Poplar Commission of the Republic of Slovenia

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Cultivation and Utilization of Poplars, Willows and other Fast-growing Trees in Slovenia

Report of the National Poplar Commission

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I. POLICY AND LEGAL FRAMEWORK

Slovenia is one of the most forested countries in Europe with 1,177,244 ha of all forests covering 58.1% of its territory (SFS Forest Annual Report, 2019). Site conditions are favorable mainly for the development of the high forest. 70 % of forests are situated within the natural distribution area of predominantly beech, fir-beech and beech-oak sites with high production capacity. The forestry sector and forest management are based on sustainable, close-to-nature principles. Clearcutting has been forbidden by law since 1947. Natural regeneration is supported in all forests. At present, the non-native tree species are less current in Slovenia, although they were introduced to a larger extent between the two world wars due to their fast-growth and high wood quality (Wraber 1951). Compared to forests in most EU countries, the semi-natural forests in Slovenia are well-preserved since sustainable, co-natural, and multifunctional management has been traditionally and legally incorporated into forestry practice.

Forest management planning is prepared for all forests regardless of the ownership by forest authorities and approved by the Ministry for Agriculture, Forestry and Food. The allowable cut is determined with forest management plans. Before taking on harvesting activities, permission from the regional unit of the Slovenia Forest Service must be obtained. The local forester of the Slovenia Forest Service regional unit also marks the trees in the forest for felling and provides forest owners with harvesting guidelines.

In no forest the stump removal is allowed except due to infrastructure demands; also no fertilization and no liming to increase yield in compensation for nutrient extraction and re-establishment of natural biogeochemical cycles are allowed. No forest machinery has been used in forests for soil preparation. Some clearing of ground vegetation cover is done manually in case of artificial regeneration of forests with planting in a few restricted cases. Forestry machinery for soil preparation is only used when decided to change forests into some other land use.

Approximately 30 different non-native tree species in total are currently present in Slovenian forests (Brus et al., 2017). Some were introduced with planting or establishing forest plantations on arable land or used for afforestation purposes. The growing stock of the non-native tree species is 0.99% of the total growing stock of forests in Slovenia (Kutnar and Pisek, 2013). According to Brus et al. (2017), black locust with 0.602% of the total forest growing stock has the largest share among them; while black walnut with <0,001% of the total forest growing stock is one of the less frequent species. According to the data calculated in the base of forest stands of the Forest Information System of the Slovenia Forest Service (2019), where the growing stock of the analyzed fast-growing tree species is equal or higher than 1 m^3, has shown that all stands with European black poplar, white poplar, and native willows cover 2.23%, and with aspen 4.57% of the total forest area, respectively. Stands with the black locust and black walnut cover 5.16% and <0,01% of the total forest area, respectively. The possibility of the non-native species introduction is clearly limited by the national and EU legislation and international biodiversity-related agreements. Common rotation lengths for native poplars, willows tree species in Slovenia forest is 60 years, whereas for other forest tree species it is 100–140 years.

No well-developed poplar, willow, black locust or black walnut timber-based industries exist in Slovenia. There are just a few separate records on the use of raw wood. The main raw material for paper manufacture used in the industry are recycled fibers obtained from the recycled paper in the deinking process; to a low extent, fresh spruce or fir, and poplar wood is used for mechanical pulpwood manufacture. Black walnut timber wood is used for industrial veneer sheets production.

In Slovenia, 37.16% (7,684 km^2) of the total territory is included in the Natura 2000. The introduction of plants or animals of the non-native species and the introduction of genetically modified organisms is restricted by the Habitat Directive and prohibited in the Natura 2000 sites. Forest covers 71 % of the Natura 2000 sites. Forest management plans need to be harmonized with the nature conservation guidelines prepared by the Institute of the Republic of Slovenia for Nature Conservation.

The largest complex of the preserved floodplains in Slovenia is located along the Mura River. During the reporting period, the Mura River Biosphere Reserve (BOM) was declared in Slovenia (https://en.unesco.org/biosphere/eu-na/mura-river) 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. The initiative for establishing this first global 5-country BR in Austria, Slovenia, Croatia, Hungary, and Serbia began as early as in 2011 when the Environment Ministers of all five countries signed a declaration and committed themselves to a transboundary BR protecting about one million hectares of floodplains in a transboundary effort. The following step was done by Hungary and Croatia in 2012, followed by Serbia in 2017, Slovenia in 2018, and the last part of the composition was declared in 2019 by Austria. The area represents the largest and most preserved natural river system in Central Europe. The Mura, Drava and Danube Rivers form a 700 km long, interconnecting corridor of floodplain river ecosystems in the Danube Basin with hotspots of rare and/or endangered species and connecting about one million ha of habitats across the five countries. Its natural beauties, endangered habitats, and diverse cultural traditions have enormous potential for sustainable development, thus tackling global pressures like climate change, loss of biodiversity, or demographic changes more efficiently. According to the classification of the EU’s Natura 2000 network, the area of the biosphere reserve belongs to the Continental Biogeographic Region.

The shared vision of the State Parties is the conservation, restoration, and wise use of the Mura-Drava-Danube Rivers and their ecosystems along Europe`s largest coherent river ecosystem. Hence, the TBR MDD takes responsibility on a global scale and acts as the backbone for the survival of the characteristic habitats and species, while people benefit significantly from its ecosystem services and its wise use. By “thinking globally and acting locally”, the countries jointly strive for a harmonized management of the TBR, serving as the best practice example of international cooperation in the river basin and water management. The development is based on a trustful collaboration between all involved State Parties and cross-sectoral participation of all relevant stakeholders and local communities. Multiculturality is one of the unique values of the TBR MDD, thus it should shine as a symbol of unity by becoming the world´s first 5-country Biosphere Reserve.

