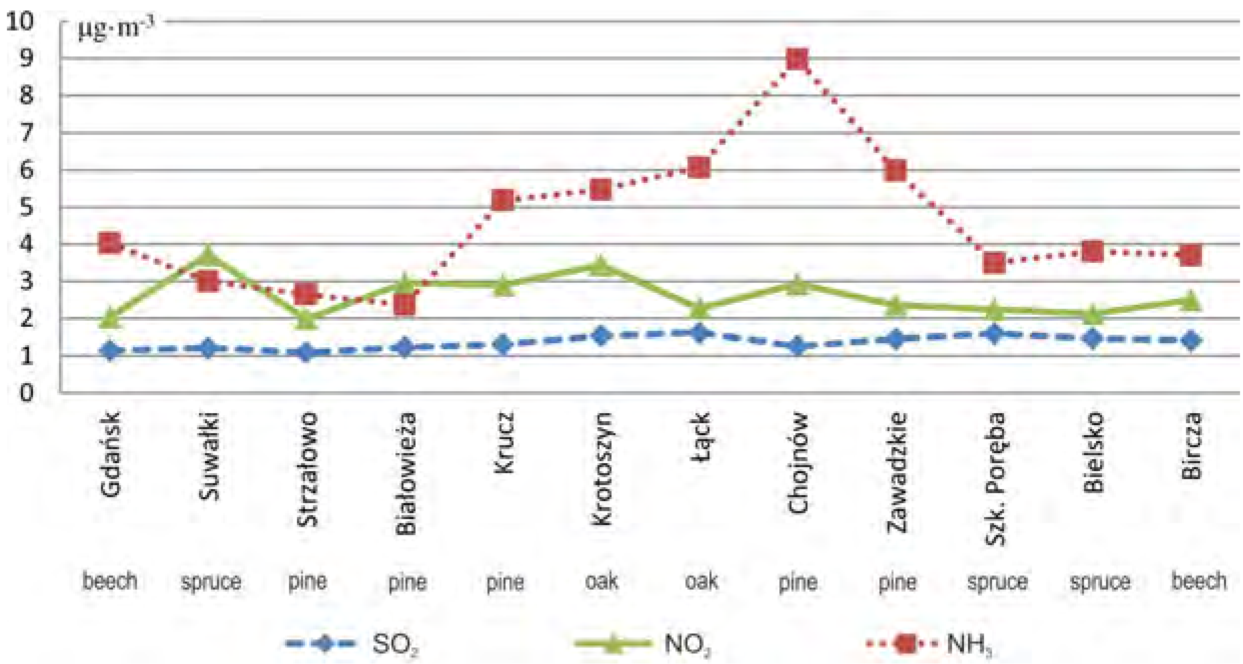


Fig. 42. Average values of concentrations of sulphur dioxides, ammonia, and nitrogen dioxide in the air measured on the POPs of Intensive Monitoring in 2010

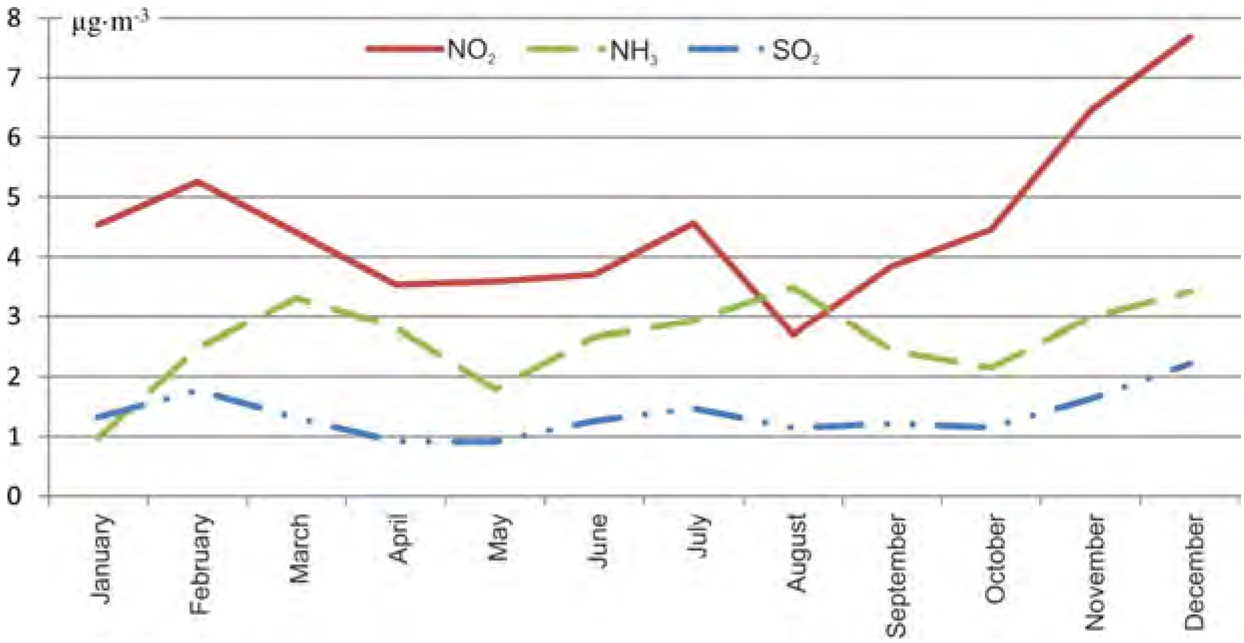


Fig. 43. Changes in the values of concentrations of sulphur dioxides, ammonia, and nitrogen dioxide in the air measured on the POPs of Intensive Monitoring in 2010

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). This can be attributed to a number of reasons, like number of inhabitants in the surrounding areas, large population concentrations and the associated increased road traffic.

The Ordinance of the Minister of the Environment of 3rd March 2008 on the level of selected pollutants in the atmosphere (Dz. U. 2008, No. 47, Item 281), having regard to the need for nature protection, sets the admissible level of sulphur dioxide at 20 µg·m-^{3} for the calendar year and winter season, and of nitrogen oxides at 30 µg·m^{-3} for the calendar year.

The average annual SO_2 concentrations and the average SO_2 concentrations for the winter season on the POPs of Intensive Monitoring did not exceed 2 µg·m^{-3}, so they were at least ten times lower than the admissible limit. Also, the average concentrations of NO_2 for 2010 were below levels permitted by the said Ordinance.

Precipitation (rainfall, drizzle, snow, mist, *etc*.) is the main route of transport by which the acidifying compounds in the atmosphere get to 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 deposition. However, the influx of these elements into the soil environment usually brings 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 Intensive Monitoring in 2010 had a pH below 5.5. Usually, precipitation acidity was the highest at the beginning of the year, in January and February. The most acidic precipitation occurred on the majority of POPs in February. The highest concentrations of undercrown deposition were recorded on the POPs located in the territory of the Szklarska Poręba and Bielsko Forest Districts. Low pH values of annual precipitation were recorded in pine stands on less fertile soils in the Chojnów, Krucz and Zawadzkie Forest Districts.

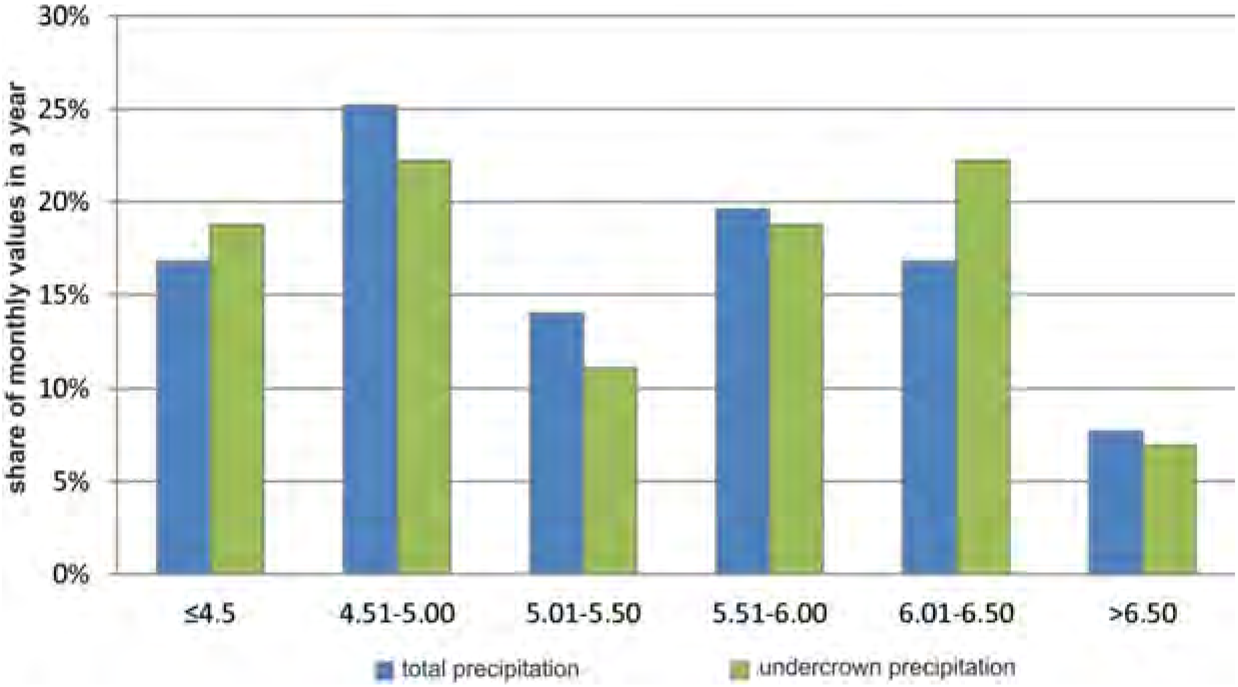


Fig. 44. Frequency of average monthly pH levels in the total and undercanopy precipitation within diverse value ranges on the POPs of Intensive Monitoring in 2010

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 is indicative of a large impact of the assimilatory apparatus on the chemistry of what pases the crowns. A similar situation (a high pH value of the summer half-year precipitation) was in the coniferous forests of the Suwałki, Strzałowo and Białowieża Forest Districts growing on relatively fertile soils, with a pH close to neutral.

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

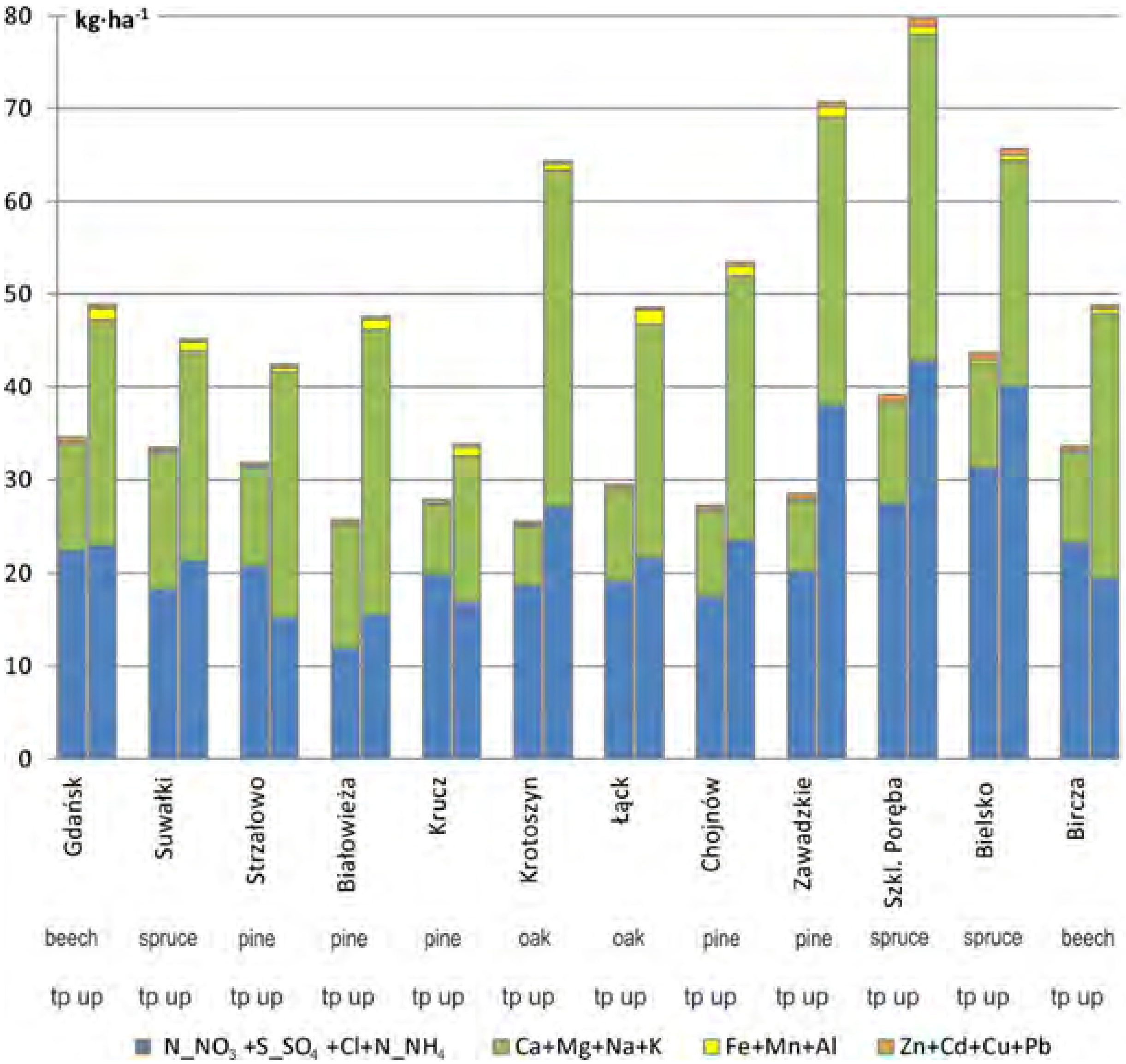


Fig. 45. Deposition of elements (kg·ha^{-1}) brought in total precipitation (tp) and undercrown precipitation (up) on the POPs of Intensive Monitoring in 2010

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 to 87 kg·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 located in the territory of Forest Districts: Szklarska Poręba (spruce), Zawadzkie (pine), Bielsko (spruce) and Krotoszyn (oak), while the lowest – in Krucz (pine) Forest District. In the case of beech POPs (Gdańsk and Bircza Forest Districts), where part of the deposit is, to a greater extent than in other forest stands, transported in the stemfall, the total deposit may be underestimated by at least 5-10 per cent.

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

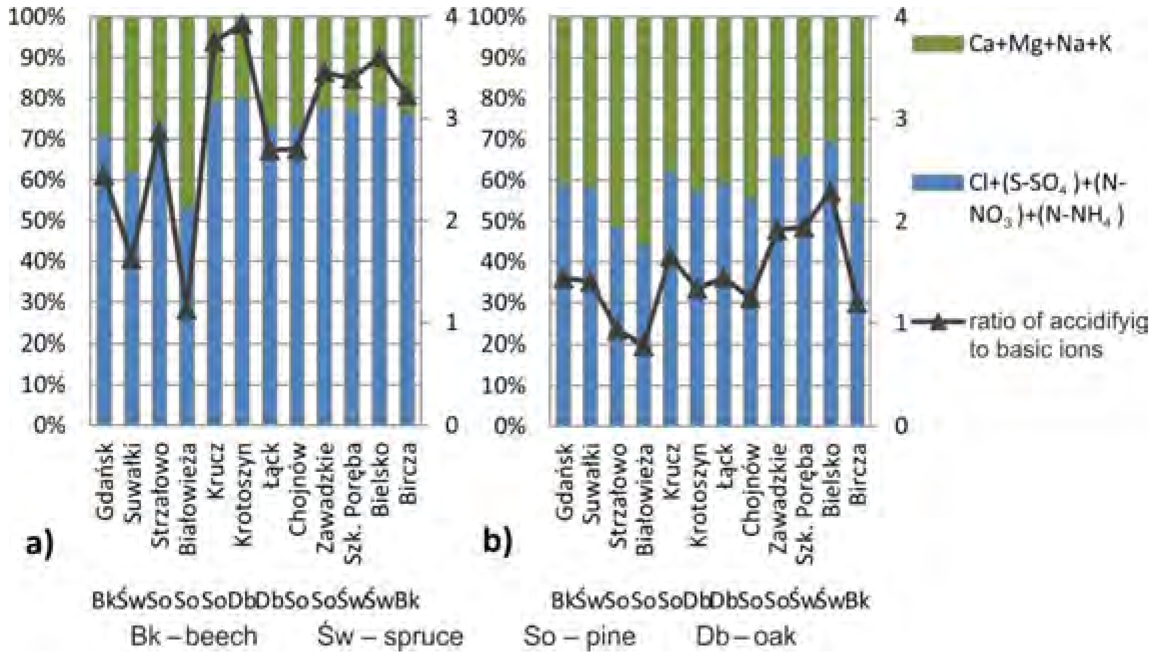


Fig. 46. Share of acidifying and basic ions in total precipitation (tp) and undercrown precipitation (up) on the POPs of Intensive Monitoring in 2010

Throughout the whole year 2010, acidifying ions represented nearly half to over three quarters of the total deposition of molar ions. Precipitation in open areas was characterized 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 tree crowns acted as a filter neutralizing, to some extent, 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 located in southern Poland in the Bielsko, Zawadzkie, Szklarska Poręba and Bircza Forest Districts.

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 soil under the stand canopy significantly increased, compared to the summer half-year in all the investigated stands. This phenomenon may be associated with the increased physiological activity of vegetation during the growing season, resulting in an intense ion exchange occurring in tree crowns and increased leaching of alkaline cations from the crown area in the summer months.

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

The data collected in 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 with the low buffering capacity and susceptible to acidification are exposed to high levels (compared to the country level) of ozone and sulphur oxides, high deposition of acidic ions and heavy metals, as well as precipitation with a lower pH value. High concentrations of nitrogen oxides in central Poland may become a potential 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 is confirmed by the studies on rainwater and soil solutions. The threats to the health condition of forests, resulting from air pollution, should be considered in relation to physiographic, climate and soil conditions, as well as to other stress factors determining or modifying the susceptibility of forest stands to damage.

3.4. Threats to forest sustainability

The impact of stress factors on forests with already reduced resistance of forest ecosystems (e.g. species composition not adjusted to habitat conditions and introduction of ecotypes of trees of foreign origin) may, in extreme cases, lead to their total decline. Such a situation occurred in 1980-1991 in the Sudeten Mountains where, due to the weakening of stands caused by industrial emissions, long-lasting draughts and 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. The decline affected all forests located higher than 800 metres above sea level. In order to protect the deforested areas from soil erosion and degradation, the State Forests carried out afforestation works often in parallel with control treatments against secondary pests. In the period 1981–1996, 14 thousand hectares of land was restocked.

The establishment of an institution for the conservation of endangered ecosystems in Poland was one of the effects of the ecological disaster in the Sudeten Mountains. 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. It was located in Miłków, at the foothills of the Karkonosze Mountains which, like the Jizera Mountains, were severely hit by the ecological disaster in the late 1970s and early 1980s.

The activity of the Kostrzyca FGB is focused on the conservation of the genetic diversity of forest plant communities. The 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 carries out many nationwide strategic programmes, including those dealing with the impact of biotic and abiotic factors, such as:

- The Programme for the Preservation of Forest Genetic Resources and Selective Breeding of Forest Tree Species for the Years 1991-2010, and its continuation in further years;
- The Programme for Progeny Testing of Selected Seed Stands, Plus Trees, Seed Orchards and Seedling Seed Orchards;
- The Programme for the Conservation and Restitution of Common Yew (*Taxus baccata* L.) in Poland;
- The Programme for the Restitution of Silver Fir in the Sudeten Mountains;
- The Programme for the *ex-situ* Conservation of the 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 continue, and the role of foresters is to take any possible actions to minimize their effects.

The development by the Katowice RDSF of a number of preventive measures to stop the process of forest decline in the Beskid Śląski and Beskid Żywiecki forests was one of such actions. In the past 30 years, work was carried out to reduce the proportion of spruce in the structure of stands. The share of spruce in the composition of stands in the Sucha, Jeleśnia and Ustroń Forest Districts was reduced by approx. 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 the strategy for the protection and management of the Beskidy forests which resulted in the conversion of nearly 3000 hectares of spruce stands. The costs of the programme implementation in 2003–2006 amounted to almost PLN 61 million.

In spite of the intensive preventive measures, an increased dieback of trees was observed in the Beskidy forests in the past four years leading to forest decline. Like in the case of the Sudeten Mountains, the cause of the phenomenon was attributed to a number of factors. For example, industrial emissions caused changes in forest soil chemistry unfavourable for tree growth – an increase in acidity (pH below 3) and aluminium content, a decrease in the level of calcium and magnesium. Adverse weather conditions, such as frost droughts in spring 2003, catastrophic wind storms in the years 2004 and 2007, high temperatures and deficiency of rainfall during the growing season 2006 had a significant impact on tree dieback. After the

1950s, an increase in the area of stands affected by *Armillaria* root-rot disease in the Beskidy Mountains was reported. The deteriorating health condition of the Beskidy stands favoured the appearance of secondary pests, 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 since private forest owners (with a significant share of forests in the region) are reluctant to carry out sanitation treatments at the required level.

The favourable weather conditions in the growing season 2009 have contributed to improvement in the health condition of the Beskidy forests and a reduction in the decline rate of spruce stands.

The occurrence of many stress factors is regarded as the cause of an increased decline of broadleaved trees observed in recent years.

The cyclic recurrences of oak decline processes observed since the 1970s have been attributed to extreme climate conditions, like the extremely high or low temperatures, long-lasting draughts, and changes in the groundwater level. Recent scientific reports point to the significant role of fungi of the genus *Phytophthora* in the decline of broadleaved stands. In 2010, the phenomenon of oak decline was the least intensive since 2000, as it covered 20.4 thousand hectares (Fig. 47).

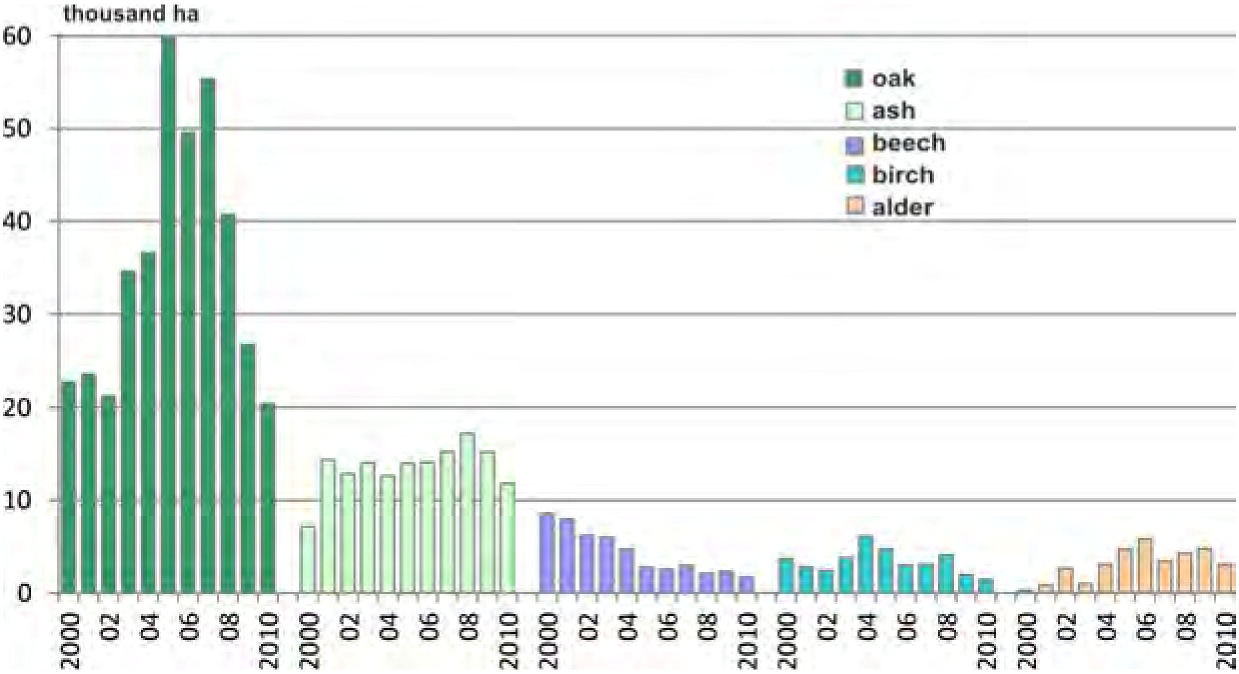


Fig. 47. Area of dieback of selected broadleaved tree species within the State Forests in the years 2000–2010

Ash decline has been observed in Poland for more than a decade. In 1999, the affected area amounted to about 2.3 thousand hectares, and since 2001, ash decline has each year been recorded in an area of 13–14 thousand hectares. The disease affects older stands, plantations and thickets, as well as seedlings in forest nurseries. The research conducted by the Institute of Forest Research shows 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 intensive tending of stands with large, well developed tree crowns (an element most strongly correlated with the health condition of the examined trees). In 2007, the area of dying ash stands for the first time exceeded 15 thousand hectares. 2008 saw further deterioration of the health condition of ash stands – symptoms of the disease were observed in an area of 17.2 thousand hectares. In 2009, the area of ash decline was similar to that in 2007. In 2010, the area of ash decline was the lowest since 2001 and amounted to 11.8 thousand hectares.

