# National Poplar Commission of Sweden

Country Report
Period 2004 through 2007

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**Activities Related to Poplar and Willow Cultivation and Utilization in Sweden**

## I. POLICY AND LEGAL FRAMEWORK

Europe and Sweden are implementing strategies to achieve greenhouse gas emission objectives, including ambitious targets for renewable energy. In Sweden, biomass production with willows, aspens and poplars on agricultural land will play a key role in this development. During recent years, Sweden has been rather successful in introducing biomass as fuel for heat and electricity production. This success was initially the result of a combination of exogenous success factors such as high levels of available forestry resources, a strong forest products industry, and the existence of an established network of district heating systems. However, even in this context, policy instruments were required to support and guide the development of biomass as an energy source for heat and electricity. The most important regulations supporting this development were:

- 1970- present, (rising) energy taxes
- 1991 Carbon Tax & Energy Tax, focus on heat
- 1997 – 2002 Investment subsidies
- 2000 Carbon tax increases
- 2003 Technology-independent Green Electricity Certificate system introduced
- 2004 Tax on electricity for Households and Services
- 2004 Reduced Combined Heat and Power Plant (CHP) Tax

The general energy policy has supported biomass for energy over the entire period, although specific policies have changed with time. Research, development and demonstration have been continuously supported, and some subsidy schemes have been applied within the frame of national Swedish as well as European regulation.

## II. SUMMARY STATISTICS

A template, summarizing statistics of key parameters in poplar and willow culture, production and trade is found in Annex I. The template appears designed for poplar forestry. Poplars and willows are hardly used at all in Swedish forestry, which made it difficult to supply the relevant information.

## III. TECHNICAL INFORMATION

Poplars, aspens *(Populus)* and willows *(Salix)* are superior in short rotation forestry under the cool-temperate to boreal climate of Sweden, due to the fast growth rate in combination with good cold hardiness of these trees (Weih 2004). Apart from their

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great potential for biomass production, those trees can enrich the coniferous forests of boreal regions and increase biodiversity in open agricultural landscapes of the boreal zone (Weih 2006, Weih and Nordh 2007). Further, plantations of *Populus* and *Salix* can serve as tools for the amelioration of environmental problems at local (e.g. phytoremediation) and global scale (e.g. increased greenhouse effect) (Dimitriou and Aronsson 2005, 2008; Grelle et al. 2007). Swedish researchers also actively contribute to the discussion of climate change effects on forest ecosystems, a discussion in which research results from *Populus* species traditionally have great impact (e.g. Hyvönen et al. 2007). The biomass yields achieved in Swedish short rotation forestry and the appropriate production systems appear not principally different from other regions in the world, but there are some climatic peculiarities (e.g., high-latitude photoperiodic conditions in combination with cool and "oceanic" climate), which affect choice of genotype/variety, production system and management actions. During the last 4 years, Swedish R&D activities regarding *Populus* and *Salix* have addressed the whole range of issues from genetics/genomics research through ecological questions related to pest control, nature conservation and biodiversity, to bioenergy systems approaches where poplars and willows are discussed as most interesting alternatives to other energy crops (e.g. Berndes and Börjesson 2007, Börjesson 2007).

## 1. Populus

Traditionally Swedish forestry and agriculture showed little interest in growing poplars and aspens. Test trials with *Populus* species as well as some small-scale breeding was performed by the Swedish match industry during the period 1940s to 1960s, but no large efforts were done to introduce poplar at a commercial scale. More recently, the increasing interest in biomass plantations on agricultural land, along with the selection of *Populus* as a model tree in genome sequencing programs, has sparked of a greatly increased interest in *Populus* research and culture also in Sweden. Thus, *Populus* biomass production on agricultural land is now regarded as a promising potential component of sustainable bioenergy systems in Sweden (e.g. Rytter 2004, 2006, Börjesson 2007).

*Production and management research*
The specific environmental conditions in Sweden, particular the northern-latitude photoperiodic conditions in combination with mild summers and harsh winters, require specific breeds adapted to the Swedish climate and possibly also specific management methods. No long-term Swedish poplar breeding program has been established so far.

Test trials with various genotypes have however been established and investigated. For example, 108 genotypes of *P. trichocarpa* and hybrids between *P. trichocarpa* and *P. deltoides* were evaluated for growth rate, phenology, frost hardiness and pest resistance under different fertilization and irrigation regimes by Christersson (2006), who concluded that fertilisation, but not irrigation, can be economically motivated under the conditions in Sweden. In southern Sweden 140 poplar clones, mainly collected from Holland and Belgium, have been tested during 10-14 years. As a result 15 clones were selected for mass propagation and commercial use (Stener 2004). The plant material consists of *P. trichocarpa*, *P. balsamifera*, *P. deltoides* and P. nigra, and hybrids between them. Hybrid aspen breeding work for southern Sweden was resumed around 1985 and has resulted in 15 clones recommended for commercial use

(Stener & Karlsson 2004). This plant material can now be ordered from Swedish nurseries.