Biosphere reserve sites are highly important for dynamic conservation of the natural biological and ecosystem diversity in Europe and among others represents also an important tool for

testing and learning different interdisciplinary approaches to floodplain management as well as understanding and managing changes and interactions between social and ecological systems, including conflict prevention and management of biodiversity. Forest management involves establishing an organic connection between economic activities in forests and nature conservation. BOM is characterized by the following Natura 2000 habitat types which are significantly represented in the area: rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation; Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*); watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation; hydrophilous tall herb fringe communities of plains and the montane to alpine levels; lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*); riparian mixed forest of *Quercus robur*, *Ulmus laevis* and *Fraxinus* sp.; natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation; molinia meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*); and Illyrian oak-hornbeam forest (*Erythronio-Carpinion*). According to the classification of the EU's Natura 2000 network, the area of the BOM belongs to the Continental Biogeographic Region. An Action Plan for Habitat Restoration in Natura 2000 Site Mura developed in An Interreg (Danube Transnational Programme) Coop-MDD project (2017-2019) outlines the activities and actions to be implemented cross-sectorally by nature conservation, water management, forest management, agriculture sectors with local communities, who are jointly responsible for the management of the River Mura and its floodplain (https://zrsvn-varstvonarave.si/wp-content/uploads/2019/08/coop-MDD_LocalActionPlan_Akcijski-nacrt_IRSNC.pdf). The focus of the Action plan in the River Mura corridor is on the two existing Natura 2000 areas under conservation acts Special Areas of Conservation (SAC) and Special Protection Areas (SPAs). Key expertise and legal framework for the Action plan was drawn from the Natura 2000 Management Programme for Slovenia, 2015-2020, representing a concretization of the Natura 2000 Management Programme for the River Mura habitats and species. Planned actions adhere also to other relevant programs and measures, namely water management, forest management, climate change, agriculture, spatial planning, and local development. In this way, the nature conservation goals will be met along with other environmental and economic goals, which all depend on favorable ecological conditions of the River Mura and its floodplain (see also II/4c).

In Slovenia, only a small amount of forest and non-forest land is covered with planted forests and forest plantations of fast-growing trees. The most important are fast wood poplar plantations established with selected biological stable and productive poplar clones in the last decades. Production plantations are now concentrated only in two main areas: Litija along the River Sava and areas in the Ljubljana Marshes (central Slovenia) and along the Mura River (northeastern Slovenia). The well-managed poplar plantations concentrated in the Vrbina area were finally cut down in 2015, and the whole production area was flooded due to the power plant pool construction on the River Sava. In recent years, new living archive and experimental forest plantations in the central and NE parts of Slovenia were established for testing new poplar clones for biomass and fast wood production in heavier soil conditions.

The possibility of the non-native species introduction is clearly limited by the national and European legislation as well as international biodiversity-related agreements. The area of production plantations will continue declining also in the future due to supporting more natural management of forest plantations according to the National Forest Programme (2007) and the Natura 2000 Management Programme. New poplar plantations with short rotation (2-4 years)

and longer production cycles (20-25 years) will be restricted to the most suitable sites on arable land located outside the declared core areas and buffer zones of the BOM (Natura 2000 sites). They will be mainly used to ensure an additional supply of fuelwood biomass from the areas with intensive agricultural production to reduce existing high pressure to endangered lowland forests and, partly, 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 technology for climate mitigation in the urban and peri-urban environment as they enable shading and cooling by evapotranspiration, pilot investment in tree plots of wildlife corridors among habitats or protected areas (e.g. well-structured windbreaks, wildlife resting place) as well as in the use of specially approved genotypes (clones) of poplar and willow trees as well as black locust for polluted land remediation and buffering.

According to the national priority tasks defined by the Republic of Slovenia (RS) on the basis of situation analyses in agriculture, food technology, and forestry, and the interaction of these economic sectors with other operational fields, the Rural Development Programme 2014–2020 was implemented in the entire territory of the RS. Forestry was included in Measure-M8 with investments in the development of forest areas, and the improvement of forest viability included the regeneration of forests after catastrophic events and investments in forest technologies and the processing and mobilization of wood. Prepared by the Slovenian Forest Service, the measure in forestry was implemented on the basis of the adopted forest restoration plans after natural disasters. Support was allocated in the form of non-refundable financial aid and the public support rate for the purchase of planting material and material for the protection of seedlings amounts to 100% of eligible costs.

National policies, laws or regulations affecting the cultivation or utilization of poplars, willows and other fast-growing trees in natural forests, planted forests, forest plantations, and agroforestry

The Forest Act (1993) regulates the protection, silviculture, exploitation, and use of forests, and the disposal of forests as natural resources aiming to ensure their close-to-nature and multipurpose management following the principles of protection of the environment and natural values, long-term and optimal working of forests as ecosystems, and enabling their functions.

The habitats of the native plant and animal species are to be preserved or recreated in forests by the general parts of forest management plans. In forests with a changed structure of living forest communities, their natural structure should be gradually re-established. Under this Act, a forest plantation is not considered a forest. It is governed by provisions of the Regulation on the use of agricultural land for forest plantations (1986). The establishment of forest plantations is allowed in agriculturally marginal soils or poor soils where there is too much or too little water for agricultural production. Short rotation coppice plantations (SRC) have been classified as eligible permanent crops. The area can also be converted back to food production at any time without having to apply for clearing and conversion authorization. This implies no afforestation authorization is required for the establishment of forest plantations and short-rotation plantations outside the forest land. This approach is intended to facilitate the establishment of forest plantations and short-rotation plantations outside the forests.

The Forest Reproductive Material Act (2002) regulates production, marketing, and use of forest reproductive material of high quality suited for various site conditions, enabling operation of the forest ecosystems to be permanent and optimal and the renewal thereof in compliance with the principles of protection of forest genetic resources. It covers the reproductive material of forest tree species and hybrids, important for forestry purposes, to be used for: regeneration with planting or seeding, afforestation, maintenance of permanent buffer or anti-erosion zones of forest trees, design and maintenance of forest plantations. Based on the Forest Reproductive Material Act, there is a list of tree species and artificial hybrids (2010) for which the regulations of FRM apply. The list contains 77 forest tree species including *Populus* x spp.*, *Salix* x spp. and *Robinia pseudoacacia* while *Juglans nigra* is not yet included. The Rules on the conditions for the approval of forest seed object in the category "source of origin" and "selected" (2003) and the Rules on the conditions and procedures for the approval of forest seed objects for production of forest reproductive material in the category "qualified" and "tested" (2004). In Slovenia, the production of the forest reproductive material (FRM) of poplar and willow species and its artificial hybrids to be placed on the market must be based on basic material in the category "Selected", "Qualified" or "Tested".

The Nature Conservation Act (2004) and the Regulation on special protection areas (Natura 2000) (2004) lay down measures for the conservation of biodiversity and the system of protection of natural values. In nature conservation guidelines for particular priority habitat types and species qualifying for Natura 2000 sites which are linked to these habitat types, zones with specific guidelines are determined in order to achieve more detailed protection goals for the conservation of protected habitat types and species in Natura 2000. The introduction of plants or animals of non-native species and the introduction of genetically modified organisms is prohibited under Natura 2000. Nature protection guidelines are prepared by the Slovenian Institute for Nature Conservation and incorporated in all forest management plans, prepared by the Slovenia Forest Service at the local forest unit level. For forest management plans prepared for forest units in Natura 2000 sites, additional specific guidelines and measures are required to achieve more detailed protection objectives set out in nature protection guidelines of the Institute of the Republic of Slovenia for Nature Conservation.

II. TECHNICAL INFORMATION

1. Taxonomy, Nomenclature, and Registration

No basic material for the production of forest reproductive material has been approved up to now on the basis of experimental plantations. Up to now, no clonal stoolbeds have been approved by the authorities. A register of clones, clonal mixtures, and parents of the family does not exist in Slovenia at present. The main reason is that the importance of using poplar or willow clones has not been recognized by the government authorities and the wood sector. Under pilot testing is the promising *Populus nigra* genotype which was selected in the riparian forest along the River Mura by the SFI.

2. Domestication and Conservation of Genetic Resources

a) *Aigeiros* section: European black poplar

European black poplar is a native pioneer species, present in riparian mixed forests. It is characterized by a metapopulation structure across the wide floodplain system. Primarily indigenous *Populus nigra* in Slovenia is preserved in small locations along the main rivers and their tributaries on alluvial sites. In stands, they are present as individual trees (solitaires) or in small groups of over-mature trees.

Within the LIFEGENMON project the concept Forest Genetic Monitoring (FGM) of *Populus nigra* L. was developed and presented at the joint Advisory Board project meeting in Thessaloniki (Božič et. al. 2019). The guideline on establishing a genetic monitoring plot and on recording all field level verifiers was prepared and discussed. FGM of European black poplar addressed the importance of genetic monitoring *in situ* and *ex situ* stands and collections. Genetic monitoring *in situ* is a priority and has to include both a natural adult metapopulation and juvenile offspring subpopulations in the wider floodplain system, while genetic monitoring of *ex situ* collections is more specialized and aimed at ensuring the availability of the best genotypes of pure *Populus nigra* plant material for conservation purposes.

In naturally regenerating forests FGM of *Populus nigra* should be implemented on the scale of the whole network of inter-linked local subpopulations (metapopulation), among which exchange of pollen and seed is present, and not on local sites in isolation due to higher genetic risks of isolated populations. For more information see the project webpage http://www.lifegenmon.si/

Figure 1: Genetic monitoring plots of local subpopulations should be parts of *Populus nigra* L. metapopulation structure across the wide floodplain system (Photo: Gregor Bozic, 2017)

Most conservation work is concentrated on *Populus nigra*. Efforts have been made to preserve the remaining populations through *in situ* and *ex situ* measures. The SFI leads both an *in 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.

A new clonal archive of native European black poplar clones 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. The clonal archive was established with cuttings of typical *Populus nigra* from its indigenous metapopulations in

Slovenia (Mura) and Bosnia and Herzegovina (Babina rijeka, Bosna, Drina, Lašva, Neretva, Spreča, Vrbas); it includes hairy black poplar (*Populus nigra* subsp. *caudina*), a xeromorphic ecotype from its habitat in Sub-Mediterranean type of climate at the River Neretva in Čapljina. Twenty-two promising genotypes from Slovenia and 127 from Bosnia and Herzegovina were planted in six replications. After the first vegetation period, trees reached a maximum height from 78 cm to 310 cm with an average of 179 cm. The overall survival rate was 73%. Hairy black poplar (14 genotypes) reached a maximum height from 82 cm to 226 cm. On average, hairy poplar survival was 42%.

Mature European black poplar trees and saplings from young natural regeneration site in the riparian metapopulation of the River Mura were additionally GPS mapped *in-situ* and sampled for genetic analyses in the frame of the project REFOCuS. The distance range among poplar offsprings in natural regeneration centers was determined for each size of the object according to the protocol developed by SFI (Rupel et al., 2018).

For the purpose of genetic monitoring, selection of plus trees, and establishment of gene archives and nurseries for *ex-situ* production of FRM, determination of European black poplar species purity is paramount. Three types of genetic markers were tested at SFI on 20 candidates of *Populus nigra* plus trees selected in the riparian forests along the river Mura in 2018/19, 22 selected genotypes grown at the SFI experimental nursery and reference samples: 1) *Amplified sequence length polymorphism markers – ASP*: win3; 2) *Single nucleotide polymorphism markers – SNP*: PPO, GA20ox, CAD-L, LFY, TB1, CBF1 genes; 3) *Short sequence repeat (microsatellite) markers – SSR*: ORPM214, WPMS15, WPMS09, PMGC14, WPMS17, WPMS20, WPMS14, ASP112322, PTR8, WPMS16, ORPM86, YIN2, GCPM1894, ORPM344, PTR4, and GCPM1719. It was determined that all three marker types enable reliable identification and differentiation of autochthonous *Populus nigra* and allochthonous *Populus deltoides* and their F1 hybrids. The 16 selected nuclear SSR markers were used to analyze adult trees and natural regeneration samples from natural European black poplar populations from Slovenia, Austria, Croatia, Serbia, and Hungary within the REFOCuS project. SSR markers were successfully used to identify clones and *Populus nigra* × *Populus deltoides* hybrids in the sampled natural populations.

b) *Leuce* section: White poplar, Aspen, and Gray poplar

The white poplar (***Populus alba* L.**) is indigenous and the least common fast-growing tree species among native poplars in Slovenia. Although it is rare, it is spread almost across the whole country. In stands, it appears mainly as individual trees and groups of trees together with *Populus nigra, Alnus glutinosa, Fraxinum angustifolia, Quercus robur, Ulmus leavis,* and *Salix* sp. Data on the occurrence of white poplar in Slovenian forests are rare. On the larger scale it can be found in the Podravje region (the area of Ptuj – Šturmovci). It is mostly present at the altitude from 80 to 215 meters and is potentially endangered species due to its small and rare occurrence as well as habitats destructions in the past. FRM of white poplar is not produced in the Slovenian nurseries.

The Eurasian aspen (***Populus tremula* L.**) is a rare but naturally widespread fast-growing tree species in Slovenia. It can tolerate 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. In stands it appears as individual trees or in small groups. It grows naturally from lowlands up to 1430 m above the sea level. Forest stands with aspen cover 53,806 hectares. 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.

The Gray poplar (***Populus* × *canescens* (Ait.) Sm.**) is a spontaneous hybrid of aspen and white poplar. In Slovenia it might be present especially in narrow areas of their ecological overlaps (Brus et al., 2012). Hybridization between both species goes in both directions and therefore poses a continuously potential threat to the conservation of pure native species gene pools.

c) Other poplar species from *Aigeiros, Leuce,* and *Tacamahaca* Sections

A national archive of poplar clones from *Aigeiros, Leuce,* and *Tachamahaca* Sections was regularly maintained in the SFI experimental nursery near Ljubljana. The 30 most bio-ecologically suitable and productive poplar clones for wood production in long rotations tested in Slovenia are included in the living archive and maintained by SFI. The genetic archive also serves as the source for collecting vegetative reproductive material for scientific purposes and genetic analyses. In the past, different allochthonous poplar species, clones as well as their hybrids, had been planted across Europe as ornamentals or for wood production in plantations. Of the many different allochthonous poplar species that were introduced to Europe (*Populus trichocarpa*, *Populus koreana*, *Populus maximowiczii*, *Populus deltoides*, and others), it is the Eastern cottonwood (*Populus deltoides*) and its hybrids with autochthonous European black poplar (*Populus nigra* × *Populus deltoides* or *Populus deltoides* × *Populus nigra*) that are the most abundant. Consequently, there is a constant risk of introgression of allochthonous poplar species into the gene pool of the European black poplar. To prevent the introduction of unsuitable European black poplar forest reproductive material (FRM) into Slovenian forests, the Forest Genetics laboratory at SFI has implemented procedures for determining the species purity of the FRM. For the purpose of certification of FRM, European black poplar samples are genotyped using 16 nuclear SSR markers, the analysis of which also provides information on potential hybridization and clonality. In case uncertainties remain regarding the potential hybridization with allochthonous poplar species, genetic markers PPO and win3 are analyzed in addition to SSRs.

d) Fast-growing tree species with similar attributes in terms of industry and energy uses and environmental applications to poplars and willows which were recognized as important by the Poplar Commission in Slovenia

Even restricted in production, black locust and black walnut are important non-native fast-growing broadleaf tree species with many benefits for the forest owners as well as interests of other stakeholders. Research for optimizing the use of certain tree species is needed.

The black locust (***Robinia pseudoacacia* L.**) is one of the earliest introduced non-native tree species in Slovenia and broadly used for afforestation of degraded lands (Brus and Gajšek 2014). As a pioneer species, the black locust rapidly colonizes forest gaps and degraded areas.

It is a naturally regenerating species with invasive uncontrolled expansion, especially in Sub-Pannonian (NE Slovenia) and Sub-Mediterranean (SW Slovenia) ecological regions, and therefore undesirable in the concept of sustainable and co-natural forest management (Kutnar and Kobler, 2013). The available climate change scenarios and the empirical model used by Kutnar and Kobler (2013) predict a further increase in the share of the black locust's growing stock in the Slovenian forests.

Due to its long history in Slovenia, the black locust could be declared also as a domesticated tree species. 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. Despite its allocthtonity, it will increase the value of the adaptation of forest and forestry to climate change (Bahor and Klopčič, 2019). Although the black locust is widely known for its high-quality timber production and other benefits, it is not intensively managed in Slovenia. The stem quality for industrial use is mainly poor. Therefore, it is mainly used by forest owners or sold as fuelwood or wood for fences and vineyard trellis due to its highly durable timber (Brus et al., 2017).

The advantage of the black locust is its capacity to grow in marginal degraded areas where the native species are not able to grow and therefore it can represent a good strategy for environmental restorations in special cases (Monteverdi et al., 2017). Due to its high adaptability to different site conditions, fast growth, and vegetative propagation, it has good potential for energy biomass production in short rotation cycles on poor soils and degraded areas as well as in coppice forestry. The main disadvantage is the risk of invasiveness and biodiversity losses due to higher competitiveness in comparison with the native species. In close canopy forest, it is considered non-invasive (Konnert and Spiecker 2017). Every decision on the use of the black locust should be well planned and regulated. There is a high need in avoiding SRC black locust plantations in close vicinity of the reserves as well as in endangered habitats to prevent further invasion under global warming changes.

The black walnut (***Juglans nigra*** L.) in Slovenia currently exists only in the form of remnants of former wider black walnut planted forest complexes as well as in forest plantations in Prekmurje region, Velika Nedelja, and Kostanjevica na Krki. It is naturally regenerating but a non-invasive species. The Slovenian Forest Service proposed adaptive management responsiveness to climate change with limited use of the non-native tree species including the black walnut in 2015. Its re-use has been justified by gap-filling in forest ecosystems after the possible loss of the endangered ash species sensitive to pests and outbreaks resulting from climate change. The black walnut in Slovenia shows high productivity and has the highest wood price from all non-native species in the market. There is a need to start the breeding program of *Juglans nigra* for wood production with experimental sites to compare different provenances and genotypes regarding the growth characteristics, shape, and resistance to biotic and abiotic stresses.

The non-native tree species should not be planted in Natura 2000 sites nor in other designated protected areas where the imperative is to ensure long-term ecosystem health and ecosystem stability of various indigenous habitats. This is particularly important nowadays with increasing environmental uncertainty due to climate change.

3. Plant Health, Resilience to Threats and Climate Change

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 forest inspection service. Phytosanitary measures are recommended and prescribed by forestry inspectors and are obligatory for nursery managers. The implementation of the measures prescribed is overseen by forest inspectors.

The most frequently observed diseases were poplar leaf rusts (*Melampsora* spp.) and marssonina leaf-spot of poplar (*Drepanopeziza punctiformis*, sin. *Marssonina brunnea*). In some favorable years for the spread of these diseases, up to seven fungicide applications were performed in nurseries. Occasionally, dothichiza bark necrosis of poplar (*Cryptodiaporthe populea*, sin *Dothichiza populea*) was detected in nurseries. In such cases, the diseased propagation material was forbidden to be marketed and phytosanitary measures were prescribed. 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 affected by rusts, some older clones (I-214) were affected by premature leaf fall because of marssonina leaf-spot of poplar. Dieback of an old poplar plantation was detected because of drought and subsequently, it was destroyed by the dothichiza bark necrosis of poplars. Poplars were felled mostly due to a complex disease which is a consequence of climate change. Other damaging agents causing the felling of the poplar trees were: wind, European mistletoe (*Viscum album*), *Armillaria* spp., thunderbolts, beaver, flooding.

Willows were mostly felled because of strong winds, complex disease, *Armillaria* spp., and drought. Minor damaging factors included beaver (*Castor fiber*) and thunderbolts.

Other fast-growing trees (*Robinia pseudoacacia* and *Juglans nigra*)

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 the wind and drought.

4. Sustainable Livelihoods, Land-use, Products, and Bioenergy

a) Nursery practices

Planting of native poplars *Populus nigra, Populus alba, Populus tremula* and willows *Salix alba, Salix eleagnos, Salix purpurea, Salix fragilis, Salix viminalis* is very rare in Slovenian forests. The reason for this is the lack of forestry nurseries specialized for poplar and willow FRM cultivation in Slovenia and therefore 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.

The newly registered forestry nursery Forestry Turnišče succeeded the former GLG MS Forest nursery in Ižakovci and maintains a collection of *Populus nigra* genotypes propagated clonally from old and genetically confirmed pure mature and young trees of the Mura River floodplain forests selected and analyzed by Slovenian Forestry Institute in cooperation with GLG MS. The Turnišče company specializes in forestry production and tree nursery which fulfills the demands for tree seedlings for the region. Tree Nursery Ižakovci spreads on 3 ha of land with annual production around 10.000 seedlings. The nursery produces *Populus nigra* and *Salix alba* seedlings from approved seeds stands in the Sub-Pannonian region as well as poplar clones: *Populus* × *canadensis* cl. Pannonia (syn. M1), *Populus deltoides* cl. 457, *Populus deltoides* cl. S1-8 and sells them at the age of 2 or 3 years on the local market. 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.

b) Planted Forests

Over the last decades, planted forests are disappearing from the national forests, largely due to the promotion of natural regeneration. Nevertheless, extreme forest sites, such as riparian ecosystems, heavily affected by the material displacement and sedimentation as well as the forests affected by natural hazards (e.g. beetle infestations and diseases, windbreaks, icestorms) call on for planted forests. Records show, that this form is very often the only possible way for preserving the existing ecosystems and for maintaining their quality gene pool.

For the first time, 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. The poplar and willow seedlings were planted in early spring 2016 as two-year old trees. After planting, no seedlings protection was done. At the end of the 3rd vegetation period (trees at the age of 5 years), the survival rate for the European black poplar was higher than for the white willow, i.e. 57.7% and 44.1%, respectively. Poplar trees reached from 530 cm to 950 cm in height and from 5,4 cm to 11,5 cm DBH, and white willows from 320 cm (trees with bushy growth due to the animal grazing) to 920 cm in height and from 2,5 cm to 8,1 cm DBH.

Plantation Forests

Since Slovenia is a mountainous country, the possibilities for poplar plantations (5 m x 5 m, 400 plants/ha) are limited. The most productive poplar plantations in Slovenia were located in Vrbina near Brežice in SE Slovenia and intensively managed by private company HPG Brežice, and along the River Mura in NE Slovenia. In the period from 2013 to 2015, almost all poplar

plantations in the Vrbina area were cut down due to the construction of a hydroelectric power plant pool along the lower part of the Sava River. In the period 2016 to 2019, additional 5 ha of poplar plantations were sold by HPG Brežice and cut down. Now only 4 ha of poplar plantations still exist in the area.

According to the data we gathered, the area of plantations with poplars for use over longer production periods on non-forested areas in Slovenia has continuously decreased from 1944 ha in 1984 to 278 ha in 2019. Forest plantations still have the potential for fast wood production in Slovenia. The mean annual increment was evaluated at around 14-18 m^3/ha/year. In recent years, production cycles were prolonged from 20 to 25 years to reach a DBH of 40 cm or more. In the reporting period, 27 ha of plantations were rejuvenated with *P.* × *canadensis* cl. Panonnia (syn. M1) and *Populus deltoides* cl. 457 in NE Slovenia. Both poplar clones are bio-ecologically suitable and traditionally used for fast wood production plantations in the region.

The first plantation for testing new poplar clone AF-8 for timber production was established near Ponikva with private investment of the landowner on heavier site conditions. 150 cuttings (poles) of the clone AF-18 in total were planted in the early spring 2019 with full plant survival after the 1st growing season.

The main barrier to the development of new forest plantations nowadays is also very limited commercial activity, no subsidies for poplar and willow cultivation and production, no nursery tradition for developing new clones, and little information available for possible investors. Through the last decades, the area of poplar plantations decreased annually as the most important potential areas for establishment production plantations were located along riverbanks and floodplain areas at an elevation up to 300 m, where we need to take into consideration the conservation of the natural habitats of Natura 2000 and natural genetic resources of the native tree species.

Experimental plantations for a renewable source of energy ("bioenergy") production

Three experimental plantations 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. 40 poplar clones altogether were planted, 5 of them pure *Populus nigra* from Slovenian, Czech, and Austrian collections. Survival, growth, biomass, and resistance to leaf rust were measured and soil conditions evaluated. By EUPOP agreement raw data of 24 poplar clones were shared with clone owners and project partners. In the experimental plantations in NE Slovenia, the selected native *Populus nigra* clone was compared with the others and evaluated.

SRC experimental plantation in Ižakovci (2013) was planted in density 3m x 0.5m (6667 trees/ha) in suitable soil conditions for poplars (loam and silty loam with plant-available P = 25). It was established with 13 poplar clones in three replications in the unused area of the tree nursery. Harvest (rotation) cycle was 2 years. It was planned to maintain at least 5 harvest cycles. The final cut was done at the end of the 3rd rotation in winter 2018/2019 due to new needs for nursery production extension. In total, 1302 two-year shoots from 372 trees were analyzed. The shoots reached 2.7m to 10.3m in height depending on the clone, development of the multi-stemmed coppice/tree and microclimatic conditions. The number of shoots/trees was

in the range from 1 to 7 with an average of 3.5. A two years old multi-stemmed coppice/tree of most promising clone AF-28 produced in average 10.15 kg DM in comparison to 5.95 kg DM for native *Populus nigra* clone. The biomass production in the case of 50 % survival rate was estimated to 33.8 t DM per ha (AF-28) and 19.8 t DM per ha for the native *Populus nigra,* which is in ratio 1:1.71

Experimental plantations for testing poplar clones from EU member states were planted in Pince-Marof in the area with heavier soil conditions (silty clay loam soil; plant-available P less than 5) in density 3m x 1m for longer testing periods. As experimental plantations are located on degraded arable land in Natura 2000 area, no herbicide treatment, fertilization, irrigation, and insecticide was implemented. Mulching was preformed regularly two times/year. The most promising clones according to the survival rates reaching up to 80 % are AF-18, AF-8, Bakan, Delvire, Oudenberg, SV885, Max1/Max4, SV882, Muur, AF-34, and Vesten. The 5 most productive clones are Bakan (t x m), Skado (t x m), AF-34 (d x n), AF-18 (d x n), and AF-8 (t x d).

c) Naturally regenerating forests

Native poplars and willows in Slovenia are *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* (Dakskobler et al., 2013). Analyses of the Forest Information System of the Slovenia Forest Service (data for 2019) revealed that forest stands including poplars (*Populus nigra* L., *Populus alba* L.) or willows (*Salix* sp.) cover 26,264 while mixed stands with poplars and willows cover 4,214 hectares. European black poplar is frequently present in forest vegetation communities: *Querco roboris – Ulmetum laevis Issler, Alnetum incanae Ludi, Salici – populetum, Salicetum gr., Ulmo – Aceretum pseudoplatani Berger and Carici remotae – Fraxinetum* W. Koch ex Faber (Marincek et al., 2002, 2003, 2006). Most willow and European black poplar communities are classified in the *Saliceta purpureae* class (Dakskobler et al. 2013).

Natural regeneration is promoted wherever possible. 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 (or preadapted) 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.

In the reporting period 2016-2019, three main internationally applied projects in the field of forestry were implemented in the Slovenian largest preserved complex of floodplains, declared as Biosphere reserve Mura.

GOFORMURA – Governance of forest habitat types and species in the selected Natura 2000 sites alongside Mura River, Prekmurje, Slovenia (2015-2017). The project was funded by the EEA Financial Mechanism 2009-2014 (SI02).

The project addressed two forest habitat types in an unsuited situation. Due to the protection measures alongside the Mura River and on nearby agricultural land in the 1960s and 1970s, flood oak-ash-elm forests are threatened by the reduction in the level of groundwater and shortened duration of floods. The unfavorable status of the riparian willow, black alder, and ash forests is also the result of the inadequate former forest management support of *Acer negundo* and no native poplars planted in forests by private landowners. The disappearance of aquatic and wetland habitats thus endanger amphibians. The disappearance of oak (*Quercus robur*) and a variable amount of deadwood also threaten the existence of some species of beetles. In the area of Gornja Bistrica and Murska šuma in the Prekmurje region recently also otter and beaver emerged; they are not yet sufficiently studied. The purpose of the GoForMura project was to examine the factors affecting habitat types and obtain more information on the status of populations of selected species of amphibians, bugs, beaver, and otter at several locations along the Mura River. The project also set up the monitoring measures of birds in an unfamiliar situation. In the same sites, some protective measures for improving conditions of GHT 91F0 and 91E0 were made (planting of oak, European black poplar, white willow, renaturation of potential beaver sites, cutting and removing invasive tree species). Inventorizing 1900 trees, deadwood, and potential habitat trees on 130 plots were done. Based on the findings, pioneer management plans for chosen Murska šuma and Gornja Bistrica Natura 2000 sites were done. The project connects the Slovenian Forestry Institute (developer) and partners: Slovenia Forest Service, Institute for Conservation of Natural Heritage (LUTRA), and Norwegian Institute for Nature Research (NINA). Further information is available on the project web page: http://goformura.gozdis.si/project/.

Coop-MDD Transboundary Management Programme for the planned 5-country Biosphere Reserve "Mura-Drava-Danube" (Interreg The Danube Transnational Programme, 2017-2019)

The Action Plan for Habitat Restoration in Natura 2000 Site of the Mura River & Nature Interpretation Concept for the Natura 2000 Site Mura was prepared. The Action plan represents a concretization of the Natura 2000 Management Programme from the Period 2015-2020 for the Mura River in Slovenia and includes four sets of actions with a collection of measures: i) Restoration of river dynamics and water habitats; ii) Restoration and preservation of floodplain forests; iii) Restoration and preservation of wet grasslands and iv) Actions for the most important Natura 2000 habitats conservation. Measures are based on knowledge and experiences from similar cases from realized restoration projects on Mura River and river and riverine habitat revitalization projects from Slovenia and Central Europe. The set of actions dedicated to forest restoration and forest management measures consists of measures for improvement of hydrological conditions in the floodplain forests, natural and artificial rejuvenation measures, measures for restoration of forest habitats, and definition of non-intervention zones (Koren *et al.* 2019). Coop-MDD Consortium consists of 11 project and 12 associated partners from Austria, Hungary, Croatia, Germany, Italy, Serbia, and Slovenia (Institute of the Republic of Slovenia for Nature Conservation, Municipality Velika Polana, Ministry of the Environment and Spatial Planning, Environment Directorate). Further information is available on the project web page: http://www.interreg-danube.eu/approved-projects/coop-mdd.

REFOCUS- Resilient riparian forests as ecological corridors in the Mura-Drava-Danube Biosphere Reserve (Interreg The Danube Transnational Programme, 2018-2021)

Riparian forests of the Mura-Drava-Danube Biosphere reserve constituting ecological corridors are in unfavorable condition and declining due to the increasing incidence of pests & diseases, unsustainable human activities and lack of guidance on how to manage riparian forests, including where to find appropriate planting material for them to continue persisting and providing all ecosystem services. REFOCuS aims to counteract this decline by building resilience into riparian forests of the Biosphere reserve by providing 1) novel silvicultural methods for forest management and conservation and 2) increase availability of appropriate planting material to be used when natural regeneration fails. REFOCuS consortium consists of 5 project and 6 associated partners from Austria, Hungary, Slovenia, Croatia, and Serbia, geographically covering the whole territory of the Biosphere reserve and is led by Slovenian Forestry Institute. REFOCuS includes four thematic working packages: 1) Interpreting knowledge, 2) Silviculture & conservation, 3) Planting material availability & 4) The policy interface supported by project management and project communication packages. It shall result in: 1) recommendations on tree species to use & promote, 2) spatial analysis of the riparian corridor, 3) management handbook for the threatened riparian forests, 4) pests & diseases riparian forests information system & identification tool, 5) transnational seed transfer zones for seven riparian tree species for the Biosphere reserve & PP countries, 6) database on planting material for riparian forests connected to the transnational seed transfer zones, 7) common regional planting material transfer procedure, 8) planting material use & conservation guidelines, 9) whole region riparian species gene bank, 10) holistic guidelines for resilient riparian forests, all drafted by PPs with support of ASPs, and discussed with target groups and other stakeholders & 11) installed demonstration sites for stakeholder education. Further information is available on the project web page: http://www.interreg-danube.eu/approved-projects/refocus.

d) Agroforestry

Officially there are no agroforestry systems in Slovenia.

5. Environmental and Ecosystem Services

a) Site and landscape improvements

Katanić, M., Grebenc, T., Bajc, M., Kraigher, H. *et al.* 2016: Ectomycorrhizal fungal community associated with autochthonous white poplar from Serbia. Iforest, 9: 330-336 http://dx.doi.org/10.3832/ifor1370-008, DOI: 10.3832/ifor1370-008.

The community of the ectomycorrhizal fungi of the autochthonous white poplar (*Populus alba* L.) stand in the Kovilj-Petrovaradin marshes (Serbia) and examination of its seasonal dynamics were analyzed. Ectomycorrhizal types were identified by combining morphological and anatomical descriptions with molecular methods (sequencing of the ITS region of ribosomal

DNA). In two seasons, 20 ectomycorrhizal types were recorded, of which 11 types were identified to the species level, six were determined to the genus level, two types were determined to the family level and one type remained unidentified. The number of ectomycorrhizal types, the number of fine roots, percentage of vital mycorrhizal roots, diversity indexes, and abundance of exploration types did not differ significantly between autumn and spring. During both seasons, the most abundant types were: *Entoloma* sp., *Tuber maculatum, Cenococcum geophilum, Tuber rufum* and *Peziza* sp. Due to the high variation of the ectomycorrhizal types-based Shannon-Weaver diversity index in poplar stands and the fact that poplars form dual mycorrhizal association, this index is not recommended as a reliable index for bioindication in poplar.

Mrak, T. *et al.* 2017 and Mrak, T. *et al.* 2018: Belowground response of ozone sensitive poplar clone to increased levels of tropospheric ozone in combination with different levels of N and P (root anatomy, root biomass and morphology of fine root system. Slovenian Forestry Institute (expertise).

This study aimed to investigate modifying effects of elevated ozone (O_3) on poplar root response to nutrient (N, P) addition. Ozone-sensitive Oxford poplar clone (*Populus maximoviczii* Henry × *berolinensis* Dippel) was used in the experiment with three levels of O_3, three levels of P and two levels of N at a free air exposure facility. Coarse and fine root biomass increment due to N addition was only up to 46% in elevated O_3 compared to ambient O_3. P concentrations in fine roots were positively affected by O_3 x P interaction and negatively by N addition. Nitrogen limitation for root growth was more pronounced at elevated O_3. Smaller root surface area per soil volume at elevated O_3 prevented the acquisition of available N, rendering N fertilization of young poplar plantations in such conditions economically and environmentally questionable. On the anatomical level, the effects of O_3 were evident as increased primary and secondary xylem area and increased number of protoxylem poles. Increased secondary xylem area resulted in increased accumulated potential hydraulic conductivity (Kh). There was a strong interaction between all three factors on the vessel grouping index.

Gričar, J. 2019: Značilnosti lesnih in floemskih prirastkov pri trepetliki (*Populus tremula* L.) = Characteristics of wood and phloem increments in Eurasian aspen (*Populus tremula* L.). Folia Biologica et Geologica, 60/2: 5-14.

Climate change and associated more frequent and intense extreme weather events like droughts, heat waves, frosts, and floods will undoubtedly affect the vitality of trees as well as the production and quality of wood in Slovenia in the coming years. 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. In addition to the economic (especially wood-processing) functions of forests, their social, ecological, and aesthetic roles are also very important. 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. Linking structures and their roles in the tree enables better insight into the short-term and long-term response of trees to changing environmental conditions.

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. Wood anatomical traits have been widely used to investigate and compare tree performance in different environments, (bark) phloem conducting cells have been less investigated in this respect, which may be partly related to methodological obstacles. For this purpose, we investigated the characteristics of wood and phloem increments in Eurasian aspen (*Populus tremula* L.) in Ljubljana, Slovenia, in the growing season of 2010. In addition, we analyzed the conductive elements in the wood (vessels) and phloem (sieve tubes) and interpreted the differences in these parameters in terms of their transport functions. We collected samples of wood and phloem at the end of the growing season, prepared cross-sections, and performed histometric analysis by using light microscopy and image analysis system. We found that the phloem increment represented 11.7% of the wood increment width, whereas the early phloem represented 80.5% of the late phloem width. These findings are in line with the previous publications about the higher intensity of cambium production of wood cells than of phloem cells in healthy trees growing in favorable environmental conditions. The vessels were statistically the widest in the first third of the xylem increment and the smallest in the last third of the increment. Consequently, the vessels in the first third of the increment had the largest areas, while in the case of vessel density there was no significant difference among the xylem increment parts. Mean diameters of the sieve tubes in the late phloem were 25.4% smaller than in the early phloem; however, these differences were not statistically significant. Sieve tubes in the early phloem were 28.2% smaller than vessels formed at the beginning of the growing season and late phloem sieve tubes were 35.4% smaller than vessels formed at the end of the growing season, indicating higher transport capacity of the conductive system in wood compared to the phloem.

Evaluation of the influence of stressors on radial growth of trees, wood structure, and patterns of secondary growth in different parts of the tree will help us to understand better the mechanism of these processes and their importance for the management of water and carbon balances in different tree species in different regions of Slovenia. After all, preserving healthy forests will contribute to the mitigation of climate change and thereby positively affect the well-being and quality of people's lives.

b) Phyto-remediation of polluted soil and water

,Shi, W.G., Mrak, T., Kraigher, H. *et al.* 2019: Abscisic acid enhances lead translocation from the roots to the leaves and alleviates its toxicity in *Populus* × canescens, Journal of Hazardous Materials, 362, 275-285, https://doi.org/10.1016/j.jhazmat.2018.09.024, doi: 10.1016/j.jhazmat.2018.09.024.

The paper investigates possibilities to enhance Pb uptake and transport to aboveground parts in *Populus* × *canescens* saplings (syn. *Populus tremula* × *Populus alba*) by application of the exogenous plant hormone abscisic acid (ABA) to improve phytoremediation of Pb-polluted soil. In the absence of exogenous ABA, Pb was taken up by the roots and mainly accumulated in the root cortex. A small fraction that was transported aboveground has resulted in decreased photosynthesis, biomass, and a burst of reactive oxygen species (ROS). When exogenous ABA was applied to the nutrient solution, the Pb uptake and loading into the vascular cylinder were

enhanced and higher amounts of Pb precipitated in leaves. Negative effects of Pb on photosynthesis, biomass, and ROS production were partly alleviated by the application of exogenous ABA. Exogenous ABA stimulated transcription of genes involved in the Pb uptake, transport, and detoxification.

Istenič, T., Božič, G. *et al.* 2017: Growth dynamic of three different white willow clones used in a zero-discharge wastewater treatment system in the sub-Mediterranean region: an early evaluation. Desalination and water treatment, 91: 260-267.

Willows can be used for treatment and reuse of municipal wastewater in the so-called evapotranspirative willow systems (EWS). The EWS is constructed as a watertight basin filled with soil and planted with willows. Municipal wastewater is first treated in a sedimentation tank and then fed to the EWS where all inflow wastewater is used for willow growth and evaporation. 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. Because there is no outflow to the environment, 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.

Figure 2: Pilot evapotranspirative willow system for treatment of municipal wastewater in Ajdovščina, Slovenia (Photo: Darja Istenic)

The transfer of EWS to the climatic conditions of Slovenia and research of water balance and material loops in EWS were topics of two national research projects: Z2-6751 ‘Development and efficiency of evapotranspirative system with zero emissions for closing wastewater material flows’ and J2-8162 ‘Closing material flows by wastewater treatment with green technologies’. The research has been carried out on a pilot EWS constructed in Ajdovščina, Slovenia (45°52′32″N 13°54′20″E) since 2016. The pilot EWS was planted with indigenous white willow ‘V 160’ (*S. alba*) and two of its hybrids: ‘V 052’ (*S. alba* var. *calva* × *S. alba*) and ‘V 093’ (*S.*

alba × *S. alba* var. *vitellina*) × *S. alba*. The willows were planted in November 2015 as one-year old trees and were cut back to 10 cm above ground level in February 2016 to promote the development of the multi-stemmed coppice. In the first vegetative period, the willows grew from 0 to 2.5-2.6 m and the biomass production was estimated to 3.2-4.4 t DM ha^{-1} while in the second vegetative period the growth was boosted: the trees reached 4.3-4.8 m and the 1st rotation (2017) yielded 34±7, 38±18 and 38±4 t DM ha^{-1}, for 'V 160', 'V 052' and 'V 093', respectively (Istenič et al. 2017). The conversion of wastewater to willow biomass was estimated to 2.6±0.4 kg of biomass per m^3 of wastewater with no significant difference between the clones for the 1st rotation.

Evapotranspiration of the system was relatively low during the first vegetative season (534±18 mm) due to the trees were young and the canopies and root system were not yet well established and increased significantly in the second vegetative season, namely to 1165±66 mm (reference evapotranspiration ETr 1032 mm).

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 rhe urban and peri-urban environment as they enable shading and cooling by evapotranspiration.

III. GENERAL INFORMATION

1. Administration and Operation of the National Poplar Commission or equivalent Organization

The Republic of Slovenia became a Contracting Party to the Convention Placing the International Poplar Commission (IPC) within the Framework of FAO on May 25, 2000. In response to the invitation from the IPC Secretary on December 18, 2013, the Scientific Board of the Slovenian Forestry Institute appointed a representative of the National Poplar Commission of Slovenia on December 20, 2013. In the framework of official cooperation, the promotion and exchange of ideas and materials between IPC, research workers, producers, and landowners are carried out.

IPC 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 the period under review, the reform was presented and discussed at the Committee of Forestry (COFO) in 2018. Slovenian representative Mr. T. Remic, Ministry of Agriculture, Forestry and Food, took part at the Special Session to vote on the proposed amendments to the Convention Placing in IPC within the framework of FAO on July 19, 2018, in coordination with the National Poplar Commission. At the session, the vote was postponed for further internal consultations. Slovenian IPC focal point Dr. G. Bozic was nominated by the Ministry of Agriculture, Forestry and Food of Republic Slovenia to represent Slovenia in the vote on the proposed amendments to the Convention Placing in IPC within the framework of FAO. Slovenia confirmed the

proposed amendments to the Convention Placing in IPC within the framework of FAO on the Special Session of IPC, held at FAO headquarters in Rome, Italy, February 6, 2019.

Slovenian IPC focal point participated at the 3rd meeting of the Hungarian-Slovenian forestry working group held in Hungary in October 2019 and presented the overview of work on joint European scientific applied projects and programs in the field of forest genetic resources regarding the development of the forest genetic monitoring - LIFEGENMON, building resilience into riparian forests – REFOCuS, and EUPOP Europe-wide collaborative testing of poplar clones for short rotation coppice culture.

2. Literature

Publications on poplars, willows, and other fast-growing trees issued in the period under review (2016-2019) including technical papers presented at meetings, congresses, etc.

Poplars and willows

Publication year 2016

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3. Relations with other countries

Poplar Commission of the Republic of Slovenia has provided cuttings of *Populus nigra* var. *italica* collected from different locations in Slovenia for an experiment established in INBO, Belgium, to investigate the genetics, epigenetics, and phenology on the fastigiate black popular cultivar/clone *Populus nigra* from different geographic regions all over Europe. The study aimed to see how the clones react to climate change.

Scientific monograph »Variability of black poplar (*Populus nigra* L.) and its preservation in Bosnia and Herzegovina« written by prof. dr. Dalibor Ballian (2017) was reviewed by the representative of the Poplar Commission of the Republic of Slovenia.

The main cooperation in the reporting period 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 (Forest 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).

IV. SUMMARY STATISTICS (Questionnaire)

The questionnaire contains data on poplars, willows, and other fast-growing trees in Slovenia and summarizes the statistics of key parameters in poplars, willows, black locust and black walnut resources, production, utilization, trade, and future trends. It is completed with data according to the Forest Information System of the Slovenia Forest Service for the year 2019. The total area is calculated based on forest stands where the growing stock of the analyzed tree species is equal or higher than 1 m^3 while the production area is divided according to the wood removals structure. Data about the total removals are based on the data on the amount of felling (m^3) collected by the Slovenia Forest Service in the year 2019.

Slovenia does not collect data on roundwood production on the tree species level (but only on the level of coniferous/non-coniferous trees). Therefore, data on the use of wood are based on expert assessment.

Country report of the National Poplar Commission is based primarily on the specialized contributions of the following individuals and institutes:

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