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 1.7 thousand hectares.

The decline of alder was for the first time reported in 1999 in an area of 31 thousand hectares. Currently, the area of threatened alder stands amounts to 3.0 thousand hectares. Most affected are the stands older than 20 years.

In total, the phenomenon of tree dieback in 2010 was observed on 40.4 thousand hectares, a decrease by about 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, the integration of Forest Monitoring with Large-Scale Forest Inventory was carried out. A network of Level I POPs, with grid density 16 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 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 over 20 years old 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, the assessment of the loss to assimilatory apparatus took place in 39 080 trees older than 20 years in stands located on 1 954 Level I POPs (20 trees per plot).

Of the trees subjected to assessment, 21.0 per cent showed no defoliation (defoliation class 0 – 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).

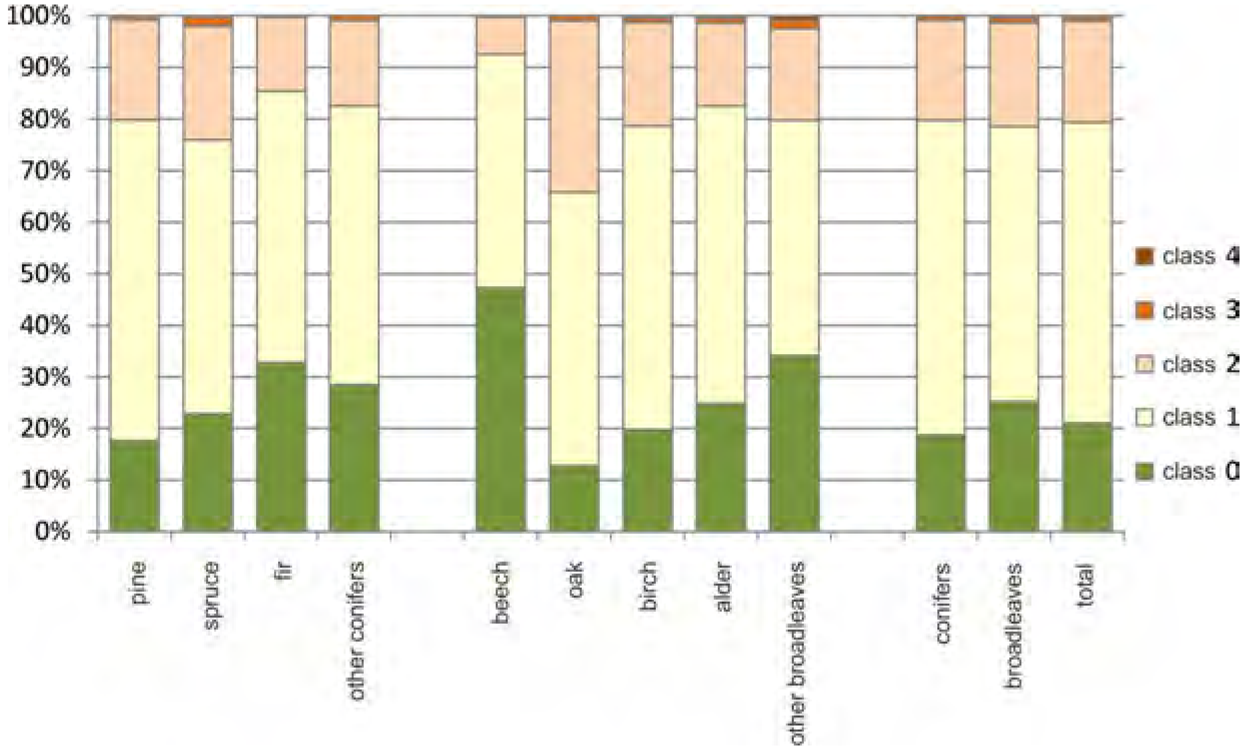


Fig. 48. Share of monitored tree species in defoliation classes on Level I POPs (Forest Monitoring) in 2010 – stands aged 20 + under all forms of ownership (Forest Research Institute)

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

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

The share of healthy trees (defoliation class 0) in the stands managed by the State Forests was 21.3 per cent; the share of damaged trees (defoliation classes 2-4) – 19.3 per cent. Forests owned by individuals were characterized by 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 and equalled 20.5 per cent.

A comparison of the level of damage to forests in the territory of the Regional Directories of the State Forests shows that the healthiest stands were in the territory of the Szczecin RDSF (45.7 per cent of trees in class 0, and 8 per cent of trees in classes 2–4, average defoliation – 15.0 per cent). Also stands in the territory of the Zielona Góra and Krosno RDSFs demonstrated good health (above 32 per cent of healthy trees, 9.6 and 20.4 per cent of damaged trees, average defoliation – 19.5 per cent). Low defoliation levels of 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 turn, a large number of healthy trees (26.0 per cent, 24.1 per cent and 20.4 per cent), 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 were noted in the territory of the Cracow, Wrocław and Radom RDSFs. The most damaged stands were reported in the territory of the Gdańsk and Warszawa RDSFs (average defoliation level was 24.3 per cent and 24.6 per cent, share of healthy trees was 8.3 per cent and 2.1 per cent, share of damaged trees was 30.9 per cent and 28.5 per cent).

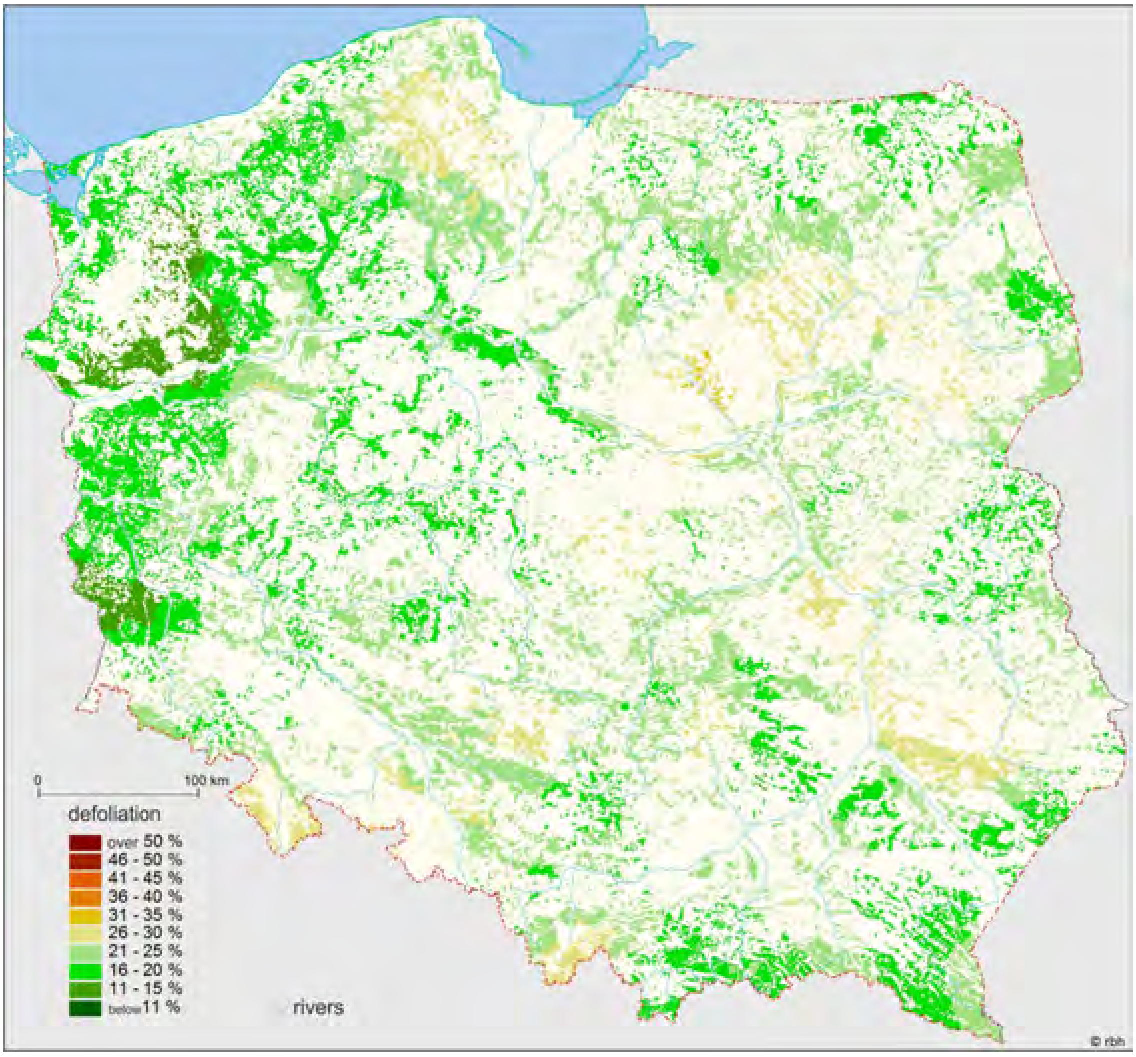


Fig. 49. The level of damage to forests on the basis of defoliation on Level I POPs (Forest Monitoring), assessed according to the 5-per cent defoliation intervals in 2010 (Forest Research Institute)

The health condition of forests in 2007-2009 did not undergo substantial changes. 2010 saw a slight deterioration of the health condition of forests. Average defoliation of species taken together in successive years was 19.8 per cent, 19.9 per cent, 19.8 per cent and 20.9 per cent respectively (Fig. 50); 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 respectively.

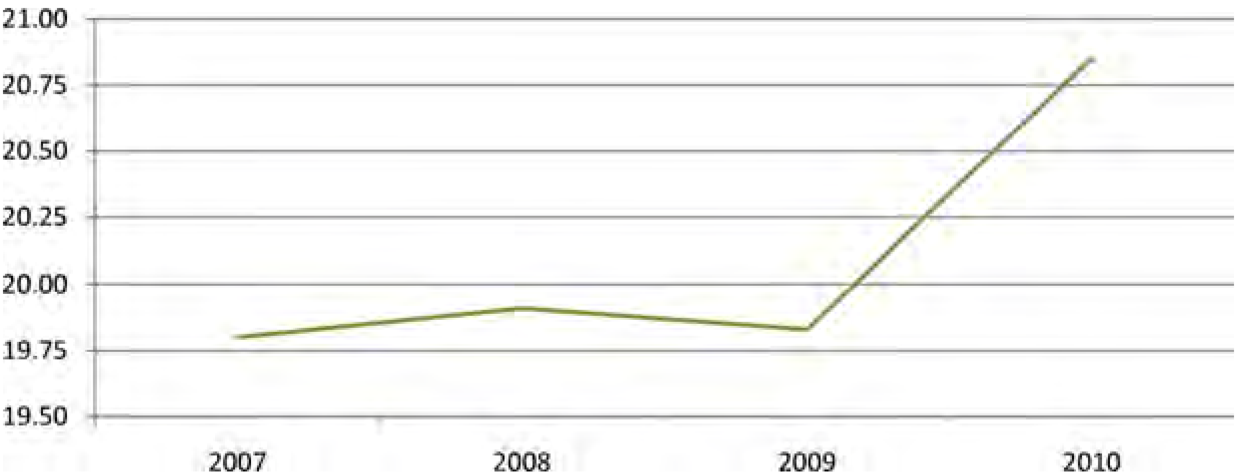


Fig. 50. The average percentage of defoliation of trees on Level I POPs (Forest Monitoring) in 2007-2010 – stands older than 20 years (Forest Research Institute)

The largest 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 – over 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 – 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 – 17 per cent). Alder demonstrated good health (over 24 per cent of healthy trees, below 18 per cent of damaged trees, average defoliation – below 20 per cent) (Fig. 51).

In the past four years the share of healthy beech trees increased from 41.7 per cent to 47.3 per cent, the share of damaged trees decreased from 13.7 per cent to 7.5 per cent, average defoliation decreased from 16.1 per cent to 14.5 per cent which indicates a gradual improvement of the health condition (Fig. 51).

The deterioration of health condition in the past four years was reported for alder and oak. The share of healthy trees decreased 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 increased from 11.9 per cent to 17.5 per cent and from 30.4 per cent to 34.2 per cent, average defoliation increased from 16.4 per cent to 20.0 per cent and from 23.0 per cent to 24.6 per cent (Fig. 51).

The period 2007-2009 saw the stabilization, while 2010 the deterioration of the health condition in pine. The health condition of spruce in 2007-2009 slightly deteriorated, while in 2010 it improved. The health condition of birch and fir was variable: in 2008 it deteriorated in comparison with 2007, in 2009 it improved, to again deteriorate in 2010 (Fig. 51).

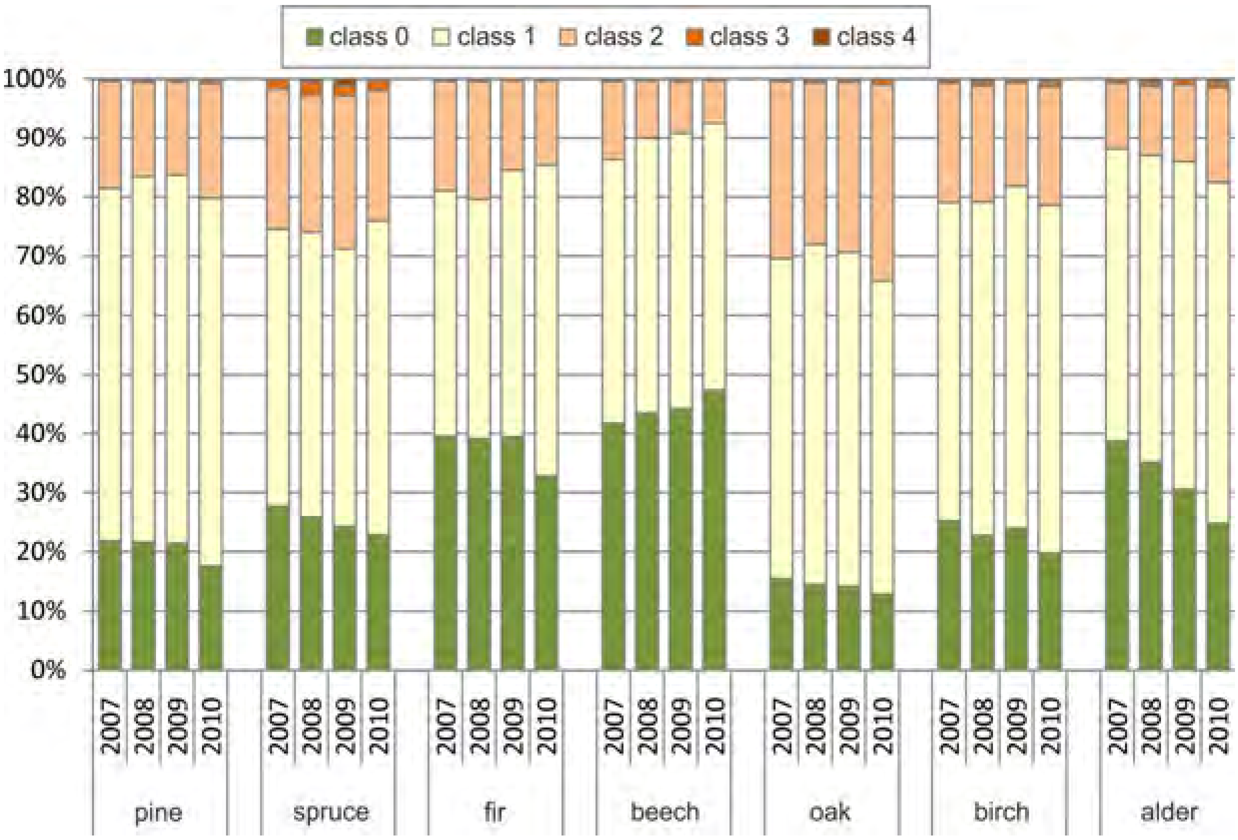


Fig. 51. Share of monitored tree species in defoliation classes on Level I POPs (Forest Monitoring) in 2007–2009, in stands older than 20 years (Forest Research Institute)

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). Also the stands administered by the Piła, Szczecinek and Poznań RDSFs demonstrate good health (10–18 per cent of damaged trees), while damaged stands (over 23 per cent) are reported in the territory of the Katowice, Radom and Warszawa RDSFs. The distribution of damage to forests in Natural-Forest Regions shows that the healthiest stands are in the Baltic Natural-Forest Region, healthy stands are in the Mazury-Podlasie and

Wielkopolska-Pomerania Natural-Forest Regions, while heavily damaged stands are in the Sudeten, Mazowsze-Podlasie, Carpathian and Silesian Natural-Forest Regions (Fig. 52).

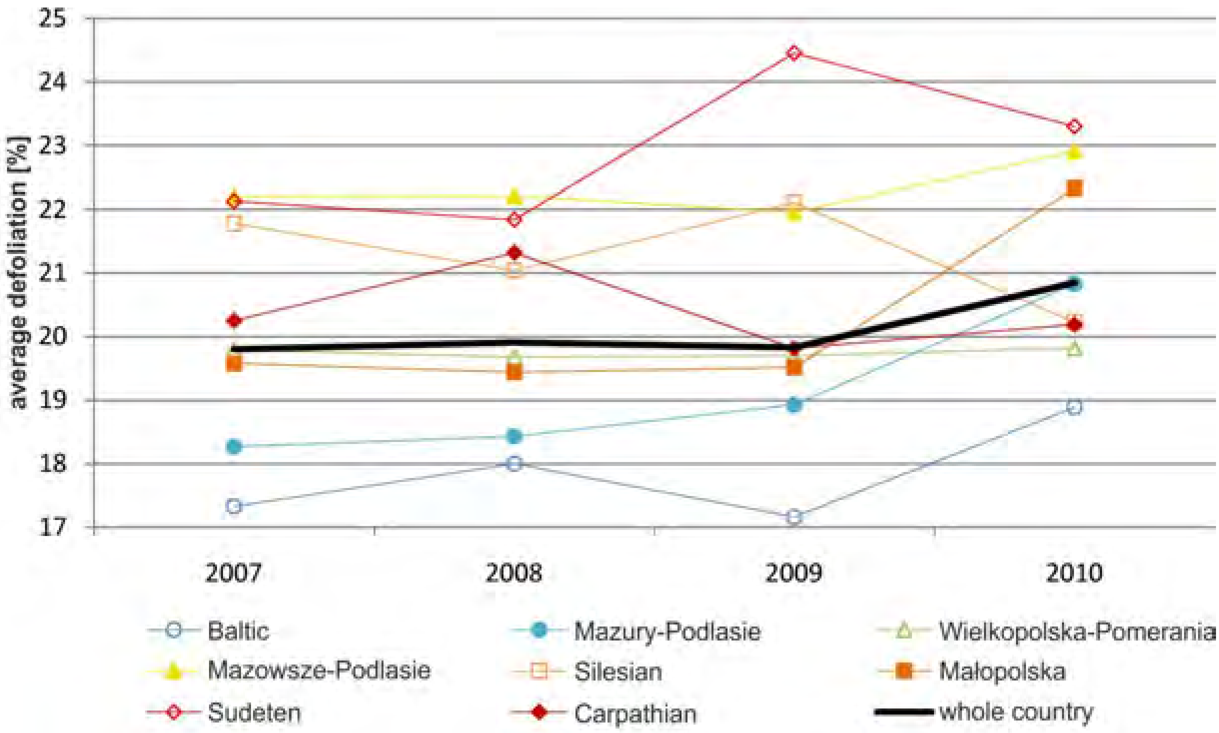


Fig. 52. Share of trees in defoliation classes 2–4 on Level I POPs (Forest Monitoring) in the Natural-Forest Regions and in the country (on average) in 2007-2010 – stands aged 20+ (Forest Research Institute)

An improvement in the health condition of forest stands in the past four years (based on a comparison of the shares of damaged trees) was reported in the Toruń, Cracow, Krosno and Zielona Góra RDSFs, while their deterioration was observed in the territory of the Białystok, Lublin, Olsztyn and Łódź RDSFs. Damage to stands occurred to a variable degree (significant increases and decreases in subsequent years) in the Wrocław and Gdańsk RDSFs. With regard to the Natural-Forest Regions, an improvement of the health condition of forest stands was reported in the Baltic and the Poznań-Pomerania Natural-Forest Regions, their deterioration – in the Mazury-Podlasie, Małopolska and Sudeten Natural-Forest Regions (Fig. 52).

Weather conditions in the growing season 2010 were favourable in most regions of the country. The average total rainfall for the country calculated on the basis of 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, causing floods in many regions of the country.

A comparison of the level of damage to forests in Poland and in other European countries is based on the report *Forest Condition in Europe – 2011. Technical Report of ICP Forests* (UNECE, Hamburg 2011).

A comparison of the levels of damage to forests in European countries in 2010, arranged in the order of increasing share of trees in defoliation classes 2-4 (all species taken together), ranks Poland among the countries with a moderate share of damage equalling 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 (below 10 per cent of trees in defoliation classes 2-4).

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

The last 20 years, particularly in the past decade, have seen changes in the importance of the major forest tree species. Today, the main trend setting the new direction in forest management is to obtain stable forest communities best adjusted to habitat conditions and with a high ability to adapt to changing environmental conditions associated with anthropopressure and climate change. The significance and share of broadleaved species in Polish forests has considerably increased. Also the area of stands established by way of 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 constantly reduced, in favour of the increasing role of complex felling. The periods of forest regeneration are frequently extended, allowing the development of forest communities with different age, species and spatial structures, more resistant to the impact of damage-causing factors.

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

The genetic erosion of forest genetic resources is not monitored in Poland. Environmental monitoring carried out by the Chief Inspectorate for Environmental Protection (CIEP) in the framework of National Environmental Monitoring applies to selected natural habitats, plants and animals. In 2006-2008, 1580 natural habitats, including forests, were covered with monitoring, which allowed the identification of threats and determination of protective measures. (Table 26). Woody species are not on the list of monitored plant species (including 16 species from 122 habitats) (CIEP, 2010). 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, carry out forest monitoring, which is a system of continuous collection of information on the environment and the health status of forest stands. It is an integral part of National Environmental Monitoring, and is also harmonized with the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP-Forest). The purpose of such monitoring is to identify the geographical distribution of damage to stands, analyze 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 to develop short-term forest health condition forecasts.

Forest monitoring in Poland has been carried out every year since 1989. In 2006, it underwent significant changes. The POPs of Forest Monitoring were integrated with the observation plots of the Large-Scale Inventory of the forest condition. The integration of these plots improved the systems of collecting information about the forest and made these systems more compatible.

The Forest Monitoring System is based on a network of POPs including Level I POPs, with grid density 8 x 8 km, and Level II POPs, representing pine, spruce, oak and beech stands. The system lacks monitoring genetic erosion of selected forest tree species.

The State Forests initiate indirect actions to limit the negative effects of genetic erosion of species. One such action is to identify and protect populations within species in order to preserve their breeding and genetic value, as well as to restore the populations in danger of extinction. Population diversity is protected mainly by adopting legal regulations governing the transfer of the FRM, forbidding introduction of the FRM of other mother populations.

The restoration of endangered populations involves actions consisting in the reproduction of the groups of trees and individual trees which have survived and the establishment of gene conservation plantations with an appropriate size and species composition. At the species level, the main activities concentrate on *Taxus baccata* L. and *Sorbus torminalis* (L.) Crantz. At the population level, they concern 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 activities to be undertaken should include permanent monitoring involving cyclical genetic studies on within-species genetic erosion, especially of protected forest tree species and selected populations influenced by genetic drift.

6. Needs and priorities for the future

Carrying out comprehensive studies on genetic diversity of forest tree species and monitoring changes in the genetic diversity within species and between existing populations in

Poland are the priority tasks of the Ministry of the Environment, the State Forests, the Forest Research Institute and other units conducting studies on forest genetic resources. These tasks are included in the Programme for the Preservation of Forest Genetic Resources and Selective Breeding of Trees in Poland for the Years 2011-2035. However, the Programme covers only the forest genetic resources under the management of 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. Therefore, to properly protect individual trees species and their populations it is necessary to acquire knowledge of the initial state of their genetic diversity. Understanding the need for comprehensive and standardized genetic studies on the variability of forest trees in Poland, the Scientific Consortium *Genetics of Forest Trees – DENDROGEN* was established in 2010, with its seat at the Institute of Dendrology, PAS in Kórnik, representing major scientific bodies involved in carrying out genetic studies on 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 Cracow, the Warsaw University of Life Sciences-SGGW, the Adam Mickiewicz University in Poznań. The Kostrzyca Forest Gene Bank also joined the Consortium as a non-associate member. The Consortium associates several dozens researchers involved in forest tree genetics. 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, as well as qualitative and productive abilities of forest stands.

It is extremely important, in the context of better understanding the significance of forest genetic resources, to provide a 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 under the sustainable and multifunctional forest management. At present, education programmes are implemented in all territorial units of the State Forests, as well as in national and landscape parks, focusing, *inter alia*, on the role and significance of genetic diversity in the development and stabilization of forest ecosystems and on the possibilities of pursuing sustainable development and conservative use of forest ecosystems.

Environmental education is also carried out by scientific institutions such as the University of Warsaw (the Warsaw Botanical Garden), the Forest Research Institute, the Centre for Nature-Forest Education in Rogów (the Warsaw University of Life Sciences – SGGW), the Institute of Dendrology (the Kórnik Arboretum), the University of Wrocław (the Botanical Garden in Wrocław and the Arboretum in Wojsławice) and many others (RoSL, 2011).

Raising the level of ecological awareness and generating a desirable approach to forests and their resources, as well as developing a many-sided and rational cooperation with nature conservation organizations and environmental associations are equally important.

The Promotional Forest Complexes (PFCs) whose principles of functioning are set in the Forest Act (1991) and the State Policy on Forests (1997) may also be regarded as areas of particular scientific significance wherein interdisciplinary studies are carried out (Fig. 53). The research results enable improvement of forest management methods and the setting of admissible limits of economic interference into forest ecosystems. The PFCs are, moreover, a pleasant alternative to the crowded national parks where tourist traffic is regulated by rigorous, strict rules.

The promotion of ecological forest management pursued by the State Forests made it possible to locate 19 PFCs in each of the 17 RDSFs. Their total area is nearly 1 million hectares of which 979 thousand hectares covers nearly 14 per cent of the territory of State Forests.

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

Issues related to the genetic diversity of Polish forests are taken up by the Kostrzyca FGB as an element of environmental education. The courses are designed for professionals dealing with forests and forestry, forest management staff, natural history students, youth and children. Annually 3140 people participate in these specialist courses (Kostrzyca FGB data for 2006-2010).

6.2. The level of public ecological awareness

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

6.2.1. Harm to forests

Frequent incidents of unlawful logging and theft of timber, illegal use of forest products, damage and poaching still take place in Poland's forests under all forms of ownership. About 55 thousand such cases are reported annually in the forests managed by the State Forests, and the value of related financial losses is estimated at about PLN 6 million (GDSF, 2011).

6.2.2. Leaving litter in forests

The Forest Service is continually patrolling forests and chasing people leaving litter. In spite of these actions, the cleaning costs incurred by the State Forests amount to about PLN 11 million per annum.

6.3. The need for legal regulations governing the effective protection of forest genetic resources

There is an urgent need for legal regulations governing 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, not only in the State Forests. These regulations should also be included in the forthcoming Forest Strategy and the National Forest Programme.

CHAPTER 2: THE STATE OF *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. Initially, it was aimed primarily at the protection and conservation of valuable natural objects in the form of individual trees or nature reserves (usually to protect populations of forest trees) and establishment of national parks. National parks are created to preserve biodiversity, resources, objects and elements of inanimate nature and landscape values, and to restore the proper state of resources and elements of nature. Moreover, their aim is to rehabilitate the degraded natural environment, habitats of plants, animals and fungi.

National parks, currently numbering 23 and covering an area of 314 474 thousand hectares, constitute 1 per cent of the country's land area (Fig. 54). The total area of nature reserves covers 194 992 hectares, of which 54 059 hectares enjoy the status of a strict reserve (Table 28).

Conservation of genetic resources of forest trees in national parks is included in the protection plan developed for parks or in their protection tasks. Forest ecosystems are placed under strict, active and landscape protection. Areas with a high degree of naturalness of vegetation cover are embraced by strict protection. The most important goal is to protect the processes involved in the functioning of natural and semi-natural ecosystems. Active protection is aimed at restoring a more near-natural character of such ecosystems through the introduction of tree species suitable for a given habitat (reconstruction). Landscape protection is to maintain the characteristics of the landscape. Collecting seeds is allowed from the trees of native origin, growing in parks. Seeds are collected from individual trees at an age prescribed for a given species, taking into account their quality and health characteristics indicative of their adaptation to the local conditions (Ministry of the Environment, 2011).

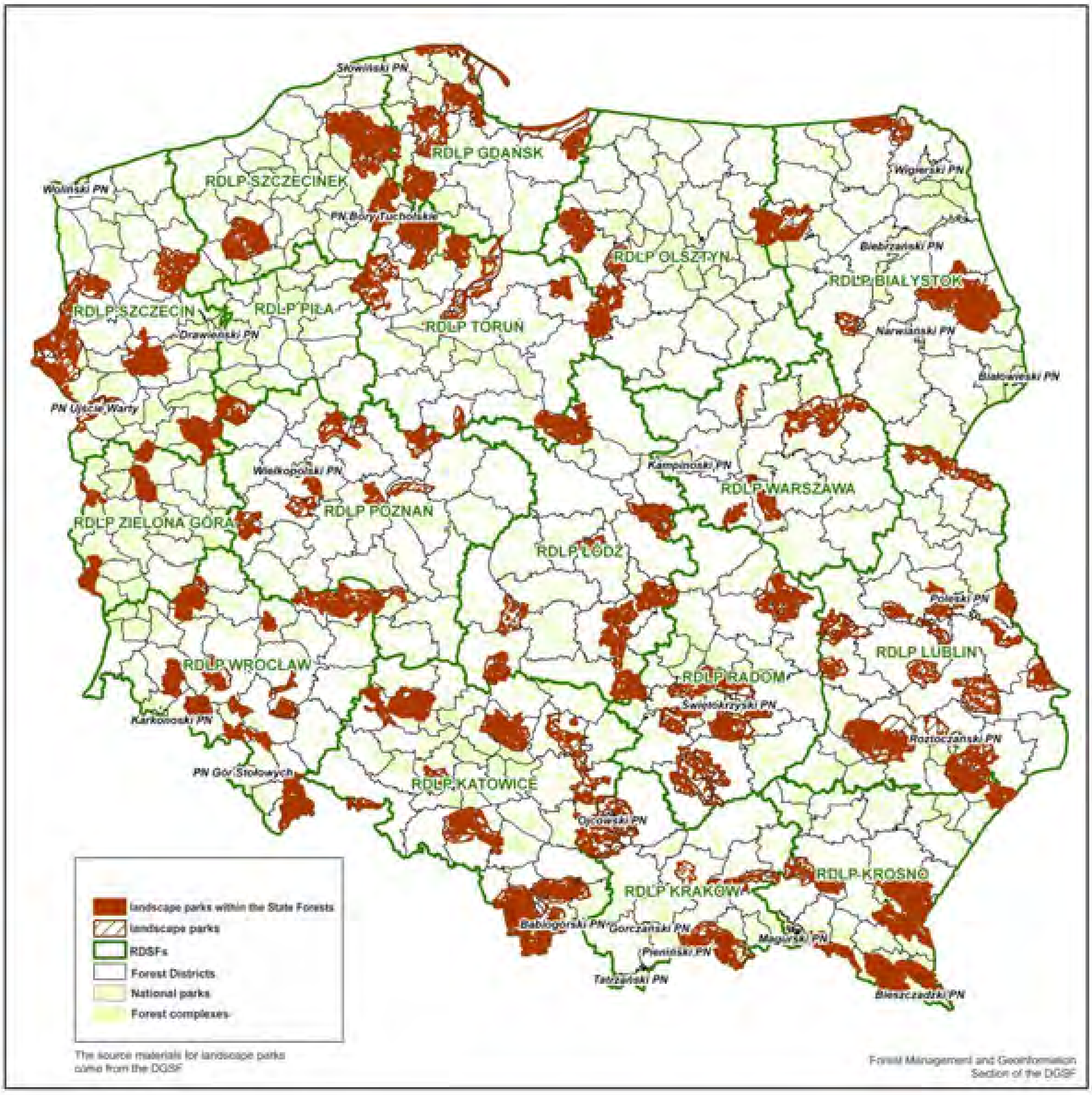


Fig. 54. National and landscape parks in Poland (GDSF)

According to the Central Statistical Office 2010 data, 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);
b) 121 landscape parks with an area of 2607.5 thousand hectares, including 1307.8 thousand hectares of forest area (50.2 per cent);
c) 386 areas of protected landscape totalling 7075.5 thousand hectares including 2227.9 thousand hectares of forests.

The Bartek Oak, the Zagnańsk Forest District, photo by K. Murat

The total area of national and landscape parks and 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). In the case of forest area, this increase was even greater, from 5.5 per cent to 40.9 per cent, respectively.

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

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 the biological diversity in Europe. All member states are obligated to establish special protection areas to be included in the Natura 2000 network. Two EU directives, the Birds Directive and the Habitats Directive are the legal basis for the implementation of the Natura 2000 programme. Both were incorporated into the Polish legislation by the Act on Nature Protection of 16th April 2004.

The Natura 2000 network consists of two types of protection areas (Fig. 55):

- Special Protection Areas (SPAs) designated 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 5571 thousand and 3792 thousand hectares respectively, were established (General Directorate of Nature Protection). These areas cover nearly 20 per cent of the country's land area.

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

Fragments of natural forests (http://pl.wikipedia.org/wiki/Puszcza) are preserved in Poland mainly in the Białowieża Primeval Forest (Białowieża National Park) (http://pl.wikipedia.org/wiki/Bia%C5%82owieski) and are unique in Europe.

1.2. Biological diversity of the Białowieża Primeval Forest

The Białowieża Primeval Forest is one of the largest tracts of forest in the Central European Plain with stands representing all types of lowland forest, typical of the boreal-nemoral zone. It is a mixture of broadleaved forests shedding leaves in winter and evergreen coniferous forests. Their phytosociological and ecological diversity corresponds to the habitat diversity, typical of the 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 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 values.

The Białowieża Primeval Forest has a high degree of naturalness, high density and vast area, as well as large tracks of virgin old-growth stands, with many trees classified as natural monuments. It owes its special position in European nature to the good condition of most of the components of the geographical environment, biological diversity, high degree of naturalness and variety of ecosystems, as well as its location in the transitional zone in Europe in terms of biogeographic, climate and hydrographic conditions. Many forest biocoenoses of the Białowieża Primeval Forest have characteristics of the 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 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 most optimal for its growth. It can often be found in nearly all types of forests, playing 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, large areas are occupied (beside the predominant oak) by birch, hornbeam and aspen, and sporadically by spruce and pine. 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. In some places they co-occur with bushy plant communities. The phytosociological studies documented the occurrence of 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. They 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 a significant share of over 100-year-old forest stands of natural origin, with 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. Also patches of non-forest habitats from Appendix I are identified. The total number of habitat types listed in Appendix I is 12 (Table 46).

Table 46. 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 an 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 and rush communities and helophilous mosses	157.87	0.25	C

9170 *Galio-Carpinetum* oak-hornbeam forests	39814.58	63.05	A
91D0 Bog woodlands	2746.92	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	0.1	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, especially of saproxylic insects. Many of them are rare in Europe. For some invertebrates (e.g. *Boros schneideri* beetle, goldstreifiger, false darkling beetle, *Pytho kolwensis*, *Rhysodes sulcatus*, Desmoulin's whorl snail) the Białowieża Primeval Forest is the only one or one of the few sites in Poland where the occurrence of these species was confirmed. Also species such as: the great capricorn beetle, hermit beetle, and the quite numerous *Cucujus haematodes* beetle are worth attention.

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 inhabit the Białowieża Primeval Forest (6 mammal species, 2 amphibian species, 1 species of reptiles, 4 fish species, 26 species of invertebrates).

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: the wolf and the lynx. Poland’s most important bison refuge is located in the Białowieża forests. The latest catalogue of the primeval forest fauna includes nearly 11 000 species (of which 40 per cent are native to Poland). Particularly rich is the fauna of insects with 9300 species. 12 species of amphibians and 7 species of reptiles are also worth attention.

Approximately 240 bird species have been identified in the Białowieża Primeval Forest. Nesting forest species prevail, but most of them migrate for the winter. There are few migratory birds and those associated with anthropogenic habitats. The Białowieża Primeval Forest also hosts a large fauna of diurnal birds of prey (15 species), 6 species of owl, 8 species of woodpeckers, 18 species of warblers. At least 45 species of birds listed in Appendix I to the Birds Directive, and 12 species of the Polish Red Data Book have been identified. During the breeding season, this 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 in the Białowieża Primeval Forest flora. According to the Natura 2000 Standard Data Form there are nearly 1020 species in the “Puszcza Białowieska” site (PLC20004). They represent half the vascular plant species of lowland Poland. Of these, 3 plant species toadflax, American pasqueflower, hairy agrimony are listed in Appendix II to the Habitats Directive. Locations of a dozen or so orchids and other endangered plant species have been identified. Moreover, the Białowieża Primeval Forest is home to 325 species of lichens, about 260 species of moss and 1,200 species of macrofungi.

According to A. W. Sokołowski (1995), the flora of vascular plants 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 the Polish flora are represented in the Białowieża forests. Also there are 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 that can be found in a single forest compartment is indicative of the richness of the forest flora.

The very rich European lowland flora and fauna, with a great variability of forest communities, is indicated by the wide range of mammalian species (bison, roe deer, red deer, elk, wild boar, wolf, lynx, badger, beaver and otter) living in the natural conditions of the Białowieża forests.

The Białowieża Primeval Forest is therefore a place of unique wildlife, largely due to its geographical location, forest condition and the protection of forest ecosystems.

The "Białowieża Primeval Forest" Promotional Forest Complex, along with other forms of nature protection within the Podlaskie Province, is part of the National System of Protected Areas (NSPA) connected *via* ecological corridors. According to art. 5 para 2 of the Act on Nature Conservation of 16th April 2004, the ecological corridor is an area allowing migration of plants, animals and fungi.

The protected areas closest to the Białowieża Primeval Forest are the Bug River Valley, the Narew River Valley, and the Knyszyn Primeval Forest located north of the Narew River Valley. The areas situated between the Białowieża Primeval Forest and the Knyszyn Primeval Forest play, in part, the role of an ecological corridor. The large share of forests in this region, shrub thickets and landscape afforestations, rivers, streams and wetlands, the valley of the Supraśl river and 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, serving as a link between the contiguous tracts of forests and extensive marshes is an excellent ecological corridor for animal migration. Also the area between the Białowieża Primeval Forest and the Bug River Valley plays the role of a potential ecological corridor.

Due to its unique natural values, the Białowieża Primeval Forest is protected in a special way, using various protection regimes depending on the legal forms of nature and landscape protection, such as the protected landscape areas, model promotional forest complexes, Natura 2000 sites, reserves, natural monuments, ecological areas and protected plant and animal species (Table 47). Additionally, in 2005, the whole area of the Białowieża Primeval Forest was declared a Biosphere Reserve. However, this has not so far been confirmed by law.

Table 47. 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 to protect refuges of rare birds [ha]	303.35	508.95	949.42	1 761.72
3.	Protection zones to protect refuges of lichens [ha]	–	198.26	56.08	254.34
4.	Natural monuments [no.]	515	82	552	1149
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	52 628.7
7.	Natura 2000 sites [ha]	12 594.47	17 860.50	19 195.00	49 649.97

The most valuable fragments of the Białowieża Primeval Forest are protected in 21 nature reserves, with a total area of 12055.38 hectares.

1.*3. Conservation of genetic diversity of forests*

1.3.1. *In situ* conservation of forest genetic resources

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

It is also necessary to establish formal and legal basis of using genetic resources of the forest tree populations located in protected areas, such as nature reserves or national parks in order to establish progeny plantations in their surrounding within the State Forests. On the one hand this will enable rational use of genetic variation in natural populations (according to one of the objectives of protection) and on the other will form a buffer zone around the protected areas. Genetic variation in this zone is comparable to that of the protected areas, therefore, it will constitute a more effective isolation of protected areas from the populations under intensive forest management.

A plus tree of European beech, Szczecinek Forest District, photo by K. Murat

The main focus of State Forests as concerns the protection and conservation of genetic resources is on forest tree species of economic importance. Many populations of these species show low stability, and even decline due to the intensified action of biotic factors (secondary to abiotic and anthropogenic ones)..

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

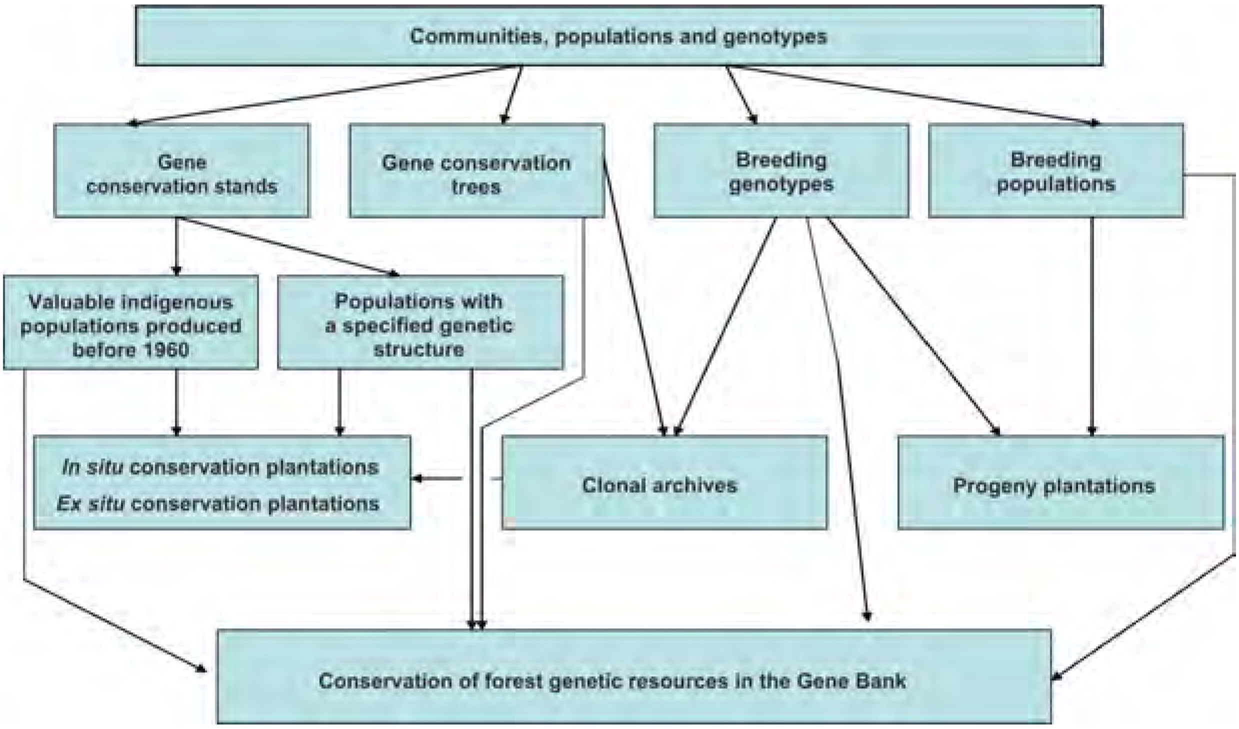


Fig 56. A flow-diagram of forest genetic resource conservation in the framework of the new Preservation Programme for 2011–2035

Seed orchard of European beech, the Warcino Forest District, photo by K. Murat

1.3.2. Implementation of the forest genetic resources conservation programme

The adopted biodiversity conservation strategy included in the Convention on Biological Diversity is related to four levels of nature organisation: species diversity, landscape diversity, ecosystem diversity and diversity of genetic resources. The State Forests implements 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 needs conservation:

- populations valuable for forestry due to their superior phenotypic traits (designed for the production of FRM in the category "*selected"*);
- individuals with valuable genotypes of economic importance for forestry, identified as a result of intentional selection (designed for the production of FRM in the category "*qualified"*);
- indigenous populations and individuals of coniferous and broadleaved species initiated before 1860.

Additionally, the Programme emphasizes the need to preserve genetic resources of other stands and trees valued for their adaptive ability (conservation stands and trees):

- populations and individuals with genotypes considered valuable on the basis of 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 main activities planned under this Programme include:

a) as regards legislation:

- actions aimed at establishing a law sanctioning the implementation of active protection of genetic diversity on land managed by the State Forests;
- amendment to the current law (the Nature Conservation Act and the Forest Act) aimed at adopting regulations permitting active protection measures for genetic diversity, also in the legally protected areas (national parks, nature reserves, Natura 2000 sites and others);

b) as regards fieldwork:

- management of conservation stands selected under the previous Programme, and the selection of new ones in this category;
- production of progeny generations from conservation stands (*in situ* conservation areas);
- establishment and management of *ex situ* conservation areas on the basis of the existing conservation stands and other conservation objects;
- establishment of progeny plantations of breeding populations;
- establishment and management of conservation and breeding seed orchards, seedling seed orchards and clonal archives (*ex situ* conservation of individual genotypes);
- collection of reproductive material (seeds, parts of plants, pollen) in gene conservation stands, breeding populations and individual genotypes for a long-term storage in the Kostrzyca FGB;
- selection and protection of species, populations and genotypes of indigenous woody vegetation (other than the main forest tree species) and development and implementation of restitution programmes in defined areas;
- complementary selection (based on genetic trials) of other populations of genotypes with specific genetic traits in order to increase the range of genetic diversity previously protected in gene conservation stands and breeding populations;

c) as regards projects implemented by the Kostrzyca FGB:

- collection of gene resources of categories II, III and IV in the National Register of Forest Basic Material from conservation objects;
- long-term storage of seeds, pollen and parts of plants, and extending the use of cryogenic methods for other species;
- genetic characterization (DNA, isozymes and other markers) of populations and genotypes selected for the conservation of forest genetic resources;
- monitoring changes in the genetic diversity of forests, with particular emphasis on areas under anthropogenic pressure;

– systematic collection of silvicultural and genetic information about the breeding and conservation populations.

The tasks for the organizational units of the State Forests in the field of conservation of genetic diversity focus primarily on the management of the already approved and selection of new objects valuable for conservation (populations and genotypes), as well as the establishment of conservation plantations (for populations) and clonal archives (for single genotypes) for selected objects.

Furthermore, it is advisable that conservation areas be established in the territory of the State Forests also from the conservation stands located in national parks. In this way it will be possible to include, in the future, these exceptionally valuable objects in the seed base of the State Forests.

Research needs

The findings of studies on genetic diversity of forest tree species should determine the long-term preservation of genetic diversity, particularly of the gene pool of valuable stands and genotypes. There is a need for:

a) Studies on genetic variation and genetic diversity based on quantitative traits and molecular analyses:
   - development and standardization of research methodology,
   - studies on the populations selected for the conservation of genetic resources (seed stands, gene conservation stands and plus trees) within the State Forests. Comparative studies and identification of valuable populations,
   - studies on the populations in areas embraced by legal protection (nature reserves, national parks, Natura 2000 sites), identification of valuable populations aimed at establishing gene conservation areas within the State Forests,
   - assessment of the level of autochthony of the population – identification of non-autochthonous populations,
   - revision of seed regionalization on the basis of studies of genetic variation and seed regionalization for individual tree species,
   - linking studies on genetic variation with the progeny testing programme,
   - linking the variation of quantitative traits with the variation at molecular level;

b) Studies on the changes in genetic diversity in the process of selection, breeding and long-term storage of seeds;

c) Assessment of the effects of forest management on genetic variation in forest trees in Poland;

d) Studies on mechanisms of preserving genetic diversity and assessment of the possibilities of using natural regeneration in the protection of genetic resources;

e) Specification of detailed criteria for the establishment and management of gene conservation plantations;

f) Assessment of the possibilities of species restitution based on an analysis of variation in genetic diversity;

g) Studies on hybridizing species, including the development of the methods of identifying and distinguishing species and their hybrids.

2. Support activities, obstacles and priorities for the future

2.1. Measures to improve the inventory and studies of forest genetic resources

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

1. The National Register of Forest Basic Material (NRFBM) maintained by the Forest Reproductive Material Office (FROM), a state administration body reporting to the Ministry of the Environment, includes forest trees species and categories of objects listed in the Act on Forest Reproductive Material;
2. The Register of Forest Basic Material of the State Forests (RFBMSF) managed by the State Forests IT Department which also includes data on tree species and other categories, such as stands, trees, conservation plantations and clonal archives not covered in 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 48. Seed base objects registered in the NRFBM (FROM, 2011)

	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
Administered by										
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, in Poland 33 628 registered natural monuments (some of them outside the forest areas) are subject to individual *in situ* conservation (Central Statistical Office, 2011). To monitor changes in the genetic diversity of forest tree species at European level, Poland has submitted data on a few hundred objects to the Bioversity International database. Of these 87 representing 17 species of trees evenly distributed across the country are included in EUFGIS (EUFORGEN) (SoEF, 2011; LBG, 2011). The examples of distribution of gene conservation units are shown in Fig. 57-63.

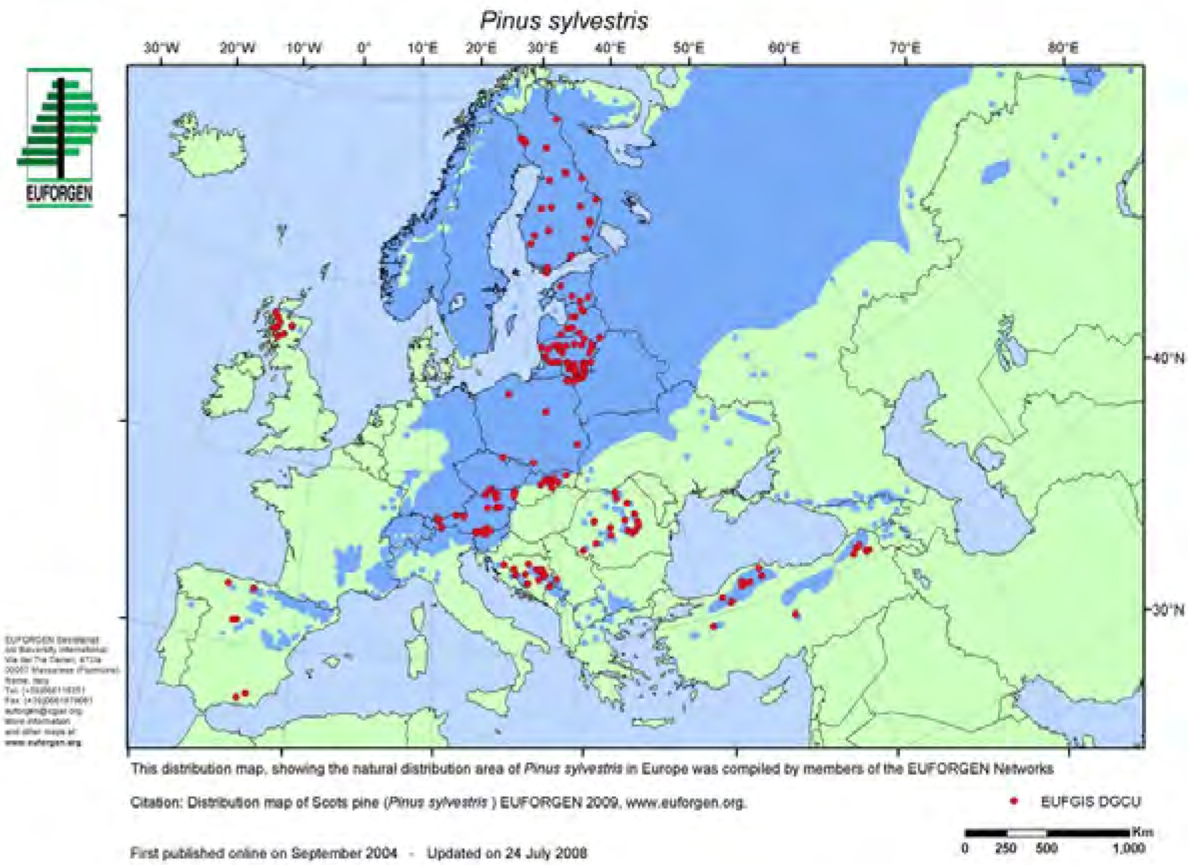


Fig. 57. Distribution of gene conservation units (GCUs) of *Pinus sylvestris* L. in Europe

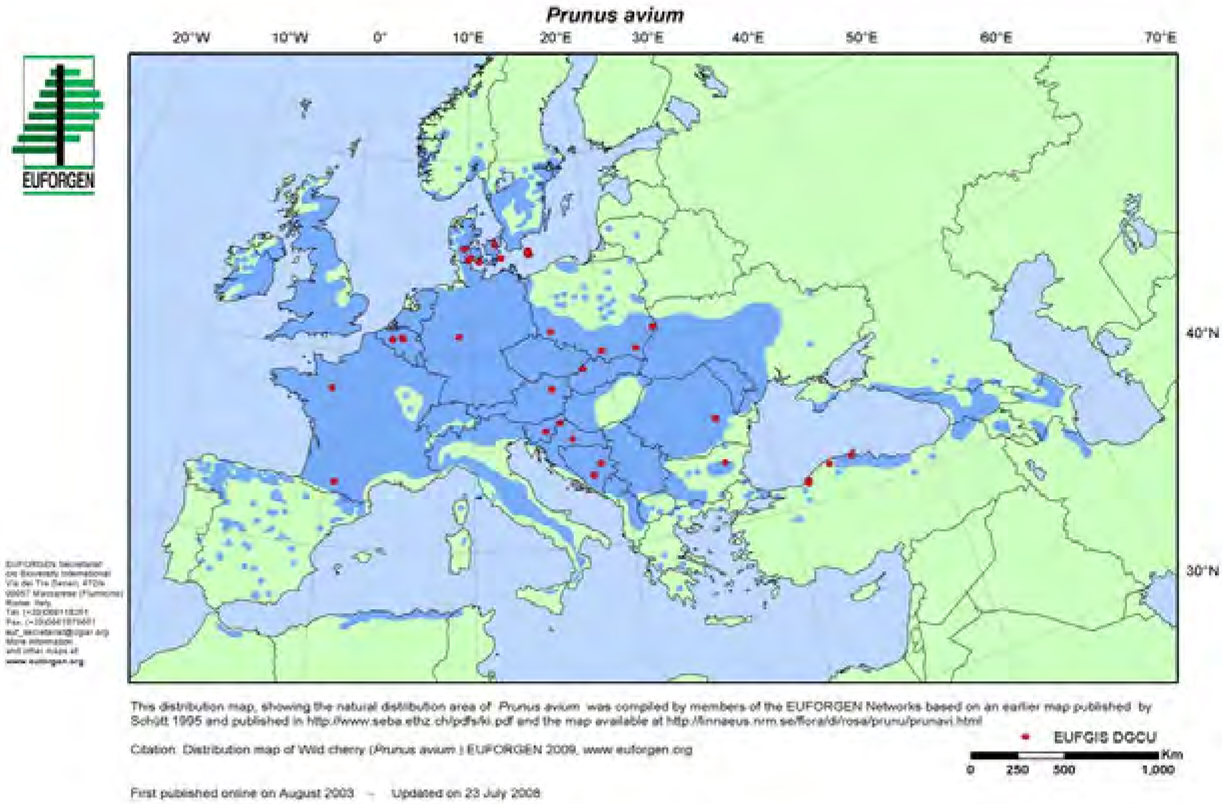


Fig. 58. Distribution of gene conservation units (GCUs) of *Prunus avium* in Europe

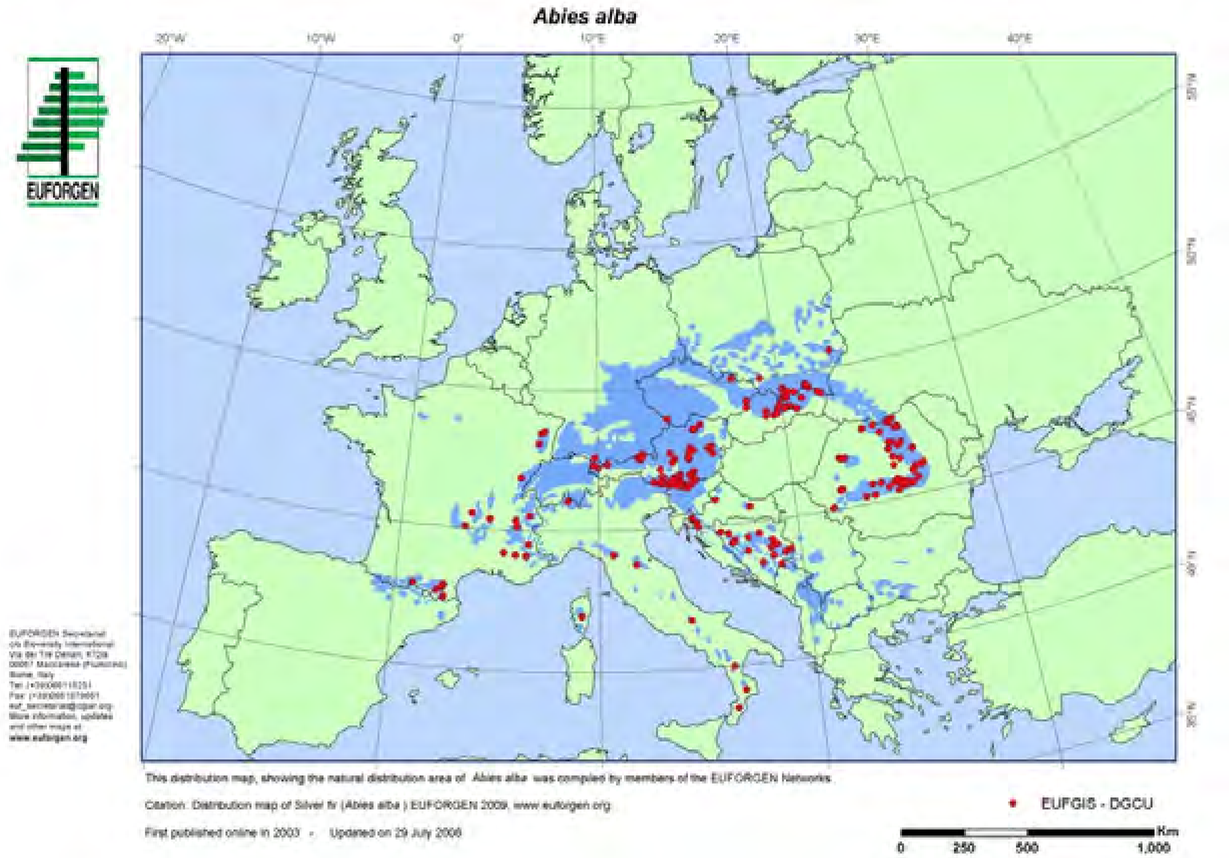


Fig. 59. Distribution of gene conservation units (GCU) of *Albies alba* Mill. in Europe

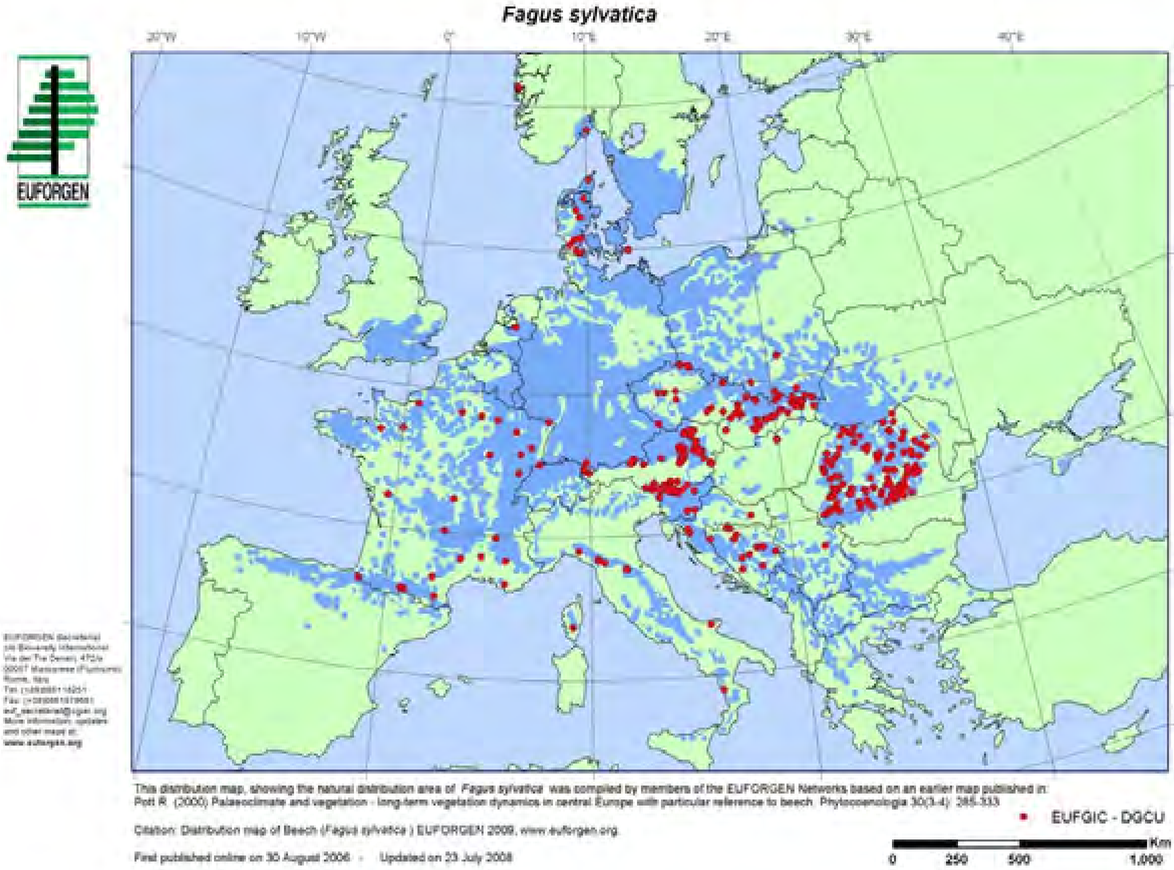


Fig. 60. Distribution of gene conservation units (GCUs) of *Fagus sylvatica* L. in Europe

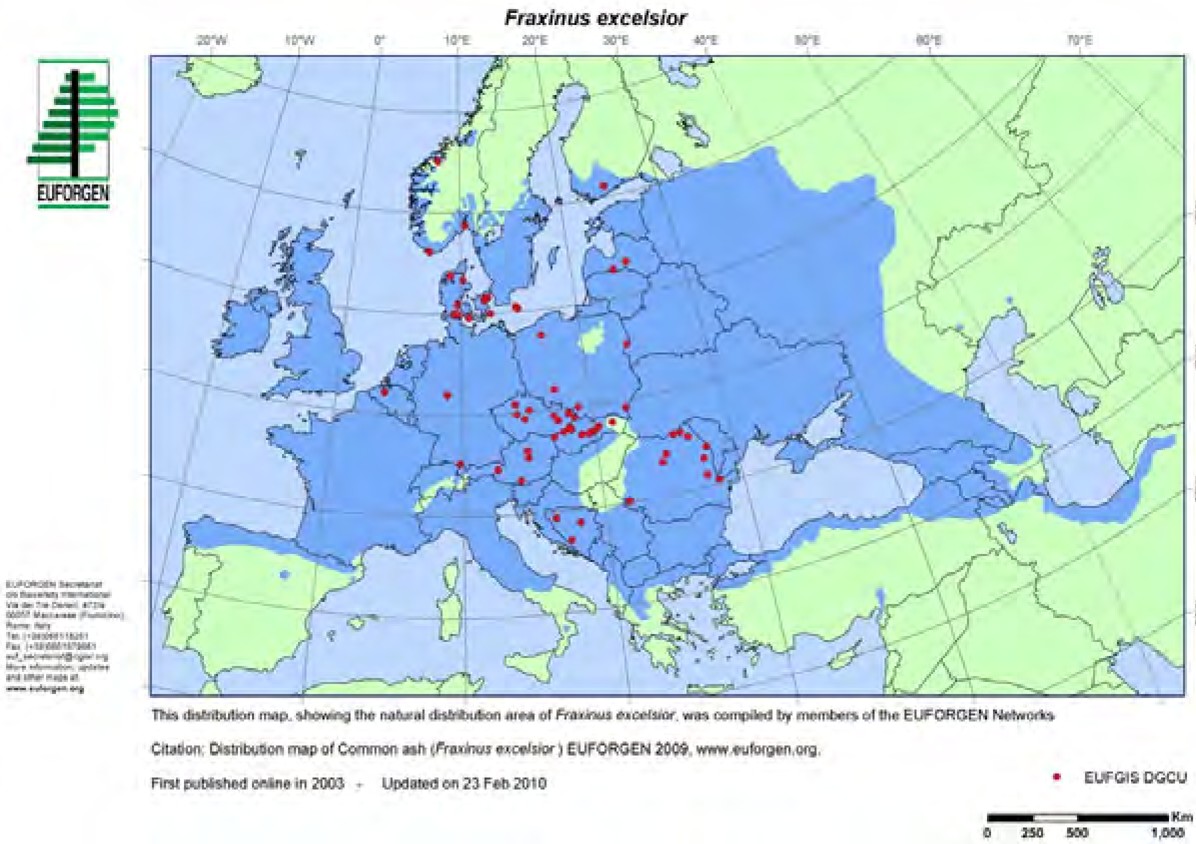


Fig. 61. Distribution of gene conservation units (GCUs) of *Fraxinus excelsior* L. in Europe

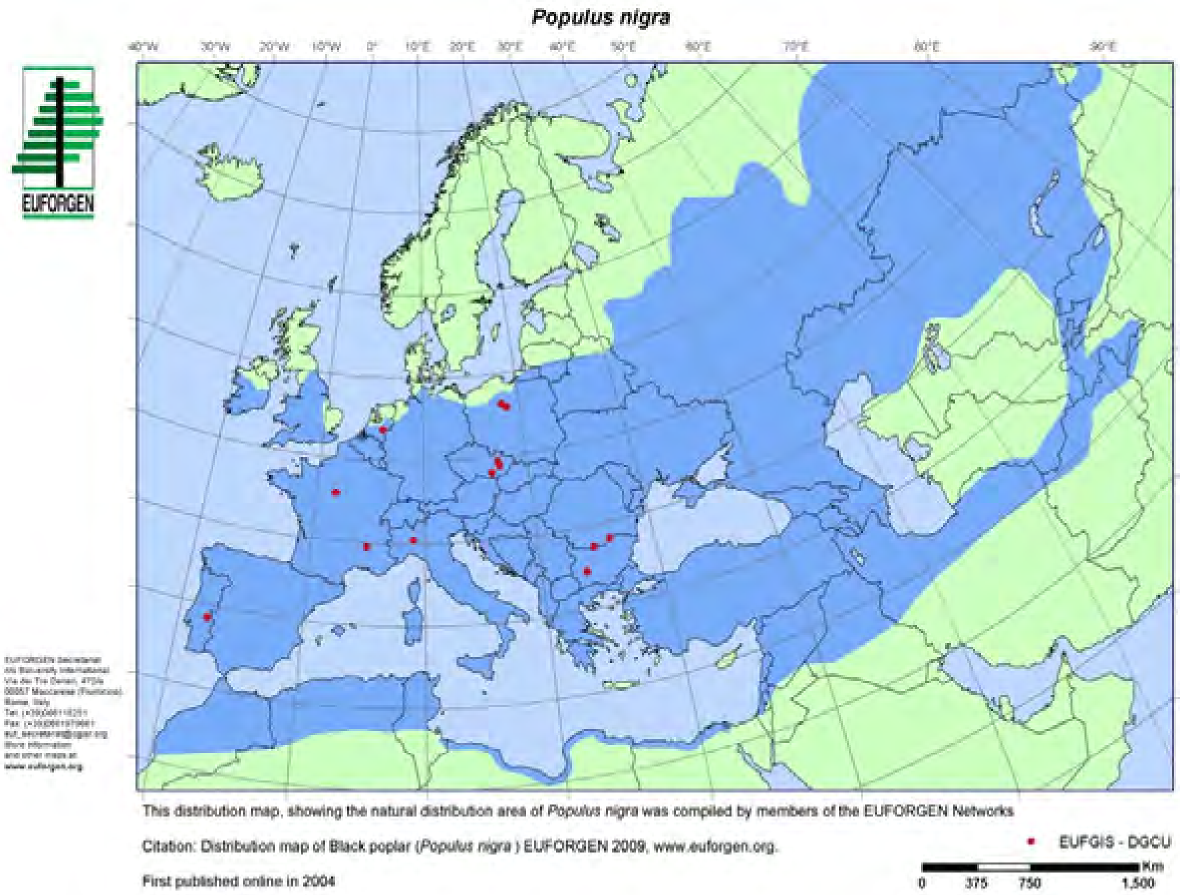


Fig. 62. Distribution of gene conservation units (GCUs) of *Populus nigra* L. in Europe

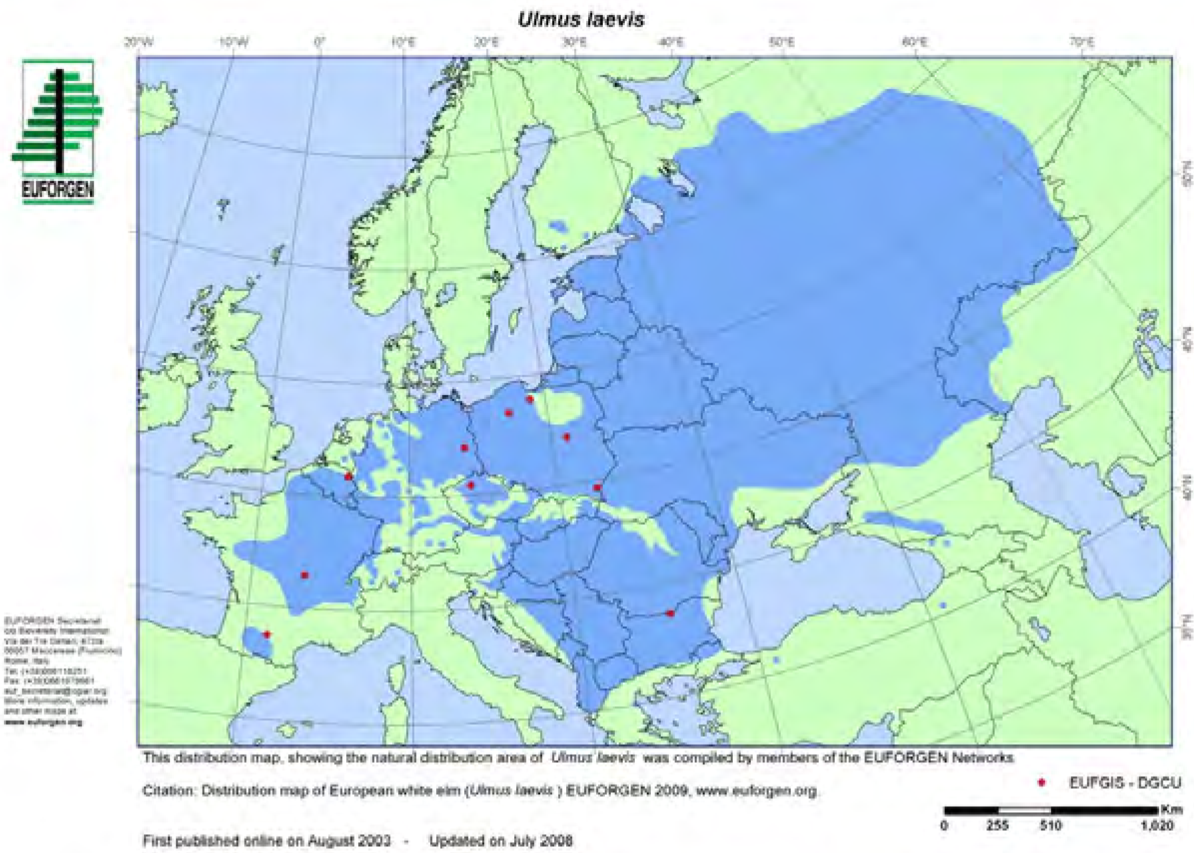


Fig. 63. Distribution of gene conservation units (GCUs) of *Ulmus laevis* Pall. in Europe

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

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

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

A major threat to the *in situ* conservation of forest resources comes from external conditions that prevent survival of the progeny generation in plantation, e.g. heavy weed growth, high groundwater level, game animals, irregular seed production in older stands, *etc*. There is also a problem with initiating reforestation in gene conservation stands, national parks and nature reserves, especially in areas enjoying strict protection. It is difficult to undertake actions in the protected areas to conserve the selected populations serving protection of genetic diversity.

2.4. Priorities for **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, including forests of all ownership categories. It is also necessary to develop criteria for selecting conservation objects on the basis of genetic information.

The starting point in implementing the long-term programme for the conservation of genetic resources is to generate a system for monitoring changes in genetic diversity. The information obtained from such monitoring will be the basis for determining the scope and urgency of conservation tasks, for developing conservation programmes and for taking immediate actions to preserve individual populations exposed to damage-causing factors.

CHAPTER 3: THE STATUS OF *EX SITU* CONSERVATION OF FOREST GENETIC RESOURCES

1. Ex situ *conservation of forest genetic resources*

Actions to preserve genetic diversity should be conducted both *in situ* through their active promotion in the forest environment, as well as *ex situ*, depending on the level of threat. In the case of protected plants in the territory of the State Forests, appropriate steps towards active protection of their genetic resources should be subject to agreement between the organizational units of the State Forests and the Directorate General and Regional Directorates for Environmental Protection. The agreed recommendations should 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 of loss of valuable stands that may appear as a result of unforeseen phenomena in the natural, forest environment, such as climate change, fires, floods, insect outbreaks, the activity of viral and fungal pathogens, the impact of wildlife or 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, *in vivo* clonal archives and by collecting and long-term storage of genetic material in the form of seeds or parts of plants in gene banks.

Long-term activities related to the restitution and reintroduction of protected plant species and endangered populations should be conducted in the framework of the Preservation Programme for 2011–2035. No specific tasks for the above-mentioned activity were set in the Programme.

1.1. The role of gene banks

The Kostrzyca FGB participates in implementing the Preservation Programme for 2011–2035, carries out conservation of genetic resources through the long-term *ex situ* storage of seeds, pollen and other parts of plants, draws up guidelines for the collection of genetic resources in order to preserve the highest variation of the selected objects, monitors their quality, ensures their timely withdrawal from further storage and takes care of setting up *ex situ* conservation plantations from seeds after their storage. The Kostrzyca FGB verifies the correctness of collecting material and performs its genetic identification. In addition, it develops and implements the new methods and technologies of 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 establishes and keeps a nationwide register of DNA data of collected and studied genetic resources, and a register of experimental sites involved in the selection and conservation of forest tree genetic resources in Poland.

Directors of RDSFs establish regional gene banks within their territories, subject to fulfilling by them the appropriate requirements, *i.e.,* above all, showing to have the necessary technical infrastructure and skilled staff. Direct supervision over the regional gene banks is exercised by the local District Forest Manager, while 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 carried out in accordance with the current guidelines. The genetic resources of the regional gene banks are, in the first place, designed to restore the endangered or lost populations and single individuals of economic importance in the territory of a given RDSF. 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 Register of FRM.

The *ex situ* conservation of genetic resources in Poland is primarily designed to complement the *in situ* conservation of genetic resources. Table 11 specifies the species for which the programme for *ex situ* conservation of forest genetic resources is being implemented. *Ex situ* conservation is carried out in the form of:

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

A list of *ex situ* protected species, the quantities of seeds and other parts of plants stored in the Kostrzyca FGB is shown in Table 11. The material gathered so far in the Kostrzyca FGB comprises 7 327 genetic resources, including 7 263 genetic resources of populations and individuals (plus trees, conservation trees, and natural monuments).

The establishment of progeny plantations and gene conservation plantations is the specificity of Polish forestry as concerns the *ex situ* conservation of genetic resources (Table 11a). In total 68 850 hectares of such plantations had been established in Poland by the end of 2010.

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

Due to the geographical-climatic conditions and species composition of our forests, with a dominant share of coniferous species determining the way by which forests are regenerated, and the low share (10.1 per cent) of natural regeneration, it was necessary on the one hand to designate and register a sizeable seed base of various forest-forming tree species, and on the other to build adequate seed extraction and storage infrastructure, and nurseries (Fonder *et al*., 2007; Suszka, 2000).

In the past two decades, the above mentioned activities facilitated the full implementation by the State Forests of the tasks arising from the Forest Act, Act on Forest Reproductive Material, and the long-term programmes for the conservation of forest genetic resources and selective breeding of trees in Poland adopted in collaboration with research centres.

Without an appropriate technical infrastructure supporting the processes of seed extraction from cones, seed storage, as well as seed stratification and assessment, it is impossible to implement the basic tasks involving *ex situ* conservation of genetic resources and the supply of fixed quantities of seeds of known origin, quality and high breeding value to forest nurseries for the production of planting stock needed to establish gene conservation and progeny plantations, and to carry out economic tasks. The reserves established to cover the annual demand of Forest Districts amount to a dozen tonnes of seeds of coniferous tree species alone and to several thousand tonnes of seeds of broadleaved tree species, on average.

In the organizational structure of the State Forests there is a number of regionally operating units dealing with seed production making up a network covering the entire country. These are: 9 Seed Testing Stations, 5 Seed Quality Control Stations (Fig. 65), 24 Seed Extraction Plants and Storage Units (Fig. 64). Due to their processing capacities, they can provide services to all organizational units of the State Forests. The network of seed testing stations and seed quality control stations operating within the State Forests enables systematic collection of data on the quality of seeds and cones from the regions of origin across the country. The data collection system allows monitoring seed crop and seed quality, as well as timely preparation of annual announcements about the anticipated level of seed crop of the main tree and shrub species. Seeds are evaluated in stations using advanced laboratory techniques involving, among others, X-raying, chemical analysis and germination tests.

Seeds are extracted and stored using modern technologies. The cold stores with controlled air humidity and temperature allow storage of seeds for several decades. Special production lines are used for seed extraction. Each operation in the seed extraction process is performed by a separate machine. In all extraction plants in Poland, seeds are removed from cones using the thermal method, consisting of gradual drying of cones with dry and hot air in a cabinet dryer. In further processes, extraction drums are used to separate seeds from open cones, as well as screens to remove impurities and fractions, seed de-wingers, gravity separators, and PREVAC vacuum separators. Seeds from fruits of broadleaved trees are extracted using macerators and special sieves. Boilers with extensions or modern cabinets are used for seed floatation tests and thermotherapy. Storage of seeds takes place 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, moreover, one of the few countries in Europe to have a forest gene bank of national reach (Kostrzyca FGB), covering the whole territory of Poland. Kostrzyca FGB carries out the majority of activities related to the *ex situ* conservation of the most valuable objects selected in Polish forests. However, its technical infrastructure allows not only for the conservation of the gene pool of forest species, but also of the endangered and protected wild plants in Poland. The Kostrzyca FGB's cubic space capacity is sufficient to store reproductive material from all strategically important seed sources in Poland, and its technological line consists of a seed extraction unit, seed store, seed stratification unit, seed assessment stations and traditional cold stores with temperatures -30C, -100C, -200C. In addition, it comprises a cryo-preservation laboratory where genetic resources, mainly of recalcitrant species, are stored in liquid nitrogen at ultra low temperatures, not always in the form of whole seeds, but often as separated apical meristems or plumulas, which significantly reduces the occupied space. The Kostrzyca FGB also has at its disposal a laboratory for DNA analysis to verify whether the genetic material delivered for *ex situ* conservation in the Bank corresponds to its region of origin.

The construction and modernization of infrastructure facilities serving seed science require a great organizational and logistical effort and huge financial resources. The changes in seed science, as well as in the techniques and technologies applied in forestry can be called a civilizational leap. In effect, the State Forests have created optimal conditions for the preservation of genetic resources, as well as for storage and conditioning of seeds.

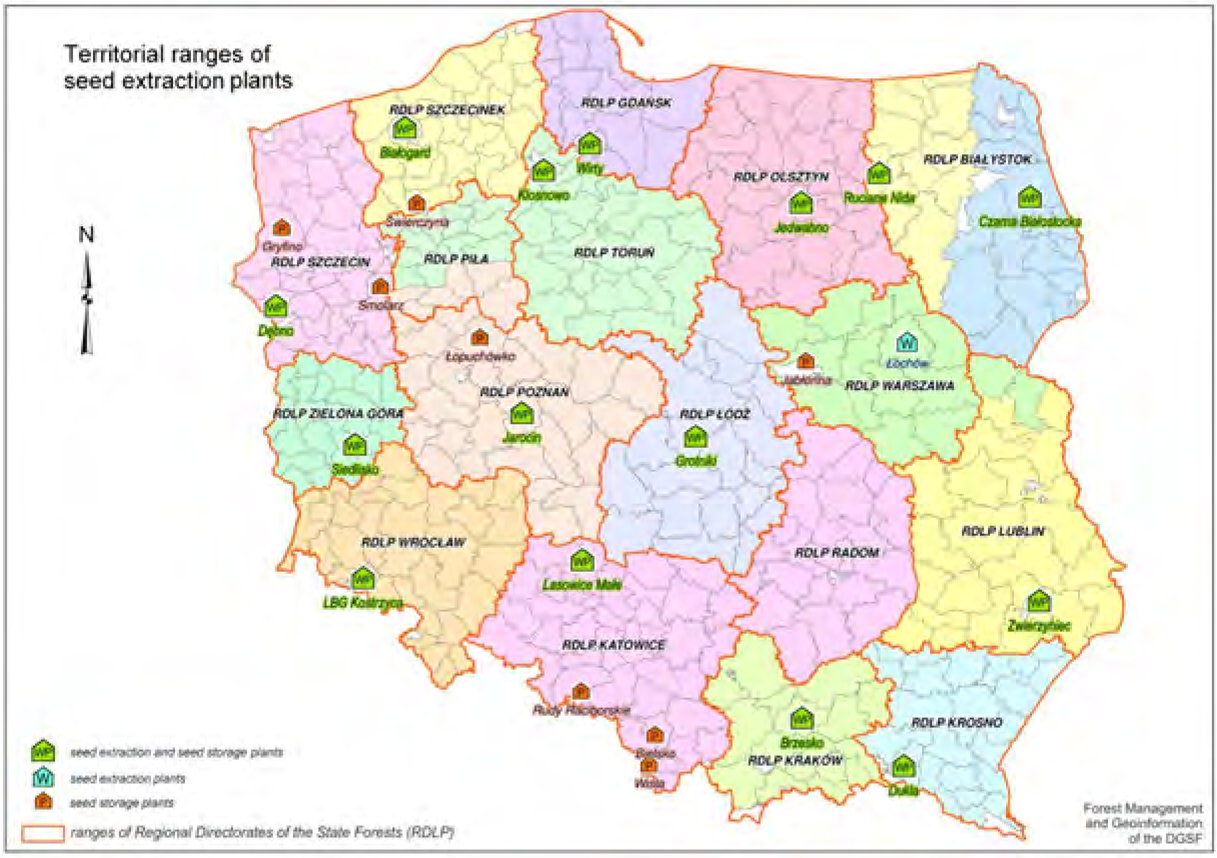


Fig. 64. Distribution of seed extraction plants and seed stores in Poland

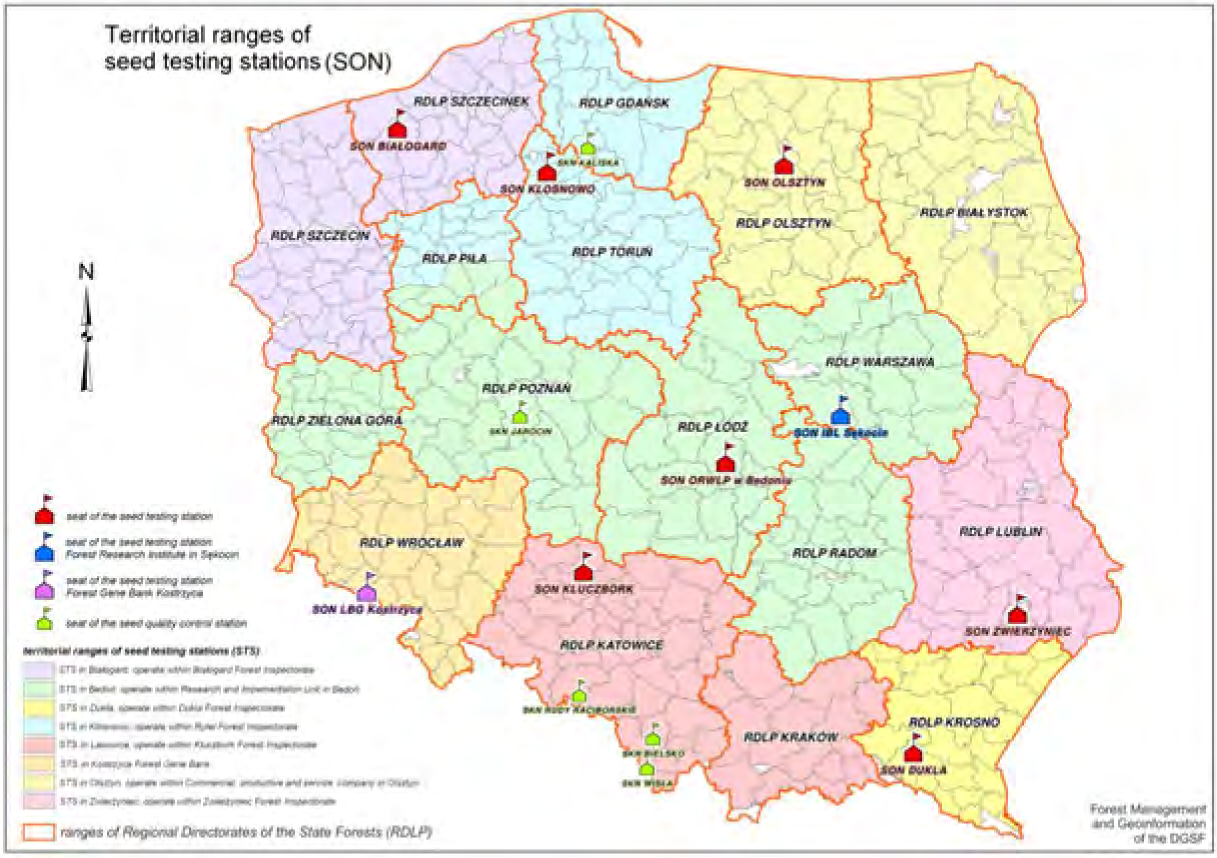


Fig. 65. Distribution of seed testing and seed control stations in Poland

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, the *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 16th April 2004 puts an obligation on 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 on the protection of wild-growing species in danger of extinction. These tasks are performed by botanical gardens by creating and maintaining collections of protected and endangered plants, brought directly from their natural habitats or propagated from the *in situ* collected seeds.

This kind of activity is carried out in the majority of botanical gardens and arboreta such as: the Botanical Garden of the Jagiellonian University in Cracow, the Botanical Garden of the University of Wroclaw, 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 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 – Centre for Biological Diversity Conservation 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 Prof. S. Białobok Forest Arboretum in Syców, the Glinna Dendrology Garden, the Dendrology Garden and Nurseries in Wirty, the Forest Arboretum of Warmia and Mazury. These institutions have collections of about 200 species of protected plants.

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

In addition, botanical gardens, are involved in the *ex situ* nature conservation through plant propagation and preparation of genetic material, participate in the 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, the seed bank is run by the PAS Botanical Garden of the – Centre for Biological Diversity Conservation in Powsin.

Collections gathered in the dendrology gardens and forest arboreta are exceptionally valuable for the preservation of FGR of indigenous and non-indigenous tree and shrub species of native and foreign origin. The oldest of them 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 located in the Gryfino Forest District and the Dendrology Garden and Nurseries located in the Kaliska Forest District.

The Prof. S. Białobok Forest Arboretum located 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.

Botanical gardens play a very important role in implementing the provisions of the Nature Conservation Act as they carry out studies on rare and endangered species (Table 30).

2. Transfer of FRM and documentation used

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

The knowledge of the possibilities of using certain populations and their seed base in diverse ecological conditions is of practical importance in that it provides the basis for successful seed management and determines the achievement of positive breeding results. The recognition of the intra- 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 developing programmes for the protection of genetic diversity.

The need to create barriers against free disposal and transfer of seeds and the plants grown from them has been known to forestry practitioners for a long time. The first regulations in this regard appeared in the Scandinavian countries in the 1920s. They regulated in general the issue of seed and seedling transfer, specifying the range of seed movement mainly from north to south and in the opposite direction. With the growing knowledge of genetic diversity of individual species within their natural ranges, these regulations became more detailed and led to the development of the concept of region of origin.

According to the O.E.C.D. Rules and Council Directive 1999/105/EC, the region of origin for a species, subspecies or a variety is the area or group of areas subject to 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 the population characterized by a specific genetic structure (different to that of the adjacent populations) formed under the impact of the region-specific external conditions (of natural selection).

In accordance with the binding legal regulations, only material from the registered seed base 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 are 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 other physical-geographical and natural conditions different from those in which it was produced.

According to the general guidelines, seeds and plants grown from them can be distributed without limitations only within the same region of origin, however in the mountains they must remain in the same altitudinal zones. In the case of absence or scarcity of seeds of valuable provenances from 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 specific rules provide otherwise. 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:

- in the first place to avoid crossing the boundaries of the physico-geographical regions and provinces,
- to adopt, where necessary (lack of a seed base for any species), the principle of transferring seeds and the seedlings grown from them from the physico-geographical regions characterized by more severe climatic conditions (East-European Depression and Carpathian Sub-Region) into other parts of the country with milder climatic conditions.

Guided by these general principles, detailed rules governing the movement of forest reproductive material between regions have been developed, which is a departure from the statutory rules demanding its use only in its region of origin. These rules are superior to 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, specific rules requiring the reproductive material to remain within altitudinal zones (Act on FRM, 2001).

2.2. Documentation used in trading FRM

The approved seed base is entered in the Register of FBM of the State Forests (Table 37) and in the National Register of FBM (Table 48). The use of the seed base for FRM production in Poland by species and seed base type is presented in Table 38.

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

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

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

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

After seed drying and obtaining proper moisture content for storage at -10°C, the seeds are packed in aluminium tins or 3-layer aluminium foil.

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 for the country's ecological security for a longer period of time (30-50 years). These are the genetic resources of the main forest tree species and endangered plant species growing in the wild in Poland.

All the technological processes related to seed production and the obtained seed weight are listed in the Seedlot 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. It states the type of resource/deposit (basic, test samples, accompanying samples, supplementary resource) and the weight of seeds in different packages.

The Kostrzyca Forest Gene Bank

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

Seed material is evaluated in the course of technological processes (Kostrzyca FGB) and checked during storage. The frequency of evaluation of all deposits and genetic resources in Poland is 2-3 years. The history of all evaluations is recorded in the initial evaluation sheets. After the completion of seed testing, a Simplified Evaluation Certificate is issued.

In accordance with the Ordinance of 28 November 2007 on detailed procedures for combating and preventing the spread of *Giberella circinata* Nirenberg & O'Donell issued by the Minister of Agriculture and Rural Development, 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 seedlots are issued plant passports.

The processed seeds are labelled. There are three different colours of labels, depending on the category of FRM. Yellow for the FRM in the category *source-identified*, green for the FRM in the category "*selected*", pink – for the category "*qualified*" and blue – for the category "*tested*". The planting stock (FRM) to be placed on the market has a label and 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. The said procedures are governed by the Act on FRM and the executive regulations to the Act.

3. Ex situ *conservation activities*

3.1. Measures to protect the existing ex situ *collections*

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

The Kostrzyca FGB, in cooperation with research centres, conducts research on new technologies and methods of storing seeds of the species representing the "*intermediate*" and "*recalcitrant*" categories, allowing a much longer storage life of seeds or their parts using cryogenic techniques.

The tests indicate possibilities of cryogenic storage (in liquid nitrogen temperature -196ºC) of the genetic resources of oak species (*Quercus robur* L.) and (*Quercus petraea* (Matt.) Liebl.), common beech (*Fagus sylvatica* L.), silver fir (*Abies alba* Mill.) and European yew (*Taxus baccata* L.).

Oak seeds are sensitive to drying, low temperature and prolonged storage. Thus, the preservation of oak genetic resources in gene banks in the form of whole seeds is not possible. The appropriate cryopreservation and drying treatments will make plumulas or apical meristems of embryos isolated from acorns tolerate the temperature of liquid nitrogen in about 60 per cent, and restore complete plants from thawed meristems in the *in vitro* cultures in the Kostrzyca FGB.

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

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

The methods of cryopreservation of fir and yew seeds consist in drying seeds to the permissible moisture content at which seeds are then frozen in liquid nitrogen. The survival rate of seeds after being stored at cryogenic temperatures is about 80 per cent.

Due to the scientific collaboration of the Kostrzyca FGB with the Institute of Dendrology, PAS in Kórnik, the Forest Research Institute in Warsaw, the PAS Botanical Garden – Centre for Biological Diversity Conservation in Powsin Warsaw, the Millennium Seed Bank, Royal Botanic Garden, Kew, and with many research centres in Europe in the framework of the ENSCONET Consortium, the methodology of seed storage in liquid nitrogen is also applied to trees and shrubs of biocoenotic species such as *Prunus avium, Ulmus gabra, Tilia cordata, Carpinus betulus*, *etc*., and many species of herbaceous plants.

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

Species with dormant seeds:

Carpinus betulus L. - common hornbeam (SHC 16.5-3.2%)
Fraxinus excelsior L. - common ash (SHC 19.5-7.2%)
Prunus avium L. - bird 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*

In order to promote the idea of *ex situ* conservation of genetic resources, the State Forests, with the participation of the Forest Research Institute, organize a series of training courses and conferences on the protection and conservation of forest genetic resources. These activities are undertaken mainly during the implementation or completion of the

Programme for the Preservation of Forest Genetic Resources and Selective Breeding of Forest Trees, implementation of new regulations of the Director General of the State Forests on issues relating to forest seed science, selection, genetics and nursery production, as well as the new legislation in this area.

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

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

- 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, and the impact of long-term storage on its genetic structure;
- unsatisfactory methods of reproduction of the material stored at cryogenic temperatures;
- limited availability of FRM from conservation stands located outside the areas administered by the State Forests;
- failure to include forests under management of national parks and forests other than state-owned in the Preservation Programme for 2011-2035;
- lack of monitoring of the loss of genetic variation in genetic material during the long-term storage.

3.4. Priorities for future actions in **ex situ** *conservation of genetic resources*

1. Because of the unsatisfactory condition of the present genetic resources in the legally protected areas, they will need in the future 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 be included in the protective task plans being developed for the Natura 2000 sites.
3. The establishment of progeny plantations, conservation plantations and clonal archives should be continued.
4. The results of research related to the storage and assessment of seed quality should be currently implemented into forest practice.

CHAPTER 4: THE USE AND SUSTAINABLE MANAGEMENT OF FOREST GENETIC RESOURCES

The way by which forest management is pursued in Poland is regulated by the Forest Act.

1. "Sustainable forest management is engaged in, pursuant to a Forest Management Plan or simplified Forest Management Plan, with account in particular being taken of the following objectives:
   1) the preservation of forests and their favourable influences on climate, air, water, soil and conditions for human life and health, as well as the natural balance;
   2) the protection of forests, especially those that, with their associated ecosystems, constitute natural fragments of native nature, or else those particularly valuable in terms of:
      a) the preservation of the diversity of nature,
      b) the preservation of forest genetic resources,
      c) valuable features of the landscape,
      d) the needs of science;
   3) the protection of soils and areas particularly vulnerable to pollution or damage, as well as of special social significance;
   4) the protection of surface and underground waters, and drainage-basin retention, in particular in water divide areas and in areas of supply for undergoud water bodies;
   5) the production – on the basis of rational management – of wood, as well as raw materials and by-products of forest utilisation.
2. Forest management in forests constituting Nature Reserves or included within National Parks shall take account of the rules laid down in nature conservation regulations.

3. Forest management in forests included in the Register of Monuments, as well as those on land that supports archaeological monuments entered in the said Register, shall be pursued 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 pursued in accordance with the principles of:

1) the general protection of forests;
2) the persistent maintenance of forests;
3) continuity and sustainable use of all forest functions;
4) augmentation of forest resources”.

1. *Breeding programmes and their implementation*

In the framework of the Preservation Programme for 2011-2035, the State Forests carries out a parallel tree improvement and selection programme for all the main forest tree species and selected biocoenotic and exotic species.

1.1. Selective breeding of forest trees

The term “*selective breeding*” of forest trees refers to the field of science dealing with the genetic improvement of desired traits in trees, as well as to practical measures aimed to produce more productive varieties of higher quality and more resistant to biotic and abiotic threats than the wild populations or recent varieties. The main tasks of forest tree improvement resulting from public expectations are as follows:

a) identification and protection of genetic variation, taking into account the preservation and restoration of endangered resources,
b) 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 crucial for successful selection, therefore, the breeding process begins with the recognition, use and artificial increase of natural variation.

The public demand for quality wood increases. The variety of methods applied for selective breeding of forest trees ensure efficient and cost-effective improvement and stability of the productive and non-productive functions of forests.

Artificial selection, as opposed to natural, is controlled by the forest tree breeder and conducted in the properly selected environmental conditions. The best effects are obtained when selection for one trait only is considered. When the object of selection is the entire population we are dealing with population selection, and when the object of selection are single trees within the population (and also outside the population) we are dealing with the individual selection. In each of these cases, different selection methods are used.

Population selection is based on the selection of superior populations (breeding objective) with respect to the adopted selection objectives and maintaining their phenotypic variation (and indirectly their genetic diversity). This ensures a high level of genetic variability of forest stands and their adaptation to local conditions. There are relatively limited possibilities of improving breeding traits, maximally by 10-15 per cent, and only in relation to the traits by which stands are selected.

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

To strengthen positive effects of selection in progeny, it is necessary that mating should occur only between selected individuals, and the selected varieties be effectively isolated from the influence of unselected individuals from the same species.

These effects can be achieved by implementing, in subsequent 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 open pollination or controlled crossing of the genotypes selected in the previous cycle;
– quantitative and qualitative traits, as well as plasticity ensuring sustainability of forest production are the criteria of selection;
– intensity of selection in successive cycles should be similar for individual traits.

The adopted detailed plans include specific actions necessary for the implementation of the long-term breeding strategy in the State Forests:

– breeding populations shall 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 largest. The Programme for Progeny Testing of Selected Seed Stands, Plus Trees, Seed Orchards and Seedling Seed Orchards will allow selecting genotypes in the progeny to create the first breeding population. 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. It should be possible to extend or exchange some genotypes within the population where breeding effects are unsatisfactory or where the genetic variation in the breeding populations is too limited;
– the number of breeding populations for the species should be equal to the number of regions of origin (however, not less than five);
– in each successive selective breeding programme, one full selection cycle should be performed. Programmes should therefore be developed for periods not shorter than the breeding cycles, that is for 25 years.

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

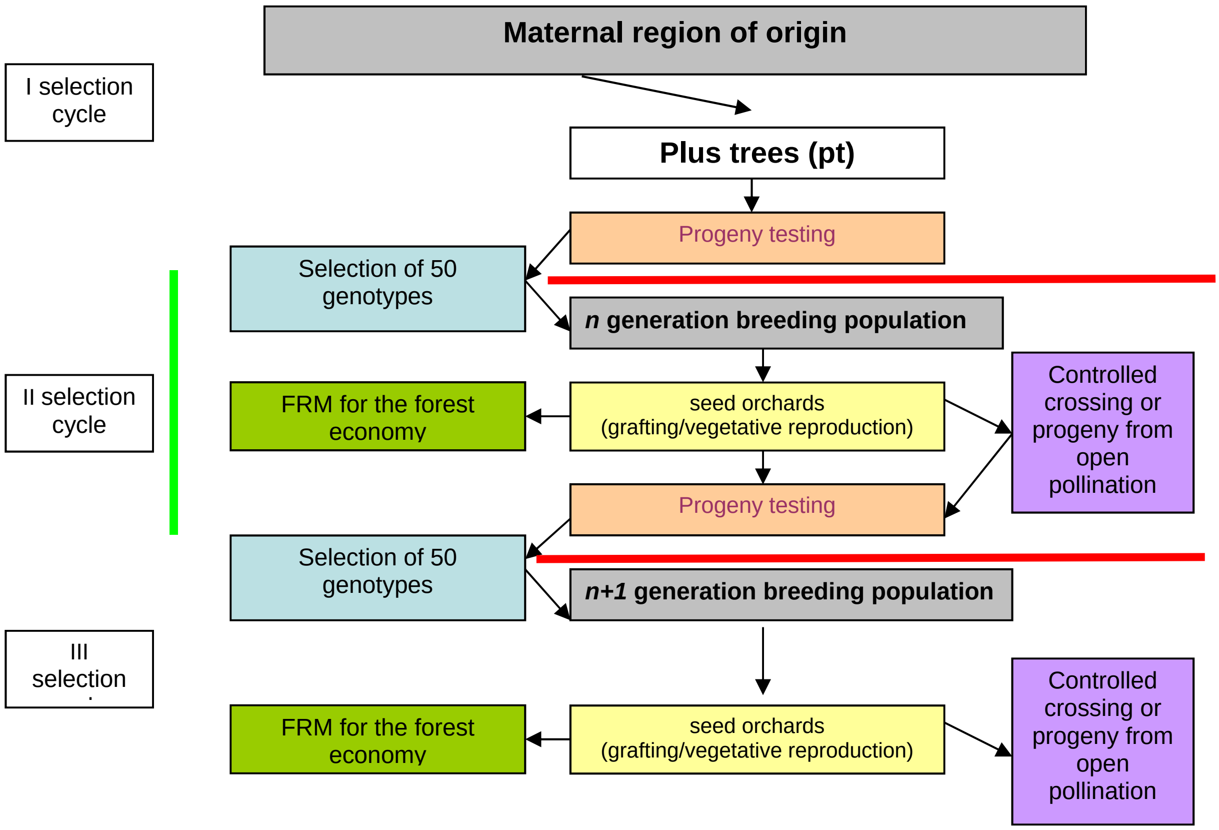


Fig. 66. A flow-diagram of the long-term selective breeding strategy of the State Forests

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) selected on the basis of the traits defined below. In these programs it is permitted and recommended to use controlled crossing and other available techniques, including molecular ones. In order to obtain a high genetic gain it is recommended that in one population no more than two traits be simultaneously selected. The planned selection tasks for individual species are shown in Table 49.

Table 49. Planned selection tasks for individual tree species

Species	Selection tasks
Silver birch and black alder	Biomass production, wood quality, wood chemical properties
European larch	Biomass production, wood quality
Douglas fir	
Pedunculate oak and sessile oak	Wood quality (valuable assortments)
Norway spruce	Resistance to biotic and abiotic factors
Common ash	
Elms (European white elm, smooth-leaved elm and wych elm)	

Silver birch

Scope and methods of work

Work will be conducted primarily in north-eastern Poland, in regions of origin 202, 203, 204, 252, 253, 207 and 208 where the most valuable birch populations are located, as shown by the provenance trials that have been conducted so far. In the first selection cycle, the testing will be based on 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. During selection control crossings will be made. The obtained 50 full-sib progenies from each breeding population will be used for establishing test sites. Evaluation of the genetic effect of selection will be possible after 10 years. In successive selection cycles, vegetative reproduction and clone testing should be employed (Fig. 67).

Anticipated effects

Production seed orchards will give a progeny that will be characterized by genetic gain from the first stage of selection of the order of 15–20 per cent relative to the selected stands. It will be used for establishing special-purpose tree plantations. It will also be possible to produce clones with desirable traits.

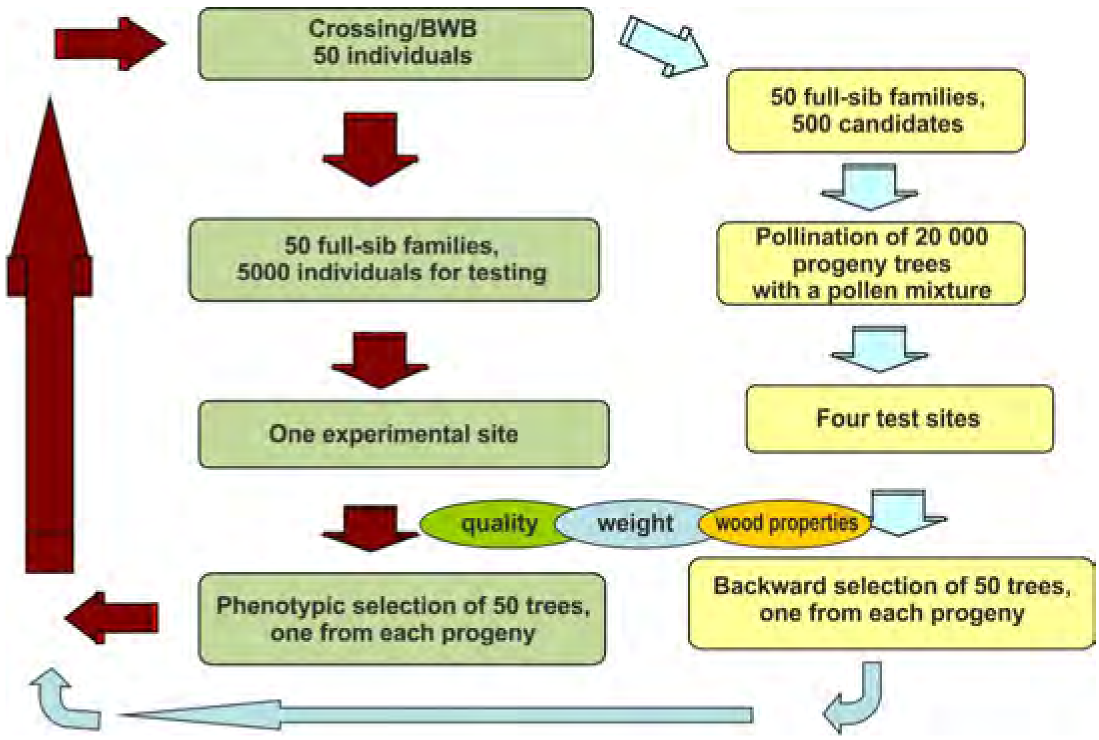


Fig. 67. A flow-diagram of selective breeding of silver birch for improving wood quality traits, its chemical properties and weight increment

European larch and Douglas fir

Scope and methods of work

Plans are to create a breeding population of European larch in the Sudeten and Świętokrzyskie Mountains. In the selection of initial material, the existing plus trees and progeny trials should be used. International cooperation in selective breeding, *inter alia*, 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. Breeding populations should consist of a minimum of 50 families. After 15 years, the best families will be selected on the basis of available information on tree growth in test plantations.

Anticipated effects

After 15 years, the genetic gain would be 20-25 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, elms and ash

Scope and methods of work

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

Anticipated effects

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

Pedunculate oak and sessile oak

Scope and methods of work

The source material will include individuals chosen from selected stands. The initial selection shall involve the existing plus trees and progeny trials. Generative propagation is usually used in selection. Breeding populations should consist of at least 50 families. The testing should take into account genetic and ecotypic variation. After 30 years, the best families will be selected on the basis of 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 20-15 per cent of 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 objective are presented in Table 13. Table 14 contains a list of species for which progenies of populations, plus trees, seed orchards and clonal seed orchards are tested (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 RDSFs. Currently, clonal archives are 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 started organizing individual clonal archives. The first clonal archive of common yew (*Taxus baccata* L.) in Poland was established in the Kostrzyca FGB. Data on the number of genotypes of trees planted so far in the clonal archives are given in Table 14.

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

In Poland, information on the breeding value of each population comes as soon as it is published mainly from regular scientific conferences and reports on the scientific achievements of the Forest Research Institute.

The Preservation Programme for 2011-2035 admitted use of larger quantities of seeds from seed orchards (40 per cent) and the reproductive material of category IV ("*tested*"). In 2005, the State Forests launched a large-scale Programme for Progeny Testing of the Selected Seed Stands, Plus Trees, Seed Orchards and Seedling Seed Orchards to test 1160 populations of the 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) that supports the circulation of forest reproductive material in seed extraction plants and stores in Poland. This application operates in all organizational units of the State Forests. The on-line access and the user-friendly interface ensure a quick transfer of data between many units. The owners of seeds can browse information on the collected seeds, successive stages of technological processes in seed extraction plants and assessment of the seeds in Seed Testing Stations. Also a module has been created for the registration of FBM objects and reporting.

The data collected from the entire territory of Poland make up a unique database which is helpful in analysing 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. The Forest Research Institute jointly with collaborating research institutions processes test results and evaluates the tested stands for their suitability for FRM category IV ("*tested*").

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

1.4. Supply/dislocation systems and availability of FRM

The rules of FRM transfer are contained in the Act on FRM. The forest seed base in Poland is large and generally available on a commercial basis to all FRM suppliers registered in the FRMO, after prior arrangements with the manager or owner of the database.

Some restrictions may only be introduced by Districts Forest Managers in the case of shortages of seeds in stores or seedlings in nurseries in periods of poor harvest of seeds, mainly of broadleaved tree species (including seeds of *Fagus sylvatica* L., *Quercus robur* L., *Quercus petraea* (Mattuschka) Liebl.). The import of seeds from abroad is reduced to a minimum and is incidental.

The providers of FRM 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 of FRM;
- buy seeds from the registered seed base stored in the State Forests' stores or Kostrzyca FGB;
- buy plants from the State Forests' nurseries for their further distribution or direct use.

In any case, the procedures concerning the circulation of relevant documents must be observed. The Act on FRM does not apply to the seeds and plants which are not included in Appendix I of tree species and their hybrids, and when FRM is moved 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 in private trade, not monitored by the FRMO, the quantity of exported seedlings and seeds can be several times larger. The official import of FRM for forestry purposes is practically reduced to zero by the regulations contained in the Ordinances of the Minister of the Environment on Forest Seed Regionalization.

The analysis of the documents on the FRM movement shows that the State Forests mostly sell the 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

According to Directive EU/1999/105/EC, the reproductive material used for forestry needs is grouped in three categories: "*source-identified*" – material derived from a source of seeds and stands of known origin, "*selected*" – material derived from selected seed stands and "*qualified*" – material derived from plus trees, seed orchards and seedling seed orchards. Category IV ("*tested*") is in the process of being established.

1.6. Varieties of tree species registered in Poland

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

Populus maximowiczii x trichocarpa – varieties 'Androscoggin' and 'Hybrida 275"

Populus maximowiczii x berlinensis – varieties 'Geneva' and 'Oxford'

Populus 'Italica' x laurifolia – variety 'Berolinensis'

Populus x euramericana – varieties 'Blanc du Poitou', 'Löns' and 'Robusta Gostynin'
Populous trichocarpa – variety 'Fritzi Pauley'.

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 2nd April 1997 (Constitution 1997) 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 that the Republic of Poland, *inter alia, safeguards the national heritage and ensures the protection of the environment based on the principle of sustainable development.* After the Rio conference in 1992, sustainable development became the fundamental principle of global forestry (Geszprych, 2007). The introduction of the Forest Act in Poland in 1991 had preceded by a year the Rio declaration.

Conservation of forest genetic resources is carried out in Poland by the State Forests on the basis of international agreements ratified by Poland, especially on 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 concerning the protection and conservation of forest genetic resources, such as the Strasbourg resolution S2,1990, the Helsinki resolution H2,1993 and the Vienna resolution 4, 2003 (Table 31).

After accession to the European Union in 2005, Poland undertook to develop and introduce a number of binding strategic documents. Unfortunately, no forestry development strategy was on the list of priorities. The visions of forestry of the late 20th century were included in the State Policy on Forests of 1997 (requiring urgent updating) introducing many concepts related to the ecologization of forest management or about the importance of forests in carbon sequestration. The provisions of the Forest Act and the State Policy on Forests included many common stipulations focusing 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 of the State Forests, its Vision, Purpose and Concept, a document drawn up under the leadership of Waldemar Sieradzki (Sieradzki, 1997). This document, however, was never formally adopted (Zaleski, 2011). The study Conservation and Sustainable Use of Forests in Poland developed under the leadership of Bogdan Łonkiewicz in 1996 (Łonkiewicz, 1996), which could be the basis for the development of the strategy, has not been implemented, so far. In 2003, the Polish Parliament adopted the National Environmental Policy 2003-2006 including prospects for 2007-2010. This document was continued in 2008 with a perspective to 2016. The chapters on nature conservation, protection and sustainable development of forests raise issues concerning the protection of natural habitats under the Natura 2000 network, augmentation of forest cover in the country, nature-forest education of society, water retention in forests, reconstruction of stands also in the framework of the Programme for the Protection and Restoration of 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. Up till now, Poland has not implemented the National Forest Programme; to some extent these functions are fulfilled by the State Policy on Forests.

The issue of conservation of forest genetic resources is quite strongly emphasized in the National Strategy and the Sustainable Use of Biodiversity and in the Action Programme 2007-2013 (Council of Ministers, 2007), implemented in Poland in 2007. Of the 8 objectives of the Strategy, 2 specifically refer to the forest genetic resources such as:

1. Preservation of biological diversity and monitoring of the existing and potential threats;
2. Preservation and/or enhancement of the existing and restoration of the lost components of biological diversity.

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

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

Some other legal documents in Poland concerning the protection and conservation of forest genetic resources

- Act of 3rd February 1995 on the Protection of Agricultural and Forest Land (consolidated text Dz.U. 2004, No. 121, item 1266 with subsequent amendments);
- Act of 13th April 2007 on the Prevention and Repair of Environmental Damage (Dz.U. z 2007, Nr 75 item 493 with subsequent amendments);
- Act of 8th June 2001 on the Allocation of Agricultural Land for Afforestation (Dz. U. 2001, No. 73, item 764 with subsequent amendments);
- Nature Conservation Act of 16th April 2004 (consolidated text Dz.U. 2009, No. 151, item 1220 with subsequent amendments);
- Environmental protection law of 27th April 2001 (consolidated text Dz.U. 2008, No. 25, item 150 with subsequent amendments);
- Hunting law of 13th October 1995 (consolidated text Dz.U. 2005, No. 127, item 1066 with subsequent amendments);
- Act of 7th June 2001 on Forest Reproductive Material (Dz.U. 2001, No. 73, item 761 with subsequent amendments);
- Act of 3rd October 2008 on Providing Information about the Environment and its Protection, Public Participation in Environmental Protection and Environmental Impact Assessment (Dz.U. 2008, No. 199, item 1227 with subsequent amendments);
- Act of 18th December 2003 on Plant Protection (consolidated text Dz.U. 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, Institute of Dendrology, PAS in Kórnik and 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, currently 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 a decision-making, initiating and opinion-giving body of the Institute; it is authorised to confer doctoral and postdoctoral degrees and to apply for conferring the title of a professor.

The Forest Research Institute carries out extensive scientific research and developmental studies for the needs of forests, forest management and forestry in the areas related to afforestation and restocking, forest tending, utilisation and protection, ecology and genetics, as well as economics and forest policy. The Institute’s research findings, study results and expert’s analyses are supportive in forest sciences, 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 and a co-organizer of many international and national meetings, seminars, workshops and conferences; it also provides nature and forest education for children and youth in the Forest Education Chamber. For 75 years, the Institute's library has been collecting forest literature, and currently its resources are the biggest in this part of Europe.

The Institute staff plays different functions in international organizations such as the International Union of Forestry Research Organizations (IUFRO) (http://iufro.boku.ac.at/) and European Forest Institute (EFI) (http://www.efi.int/). They are experts in 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 are from contracts and subsidies from the State Forests).

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

The Institute is a research unit of the Polish Academy of Sciences. The aim of the Institute is to conduct research in the area of biology and forest sciences concerning woody plants and to disseminate findings. The major statutory task of the Institute is to carry out biological and forest studies on woody plants, in particular:

- systematics and chorology;
- physiology and ecophysiology;
- molecular biology;
- seed biology;
- genetics;
- proteomics;
- ecology;
- bioindcation;
- phytoremediation;
- mycology and mycorrhizas;
- selection, silviculture and reproduction;
- phytopatology;
- entomology;
- introduction and acclimation of alien species;
- 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 forest-related research, and enhances 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 Cracow;
- Wood Technology Institute in Poznań;
- Forest Research Institute in Warsaw;
- Institue of Dendrolgy of the Polish Academy of Sciences in Kórnik.

Professor Władysław Chałupka (D.Sc.Habil.) from the Institute of Dendrology, PAS in Kórnik is a Member of the IUFRO International Council representing Poland (mailto: idkornik@man.poznan.pl).

Poland has personal membership in the International Seed Testing Association (ISTA) of in the Forest Tree and Shrub Seed Committee (FTSSC), 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, as well as seed storage, stratification and diseases.

2. International Programmes

EUFORGEN

Poland is a member of the European Forest Genetic Programme (EUFORGEN) (Bioversity International) which promotes conservation and sustainable use of forest genetic resources. The EUFORGEN serves as a platform for pan-European collaboration in this area, bringing together scientists, managers, policy-makers and other stakeholders.

The EUFORGEN facilitates development of science-based strategies, methods and recommendations for policy-makers and managers to improve the management of genetic resources of forest trees in Europe. It also contributes to various initiatives and projects making available better information on forest genetic resources in Europe. The EUFORGEN was established in 1994 as an implementation mechanism of Strasbourg Resolution S2 (Conservation of Forest Genetic Resources) of the first Ministerial Conference on the Protection of Forests in Europe (MCPFE), held in France in 1990. Dr. John Matras (Forest Research Institute in Warsaw) is the National Coordinator of the Programme. The EUFGIS (Establishment of European Information System on Forest Genetic Resources) project is an information system to support the EUFORGEN. The EUFGIS supports European countries in their efforts to implement and document dynamic gene conservation of FGR of forest trees. Czesław Kozioł (Kostrzyca FGB) is the National Focal Point in Poland for contacts with the EUFGIS.

Furthermore, Polish scientific institutions are involved in international research on tree breeding and forest tree genetics, whose findings are used for the implementation of tasks related to FGR conservation including: Treebreedex, Evoltree Trees4Future, ENCONET, ESBRI.

Poland’s participation in the IUFRO, Treebreedex and Euforgen Programmes is most effective as concerns the protection and conservation of FGR, as well as cognitive studies on forest trees genetics, compared to other programmes mentioned above.

To strengthen the international cooperation in the area of FGR conservation, it would be desirable to develop studies on seed quality assessment and storage, and to ensure that one of the Polish forest research institutes fully participates in the ISTA programme. The Forest Research Institute, as an independent research unit having a well-developed and equipped seed testing station and a huge research experience seems to be most suitable for this function.

In view of the increasing impact of climate change, the *ex situ* conservation of valuable populations and genotypes in gene banks seems to be a necessity today. This form of activity in other countries should lead to the creation of a pan-European network of forest gene banks storing genetic resources of forest trees.

In the framework of international collaboration in the area of FGR protection, conservation and research, the following projects should be developed and implemented:

- Periodic training for FGB managers, policy-makers and stakeholders highlighting the need for monitoring FGB studies and *ex situ* conservation;
- Further development of joint pan-European projects and programmes involving studies on genetic variation of forest tree species on national and continental European scale;
- 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 risks and the necessary actions to preserve genetically not depleted FGR;

– The creation of a pan-European system of monitoring genetic changes occurring within forest tree species and the development of plans for counteracting the phenomenon of potential genetic drift to be included in the national programmes.

3. International agreements

The agreements are presented in Tables 32–36.

CHAPTER 7: AVAILABILITY OF FOREST GENETIC RESOURCES

In Poland, forests constituting the Treasury property are accessible to the populace. Only in very exceptional cases the right to enter the forest is limited. Ban on access to forests applies to plantations up to 4 metres in height, experimental areas or seed stands and refugia designated for animals, spring areas of rivers and streams and areas threatened by erosion.

According to Forest Act 1991: "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 arose that may endanger the safety of people (e.g. storms), "management measures are in progress in connection with silviculture, forest protection or timber harvesting". The obligation to introduce temporary bans on entry and putting up 'Ban on Entry' signs refers also to forest owners under other forms of ownership. "Traffic comprising motor or animal-drawn vehicles in forest on public roads is not permitted unless the said roads are indicated by signs allowing such traffic. Horse riding in a forest is only permitted via forest roads designated for the purpose by the District Forest Officer. Forests constituting 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 concluding an agreement with the given Forest District. An owner of a forest not constituting Treasury property may prohibit entry into a forest, marking such a forest with a board with the appropriate inscription."

Moreover, in forests, it is forbidden (Forest Act 1991):

1) "to pollute soils and waters;
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 District Forest Officer;
11) to collect eggs or nestlings of birds or destroy their breeding grounds or nests, or to destroy the holes, dens, lairs and setts of animals, as well as anthills;
12) to scare, chase, catch, trap and/or kill wild animals;
13) to let dogs off the leash;
14) to make noise or use sound signals, save in cases where there is a need for the alarm to be raised."

The provisions of para. 1, points 3 and 5 do not apply to activity relating to forest management, while points 12-14 do not apply with respect of 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, and in particular:

a) the starting of fires away from the places designated for that purpose by the forest owner or District Forest Officer;
b) the use of a naked flame;
c) the burning of surface soil layers or remnants of vegetation.

The provisions of para 3 do not apply to activities associated with forest management, provided that the said activities do not pose a fire threat.

In national parks and nature reserves, it is forbidden (Nature Conservation Act 2004):

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 destruct eggs, juvenile forms and developmental forms of animals, deliberately disturb vertebrate animals, collect antlers, 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, or intentionally damage, leave litter in, or make changes to natural objects, areas and resources, as well as formations and elements of nature;
6) to introduce changes in water relations, regulation of rivers and streams, unless they serve nature protection;
7) to collect rocks, including peat, and fossils such as fossil remains of plants and animals, minerals, and amber;
8) to cause soil disturbance or changes in land designation and use;
9) to light fires and tobacco products, 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 decision of the respective regional director for environmental protection;
10) to perform manufacturing, trade and agricultural activities, except in the areas set in the conservation plan;
11) to use chemical and biological plant protection agents and fertilizers;
12) to collect wild plants and fungi and parts thereof, except in the areas designated by the director of a national park, and by the respective regional director for environmental protection in a nature reserve;
13) to catch fish and other aquatic organisms, except in areas set 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, and by the respective regional director for environmental protection in a nature reserve;
15) to let dogs into the areas under strict and active protection, except into the areas designated for that purpose in the protection plan, and to let herd dogs into the areas covered by active protection where the protection plan or protective tasks allow grazing;
16) to climb, explore caves or water reservoirs, except in the areas designated for that purpose by the director of a national park, and in a nature reserve by the respective regional director for environmental protection;
17) to drive vehicles off public roads and off the roads located on a property that is under the permanent management of a national park, designated by the director of a national park, and in nature reserves – by the respective regional director for environmental protection;
18) to place billboards, signs, advertising boards and other signs not relating to nature protection, access to nature reserves, environmental education, except for the road signs and other signs relating to public security and protection of public order;
19) to disturb the silence;
20) to use motor boats and other motor vehicles, play water sports, swim and sail yachts, with the exception of the waters or trails designated by the director of a national park, and in a nature reserve – by the respective regional director for environmental protection;
21) to perform earthworks causing permanent deformation of the topography;
22) to camp, except in the places designated by the director of a national park, and in a nature reserve – by the respective 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 respective regional director for environmental protection;
24) to introduce species of plants, animals and fungi without the consent of the Minister relevant 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 park director, and in a nature reserve without the permission of the respective regional director for environmental.

The above-mentioned bans in national parks do not apply to:

1) performance of the tasks arising from the protection plan or protection tasks;
2) carrying out rescue operations and activities related to general safety;
3) performance of national defence tasks in the case of threat to state security;
4) areas of protected landscape during their economic use by organizational units, legal entities or individuals exercising of ownership rights, in accordance with the provisions of the Civil Code.

Relevant prohibitions also apply to landscape parks.

There are no proven methods and agreements in Poland concerning the sharing of benefits from the use of FGR. If actions were to be taken to draw up a legal act regulating the matters of sharing benefits, attention should be given to ensuring that relevant provisions pertaining to foreign buyers and private owners of FBM be included in the act.

Table 1. Characteristics and area of forests (FRA)

Main forest characteristics	Area (ha)*
Primary forests	54 000
Naturally regenerated forests	394 000
Planted forests	8 889 000
Reforestation	451 300**
Afforestation	146 000**

* data for 2010 (County Report of the state forestry 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%	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)	
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
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

Table 5. Forest species currently used in Poland, with division into native (N) or exotic (E)

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)
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	
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
Pulp and paper
Energy (fuel)
Non-wood forest products (food, fodder, medicine, *etc*.)
Used in agroforestry systems
Other

Table 6. Main tree and other woody forest species providing environmental services or social values, with division into native (N) or exotic (E)

Species (scientific name)	Native (N) or exotic (E)	Environmental service or social value (code)
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
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 values include:

1. Soil and water protection including watershed management
2. Soil fertility
3. Biodiversity conservation
4. Cultural values
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 genetic conservation point of view

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: widespread (W), rare (R), or local (L)	Type of threat (Code)	High	Medium	Low
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		
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)				
Abies alba Mill.	N	3 955	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	1 553	94%	3.0%	1.0%
Fagus sylvatica L.	N	23 521	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	6 639	81%	11.0%	8.0%
Quercus petraea Liebl.	N	8 511	99%	1.0%	0.0%
Quercus robur L.	N	87 248	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 decidous	N	3 412	100%	0.0%	0.0%

* 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 seedlings from documented sources (provenance/ delimited seed zones)	Quantity of seedlings from tested (provenances /provenance trials established and evaluated)	Quantity of vegetative reproductive material used	Quantity of seedlings that are genetically improved
Scientific name	Native (N) or exotic (E)					
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 decidous	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
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
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	4 764
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**

Table 12. Seed and vegetative propagules transferred internationally per annum (average of last 5 years)

Species	Quantity of seed (kg)		Quantity of seed (kg) per annum		Number of vegetative propagules		Number of seedlings		Number of seedlings per annum		Purpose
	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	
Abies alba Mill.	5.00	0	1.00	0.00	0	0	100	363 565	20	72 713	for forestry purpose
Abies grandis	2.50	0	0.50	0.00	0	0	800	17 500	160	3 500	for forestry purpose
Acer platanoides L.	15.00	1 007	3.00	201.40	0	0	0	224 019	0	44 803,8	for forestry purpose
Acer pseudoplatanus L.	155.00	0	31.00	0.00	0	0	0	28 470	0	5 694	for forestry purpose
Alnus glutinosa Gaertn.	36.10	40	7.22	8.00	0	0	0	413 500	0	82 700	for forestry purpose
Betula pendula Roth.	26.25	9	5.25	1.80	0	0	0	1 557 375	0	311 475	for forestry purpose
Betula pubescens Ehrh.	1.00	0	0.20	0.00	0	0	0	5 000	0	1 000	for forestry purpose
Carpinus betulus L.	40.00	493	8.00	98.60	0	0	0	12 271	0	2 454.2	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.	9 178.60	3 340	1 835.72	668.00	0	0	0	738 599	0	147 719.8	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	15 525	0	3 105	for forestry purpose
Larix decidua Mill.	7.00	0	1.40	0.00	0	0	1 000	238 900	200	47 780	for forestry purpose
Larix eurolepis Henry.	6.90	0	1.38	0.00	0	0	0	370 025	0	74 005	for forestry purpose
Larix kaempferi Carr.	2.50	0	0.50	0.00	0	0	0	16 900	0	3 380	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	1 706.8	11.95	341.36	0	0	306 200	6 147 230	61 240	1 229 446	for forestry purpose
Picea sitchensis Carr.	1.88	0	0.38	0.00	0	0	0	41 990	0	8 398	for forestry purpose
Pinus cembra L.	95.00	0	19.00	0.00	0	0	1 250	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	1 000	0	200	0	for forestry purpose
Pinus sylvestris L.	7.75	1	1.55	0.20	0	0	0	53 325	0	10 665	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	27 750	136 800	5 550	27 360	for forestry purpose
Quercus petraea Liebl.	28 841.00	3 000	5 768.20	600.00	0	0	191 000	1 125 110	38 200	225 022	for forestry purpose
Quercus robur L.	7 844.88	0	1 568.98	0.00	0	0	111 000	1 590 900	22 200	318 180	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	3 000	0	600	0	for forestry purpose
Tilia cordata Mill.	0.00	990	0.00	198.00	0	0	200	479 085	40	95 817	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 Cranz.	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 program
**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 clo-nes sele-cted	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
** the list of progeny trials also includes seedling seed orchards which are used for genetic evaluation of plus trees
***data for clonal archives, which are not tested

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

*Generation refers to 1st, 2nd, 3rd, etc., breeding cycle.

Table 15a. A list of seedling seed orchards

Species (scientific name)	Seedling seed orchards		
	Number	Generation*	Area (ha)
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
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

*Generation refers to 1st, 2nd, 3rd, etc., breeding cycle.

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
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.					
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 conservation and use of forest genetic resources

Name of Institution	Type of Institution	Activities or Programmes	Contact Data
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 Cracow (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/jednost ka /wydzial_przyrodniczy
Adam Mickiewicz University in Poznań (Faculty of Biology)	University	Scientific research	www.biologia.amu.edu.pl
International Paper – Kwidzyn S.A.	Industrial plant	Experimental sites	www.internationalpaper.co m/POLAND/PL/Company/ Facilities/Kwidzyn.html

Table 18. Needs 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 sanction 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*,

*** Examples of activities:**

- Information exchanges
- Establishment of genetic conservation strategies
- Germplasm exchange
- Elaboration, submission and execution of joint research projects.

Other (Please specify)

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 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 our country – not specified

Use for poverty reduction

Species		Use for food security	Use for poverty reduction
Scientific name	Native (N) or exotic (E)		

Does not concern
Source of information

Table 23. Types and sub-types of forest soils (State Forests Information Centre, 2003)

No.	Soil type	Soil sub-type	Current symbol
1	Lithic Leptosols		**IS**
2	Haplic Regosols		**IR**
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**
5	Pelosols		**PE**
6	Rędzinas 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**
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**
		Haplis 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**
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 natural general potential vegetation map of Poland, legend units

<table>
<tr><th colspan="3">Community groups</th><th colspan="3">Description of potential natural vegetation cartographic unit</th><th rowspan="2">Total unit area [sq km]</th><th rowspan="2">[Unit share of country area [%]</th><th rowspan="2">Number of point marks on the map</th></tr>
<tr><th>I</th><th>II</th><th>III</th><th>Code</th><th>English name of potential community type</th><th>Latin name (associations and other units)</th></tr>
<tr><td rowspan="9">Hygrophilous deciduous forests</td><td colspan="2">Lowland alder and/or birch swamp or peat forests</td><td>1</td><td>Middle-European alder fen forest</td><td>Carici elongatae-Alnetum (=Ribeso nigri-Alnetum + Sphagno squarrosi-Alnetum)</td><td>6 474.0</td><td>2.069</td><td></td></tr>
<tr><td rowspan="7">Deciduous alluvial forests, as well as hygrophilous broadleaved and forb-rich forests on the ground-water soils</td><td rowspan="4">Lowland riparian forests</td><td>2</td><td>Lowland willow-poplar floodplain forest; regularly flooded</td><td>Salici-Populetum (=Salicetum albo-fragilis + Populetum albae)</td><td>4 395.3</td><td>1.405</td><td></td></tr>
<tr><td>3</td><td>Lowland ash-elm floodplain forest; occasionally flooded</td><td>Ficario-Ulmetum typicum</td><td>6 978.3</td><td>2.231</td><td></td></tr>
<tr><td>4</td><td>Lowland eutrophic forb-rich elm-oak forests on the ground-water soils out of floodplains</td><td>Ficario-Ulmetum chrysosplenietosum</td><td>4 401.6</td><td>1.407</td><td></td></tr>
<tr><td>5</td><td>Lowland alder and ash-alder forest on the periodically swamped ground-water soils</td><td>Fraxino-Alnetum (=Circaeo-Alnetum)</td><td>31 389.9</td><td>10.034</td><td></td></tr>
<tr><td rowspan="2">Submontane /montane Riparian forests</td><td>6</td><td>Submontane/montane grey alder floodplain forest</td><td>Alnetum incanae</td><td>1 570.9</td><td>0.502</td><td></td></tr>
<tr><td>7</td><td>Submontane forb-rich ash forests along streams and little rivers</td><td>Carici remotae-Fraxinetum</td><td>711.8</td><td>0.228</td><td></td></tr>
<tr><td colspan="3">Total riparian forests</td><td></td><td>49 447.8</td><td>15.806</td><td></td></tr>
<tr><td colspan="4">Total hygrophilous deciduous forests</td><td></td><td>55 921.8</td><td>17.875</td><td></td></tr>
</table>

	Lowland/submontane mesophilous broad-leaved forests, mostly 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	
			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, eutrophic ("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**	
	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**
	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*	534.0	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- (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	
			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- (rarerly fir-spruce-) forests	*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**	
	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 - so called steppelike 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*	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	in dam^3										
T O T A L	**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

* On the basis of 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 Environment Protection, www.gios.gov.pl**)**

Code	Type of natural (forest) habitat	Protection Recommendations
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 the 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 the existing one must be used with the utmost care to preserve the natural habitat.
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) ensure maintaining the favourable conservation status of the habitat. Due to its small area and high natural values, 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, admission of selection felling, or active protection like damming up water using gates, 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, *i.e*. 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 specimens examples of 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. ✓ 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. To consequently 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 over 100 years-old stands. ✓ 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 it needs thinning of the canopy of the stand to ensure the conditions of growth for thermophilous species deciding about 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, the lack, in some cases, of natural regeneration of fir do not pose 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 is from over-exploitation of stands in older age classes. **Protection recommendations:** maintain the current management, retain deadwood in the forest, supervise harvest in private forests. Prospects for the preservation of the habitat seem to be 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. A list of threats and potential conflicts between human activity and preservation of the habitat condition mainly consists of these types of human activity that are associated with forest management, mainly the removal of dead trees. Threats from tourism and plant collection seem to be less severe.
91Q0	Relic Western Carpathian calcicolous *Pinus sylvestris* forests	**Major threats:** Potential, mechanical damage by trampling. **Protection recommendations:** it is recommended to continue the current passive protection. 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 form 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, like removal of all slash and wood residue after management treatments, removal of pine and oak regeneration Reports seem 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 the 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 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	Cracow	Piwniczna, Forest Experimental Station in Krynica (University of Agriculture in Cracow)	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 n**	**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	21 197.3	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
Babia Góra	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 Sate Forests

Item	Forest District – store	RDSF	Conifers – maximum weight of stored seeds [kg]	Broadleaves – maximum weight of stored seeds [kg]	Notes	Number of cold store rooms	Temperature range in the cold store
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			1	Cold store with constant temperature 4-5°C
3.	Kaliska	Gdańsk	3 900.00	0.00	no possibilities to 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	Cracow	12.5 m^3	0.00	no possibilities to store seeds of deciduous species	2	a) 1 room from 0 to -6°C b) 2 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.
10.	Jarocin	Poznań	12 000.00	30 000.00		4	a) one room from 0 to -10°C. b) three room 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^{o}C
13.	Białogard	Szczecinek	6 000.00	29 300.00		5	a) two rooms to -10^{o}C. b) one room to -3^{o}C. c) two rooms +3^{o}C.
14.	Świerczyna	Szczecinek	0.00	16 000.00		2	+3 : -20^{o}C
15.	Rytel	Toruń	3 000.00	2 500.00		2	a) one room to -3^{o}C. b) one room to -9^{o}C.
16.	Jabłonna	Warsaw	400.00	15 000.00		3	a) two rooms from -3^{o}C to +3^{o}C. b) one stratification room from -3^{o}C to +25^{o}C
17.	Kostrzyca FGB*	Wrocław	10 000.00	15 000.00		11	a) two rooms +3^{o}C. b) four stratification rooms +15^{o}C: 20^{o}C. c) one room -3^{o}C. d) three rooms to -10^{o}C e) one room -20^{o}C
18.	Nowa Sól	Zielona Góra	3 000.00	6 960.00		5	a) two rooms +3^{o}C. b) one room -3^{o}C c) one room -5^{o}C d) one room -7^{o}C

Table 30. List of Botanical Gardens and Arboreta in Poland

Item	Name	Contact data	Area [ha]	Activities
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 at their natural occurrence Arboretum has a collection of rhododendrons, lilacs, junipers, clematises, barberries, hostas, dogwoods, ferns, aquatic and wetland plants. The Arboretum includes a stand of 180 year old trees. The Arboretum vegetation consists mostly of common plants widespread all over 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 Biskup 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 consists of 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 consists 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. Particularly numerous species are representatives of the woody flora of East Asia (Japan, Korea, China) and North America. The collections also consist of 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) along with a collection of aquatic and protected plants, a nursery, seed orchards, clonal archives of valuable species and "green school". The genetic resources/germplasm collected in the arboretum come from western Poland. Conifers are represented by 26 genera, with most numerous pine (more than 60 species and varieties, including dwarf varieties of European black pine (*Pinus nigra*)), spruce, fir, larch, juniper, false cypresses and cedars. Among deciduous trees and shrubs, species and varieties of maple, birch, magnolia and beech make up the largest collections. The collection of rhododendrons – about 300 taxa.
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 provenance: 5667 – Number of specimens: 35 750 As concerns the collections of woody plants, the Arboretum specializes particularly in several groups of plants: – coniferous trees and shrubs - botanical taxa – genus *Acer* L. – the National Collection

				– dendroflora of China – genus *Stewartia* L. **-** the National Collection – family Araliaceae, and in particular the genus *Eleutherococcus* Maxim. **-** the National Collection of – genus *Sorbus* L. The Alpinarium takes up 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 the mountains around the world. A small area in the Alpinarium is occupied by collections of **Polish flora** of protected, endangered and rare plants. In this section, as well as throughout the Arboretum one can find more than 80 endangered and legally protected plant species in Poland. **Collections of herbaceous plants** are mainly located 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). **Forest experimental sites** are small areas with alien species, set up for experimental purposes. The planted trees are subjected to tests and observations, which are designed to check the growth, health condition and productivity of individual species for forest management needs. The Arboretum consists 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	The number of species and varieties are around 2000, including 1500 trees and shrubs, genus *Rhododendron* – 470 species; the National Collection includes 60 individuals of the genus *Rhododendron, Lusatian* race.
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 consists of two main sections: the southern section with cultivars tree and shrub varieties, and the northern section (elevated - dominated by botanical species originating from the geographical areas of 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:	15,69	The Arboretum is a forest park with elements of landscape topography, thinned areas in the stands of trees, water bodies, paths, roads, footbridges, bridges and open-sided roofed shelters. Collections of trees and shrubs growing in the arboretum number **about 1000 species** and **varieties.** Sections:

		w.szumarski@olsztyn.lasy.gov.pl		✓ **The Polish Flora**. A collection of approximately 300 species and varieties of trees and shrubs is one of the finest and largest collections of trees and shrubs of native species occurring in Poland. ✓ **The Arboretum Collection**. Collections of more than 700 species and varieties of trees and shrubs. The most represented plants are the maples (more than 30 species), cotoneaster plants (29 species) and wild-growing honeysuckles and roses. The collections of junipers, spruces, firs and other coniferous species are also worth mentioning. ✓ **The Natural Forest**. This is 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	It consists of 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% from Europe. The conifers include nearly 100 taxa from 25 genera. Maple, magnolia, holly, dogwood, birch, and viburnum are among the best-represented genera of deciduous plants.
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 with 110-year-old oak trees covering an area of 1.01 ha serves today as a selected seed stand.
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 firs, spruces, pines, alders, oaks, shadbushes, euonymus, maples, dogwoods, and species of the families Caprifoliaceae, Cupressaceae, Juglandaceae, Ulmaceae, Berberidaceae, Rosaceae, Fabaceae and Rutaceae occurring in Poland in the wild, as well as 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: wild service (*Sorbus torminalis*), flowering specimens of common ivy (*Hedera helix*) creeping up the old trees. Also specimens of the protected, rare and endangered herbaceous species recorded in the Polish Red Data Book of Plants, as well as the 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 consists of the following sections - The Old Park with the hornbeam-lime alley, lime alley, specimens of: nootka cypress, Western red cedar, 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 oaks: red oaks and pin oaks, and Eastern hemlock; - The Animal Show Farm with bison, Polish horse, wild boar and fallow deer, the Museum of Forestry "Oficyna", and the “Powozownia and Owczarnia " complex.
15.	**The Forest Arboretum in 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	Since 1870, research has been conducted, *inter alia*, in the territory of the Arboretum to determine the suitability of alien species of trees for forest management. Experimental plots were established for this purpose. The Arboretum consists of two sections: Observation and Research. The Arboretum boasts over 800 species and varieties of trees and shrubs, both of native and foreign origin, particularly protected species. The scope of research includes acclimation and suitability of various species for forest purposes, preservation of forest genetic resources, collection of rare and endangered taxa, 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). Plant collection is divided into five sections: Ecological, Medicinal Plants, Ornamental Plants, Arboretum and Woodlands. 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 the Tatras (e.g. *Cochlearia tatrae*, *Saxifraga wahlenbergii, Delphinium oxysepalum, Oxytropis carpatica*). The collection of plants protected by law comprises about 70 species under strict or partial protection representing 18 per cent of all the protected plants in Poland. (e.g.. *Crocus scepusiensis, Cypripedium calceolus, Gentiana verna, Lilium martagon*).
19.	**The Botanical Garden of City 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	The number of taxa – 800. ✓ 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 other; ✓ Greenhouses with more than 340 taxa of plants from different climatic zones of the world.
20.	**The Botanical Garden, 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	Collections of plants are used for scientific research coordinated by the Institute of Plant Breeding and Acclimation (IHAR) in Radzikowo n. Warsaw. The research focuses mainly on collecting and assessing the gene resources of grasses.

21.	**The Botanical Garden in Forest Park of Culture and Leisure "Myślęcinek"**	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 forest communities (oak-hornbeam forests, floodplain forests, sycamore maple forests), aquatic and reed bed vegetation, meadows and grasslands; ✓ The Arboretum – forests of the North America, euxine forests, broad-leaved forests, tundra vegetation, trees and bushes from arid areas, sclerophyllous vegetation. Many collections and displays, *inter alia*, of beech, maple, rose, heather spp., plants under legal protection, evergreen plants, a spring garden will supplement the botanical resources of the Garden; ✓ The Garden of Conifers–is a composition in the shape of an amphitheatre in which shrub species are arranged in strips from the lowest towards the upper end with the groups of high trees. One can find here many species and varieties of fir, spruce, juniper, false cypress, Douglas fir, microbiota and ginkgo; ✓ The Alpinarium; ✓ Collections of Plant Genera– collections of pines, rhododendrons, lilacs, cherry and apple blossom garden, magnolias, spireas and dogwoods; ✓ Thematic Expositions; ✓ The Agrobotanical Garden; ✓ The Botanical Trail for the blind and partially sighted persons.
22.	**The Botanical Garden of the Adam Mickiewicz University in Poznań**	ul. Dąbrowskiego 165 60-594 Poznań e-mail: obuam@amu.edu.pl e-mail: 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 Maria Curie-Skłodowska University in Lublin**	ul. Sławinkowska 3 20-810 Lublin e-mail: botanik@hektor.umcs.lublin.pl	21,25	**Number of taxa:** 6700 Plant collections used for didactic and educational purposes, as well as for research conducted by the staff and students of Lublin universities.

		tel. (81) 743 49 00; (81) 742 67 00 Director: dr Grażyna Szymczak		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
24.	**The Botanical Garden of the Jagiellonian University in Cracow**	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	The number of taxa in the collection: about 5000 cycads, orchids, carnivore plants, succulents, epiphytes, tropical utility plants, palms. Scope of activity: ✓ Studies on rare and endangered species are conducted in southern Poland, mainly in the Carpathians. ✓ Studies on 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 and botany during the Renaissance and the nineteenth century, the history of herbaria, the history of Polish names of plants, etc., ✓ 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	22	Collections of over 5000 species. Purpose – to preserve the biodiversity of both wild-growing plants and cultivars. 20 years of research and monitoring of the population of almost 50 species of

		Director: dr Hanna Werblan-Jakubiec		plants in north-eastern Poland, including rare species such as: Jacob's ladder (*Polemonium caeruleum*) and cloudberry (*Rubus chamaemorus*). Several years ago, the first in Poland collection of endangered native varieties of ornamental trees and shrubs was started to be built, almost 20 old cultivars have been saved so far from disappearance – including *Acer pseudoplatanus 'Foliis Atropurpureis Argenteovariegatis', Alnus glutinosa 'Pyramidalis', Alnus incana 'Foliis Aureomarginatis', Robinia pseudoacacia 'Rozynskiana'.* The Garden carries out taxonomic research, using the methods of molecular biology. Particularly interest is 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	**Numer of taxa:** about 12 000 ✓ **The Plant Taxonomy Section** is located in the central part of the Garden, arranged according to the Adolf Engler system; ✓ **The Alpinarium** – containing mountain and rock vegetation; ✓ **The Arboretum** – its eastern part is an English-style park, with trees and shrubs of the temperate zone of Europe, Asia and America; ✓ **The Educational Section** with expositions presenting various morphological, ecological and physiological aspects, plants protected by law, the "Green Class" pavilion and **collections of vines** and Polish varieties of ornamental plants; ✓ **The Aquatic and Wetland Plant Section** includes vegetation of the semi-natural pond, the pool with a collection of water lily (Nymphaea), several smaller outdoor reservoirs, and 29 tropical freshwater aquariums with a capacity of 1200 litres each; ✓ **The** tropical and subtropical terrestrial plants, including bromeliads (Bromeliaceae), aroids (Araceae), orchids (Orchidaceae), and 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 e-mail: sekretariat@botaniczny.lodz.pl Director: dr Dorota Mańkowska	64	Plant collections in the Garden currently count more than 3000 taxa, 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, among others, the dawn redwood (*Metasequoia glyptostroboides)*, asunaro (*Thujopsis dolabrata)* and varieties of Japanese Cherry (*Prunus serrulata)* are grown here: ✓ **The Alpinarium** – (4.5 ha) is located on four hills enclosed by granite, limestone and sandstone blocks of rock brought in from the quarries from all over Poland. The foot of the hills and their slopes are covered by trees and shrubs. Of special interest are: Serbian spruce *Picea omorica*, Caucasian

				spruce *Picea orientalis* and a variety of White cedar with characteristic filamentous shoots *Thuja occidentalis* 'Filiformis'. In addition to trees and shrubs, perennials, mostly low- and cushion-forming species can be found in the Alpinarium; ✓ **The Arboretum** – most of the species do not exceed the age of 30 years. The most interesting are: the bald cypress *Taxodium distichum* and honey locust *Gleditsia triacanthos*; ✓ **The Polish Flora** (9.6 ha) – post-nursery trees, over 50 year-old monocultures of pedunculate oak (*Quercus robur*), beech (*Fagus sylvatica*), gray alder (*Alnus incana*) and common hornbeam (*Carpinus betulus*). The collections of rare and endangered species are located 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 approximately 100-year-old lime trees: small-leaved lime (*Tilia cordata*), large-leaved lime (*Tilia platyphyllos*) and silver lime (*Tilia tomentosa*). No less impresive are flower beds with perennials covering 1600 m^2 and beech (*Fagus sylvatica*) hedges of over 25 years of age; ✓ **The Plant Biology Section** (5 ha) – the collections illustrate various aspects of plant biology, such as morphology of shoots and foliage and their transformations, differences in the shape of trees and shrubs, the 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, 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 the native flora, such as the stinging nettle (*Urtica dioica*) and German chamomile (*Matricaria chamomilla*), the species of foreign origin grow well here, like borage (*Borago officinalis*), common thyme (*Thymus vulgaris*) and purple coneflower (*Echinacea purpurea*).