In addition, a method for rapid clone testing was evaluated on young *Populus* plants (Karacic and Weih 2006). Traditional management questions, such as the development of biomass equations for Swedish *Populus* stands (Johansson 2006) and a study of the effect of rotation period on *Populus* biomass production (Eriksson and Johansson 2006) are in the focus of research programs. Management regimes that combine early harvests and thinning with conventional forestry techniques are being developed and tested for hybrid aspen (*Populus tremuloides* x *P. tremula*) grown under Swedish conditions (Rytter and Stener 2005, Rytter 2006, Rytter and Werner 2007). Very recently (2007), test trials of various *Populus* genotypes were established along a latitudinal gradient from southern to northern Sweden, but evaluation of growth and other parameters was being started only recently and no results are available so far.

*Genetics and genomics research, breeding*
There are currently two new *Populus* cultivars registered at the Swedish Forestry Agency. One is hybrid aspen (No. KB-002) consisting of 15 clones, the other is a mixture of poplars (No. KB-003) also consisting of 15 clones. Both cultivars were tested by The Forestry Research Institute of Sweden (Stener 2004, Stener & Karlsson 2004). Apart from this, Swedish researchers are actively involved in the sequencing of the *Populus* genome (e.g. Sterky et al. 2004, Sjödin et al. 2006, Tuskan et al. 2006) and the genomics research initiated by the sequencing activities. Studies are being performed on phenological traits (e.g. autumn senescence) that are responsible for climatic adaptations in European aspen (*P. tremula*) (e.g. Andersson et al. 2004, Ingvarsson 2005, Ingvarsson et al. 2006, Hall et al. 2008). For example, *P. tremula* genotypes were collected from twelve natural populations across a latitudinal gradient in Sweden and grown in common gardens (the *SwAsp* collection; Luquez et al. 2008). Other foci of the Swedish *Populus* genomics research are on the processes involved in wood formation (e.g. Djerbi et al. 2004, Aspeborg et al. 2005, Israelsson et al. 2005, Andersson-Gunneras et al. 2006, Björklund et al. 2007, Gray-Mitsumune et al. 2008, Mellerowicz and Sundberg 2008) and the functional genomics of plant – pathogen relationships (e.g. Smith et al. 2004).

## 2. Salix

Historically, the cultivation of willows was performed at a rather small scale until relatively recently, when the potential of willow as bioenergy crop came into focus. Today Sweden is one of the few countries in the world where willow cultivation exceeds poplar growing.

*Commercialisation of willow production for bioenergy use*
Research on willows for the purpose of biomass production was firstly initiated in Sweden in the late 1960s in response to a predicted shortage of raw material for the pulp and paper industry. Thus, in Sweden, willow cultivation as a source of biomass for energy purposes has been developed within the frame of a National Energy Forestry Programme and expanded from a few hectares around 1970 to about 16 000 ha by the end of the 1990s. The development of willow culture in Sweden (and

elsewhere) is described by Kuzovkina et al. (2008). The research and development of willow culture in Sweden was accompanied by commercialization of both production system and breeding. Historically, the rapid development of commercialization and large-scale implementation of *Salix* culture in Sweden was favored by, among other things, the existence of many district heating systems in Sweden (Hoffmann and Weih 2005). Most commercial willow plantations in Sweden are today administrated by the Federation of the Swedish Farmers Coops, through the company Lantmännen Agrobränsle AB located in central Sweden. This enterprise has contacts with subcontractors and utility operators and guarantees the proper handling of the crop through advisory service. Lantmännen Agrobränsle AB takes also care of harvest and delivery of the willow wood chips to the closest district heating plant.
Since a wave of commercial *Salix* planting rolled over Sweden in the early 1990s, many of the first plantations were terminated or reduced much sooner. The reasons for this retreat are analysed and evaluated by Helby et al. (2006) and Rosenqvist (2007). A particular problem is the high risk that farmers face when planting *Salix*, as future demand is uncertain and prices difficult to predict.

*Production and management research*

The implementation and commercialisation of willow culture in Sweden was prepared and is being followed up by a bunch of research projects dealing with all aspects of production biology, ecology and pest control. During recent years, the research has increasingly focused on aspects with great relevance for breeding, especially under different kinds of environmental stress. For example, plant physiological key traits for shoot biomass production in young, pot-grown plants compared to mature, field-grown trees are being identified (Weih and Nordh 2005, Weih and Rönnberg-Wästljung 2007) and water relations were studied with particular foci on water use efficiency, drought responses and the possibilities for breeding (Wikberg and Ögren 2004, Weih et al. 2006, Wikberg 2006, Linderson et al. 2007, