Synthesis of Country Progress Reports
July 2020

The International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment (IPC)

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The IPC would like to express our gratitude to the National Commissions of Austria, Bulgaria, Canada, China, Croatia, Egypt, Germany, Iran, Ireland, Italy, Korea, New Zealand, Portugal, Slovenia, South Africa, Spain, Sweden and Turkey for fruitful collaboration and national reports provided.

The scope and diversity of information available on natural and planted forests consisting of poplars, willows and other fast-growing species is reflected by the range of authors, from many IPC-member countries.

It is with appreciation that the efforts of the National Commission personnel are recognized for submitting Country Progress Reports in compliance with the general textual and statistical guidelines, which facilitated preparation of the global synthesis.

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FOREWORD

The International Poplar Commission (IPC) has been working since 2012 to Reform its Convention and organization to maintain its relevance for today's challenges, and in 2019 received a mandate from its Member Nations to work not only on species important in temperate and boreal climate zones (the poplars, willows, and cottonwoods), but on any fast-growing tree species that can further the IPC mandate. The title of the Commission became therefore the "The International Commission on Poplars and Other Fast-Growing Trees Sustaining People and the Environment".

This synthesis report was compiled during the COVID-19 pandemic in 2020 from the available country progress reports. It highlights status, innovations, issues and trends in regards to cultivation, management and utilization of poplars, willows and other fast-growing species.

Seventeen member countries of the International Poplar Commission (IPC) have submitted country reports in 2020: Austria, Bulgaria, Canada, China, Croatia, Egypt, Germany, Iran, Ireland*, Italy, Korea, New Zealand, Portugal, Slovenia, South Africa*, Spain, Sweden and Turkey. In these countries, poplars, willows and other fast-growing species are grown in indigenous or planted forests, agroforestry production systems and as distinctive landscape components for protective and productive purposes.

Country reports provided detailed information on topical issues, statistics, innovations and trends in poplar and willow culture and use. Due to challenges in submission created by the coronavirus quarantine measures around the world and postponement of the 26th IPC Session from October 2020 to March 2021, IPC member ccountries may be requested to produce updates or provide full reports in 2021.

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HIGHLIGHTS OF THE REPORT

The synthesis of country progress reports offers information on status, research advancements and issues concerning poplar and willow cultivation and use during the period 2016 to 2019, as reported more extensively by member countries of the International Poplar Commission for the 26th Session of the IPC. In total, 17 member countries of the IPC reported for this period.

Policy and legal framework

- Fast-growing species have a high potential to produce raw materials for renewable products, liquid biofuels and bioenergy, and that plantations with fast-growing species on agricultural land have threefold biomass production potential compared to forestland

Taxonomy, nomenclature and registration

- Programmes concerning the genetic modification of poplars and willows continue to be actively pursued, both in developed and developing countries. They report significant progress in genetic characterization and manipulation to enhance resistance against pests, diseases and other stresses, namely drought or flooding, improve technical properties as well as growth and yield, particularly with the objective of biomass production.

Domestication and conservation of genetic resources

- Most countries reported on their efforts to preserve the genetic resources of poplars and willows and to optimize breeding and selection of fast-growing plantations. Work focused mainly on improving the attributes of planting material in terms of productivity, wood density, higher resilience to climatic conditions and diseases, phytoremediation and biodiversity conservation.

Plant health, resilience to threats and climate change

- Various research projects are underway to better understand the life cycles and infestation patterns of damaging pathogens, and to determine the most effective treatments.
- In the reporting period historically extreme climatic conditions greatly influenced the phytosanitary situation of fast-growing plantations.

Sustainable livelihoods, land use, products and bioenergy

- Certain measures of state policy on the use of land, as well as fiscal and incentive measures (tax exemption, credit, provision of plant material and technology support) could help poplar and willow cultivation on privately owned marginal land.
- Pulp, paper and plywood are the major products from commercial poplar plantations, but there has been a growing interest in the use of poplar wood for higher-value products such as fibre boards, particle boards, oriented-strand boards (OSB) and furniture.

Environmental and ecosystem services

- Fast-growing species have been extensively used in many countries to establish shelterbelts and windbreaks to protect agricultural and horticulture fields and fruit orchards, to preserve coastal and riparian buffer zones, and to control erosion, sediment transport and desertification.

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- The use of poplar and willow trees in environmental phytoremediation applications continues to be studied and explored in various research projects.

National poplar commissions and international cooperation

- Many member countries reported that they had increased strategic cooperation with other countries, international organizations, and professional networks.
- Cooperation focuses in particular on the transfer of knowledge and technology, and on the planning and implementation of joint research programs.

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I. INTRODUCTION

The main aim of this synthesis is to identify issues, innovations and trends in terms of poplars, willows and other fast-growing species' culture and use as reported by IPC member countries. A secondary purpose is to draw the attention of IPC members and individuals to the rich diversity of experience documented in the national reports, which are available on the IPC website.

Poplars, willows and other fast-growing species have become significant resources in agriculture and forestry, which are ideally suited for supporting rural livelihoods, enhancing food security, alleviating poverty and contributing to sustainable development. They provide raw material supplies for industrial purposes and valuable non-wood products (e.g. livestock fodder, medicinal extracts, food products).

Poplars, willows and other fast-growing species are highly valued for the provision of social and environmental services including shelter, shade and protection of soil, water, crops, livestock and dwellings. They are more and more used in phytoremediation of severely degraded sites, rehabilitation of fragile ecosystems, combating desertification and in forest landscape restoration. They are effective at sequestering carbon and as carbon sinks, thus contributing to the adaptation to and mitigation of the effects of climate change.

This synthesis report is complemented by a comprehensive listing of reference documents released during 2016 – 2019 by member countries, encompassing more than 1000 technical publications.

In total, 17 member countries of the IPC reported for the 2016-2019. The synthesis follows the structure of the National Reporting Guidelines. It will be presented online to the 26th IPC-Session and will also be posted on the IPC website.

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II. POLICY AND LEGAL FRAMEWORK

This section summarizes major developments in national policies, laws, or regulations, which affected the cultivation and utilization of poplars, willows and other fast-growing trees, in natural forests, planted forests and agroforestry. It includes relevant policies concerning growing, harvesting, marketing, transportation, utilization and trading of poplars, willows and other fast-growing trees; financial, fiscal or other incentives, environmental regulations which affect the growing of poplars, willows and other fast-growing trees; and policies promoting the emerging use of poplars, willows and other fast-growing trees for bioenergy (including fiscal incentives, subsidies etc.), carbon sinks and other environmental uses.

Fast-growing species continue to be used for afforestation purposes through establishment of protective forests. Jurisdiction over forestry and environmental policy mainly rests with the local governing bodies. In the reporting period, numerous successful projects were conducted through joint action of forest authorities. National Forestry Frameworks are being revised to respond to climate change by managing and improving the role of forests as carbon sinks and to contribute to the realization of low carbon society. National programs derived from national and international frameworks and strategies have a direct effect on the use of fast-growing species, while their harvesting and utilization for industrial products (wood, bioenergy or other commercial purposes) generally depends on the manufacturing capacities and forest management plans. Through various funding programs and initiatives focused on climate change, environmental sustainability and the development of new products and processes, national governments encourage planting, harvesting and utilization of fast-growing species and improved technical training of forestry employees.

Austria (p.2) indicated that the general legal setting for the cultivation and utilization of fast-growing tree species in forests has not changed. A specific regulation by the relevant Government Ministry lists tree species that may be grown under rotation regimes that are shorter than standard forestry practice. These are Douglas-fir (*Pseudotsuga menziesii*), Eastern white pine (*Pinus strobus*), grand fir (*Abis grandis*), common ash (*Fraxinus excelsior*), black alder (*Alnus glutinosa*), birch (*Betula sp*.), poplars (*Populus sp*.), willows (*Salix sp*.) and black locust (*Robinia pseudoacacia*). Specific regulations for short-rotation cultivation also include minimum distances from other agricultural crops, in provincial legislations. The conversion of permanent grassland is not possible any longer, and many cultivation trials and tests were stopped despite the availability of the relevant infrastructure. There is an ongoing discussion in Austria to open up the Forest Law and its Annex 1 for more tree species. Among them, many species exotic to Central Europe, and a few fast-growing ones, are being discussed.

During 2016-2019 **Bulgaria (pp.1-2)** conducted a number of revisions through amendments and additions to the national legislation regulating forestry activities, including a national strategy for the development of the forest sector in Republic of Bulgaria for 2013-2020 and a national strategic plan for the development of the forestry sector in Republic of Bulgaria 2014-2023. Establishment of protective forests through afforestation with fast-growing tree species is a priority in Bulgaria. The European ecological network NATURA 2000 in Bulgaria includes extensive poplar and willow stands along the Danube river and other rivers in the country.

Canada (pp.5-10) reported that jurisdiction over forestry, agriculture and environmental policy mainly rests with the provinces, and most of Canada's forest land – approximately 90%, accounting for 85% of the annual wood harvested – is publicly owned by the provinces and territories and is called 'Crown Land". The degree to which poplars, willows and other fast-growing species (OFGS) are used or managed on Crown lands depends on manufacturing capacities and forest management plans. Provincial governments generally regard their Crown land forests as natural preserves in which, although the forests can be harvested sustainably, their natural ecology should be preserved as much as possible. Therefore, poplar or willow hybrids are generally grown on privately owned agricultural lands, rather than on forested Crown Lands. The production and harvest of fast-

growing species for industrial products (wood, bioenergy or other commercial purposes) is generally not affected by federal or provincial regulations. Programs derived from national and international frameworks and strategies have a direct effect on the use of poplars and willows in Canada. In 2017, the Canadian Council of Forest Ministers published "A Forest Bioeconomy Framework for Canada", which considers the use of sustainable wood supply and biomass plantations, among others, from fast-growing willow species. An opportunity for agroforestry research/application may be found in a new program by Agriculture and Agri-Food Canada. Known as the Living Laboratories Initiative, it will commence in 2020 and be similar in concept to the EU Network of Living Labs.

China (pp.1-2) launched the "National Reserve Forest Program" in 2016. This is a national project that targets cultivation of 97 forest species (including poplars, willows and eucalyptus) for the development of plantation forests. A catalog of major forest species for the bioenergy production was further published in November 2017, including poplar, willow, eucalyptus, elm, and black locust, aiming to promote forest biomass energy through forest cultivation. In April 2018, China's National Forestry and Grassland Administration issued the national reserve forest construction plan (2018-2035), proposing to create 20 million hectares of national reserve forest. In September 2018, the central government issued the strategic plan for rural revitalization (2018-2022) with a particular emphasis on the role of forestry sector in achieving sustainable rural development, and issued a circular requiring all local governments and departments to ensure its timely implementation.

Croatia (p.1) indicated that since joining the European Union in 2013,the government has been working towards harmonization of the national legislation with the European Union legal framework, particularly through adoption of the Nature Conservation Act, the Act on Agricultural Land, the Water Act, the Act on Forest Reproductive Material, the Act on Short Rotated Woody Forest Cultures (2018), the Air Protection Act and the Climate Change and Ozone Layer Protection Act (2019). Cultivation of *Alnus, Betula, Carpinus, Miscanthus, Populus, Salix* and *Paulownia* species is permitted in short rotations, but only on forest and marginal or abandoned agricultural lands. Ongoing activities are also targeting sustainable forest management and improved technical training of forestry employees.

Egypt (p.2) informed that the legal framework on cultivation and utilization of poplars and willows remains without significant changes. Among the most important legal acts related to fast-growing species there is the Law on Public Roads and Trees Planted Around Them, the Law on Agriculture, the Law on Public Roads, the Law on Protected Areas, and the Law on Nature Conservation. Most of these laws embody provisions encouraging tree planting and prohibiting tree cutting. Many successful projects were conducted through the joint action of forest authorities, such as establishment of 6603 ha of planted forest in desert land using treated wastewater through cooperation between the Ministry of Ministry of Agriculture and Housing and Ministry of Environment.

Germany (pp.5-6) reported that in 2008 poplar breeding experienced a renaissance with the call for wood from short rotation coppice plantations as a renewable energy resource, but due to the country's increased interest in biogas and the preference for maize as the raw material for that energy resource, poplar plantations were not developed further. Trade in forest reproductive material (including their use at short rotation coppice plantations and agroforestry sites) is regulated by the "Act on Forest Reproductive Material" (FoVG). Poplars, hybrid larch and black locust are subject to the FoVG, but willows are not. Short rotation coppice plantations and agroforestry sites are classified as eligible permanent crops, though the possibility of eligibility under the single farm payment exists only for poplars, willows and black locust. In 2014, greening (direct payment regulation) was introduced in the EU agricultural promotion. It stipulates that the creation of short rotation plantations can be counted as ecological priority areas, but only with a factor of 0.3. Fewer tree species are permitted for cultivation on ecological priority areas; only certain poplar and willow hybrids allowed, and black locust is not included.

Iran (pp.1-4) has reported that its National Poplar and Fast- growing tree species Commission is currently operating under the supervision of the Ministry of Jihad-e-Agriculture to identify potentials and capacities for

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developing wood farming. Recent country forest monitoring in 2019 has identified 30,000 hectares of indigenous poplars and alders in various regions of the country, both naturally regenerating and planted, combined with other fast-growing tree species, that have a protected area status.

Wood farming activities in Iran are focused on poplars and eucalyptus and have a potential to produce more than 2.78 million m^3 of wood per year through using improved cultivars, and scientific and technical management of traditional farms. In 2018 the Forest and Rangeland Research Institute (RIFR) started three projects on the wood farming: satellite data surveillance of poplar plantations, quantitative and qualitative assessment of the status and production potential of poplar plantations, and investigation of the regions with wood farming potential. The National Wood Farming program, prepared in 2019 by the Forests, Rangelands and Watershed Management Organization (FRWO) in cooperation with the Forests and Rangelands Research Institute (RIFR) in its 10 year action plan targets cultivation of fast-growing species; it aims to ensure increased cultivation area and improved conservation of forest resources, increased productivity and demand for wood products, and supports local communities, job creation, private sector cooperation, financial incentives and subsidies. Development of the wood farming program includes both qualitative and quantitative elements carried by the RIFR and FRWO respectively.

In **Italy (pp.1-2)**, poplar cultivation represents one of the most important sources of timber supply for the processing industry, and the “Memorandum for the poplar sector development" was signed in Venice in January 2014 by various poplar growers and industrial associations and poplar research institutions. “Guidelines for sustainable poplar cultivation”, elaborated in 2018, refers to the cultivation of poplar in plantation, involving use of poplar clones in a medium-long cycle or in rows alternating with agricultural crops. These guidelines are intended to be a first analysis document and a tool for comparison between technical and institutional bodies, associations of producers and users, standardization bodies and environmental associations.

Korea (pp.1-2) indicated that the National Framework Act on Forestry was revised in November 2017, in order to respond to climate change by managing and improving the role of forests as carbon sinks and to contribute to the realization of a low carbon society. Yellow poplar, larch, oak and cypress are core species for sustaining carbon absorption in Korea. They are used for reforestation actions subsidized by the government, bioenergy purposes and timber production. Since 2016, more than 3.5 million seedlings of yellow poplar were planted in around 1,200 hectares each year. A similar level of planting is expected in the future until most of the old pitch pine stands are replaced. Mature yellow poplar trees are being planted as roadside trees throughout the country.

New Zealand (p.2) reported that since 2012, due to changes in the government’s research investment process there has been little opportunity to continue regular poplar and willow breeding programmes. This programme relies heavily on the financial support of local government. On the other hand, a 1BillionTrees Initiative was financed by the government in order to increase tree planting. It includes encouragement for increased rates of planting of poplars and willows in pastoral land, particularly hill country. It is expected that this initiative will result in additional support for poplar and willow breeding and research.

Portugal (pp.3-5) indicated that its national forest sector is regulated by the Forest Policy Act of 1996, as well as other specific legislation. The Portuguese National Strategy for Forests (NSF) is aligned with European commitments for forest policies, assumes maximization of the forest’s total economic value as its main purpose, and its aims and targets are articulated within seven Regional Forest Plans (PROF). Forest Intervention Zones (ZIF) enable associations of forest owners and producers to undertake common management through the endorsement of the cooperative management of forest lands. Forest Management Plans (FMP) are mandatory on the public and private forests, and on the “forest intervention zones” (ZIF). Premature cutting of *Eucalyptus* and *Pinus* species in areas superior to two hectares requires authorization by the National Forest Authority. Afforestation and reforestation regulation establish the essential technical standards to be considered in the

scope of afforestation and reforestation project design, and the minimum qualifications required short rotations stands with *Eucalyptus* species.

Slovenia (pp.2-6) informed that the most important poplar plantations established with selected poplar clones in the last decades are situated in Litija along the River Sava, and in areas of the Ljubljana Marshes and along the Mura River. The Mura River Biosphere Reserve (BOM) was declared in Slovenia in 2018. It forms a part of the 5-country Transboundary Biosphere Reserve "Mura-Drava-Danube" (TBR MDD) to be established globally within the UNESCO MAB Programme. In recent years, new living archive and experimental forest plantations in the central and northeast parts of Slovenia were established for testing new poplar clones for biomass and fast wood production in heavier soil conditions. Approximately 30 different non-native fast-growing tree species in total are currently present in Slovenian forests, including black and white poplar, willow, aspen, black locust and black walnut, with a common rotation length of 60 years. Poplar plantations with short rotation and longer production cycles are mainly used to ensure additional supply of fuelwood biomass from the areas with intensive agricultural production, to reduce existing high pressure to endangered lowland forests, and to supply the wood processing industry. Up to now, no subsidies for poplar and/or willow cultivation and production have been adopted. Further possibilities for use of fast-growing trees are in supporting green technologies as they enable shading and cooling, pilot investment in tree plots of wildlife corridors among habitats or protected areas, and use of poplar, willow and black locust clones for polluted land remediation and buffering.

Spain (p.2) reported that in the Autonomous Community of Castilla and León work continues on the publication of a new decree regulating establishment and exploitation of poplar plantations in private forests, that should be managed through responsible declaration procedure. In the Autonomous Community of La Rioja authorities are working on the establishment of a legal framework that will regulate the procedure for receiving public aid aimed to improve management and use of private and public forest lands. This framework will be based on the previous resolutions by the Ministry of Agriculture, Livestock and Environment on the approval of subsidies for the planting of poplars and cultural care in poplar groves in rural areas.

Sweden (pp.1-2) indicated that the total area of willow, poplar and hybrid aspen plantations has decreased since 2015, mainly due to reduction of *Salix* area, co-occurring with low market prices of wood chips and low motivation of landowners to invest into poplar or hybrid aspen plantations. Willow, hybrid poplar and hybrid aspen are eligible for the Basic Payment Scheme, which provides financial support per each cultivated hectare of agricultural land in the framework of the European Common Agricultural Policy. The National Board of Agriculture supports cultivation of poplar and willow by areal support if the rotation period does not exceed 20 years. Landowners can also apply for investment support from the Rural Development Program for seedlings and planting on agricultural land, as well as for fencing.

Turkey (p.1) reported that leading fast-growing species in the country are *Pinus brutia* and *Populus tremula*. Since there is a shortage of raw wood material in Turkey to meet the demands of forest industries, Turkey has started importing wood material and giving priority to industrial plantations based on fast-growing species to fill this shortage. In recent years, the share of private nurseries in the production of poplar saplings has considerably increased. Almost all of poplar plantations are carried out by private growers in Turkey. State owned nurseries continue producing poplar sapling from selected poplar clones for demonstrative purposes of nursery and plantation techniques.

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III. TECHNICAL INFORMATION

This chapter focuses on a number of specific technical advancements in the cultivation of poplars, willows and other fast-growing species, and includes six sections.

Section 1 "Taxonomy, Nomenclature and Registration" includes information on accomplishments in identification and on proposals made for the registration of new cultivars of poplars, willows and other fast-growing species.

Section 2 "Domestication and Conservation of Genetic Resources" provides most recent updates on the research and applications of technology in genetics, conservation and tree improvement achieved by poplar, willow and other fast-growing species categories.

Section 3 "Plant Health, Resilience to Threats and Climate Change" includes information on the incidence, scale and impacts of damage in poplars, willows and other fast-growing trees by biotic (including insects, diseases and other animal pests) and abiotic (including winds, floods, droughts, pollution and others) agents, and outlines economic aspects and success of control measures undertaken and damage prevention in the future.

Section 4 "Sustainable Livelihoods, Land-use, Products and Bioenergy" presents national progress on the application of new knowledge, technology and techniques for production, protection and conservation of poplars, willows and other fast-growing trees. A subsection on nursery practices and propagation techniques includes applications of biotechnology - particularly plant propagation, reproductive materials, use of GMOs, etc. The Planted Forests subsection puts emphasis on the choice of cultivars, type of plants, spacing and layout of plantations; planting and tending (fertilization, irrigation, weeding, pruning, thinning etc.); and management (growth, rotation in relation to yields and industrial requirements). The Naturally Regenerating Forest subsection provides details regarding experiences and experiments concerning silvicultural treatments, harvesting, management, protection and regeneration. Finally, the Agroforestry and Trees Outside Forests subsection describes their effects on forest and agricultural crops or livestock and diversification of the landscape.

Section 5 "Application of new knowledge, technologies and techniques" provides up-to-date information on harvesting, utilization of poplars, willows and other fast-growing trees for various wood products, as well as their utilization as a renewable source of energy.

Section 6 "Environmental and Ecosystem Services" reports on the application of new knowledge, technologies and techniques for cultivation of poplars and willows. It briefly reports on other fast-growing species for site and landscape improvement (bank stabilization, combating desertification and salinization, shelterbelts and windbreaks, soil rehabilitation, urban and peri-urban forestry for climate modification), and phyto-remediation of polluted soil and water (buffer zones, contaminated sites, and waste water management and treatment).

1. TAXONOMY, NOMENCLATURE AND REGISTRATION

There is a strong need for conservation and sustainable management of fast-growing species and increased focus on training and extension efforts in their cultivation. Identification and registration of new fast-growing species' clones from different origins are being conducted in the national experimental nurseries. Clonal testing is conducted across countries on various types of soils, for the selection of optimal poplar and willow genotypes.

Forestry studies also proved that growth rate of some species is higher in some countries in comparison with others, especially in case of pines and firs, creating a great opportunity for profitable investment. Several countries identified that cultivation of poplars or willows for wood products, fuelwood or bioenergy do not have

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significant commercial interest, instead planting of fast-growing tree species is commonly used for environmental purposes like slope and riverbank stabilization, erosion control, bee fodder and animal welfare.

Eucalyptus is seen as one of the species with highest potential for clonal development and commercialization due to good documentation matching cones to specific site conditions and their high resistance to drought, pests, frost and other site restrictions.

In **Austria (p.3),** BFW (Genome Research Unit) is surveying existing trials with poplar clones and will act in case of emerging good test results, but no proposals for registering new cultivars of fast-growing tree species in the reporting period were raised.

In **Bulgaria (pp.1-2)**, poplars and willows cultivation stands are located predominantly in the strip of lands between the dike and the riverbank as well as on the islands of Danube River. Most of these lands are state-owned forest territories, while poplars and willow's stands in the plains – on agricultural lands, around dams, irrigation canals and other water bodies - are mainly in municipal and private ownership. From 2014 to 2017, Bulgaria's Executive forest agency in partnership with Forest seed control station Teisendorf, Germany conducted poplar clones testing for production of biomass, resulting in a successful testing of 13 new poplar clones in State forest enterprises Pazardzik and Montana.

Canada (pp. 20-22) informed, that the genus *Salix* is one of the most diverse woody genera in the country and is currently represented with 76 species. Most naturally occurring *Salix* species are shrubs that have limited commercial value but play major roles in ecosystems by stabilizing disturbed sites preventing erosion and providing wildlife food and habitat. Among *Alnus* species and subspecies growing naturally in Canada there are *A. rubra, A. serrulate, A. incana* (that includes subspecies *ssp. rugosa* and *ssp. Tenufolia*) and *A. viridis* (with subspecies *ssp. sinuata, ssp. crispa and ssp. Fruticose*). Among poplar sections, there are balsam poplars (Tacamahaca section), cottonwoods (Aigeiros section) and aspens (Leuce section). The National Poplar and Willow Council has created an electronic database containing poplar and willow germplasm (pollen, seedlot, progeny or clone) data, which has functioned for more than 30 years and provides a forum for Canadian breeders to archive breeding lines and released cultivars in a searchable format.

China (p.2) reported that according to the Methods for the Examination and Approval of Main Forest and Tree Varieties (EAMFTV) revised by the State Forest Agency (SFA) in 2017, poplar and willow clones must be tested and authorized on the provincial and national level before their cultivation and plantation in China. During 2016-2019, 45 poplar clones and 27 willow clones were registered and defined as new varieties according to National Standard Guidelines for the conduct of tests, and 6 poplar varieties and 2 willow varieties were approved and added to the national list of genetically improved tree varieties issued by the National Review Committee on Improved Tree Species/Varieties. In addition, some poplar and willow varieties were approved as improved varieties by the seedling stations in each province.

In **Croatia (pp.1-2)**, a multiclonal approach in poplar and willow plantations is being practiced, with a mosaic clone arrangement. All the selected poplar and willow clones are entered into live archives for preservation through the 'ex situ' method. Clonal testing is conducted across the country on various types of hydromorphous soils, for the selection of optimal poplar and willow genotypes. Poplar testing includes different selections of American black poplar (*Populus deltoides*), hybrids of American black poplar and European black poplar (*P.* x *euramericana*), hybrids of American black poplar and balsam poplar (*P.* x *interamericana),* as well as the clone tests of *P. trichocarpa* and *P. simonii*. The clone tests of the arborescent willows include the autochthonous clones of the white willow (*Salix alba),* interracial hybrids of autochthonous white willow and the English 'cricket' willow (*S. alba var. calva*), interspecies hybrids (*S. matsudana x S. alba*), as well as the multispecies hybrids of willows.

Egypt (p.2) indicated a strong need for conservation and sustainable management of fast-growing species and increased focus on training and extension efforts in their cultivation. The country also reported on the establishment of planted forest consisting of various fast-growing tree species. These are irrigated using a drip system, with treated wastewater, as part of cooperation between the Ministry of Agriculture and Housing and Ministry of Environment. Species like *Khaya senegalensis, Dalbergia sissoo, Azadirachta indica, Cupressus sempervirens, Casuarina equisetifolia* showed high productivity. Forestry studies also proved that growth rate of some species in Egypt is much higher than in Europe; for example the growth rate of *Pinus spp*. was four times higher than the growth of the same species in Germany, creating an opportunity for profitable investment. Recently, the state agreed to start leasing areas designated for the establishment of forest plantations that can be irrigated with sewage water to increase investments from the private sector.

In **Germany (pp.6-8),** the Federal Agency for Agriculture and Food (BLE) maintains the register of approved clones and clone mixtures, while federal states keep their own registers for all other tree species. A total of 15 poplar clones in the reporting period were proposed for provisional approval for a period of 10 years as a basic material for the production of forest reproductive material for the use of biomass production in short rotation due to their significant superiority in their biomass characteristics. For some of the poplar clones, plant variety protection applications have been made to the Community Plant Variety Office (CPVO) in Angers / France.

Iran (p.4) reported that the Research Institute of Forests and Rangelands (RIFR) has successfully released two poplar clones - *P. deltoides* clone “Gildar” and *P. nigra* clone "Alborz". Gildar clone showed the highest yield of wood in north of Iran (Gilan province), while the “Alborz” clone attained the best results for wood production in northwestern, western and central provinces.

In **Italy (p.2)**, new epithes of *P. deltoides* cultivars by Wimco Seedlings Limited, and five new clones of black poplar (*P. nigra)* by The Silva Tarouca Research Institute for Landscape and Ornamental Gardening were included in the National Register. The International Register of *Populus* Cultivars maintains 363 epithets. The Checklist of *Populus* Cultivars records four hundred and seventy-five unregistered names and one hundred three cultivars with experimental codes.

New Zealand (p.2) informed that cultivation of poplars or willows for wood products, fuelwood or bioenergy do not have significant commercial interest. Instead planting of fast-growing tree species is commonly used for environmental purposes like slope and riverbank stabilization, erosion control, bee fodder and animal welfare. Planting rates of fast-growing species are low (<1%) compared with commercial forestry, and no new poplar or willow clones were commercialized during 2016-2019. Commercial cultivation is dominated by regional councils responsible for environmental management. Within regional councils the general trend is towards expanding nurseries for cultivation of both poplars and willows.

Portugal (p. 6) indicated that *Eucalyptus globulus* Labill, or Tasmanian blue gum, is the most common eucalypt species used in short rotation pulpwood plantations. Currently, nurseries belonging to the two major eucalypt forest companies operating in Portugal (The Navigator Company and Altri) are responsible for the development and commercialization of all eucalypt clones deployed in Portugal. Overall, there are up to 15 clones registered and able to be produced. These clones differ in their suitability to specific site characteristics, with contrasting resistance to drought, pests, frost and other site restrictions. In recent years, there has been an increase in certified orchard areas by The Navigator Company. All commercial clones and seedlots being produced are classified in the category “Tested Material”. Clonal Identity Certification protocols have been developed and optimized based on Microsatellite markers, an effort done in collaboration with European and Brazilian partners such as the INRA (Institute National de la Recherche Agronomique) and EMBRAPA.

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Slovenia (p.6) indicated a need to develop a national register of clones and clonal mixtures for fast-growing species. Ongoing pilot testing of black poplar (*Populus nigra)* genotype which was selected in the riparian forest along the River Mura is expected to bring positive developments to the cultivation of fast-growing tree species in the country.

Sweden (p.3) indicated some of its indigenous species, like silver birch (*Betula pendula* Roth) and downy birch (*Betula pubescens* Ehrh.), are valuable raw materials with high yields for pulp and for mechanical wood manufacturing, that account for 12.5% of total growing stock in Sweden and form mixed stands of variable proportions. Several clonal trials, established between 2003 and 2014 with hybrid poplars from the Tacamahaca section, have been evaluated during 2016-2019 to identify site suitable clones for different climates and latitudes in Sweden. Among registered new clones of other fast-growing tree species there were mentioned new *P. trichocarpa* and *Salix* cultivar Julia.

Turkey (pp.1-2) reported that identification and registration of new fast-growing species' clones from different origins are being conducted in the experimental nurseries, with improved materials further supplied to private nurseries. As the result of conducted poplar genetic studies during the reporting period one hybrid poplar clone (*P. x euramericana*) and Eastern cottonwood (*P. deltoides*) clones showed the highest productivity and thus were offered to be commercially produced in various regions of Turkey.

2. DOMESTICATION AND CONSERVATION OF GENETIC RESOURCES

Activities on domestication and conservation of poplar species in the reporting period included preservation of poplar genetic resources through the 'ex situ' method and various breeding programmes established on at the both national and international levels. Poplar breeding programs are targeting "ideal poplar ideotypes" with fast growth rates, temperature- and drought resistance, insect and disease resistance, and have an optimum form for maximizing carbon storage. Breeding programs target development of hybrids in support of ecological services such as farm and field shelterbelts, intercropping, enhancement of pollinator habitat, riparian restoration and protection. Ongoing work on hybridization and development of genomic resources has also provided cost-effective markers to distinguish genotypes that can help address specific forest management or restoration questions.

In regard to conservation and domestication of willow hybrids and clones, ensuring authentic materials, cultivar purity and establishment of stool beds for production of leading shoots and cuttings were indicated as the main guarantees for the successful production of planting stocks. Willow clones have an accepted role for shelterbelts, nutrient management, carbon sequestration, phytoremediation, bioenergy plantations, riparian protection and fibre production. Willow selection and breeding traditionally focuses on high biomass production under optimum environmental conditions. New willow genotypes are being screened for the needs of multi-purpose agroforestry, reforestation purposes and biomass and bioenergy production.

Domestication of other fast-growing species is aiming to ensure their increased commercial use, as well as use for phytoremediation and conservation purposes. Several countries reported on the efforts to ensure climate change mitigation through breeding of fast-growing tree species, as they provide propagation material with high adaptability, growth performance and quality. Fast-growing species are often seen as highly productive and adaptable species, that can be very profitable for the economy of mountain areas when managed under multifunctional silvicultural regime. Their capacity to grow in marginal degraded areas can represent a good strategy for environmental restorations in special cases, as well as energy biomass production in short rotation cycles on poor soils and degraded areas and in coppice forestry.

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Shortlisted main clones and hybrids of poplars, willows and other fast-growing species reported by the IPC member countries are presented in the Table.

Table 1 Domestication and utilization of poplar, willow and other fast-growing species in the IPC member countries

Country	Poplars	Willows	Other fast-growing species
Austria	Aigeiros and Tacamahaca poplar sections	Various clones and hybrids	-
Bulgaria	Various clones and hybrids	Various clones and hybrids	-
Canada	trembling aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), *P. deltoides, P. tremuloides* (Trembling aspen), *P. grandidentata* (Bigtooth aspen), *P. balsamifera* (Balsam poplar), *P. trichocarpa* (Black cottonwood) and *P. angustifolia* (Narrowleaf cottonwood)	Various clones and hybrids	*A. rubra* (Red alder), *A. incana ssp. rugosa* (Speckled alder), *incana ssp. tenufolia* (Mountain alder), *viridis ssp. sinuata* (Sitka alder), *A. viridis ssp. crispa* (Green alder), *A. viridis ssp. fruticosa* (Siberian alder) and A. *serrulata* (Hazel alder)
China	-	-	eucalyptus, black locust (*Robinia pseudoacacia*) and paulownia (*Paulownia tomentosa and P. fortune)*
Croatia	European black poplar (*Populus nigra*) and *P. nigra ssp. caudina*	Chinese willow (*Salix matsudana*), autochthonous White Willow (*Salix alba*), S. alba var. calva, interspecies hybrids *(S. matsudana × S. alba*)	-
Egypt	White poplar (*Populus alba*)	-	
Germany	Black poplar (*P. nigra*)	-	sycamore maple (*Acer pseudoplatanus*), Douglas-fir (*Pseudotsuga menziesii*), pedunculate oak (*Quercus robur*), sessile oak (*Q. petraea*), Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), larch (*Larix decidua, L. kaempferi*), and hybrid larch (*L. × eurolepis*)
Iran	*P. deltoides, P. euramericana, P. nigra, P. alba, P. caspica* and *P. euphratica*	*S. excelsa, S. alba, S. acmophyll ,S. caramanica, S. caprea, S. aegyptiaca*	*Eucalyptus camaldulensis, Alnus glutinosa* and *Alnus subcordata*
Italy	Eastern cottonwood (*P.deltoides*) and European black poplar (*P.nigra*)	*S. alba, S. jessoensis* and *S. matsudana*	*Eucalyptus viminalis, E. globulus ssp globulus and E. globulus ssp bicostata*, black locust (*Robinia pseudoacacia*), Monterey pine and Douglas fir (*Pseudotsuga menziesii*)
Korea	Korean aspen (*Populus tremula var. davidiana or P. davidiana*), clones of *Populus alba x Populus tremula var. glandulosa*	-	
New Zealand	*Populus × euramericana*, *P. deltoides × yunnanensis*, *P.× euramericana ×*	*Salix matsudana, S. matsudana × alba*	-

Country	Poplars	Willows	Other fast-growing species
	yunnanensis 'Toa', *P.× euramericana × nigra* 'Crowsnest', *P. nigra* 'Italica' and *P. nigra × maximowiczii* 'Shinsei', *P. deltoides × nigra*, (*P. euramericana* x *deltoides*) × *cathyana*, (*P. euramericana* x *deltoides*) × *nigra*, (*P. euramericana* x *deltoides*) × *simonii*, (*P. euramericana* x *deltoides*) × *szechuanica*, (*P. euramericana* x *deltoides*) × *yunnanensis*, *P. nigra* × *cathayana* ,*P. simonii* × *nigra*, *P. trichocarpa* × *nigra, P. trichocarpa* × *simonii*, *P. trichocarpa* × *szechuanica* and *P. trichocarpa* × *yunnanensis.*	'Tangoio', 'Moutere', 'Hiwinui', *S. purpurea* 'Irette', 'Pohangina', 'Booth', 'Glenmark', *S. schwerinii* 'Kinuyanagi', *S. viminalis* 'Gigantea' *and S. alba* var. *vitellina, Salix matsudana × S. lasiandra, S. lasiandra × S. pentandra, S. matsudana × S. pentandra, S. lasiolepis × S. reichardtii, S. lasiolepis × S. viminalis* and *S. lasiolepis × S. opaca*	
Portugal	-	-	***E**ucalyptus globulus*
Slovenia	Black poplar (*Populus nigra*), white poplar (*Populus alba L.*), Eurasian aspen (*Populus tremula L.*) and Gray poplar (*Populus × canescens (Ait.) Sm.).*	-	Black locust (*Robinia pseudoacacia*) and black walnut (*Juglans nigra L.*)
South Africa	-	-	*Eucalyptus grandis, Eucalyptus nites, Eucalyptus marcathrii*, pine and wattle species
Spain	-	-	
Sweden	*Picea abies*, *Betula* and *Populus*	*Salix viminalis* x *(S. viminalis* x *S. schwerinii*)	Grey alder (*Alnus incana*)
Turkey	Indigenous black poplar (*Populus nigra L.*), white poplars and Aspens, Euphrates poplar (*Populus euphratica Oliv.*)	White willow *(S. alba)*	Turkish red pine (*Pinus brutia*), Wild Cherry (*Prunus avium*), Narrow-leafed ash (*Fraxinus angustifolia*), European black alder (*Alnus glutinosa*), black locust (*Robinia pseudoacacia), Eucalyptus,* Maritima pine (*Pinus pinaster Aiton*), *Pinus radiata D. Don, Pseudotsuga menziesii Mirb. Franco* and *Pinus taeda*

More details on their cultivation and domestication can be found in the relevant subsections.

2.1 Poplars

Austria (p.3) reported on the establishment of molecular genetic identification tests for the Aigeiros and Tacamahaca poplar sections by BWF Genome Research Unit. Selection of candidate clones will be continued in existing test plantings, mainly for short-rotation biomass production.

Bulgaria (pp.2-3) reported that the main production of stem cuttings is organized in two national nurseries - state forest enterprises Svishtov and Pazardzik. Further successful production of planting stock will depend on ensuring authentic materials and standard size of the cuttings, establishment of stool beds for production of leading shoots and cuttings, and production of standard plants for afforestation.

Canada (pp.22-28) indicated that trembling aspen (*Populus tremuloides*) and balsam poplar (*Populus balsamifera*) are the main commercially harvested poplar species, both regenerating naturally and used mainly for pulp or oriented strandboard (OSB), sawn wood for pallets and containers or fuelwood. Among other poplar species growing in Canada there are Trembling aspen *(P. deltoides),* Quaking aspen *(P. tremuloides*), Bigtooth aspen *(P. grandidentata*), Balsam poplar (*P. balsamifera*), Black cottonwood (*P. trichocarpa*) and Narrowleaf cottonwood *(P. angustifolia*). The Agriculture and Agri-Food Canada (AAFC) poplar breeding program is one of the most successful poplar breeding and testing programs in the country, aiming to develop "ideal poplar ideotypes" with fast growth rates, that are highly temperature- and drought resistant, have insect and disease resistance, and optimum form for maximizing carbon storage. In the short term, the AAFC program targets development of hybrids in support of ecological services such as farm and field shelterbelts, intercropping, enhancement of pollinator habitat, and riparian restoration and protection. Ongoing work on hybridization and development of genomic resources has also provided cost-effective markers to distinguish genotypes that can help address specific forest management or restoration questions. In order to understand better how species adapt to their environment, Canadian researchers are using different genomic approaches alone or in combination, including genotype-environment association (GEA) and genotype-phenotype association (GPA).

China (pp.2-4) informed on the development of an "ecological poplar breeding" concept, based on climate and poplar biology. A series of advances have been made in the fields of poplar geomics analysis, genome editing, mechanisms of wood formation and stress tolerance. Nanjing Forestry University and Beijing Forestry University have made progress on the research on the evolution of poplar and willow species, revealing the evolutionary process and potential functions of different evolutionary selection pressures. Northeast Forestry University, Chinese Academy of Forestry, Southwest University and Chinese Academy of Sciences have improved genetic transformation and genome editing techniques. Based on the poplar germplasm collection and the evaluation of the growth and quality of wood fiber and other important economic characters, Beijing Forestry University established a germplasm information database, and new poplar varieties with fast growth, high quality and high resistance were selected and bred.

Croatia (pp.2-3) has reported on the ongoing preservation of European black poplar (*Populus nigra*) genetic resources through the 'ex situ' method, carried out on the area of the Sava, Drava, Danube and Mura rivers. A study on the differences between European black poplar and hairy type of black poplar (*P. nigra ssp. caudina*) was conducted during the reporting period. Through the European black and white poplar conservation program Croatia was included in the European programme EUFORGEN (Bioversity International). As a result, the area of riparian forests along the river Drava (the Slatina Drava river basin forests) were exempted from regular management as a genetic conservation unit for the protection of the black and white poplar on about 200 ha.

Egypt (p.2) reported on efficient transformation systems for white poplar (*Populus alba)* obtained through use of an agrobacterium tumefaciens mediated technique. Genetic transformation of an elite white poplar genotype was performed to enhance resistance to abiotic harmful stress and salt tolerance. Use of Ferric Oxide and Magnesium Oxide in various combinations were tested for shooting and rooting ability improvement, and a noticeable increase in stem diameter linked with remarkable increase in all measurements was documented.

Germany (pp.9-11) informed that importance and cultivation of fast-growing tree species may increase due to the dramatic forest damage caused by drought, storms and beetle damage in 2018 and 2019. From 2009 to 2018,

suitable poplar and willow clones were grown and registered in three successive FastWOOD projects funded by the FNR (Fachagentur Nachwachsende Rohstoffe e. V.) for the production of energy wood in short rotation plantations (SRC). Research on black poplar (*P. nigra*) determination and characterization of stands and their seedling progeny was carried out using genetic investigation methods, and provision of basic material for the production of high-quality propagation material by vegetative or generative propagation was conducted in the report period. Due to the close cooperation of the forest administration with the waterway and shipping administration in Rhineland-Palatinate, it was possible to provide pure black poplars (*P. nigra*) for numerous re-wilding projects from the stool beds of the local research station.

Iran (p.4-5) reported that Poplar and Eucalyptus are fast-growing tree species mostly used for wood production by the private sector. Plantations of *P. deltoides* and *P. euramericana* are located in the north along the coastal plain of the Caspian sea, and clones of black and white poplars (*P. nigra* and *P.alba*) mainly grow in arid and semi-arid climates. To ensure protection of forest resources, harvesting of *P. caspica* and *P. euphratica* is legally prohibited. Mother gardens were established for preservation and development of clones.

Italy (pp.2-3) reported that conservation of poplar clones involves both in situ and ex situ efforts. The breeding program, aligned with CREA's strategy, is based on inter-specific hybridization between Eastern cottonwood (*P. deltoides*) and European black poplar (*P. nigra*), and both long-term and short-term strategies are adopted. In order to enhance *P. nigra* germplasm a pool of native genotypes has been characterized and selected for environmental restoration activities. A restricted pool of black poplar (*P. nigra)* clones characterized by good growth performances and stem forms has been selected for cultivation in fluvial areas with restrictions for growing commercial hybrids. Collections of genetic materials from white poplars (*P. alba)* native genotypes have been carried out in order to supplement the germplasm bank of this species that is also effectively used in restoration activities, urban forestry, phytoremediation and biofuels/biomaterials production. Following cooperation activities on poplar breeding with the Chinese Academy of Forestry (CAF) a progeny obtained by crossing *P. simoni* and *P. nigra* parent plants is maintained at the CREA farm in Casale Monferrato for selection and phenotypic characterization.

Korea (pp.2-3) indicated that Korean aspen (*Populus tremula var. davidiana* or *P. davidiana*) is one of the its main fast-growing species, distributed besides Korea in the Far East of Russia, China and Mongolia. *P. davidiana* contains a high level of genetic variation and thus has high value in conserving biodiversity. However, due to the climate change its population has already started declining and may eventually disappear. To conserve the remnant populations, the National Institute of Forest Science has established ex situ conservation stands in 1991 and 1992. The clones could be utilized in the future when the demand arises. Although poplars are not being intensively cultivated in Korea, genetics research is actively carried out with the species. During 2016-2019 several transgenic poplar clones of *Populus alba x Populus tremula* var. *glandulosa* were developed, aiming to increase biomass production and salt stress tolerance and improve chemical and physical properties of the wood.

New Zealand (pp.3-5) informed that various poplar breeding crosses were produced in 2017, among them *P. deltoides* × *nigra*, *P. deltoides* × *yunnanensis*, (*P. euramericana* x *deltoides*) × *cathyana*, (*P. euramericana* x *deltoides*) × *nigra*, (*P. euramericana* x *deltoides*) × *simonii*, (*P. euramericana* x *deltoides*) × *szechuanica*, (*P. euramericana* x *deltoides*) × *yunnanensis*, *P. nigra* × *cathayana* ,*P. simonii* × *nigra*, *P. trichocarpa* × *nigra, P. trichocarpa* × *simonii*, *P. trichocarpa* × *szechuanica* and *P. trichocarpa* × *yunnanensis.* A number of poplar crosses were planted in wide-spaced field trials on pastoral land during 2014-2018. They are being monitored for performance against several widely planted commercial clones, primarily *P. × euramericana* clones. The main cultivars in use include poplars: *Populus × euramericana* 'Veronese', 'Fraser', 'Weraiti', 'Otahuao', *P. deltoides × yunnanensis* 'Kawa', *P .× euramericana × yunnanensis* 'Toa', *P .× euramericana × nigra* 'Crowsnest', *P. nigra*

'Italica' and *P. nigra × maximowiczii '*Shinsei'; and willows: *Salix matsudana, S. matsudana × alba* 'Tangoio', 'Moutere', 'Hiwinui', *S. purpurea* 'Irette', 'Pohangina', 'Booth', 'Glenmark'*, S. schwerinii '*Kinuyanagi'*, S. viminalis* 'Gigantea' *and S. alba* var. *vitellina.*

Slovenia (pp.7-9) reported that within the LIFEGENMON project the concept of Forest Genetic Monitoring (FGM) for *Populus nigra* L. was developed, followed by the preparation of guidelines on establishing a genetic monitoring plot and on recording all field level verifiers. A national genetic archive of poplar clones from Aigeiros, Leuce, and Tachamahaca Sections was set up in the Slovenian Forestry Institute experimental nursery near Ljubljana on alluvial soils in 2018 in the frame of international collaboration with SFI and the Forest Faculty in Sarajevo. It serves as the source for collecting vegetative reproductive material for scientific purposes and genetic analyses. The clonal archive was established with cuttings of typical black poplar (*Populus nigra*) from its indigenous metapopulations in Slovenia and Bosnia and Herzegovina. The Slovenian Forestry Institute leads in the situ and ex situ conservation program within the tasks of the Public Forest Service, financed by the Ministry of Agriculture, Forestry and Food of the Republic of Slovenia. Among other rare naturally widespread fast-growing tree species in Slovenia there are white poplar (*Populus alba* L.), Eurasian aspen (*Populus tremula* L.) and Gray poplar (*Populus × canescens* (Ait.) Sm.). The white poplar is indigenous and the least common fast-growing tree species among native poplars in Slovenia. The Eurasian aspen is highly tolerant to a wide range of habitat conditions and typically colonizes disturbed areas after the fire, sleet, windthrow, and calamities. As a pioneer species aspen is used for afforestation of bare land. On the larger scale, it can be found in the southern, western, and eastern parts of the country. The wood is mainly used for energy purposes as fuelwood from forests.

Sweden (pp.3-4) informed that 96% of all planted seedlings in Swedish forests are Norway spruce (*Picea abies)* since this species is a major raw material in the forest industry. *Betula* and *Populus* are economically important hardwoods as raw material in present pulp mills and most likely in future biorefineries and deserve increased attention as raw material in forest industry. An ongoing project "Climate-Adapted Poplar through more efficient breeding and better tools for matching genotype and site – developing the poplar bio-economy market in Sweden and the Baltic" aims at identification of genes behind bud flushing, growth cessation and bud set. This project aims to contribute to the developing molecular markers for selection of clones with proper adaptation to different climates and facilitate genetic improvement of fast-growing ligno-cellulosic crops for different end-uses.

Turkey (pp.2-6) reported that poplar species have high economical value and are distributed naturally in Turkey. Most of the cultivated poplars in Turkey belong to the Aigerios section. Indigenous black poplar (*Populus nigra* L.) is an important tree species in terms of social, economic, and ecological interest in Turkey. Although large poplar plantations meet the needs of the economy, the natural genetic resources of the species have been highly degraded due to anthropogenic effects such as overexploitation and habitat fragmentation. Traditional management of indigenous black poplar coupled with bottleneck and hybridization events has played an important role in reduced genetic diversity and degradation of the genetic resources of the species in two river systems. The Leuce section in Turkey is comprised of white poplars and aspens. White poplar is not grown commercially and is mainly used as ornamental tree. Aspen has a large geographic range in Turkey as it occurs in natural forest, sometimes forms pure stands as initial forms of development of forest communities, or occurs in groups or as individual trees. Aspen has a significant potential to be used for reforestation and afforestation activities in the semiarid-subhumid region of Central and Northeastern Anatolia. Euphrates poplar (*Populus euphratica* Oliv.) is one of the four native species of poplars distributed naturally in southwestern Turkey and possesses great importance for both renewable energy resources and ensuring healthy river ecosystem.

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2.2 Willows

Bulgaria (pp.2-3) reported on the ongoing development of activities for genetic improvement of willows in the country. Production of stem cuttings is organized in state nurseries - State forest enterprises Svishtov and Pazardzik. Ensuring authentic materials, cultivar purity and establishment of stool beds for production of leading shoots and cuttings are indicated as the main guarantees for the successful production of planting stocks.

Canada (pp.30-35) indicated that willow species are not considered commercial forest hardwood species and are not harvested on Crown Land. Willows occur naturally, largely in wetlands, and are thus protected by laws that protect riparian zones and are not harvested in such areas. Willow clones have an accepted role for shelterbelts, nutrient management, carbon sequestration, phytoremediation, bioenergy plantations, riparian protection and fibre production in Canada. Willow selection and breeding traditionally have focused on high biomass production under optimum environmental conditions. New willow genotypes are being screened for the needs of multi-purpose agroforestry as well as biomass production. The majority of *Salix* cultivars used commercially in Canada are produced at two nurseries, Agro Energie in Quebec and Double A Vineyards Nursery in Fredonia, New York. Willow trees are often planted on marginal lands surrounding agricultural fields to act as riparian buffers. Harnessing the ability of these willow trees for uptake, storage and remobilization of nutrients in above-ground tissue could facilitate the long-term management of phosphorus levels in both water and soil, while providing a reliable source of biomass for fibre, biofuel production and even biochar. To amend soil quality, revegetate salt-affected fields and recover economic loss associated with soil salinization, the establishment of short rotation coppice plantations with willows has been suggested as a possible solution. Development of selected, superior clones is being done in support of ecological services such as enhancement of pollinator habitat, riparian restoration, riparian protection, water quality, soil development, soil surface erosion control, and commercial biomass production on highly disturbed areas such as former mine sites. Conservation of willow genetic resources is mainly done through a national ex situ conservation program for selected *Salix* species native to Canada. Traits of interest for willow selection for Canada include coppice ability, height and biomass, growth form, wood characterization, cold hardiness, salinity tolerance and hyper accumulator of heavy metals on roots.

China (p.4) reported that studies on genetic variation were conducted in the Erguna river basin and the West Liaohe river basin (Liaoning province). Hybridization was carried out by using the plus trees of *S. matsudana*, in-species hybridization compatibility was studied, and environmental remediation of pollution was carried out by using willow clones. Through willow clones testing in Shandong province, several varieties for short-period pulp and industrial timber were selected. In Jiangsu province, willows for ornamental and drought- and salt-tolerant varieties were bred based on growth, ornamental characteristics, abiotic and biotic resistance, and fruitless.

Croatia (pp.3-4) indicated that selection of arborescent willows has been carried out in the natural populations aiming to create clone collection and establishment of intensive plant cultivation on the optimal sites, planting of pre-cultivated plants for reforestation purposes and establishment of short rotation biomass production plantations. Chinese willow (*Salix matsudana*) was used as the partner to the inter-species hybridization of the autochthonous white willow. Among arborescent willows growing in Croatia there are autochthonous White Willow (*Salix alba*), interracial hybrids of the autochthonous White Willow and the English 'cricket' Willow (*S. alba* var. *calva*), interspecies hybrids (*S. matsudana × S. alba*), as well as multispecies hybrids of willows. Willow clones showed high biomass production on marginal sites and dry biomass could be considerably increased with the application of intensive silvicultural and agrotechnical measures.

Iran (p.5) reported on the importance of willow species such as *S. excelsa, S.alba, S. acmophyll* ,*S. caramanica, S. capr* and *S. aegyptiaca*, that grow naturally and play an important role in river banks' protection. Pussy willow is generally cultivated for hedge and ornamental purposes and used for traditional production of "Araghe

Bidmashk" distillate. Despite the efforts of the Forests, Rangelands and Watershed management Organization (FRWO), illegal harvesting of willow trees in natural habitats for using wood continues.

In **Italy (p.3)**, willow accessions such as *S. alba, S. jessoensis* and *S. matsudana* are maintained in clonal archives. New clones selected among the progenies of *S. alba × S. alba* and *S. matsudana* (open pollinated) are under testing in terms of their growth-rate and tree architecture. Their tolerance to diseases and pests and physical features is taken into consideration for biomass production and as biofuel resource.

New Zealand (pp.3-5) informed that willow crosses carried out in 2016 were to extend and enrich willow flowering season for the apiary industry and also to enhance resistance/tolerance to giant willow aphid (*Tuberolachnus salignus*,) which has become a significant willow pest within two years of its arrival in summer 2014 to New Zealand**.** *Salix matsudana × lasiandra* tree willow clones were released in 2017 to regional councils for bulking up. These tree willow clones were bred for resistance to the willow sawfly (*Nematus oligospilus*) and have shown tolerance to the giant willow aphid (*Tuberolachnus salignus*). Selections of the following tree willow crosses such as *Salix matsudana × S. lasiandra*, *S. lasiandra × S. pentandra, S. matsudana × S. pentandra* and the following osier willow crosses: S*. lasiolepis × S. reichardtii*, *S. lasiolepis × S. viminalis* and S*. lasiolepis × S. opaca* were planted for trials on pastoral land and in close-planted riverbank trials in the period 2017-2019.

Sweden (pp.4-5) reported that willows are currently being investigated within the project "Optimized Utilization of *Salix*" as potential source for bioenergy including liquid biofuels. To facilitate breeding and selection of high-yielding clones, genotype-phenotype associations were studied in key biomass and phenology traits in a hybrid *Salix viminalis* x *(S. viminalis* x *S. schwerinii*) population. This study revealed that many genes with small effects influence lignin, cellulose, hemicellulose and the water content of the wood samples in *Salix viminalis* x (*S. viminalis* x *Salix schwerinii*) population, and higher content of cellulose and hemicellulose resulted in a faster methane production. Biomass recalcitrance to anaerobic digestion was also studied in a selected part of the above-mentioned population.

Turkey (pp.6-7) indicated twenty-seven naturally growing willow species in the country, used for maintaining healthy river ecosystem and as effective phytoremediation tools. Several studies were carried out on determination and protection of genetic diversity of willows and on their breeding in 2016-2019. *S. alba* populations in Turkey were comprehensively analyzed in terms of genetic diversity and population structure. High levels of genetic diversity were detected in the studied populations. Genetic structure analysis revealed that *S. alba* populations in different river systems represent different founder populations with high membership values.

2.3 Other fast-growing tree species

Among other fast-growing tree species in **Canada (pp.28-29)**, there is particular interest for alder species, including Red alder (*A. rubra*), Speckled alder *(A. incana ssp. rugosa*), Mountain alder *(A. incana ssp. tenufolia*), Sitka alder *(A. viridis ssp. sinuata*), Green alder (A*. viridis ssp. crispa*), Siberian alder *(A. viridis ssp. fruticosa*) and Hazel alder *(A. serrulata*). Red alder (*Alnus rubra*) is commercially significant as a fast-growing tree species in Canada. Considering its productivity, easy regeneration and low risk of being affected by damaging agents, it is a suitable species for intensive management on some coastal sites, especially those where the establishment of conifers is difficult (e.g., on riparian sites). Red alder is also suitable as a nurse crop species on nitrogen-poor sites and severely disturbed sites.

China (p.5) reported on the use of eucalyptus, black locust (*Robinia pseudoacacia)* and *Paulownia sp.* as other fast-growing tree species, collected commercially during 2016-2019. Eucalyptus breeding strategies were

developed to achieve fast growth, desired wood properties, wind resistance, disease resistance and other properties. *Robinia pseudoacacia* germplasm in different regions was collected and genetically evaluated for further breeding. Breeding of new *Paulownia* varieties was carried out in Henan province, and a number of excellent varieties were selected. Henan Agricultural University used *Paulownia tomentosa* and *P. fortunei* as the parents to obtain a F1 mapping population for linkage map construction based on Single Nucleotide Polymorphism (SNP) markers.

Germany (p. 9) reported on the introduction of the "Strategy for the medium and long-term supply of high-quality forest reproductive material through breeding in Germany", aiming to address climate change mitigation through breeding of fast-growing tree species such as sycamore maple (*Acer pseudoplatanus*), Douglas-fir (*Pseudotsuga menziesii*), pedunculate oak (*Quercus robur*), sessile oak (*Q. petraea*), Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), larch (*Larix decidua, L. kaempferi*), and hybrid larch (*L. × eurolepis*). The aim of this strategy is to provide propagation material with high adaptability, growth performance and quality. In addition, propagation material with special stability and production characteristics can be made available for forestry by breeding. Implementation of the breeding strategy takes about 15 years and was started with the projects "FitForClim" and "AdaptForClim" funded by the Forest Climate Fund.

Iran (p.5) indicated the importance of eucalyptus and alder species in its forestry sector. *Eucalyptus camaldulensis* plantations produce high yields in tropical regions like Khuzestan, Hormozgan and Bushehr provinces. Alder is one of the native trees of Hyrcanian forests and as a nurse tree plays an important role in the establishment of other forest species. It helps natural regeneration of lowland forests and is represented in Iran by *Alnus glutinosa* and *Alnus subcordata*, planted with oak, maple, elm, hornbeam, and honey locust trees.

Italy (pp.3-4) indicated eucalyptus, black locust, douglas fir and monterey pine among its other fast-growing tree species. Ex situ genetic reserves of eucalyptus and black locust species are maintained at the CREA experimental farm in Rome, such as *Eucalyptus viminalis*, *E. globulus ssp globulus* and *E. globulus ssp bicostata*, as well as 180 provenances of black locust. Douglas fir (*Pseudotsuga menziesii*) covers about 30,000 hectares in Italy, distributed along the Apennines. It is a highly productive and adaptable species, can be very profitable for the economy of mountain areas and most stands are managed under multifunctional silvicultural regimes. Monterey pine grows in the Mediterranean climate zone of Italy, mainly in Sardinia. In this part of the country, Monterey pine grows faster than native species and starts natural processes of regeneration even in presence of severe disturbances. Under these conditions, mature plantations of *Pinus radiata* are managed as silvicultural systems, implemented through shelterwood cutting. In central-eastern Sardinia the regional forestry agency actively supports this type of management to produce timber suitable for the packaging industry, as the average production of Monterey pine plantations in Sardinia is higher than the average production of best poplar plantations in Northern Italy.

Portugal (pp.6-7) indicated that the first eucalyptus plantations in the country date back to the beginning of the 19th century. To understand the genetic basis of this local landrace, RAIZ Institute, in collaboration with the University of Tasmania, found that while diversity was high, most *E. globulus* in Portugal originated from one or two native provenances (Southwest Tasmania and to a lesser extent Southwest Victoria), although several other native Australian races (from Furneaux, Southeast and South Tasmania and Recherche Bay) were also detected. Eucalyptus is managed as the most significant fast-growing species in Portugal, and its productive chains are truly relevant to national economy, comprising forest private owners, industries and the State. These actors are congregated under a structured productive chain encompassing producers' forest associations and cooperatives; the pulp and paper industries are organized within CELPA, the Association of Paper Industries. Within research, the highlight for RAIZ - Forest and Paper Research Institute- a private, non-profit research center, focused on forest and paper, which is recognized by the National Scientific and Technological System as an Interface Center for Technology Transfer and Valorization.

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Slovenia (pp.9-10) identified black locust (*Robinia pseudoacacia* L.) and black walnut (*Juglans nigra* L.) as fast-growing tree species with the highest potential for commercial, energy and environmental uses, and important non-native broadleaf species with many benefits for the forest owners as well as interests of other stakeholders. Black locust is one of the earliest introduced non-native tree species in the country. It became popular because of its capacity to grow in marginal degraded areas and can represent a good strategy for environmental restorations in special cases, as well as energy biomass production in short rotation cycles on poor soils and degraded areas and in coppice forestry. Since past experiences with the black locust are primarily positive in some parts of the country (soil improvement due to nitrogen assimilation, durable wood, beekeeping), it could be also one of the most competitive tree species in Slovenia. Black walnut in Slovenia currently exists only in the form of remnants of former wider black walnut planted forest complexes as well as in forest plantations. It shows high productivity and has the highest wood price from all non-native species in the market.

South Africa's plantation (commercial) forestry area accounts for 1.19 million hectares of the country's more than 40 million hectares of forest land. The majority of plantation area (99.6%) is cultivated with *Eucalyptus grandis*, *pinus* and wattle species. The balance (0.4%) is cultivated and used for other eucalyputus species such as *Eucalyptus nites*, *Eucalyptus marcathrii,* as well as other fast-growing species such as poplars.

Sweden (p.5) indicated the importance of Grey alder (*Alnus incana*) as an indigenous fast-growing species adapted to grow in wet and harsh habitats in Northern Europe. Gray alder has productivity around 6-7 tonnes per ha per year of aboveground woody biomass during a rotation up to 25 years.

Turkey (pp.7-13) reported on several natural and exotic fast-growing tree species, including turkish red pine (*Pinus brutia*), wild cherry (*Prunus avium*), narrow-leafed ash (*Fraxinus angustifolia*), european black alder (*Alnus glutinosa*), *Robinia pseudoacacia*, eucalyptus, maritima pine (*Pinus pinaster* Aiton), *Pinus radiata* D. Don, *Pseudotsuga menziesii* Mirb. Franco and *Pinus taeda*. Among natural fast-growing species turkish red pine (*Pinus brutia*) has the most intensive distribution. Narrow-leafed ash (*Fraxinus spp.*) is represented by three native species in Turkey: *Fraxinus angustifolia, Fraxinus excelsior,* and *Fraxinus ornus. F. angustifolia*, particularly suitable tree for lowland and sub-mountain areas. During the reporting period, a progeny trial of Manna ash (*Fraxinus ornus subsp. cilicica L.*) was conducted for variation, correlation and heritability for survival, seedling height and root collar diameter. European black alder in Turkey is represented by two species belonging to the *Alnus subgenus: Alnus glutinosa L.* and *Alnus orientalis*. *A. glutinosa subsp. barbata* is the most economically valuable among the other naturally distributed black alders due to its high biological regeneration ability and significant potential for use at plantations in the region. Black locust (*Robinia pseudoacacia)* species has resistance to air pollution and drought and grown as outdoor plants. *Robinia pseudoacacia L*. has become a naturalized species in Turkey and has been widely cultivated along roads, at schoolyards, train stations, and village plantations. Maritima pine (*Pinus pinaster Aiton*) is one of the fast-growing forest tree species widely used in industrial plantations in Turkey. It has the widest distribution area after poplar plantations among the exotic fast-growing species in Turkey. *Pinus radiata D. Don* reaches the fastest growth in Western and Eastern Blacksea region and Eastern Marmara and is one of the most investigated species in Turkey.

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3. PLANT HEALTH, RESILIENCE TO THREATS AND CLIMATE CHANGE

In terms of plant health and resilience, the biggest damage is caused by biotic factors such as insects and diseases related to changing climate conditions. Success and productivity of plantations is varying in some countries in recent years due to irregular rainfall. As preventive measures for control of diseases and pests, regular phytopathological examinations are carried out around countries, and biosurveillance is seen as a proactive approach that may help limit the spread of invasive fungal pathogens of trees.

Abiotic factors damaging poplar, willow and other fast-growing species can be divided into human activity related, soils related, and weather related. The most restricting abiotic factors in the report period included droughts and thunderstorms, high temperatures, floods, wind damages and soil salinity. In view of increasing water stress combined with raising temperatures due to changing climate, the deployment of well-adapted, water use efficient, and productive genotypes will be essential for the sustainability of both forests and wood supply for the forest industry.

3.1 Biotic factors, including insects, diseases and other animal pests

Various biotic factors were reported as damaging for poplars, willows and other fast-growing species in the reporting period. The most damaging are presented in Table 2.

Table 2 Biotic factors, that had damaging impact on fast-growing species during 2016-2019

Country	Main biotic harmful agents
Austria	leaf rust (*Melampsora sp*.), bark necrosis (*Cryptodiaporthe populea (Sacc.) Butin),* shoot dieback (*Phytophthora sp.)*
Bulgaria	*Chrysomela populi L., Gypsonoma aceriana Dup, Pavanthrene taboniformis Rott* and *Saperda populnea L.,* bark necrosis, caused by *Dothichza populea, Cytospora sp., Fusarium sp*.; slime flux; leaf blight, caused by *Marssonina brunnea*.
Canada	*Melacosoma disstria, Armillaria spp*., gray willow leaf beetle (*Micruapteryx salcifoliella*), large aspen tortrix (*Choristoneura conflictana*), linden looper (*Erannis tiliaria*), serpentine leafminer (*Phyllocnistis populiella*), leaf blotch miner (*Micrurapteryx salicifoliella*), *Tricholochmaea decora, Chryptorhynchus lapathi, Chinodes mediofuscella, Micrurapteryx salicifoliella, Caloptilia stigmatella*, eirphyid mites, *Trichiosoma triangulum* and aphids, bronze leaf fungal disease (*Apioplagiostoma populi*), *Septoria musiva,* Cytospora canker (*Valsa sordida*), *Micrurapteryx salicifoliella,* Septoria canker, ungulates (mainly moose and deer) and rodents (beavers, rabbits and voles)
China	*Cryptorrhynchus lapathi, Cytospora chrysosperma, C. nivea* and *Cryptosphaeria pullmanensis, Pectobacterium carotorum sub sp. Carotovorum* and poplar and willows Erwinia *(Brenneria salicis), Paenibacillus taiwanensis, Elsinoe tomentosae* and *Botryospaeria dothidea*
Croatia	*Operothera brumata L Melasoma populi L., Phyllodecta vitelinae L., Phylobius sp., Polydrosus sp., Rhabdophaga salicis Shrank., Helicomyia saliciperda Duf., Phyllocnistis suffusela Z., Lithocoletis populifoliella Fr., Lispothrips crasipes Jabl.*; red deer, hare, leaf rust (*Melampsora sp.)*, poplar bark cancer (*Dothichiza populea Sacc. Et Br*.), bark disease *Glomerella miyabeana*, *Pollaccia saliciperda*, dusky clearwing (*Paranthrene tabaniformis Rott.)*, hornet moth (*Aegeria apiformis* Clerck), etc. *Glomerella miyabeana*
Germany	Melampsora rust, askomycete *Venturia macularis*, or *Pollaccia radiosa.*
Italy	Poplar jewel beetle (*Agrilus suvorovi Obenberger*) and Melanophila stem borer *Melanophila picta (Pallas*), Poplar and willow borer *(Cryptorhynchus lapathi (L.),* Large poplar *borer Saperda carcharias (L.),* goat moth *Cossus cossus (L.),* poplar woolly aphid *Phloeomyzus passerinii*, poplar twig borer, poplar leaf beetle (*Chrysomela populi L*.), leaf-rolling weevil, roe deers and wild boars, green leafhopper red gum lerp psyllid, locust gall midge, *Phomopsis spp., Cytospora spp*. and "Dothichiza" stem canker, *Teratosphaeria* stem canker
Portugal	snout beetle (*Gonipterus platensis)*, longhorned borers (*Phoracantha spp*.)

Slovenia	*Chrysomela populi, Sciapteron tabaniformis* and *Saperda populnea*, European mistletoe (*Viscum album*) and *Armillaria spp*.; beavers (Castor fiber), leaf rusts (*Melampsora spp.)* and marssonina leafspot, dothichiza bark necrosis of poplar (*Cryptodiaporthe populea, sin Dothichiza populea*)
Spain	*Phloeomyzus passerinii (Hemíptera, Aphididae),* Lanigid aphid, *Paranthrene tabaniformis (Lepidóptera, Sesiidae)*, *Cryptodiaporthe populea (Sacc.) utin, Gypsonoma aceriana (Lepidóptera, Tortricidae)* bud and bud borer, aphid *hecabius affinis (Hemiptera, Aphididae), Phloeomyzus passerinii (Aphididae).* (Lanigid aphid), *Paranthrene tabaniformis (Lepidoptera, Sesiidae*)
Sweden	leaf rust fungus (*Melampsora larici-epitea*), *Phytophthora* pathogens
Turkey	*Gryllus desertus Pallas, Gryllotalpa gryllotalpa, Chionaspis salicis (L.), Lepidosaphes ulmi (L.), Polyphylla fullo, Saperda populnea, Paranthrene tabaniformis, Lymantria dispar L., Crepidodera aurata Marsham, Hemiptera heteroptera ve Cerambyx cerdo*, *Lepidosaphes ulmi, Clostera anastomosis, Prociphilus sp., Hyphantria cunea, Myzus persicae, Philaenus spumarius, Ceresa bubalus, Pterocomma pilosum Buckton, Trachys minutus, Chrysomela vigintipunctata, Crepidodera aurata, Crepidodera aurea, Phyllodecta vitellinae, etc.*

In **Austria (p.3**), leaf rusts (*Melampsora sp*.) cause problems in short-rotation poplar plantations in Eastern Austria. Together with late frost damage and *Cryptodiaporthe populea (Sacc.) Butin. (Syn. Dothichiza populea)* shoot die-back in the following spring, this has led to the failure of some plantations. Recent hot and dry years do not seem to have affected the cultivation of fast- growing tree species to a great extent. *Alnus glutinosa* is still affected by *Phytophthora sp.* (a big problem for *A. incana* stands). Otherwise, no emerging or major continuing biotic problems have been recorded. Plantation success is varying in recent years due to irregular distribution of rainfall over the year (dry winter, spring or autumn).

In **Bulgaria (p.3)**, insect pests such as *Chrysomela populi L., Gypsonoma aceriana Dup,* followed by *Pavanthrene taboniformis Rott* and *Saperda populnea L.* are extremely aggressive and cause extensive damage. The most common poplar diseases related to climate conditions in Bulgaria are bark necrosis, caused by *Dothichza populea, Cytospora sp., Fusarium sp.;* slime flux; and leaf blight on P. euroamericana, caused by *Marssonina brunnea*. In order to prevent implement measures for control of diseases and pests on poplars, willows and other fast-growing species, regular phytopathological examinations are carried out by the three Forest Protection Stations on the territory of the Republic of Bulgaria.

In **Canada (pp. 35-39)**, Tower poplar (*Populus xcanescens*) and Swedish aspen (*Populus tremula 'Erecta'*), have proved to be highly susceptible to bronze leaf fungal disease (*Apioplagiostoma populi*), specific to species and hybrids of aspens, grey and white poplars. The fastigiate hybrid poplar AC Sundancer has proven to be resistant to the disease and is being used as a replacement in urban parks. *Septoria musiva* has been repeatedly detected in leaf spots and cankers on hybrid *Populus* in British Columbia. Between 2016 and 2019 massive dieback of trembling aspen was reported in the northern half of Alberta due to the extended drought and forest tent caterpillar (*Melacosoma disstria*) infestations. Other biotic damaging vectors in Alberta during the reporting period include armillaria (*Armillaria spp*.) root disease, gray willow leaf beetle (*Micruapteryx salcifoliella*), large aspen tortrix (*Choristoneura conflictana*), linden looper (*Erannis tiliaria*), serpentine leafminer (*Phyllocnistis populiella*), tomentosus root rot (*Inonotus tomentosus*), aspen twoleaf tier (*Enargia decolor*) and willow leaf blotch miner (*Micrurapteryx salicifoliella*). In Alberta, *Calligrapha verrucosa* (a species of leaf beetle in the family *Chrysomelidae*) was the most serious insect pest found in the willow plantations. Other insects found include *Tricholochmaea decora* (gray willow leaf beetle), *Chryptorhynchus lapathi* (poplar and willow borer), *Chinodes mediofuscella* (leaf tiers), *Micrurapteryx salicifoliella* (willow leaf blotch miner), *Caloptilia stigmatella* (leaf rollers), eirphyid mites, *Trichiosoma triangulum* (willow sawfly) and aphids. Fortunately, natural control agents such as birds, parasitic wasps and carabid beetles were also found in abundance. The major disease affecting the willows was *Cytospora canker (Valsa sordida*). For willows, an outbreak of *Micrurapteryx salicifoliella* (willow leaf blotch miner) was observed on natural willow trees in the provincial forest in 2016 but had subsided by 2017. In Québec, there was a significant forest tent caterpillar outbreak from 2016 to 2018 in poplar, that caused heavy defoliation. Over the past years, there has been increasing spread of *Septoria* canker in typically Septoria-free

zones. Biosurveillance can be a proactive approach that may help limit the spread of invasive fungal pathogens of trees. Herbivory of poplars and willows by ungulates (mainly moose and deer) and rodents (beavers, rabbits and voles) have been reported in all Canadian provinces and territories. Young poplars and willows are especially susceptible to damage by bark-eating ungulates and rodents during winter. Rabbits frequently clip young shoots during winters of heavy snowfall. Tall grass and other heavy ground cover around trees increase the likelihood of damage by mice and voles feeding on the bark during winter, especially in years of large populations. Stems are injured by ungulates rubbing their antlers on them or by gnawing or stripping bark off trees with their incisor teeth. Secondary infections of fungi often enter trees through wounds caused by animals, compounding the damage. Control recommendations in all provinces include grass control to minimize damage by voles, applying physical barriers around tree stems to discourage small mammals from feeding and applying repellents to protect trees by discouraging animals from feeding on them. In some cases where ungulate populations are high and damage likely to occur, protective game fencing is installed.

In **China (pp.5-6)**, evaluation of poplar clones' resistance to *Cryptorrhynchus lapathi* related to xylem hardness, bark hardness, thickness and chest diameter was conducted by Northeast Forestry University. Pathogenic bacteria such as *Cytospora chrysosperma, C. nivea* and *Cryptosphaeria pullmanensis* were identified as cause for poplar and willow rot in southern Xinjiang. Poplar wet heartwood by carrots soft rot was caused by pectic bacillus subspecies (*Pectobacterium carotorum sub sp. Carotovorum*) and poplar and willows Erwinia (*Brenneria salicis*). *Paenibacillus taiwanensis* was identified as the inhibitory effect of willow Erwinia. In Nanjing, Jiangsu province, a new leaf spot disease was found on the leaves of *P. tomentosa*, and the pathogen belonged to the genus *Elsinoe*, which was the first reported new species named *Elsinoe tomentosae*. *Botryospaeria dothidea* strain that causes pathogenicity to the branches was found in Baoji area of Shaanxi province.

Poplar wood production in **Croatia (pp.4-6)**, in monoclonal or oligoclonal plantations with the large increment of the selected clones represents one of the biggest risks for the plant disease and the outburst of noxious insects and other injurious organisms. Among the most common diseases there are leaf rust (*Melampsora sp.)*, poplar bark cancer (*Dothichiza populea Sacc. Et Br*.), bark disease (*Glomerella miyabeana)*, seasoning of willow sprouts *(Pollaccia saliciperda)*, dusky clearwing (*Paranthrene tabaniformis Rott.)*, and hornet moth (*Aegeria apiformis* Clerck). *Glomerella miyabeana* on the willow seedlings is particularly dangerous, as it causes the red fire disease and arson of willow bark, and in two weeks can destroy the whole plantation. The spring pest defoliators have been recorded each year in the foliation period, including *Operothera brumata L Melasoma populi L., Phyllodecta vitelinae L., Phylobius sp., Polydrosus sp., Rhabdophaga salicis Shrank., Helicomyia saliciperda Duf., Phyllocnistis suffusela Z., Lithocoletis populifoliella Fr.* In the years with severe late spring frosts, poplar trees which suffered under low temperatures are affected by distinctively secondary Trypophloeus species, which otherwise do not appear in large numbers. Some habitats become unproductive for poplar caused the change of habitat and the subsequent outbreak of thrips (*Lispothrips crasipes Jabl.)* caused by dry periods and stress through which the young poplar trees suffer in these areas. In the newly planted poplar plantations great damages are done by the red deer (*Cervus elaphus L*.) through breaking plants while the hare (*Lepus europus*) barks the willow seedlings. The study of weed flora and weed killing is done every year adjusting the way and method to the weed species and new herbicides. Regular diagnostic and prognostic service following the disease outbreak and pests is organized to give the instructions for the control and wiping out by Croatian Forest Research Institute (CFRI). The seedlings in the nurseries must be examined twice a year by the Institute for Plant Protection.

Breeding projects in **Germany (p.11)** are concerned with the provision of high-quality, adaptable, high-performance, and resistant propagation material. Poplar leaf grids of the *Melampsora* genus are among the economically most important fungal diseases in poplars and willows. The years 2016, 2018 and 2019 featured a low overall *Melampsora* infestation pressure, while this tended to be more pronounced in 2017. There were also differences between clones, progeny and progeny groups. Tests confirmed that the hybrids from *P. tremula × P. tremuloides* have a high resistance to *Melampsora* rust. Another dangerous poplars' disease is shoot tip disease

or branch drought. The symptoms to be observed on leaves and branches are caused by the askomycete *Venturia macularis*, which is also well known as Pollaccia radiosa. The overall infestation was very low in the reporting period. With a targeted selection of less susceptible offspring, the risk of infestation can be reduced.

In **Italy (pp.5-9)**, droughts and high temperatures during the growing season cause increased incidence of various pests. Buprestid beetles, i.e. Poplar jewel beetle (*Agrilus suvorovi Obenberger*) and Melanophila stem borer *Melanophila picta (Pallas*), were often reported in new plantations suffering from transplant stress or drought, causing weakening of young trees or stem breakages. Poplar and willow borer *(Cryptorhynchus lapathi (L.)* were confirmed as the most dangerous pests in Italian poplar cultivation. Large poplar borer *Saperda carcharias (L.)* and the goat moth *Cossus cossus (L.)* have an impact on quality of plywood industry products. Besides pests, existing pest inhibitors should be replaced by environmentally more sustainable molecules, or biologic control strategies need to be developed. Among phytomyzous insect pests, the poplar woolly aphid (*Phloeomyzus passerinii (Sign.)* is the most injurious one, causing bark damage and death of trees when attacks were heavy and prolonged. Brown marmorated stink bug (*Halyomorpha halys (Stål)* induces frequent and severe damage on young trees consisting of necroses and malformations on trunks. Poplar clearwing moth *Paranthrene tabaniformis (Rott.)* and the poplar twig borer *Gypsonoma aceriana (Dup.)* occasionally affect nurseries and young poplar stands. Among defoliators, poplar leaf beetle (*Chrysomela populi L.),* leaf-rolling weevil (*Byctiscus populi (L.)* and fall webworm (*Hyphantria cunea (Drury)* induce locally early defoliations mainly in *P. deltoides* plantations. Investigations to find strategies of control (including the use of semiochemicals) are advancing in order to reduce damage in the affected areas and to avoid chances of spreading. Damage by roe deers (Capreolus capreolus L.) and wild boars (Sus scrofa L.) has significantly increased in nurseries and especially in new plantations following the expansion of these mammals; it consists of bark removals, with consequent formation of proliferating scar tissues, inducing a quality loss and stem ruptures. On the newly established plantations, weak attacks of *Phomopsis spp., Cytospora spp*. and "*Dothichiza*" stem canker induced by *Chryptodiaporthe populea (Sacc.) Butin*, inducing bark necroses, were observed. Increasing stem necroses in nurseries and young plantations seem associated with *Fusarium spp. (F. solani (Mart.) Sacc., F. lateritium Nees*, and *F. incarnatum (Desm.) Sacc.* The damage of rusts on the short rotation forestry must be seen more in terms of stump survival and, in the long period, of integrity of the coppice stand rather than in terms of quantitative losses of dry matter. Among willow pests, the green leafhopper *Asymmetrasca decedens (Paoli),* a polyphagous species able to transmit phytoplasmas probably responsible for leaf deformations and yellowing is worth mentioning. Biological control could be pursued, enhancing the spreading of the egg parasitoid *Anagrus atomus (L.),* already present in Europe, including Italy. In the last years an important new fungal pathogen was found on eucalypts in Southern Italy. It is *Teratosphaeria gauchensis*, pathogenic agent of the *Teratosphaeria* stem canker disease (formerly known as *Coniothyrium* canker), reported for the first time in 2015 on hybrid *Eucalyptus camaldulensis Dehnh × E. viminalis Labill.,* but already well known worldwide. Among pests, the red gum lerp psyllid (*Glycaspis brimblecombei Moore*), cosmopolitan, is now spread in large territories of Campania, Sicily, and Sardinia, and has become in a few years very detrimental especially on *E. camaldulensis*. A biologic control with the hemipter predator *Anthocoris nemoralis Fabr*. seems potentially the most efficient. The locust gall midge *Obolodiplosis robiniae (Haldeman)* pest has been reported with a certain frequency on the few black locust plantations in Italy, and a wasp could be used in possible biologic control studies, i.e. the parasitoid *Platygaster robiniae Buhl & Duso*. Douglas fir stands, well established in Italy for decades, are subjected to the conifer root rot *Heterobasidion annosum sensu stricto (Fr.) Bref*., whose damage, in heaviest cases, can consist of the death of several trees. Its management may be preventive, by avoiding new plantations on former crop or grassland soils, or extinctive, by treating stumps, just after cutting, with a suspension of *Phlebiopsis gigantea (Fr.) Jülich* spores, a saprobic competitor. Caliciopsis canker, induced by the ascomycete *Caliciopsis pinea Peck*, is at present the most incident disease in Monterey pine plantations. Once described as a secondary pine pathogen, *C. pinea* has been associated with severe damage in Italy, causing sharply delimited cankers on trunks and branches, crown wilting, defoliation, and a profuse resin production.

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In **Portugal (p.7),** Eucalyptus plantations can be greatly affected by biotic and abiotic risks depending on both site conditions (climate, topography, geomorphology, landscape occupation and soil type) and forest management. The most important pests and diseases of *Eucalyptus* are the snout beetle *Gonipterus platensis* and the longhorned borers *Phoracantha spp.* Without control measures, the snout beetle is estimated to affect up to 20% of eucalypt plantations every year, despite some variations between years, depending on environmental conditions. Longhorned borer attacks are associated with drought conditions. The unusually dry year of 2017 resulted in extensive losses that lasted up to 2019. Control methods are available for both pests, and include the use of resistant plant varieties, biological control, log trapping, sanitary felling, and insecticide applications. Research and development of new or improved control methods is underway, with emphasis on resistant genotypes and biological control, as well as improved monitoring techniques using remote sensing.

In **Slovenia (p.11)**, the health status of all reproductive material in poplar nurseries is inspected twice a year by the Slovenian Forestry Institute, authorized for the official supervision of the health of all reproductive materials for forest plantings; the inspection is carried out in cooperation with a forest inspection service. Phytosanitary measures are recommended and prescribed by forestry inspectors and are obligatory for nursery managers. The most frequently observed diseases in the reporting period were poplar leaf rusts (*Melampsora spp*.) and marssonina leafspot of poplar (*Drepanopeziza punctiformis, sin. Marssonina brunnea*). Occasionally, dothichiza bark necrosis of poplar (*Cryptodiaporthe populea, sin Dothichiza populea*) was detected in nurseries. The most frequently observed pest was *Chrysomela populi*, which was regularly controlled by insecticide applications. *Sciapteron tabaniformis* and *Saperda populnea* were often found in poplar nurseries but caused little damage. Poplar plantations were mostly felled due to European mistletoe (*Viscum album*) and *Armillaria spp*. Willows were mostly felled because of strong winds, complex disease, *Armillaria spp*., and drought. Minor damaging factors included beaver (Castor fiber) and lighting.

In **Spain (pp.4-5)** in the reporting period a number of pests were detected in nurseries and private plantations. In 2016 *Phloeomyzus passerinii (Hemíptera, Aphididae*), Lanigid aphid in a private property poplar in Baños de Rioja, and *Paranthrene tabaniformis (Lepidóptera, Sesiidae*) in the "Prado Arrauri" (Haro) nursery were detected. An attack of fungus disease *Cryptodiaporthe populea (Sacc.) Butin* was observed in the nursery of "Prado Arrauri" (Haro). In 2017, *Gypsonoma aceriana (Lepidóptera, Tortricidae*) bud and bud borer affected poplar plantation (*Populus x euramericana and P. x Interamericana*) from the "Prado Arrauri" forest nursery in Haro, which were treated with Alpha-cypermethrin mixed with summer oil. The same year, numerous galls of aphid *hecabius affinis (Hemiptera, Aphididae)* were observed on black poplars from the banks of the Ebro and Leza. During 2018, *Phloeomyzus passerinii (Aphididae) (Lanigid aphid)* was detected in 4 4-year-old poplars in Anguiano and successfully treated. *Paranthrene tabaniformis (Lepidoptera, Sesiidae*) In the "Prado Arrauri" (Haro) nursery was identified, and 36 traps with *Paranthrene tabaniformis* pheromones were placed to capture males of this drilling lepidopteran, between May and September, obtaining similar catches to previous years.

In **Sweden (p.5),** leaf rust fungus *Melampsora larici-epitea* was identified in a *Salix viminalis x (S. viminalis x S. schwerinii*) breeding population in several regions. Besides ongoing research on Melampsora, few studies have focused on fungal pests in hybrid poplars. Invasive Phytophthora pathogens were identified as cause of stem lesions in industrially important broadleaved tree species, *Fagus sylvatica* and *Quercus robur*, in Southern Sweden. A recent study has identified several *Betula pendula* genotypes and one P*. trichocarpa* genotype susceptible to three different taxa of invasive soil borne pathogens that cause widespread decline of *Fagus sylvatica*. These results emphasize that emerging breeding program of commercial poplar clones for Sweden and Baltic Sea Region needs to consider tolerance/ resistance against fungal pests of commercially deployed genotypes.

In **Turkey (pp.13-15)**, several studies conducted in Kastamonu region identified *Gryllus desertus Pallas, Gryllotalpa gryllotalpa, Chionaspis salicis (L.), Lepidosaphes ulmi (L.), Polyphylla fullo (L.), Saperda populnea (L.),*

Paranthrene tabaniformis (Rott.), Lymantria dispar L., Crepidodera aurata Marsham, Crepidodera aurea (Geoffrey), and Melasoma populi L. as the main poplar pests. According to the study, *Hemiptera heteroptera ve Cerambyx cerdo* damage the poplar trees, *Chrysomela (Chrysomela) populi Linnaeus 1758, Lepidosaphes ulmi, and Clostera anastomosis* damage *Populus spp. whereas Prociphilus sp. and Hyphantria cunea* are harmful pests for Fraxinus spp. In addition, there was damage of *Myzus (Nectarosiphon) persicae* on Prunus avium L. Willows utilized both as firewood and construction wood in Turkey are valuable species which have traditionally been cultivated on the borders of fields and river sides. Recently, willow plantations have been established because of the increasing demand on the need of wood raw material and several experiments have been performed considering willow cultivation. In a study conducted on willows in Bartın region, *Philaenus spumarius (Linnaeus), Ceresa bubalus (Fabricius), Pterocomma pilosum Buckton, Trachys minutus (Linnaeus), Chrysomela vigintipunctata (Scopoli), Crepidodera aurata (Marsham), Crepidodera aurea (Geoff.), Phyllodecta vitellinae (Linnaeus), Plagiodera versicolora (Laicharting), Pyrrhalta (Galerucella) lineola (Fabricius), Scoliopteryx libatrix (Linnaeus), Lymantria dispar (Linnaeus), Nymphalis antiopa (Linnaeus), Nymphalis polychloros (Linnaeus), Lygaeonematus compressicornis (Fabricius),* and *Pontania proxima (Lepel)* were determined as harmful insects for willows. In terms of other fast-growing species, the pine processionary moth which commonly damages to coniferous species, especially *Pinus brutia*, is one of the most important forest pests in Turkey. To reduce the negative effect of continuously using chemical pesticides on the environment and human health, alternative fighting methods against pests are gaining importance. In this case, many studies have been carried out to fight harmful insects by utilizing entomopathogenic fungi and essential oils as effective and safe methods. Harmful and useful insect species for *Robinia spp* were also studied in this report period. As a result of studies, while *Acyrthosiphon pisum (Harris), Aphis craccivora Koch, A. gossypii Glover (Hemiptera: Aphididae), Calocoris annulus (Brullé), C. roseomaculatus subsp. angularis (Fieber) (Hemiptera: Miridae) and Hypera postica (Gyllenhal) (Coleoptera: Curculionidae)* were identified as main pests for Robinia spp., *Coccinella septempunctata (L.), Scymnus rubromaculatus (Goeze) (Coleoptera: Coccinellidae), Episyrphus balteatus De Geer (Diptera: Syrphidae), Lipolexis gracilis (Foerster) (Hymenoptera: Braconidae*). Pests such as *Archips rosanus L., Rhagoletis cerasi Linnaeus, Tropinota hirta Poda, Stephanitis pyri Fabricius, Myzus cerasi F., Capnodis tenebrionis L., Scolytus rugulosus Müller and Tetranychus urticae Koch* and insects *Coccinella semptempunctata L., Synharmonia conglobata L., Scymnus pallipediformis Gunther, Metasyrphus corollae Fabricius and Chrysoperla carnea Stephens* were identified as mainly destructive for cherry (Prunus spp.). Among main pests and insects that attack Pinus brutia trees there are *Neodiprion sertifer, Dioryctria sylvestrella (Ratxeburg) (Lepidoptera: Pyralidae), Heterobasidion annosum, Thaumetopoea wilkinsoni Tams, Thaumetopoea pityocampa, Tomicus destruens Woll., Anomognathus ispartaensis sp. M. (Coleoptera:Staphylinidae: Aleocharinae), Marchalina hellenica Genn., Artemisia santanicum L. and Artemisia absinthium L.* Phenolic compounds and antioxidant capacity of Fraxinus excelsior and Fraxinus americana leaves were studied and phytoplasma disease on Acacia spp. growing in architectural landscapes were determined.

3.2 Abiotic factors, including storms, floods, droughts, pollution and others

In **Bulgaria (p.3)** in recent years, lower survival rates of poplar crops have been reported, mainly due to prolonged periods of drought in the second half of the year and extremely high summer temperatures. In Southern Bulgaria, the reason is the low water level in the rivers and the low level of groundwater. Damages from strong winds and hail is also reported annually. In 2019 and 2016, damaged poplar crops were reported as a result of prolonged flooding of the Danube, in 2018 such floods were reported along the Arda and Struma rivers, and in 2016 along the rivers Maritsa and Mesta. For modernization of the production in the poplar nurseries the biggest investments are made for water supply and construction of drip irrigation systems.

In **Canada (pp.39-40)**, abiotic stress in poplars, willows and other fast-growing trees can be divided into three categories: human activity related, soils related and weather related. The most restricting abiotic factors

affecting poplar and willow in Canada are drought, temperature and soil salinity. The major abiotic disturbances reported in Saskatchewan province during 2016-2019 were wind damage, floods and drought. Wind damage was the most prevalent disturbance agent in natural stands of trembling aspen, with over 42,000 ha of aspen forest affected. Floods resulted in tree mortality of 16,500 ha of trembling aspen between 2016 and 2019, and drought stress together with bark beetles and woodborers led to trembling aspen decline on an estimated 14,000 ha in Saskatchewan. In Alberta, the major abiotic vectors affecting poplars and willows were flooding, drought and wind. A study in northern Alberta characterized key traits among new genotypes of hybrid poplars (*Populus spp*.) in water use efficiency (WUE) and evaluated the adaptive capacity of the genotypes to water deficits. This study showed hybrids between *Populus balsamifera* and *Populus maximowiczii* species showed a slightly greater adaptive potential to the geographic area of the study than the other tested cross types. Research at the University of British Columbia used field and controlled growth chamber tests to assess population-wide patterns in bud-break from wild-sourced black cottonwood (*Populus trichocarpa*) genotypes. They conducted a genome-wide association study (GWAS) with single nucleotide polymorphisms (SNPs) derived from whole genome sequencing to test for loci underlying variation in bud-break. The researchers proposed GWAS-identified loci underpinned the geographical pattern in *P. trichocarpa* and that variation in bud-break reflected different selection for winter chilling and heat sum accumulation, both of which can be affected by climate warming.

In **China (pp.6-7)**, abiotic stress factors for poplar, willow and other fast-growing tree species differ between regions: in the northern region it is mainly low temperature, drought, soil salinity and wind damage, while in the southern region it is flood, high temperature and environmental pollution. Abiotic stress has taken a toll on the growth and development of forest trees. The molecular mechanism of plant stress response, resistance and related gene mining has been carried out and aims to provide the means to breed resistant varieties, to alleviate the abiotic stress damage. Jiangsu Academy of Forestry in Southern China also developed several techniques for the abiotic stress reduction, including willow ridge cultivation technology, and forestation technology using willow cuttings in rainy season on saline-alkali land.

In **Croatia (p.6)**, significant damage was caused to poplar plantations by the thunderstorms in 2016. These thunderstorms took place in the Osijek region located in the Eastern part of the country and destroyed 700 ha of poplars along Drava river.

In **Germany (pp.11-12)**, climate change and the associated extreme events such as storms and drought, as well as the subsequent beetle infestation, pose new challenges to the tree species. The dry years of 2018 and 2019 led to significant growth losses in poplar plantations, with higher failures observed in younger plantations. On the other hand, failures in young test areas with hybrid aspens were hardly noticeable. Larger failures due to insect infestation (e.g., bark beetle) after drought occurred in larch stands, particularly in central Germany. No significant damage is known for the black locust, which is considered to be tolerant to heat and drought.

Iran's geographical location, global warming and water scarcity cause serious challenge to the development of wood farming. The Office of Education and Promotion continues its work aiming to increase water productivity through improved irrigation systems and sustainable planting methods. For increased water efficiency, production of poplar and fast-growing tree species with drip irrigation systems is expanding, and the government is supporting this type of irrigation system. Poplar clones that maintain their wood production in climatic conditions with less moisture and rainfall and have become the priority.

In **Italy (p.5),** vegetative seasons in the recent years were often characterized by extended periods of drought, causing dehydration of the tissues of young trees, with consequent weakening of the sprouting shoots. Dry summer conditions with high temperatures induced drastic thinning of the crown and consequent reduction of the annual growth, defective lignification of young buds and reduction of reserve substances for the quiescent

period. In mature plantations stressed by water deficit, the syndrome known as “brown spots” physiologic disorder has been frequently observed. Significant summer drought together with mild average temperatures in winter contributes to the frequent pest outbreaks that have been observed.

In **Portugal (p.8),** Eucalyptus are present in regions where total annual precipitation range from 500 mm to 2000 mm, with a well-established dry summer season, typical of Mediterranean climates. Under a climate change scenario with less precipitation, higher evapotranspiration, and expected increase in extreme drought events, the success of eucalypt plantations in some regions may be compromised. The drought event of 2017 resulted in extensive mortality and subsequently large production losses. Genetic improvement programs have been selecting and testing new eucalypt clones in order to maintain or increase stands’ productivity in drier sites of Portugal. Some soil characteristics are known to be unfavorable to the performance of eucalypts growth increasing the economic risk. These include shallow, incipient soils, highly sandy soils, high clay content, or with adverse chemical, soil with natural high compaction and with hydromorphic characteristics. Forest fires are one of the main threats to eucalyptus plantations. Payment for ecosystem services is foreseen as an important tool to promote more active management practices in eucalyptus plantations. Otherwise, abandonment will prevail and the societal value of these plantations would decrease.

For **Slovenia (p.11)**, main abiotic factors that cause damage and felling of poplars include wind, thunderbolts, and flooding. Willows were mostly felled because of strong winds, complex disease and drought. Minor damaging factors included lightning. Black locust (*Robinia pseudoacacia*) was mostly affected by the wind, complex disease, drought, *Viscum album*, and rodents. The health status of black walnut (*Juglans nigra*) was affected mostly by wind and drought.

In **Sweden (p.5),** droughts can be harmful to poplar and other fast-growing tree plantations. Therefore, selection of genotypes with high biomass yield needs to be conducted specifically in the environments where the clones will be deployed at commercial scale. A great variability of water use patterns in closely related Salix genotypes will allow selection of suitable genotypes for different drought conditions.

The main damage due to abiotic factors in **Turkey** (p.16) was created by fires. Since 2016, an average of 2,611 forest fires occurred in the country, resulting in the 9,531 ha of burned forest area, 90.7% of which was Red Pine forests.

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4. SUSTAINABLE LIVELIHOODS, LAND-USE, PRODUCTS AND BIOENERGY

Nursery practices and propagation techniques in the reporting period mainly remained traditional, conducted by specialized public and private nurseries, with production techniques and approaches varying between countries. Plantations of poplars, willows and other fast-growing species have numerous applications in the IPC member countries. They are used for intensive production of timber, pulpwood, OSB, carbon sequestration and bioenergy, afforestation purposes, planted along riverbanks, on higher altitude and along mountain rivers and on humid soils, cultivated on sand-clay soils, in coastal zone and on drained terrains. Agroforestry and intercropping are seen as sustainable approach for developing wood farming and improved economic efficiency and livelihoods conditions of farmers.

Sustainably managed poplar plantations represent an opportunity both for the use of wood for construction (that will contribute to the climate change mitigation), and production of susceptible biomass for various bioproducts (that replace fossil fuels as a source of renewable energy). The main barrier to the development of new forest plantations nowadays is limited commercial activity, lack of subsidies for poplar and willow cultivation and production, and little information available for possible investors.

Outside forests, poplars and willows are also being used for modern landscape architecture around towns and villages, as they have exceptional species and form variety and rapid growth. They also serve as windbreaks, ensure riparian protection and other environmental purposes. Intercropping (silvoarable or alley cropping systems) with nurse trees can represent a suitable option for tree farming and agroforestry, beneficial from economic and environmental point of view.

4.1 Nursery practices and propagation techniques

In **Austria (p.4),** nursery practices remain traditional. A few private nurseries are propagating Paulownia plants for biomass and timber production in the warmest parts of Austria. Greenhouses are being tested for securing plant production. Biomass production systems for poplars and willows have been planted directly from cuttings in rows with rather dense spacing within rows. A biomass variety testing site for poplar is now thinned at intervals, in order to gather experience. There is a pilot planting of poplar varieties for biomass production combined with noise protection along a major motorway in Lower Austria.

In **Bulgaria (p.4)**, established production of more than 2 million stool bed cuttings per year provides for the needs of the country. Poplar shoot production is organized from 1-year-old stool beds using the stool beds scheme and controlled irrigation and fertilization. The vitality of the stool beds is about 20 years.

In **Canada (pp.41-43)**, due to cancellation of nursery production in the Canadian prairies in 2013, rooted poplars and willows of a suitable clone, price, size and quality are often difficult to obtain for prairie shelterbelts, causing some conservation districts to access these materials and other tree/shrub seedlings from Lincoln-Oakes Nurseries. Deciduous seedlings, including poplar and willow cuttings, are available in Québec through the provincial nursery of the Ministère de Forêts, Faune et Parcs (MFFP) at Berthierville, Québec. The MFFP also lists private nurseries that produce forest seedlings. Hybrid poplar selections adapted for use in shelterbelts or other applications in the Prairie Provinces are available as rooted plugs from Tree Time Services in Edmonton, Alberta and from Prairie Shelterbelt Program in Sundre, Alberta.

In **China (p.7)**, techniques such as black mulching film covering, cutting propagation, big seedling cultivation with whole stems and integrated disease and insect prevention and control are used in combination to promote the standardization of seedling cultivation of new poplar varieties and save labor cost. The management protocol of

seedling cultivation is standardized for new varieties of *P. deltoides* and its hybrids with black poplars (*P. nigra)*. Willow seedling technology in greenhouses and rooting technology of tissue cultured willow cuttings were developed for facilitation of the large-scale willow propagation. Research conducted in Yili prefecture, Xinjiang province, on willow shrubs and willow trees showed higher growth performance of willow shrub, thus it could be considered for ecological and bioenergy use in Yili.

In **Croatia (pp. 6-7)**, production of poplar and willow plants is conducted by specialized nurseries and based exclusively on autovegetative propagation capability with a two-year production cycle. Production of rooted seedlings is practiced in poplar planting production. Reproductive material is mainly produced on special areas, so-called 'root swellings', with annual productivity about 70,000 pieces per hectare. In some regions, simultaneous production of reproduction material and seedlings for planting production is being practiced. Storage of cuttings is managed by using refrigerators.

In **Korea (p.4),** production of seedlings (emblings) is usually conducted from somatic embryogenesis through tissue culture technique. After production, emblings get transferred to nursery at National Institute of Forest Science. However, seedlings production is still more expensive than conventional seed sowing techniques.

For **Slovenia (pp.11-12)**, planting of native poplars *Populus nigra, Populus alba, Populus tremula* and willows *Salix alba, Salix eleagnos, Salix purpurea, Salix fragilis, Salix viminalis* is rare due to the lack of forestry nurseries specialized for poplar and willow FRM cultivation. This creates a lack of forest reproductive material on the market. During the reporting period, new forest nurseries were officially registered for producing and trading FRM on the local scale, including Forestry Turnišče that maintains a collection of Populus nigra genotypes from Mura River floodplain forests. Native poplar and willow species are being introduced as pioneer crops in mixed stands in calamity areas or other afforestation areas as well as for rejuvenation of old poplar plantations on arable lands. The newly registered forestry nurseries Arboris and BLS Gozd Company started with their own selection of *Populus nigra* mature trees in natural stands along the lower part of the Mura River system in winter 2018/2019 for cuttings collection and stoolbeds establishment. Common agricultural machinery is used in soil preparation in forest tree nurseries. The use of GMOs is forbidden.

In case of **Sweden (p.6)**, production and storage of willow cuttings for further nurseries establishment have been studied during 2016 – 2019. A study showed that willows from freshly harvested cuttings, which were planted early in the growing season, had better ability to suppress weeds compared to willows established from dormant cold-stored cuttings, while the aboveground biomass of willows from these two different types of cuttings did not differ. This implies that storage costs for willow cuttings can be avoided, which also should decrease the market price of willow cuttings. Effective micropropagation protocols were developed for provenance hybrids of P.trichocarpa to facilitate mass propagation of these new poplar cultivars for commercial deployment. Two critical steps in the micropropagation of these poplars were identified: establishment of the contamination-free stock plants, and large clonal differences in propagation rate.

In **Turkey (pp.16-17)**, the need for thick wood material in wood industries is decreasing while the demand for thin material is increasing. Due to the raising environmental pollution several researches were conducted on different fast-growing species to find out the effect of planting density, ecological diversity, and different treatments on their growth and wood properties and to try prevent the ecology from using chemicals on wood materials. The effect of sowing type and seedbed density on the morphological characteristics of narrow-leaved Ash (*Fraxinus angustifolia ssp. oxycarpa Vahl*.) seedlings have been investigated in nurseries in İzmit and Hendek in Turkey). According to the results, while sowing type was not affecting the morphological characteristics of ash seedlings, seedbed density significantly influenced them. The effects of seedbed density on some morphological properties in Douglas-Fir (*Pseudotsuga menziesii (Mirb.) Franco*) seedlings were studied since 2016. The results revealed that the maximum number of quality Douglas seedlings per unit area can be obtained from 2+0 aged

Douglas seedlings grown in 3 cm seedbed density. The effects of growing incidence and the use of herbicide on the production of quality seedlings from Pinus brutia were studied during the report period. Analyses showed that the spacing of 7.5 cm resulted in the best seedling based on morphological characteristics.

4.2 Planted Forests

In **Bulgaria (pp.4-7)**, timber from poplar and willow plantations is mainly used for intensive production of large-sized sawn and industrial timber. Recently the following poplar cultivars are available in Bulgaria: *Populus euramericana (Populus nigra × Populus deltoides), Populus deltoides, Populus × interamericana (Populus trihocarpa × Populus deltoides), Populus alba, Populus canescens, Populus tremula and Populus maximowiczii × Populus trichocarpa*. *Populus euramericana* is the most used species for timber production in Bulgaria (from 60 to 80% of total volume). Cottonwoods are being planted along riverbanks, hybrids of balsam poplars are used on higher altitude and along mountain rivers and on humid soils, and other poplar hybrids are being cultivated on sand-clay soils, in coastal zone and on drained terrains. Care for poplar crops is being taken through tillage, irrigation, fertilization, and pruning.

In **Canada (p. 43),** a substantial area of hybrid poplar plantations has been established in Québec. Planting of hybrid poplar as a source of wood has generally decreased in Canada following several decades of pilot projects, clonal improvements and clonal testing and programs by government and industry to explore the use of poplar plantations for pulpwood, OSB, carbon sequestration and bioenergy. Although no new aspen plantings are being established, the existing plots and clonal materials are being monitored for growth, disease resistance and other selection criteria.

In **China (pp.7-8)**, poplar and willow plantations are used for afforestation purposes using water retention agents on sand lands, that helps to shorten rotation, avoid scarification, and ensure high efficiency of afforestation and tree growth. This approach is particularly useful in cultivation of high-quality poplars. Based on the field surveys, operational simulations and economic benefit evaluation, a decision-making tool for integration of plantation management model systems for southern poplars was established. Research on eucalyptus cultivation in China is based on the distribution of the big-diameter wood species, climate data, soil and terrain factors. A combination of traditional and molecular tools was used to obtain the morphological characteristics of roots, use of fertilizers, and transcriptome differences of species, which help to understand nutrient uptake differences among eucalyptus species.

In **Croatia (pp.8-10)**, poplars and willows are being cultivated in combination or in close vicinity to the existing large forest tracts, thus forming economic entireties with them. The development programme supports poplar and willow production on light alluvial soil along the Drava and the Danube. Conversion of existing poplar plantations into common oak units is almost completed in this area. Sixty-six percent of the poplar and willow plantation in Croatia is owned by the state. Plantation and cultures technology, used for the cultivation of poplars and willows, encourages use of selected plant material, mechanized planting and agrotechnical measures. The clone production palette is corrected continuously, based on single clones sprouting and growing progress analyses. Among poplars the most common clones are *P. x euramericana, P. deltoides.* and *(P. alba)*. The possibility to cultivate mixed white willows *(Salix alba)* and black alder *(Alnus glutinosa)* exists on the peat-gley soils in the central Drava basin (Đurđevac).

In **Germany (p.12)**, due to the general rise in energy prices, energy crops offer planning security and an additional perspective of sustainable management. It also provides the housing industry and other heat users a stable framework for regenerative heat supply. Fast-growing tree species planted on agriculturally less productive land can be a solution for production of wood chips. The focus is on tree species that have the property of sprouting

again after harvesting. Depending on the type of soil and the amount of precipitation, poplars, willows and black locus are particularly suitable. The aim is a sustainable timber yield of 10-12 tonnes of absolute dry matter per year per hectare.

In **Iran (pp.6-7)**, the Forest and Rangeland Research Institute conducted monitoring of poplar plantations in 2018 and identified the need for production of more than 5 million rooted poplar cuttings. *Populus nigra, P. deltoides* and hybrid *P. euramericana* clones are among the most productive species, planted around farmlands and used for environmental protection and wood production. An integrated farming system (agroforestry) is seen as an ideal approach for developing wood farming and improved economic efficiency and livelihoods conditions of farmers. There is particular interest in the intecropping of wheat, alfalfa and peanuts with poplar plantations.

In **Italy (pp.9-10)**, poplar propagation and nursery techniques continue by adapting the conventional practices (irrigation, fertilization and pruning) to new poplar clones, especially for those with greater environmental sustainability. Response of a biostimulant of natural origin, based on amino acids and peptides on *Eucalyptus globulus ssp.* seedlings was tested. Seedlings treated with biostimulant have recorded growth in terms of aboveground and total biomass, approximately twice the control level. Biostimulant's use promotes a positive reaction in plant metabolism, increasing its development, and may be important for obtaining plant material in a shorter time (through reduction of time spent in a nursery).

In **Korea (p.4)**, the Korea Forest Service (KFS) recommends planting yellow poplars with a spacing between lines of 3 meters and a spacing of plants within a line of 3 meters, a planting density of 1100 trees per hectare for timber production. KFS also recommends the use of 2.5m x 2m spacing, a planting density of 2000 trees per hectare for biomass production purpose. A heading (or topping) cut just above stem nodes is strongly recommended right after planting.

In **Portugal (p.9),** more than 80% of eucalyptus plantations are being owned and managed by numerous small forest landowners under a coppice regime. Several investments have been made in overcoming rooting problems and modernizing the production of eucalypt cuttings. Recent developments included a new mini-cuttings production line by The Navigator Company's clonal nursery. Ongoing research projects in this area include iPLANT, a nationally funded project aiming to develop innovative cuttings technology based on hydroponic and aeroponic systems. Among other projects specifically targeting improvements in eucalyptus culture there is mySustainableForest, a H2020 project aiming to test and develop innovative use of remote data and implementation of advanced detection technologies. Several forest extension initiatives are underway, including support to forest growers. Furthermore, a web-based e-globulus platform funded by State's SIAC initiative (Incentive System for Collective Actions for the Transfer of Scientific and Technological Knowledge) has been released free of charge. In 2018 the Inpactus project (Innovative Products and Technologies from Eucalyptus) was launched, led by Portuguese Industry and Universities and involving several European partners. It aims to develop new solutions, such as cellulosic pulps with innovative features, new paper products with different specificities and functions, tissue paper with innovative properties, new bio-products, biofuels and other materials obtained from the deconstruction and conversion of forest biomass and by-products from the pulp industry.

In **Slovenia (pp.12-14)**, a wide floodplain forest area of the Mura River and in Slovenia was artificially regenerated with the native *Populus nigra* and *Salix alba* seedlings. Both species were used for establishing a beaver feeding area along the river terrace and converting a poplar hybrid plantation to more natural structures in the frame of the GOFORMURA project. Three experimental plantations for bioenergy production were established on the arable land of NE Slovenia (Ižakovci, Pince-Marof) in the frame of Interreg SI-AT project PEMURES and EUPOP project (2013, 2014) in different soil and climate conditions for testing old and new poplar clones from EU member states for use in short rotation coppice. Experimental plantations for testing poplar clones from EU

member states were planted in Pince-Marof in the area with heavier soil conditions for longer testing periods. As experimental plantations are located on degraded arable land in Natura 2000 area, no herbicide treatment, fertilization, irrigation, and insecticide were implemented.

In **South Africa**, planting of poplar species is almost entirely limited to one private company, namely, Lion Match (Pty) Ltd which commenced its forestry operations in 1922 and owns about 5 225 hectares. The Company has since decided to scale down the cultivation of poplar species and switching to certain suitable pine species for their timber products requirements. The switch from poplar to pine species was triggered by the stringent environmental regulations which make planting of fast-growing tree species, which are perceived as high-water resources users, virtually impossible. Currently, 95% of the timber products at the Lion Match Company are derived from pinus species and the intention is to completely withdraw from planting of poplars.

In **Spain (pp.6-7)**, development of the Bioeconomy Strategy in 2016 based on the use of biological resources capable of satisfying demand for food, materials and energy for a growing population, involves taking wood into account as a resource for bioproducts and bioenergy. Sustainably managed poplar plantations represent an opportunity both for the use of wood for construction (that will contribute to the climate change mitigation), and production of susceptible biomass for various bioproducts (that replace fossil fuels as a source of renewable energy). In this context, the INIA Forest Research Center (CIFOR) through both basic research projects and in collaboration with companies, has carried out different activities that are based on poplar plantations, including projects like “Biomass for Bioeconomy (BIBI): Producing, Quantifying and Valuing Forest Crops”; and “Optimization and modeling of the sustainable production of lignocellulosic biomass to obtain bioproducts under climate change scenarios” (LIGBIO). These projects contributed to identification of soil and climate factors that have greatest impact on the adaptation of plant materials for biomass production in Mediterranean, evaluation of productive potential for using fast-growing species mix in high-density planning under different mix ratios and in restrictive water scenarios, and identification of indigenous Populus alba genotypes for biomass production in high-density systems.

In **Sweden (pp.6-8)**, fast-growing species like willow, poplar, hybrid aspen, birch, larch and Norway spruce are being sustainably cultivated and produce high yields in the warming climate conditions. Establishment of hybrid poplar plantations have been tested on set-aside agricultural lands since the beginning of the 1990s. Increased demand for hardwoods for manufacturing of textile pulp in Southern Sweden has led landowners to consider poplar as a new cash crop. Economic aspects of medium rotation forestry with hybrid aspens and poplars should receive more attention during coming years. Aspects such as acidity (pH level) of forest soils, soil water content, herbicide treatment, fertilization and weed removals significantly affect biomass yields from aspen, willow and poplar plantations.

In **Turkey (pp.17-19)**, regions such as the Sakarya and Samsun provinces, located in the Marmara region and Middle Black Sea region respectively, have a great potential for cultivation of hybrid poplars. The continental climate zone is the most suitable for *Populus nigra* clones while coastal and temperate climate zones are recommended for *Populus deltoides* and *P x euramericana* clones. *Populus euphratica* was identified as more resistant to salinity, high temperature and droughts than *Populus sp.,* therefore utilization of this species is recommended in southern regions to improve the soil and ensure high yields.

4.3 Naturally regenerating forest

In **Bulgaria (pp.7-8)**, work on preservation of *Populus Nigra L.* indigenous cultivars through production of propagation material is ongoing in the State forest enterprise Pazardzik. Anthropogenic factors caused a strong negative impact on indigenous plantations in the plains along the rivers. Logging and rooting out these riverside

ecosystems fragmented and limited the natural distribution area of the local tree species. Diversity and species composition were reduced, and this necessitated seeking opportunities to use native tree species, which are typical for these habitats (wet zones), including *P. nigra L; P.alba L; P. canescens Sm*. and various willow species. In the report period, mapping of the black poplar population along the Danube River was done. Ex situ collections for conservation and description of the genetic diversity and for restoration of priority habitats in Natura 2000 were created. Plants for in situ conservation in the area of their natural distribution were organized. Selection and propagation of black poplar (*P. nigra*) from natural stands, bio groups or single trees, in connection to restoration activities, production of planting material and creation of plantations were performed.

In **Canada (pp.43-44)**, trembling aspen and balsam poplar are the main harvested poplar species that occur naturally. Trembling aspen has by far the greatest volume of harvestable wood, grows in nearly pure stands or dominates the stands in the southern edge of the boreal forest, and grows in association with softwoods further to the north. Other naturally occurring poplar species that are harvested in smaller quantities in Canada are black cottonwood (*P. trichocarpa*), plains and eastern cottonwood (P. deltoides), and largetooth aspen (*P. grandidentata*). Red alder is a pioneer species in coastal BC and establishes quickly from seed following harvesting of a site and there is no requirement for planting. In the prairies, naturally occurring willow rings surrounding ephemeral wetlands provide valuable bio-filtering roles and can help control salinization. Canadian Indigenous peoples have used willows for fuel, construction, basketry, medicines, tools and weapons, and ceremonially.

China (p.8) aims to stop logging and ensure sustainable forest management of natural forests to maximize its ecological functions.

In **Croatia (pp.10-11)**, three approaches to forest stands management are distinguished: natural stands derived from seed (with rotation up to 60 years), coppice stands (with rotation up to 40 years), and mixed stands derived through planting of selected poplar and willow clones in unforested natural stands after clear cuts. In the intensive poplar cultivation period, other species were experimentally introduced in order to lessen the negative monocultural affect. Besides poplars and willows, there are also *Ulmus laevis,* narrow-leaved ash (*Fraxinus angustifolia*) and common oak (*Quercus robur*) growing as part of naturally regenerating forests. In the western and central parts of Croatia the black alder (*Alnus glutinosa*) and white alder (*Alnus incana*) regenerate naturally as well. The black alder makes independent coherent stand tracts in the central part of the Drava basin. In addition to the black alder, ashleaved maple (*Acer negudo*) and white ash (*Fraxinus americana*) were planted. In East Croatia, black locust (*Robinia pseudoacacia*) and mulberry tree (*Morus* sp.) have extraordinarily adapted to the habitat conditions and thanks to natural reforestation propagated on a large area.

In **Italy (pp.10-11),** poplar logs are used for plywood panel production, paper or OSB panels, particle board or bioenergy. Recently at the CREA Research Centre for Forestry and Wood, *Populus canadensis* clones were selected to be used in the energy sector, for particle board production, as well as production of veneers for plywood panels. All these clones are included in the official list of clones with greater environmental sustainability (MSA). Adoption of cultivation models based on the use of these MSA poplar clones is providing poplar growers with numerous productive, economic and environmental benefits.

In **Slovenia (pp.14-16)**, natural regeneration of forests is promoted through use of native poplars and willow species such as *Populus nigra, Populus alba, Populus tremula, Salix alba, Salix fragilis, Salix x rubens, Salix eleagnos, Salix purpurea, Salix fragilis, Salix viminalis, Salix cinerea, Salix triandra, Salix myrsinifolia, Salix petandra, Salix daphnoides*. For the artificial regeneration of forests with planting, seeding, use of cuttings, only the FRM harvested in approved forest seed stands of categories source identified, selected and from forest seed plantations of the category qualified can be used. The use of GMOs is forbidden. The use of the site adapted seed or planting material of native species of high genetic diversity, high quality, and increased

tolerance/resistance properties is considered as the primary option for artificial regeneration, afforestation, or habitat reconstruction activities.

For **Sweden (p.8),** *Populus tremula* and *Salix caprea* are keystone species in the boreal biome. Increased abundance of these native species contributes to restoration of biodiversity of managed forests. To increase the abundance of fast-growing deciduous keystone species, they need suitable conditions for recruitment. In a gradient between the boreal and temperate forest biome in Sweden, the recruitment of these keystone species is limited by increased abundance of large herbivores.

In **Turkey (pp.19-21)**, there are five naturally distributed poplar species: black poplar *(Populus nigra L.),* white poplar *(Populus alba L.),* grey poplar *(Hybrids tremula x alba* named as *Populus x canescens Smith),* aspen *(Populus tremula L.)* and euphrates poplar *(Populus euphratica Oliv.). Populus tremula L*. is the pioneer species among poplar naturally distributed in Turkey. It covers 287005,5 ha as pure stands or groups with coniferous and deciduous tree species. The natural distribution of *Populus tremula L.* occurs in forest areas apart from the step regions of Southeast and Middle Anatolia in Turkey and its most intensive distribution in Turkey is observed in Gümüşhane, Erzurum, Koyulhisar, Bingöl, and Şebinkarahisar. Black poplars (*Populus nigra L*.) are one of the main tree species in central and east part of Turkey, traditionally cultivated in row plantations along riverbanks, in the field or as roadside plantations. White and grey poplars often can be seen along the edges of streams and rivers. Willows have a wide natural distribution in Anatolia, as they can spread out along the valleys of major rivers as small groups or individually. *Salix alba* is the most important willow species in Turkey, with many ecotypes and hybrids from *Salix fragilis* and *Salix excelsa* available. Besides those, there are endemic willow species such as *Salix rizeensis* in Soğanlı Mountains of Black Sea region, *Salix anatolica* in Adana, and *Salix purpurea subsp. leucodermis* in Aegean region of Turkey.

4.4 Agroforestry and trees outside forests

The importance of poplars and willows in **Bulgaria (pp.8-9)** is well recognized, as they perform protective and economic functions. They are planted along canals, roads, dams, fields, rivers, valleys, and urban areas. Poplars and willows in Bulgaria are also being used for modern landscape architecture around towns and villages. Willow trees and shrubs and pyramid poplars are best biologically adapted to the growth characteristics around water areas. Landscaping companies use mostly poplars and willows in their operations, for example pyramidal forms of poplars *P. Simonni, P. cv. Italica, P. nigra Shipka,* and male poplars with decorative qualities. Especially valuable are various willow shrubs with their color tint, as well as various forms of willow trees S. madtsudana and *Salix babylonical*.

In **Canada (pp.44-45),** poplars and willows growing outside of forests in agricultural zones occur naturally in many cases, growing in riparian zones or other areas not used for agricultural crop production. Trees planted, either for their co-benefits with agricultural production or as dedicated plantations, usually include hybrid poplars. In the Prairies Provinces, poplars and willows are often used as windbreaks, usually around farmyards or acreage homes built near cities. Other types of tree plantings are established by conservation groups as wildlife habitat, riparian protection or other environmental purposes. Afforestation designs sometimes include poplars in a mixture as nurse trees to provide protection for more slow-growing hardwoods. Regional special projects continue across Canada. In 2014, an alley-cropping project on the Doig River First Nation, BC, consisted of hybrid poplars and aspen, intercropped with a number of native grasses for grass seed production.

In **China (pp.8-9)**, cultivation of large diameter timber is the ultimate goal, managed through belt configuration technology that helps to improve forests' protective functions. Design of the cluster pattern and multipurpose management can also improve ventilation conditions, light transmission and promote rapid growth of the

clustered trees. This model can be used to adjust the structure of agroforestry to improve the ecological conditions, while the forest coverage could be increased by more than 20%. Using fast-growing, resilient willow varieties, this multipurpose agroforestry management technology is applied in the wetland areas of Hongze lake and along the Yangtze river, supported by technical training and willow seedlings. It promotes production of industrial raw materials and improves the farmland microclimate.

In **Croatia (p.11)**, agroforestry is usually practiced through row plantations along the canals and roads, though it is not very common. Previous intercropping experience along the plantations caused partial elimination of the previous row plantations, which as a rule, are not reforested.

In **Italy (pp.11-13)** in 2016-2019, in the frames of Horizon 2020 WOODNat project that carried out an investigation on walnut plantations, three different silvicultural systems (pure plantations, polycyclic plantations, and agroforestry systems) were planted and tested. In these three systems, hybrid walnut and common walnut have been tested together with poplar clones. In the recent period polycyclic line plantations are tested in agroforestry system. This approach, where crop trees with different rotation period and wood production (walnut and oak etc. for veneer, poplar clones for plywood and SRCs for wood for energy) intercropped with nurse trees, can represent a suitable option for tree farming and agroforestry, beneficial also from economic and environmental point of view. Such intercropping forms are now named silvoarable or alley cropping systems. In silvoarable systems, in order to be technically sustainable and economically profitable, there must be synergistic or complementary interactions higher than competitive ones in the use of primary resources (water, phyto-nutrients and solar radiation). Among the various types of agroforestry, a consociation model called Alley Coppice was introduced in Italy; it combines the production of valuable wood for the industry with the production of wood for energy. In an experimental site planted near Biella (Piedmont) the model was tested with different poplar and willow clones for biomass production, and valuable hardwoods for industrial wood.

In **Turkey (p.21)**, agricultural intercropping can be applied during the first three years of hybrid poplar plantations and targets two main objectives: to increase profitability of poplar plantation investments, and to provide some annual income for the farmers who have allocated a part of their limited land for poplar cultivation. Poplar plantations should be established at larger spacing such as 6m x 6m, 5m x 7m and 5m x 8m in order to increase productivity and profitability of agricultural intercropping. Such agricultural crops as beans, potato, tomato, corn, sugar beet, melon, water melon, green pepper, eggplant, zucchini, lettuce and cucumber are recommended as agricultural intercrop species and can be grown successfully along the poplar trees, but they require irrigation and top soil working for their cultivation.

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5. APPLICATION OF NEW KNOWLEDGE, TECHNOLOGIES AND TECHNIQUES

Application of new techniques and technologies for harvesting and utilization of poplars, willows and other fast-growing species for various wood products and as a source of bioenergy vary between IPC member countries. In general, demand for poplar and willows timber is increasing, particularly for production of furniture, structural wooden materials, plywood, pulp or oriented strand board (OSB).

Given the increasing interest in the use of wood in construction in Europe, mainly due to the new European Directive on Building Energy Efficiency, there is a growing need for fast-growing cultivated species. In China, combining timber from fast-growing species with agriculture and forestry residues gives the raw material for products including ethanol/butanol, nanofiber composite materials, and lignin modified functional materials (e.g. green slow-release fertilizer).

5.1 Harvesting of poplars, willows and other fast-growing trees

In **Canada (pp.45-46),** aspen-dominated forests are often clear-cut and the poplars regenerate naturally from abundant root suckers. In some cases, it is considered more ecologically appropriate and more profitable to encourage softwood regeneration in mixed s tands in which aspen normally delay the regeneration of softwood species. In such cases, selective harvesting of mature aspen while avoiding softwood undergrowth trees may hasten this process. Riparian planted willow buffers in Prince Edward Island are harvested on a 3-year rotation.

In **China (pp.8-9),** harvesting time is calculated based on the age distribution of plantations, and comparison between former and later inventories. For poplars, harvesting is recommended each 4 to 8 years. For black locust, the initial period of tending and cutting is 10-11 years, and the interval period is 4-5 years. For Eucalyptus, it is found that the use of the joint cutting machine can save 43% of the cutting cost by the chainsaw, greatly reduce the labor intensity and significantly improving labor efficiency.

In **Croatia (p.11),** forest logging is traditionally carried out in three phases: cutting and working up, hauling, and transportation. The cutting and working up is done by power-saws, individually, predominantly by assortment and working up longer wood for chemical processing. Felling is done in the dominant wind direction on the plantations because of the shorter hauling time per product unit. Recently, logging productivity was significantly improved by using harvesters. The hauling is done by the tractors, mainly specialized for forestry (forwarders), but also by adjusted agricultural tractors. Transportation is mostly done by trucks and by railway, in case of longer distance. In recent years, wood waste that remains after logging is being ground and sold as forest biomass for energy production.

In **Italy (pp.13-14),** harvesting is organized according to different methods, with various level of mechanization. The traditional method involves use of a suite of multipurpose agricultural machinery with specialized equipment. Felling can be done by an operator with chainsaw, generally supported by a tractor equipped with a swing-arm log handler. This step is followed by log preparation, divided into phases of selection and measuring, debranching and cross cutting. As an improvement on the traditional method, use of a mobile crane equipped with a claw and chainsaw kit is increasingly adopted. It involves limited investment and is very efficient for industrial roundwood harvesting. Highly mechanized methods have great advantages in terms of productivity, e.g. combining the harvester with a woodchipper for the mechanized preparation of smaller assortments.

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In **Korea (p.4),** allometric equations and biomass expansion were determined to survey biomass resources of yellow poplar growing in Korea. To build statistical data, stem density, biomass expansion factor, and root-to shoot ratio were determined. Growth equations were developed using the diameter at breast height and height.

In **New Zealand (p.6),** all plants are treated as exotic and therefore neither poplar nor willow plantings are grown or managed primarily for timber. A series of videos were produced to promote management and utilization of poplars for multiple uses: soil stabilization, shade and shelter, stock fodder, and wood products. Poplar wood is an underused resource in New Zealand.

In **Spain (p.7),** an ongoing project dedicated to evaluation of timber quality from poplar and walnut forest crops using non-destructive methods (SELVIAGROTEC) studies temporal variation of the mechanical stiffness of wood in poplar and walnut forest crops using a non-destructive inspection tool. Such evaluation allows the wood to be valued and classified, leading to greater profitability and improvement in decision-making on crop management. The project aims to provide reliable data on the mechanical quality of different Poplar and walnut species and clones, the effect of silvicultural management, and the response to water limitations.

In **Sweden (p.8),** forest thinnings are promoted as an approach for development of hybrid aspens that do not decrease production volume during a rotation. Harvesting of willows during winter is a common practice in Sweden. However, most biomass processing plants require continuous year-round delivery of raw material. A whole stem harvesting and handling system was designed for cost-effective year-round deliveries of willow biomass.

In **Turkey (pp.21-22),** approximately 31% of the average wood raw material is obtained from natural stands of fast-growing species, mainly *Pinus brutia, Populus tremula, Fraxinus spp., Alnus spp., Salix spp., Eucalyptus spp., Psuedotsuga menziesii,* and *Pinus radiata.* Estimations of single tree biomass production and short-term biomass production, natural regeneration of the pure and mixed stands of various fast-growing species, operation and the optimal schedule of timber harvesting were evaluated in this report period.

5.2 Utilization of poplars, willows and other fast-growing trees for various wood products

In **Bulgaria (p.9),** demand for poplar and willow timber is increasing, particularly for production of furniture and linings, beehives and floor planking. Due to a shortage of poplar wood in the country, big manufacturers seek to cover this demand through imports. The cost of wood extraction in the country is also relatively high because harvest is not highly mechanized. Short-rotation poplar and willow plantations in Bulgaria are still experimental. Collected scientific information and experimental activity allow the technological implementation for an effective production in practice. Forest landowners show interest but feel hesitations about the processing and utilization of the harvested material (phyto mass) into marketing products.

In **Canada (p. 46),** trembling aspen is the main poplar used industrially. It grows in association with balsam poplar and adapted softwoods (spruce, pine, fir) in Canada's boreal forest. Poplar wood is used mainly for pulp or oriented strand board (OSB). In Saskatchewan, the Annual Allowable Cut (AAC) of hardwoods consists of trembling aspen (83%), balsam poplar (11%) and paper birch (6%). Partnerships between Agriculture and Agri-Food Canada, forestry companies, Canadian Forest Service and universities resulted in pilot projects/programs, in which hybrid poplars were grown and tested for productivity, while other test plantations incorporated poplar clones from other sources, such as the United States, in small or large-scale clonal comparisons.

In **China (pp.9-10),** several achievements have been made in the technological processing and utilization of poplar wood, mainly related to manufacturing of aldehyde-free wood-based board, increased use of fast-growing

poplar wood for furniture, manufacturing of poplar structural materials and poplar plywood automatic processing. Application of formaldehyde-free isocyanate adhesive in the production of particleboard and MDF has been a great success, which greatly promotes the development of environment-friendly particleboard and MDF industry. Development of soybean protein adhesive and its application in the production of poplar plywood are welcomed by users due to the free or ultra-low formaldehyde release of poplar plywood products. Research and popularization of surface treatment technology of fast-growing poplar wood, including surface densification, surface carbonization, bleaching, dyeing, coating provide technical supports for solid wood-based application of poplar wood in furniture. Application of fast-growing poplar in the production of CLT has made progress, and the manufacturing of reconstituted fiberized veneer has been industrialized. Basic research on wood utilization in China mainly focuses on wood quality improvement, nanocellulose preparation and biomass energy utilization. Wood quality improvement includes surface densification, dip and high temperature treatment, flame retardant treatment to achieve high wood density, strength, dimensional stability and flame retardant properties, for the use to floor, furniture or solid wood. Chemical methods (TEMPO) and physical methods (high pressure homogeneous or grinding method) were used in preparation of cellulose nanomaterial (cellulose nanocrystal CNC or cellulose nanofibril CNF) as the new direction of lumber with novel physical and chemical properties.

In **Iran (p.7)** due to the presence of fossil fuels, timber from fast-growing trees is used mainly for various wood products (such as MDF, paper pulp) at the timber factories located in the northern provinces of Gilan and Mazandaran, and some wood is used by local workshops for pallet making and furniture.

In **Italy (pp.14–15)**, 46% of poplar wood is used in plywood production, 12% in wood pulp, 12% in sawn wood, 9% particle board, and 21% in fuelwood. A large industrial group has recently established an OSB (Oriented Strand Board) production line, which is the first of this kind in Italy and the first expressly set up to use only poplar wood. Among some of the innovative projects that took place in Italy in the report period, there is a research project carried on at the University of Turin that aimed at developing, testing and manufacturing wood-based products for acoustic improvement. Another initiative, called the ThermoPoplarPly project, is dedicated to assessment of use of high temperatures on poplar wood and its assortments (veneer, plywood and logs) for increased resilience to biodegradation.

In **Spain (p.8),** given the increasing interest in to the use of wood in construction, mainly due to the new European Directive on Building Energy Efficiency, there is a growing need for fast-growing cultivated species. Poplar wood is used especially in packaging and plywood boards for furniture, but low diversity of applications, together with competition with other species, has been causing a decrease in the profitability of crops. A project on the development of engineering products made from poplar planks or sheets with composite material inserts for use in construction took place in 2017-2019, looking into two new product lines derived from the integrated combination of poplar planks/sheets and carbon or basalt composite material. This project proposes incorporation of carbon or basalt inserted into the multilayer structure, using laminates, fabrics or pultruded rods. New products with high structural efficiency will be less affected by the intrinsic low mechanical properties and natural defects of poplar wood, maintaining its low density.

In Sweden (p.8), pruning of trees is a management practice that improves wood quality during growth. Fast-growing hardwood species are suitable raw materials in an innovative process for future biorefineries. Catalytic fractionation uses poplar and birch wood in an innovative *organosolv* pulping process, which results in viscose fiber for textile industry and lignin-oil for production of liquid biofuels.

In **Turkey (pp.22-24),** poplar timber and other fast-growing species are used in the wood industry for production of veneer, pulp, paper and packaging, furniture, wood chips, and in construction sector. In the report period, the highest industrial wood production was provided by natural stands of *Pinus brutia* and further used in fibre, chips, pallet, construction industries, etc. All the production obtained from the natural stands of *Populus tremula*

was utilized by fibre industries. Timber from natural stands of *Fraxinus spp.* was used by fibre, furniture, plywood, joinery and flooring, coating, decoration and other industries. More than half of the production obtained from the natural stands of *Alnus spp.* was used by fibre industries and this usage was followed by furniture, plywood and other industries. Willow timber was used in fibre-chips, pallet and packaging industries. More than half of the production obtained from poplar plantations was used by construction industries. Pinus pinaster wood was mainly used in fibre-chips (84%) and pallet industries (16%). Eucalyptus spp. was utilized in fibre-chips industries and pallet industries. Nearly all industrial wood production obtained from the plantations of *Pseudotsuga menziesii* was used in fibre-chips industries whereas all industrial wood production made from the plantations of *Pinus radiata* was used by fibre-chips industries. It is expected to obtain qualified and quantitatively wood raw material from the plantations when priority is given to establishment of plantations to meet the shortage of wood raw materials.

5.3 Utilization of poplars, willows and other fast-growing trees as a renewable source of energy

In **Canada (pp.46-47),** harvest by-products from the utilization of native aspen from Canada's boreal forests are the major source of poplar/willow wood for bioenergy, and 600 thousand m^3 of hardwood was used nationally in 2017 for fuelwood and firewood. Many wood-processing companies use sawdust, bark and branches to produce power for their mills through co-generation facilities. Selected hybrid poplar and willow clones can be grown in stands and used as dedicated biomass sources for bioenergy. Willow clones, especially hybrids and selections of *Salix viminalis, S. miyabeana, S. purpurea, S. eriocephala, S. discolor and S. dasyclados,* are particularly suitable for bioenergy because they can be repeatedly coppice-harvested on 3-4 year rotations. Many of these clones have been tested throughout Canada and are well-adapted to eastern and central Canada as well as the Pacific coast in BC. A separate program of clonal testing will be conducted for the Prairie Provinces, to choose material that would survive the severe winters.

In **China (pp.11),** lignocellulosic biomass pretreatment technology is under development, and poplar and willow clones with high biomass production are used for bioenergy purposes. Restructuring of compound material technology, such as gasification and oil technology, has made a great progress for fast-growing trees.

In **Germany (p.12),** poplars, willows and black locust are used in conventional rotation times according to the usual forestry methods. The sorting is done according to the legal regulations on legal trade classes for raw wood. Biomass produced in short rotation coppices (SRC) is primarily important as a solid fuel, which is mainly burned as wood chips and to a small extent as pellets in specially adapted boiler systems. Processes for the gasification of wood biomass (pyrolysis) or liquefaction for fuels (Fischer-Tropsch process) have not yet reached practical maturity.

In **Italy (pp.15-16),** fuelwood coming from short rotation coppice (SRC) amounts to about 70 thousand m^3. Pinus radiata plantations are used for production of firewood, pallets for packaging and wood chips. Traditional mechanization tools, harvesters and woodchippers are used during the production cycle. In the more mature stages of the pine stands, grazing is allowed locally in fenced areas and native species Quercus ilex and Q. pubescens naturally start to settle under pine cover. This kind of management of the fast-growing Monterey pine allows it to obtain multiple advantages: economic (by activating the local economy linked to the firewood and small packaging industry), environmental (progressive improvement of soil conditions and settlement of native species, bioenergy production) and social (local occupation). An indispensable requirement is the presence of an efficient fire protection system during summer month. Despite these positive aspects, there are no direct financial or fiscal subsidies that favor new plantations.

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In **Korea (p.4),** forest biomass is widely used as an alternative fuel and considered a key source for addressing climate change. In 2020 Korea Forest Service supplied wood-pellet boilers to 143,000 rural households (which make up 16% of 900,000 rural households using oil boilers) with a target to facilitate domestic wood-pellet production over 1 million tons. A wood-pellet processing plant was built in Yeoju in 2008 to promote use and production of wood pellets. Plantations of yellow poplar during thinning generate wood further used as fuel, wood pellets and chips by local communities.

In **Spain (p.9)** In the Castilla y León region, poplar production plantations are being established by the private sector using short shifts for the biomass production in the form of chips, further used as bioenergy.

In **Sweden (p.9),** increased area of fast-growing woody biomass crops is considered as one of the methods to reduce fossil CO_2 emissions. Several life cycle assessments of willow coppice systems have been carried out earlier. Poplars are grown as single-stem medium rotation systems (ca 20 years) on agricultural lands. Compared to willows, poplar-based systems are more energy efficient, due to higher energy output: input ratio, and higher yields without fertilization. Plantations of fast-growing trees have a significant effect on biogenic C fluxes on landscape scale. Climate policy should be developed based on life-cycle assessment (LCA) of different bioenergy systems (long-rotation vs short rotation) on a landscape scale. Use of willow biomass for energy from agricultural land creates positive effect on biogenic carbon and increases total carbon stocks at landscape scale.

In **Turkey (p.24), a** study based on the determination of the poplar clones for bioenergy was started in 2017 to contribute to energy production by using the biomass of fast-growing species as renewable energy resources and establishing plantations based on fast-growing species. The project still continue and it will be finished in 2031.

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6. ENVIRONMENTAL AND ECOSYSTEM SERVICES

Variety of environmental and ecosystem services derived from poplars, willows and other fast-growing species includes phytoremediation of contaminated water and soils, disposal of municipal wastewater and biosolids, shelterbelt protection, riparian protection and streambank stabilization, erosion control, carbon sequestration, improved soil management, farmland protection and pollutant treatment, soil quality improvement and ability in regulation of microclimate in poplar agroforestry, etc.

Use of fast-growing and high biomass-producing species to preserve, improve or restore the structure and functioning of soils contaminated by heavy metals is a useful function of these trees. Besides this, potential of willow bark and leaf extracts were evaluated in Turkey as plant-based biostimulants and are suggested for regular use to improve crop performance; they are attractive options due to their safety, renewability, and low cost.

Willows can be also used for treatment and reuse of municipal wastewater in evapotranspirative willow systems (EWS; they are already used in northern Europe for onsite treatment of domestic wastewater in sensitive areas with strict discharge limits for treated water.

6.1 Site and landscape improvement

Canada (pp.50-52) indicated that poplars and willows continue to be used for environmental applications, including phytoremediation of contaminated soils, disposal of municipal wastewater and biosolids, shelterbelt protection, riparian protection and streambank stabilization. The Federal Agriculture and Agri-Food Canada department have launched five projects with focus on agroforestry practices that utilize poplar and willow in the system. Some wood from hybrid poplar plantations is currently being used for small amounts of biochar. Among other environmental applications, plantings of selected early-flowering willows have been incorporated into commercial blueberry harvesting operations to increase the abundance of native pollinators.

In **China (pp.11-12),** ongoing research on the use of fast-growing species for environmental improvement is focused on potential of poplar and willows in carbon sequestration, improved soil management, farmland protection, river shoal management and pollutant treatment, soil quality improvement and ability in regulation of microclimate in poplar agroforestry, etc.

Croatia (pp.11-12) reported that its national strategy for preservation of genetic characteristics of autochthonous poplar includes three operational goals: ensure the optimum quality of natural restoration, prevent the loss of biodiversity in the next generations and define and preserve the local genetic basis. Plans for environmental management on protected areas insist on full replacement of alochtonous with autochthonous species. Replacement of Canadian poplar clones with European black poplar is foreseen to take place in the next 50 years.

In **Germany (p.13),** willows and black locust, as well as most poplars, are characterized by special ecological tree characteristics with increasing age, which are habitats for numerous living things. Woody structures have always played an important role in agricultural landscapes: they represent a habitat for numerous species, offer wind protection, shape the landscape in different ways and connect biotopes. Agricultural wood from fast-growing trees for energy production has great potential, particularly in cleared agricultural landscapes, to enrich structural diversity and other habitat resources and thus biodiversity, especially that of insects. This applies both to agricultural wood in plantations and to agroforestry systems.

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In **Iran (p.7),** planting fast-growing trees (especially poplars) in the farm margin along irrigation route is a common practice. These plantations are used for wind protection and considered a source of income for farmers. Poplar trees after reaching certain diameter are harvested and sold, and new seedlings planted.

Italy (pp.16-17) indicated that carbon sequestration by poplar plantations is at the moment the only ecosystem service for which a voluntary market is possible. Life Cycle Assessment (LCA) of 2 poplar clones – traditional one and MSA clone 'Senna' (the acronym for Italian 'Maggior Sostenibilità Ambientale', that means 'greater environmental sustainability) was performed according to ISO 14040 series recommendations using software SimaPro 8.0. The environmental impact of poplar production cycle was analyzed using Ecoinvent v3 as main database for input data and the IPCC 100 is the method applied for impact calculation.

In Korea (p.5) during 2013-2018, 156 hectares of *Populus euramericana, P. deltoides* and *Populus alba x Populus tremula var. glandulosa* plantations were established in the Saemangeum reclaimed tideland for rehabilitation and wood production. At government's initiative, mature yellow poplars are being planted along the roads in order to combat urban pollution and use of poplars as roadside trees is getting more attention in many local governments.

In **New Zealand (p.6),** poplars and willows are predominantly used for erosion control in pastoral hill country and along riverbanks. Increased rainstorm frequency has accelerated soil erosion with consequent reduction of water quality. These drivers have prompted increased poplar and willow planting rates. Animal welfare issues, particularly in relation to shade and shelter, driven by market requirements, are also benefitting planting rates. Demand for poles, as the primary vegetative propagating mode, is high and difficult to meet.

In **Portugal (pp.9-10),** eucalyptus plantations have a major role in the control of possible erosive processes and in the hydrological regime regulation. Effects of eucalyptus plantations on surface water runoff depend on climate conditions, rainfall indexes (quantity, distribution and intensity), geomorphology, silviculture practices and the land cover than on the crop itself. Other positive ecosystem services of eucalyptus stands include carbon sequestration and their use for ecological restoration of degraded areas.

In **Slovenia (pp.16-18),** climate change and associated extreme weather events like droughts, heat waves, frosts, and floods affect the vitality of trees as well as the production and quality of wood. These changes will be one of the major factors limiting species distribution and establishment in the near future, and therefore present many challenges for forest managers. An increased understanding of plant function in stressful conditions is highly relevant to biogeochemistry and ecosystem ecology as plants make up over 90 % of the living biomass stock and the carbon stored in the highly lignified cells of trees is a crucial component in the global carbon cycle. Therefore, several studies were conducted in the reporting period, including expertise conducted by Slovenian Forestry Institute on response of ozone sensitive poplar clone to increased levels of tropospheric ozone in combination with different levels of Nitrogen and Phosphorus; and study of wood and phloem increments in Eurasian aspen (*Populus tremula L*.), etc. Information on wood and phloem anatomies is crucial for a better understanding of their plasticity in terms of adapting their structure to the given environmental conditions and thus ensuring optimal functioning of the tree. Evaluation of the influence of stressors on radial growth of trees, wood structure, and patterns of secondary growth in different parts of the tree aim to help understanding better the mechanism of these processes and their importance for the management of water and carbon balances.

In **Sweden (pp.9-10),** planting mixtures of genotypes with different functional traits in plantations with fast-growing woody species aims to increase species richness at various trophic levels, which contributes to pest resistance in tree plantations. Increased species richness contributes to increased plant resistance to pests and

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diseases and promotes sustainable biomass production in cropping systems with fast-growing woody species. The effect of afforestation with hybrid aspens, hybrid poplars, and willows on soil properties of agricultural land has gained attention in the reporting period in Sweden.

In **Turkey (pp.25-26),** fast-growing species contribute to combating desertification (through increased cold and drought resistance) and salinization, and used for creating shelterbelts and windbreaks, as well as gallery plantations. The potential of willow bark and leaf extracts were evaluated as plant-based biostimulants to improve maize growth in the absence and presence of salinity stress. In hydroponics experiments willow bark extracts enhanced root growth and development and may be used as biostimulants to improve crop performance attractive options due to their safety, renewability, and low cost. Alnus glutinosa subsp. Barbata, Fraxinus excelsior L. and Robinia pseudoaccacia provide valuable ecosystem services and can be used as a part of restoration practices in degraded forestlands. Also, the effect of cold stress, climate change, summer drought, soil-bedrock properties on Pinus brutia and the ability of soil recovery of Pinus brutia were evaluated in the reporting period. Row plantations from hybrid poplar species are traditionally established in the sides of fields and rivers or alongside roads and watercourses and also used as windbreaks in the areas which have the dry climate and the sweep effect of the wind.

6.2 Phyto-remediation of polluted soil and water

In **Bulgaria (pp.9-10**), various ponds, rivers and streams are placed across the richest agricultural areas, which require rational measures for their purposeful afforestation in order to mitigate the watercourse, ensure soil protection along the coast, mitigate wind erosion, etc. Poplars and willows are used to regulate ecological balance along the Danube river and along the banks of inland rivers through planted 10-15 m strips. Their purpose is to control landslides and protect plantations. Poplars and willows also have good water and soil protective functions. Poplar and willow plantations play an important sanitary and microclimate regulation role, as they serve as dust collectors and protection against climatic changes. *Daphnoides* willow species have extreme drought tolerance and can be efficiently used for strengthening shifting sands, for planting on sandy deserted places and other abandoned places.

In **Canada (pp.47-50),** poplars and willows continue to be used for environmental applications such as phytoremediation of contaminated soils, disposal of municipal wastewater and biosolids, shelterbelt protection, riparian protection and streambank stabilization. Two large-scale willow phytoremediation plantations have been established in Alberta. In BC, several phytoremediation poplar plantings continue to be tended and monitored by Passive Remediation Systems (PRSI). Waste Management Canada has incorporated poplar plantations into two landfill sites in Ontario and engaged with the engineering firm CH2M Hill, which designed a poplar plantation for the safe disposal of landfill leachate. Riparian and streambank protection of watercourses and riparian areas is supported by provincial jurisdictions throughout the country as well as by the Government of Canada. Nationally, the Canadian Wildlife Federation promotes the use of native shrub willows for bioengineered protection of degraded streambanks. Previous Agriculture and Agri-Food Canada research has shown that willows are an excellent choice for riparian buffers.

In **China (pp.12-13),** research mainly focuses on the remediation efficiency of poplars, willows and eucalyptus trees to different sewage, wastewater and waste residues, heavy metals and organic pollutants in soil and atmosphere. Jiangsu Academy of Forestry has developed a domestic sewage treatment system for the irrigation of fast-growing willow shrub, which has achieved initial results in the application of domestic sewage treatment. Northwest Agriculture and Forestry University and Nanjing University have developed a "willow-based fluid purification of wastewater method", which is suitable for the decentralized treatment of rural domestic sewage

purification system. This method has high economic efficiency and contributes to landscape restoration, as the harvested biomass could be used for weaving without any secondary pollution effect.

In **Egypt (p.3),** willows are used for phytoremediation purposes, as they have a significant capacity to absorb heavy metals (Cd, Pb, Zn) and other elements (N, P and K) from contaminated soil and water of agricultural drains, and accumulate them in different plant parts. Therefore, willow plantations are considered an excellent phytoremediation model that improves soil properties.

In **Iran (p.7),** due to decreasing water resources, sustainable use of wastewater in large cities is one of the policies of the National Wood Farming Development Program. Since use of wastewater for irrigation of agricultural crops is legally banned, use of wastewater is recommended for irrigation of wood crops and plantations of fast-growing tree species.

In **Italy (pp.17-18),** use of fast-growing and high biomass-producing species to preserve, improve or restore the structure and functioning of soils contaminated by heavy metals is a dendroremediation strategy. The CREA Research Centre for Forestry and Wood together with the University of Turin carried out a study aimed at investigating the effects of heavy metals on poplar and willow clones by assessing their tolerance and phytoextraction potential and their accumulation pattern. Among the sediment remediation technologies, phytoremediation and co-composting of sediments have proven to be effective in reducing the concentration of organic pollutants and toxicity, and induce physical, chemical and biological fertility in dredged contaminated sediments. Composted sediments can be a good growth media for poplars and willows as common soil used in the nursery phase. An experiment aimed at verifying the usefulness of phytoremediation using Short Rotation Coppice (SRC) was carried out in Turin, by University of Turin and CREA. Besides elemental uptake and reclamation, the SRC method was applied to evaluate the additional benefits of a green infrastructure, using poplar, willow and Robinia clones. The short rotation coppice method proved to be useful in an urban context, for both landscape and limiting the access to the contaminated area. Improving the biomass yield through the phytomanagement options could make SRC phytoremediation an economic and effective solution to manage urban contaminated areas, coupling the added values of biomass production to the landscape benefits.

In **Korea (pp.5-6),** a short rotation poplar coppice plantation was established in a riparian area to select the most suitable clones for biomass. Biomass production, nitrogen and carbon absorption were determined in *Populus deltoides* hybrid clone, *P. euramericana* clone and *P. alba* x *P. tremula* var. *glandulosa* clone. The average annual above-ground biomass was 16.1 tons per hectare per year for *P. deltoides* hybrid clone, followed by 12.3 tons for *P. alba* x *P. tremula* var. *glandulosa* clone and 5.4 tons for *P. euramericana* clone. The average annual nitrogen uptake of the clones was 46.5 kg per hectare per year. *P. alba* x *P. tremula* var. *glandulosa* clone absorbed as much as 63.1 kg nitrogen per hectare per year. As for carbon absorption, *P. deltoides* hybrid clone showed the best results with 7.7 tons of carbon per hectare per year.

In **Slovenia (pp.18-20),** the growth dynamic of different white willow clones used in a zero-discharge wastewater treatment system in the sub-Mediterranean region was evaluated in 2017. It showed that willows can be used for treatment and reuse of municipal wastewater in the so-called evapotranspirative willow systems (EWS). EWSs are in practical use in northern Europe for onsite treatment of domestic wastewater in sensitive areas with strict discharge limits for treated water and in areas where there is no recipient water body or percolation is limited due to low soil permeability. EWSs enable closing material loops and reuse of water for biomass production and evapotranspiration. Evapotranspiration of wastewater on the site of its production enables the cycling of water on a local level and enables the reduction of the heat island effect. In the framework of national and international research projects, the monitoring and research of the pilot EWS will continue also in the following years to evaluate the changes in water and nutrient balance with the system's age and between different clones of white

willow. EWS will also be evaluated as a green technology for climate mitigation in the urban and peri-urban environment as they enable shading and cooling by evapotranspiration.

In **Sweden (pp.10),** NO_3-N leaching from poplar plantations in Central and Southern parts of the country was compared to NO_3-N leaching from adjacent agricultural fields. NO_3-N leaching from poplar plantations was significantly lower than leaching from adjacent cereal fields but did not differ when compared to neighboring grasslands. Establishment of buffer zones with fast-growing willows along Southern coast of Sweden would avoid leaching of 626 Mg $PO_{(4)}$e to watercourses each year.

In **Turkey (pp.26-27),** since Boron (B) toxicity is an expanding environmental problem throughout Turkey, boron removal performance of poplar and willow species in constructed wetland (CW) were investigated, as they have potential for remediation of wastewater in CW by increasing the filtering capacity of the sediment and leading to phytostabilization of boron around the rhizosphere. In terms of their B removal ability, *P. nigra* and *S. anatolica* had the highest B removal capacities with phytoextraction while *S. alba, P. alba* and *S. babylonica* had more phytostabilization performance in CW.

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IV. GENERAL INFORMATION

This chapter includes information regarding Administration and Operation of the National Poplar Commission, achievements and perspectives in relations with other countries, various innovations, as well as the list of other fast-growing species of interest for IPC member countries.

The Section on Administration and Operation of the National Poplar Commissions provides insights on the changes in the composition of the Commission, amendments to its statutes, describes relevant meetings, congresses and study tours, reports other activities of a general nature organized by the Commission at the national level, and identifies recent challenges encountered by the Commission in the course of its work and lessons learned.

A list of publications on poplars, willows and other fast-growing trees issued during reporting period 2016-2019 includes various technical papers presented at meetings, congresses, etc. and is presented in the Annex 3. Section on Relations with other countries provides details on the international exchange of cuttings and plants of poplars, willows and other fast-growing trees, conducted international trainings, etc.

Operational activities of National Poplar Commissions in the reporting period were closely connected with the various national research entities; a significant number of national, regional and international meetings, symposiums and conferences took place between 2016 and 2019, resulting in increased international knowledge exchange and collaboration. Areas of collaboration with foreign partners usually include knowledge transfer, plant propagation, transfer of reproductive material and research projects.

Exchange of scientific materials and research-relevant ideas with colleagues from abroad is a common practice in IPC member countries. Permanent connections with NPCs, nurseries and research institutions were established between China, Italy, USA, Canada, Croatia, Hungary, Germany, France, UK. The cooperation and exchange of poplar breeding materials is going well between China and Italy. A number of protocols was signed by Turkey with Central Asia and European countries.

Administration and Operation of the National Poplar Commission or equivalent Organization

In **Austria (p.4),** there is an appointed National Focal Point. ARGE Waldveredelung, private association of nursery people, forest managers and other stakeholders with an interest in poplars and willows, organizes seminars and excursions for fast-growing tree species.

In **Bulgaria**, there is recently no National Poplar Commission.

In **Canada (pp.53-56),** The Poplar and Willow Council of Canada (PWCC) is based in Edmonton, Alberta and has an elected Board of Directors which provides overall direction and an Executive Committee that is responsible for coordinating day-to-day activities. The Council is a federally incorporated not-for-profit organization; it coordinates member services, maintains a library with poplar and willow references, and administers Poplar and Willow Council communication, finances and administration. The membership of the Council represents a cross-section of individuals and corporations who are interested in the development and utilization of poplar and willow resources in Canada. The PWCC has three distinct working groups addressing specific issues and

challenges with poplar and willow management. The current working groups are genetics and breeding, pesticides and environmental service and bioenergy.

In **China (p.13),** the National Poplar Commission was established in 1980 and renamed as the Poplar Special Commission (PSC), a secondary sub-society of Chinese Society of Forestry (CSF). The PSC secretariat is affiliated to and located in Research Institute of Forestry, Chinese Academy of Forestry, Beijing. With the leadership of Chinese Society of Forestry (CSF), the Poplar Special Commission (PSC) is annually active in organizing and hosting conferences or meeting of CSF on scientific and technological themes each year as well as several meetings of the board during the last four years. PSC is also involved in public discussions, technical consulting activities and provides technical advices to relevant organizations dealing with fast-growing tree species.

Croatia (p.12) became a member of the International Poplar Commission on 23rd September 1992.

In **Germany (p.13),** the National Poplar Commission is chaired by the head of Department 5 (Forestry, Sustainability, Renewable Resources) of the German Federal Ministry of Food and Agriculture. The secretariat of the National Poplar Commission is maintained by the Federal Ministry of Food and Agriculture. Germany is active in standardizing the production and distribution of forest reproductive material.

In **Iran (pp.8-9),** National Poplar and fast-growing tree species Commission actively participates in the preparation, compilation and implementation of the national wood farming program. In 2018, the Forests, Range and Watershed management Organization (FRWO) selected an executor of wood farming development to implement the wood farming programs and goals.

In **Italy (pp.18-19)**, The National Poplar Observatory (ONP), which serves as National Commission for Poplar since 2015, is a part of the Ministry of Agricultural, Food and Forestry Policies (MIPAAF). After the first three-year period (2015- 2017) of the launch of the new national structure dedicated to poplar (ONP), managed by the DISR III Office of the Rural Development General Directorate of the European International Policies Department Rural Development (DIPEISR), since 2018 the coordination of the ONP has been ensured by the DIFOR III Office of the new General Directorate Forests, established within the departmental structure of the MIPAAF dedicated to European and International Policies and Rural Development. The ONP has actively participated in relevant forest congress areas including the National Forestry Congress held in Turin in 2019. The main difficulties encountered were those caused by the institutional changes; however, the solutions adopted, flanking the two coordination and extension for 2018 – 2020, have made it possible to ensure the smooth functioning of the ONP.

In **Korea (p.6)**, the National Poplar Commission during 2016-2019 carried out poplar related projects received as an outside operation from National Institute of Forest Science, including a study on selection of superior individuals in Populus nigra var. italic and Populus simonii (2017), Growth characteristics and selection of superior trees of Korean aspen (2018), and Selection of superior clones of Korean aspen (2019)

In **New Zealand (p.7),** the National Poplar Commission (NPC) operates under the auspices of the New Zealand Poplar & Willow Research Trust which meets twice per year. It does not have representation from central government but does have representation from regional government (both land and river management), landowners, and research institutes.

In **Portugal (pp.10-11),** National Poplar Commission is not established. The National Forest Authority is embodied under the mission and competences of the Institute for Nature Conservation and Forest, a Central Government Body. The Forest Advisory Council, created by the Forest Policy Act of 1996, is the consultation body for sectorial tutelage, through which the position of the agents of the sector is articulated, enabling consultation on public policies in the face of changes in context with implications on forest based sector.

Slovenia (pp.20-21) created its National Poplar Commission and appointed a representative of the NPC on December 20, 2013. In the official cooperation framework, promotion and exchange of ideas and materials between IPC, research workers, producers, and landowners are carried out. NPS in Slovenia has been undergoing a comprehensive institutional reform since September 2012, including a wider range of fast-growing genera/species with similar attributes to poplars and willows in terms of industry and energy uses and environmental applications.

In **Spain (pp.9-12),** the National Poplar Commission is currently attached to the General Directorate for Rural Development, Innovation and Forest Policy of the Ministry of Agriculture, Fisheries and Food, with permanent Secretariat based in Madrid. NPC reports to the Director of Rural Development, Innovation and Forest Policy, Director of the National Institute of Agricultural and Food Research and Technology (INIA), and Director General of Agricultural Productions and Markets at Ministry of Agriculture, Fisheries and Food. Proper functioning of the Commission is mainly limited by its budget.

In **Sweden (p.11)** in April 2020, the National Poplar Commission was renamed into National Commission for Fast-Growing Deciduous Species and was set up as a discussion forum for different stakeholder groups from forestry and agricultural sector, academia and governmental agencies. Its new goals include increased exchange of ideas and knowledge between enterprises from forestry and agricultural sector, academia and consumers about the social and climate benefits of native and introduced fast-growing deciduous trees and promote their increased cultivation. Establishment, suitable clones and management have been the major focus during 2016-2019. The main challenge for proper functioning of National Commission for Fast-Growing Deciduous Species in Sweden is the lack of financial support.

In **Turkey (p.27),** National Poplar Commission conducts its activities in accordance with the regulation issued in 1964 by the government of the Republic of Turkey. The first NPC Executive Board Meeting was made in Ankara in May 2017, followed by the 9th National Poplar Commission in April 2019 in Afyon. In the meeting, the importance of using registered poplar species and poplar species which will be registered in the future to fill the shortage of the wood raw material in Turkey and conserving gene resources of poplar and willow species were addressed as well as discussions were made on presentations prepared and given by researchers dealing with poplar and willow species. Each year, a daily education including technical information and applications on the poplar cultivation are given to the students of the Faculty of Forestry.

Literature

Since the last session in 2012, a large amount of literature related to poplars and willows has been published by IPC member countries, as well as others. The list of scientific articles, publications and manuscripts (by country) is presented in Annex 3.

Relations with other countries

In **Austria (p.5),** the European trial organized by AWG (ASP) Teisendorf, where several recently introduced varieties are being tested, is still used to select clones for biomass and timber production purposes in the future.

In **Bulgaria (p.11)**, with regard to the need for cooperation in the field of poplar clonal selection in order to spread the results of breeding activities to the benefit of growers and users, the exchange of poplar clones at European level was intended within the project EUPOP during 2014-2017. The project was coordinated by the Bavarian Office for Forest Seeding and Planting (ASP) in behalf of the Bavarian Ministry for Nutrition, Agriculture and

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Forestry. Executive forest agency was a partner organization and 13 poplar clones were tested in two test areas in the country for production of biomass.

In **Canada (p.98),** the National Poplar and Willow Council represents country in the international forestry arena and has strong connections to poplar and willow colleagues in the United States including the Short Rotation Woody Crops Operations Working Group and Poplar Council of the United States. Informally poplar and willow academics and scientists maintain research collaborations with colleagues at universities and research institutes worldwide.

In **China (p.18),** the exchange of scientific materials and research-relevant ideas with colleagues from abroad is a common practice. Permanent connections have been held with specialists from Italy, USA, Canada, Germany, France and UK. The cooperation and exchange of poplar breeding materials is going well between China and Italy.

In **Croatia (p.13),** on behalf of National Poplar Commission, the international collaboration was established by the Ministry of Regional Development, Forestry and Water management, as well as Faculty of Forestry in Zagreb, Croatian Forest Research Institute and Public Company "Croatian Forests", with organization such as Bioversity International (EUFORGEN), Rome, Italy; Forestry Research Institute, Sárvár, Hungary, CRA-ISP Casale Monferrato, Italy.

In **Egypt (p.4),** improvements in cooperation with the countries of the Mediterranean basin in the field of personnel training are desirable. Several hybrid poplars coming from Eastern Europe were evaluated under local conditions in the reporting period.

In **Germany (pp.19-20),** areas of collaboration with foreign partners include knowledge transfer, plant propagation, transfer of reproductive material and projects such as GenTree. The scientists of the research institutions and universities in Germany are in active exchange of information with those abroad through international conferences. In Germany, 21 poplar clones are cultivated in vitro and the plants supplied to Sweden. In cooperation with the poplar technology center of the University of Talca, Chile, pegs were made available for trial cultivation by the plywood manufacturer GARNICA in Spain. European conservation activities are coordinated and implemented within the framework of the European Forest Genetic Resources Program (EUFORGEN). EUFORGEN aims to promote the conservation and sustainable use of forest genetic resources for the benefit of current and future - 20 - generations. Against the background of climate change and a developing demand for forest products and forest services, the goal of GenTree, a Horizon2020 project, is to equip the European forestry sector with better expertise, methods and tools for the management and sustainable use of forest genetic resources in Europe. GenTree improves the state of in-situ and ex-situ conservation of forest genetic resources and supports the designation, conservation, characterization, evaluation and use of important forest genetic resources in breeding and forest practice as well as in politics. The project also intends to standardize, rationalize and improve the management of existing collections of genetic resources and specialist databases. The European strategy for cooperation in research and development will also be strengthened. The project develops new strategies for the dynamic conservation of forest genetic resources in Europe. These are based on an improved phenotypic and genotypic characterization of important European tree species (including black poplar) in their distribution area and derived adaptation reactions to possible environmental changes. Finally, new forest management scenarios and political framework conditions are developed, which include all aspects of genetic conservation and breeding, in order to better adapt forests and their management to changing environmental conditions and socio-economic requirements.

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In Iran **(pp.18-19),** *P. nigra* and *P. alba* clones imported by Research Institute of Forests and Rangelands (RIFR) from Europe and tolerant to moderate and cold climates are used in arid and semi-arid regions with the moderate cold climate. *P. deltoides* and *P. euramericana* clones were imported in 1965 and planted in the north region. RIFR conducts research on poplar hybrids that can be planted in warm and dry climates and tolerant to saline soil. For this purpose, Mofid (*P. euphratica x P. alba*) hybrid clone and the *P. nigra* clones are being imported from Turkey.

In **Italy (p.39)** in 2017, CREAFL sent cuttings of *P. xcanadensis* clones for propagation and subsequent evaluation in experimental plantations by the IDF. In 2019 CREA provided *P. nigra, P. deltoides* and *P. xcanadensis* clones at INRA for Melampsora screening activities as part of the European B4EST project. Others *P. nigra and P. deltoides* clones were sent by CREA to INRA again for the screening activities as envisaged in the B4EST project. Following cooperation activities on poplar breeding with the Chinese Academy of Forestry (CAF) a progeny obtained by crossing *P. simoni* and *P. nigra* parent plants is maintained at the CREA farm in Casale Monferrato for selection and phenotypic characterization.

In **Korea (p.9)** since 2008 Korea Forest Service planted 4,400,000 poplar trees in Kubuqi desert in China to combat desert expansion. The project will be continued in the coming years.

New Zealand (p.7) exported cuttings of *P maximowiczii × nigra*, and *P. deltoides × ciliata* clones, bred in New Zealand in 2019 to University of Florida.

In **Portugal (p.17),** several Portuguese institutions contributed to the "Non-native tree species for European forests - experiences, risks and opportunities" project in 2017. NNEXT has established an in-depth analysis of the associated risk and challenges in growing non-native forest tree species within European forestry sector. A detailed assessment of current eucalyptus management options, associated risks and challenges was produced.

In **Slovenia (p.27),** the National Poplar Commission has provided cuttings of *Populus nigra var. italica* for an experiment established in INBO, Belgium, to investigate the genetics, epigenetics, and phenology on the fastigiate black poplar cultivar/clone *Populus nigra* from different geographic regions all over Europe. The study aimed to see how the clones react to climate change. International cooperation was carried out between the Slovenian Forestry Institute and research institutions, universities and nurseries in Belgium (INBO, Geraardsbergen), Croatia (Forestry Faculty, Zagreb), Bosnia and Herzegovina (Forestry Faculty, Sarajevo), Hungary (Research Institute Sarvar), Germany (AWG, Teisendorf), Austria (Federal Research and Training Centre for Forests, Natural Hazards and Landscape, Vienna), Serbia (Institute of Lowland Forestry and Environment, Novi Sad and Faculty of Forestry, Belgrade), Italy (Alasia Franco Vivia, Savigliano), Spain (INIA, Madrid).

In **Spain (p.17),** INIA-CIFOR and MAGRAMA-Centro El Seranillo have collaborated with fourteen European institutions (INBO, INRA, CRA, University of Tuscia, FAO, Slovenian Forestry Institute among others) under the coordination of ASP-Bayern (Germany) in the constitution of a multi-environment Trials Network for the selection of genetic material, facilitated by the breeders corresponding to the different trial hosts.

In **Sweden (p.12),** new *P.trichocarpa* hybrids adapted to Northern European climate are in commercialization phase at SweTree Technologies AB. These clones are shared with stakeholders from forestry or agricultural sector in Lithuania, Latvia and Estonia. A clonal trial, established in Northern Poland during 2018, include these new clones. Innovative machinery, which contributes to significantly reduced cost of establishment of *Salix* plantations, is developed in Sweden. This technology is currently exported to Lithuania, United Kingdom and Canada. The technology is also helpful during establishment of plantations with hybrid poplars.

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In **Turkey (p.59),** a number of protocols was signed with Central Asia and European countries, including "The Development Project of Georgia's Poplar Cultivation" with Georgia in 2017, "Cooperation Protocol in Forestry Field" with Uzbekistan in 2018 and "The Development Project of Uzbekistan's Poplar Cultivation" with Uzbekistan in 2015.

Innovations not included in other sections

Sweden (p.12) reported on invention related to the identification and characterization of poplar genes involved in induced flowering and repression of short-day induced growth cessation. This invention is relevant in breeding process to facilitate early flowering of genotypes of trees that otherwise have long generation times.

Germany (pp.20-24) reported that during 2016-2019 20 sub-projects on genetics and breeding, cultivation, physiology, resistance of poplar, willow, hybrid larch and black locust, harvesting, and recycling of their wood were completed, supported by the federal government (mainly BMEL) and the federal states. Both the material and the energetic use of the wood were equally in focus.

In **New Zealand (p.8),** annual commercial production and plantings of poplars and willows is trending upwards. Availability of nursery irrigation water during the growing season is becoming a limiting factor as it extends the time for pole production by one year.

In **Spain (p.17),** a reference website for populiculture professionals and owners in Castilla y León was created. It contains information on populiculture, the poplar sector, the wood market and various tools intended to guide owners and woodcutters.

In **Turkey (p.59),** atmospheric pollen concentration has been studied in 62 locations of Turkey. Willow bark and leaves are being utilized as a treatment of various disorders in the traditional medicine. The extract contents of *Pinus brutia* and *Pinus pinaster* were evaluated in the period of this report time. While turpentine and resin of both *Pinus brutia* and *Pinus pinaster* were analyzed, essential oil and bark tannin extracts of *Pinus brutia* were also evaluated in the reporting period.

Other fast-growing species of interest to member countries

Interest in cultivation and utilization of other fast-growing species in the recent years have significantly increased, based on the geographical position and climate conditions of each member country, as well as potential for wood and biofuel production. Main other fast-growing species of interest for member countries are presented in Table 3

Table 3 Other fast-growing tree species of interest by Member

Country	Other fast-growing tree species
Austria	black locust, birch, alders and linden
Bulgaria	silver linden, black locust
Canada	alders, larch, birch, maple, spruce and pine
China	Eucalyptus, black locust and paulownia
Croatia	Ash, oaks, alders, maple, black locust, mulberry
Germany	hybrid larch and black locust
Iran	eucalyptus and alder
Ireland	eucalyptus
Italy	eucalyptus, Douglas fir, black locust and Monterey pine

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Portugal	eucalyptus
South Africa	eucalyptus
Spain	walnut
Sweden	birch, aspens and grey alder
Turkey	eastern cottonwood, Turkish red pine, wild cherry, ash, alder, black locust, eucalyptus, pines (maritime, radiata, Douglas fir)

Therefore, among the most common other fast-growing species there are alder, larch, birch, pine, spruce, black locust and eucalyptus.

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The International Poplar Commission and its Secretariat would like to express its appreciation and gratitude for the highly productive collaboration to all its National Poplar Commissions. The list of contacts and names of Chairpersons of the National Poplar Commissions is provided below.

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V. SUMMARY STATISTICS

Statistics related to poplar, willow and other fast-growing tree species' cultivation and management are detailed in tables provided in Annex 1 (summary tables by country) and Annex 2 (country tables). These were drawn from the most current information provided by IPC member countries in their country progress reports.

For those countries which were not able to produce an update or others that provided only partial data, data collected for the 2020 Synthesis Report were used to extract reasonable trends or to estimate world totals. The following tables are available:

Annex 1 Summary tables by country	Annex 2 Country tables
Total area Area by forest function • Poplars • Willows • Mixed cultivation • OFGS Planted forest • Poplars • Willows • OFGS Wood removals • Poplars • Willows • OFGS Wood products • Poplars • OFGS	1. Austria 2. Bulgaria 3. Canada 4. China 5. Egypt 6. Germany 7. Iran 8. Ireland 9. Italy 10. Korea (Republic of) 11. New Zealand 12. Portugal 13. Slovenia 14. South Africa 15. Spain 16. Sweden 17. Turkey

Areas

The overall area of poplars, willows and other fast-growing species reported by 17 countries is estimated at ***71,803,129 ha***. The vast majority of the total area – ***49,405,792 ha, or 69%*** consists of poplar formations, ***21,036,653 ha, or 29%*** of other fast-growing species plantations, willow stands cover ***880,376*** ha and ***462,878*** ha represent mixed poplar and willow formations.

The biggest area covered by fast-growing species is reported in China, Sweden, Canada and Turkey. Poplars are well presented in China, Canada and Turkey. Biggest willow stands are reported by China and Portugal, mixed cultivation stands – by New Zealand and Portugal, and OFGS – by China, Turkey, Portugal, Sweden and Canada.

Cultivation

Though not all poplar areas could be assigned by the countries to a particular use, wood production (industrial roundwood, fuelwood, biomass) remains the main purpose for poplar cultivation. Planted poplars cover in total **8,057,072** ha, of which **4,945,783 ha (**61%) goes for industrial roundwood, **1,898,782** ha (24%) used for environmental protection, **765,765 ha,** or 10% - for fuelwood biomass and **446,741 ha, or** 6% for other purposes. Planted willows cover **498,958** ha in total, out of which 234,206 ha (47%) is being used for industrial roundwood,

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190,584 ha (38%) - for other uses, and 7 and 8% respectively – for fuelwood biomass and environmental protection.

Plantations of other fast-growing species cover **10,712,000** ha. Timber from these species is mainly being used for industrial roundwood (80%), environmental protection (12%), other uses (6%) and fuelwood biomass (2%).

Poplar wood in particular is used for veneer/plywood, pulpwood, sawn timber, fuelwood/biomass and industrial roundwood. Other minor uses are poles, chips for OSB, baskets, matches, furniture and cricket bats. The wood from willow clones is mainly used for fuelwood/biomass and pulpwood.

Wood removals

The removals of poplar wood reported by 10 countries add up to **8,281,939** m^3. The top producers of poplar wood with reported removals of more than 1 million m^3 are Iran, Turkey and italy. The vast majority of the poplar wood is used for veneer and plywood (58%), pulpwood (5%), sawnwood (26%), fuelwood and woodchips (11%).

Removals from willow forests are comparatively small. The removals from six reporting countries add up to **539,262** m^3, of which 75% are estimated to be used for pulpwood, and 19% for sawnwood. The major producers of willow wood are Iran and Germany.

Removals of other fast-growing tree species account for **23,069,174** ha in 9 reporting countries, with the highest amount of removals taking place in Turkey, Portugal and Sweden. Out of total removals, 64% of the timber goes for pulpwood production, 19% for sawnwood, 9% for fuelwood and 8% for veneer and plywood.

Forest products

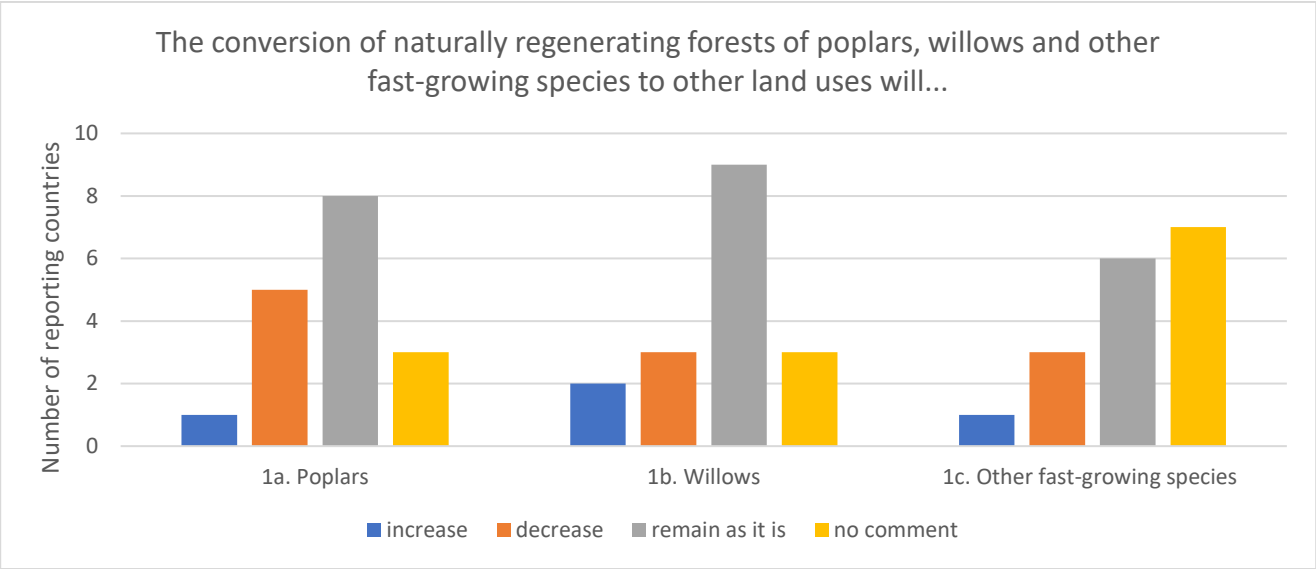
Seven countries reported on the main products derived from poplars, and eight countries on other fast-growing species. Poplar timber is used for industrial roundwood production (36%), fuelwood (36%), particleboard and fibreboard (19%), plywood (5%), wood pulp (3%), as well as chips, veneer sheets and sawnwood. Timber from other fast-growing species is almost totally used as fuelwood in Egypt and Germany, Industrial roundwood in Germany, woodpulp in China, etc.

Trends and opinions

The IPC member countries had been requested to assess possible trends until 2020 in the development of poplars, willows and OFGS in their respective countries. In total, 17 member countries had reported for this assessment. Their opinions are presented in the following column diagrams for each of the 9 groups (27 questions) asked.

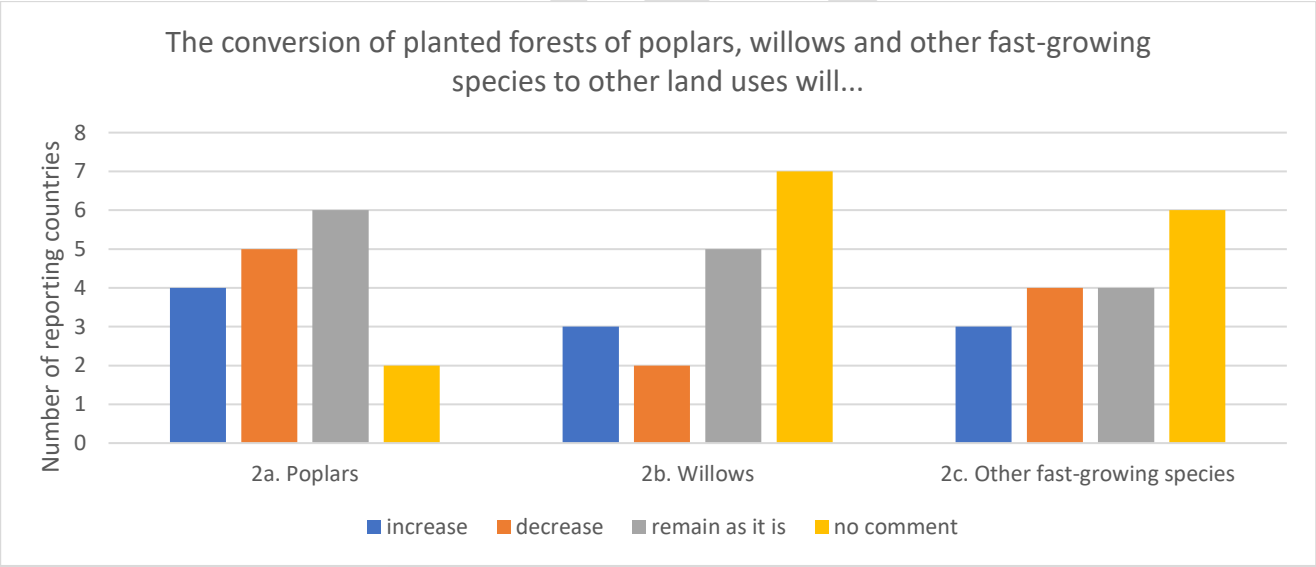
1) Conversion of **naturally regenerating** forests to other land uses

Most of the member countries reported that conversion of naturally regenerating forests to other land uses will mainly remain the same in the coming years. Possibility of decrease was indicated by Bulgaria, China, Iran, Spain and Turkey. In Austria, there is a possibility of increased conversion regarding all types of fast-growing species.



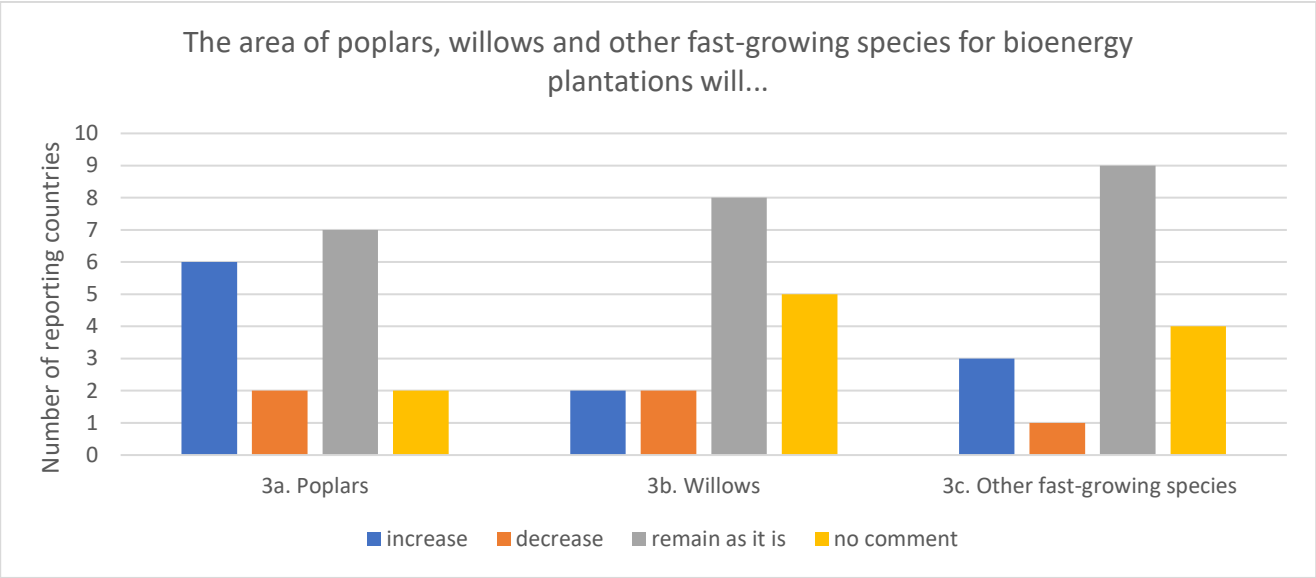
2) Conversion of **planted** forests to other land uses

Conversion of planted forests consisting of poplar, willow and OFGS to other land uses will mainly remain the same. Austria, China and some other countries may increase the conversion in the coming years, while Bulgaria, Iran, Italy, South Africa, Turkey, Germany and Korea reported on the possibility of its decreasing.



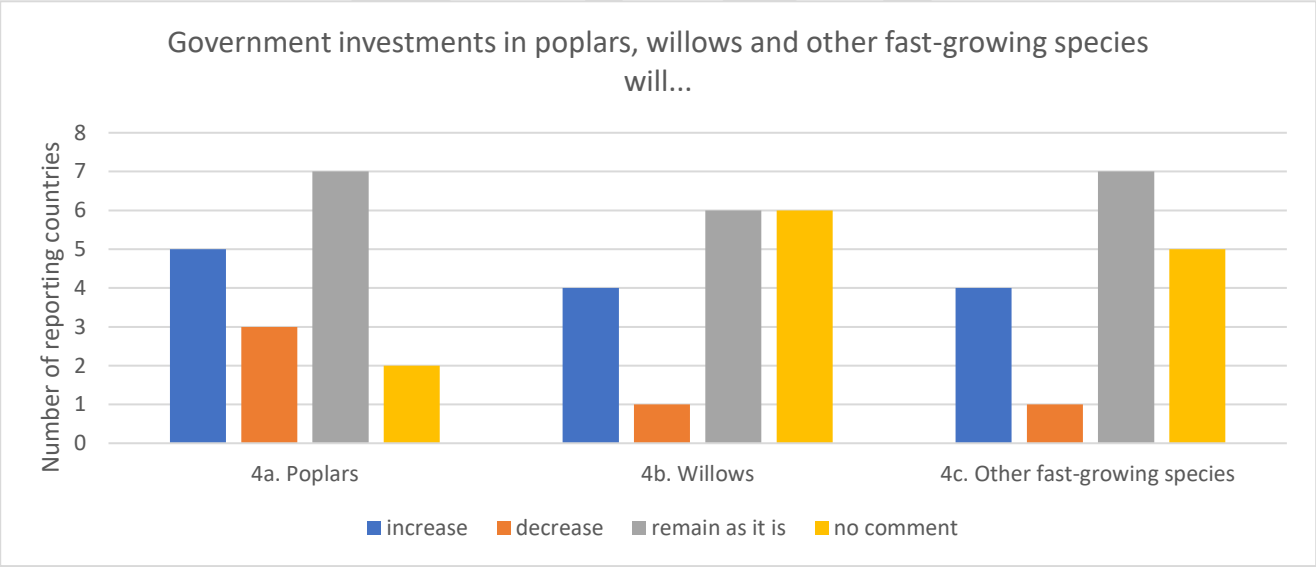
3) Area for bioenergy plantation

The trend of increasing poplar and willow areas is even more pronounced with regards to the establishment of bioenergy plantations. Use of poplar and willow plantations for bioenergy production is expected to remain the same in Bulgaria, Canada, Egypt, Germany, New Zealand, Portugal and Slovenia. Possible decreases are reported only from Iran and Italy, while Austria, China, Korea, Spain, Sweden, Spain and Turkey reported on potential for the increase in using poplar, willow and OFGS plantation for the bioenergy production.



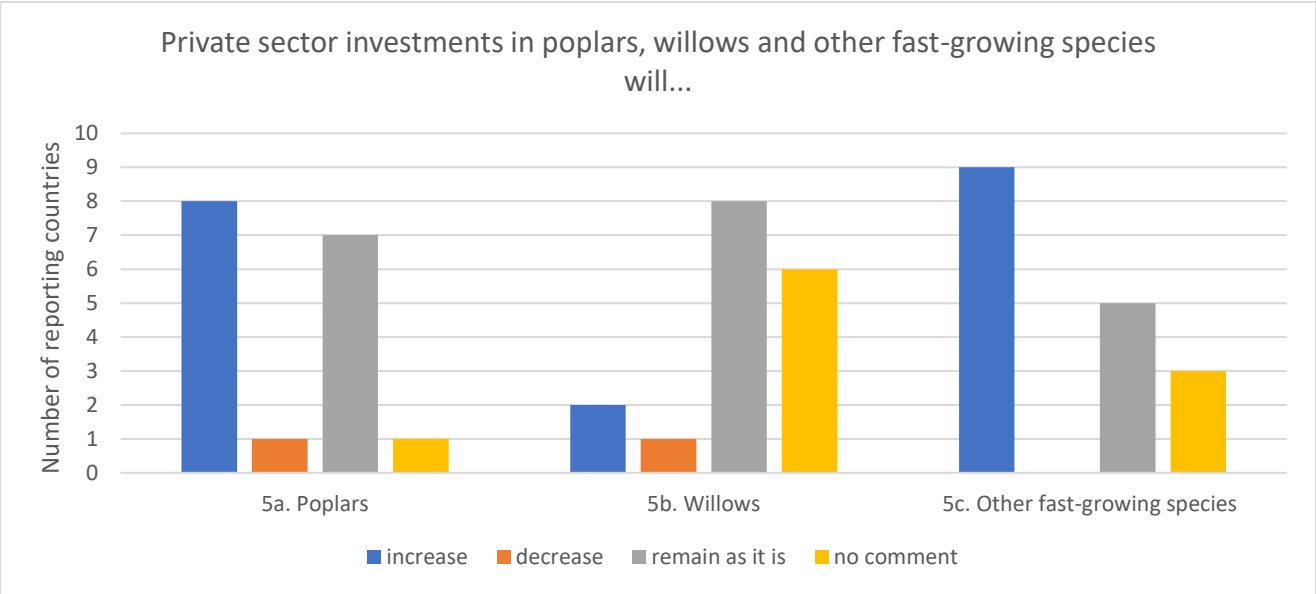
4) Future government investments

The opinion of the reporting countries on government investments appear not to show a clear trend, though investments in tree breeding programmes are assessed by some countries to increase. In Canada and Croatia, investments will most likely decrease, while in Canada, Iran, Italy, New Zealand, Slovenia, Germany, Korea and Turkey a significant increase is foreseen.



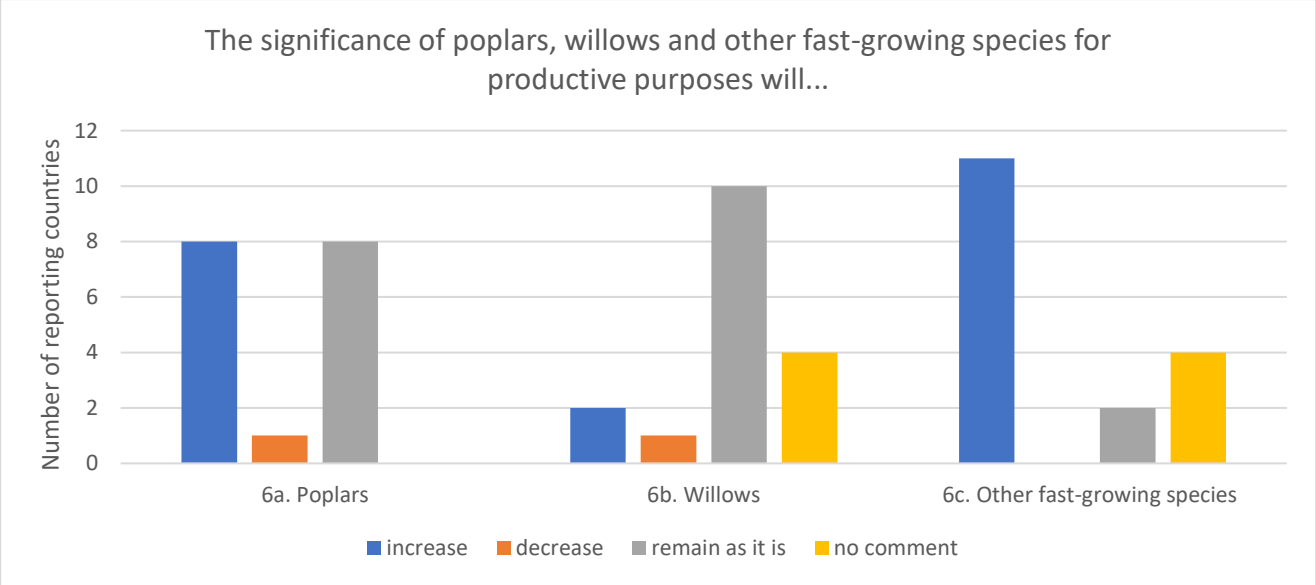
5) Future private sector investments

In most of the countries, there is a growing trend for private investments in the fast-growing species sector, which are anticipated to increase due to the growing interest in afforestation of agricultural lands and biomass production, especially in Canada, China, India, Iran, and many European countries (including Austria, Turkey, Spain, Sweden, Slovenia, Croatia, Germany, Bulgaria and some others).



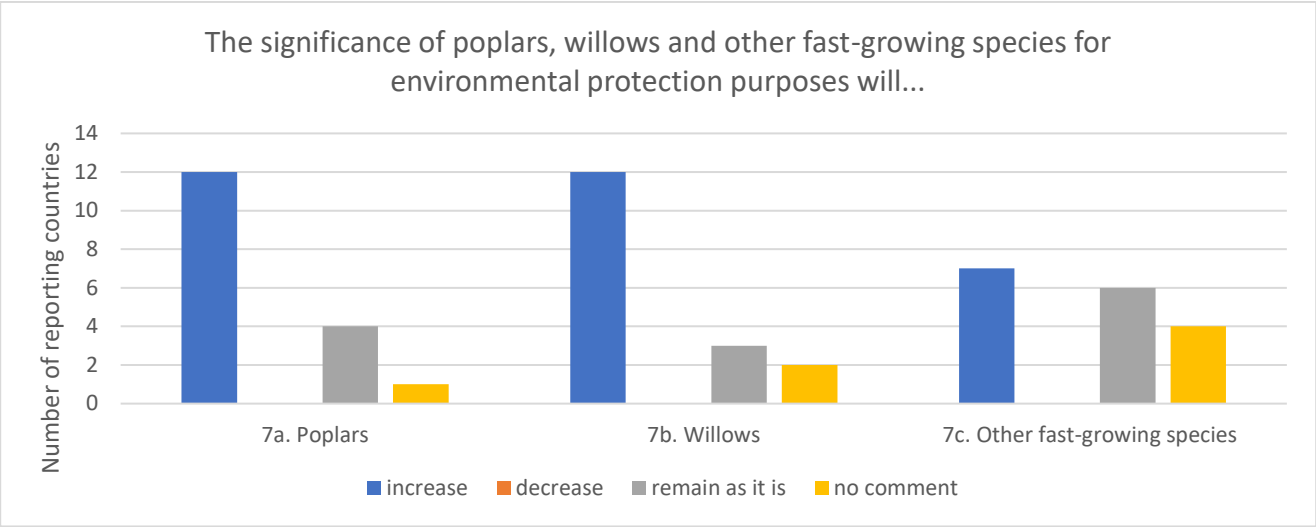
6) Significance for **productive** purposes

Most countries predict that the significance of poplars and willows for productive purposes will increase in the future (in Austria, Bulgaria, Canada, China, Egypt, Germany, Iran, Italy, Korea, Portugal, Sweden, Turkey) or remain the same. Decrease in production was reported only from South Africa.



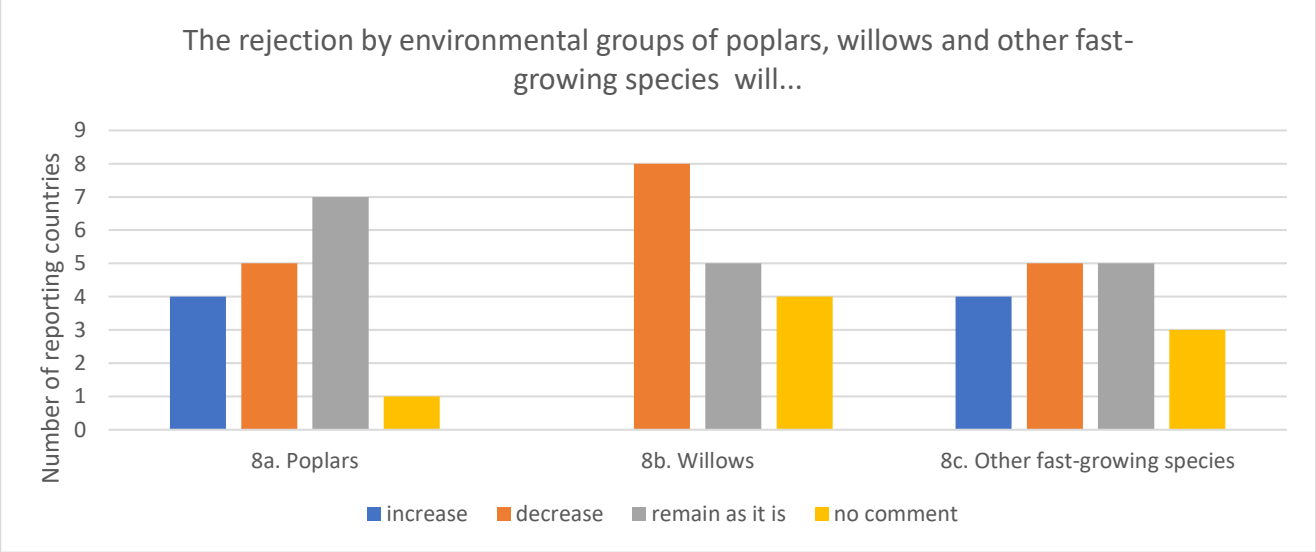
7) Significance for **environmental protection** purposes

None of the reporting countries expect decrease in the significance for environmental purposes. The conversion of natural poplar and willow forests to other land uses is assessed to remain the same by most countries, as most natural poplar and willow forests are guarded by legal regime of environmental protection.



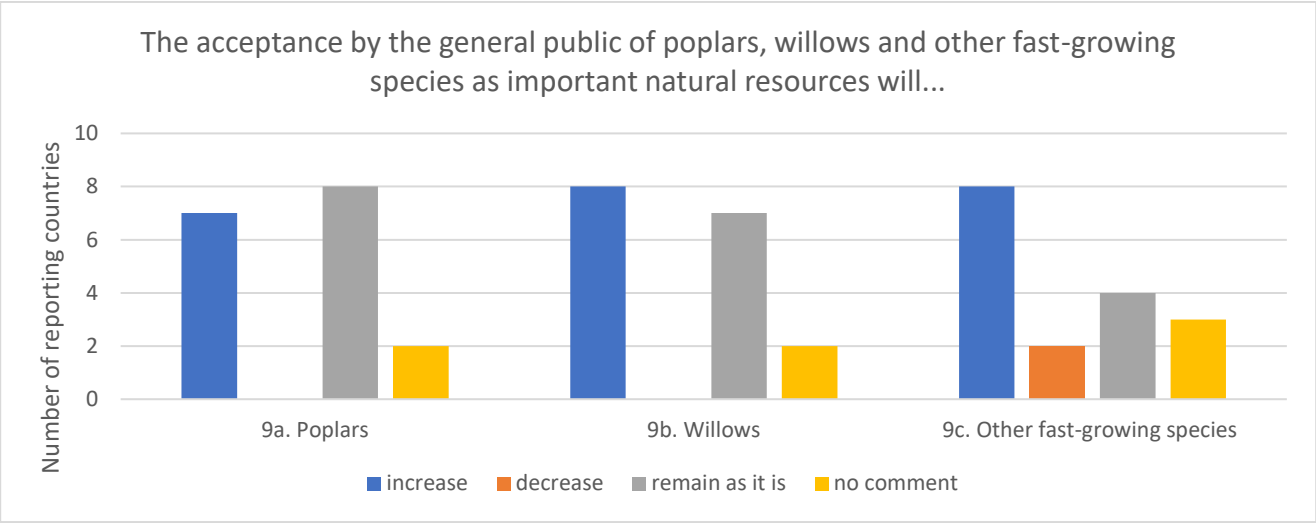
8) Rejection by environmental groups

Many countries foresee decrease in rejection by environmental groups in the coming years due to the increasing scope for environmental applications of poplars and willows in phytoremediation and agroforestry production systems. At the same time, potential increase in rejection is reported by Austria, Slovenia, Croatia, South Africa, Portugal and Spain.



9) Acceptance by the general public as important natural resources

The acceptance by the general public of poplars and willows being important natural resources is assessed predominantly positive, as nine countries opine that the acceptance will increase (for example in Bulgaria, Canada, Egypt, Iran, Korea, Slovenia, Sweden, Turkey, and new Zealand) and more than 10 countries think that it will remain as it is. Only South Africa and Portugal predict that public acceptance will decrease.


The acceptance by the general public of poplars, willows and other fast-growing species as important natural resources will...
Number of reporting countries
10
8
6
4
2
0
9a. Poplars
9b. Willows
9c. Other fast-growing species
increase
decrease
remain as it is
no comment

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ANNEX 1: SUMMARY TABLES BY COUNTRY 2020

Total area

Country	Total area, ha	Poplars, ha	Willows, ha	Mixed cultivation, ha	OFGS, ha
Africa					
Egypt	*61,206*	*7,000*			*53,681*
South Africa	*135*	*135*			
Asia					
China	*23,363,800*	*9,187,200*	*480,300*		*13,696,300*
Iran	*262,214*	*64,000*	*13,000*		*185,214*
Korea	*1,800*	*1,800*			
Turkey	*5,350,835*	*430,605*	*3,020*		*4,917,210*
Europe					
Austria	*2,400*			*2,400*	
Bulgaria	*23,508*				
Croatia	*40,463*	*12,901*	*16,296*		*11,266*
Germany	*273,461*	*146,764*	*74,788*	*6,600*	*45,309*
Ireland	*2*	*1*			*1*
Italy	*50,945*	*48,925*			*2,020*
Portugal	*991,000*		*179,000*	*160,000*	*652,000*
Slovenia	*141,132*	*61,237*	*14,914*	*4,214*	*60,867*
Spain	*181,892*	*132,819*	*5,409*	*43,664*	
Sweden	*1,458,401*	*242,430*	*5,971*		*1,210,000*
America&Oceania					
Canada	*39,357,735*	*39,066,810*	*87,665*	*16000*	*187,260*
New Zealand	*245,000*			*230000*	*15,000*
Total	***71,803,129***	***49,405,792***	***880,376***	***462,878***	***21,036,653***
Share		***69%***	***1%***	***1%***	***29%***

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Area by forest function

Poplars

Country	Total poplar area, ha	Total poplar area by forest function, ha			
		Production		Environmental protection, ha	Other, ha
		Industrial roundwood, ha	Fuelwood biomass, ha		
Africa					
Egypt	*7,000*				
South Africa	*135*				*135**
Asia					
China	*9,187,200*	*4,542,420*	*75,707*	*3,428,350*	*459,360*
Iran	*64,000*	*34,000*	*1,500*	*36,100*	*4,100*
Korea	*1,800*	*1,800*			
Turkey	*430,606*	*292,113*		*861*	*137,632*
Europe					
Austria					
Bulgaria					
Croatia	*12,901*	*3,125*		*1,157*	*8,655*
Germany	*146,764*	*65,000*		*3,353*	*78,411*
Ireland	*1*				*1*
Italy	*48,925*	*45,990*	*2,935*		
Portugal					
Slovenia	*61,237*	*426*	*6,433*	*572*	
Spain	*132,819*	*111,098*	*4,883*	*9,993*	
Sweden	*242,430*	*73,701*	*24,729*	*144,000*	
America&Oceania					
Canada	*39,057,810*	*760,859*		*5,653,590*	*32,653,825*
New Zealand					
Total	***49,405,792***	***5,930,532***	***116,187***	***9,277,976***	***33,341,984***
Share		**12%**	**1%**	**19%**	**67%**

* According to the national report, poplars in South Africa are cultivated by private sector for producing matches, so this area was assigned fully to the Other column

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Willows

Country	Total willow area, ha	Total willow area by forest function, ha			
		Production		Environmental protection, ha	Other, ha
		Industrial roundwood, ha	Fuelwood biomass, ha		
Africa					
Egypt					
South Africa					
Asia					
China	*480,300*	*231,975*	*30,930*	*199,566*	*17,829*
Iran	*13,000*		*1,300*	*9,100*	*2,600*
Korea					
Turkey	*3,020*	*287*			*2,733*
Europe					
Austria					
Bulgaria					
Croatia	*16,296*	*5,603*		*1,356*	*9,337*
Germany	*74,788*				*74,788*
Ireland	*1*				
Italy					
Portugal	*179,000*				*179,000*
Slovenia	*14,914*		*11,035*	*3,879*	
Spain	*5,409*			*5,409*	
Sweden	*5,971*		*5,971*		
America&Oceania					
Canada	*87,665*	*28,384*		*9,485*	*49,796*
New Zealand					
Total	***880,376***	***266,249***	***49,236***	***228,795***	***336,083***
Share		**30%**	**6%**	**26%**	**38%**

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Mixed cultivation of poplars and willows

Country	Total mixed area, ha	Total mixed cultivation area by forest function, ha			
		Production		Environmental protection, ha	Other, ha
		Industrial roundwood, ha	Fuelwood biomass, ha		
Africa					
Egypt					
South Africa					
Asia					
China					
Iran					
Korea					
Turkey					
Europe					
Austria	*2,400**		*2,400*		
Bulgaria					
Croatia					
Germany	*6,600*		*6,600*		
Ireland					
Italy					
Portugal	*160,000*				*160,000*
Slovenia	*4,214*	*84*	*1,896*	*2,234*	
Spain	*43,664*			*43,664*	
Sweden					
America&Oceania					
Canada	*16,000*			*16,000*	
New Zealand	*230,000*			*230,000*	
Total	***462,878***	***84***	***10,896***	***291,898***	***160,000***
Share		**0%**	**2%**	**63%**	**35%**

* Sum of biomass plantings in 2016 were approximately 2400 ha, out of which sum of biomass plantings on forest land are equal to 2421 ha, and sum of biomass plantings on agricultural land are equal to 217 ha.

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Other fast-growing species (OFGS)

Country	Total OFGS area, ha	Total OFGS area by forest function, ha			
		Production		Environmental protection, ha	Other, ha
		Industrial roundwood, ha	Fuelwood biomass, ha		
Africa					
Egypt	*53,681*			*53,681*	
South Africa					
Asia					
China	*13,696,300*	*7,733,790*	*164,154*	*5,310,676*	*487,680*
Iran	*185,214*	*5,132*			*180,082*
Korea					
Turkey	*4,917,210*	*3,724,106*		*21,196*	*1,171,908*
Europe					
Austria					
Bulgaria					
Croatia	*11,266*	*3,796*		*406*	*7,064*
Germany	*45,309*	*45,309*			
Ireland	*1*				*1*
Italy	*2,020*		*2020*		
Portugal	*652,000*	*529,000*			*123,000*
Slovenia	*60,867*	*12,184*	*42604*	*6,079*	
Spain					
Sweden	*1,210,000*	*679,000*	*291000*	*240,000*	
America&Oceania					
Canada	*187,260*	*1,873*		*28,089*	*157,298*
New Zealand	*15,000*			*15,000*	
Total	***21,036,653***	***12,734,190***	***499,778***	***5,675,127***	***2,127,033***
Share		**61%**	**2%**	**27%**	**10%**

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Planted forest area

Poplars

Country	Total area, ha	Industrial roundwood, ha	Fuelwood biomass, ha	Environmental protection, ha	Other, ha
Africa					
Egypt					
South Africa	*135*				*135**
Asia					
China	*7,570,700*	*4,542,420*	*757,070*	*1,892,675*	*378,535*
Iran	*30,300*	*30,300*			
Korea					
Turkey	*140,000*	*140,000*			
Europe					
Austria					
Bulgaria	*3,165*				*3,165***
Croatia	*43*			*2*	*41*
Germany	*130,000*	*65,000*			*65,000*
Ireland					
Italy	*48,925*	*45,990*	*2,935*		
Portugal					
Slovenia	*288*	*140*	*147*	*1*	
Spain	*122,086*	*111,098*	*4,883*	*6,104*	
Sweden	*2,430*	*1,701*	*729*		
America&Oceania					
Canada	*9,000*	*9,000*			
New Zealand					
Total	***8,057,072***	***4,945,783***	***765,765***	***1,898,782***	***446,741***
Share		**61%**	**10%**	**24%**	**6%**

* According to the national report, poplars in SA are cultivated by private sector for producing matches, so all area was assigned fully to the Other column

** As there is no information on the utilization of planted forests in the national questionnaire, all area was assigned to the Other column

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Willows

Country	Total area, ha	Industrial roundwood, ha	Fuelwood biomass, ha	Environmental protection, ha	Other, ha
Africa					
Egypt					
South Africa					
Asia					
China	*309,300*	*231,975*	*30,930*	*37,116*	*9,279*
Iran					
Korea					
Turkey					
Europe					
Austria					
Bulgaria	*13*				*123*
Croatia	*4,667*	*2,231*		*135*	*2,301*
Germany					
Ireland					
Italy					
Portugal	*179,000*				*179,000*
Slovenia	*7*			*3*	*4*
Spain					
Sweden	*5,971*		*5,971*		
America&Oceania					
Canada					
New Zealand					
Total	***498,958***	***234,206***	***36,901***	***37,254***	***190,584***
Share		**47%**	**7%**	**8%**	**38%**

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OFGS

Country	Total area, ha	Industrial roundwood, ha	Fuelwood biomass, ha	Environmental protection, ha	Other, ha
Africa					
Egypt	*6,603*				*6,603**
South Africa					
Asia					
China	*9,753,600*	*7,733,790*	*164,154*	*1,367,976*	*487,680*
Iran	*159,098*	*159,098*			
Korea					
Turkey	*66,524*	*66,111*		*413*	
Europe					
Austria					
Bulgaria	*506*				*505.5*
Croatia	*11,266*	*3,796*		*406*	*7,064*
Germany	*45,309*	*45,309*			
Ireland					
Italy	*2,020*		*2,020*		
Portugal	*652,000*	*529,000*			*123,000*
Slovenia	*74*	*25*	*49*		
Spain					
Sweden					
America&Oceania					
Canada					
New Zealand	*15,000*			*15,000*	
Total	***10,712,000***	***8,537,129***	***166,223***	***1,383,795***	***624,853***
Share		**80%**	**2%**	**12%**	**6%**

* As national questionnaire did not provide information regarding use of the planted area, it was fully included into the Other column

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Wood removals

Poplars

Country	Total removals, m³	Veneer/ plywood, m³	Pulpwood, m³	Sawnwood, m³	Fuelwood and woodchips, m³
Africa					
Egypt					
South Africa					
Asia					
China*	*15,000*	*15,000*			
Iran*	*2,255,000*	*2,255,000*			
Korea					
Turkey	*3,478,408*	*1,420,072*	*93,254*	*1,773,821*	*191,261*
Europe					
Austria					
Bulgaria**	*212,732*	*83,782*	*46,141*	*55,855*	*26,954*
Croatia	*68,987*	*5,013*		*22,316*	*41,658*
Germany	*492,000*			*246,000*	*246,000*
Ireland					
Italy	*1,194,000*	*674,000*	*225,000*		*295,000*
Portugal					
Slovenia	*14,009*		*630*	*1,234*	*12,145*
Spain	*531,553*	*324,557*	*21,352*	*81,222*	*104,422*
Sweden					
America&Oceania					
Canada***	*20,250*	*12,515*	*7,337*		*398*
New Zealand					
Total	***8,281,939***	***4,789,939***	***393,714***	***2,180,448***	***917,838***
Share		**58%**	**5%**	**26%**	**11%**

* For both China and Iran, national data provided in questionnaires does not specify the exact utilization of wood removals for any wood products. Based on the national trends in wood production, all volume was inserted into the veneer and plywood section.

** The data are for 2019. Only total wood removal for poplars available

*** The National Forest Database reports harvest (roundwood) as: Fuelwood and firewood; Logs and bolts; Other industrial roundwood; Pulpwood. The figures for logs and bolts and other industrial were combined in the "veneer/plywood" category. It is not known how much of this should be categorized as "sawnwood"

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Willows

Country	Total removals, m^3	Veneer/ plywood, m^3	Pulpwood, m^3	Sawnwood, m^3	Fuelwood and woodchips, m^3
Africa					
Egypt					
South Africa					
Asia					
China					
Iran	*400,000*			*400,000*	
Korea					
Turkey	*21,740*	*7,174*	*6,522*	*8,044*	
Europe					
Austria					
Bulgaria					
Croatia	*24,893*	*626*		*5,392*	*18,875*
Germany	*88,000*				*88,000*
Ireland					
Italy					
Portugal					
Slovenia	*3,313*				*3,313*
Spain	*1,316*			*790*	*526*
Sweden					
America&Oceania					
Canada					
New Zealand					
Total	***539,262***	***7,800***	***6,522***	***414,226***	***110,714***
Share		**1%**	**1%**	**77%**	**21%**

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OFGS

Country	Total removals, m^3	Veneer/ plywood, m^3	Pulpwood, m^3	Sawnwood, m^3	Fuelwood and woodchips, m^3
Africa					
Egypt					
South Africa					
Asia					
China*	*33,000*	*33,000*			
Iran*	*128,300*	*128,300*			
Korea					
Turkey	*5,809,640*	*15,745*	*2,977,551*	*2,499,752*	*316,592*
Europe					
Austria					
Bulgaria					
Croatia	*67,776*	*13,149*		*31,703*	*22,924*
Germany	*155,000*			*155,000*	
Ireland					
Italy	*50,000*				*50,000*
Portugal	*8,722,100*		*8,722,100*		
Slovenia	*3,358*			*660*	*2,698*
Spain					
Sweden	*8,100,000*	*1,620,000*	*3,240,000*	*1,620,000*	*1,620,000*
America&Oceania					
Canada					
New Zealand					
Total	***23,069,174***	***1,810,194***	***14,939,651***	***4,307,115***	***2,012,214***
Share		**8%**	**64%**	**19%**	**9%**

* For both China and Iran, national data provided in questionnaires does not specify the exact utilization of wood removals for any wood products. Based on the national trends in wood production, all volume was inserted into the veneer and plywood section

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Forest products

Poplars (in roundwood equivalents (1000 m³ r)

Country	Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particle board and fibre board	Veneer sheets	Plywood	Sawnwood
Africa								
Egypt								
South Africa								
Asia								
China				*12,000*	*122,000*		*30,000*	
Iran			*208*	*900*	*825*			*450*
Korea								
Turkey	*337*	*7*	*233*	*0*	*1,400*	*475*	*425*	*3,193*
Europe								
Austria								
Bulgaria								
Croatia								
Germany	*246,000*		*246,000*					
Ireland								
Italy	*452*			*275*	*200*		*1,000*	*260*
Portugal								
Slovenia								
Spain	*9*	*79*				*116*	*509*	*79*
Sweden								
America&Oceania								
Canada	*398*			*7,338*	*12,515*			
New Zealand								
Total	***247,196***	***86***	***246,441***	***20,513***	***136,940***	***591***	***31,934***	***3,982***
Share	36%	0%	36%	3%	19%	0%	5%	1%

OFGS (in roundwood equivalents (1000 m³ r)

Country	Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particleboard fibreboard	Veneer sheets	Plywood	Sawnwood
Africa								
Egypt*	*17,830,162*	*6,750*	*0*	*41,000*	*24,300*	*7,000*	*28,000*	*1,000*
South Africa								
Asia								
China				*22,000*			*11,000*	
Iran								
Korea								
Turkey	*558*	*11*	*7,319*	*125*		*14*	*21*	*4,499*
Europe								
Austria								
Bulgaria								
Croatia								
Germany	*82,000*		*73,000*					
Ireland								
Italy	*50*							
Portugal				*9,066*				
Slovenia								
Spain								
Sweden			*7,331*	*7,124*				*207*
America& Oceania								
Canada								*170*
New Zealand								
Total	***17,912,770***	***6,761***	***87,650***	***79,315***	***24,300***	***7,014***	***39,021***	***5,876***

* Data provided in the questionnaire does not specify the exact name of other fast-growing species, used for production. Therefore, it is assumed that all production is based on eucalyptus - main OFGS growing in Egypt.

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ANNEX 2: COUNTRY TABLES 2020

AUSTRIA

Table 1. Area

Land Use Category		Total area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Planted forest							
	Poplars						
	Willows						
	Mix of P&W	2,400*		100			
	OFGS*						
Grand Total		2,400		100			

* Sum of biomass plantings in 2016 were approximately 2400 ha, out of which sum of biomass plantings on forest land are equal to 2421 ha, and sum of biomass plantings on agricultural land are equal to 217 ha.

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BULGARIA

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Planted forest							
	Poplars						3,165
	Willows						12.5
	Mix of P&W						
	OFGS*						
	Tilia tomentosa, Robinia pseudoacacia						505.5
Grand Total		23,508**					3,683

**No separate data about naturally regenerating and planted poplars, willows and OFGS available, the recent data about the area are from 2015

Table 4 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m^3				
		Total removals	for industrial round wood			for fuelwood, wood chips
			Veneer/plywood	Pulpwood	Sawnwood	
Planted forest						
	Poplars					
	Willows					
	Mix of P&W					
	OFGS*					
Grand Total		**212,732****	**83,782**	**46,141**	**55,855**	**26,954**

** The data are for 2019. Only total wood removal for poplars available

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CANADA

Table 1. Area

Land Use Category		Total area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Naturally Regenerating Forest							
	Poplars	37,592,950	2		15	83	N/A
	Willows	59,281			16	84	N/A
	Mix of P&W						N/A
	OFGS*						
	Alder	187,260	1		15	84	N/A
Planted forest							
	Poplars	9,000	100				3,000
Other Land with Tree Cover							
Agroforestry	**Poplars**	1,464,860			0.9	99.1	200
	Willows	28,384					200
	Mix of P&W	16,000			100	100	200
	Grand Total	39,357,735					3,600

N.B. "Trees Outside Forests" area is comprised of the poplar area in the "Prairies" and "Mixedwood Plains", which are primarily agricultural areas. The total poplar area in the NFI was given as 39,057,810 hectares. The percent for industrial roundwood is based on the area harvested. Red alder is used to a significant extent in BC (average 161 thousand m3/year) and is the most common deciduous tree in the Pacific Maritime Ecozone. The 187,260 hectares reported in the NFI as "Other Hardwoods" and "Unspecified Hardwoods" was therefore assumed to be red alder. Most poplar plantations in forests are assumed to be for industrial purposes. Willows in "Naturally Regenerating Forests" and "Trees Outside Forests" were considered to be of the same area as in the most recent report. Most of these willows are naturally occurring willows that protect riparian zones.

Table 5 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m^3				
		Total removals	for industrial round wood			for fuelwood, wood chips
Naturally regenerating forest			Veneer/plywood	Pulpwood	Sawnwood	
	Poplars	20,250	12,515	7,338	0	398
	Grand Total	20,250	12,515	7,338	0	398

** The National Forest Database reports harvest (roundwood) as: Fuelwood and firewood; Logs and bolts; Other industrial roundwood; Pulpwood. The figures for logs and bolts and other industrial were combined in the "veneer/plywood" category. It is not known how much of this should be categorized as "sawnwood"

Table 6 Forest products in roundwood equivalents (1000 m3 r)

Forest category		Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particleboard fibreboard	Veneer sheets	Plywood	Sawnwood
		'000 m^3 (r)							
Naturally regenerating forest									
	Poplars	398			7,338	12,515			
	OFGS*								
	Alder								170
	Grand Total	398	0	0	7,338	12,515	0	0	170

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CHINA

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Naturally Regenerating Forest							
	Poplars	1,616,500			95	5	N/A
	Willows	171,000			95	5	N/A
	OFGS*						
	Bamboo	3,903,800					N/A
	Eucalyptus						N/A
	Robinia	38,900					N/A
Planted forest							
	Poplars	7,570,700	60	10	25	5	
	Willows	309,300	75	10	12	3	
	OFGS*						
	Bamboo	2,507,800	80	3	12	5	
	Eucalyptus	5,467,400	95			5	
	Robinia	1,778,400	30	5	60	5	
	Grand Total	23,363,800					

Table 7 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m^3				
		Total removals	for industrial round wood			for fuelwood, wood chips
			Veneer/plywood	Pulpwood	Sawnwood	
Planted forest						
	Poplars	15,000				
	OFGS*					
	Bamboo	6,000				
	Eucalyptus	27,000				
	Grand Total					

Table 8 Forest products in roundwood equivalents (1000 m3 r)

Forest category		Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particleboard fibreboard	Veneer sheets	Plywood	Sawnwood
'000 m^3 (r)									
Planted									
	Poplars				12,000	122,000		30,000	
	OFGS*								
	Bamboo							6,000	
	Eucalyptus				22,000			5,000	
	Grand Total				34,000	122,000		41,000	

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CROATIA

Table 1. Area

Land Use Category	Total area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
		Production		Protection (%)	Other (%)	
		Industrial roundwood (%)	Fuelwood biomass (%)			
Naturally regenerating forest						
Poplars	12,858	24,3		8.8	66.9	N/A
Willows	11,629	29		10.5	60.5	N/A
Planted forest						
Poplars	43			2.6	97.4	91
Willows	4,667	47.8		2.9	49.3	56
OFGS						
P. xeuramericana	11,266	33.7		3.6	62.7	1,095
Grand Total	40,463					1,242

Table 9 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m³				
		Total removals	for industrial round wood			for fuelwood, wood chips
Naturally regenerating forest			Veneer/plywood	Pulpwood	Sawnwood	
	Poplars	59,637	4,121		18,969	36,547
	Willows	4,092	201		1,312	2,579
	OFGS*					
	P. xeuramericana	12,848	1,830		4,392	6,626
Planted forest						
	Poplars	9,350	892		3,347	5,111
	Willows	20,801	425		4,080	16,296
	OFGS*					
	P. xeuramericana	54,928	11,319		27,311	16,298
	Grand Total	161,656	18,788		59,411	83,457

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EGYPT

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Naturally Regenerating Forest							
	OFGS*						
		525			100		N/A
Planted forest							
	OFGS*						
		6,603					100
Other Land with Tree Cover							
Agroforestry	**Poplars**	7,000					
	OFGS*						
		45,800				100	200
Trees in urban settings	**Poplars**						
	OFGS*						
		1,278				100	250
Grand Total		61,206				100	550

Table 10 Forest products in roundwood equivalents (1000 m3 r)

Forest category	Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particleboard fibreboard	Veneer sheets	Plywood	Sawnwood
'000 m³ (r)								
OFGS Grand Total	17,830,162	6,750	0	41,000	24,300	7,000	28,000	1,000

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GERMANY

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Naturally Regenerating Forest							
	Poplars	16,764			20	80	N/A
	Willows	74,788				100	N/A
Planted forest							
	Poplars	130,000	50			50	550
	Mix of P&W	6,600		100			
	OFGS*						
	Black locust	42,239	100				
	Hybrid larch	3,070	100				
Grand Total		273,461					550

Table 11 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m³				
		Total removals	for industrial round wood			for fuelwood, wood chips
			Veneer/plywood	Pulpwood	Sawnwood	
Planted forest						
	Poplars	492,000			246,000	246,000
	Mix of P&W	88,000				88,000
	OFGS*					
	Black locust	136,000			136,000	
	Hybrid larch	19,000			19,000	
Grand Total		**735,000**			401,000	334,000

Table 12 Forest products in roundwood equivalents (1000 m3 r)

Forest category		Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particleboard fibreboard	Veneer sheets	Plywood	Sawnwood
'000 m³ (r)									
Naturally regenerating forest									
	Poplars	246,000		246,000					
	Mix of P&W		88,000						
	OFGS*								
	Black locust	82,000		54,000					
	Hybrid larch			19,000					
Grand Total		328,000	88,000	319,000					

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IRAN

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Naturally Regenerating Forest							
	Poplars	30,000		5	90	5	N/A
	Willows	13,000		10	70	20	N/A
	OFGS*						
	Alder	25,716					N/A
Planted forest							
	Poplars	30,300	100				8,094
	OFGS*						
	Alder	153,966					13,856
	Eucalypt	5,132	100				2,824
Other Land with Tree Cover							
Agroforestry	**Poplars**	2,200	100				650
Trees in urban settings	**Poplars**	1,500					
	OFGS*						
	Eucalyptus	400					
Grand Total		**262,214**					**25,424**

Table 13 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m³				
		Total removals	for industrial round wood			for fuelwood, wood chips
			Veneer/plywood	Pulpwood	Sawnwood	
Planted forest						
	Poplars	2,200,000				
	Willows	400,000				
	OFGS*					
	Eucalypt	128,300				
Other Land with Tree Cover						
Agroforestry						
	Poplars	55,000				
	OFGS*					
Grand Total		**2,783,300**				

Table 14 Forest products in roundwood equivalents (1000 m3 r)

Forest category	Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particleboard fibreboard	Veneer sheets	Plywood	Sawnwood
'000 m³ (r)								
Grand Total	**0**	**0**	**208**	**900**	**825**	**0**	**0**	**450**

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IRELAND

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Planted forest							
	Poplars	0.85					23.04
	Willows	0.30					5.16
	Mix of P&W						
	OFGS*						
	Eucalyptus	0.85					2.4
Grand Total							

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ITALY

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Planted forest							
	Poplars	48,925	94	6			14,600
	OFGS*						
	Eucalyptus	2,020		100			
Grand Total		50,945					14,600

Table 15 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m³				
		Total removals	for industrial round wood			for fuelwood, wood chips
			Veneer/plywood	Pulpwood	Sawnwood	
Planted forest						
	Poplars	11,940,000	674,000	225,000		295,000
	OFGS*					
	Eucalyptus	50,000				50,000
Grand Total		**12,440,000**	674,000	225,000		345,000

Table 16 Forest products in roundwood equivalents (1000 m3 r)

Forest category		Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particleboard fibreboard	Veneer sheets	Plywood	Sawnwood
		‘000 m³ (r)							
Planted									
	Poplars	452			275	200		1,000	260
	OFGS*								
	Eucalyptus	50							
Grand Total		502			275	200		1,000	260

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KOREA

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Planted forest							
	Poplars						156.5
	OFGS*						
	Yellow poplar	1,800	100				7,036
Grand Total		1,800					7,192.5

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NEW ZEALAND

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Planted forest							
	OFGS*						
	Eucalyptus	15,000					
Other Land with Tree Cover							
Agroforestry	**Poplars**		5		95		6,000
	Willows				100		1,300
	Mix of P&W	230,000			100		4,700
Grand Total		245,000					12,000

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PORTUGAL

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Planted forest							
	Poplars						103.61
	Willows	179,000				19,000	8.56
	Mix of P&W	160,000					
	OFGS*						
	Eucalyptus	652,000	100			123,000	19,788.2
Grand Total							

Table 17 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m³				
		Total removals	for industrial round wood			for fuelwood, wood chips
			Veneer/plywood	Pulpwood	Sawnwood	
Planted forest						
	OFGS*					
	Eucalyptus	8,722,100		8,722,100		
Grand Total		8,722,100		8,722,100		

Table 18 Forest products in roundwood equivalents (1000 m3 r)

Forest category		Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particleboard fibreboard	Veneer sheets	Plywood	Sawnwood
'000 m³ (r)									
Planted									
	OFGS*								
	Eucalyptus				9,066				
Grand Total					9,066				

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SLOVENIA

Table 1. Area

Land Use Category		Total area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Naturally Regenerating Forest							
Populus nigra, Populus alba	**Poplars**	7,143	4	88	8	0	N/A
Populus tremula		53,806	0	100	0	0	N/A
	Willows	14,907	0	74	26	0	N/A
	Mix of P&W	4,214	2	45	53	0	N/A
	OFGS*						
	Robina pseudoacacia	60,793	20	70	10	0	N/A
Planted forest							
	Poplars	10	10	80	10	0	8
	Willows	3	0	0	100	0	2
	OFGS*						
	Robina pseudoacacia	30	10	90	0	0	0
	Juglans nigra	30	50	50	0	0	0
Plantation forest							
	Poplars	278	50	50	0	0	27
	Willows	4	0	100	0	0	0
Juglans nigra	**OFGS***	14	50	50	0	0	0
	Grand Total	**141,232**					**35**

Table 19 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m3				
		Total removals	for industrial round wood			for fuelwood, wood chips
Naturally regenerating forest			Veneer/plywood	Pulpwood	Sawnwood	
	Poplars	11,909	0	0	1,024	10,885
	Willows	3,313	0	0	0	3,313
	OFGS*					
	Robinia pseudoacacia	3,003	0	0	6,00	2,403
Planted forest						
	OFGS*					
	Robinia pseudoacacia	300	0	0	30	270
Plantation forest						
	Poplars	2,100	0	630	210	1,260
	Willows	N/A	0	0	0	N/A
	OFGS*					
	Juglans nigra	55	0	0	30	25
	Grand Total	**20,680**	0	**630**	**1,894**	**18,156**

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SOUTH AFRICA

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Planted forest							
	Poplars	134.7					
Grand Total		134.7					

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SPAIN

Table 1. Area

Land Use Category		Total Area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Naturally Regenerating Forest							
	Poplars	3,889			100		N/A
	Willows	5,409			100		N/A
	Mix of P&W	40,730			100		N/A
Planted forest							
	Poplars	122,086	91	4	5		
Other Land with Tree Cover							
Agroforestry	**Poplars**	6,844					
	Mix of P&W	2,934					
Grand Total							

Table 20 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m³				
		Total removals	for industrial round wood			for fuelwood, wood chips
Naturally regenerating forest			Veneer/plywood	Pulpwood	Sawnwood	
	Poplars	140			83	57
Planted forest						
	Poplars	531,413	324,557	21,352	81,139	104,365
	Willows	1,316			790	526
Grand Total						

Table 21 Forest products in roundwood equivalents (1000 m3 r)

Forest category		Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particleboard fibreboard	Veneer sheets	Plywood	Sawnwood
Planted forest									
	Poplars	8.7	78.6				116	509	78.7
Grand Total		8.7	78.6				116	509	78.7

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SWEDEN

Table 22 Area

Land Use Category		Total area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Naturally Regenerating Forest							
	Poplars	240,000	30	10	60		N/A
	OFGS*						
	Betula sp.	970,000	70	30			N/A
	Alnus sp.	240,000			100		
Planted forest							
	Poplars	2,430	70	30			355
	Willows	5,971		100			-3045
Grand Total							

Table 23 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m³				
		Total removals	for industrial round wood			for fuelwood, wood chips
Naturally regenerating forest			Veneer/plywood	Pulpwood	Sawnwood	
	OFGS*					
	Alnus+Betula	8,100,000	20%	40%	20%	20%
Grand Total						

Table 24 Forest products in roundwood equivalents (1000 m3 r)

Forest category		Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particleboard fibreboard	Veneer sheets	Plywood	Sawnwood
Naturally regenerating forest									
	OFGS*								
	*Betula sp.***			6,037	5,964.7				72.3
	*P.tremula+Fagus sylvatica mainly***			1,293.7	1,159				134.7
Grand Total									

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TURKEY

Table 25 Area

Land Use Category		Total area 2019 (ha)	Total area by forest function in %				Area planted from 2016 2019 (ha)
			Production		Protection (%)	Other (%)	
			Industrial roundwood (%)	Fuelwood biomass (%)			
Naturally Regenerating Forest							
	Poplars	287,005.5	53		0.3	46.7	N/A
	Willows	3,020.1	9.5			90.5	N/A
	OFGS*						
	Pinus brutia	4,612,156	75		0.4	24.6	22,322
	Alnus spp.	210,223.1	83		0.6	16.4	0
	Fraxinus angustifolia	14,057.6	85		2.9	12.1	717
	Prunus avium	10,730.5	88		4.2	7.8	0
	Robinia pseudoacacia	3,518.4	87		4.4	8.6	0
Planted forest							
	Poplars	140,000	100				888
	OFGS*						
	Pinus pinaster	57,378.4	99.2		0.8		4,486
	Eucalyptus spp.	5,212.7	100				361
	Pinus radiata	1,709.2	996		0.4		0
	Fraxinus angustifolia	1,347	100				0
	Pseudotsuga menziesii	608.6	98.8		1.2		0
	Prunus avium	232	100				0
	Pinus taeda	36.3	100				0
Other Land with Tree Cover							
Agroforestry	**Poplars**	3,600				100	0
	Grand Total	5,347,935.4					28,774

Table 26 Wood removals

Forest category and species, cultivar or clone		Wood removals 2019 in m³				
		Total removals	for industrial round wood			for fuelwood, wood chips
Naturally regenerating forest			Veneer/plywood	Pulpwood	Sawnwood	
	Poplars	93,254		93,254		
	Willows	21,740	7,174.2	6,522	8,043.8	
	OFGS*					
	Pinus brutia	5,510,542		2,759,679.43	2,441,170.11	309,692.46
	Fraxinus spp.	74,313	14,297.82	37,305.13	18,087.78	4,622.27
	Alnus spp.	26,300	1,446.50	14,451.85	8,124.07	2,277.58
Planted forest						
	Poplars	3,385,154	1,420,072.10		1,773,820.70	191,261.20
	OFGS*					
	Pinus pinaster	180,391.18		151,474.48	28,916.71	
	Eucalyptus spp.	17,579.13		14,137.14	3,442	
	Pseudotsuga menziesii	476.27		464.70	11.57	
	Pinus radiata	38		38		
	Grand Total	9,309,787.58	1,442,990.62	3,077,326.73	4,281,616.73	507,853.51

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Table 27 Forest products in roundwood equivalents (1000 m3 r)

Forest category	Fuelwood	Chips	Industrial roundwood	Wood-pulp	Particleboard fibreboard	Veneer sheets	Plywood	Sawnwood
Naturally regenerating forest								
Poplars			233.14					
Willows			16.31			13.63		14.48
OFGS*								
Pinus brutia	546.30	10.53	6,824.20	75				4,394.11
Fraxinus spp.	8.15	0.16	93.26			13.87	17.69	32.43
Alnus spp.	4.03	0.08	36.13				3.62	14.62
Planted								
Poplars	337.38	6.50			1,400	475	425	3,193.01
OFGS*								
Pinus pinaster			328.69	50				52.05
Eucalyptus spp.			35.34					6.20
Pseudotsuga menziesii			1.16					0.02
Pinus radiata			0.10					
Grand Total	895.85	17.27	7,568.32	125	1,400	502.49	446.30	7,706.91

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