28.	**The Garden of Medicinal Plants, 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 grouped in four sections: Plant Taxonomy Section, Medicinal Plant Section, Ornamental Plant Section and 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	In the Garden there are approximately 1500 taxa, of which more than 400 were the object of detailed studies on acclimation, breeding, cultivation and phytochemistry, and created the basis 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	It is one of the oldest gardens in Europe of this type. Its unique collection contains 17 thousand plants of 1100 species.
31.	**The Polish Academy of Sciences Botanical Garden – 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: Arboretum, Collection of Polish Flora, Ornamental, Utility and Exotic Plants.
32.	**The "Botanical Garden" 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	Currently, the Garden has over 300 species and taxa of lower order of trees and shrubs, broadleaves and conifers, of native and foreign origin, including the unique and relict species. Phytogeographically-alien species come mainly from Asia and North America. There is a small share of trees and shrubs originating from the Mediterranean area, including North Africa. Half of them are plants from their natural range in Europe. 15 species of trees and shrubs growing in the Garden are legally protected (*inter alia*, shrubby birch, dwarf birch, mezereon, Swiss pine, dwarf cherry, bladdernut).

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 in favour of conservation of biological diversity, ecological and natural education and the development of attitudes conducive to the realization of sustainable development. The Laboratories of Ornamental Plants Collection, Scientific Research and Conservation Collection and Habitat Collection carry out one of the main statutory objectives of the Silesian Botanical Garden, which is growing plants of the selected species and conservation of biological diversity in accordance with the Decision of the Minister of the Environment of 7 February 2006 on.
34.	**The Orle Arboretum**	83-420 Liniewo Orle 35 Tel. (58) 687 94 15 Maria i Klaudiusz Buzalscy e-mail: mariabuzalska@wp.pl		
35.	**The Podlaski Botanical Garden**	Koryciny 73B, 17-315 Grodzisk e-mail: biuro@darynatury.pl tel. (85) 656 86 68; (85) 656 86 62; 502 646 947 mgr Mirosław Angielczyk		A total of 700 species of plants. The Garden collected almost all utility plant species occurring in Poland and in a large part of Europe. It serves scientific studies on the preservation of natural habitats of medicinal plants. The 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, 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		

Table 31. Declarations and Resolutions adopted at Ministerial Conferences for the protection of forests in Europe (MCPFE)

Ministerial Conference/location	Data	Declarations	Resolutions
I MCPFE Strasbourg. France	18 December 1990	Strasbourg Declaration	• Resolution S1 "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 the Biodiversity" • Resolution H3 "Cooperation with Countries with Economies in Transition" • 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 "Economic Viability of SFM" • Resolution V3 "Social and Cultural Dimensions of SFM" • Resolution V4 "Forests Biological Diversity" • 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 of the EU

Country	Date of Agreement	Status	Agreements and memoranda
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 cooperation in the field of environment.

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 Department of the Environment and the Department of Industry of Canada on cooperation in the field of environmental protection, with an Annex of June 2000 on joint implementation projects, extended with amendments till 2014.
	15.06.2000	In force	Memorandum between the Minister of Environmental Protection, Natural Resources and Forestry of the Republic of Poland and the Department of the Environment and the Department of 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 Department of the Environment and the Department of Industry of Canada on cooperation in the field of environmental protection.

Table 33. Agreements with European countries outside of the EU

Country	Date of Agreement	Status	Agreements and memoranda
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).
	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 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 in the field of prevention of industrial accidents, natural disasters and liquidation of their consequences.
	25.08.1993	In force	Agreement between the Government of the Republic of Poland and the Government of the Russian Federation on cooperation in 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 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 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 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 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 Poland and the Government of Ukraine on cooperation in the field of water management on border waters.
	19.02.2002	In force	Agreement between the Government of the Republic of Poland and the Cabinet of Ministers of Ukraine on cooperation and mutual assistance in the field of prevention of disasters, natural calamities and other extraordinary events, and removal of their effects.

Table 34. Bilateral agreements with EU countries

Country	Date of Agreement	Status	Agreements and memoranda
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	The agreement between the Minister of the Environment 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 in the field of water management on border waters.
	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.
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 (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 (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.
	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 of Environmental Protection.
	19.05.1992	In force	Agreement between the Republic of Poland and the Federal Republic of Germany on cooperation in the field of water management on border waters.
	07.04.1994	In force	Agreement between the 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 Polish 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.

	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 water management on 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 combating of pollution of the Baltic Sea.
	01.10.1999	In force	Agreement between the Government of the Republic of Poland and the Government of the Kingdom of Sweden on the implementation of debt 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
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	Cartagena Protocol on BioBiosafety to the nvention 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
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 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
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)	
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 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 pertains to 2007

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 – years old Scots pine (*Pinus sylvestris* L.) of European provenances. IUFRO Symposium Kaunas ,p. 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 64/68 na powierzchni doświadczalnej w Krynicy. Sylwan, 133(11-12): 19-30.

Bałut S., Kulej M., 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 1964/68 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 1964/68 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. Zesz. Nauk. AR 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. [W:] Hodowla dębów w Polsce. Wybrane zagadnienia. Opr. zbiór, pod red. P. Rutkowskiego. Idee ekologiczne, 16: 35-44. Publisher 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.). Spraw. 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.). Spraw. 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.) Spraw.

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* (Matt.) Liebl.) w doświadczeniu proweniencyjnym z 1993 r. Zeszyty Naukowe Akademii Rolniczej im. Hugona Kołłątaja w Krakowie nr 394: 189-198.
Barzdajn W. 2002. The variability of dimensions of *Quercus robur* L. and *Q. petraea* (Matt.) Liebl. acorns in Poland. Dendrobiology 47: 21s–24s.
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. W: 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* [Matt.] 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 1: 79-85.
Bernadzki E. 1995. Półnaturalna hodowla lasu. Ochrona różnorodności biologicznej w zrównoważonej gospodarce leśnej. Warszawa, 45-51.
Bernadzki E. 2006. Lasy i leśnictwo Krajów Europejskich i ich organizacja. CILP, Warszawa.
Brincken J. 1828. Mèmoire Descriptif sur la Forêt Impèrial de Białowieża en Lithuanie. Varsovie, 1828: fragments translated by J.J. Karpiński in: „Białowieża". Warszawa, 1947. „O żubrze litewskim i polowaniu na niego". (translator D.W.) Sylwan 1828, Nr. 1-3. O Puszczy Białowieskiej (translator D.W.) Dziennik Warszawski Nr 11, 1826, Sylwan 1827, Nr 3.
Broda J. 1965. Puszcze karpackie i sudeckie. W: Polskie Towarzystwo Leśne, Stoważyszenie 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.). Publisher Centrum Informacyjne Lasów Państwowych, Warszawa:

597 – 617.
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, nr 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, Białystok, (typescript).
Chmura D.J. 2002. Bud burst phenology of Polish provenances of pedunculate (*Quercus robur* L.) and sessile (*Q. petraea* (Matt.) 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 Pulawy (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, France: 76 – 83.
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, Publisher SGGW, Warszawa: 34-37.
Choiński A. 2006. Katalog jezior Polski. Wydawnictwo Naukowe UAM, Poznań: 234, 416, 575.
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, 27th-28th 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. Wyd. Instytut Badawczy Leśnictwa, Sękocin Stary: 314-325.
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, w: Materials for the Conference: Postępowanie z drzewostanami „przejściowymi"

w nadleśnictwach Leśnego Kompleksu Promocyjnego „ Lasy Puszczy Białowieskiej”. Białowieża, (typescripts).
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. Warszawa 1993, (typescripts).
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. Warszawa 1994, (typescripts).
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). Warszawa 1995, (typescripts).
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), Warszawa 1998, (typescripts).
Dederko B. 1958. Handel „towarem leśnym” w Polsce w XVIII wieku. Sylwan, Nr 8.
Dederko B. 1926. Polityka leśna Litwy za Zygmunta Augusta. Las Polski 1926, Nr 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 L 206/7.
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 Uniw. 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: 97-142.
Faliński J.B. 1986. Vegetation dynamics in temperete forests. Ecological Studies in Białowieska Forest. Junk Publ. 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. Lasy Państwowe. 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. Arboretum Kórnickie 43: 67-78.
Fober H. 1999. Wewnątrzgatunkowa zmienność dębu szypułkowego (*Quercus robur* L.) w doświadczeniu proweniencyjno-rodowym. Arboretum Kórnickie 44: 59-72.
Fober H., Rożkowski R. 2006. Ocena polskich ras dębu szypułkowego (*Quercus robur* L.) i bezszypułkowego (*Q. petraea* (Matt.) Liebl.) testowanych w doświadczeniu proweniencyjnym w Kórniku. Sylwan (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. Publisher Instytut Badawczy Leśnictwa, Sękocin Stary: 43-62
***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, 29th-30th June 2006., Poland. Sękocin Stary: 94-104.
Giertych M. 1977. Genetyka. [In:] Świerk pospolity. *Picea abies* (L.) Karst. Nasze drzewa leśne. PWN Warszawa - Poznań, s. 287-331.
Giertych M. 1978. Plastyczność polskich ras świerka (*Picea abies* (L.) Karst.) w świetle doświadczenia IUFRO z lat 1964-1968. Arbor. Kórnickie 23: 185-206.
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. Arbor. Kórnickie 25: 135–160.
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, 1993.
Giertych M. 1998. Genetyka. Zmienność proweniencyjna i dziedziczna. [In:] Biologia świerka pospolitego. Bogucki Wydawnictwo Naukowe Poznań. 213-239.
Giertych M. 1999. Wartość genetyczna świerka z północno-wschodniej Polski.39-60. In: Materials from the conference Genetyczna i hodowlana wartość polskich populacji świerka z zasięgu północno-wschodniego. In: Materiały z konferencji 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), Forest Research Institute, Warsaw: 59 – 78.
Giertych M. 2002. Troska o bioróżnorodność. Sesja naukowa nt. „Zagospodarowanie oraz wartość genetyczna populacji drzew gatunków domieszkowych i introdukowanych w aspekcie stabilizacji ekosystemów leśnych Karpat". Zeszyty Naukowe Akademii Rolniczej w Krakowie, nr 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). Szkoła Główna Gospodarstwa Wiejskiego w Warszawie. Doctoral thesis, 2010.
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, Country Report Poland, FRA 2010/166, 2010. 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. (red.). Materiały Międzynarodowej Konferencji, Sękocin Stary, 29-30 June 2006, Poland. Sękocin Stary: 105-123.
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. Instut 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, Nr 6.
Hartman W. 1939. Wypalanie potażu bartnictwo i łowiectwo w dawnej Puszczy Białowieskiej. Echa Leśne, No. 7 and 9.
Hedemann O. 1939. Dzieje Puszczy Białowieskiej w Polsce przedrozbiorowej (w okresie do 1798 roku). Warszawa, 1939.
Heuertz M. 2003. Population genetic structure in common ash: a focus on southeastern European genetic resources. doctoral thesis, Free University of Brussels, Belgium and the Public Research Centre - Gabriel Lippmann, Luxembourg.
Instrukcja wyróżniania i kartowania siedlisk leśnych - Załącznik do Zarządzenia Nr 43 Dyrektora Generalnego Lasów Państwowych z dnia 18 kwietnia 2003 r. 2003. 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, Cracow.
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 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 (*Fraxinus angustifolia*). *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. IBL, Warszawa, p. 78-99.
Kocięcki S. 1977. Zmienność. In: Świerk pospolity *Picea abies* (L.) Karst. Nasze drzewa leśne. PWN, Warszawa - Poznań, p. 37-62.
Kocięcki S. 1987. Badania nad wzrostem i formą modrzewia i przydatnością różnych

pochodzeń. (a typescript document). Instytut Badawczy Leśnictwa, Warszawa.
Kocięcki S., 1990. Wykaz uznanych drzewostanów nasiennych. DGLP, IBL, Warszawa.
Kondracki J. 1998. Geografia regionalna Polski. Wydawnictwo Naukowe PWN, Warszawa 1998.
Konstytucja Rzeczypospolitej Polskiej z dnia 2 kwietnia 1997 r. Dz.U. 1997, 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, Nr 8.
Kowalczyk R., Ławreszuk D., Wójcik J. M. 2010. Ochrona żubra w Puszczy Białowieskiej. Zakład Badania Ssaków PAN 2010, 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 sylvest*ris L.). Spraw. 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-years 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, Lviv, Ukraine.
Kowalski T. 2006. *Chalara fraxinea* sp. nov. associated with dieback of ash (*Fraxinus excelsior*) 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. Wyd. Instytut Badawczy Leśnictwa, Sękocin Stary: 83-100.
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 pf 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, Forestry, http://www.ejpau.media.pl/plvolume9/issue2/art-29.htlm.

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 eksperimental forest. Electronic Journal of Polish Agricultural Univesities, Forestry (http://www.ejpau.media.pl/volume8/issue4/art-l0.html).

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 matting 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 common 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. Wyd. Instytut Badawczy Leśnictwa, Sękocin Stary: 13-17.

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. Mol. Ecol. 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. Spraw. Nauk., 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, IBL, Warszawa.
Matras J., 1996. Rejestr bazy nasiennej w Polsce. DGLP, IBL, Warszawa.
Matras J. 2006. Wytyczne wykorzystania populacji świerka pospolitego na skale gospodarczą. IBL DGLP:(1- 37).
Matras J. 2006 a. Badania porównawcze populacyjnej i rodowej zmienności cech hodowlanych wybranych pochodzeń świerka pospolitego (Picea abies Karst.). Wyd. IBL Warszawa.
Matras J. 2006 b: 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. Z.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). Spraw. 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). Kazimierz Wielki University, 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. Arbor. Kórnickie 21: 125-187.
Mejnartowicz L. 1979. Polymorphism at the LAP and GOT loci of *Abies alba* Mill. Populations. Bull. Acad. Pol. Des Scien. Biol. 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 silver-fir populations in the Beskides. Acta Soc.Bot. 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 Silver-fir Populations in the North Carpathian and Sudeten Mountains. Acta Soc. Bot. Polon. 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. Szafer Institute of Botany, Polish Academy of Sciences Instytut Botaniki im. W. Szafera, Polska Akademia Nauk, Kraków, Cracow.
Misiorny A. 2007. Występowanie obupłciowych kwiatów na świerku pospolitym. Sylwan 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* (Matt.) Liebl. in Germany. In: Müller-Starck, G. and Ziehe, M. (eds) Genetic Variation in European Populations of Forest Trees, pp. 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 Pr. Bad., 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), ss. 4.
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, FRI, PROFOREST Centre of Excellence, Warsaw 2005, 9-24.
Nowakowska J. A. 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, IBL Warszawa 2007, ISBN 978-83-878647-70-4,118 pages.
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 nr 13 (2010): 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, realized: 1.01.2001 - 31.12.2005. Dokum. naukowa Inst. Bad. Leś. Warszawa, 112 pages.
Nowakowska J., Bieniek J., Jabłonowski S. 2006. RAPD polymorphism of Norway spruce (*Picea abies* 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 nr 13 (2010): 37-53.
Nowakowska J., Jabłonowski S., Mockeliūnaitė R., Bieniek J. 2004. Comparison of genetic variability within and among Polish and Lithuanian populations of common 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. Leś. Pr. Badaw. 2007/3: 33-51.
OECD scheme for the control of forest reproductive material moving in international trade. 2001. Orgaznization for Economic Co-operation and Development, Paris 1974 (including 2001 amendment): (1-28).
Ogris N., Hauptman T., Jurc D., Floreancig V., Marsich F., Montecchio L. 2010. First report of *Chalara fraxinea* on common ash in Italy. *Plant Disease* **94**(1): 133.
Oleksyn J., Reich P.B., Chalupka W., Tjoelker M.G. 1999. Differential above- and below-ground biomass accumulation of European *Pinus sylvestris* populations in a 12-year-old provenance experiment. Scand. J. For. Res. 14 (1): 7 - 17.
Oleksyn J., Reich P.B., Tjoelker M.G., Chalupka W. 2001. Biogeographic differences in shoot elongation pattern among European Scots pine populations. For. Ecol. Manage. 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. IBL, Warszawa, maszynopis.
Plany urządzenia lasu Nadleśnictw Białowieża 2001. Browsk, Hajnówka for the period 01.01.2002 – 31.12.2011, Białystok, typescript.
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 2006r., 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. Wyd. Instytut Badawczy Leśnictwa, Sękocin Stary: 29-42.
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. Wyd. Instytut Badawczy Leśnictwa, Sękocin Stary: 24-26.
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. PTL, Gdańsk, 34-44.
Podstawy strategii zarządzania Puszczą Białowieską. 2001. Joint publ.: Członkowie GR Projektu DANCEE Puszcza Białowieska, Białowieża.
Polak-Berecka M. 1999. Określenie zmienności genetycznej drzew doborowych wybranych prowieniencji świerka pospolitego *[Picea abies* (L.) Karst.] z terenu Karpat metodą markerów izoenzymowych. Zeszyty Naukowe AR 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 AR 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, 151(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, Białowieża, typescirpt.

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 publ., Białowieża, typescript.
Prus - Głowacki, W., Bielewicz A., **Modrzyński J. 2007.** Struktura genetyczna populacji świerka (Picea abies) z dolnego i górnego regla Karpat i Sudetów. Zeszyty Naukowe AR w Krakowie. Sesja Naukowa 439. Z.92. Ochrona i zachowanie leśnej bioróznorodności w Karpackim Banku Genów. Rola świerka pospolitego i innych gatunków w azachowaniu 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. Zlecenie DGLP Warszawa, typescript.
Przybył K. 2002. Przyczyny zamierania drzew i drzewostanów jesionowych w Polsce. Projekt badawczy zlecony przez DGLP, Instytut Dendrologii PAN w Kórniku, Kórnik.
Przyczyny i ocena zagrożenia drzewostanów Puszczy Białowieskiej przez kornika drukarza w latach 2000-2001, 2001. Materials from a semina, Białowieża, typescript
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 Przyr. Ojcz. 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. Dokum. naukowa Inst. Bad. Leś. Warszawa, November 2005, 112 pages.
Raport o stanie lasów w Polsce 2010. 2011. Dyrekcja Generalna Lasów Państwowych, 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. Wyd. Instytut Badawczy Leśnictwa, Sękocin Stary, 291-313.
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. 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 rozprzestrzenianiu 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 AR 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, R.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 Polisch 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 Depatrment 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, T.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, p. 3.
Rzeźnik Z. 1980. Zmiany w jakości drzew sosny zwyczajnej po cięciu pielęgnacyjnym na powierzchni proweniencyjnej w LZD Siemianice. Roczniki AR 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 AR 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 N-ctwie Wisła. Project typescript. RDLP Katowice. Zakład Nasiennictwa, Szkółkarstwa i Selekcji Drzew Leśnych AR 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 AR 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 AR w Krakowie, 358, ser. Sesja Naukowa, 69: 139-152.
Sabor J. 2002. Doświadczenie proweniencyjne modrzewia w Kolanowie pod Bochnią. Zeszyty Naukowe AR 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 86/90 Zeszyty Naukowe AR 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. Joint publ. Ed. S. Kowalski. Wyd. CILP, Warszawa, 176-187.
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 1964/68, 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 syhatica* 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, 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. Institute of Dendrology. Kórnik ss. 266.
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 86/90 w Nadleśnictwie Baligród. Zeszyty Naukowe AR 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 AR 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* Mili.) w doświadczeniu proweniencyjnym Jd PL 86/90. Zeszyty Naukowe AR 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 86/90. 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: 403^114.
Skrzyszewska K., Sabor J. 2007. The genetic value of Polish Carpathian provenances of silver fir *(Abies alba* Mill.) in the experiment Jd PL 86/90. 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 from 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. Ochr. Przyr. 1991, 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 Forest. Pol., Series 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 199l, 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. Białowieża.
Sokołowski A. W. 1998. Charakterystyka oraz inwentaryzacja lasów naturalnych na terenie Nadleśnictw: Białowieża i Browsk. IBL Zakład Lasów Naturalnych, Białowieża 1998.
Sokołowski A. W., Wołkowycki M. 2000. Uzupełnienie do flory roślin naczyniowych Puszczy Białowieskiej. Parki Nar. Rez. Przyr., (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. 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 No 73, 2010; 15-23.
Sułkowska M., Kowalczyk J., Przybylski P. 2008. Zmienność genetyczna i ekotypowa buka zwyczajnego (*Fagus sylvatica* L.) w Polsce. Leś. Pr. Bad.,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, no. 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, 1989, t. 40, nr 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. Spraw. Naukowe IBL.
Szmit Z. 1923. Zarys geologiczny i przyczynek do badań archeologicznych Puszczy

Białowieskiej. Białowieża, 2: 7-27.
Szujecki A. 1992. Raport o stanie Puszczy Białowieskiej. Warszawa, typescript.
Szujecki A. (ed.) 2001. Próba szacunkowej waloryzacji lasów Puszczy Białowieskiej metodą zooindykacyjną. SGGW, Wyd. Warszawa.
Ścibor J. 1958. Bobry w Puszczy Białowieskiej. Las Polski, Nr 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, Rzeczypospolitą 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 2003r. L 236.
Trampler T., Kliczkowska A., Dmyterko E., Sierpińska A. 1990. Regionalizacja przyrodniczoleśna 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, Springer, Dordrecht, The Netherlands: 97-106.
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 condition. Microbial Ecology 236: 375-384.
Tyszkiewicz S. 1969. Population studies of Norway spruce in Poland. IBL 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 UR 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. 1227z 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, Nr 10.
Walankiewicz W., Czeszczewik D., Mitrus C., Bida E., 2002. Znaczenie martwych drzew dla zespołu dzięciołów w lasach liściastych Puszczy Białowieskiej. Not. Orn., 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. Wyd. Instytut Badawczy Leśnictwa, Sękocin Stary: 18-28.
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, Nr 8.
Zaręba R. 1962. „Ogrody do polowania" w Puszczy Białowieskiej w czasach Stanisława Augusta Poniatowskiego. Sylwan , Nr 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. Białystok, typescript.
Zasady postępowania w drzewostanach gospodarczych i ochronnych Puszczy Białowieskiej zagrożonych przez korniki, 2008. Materiały z seminarium, Białowieża, maszynopis.
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. Zesz. Probl. Post. Nauk Roln. 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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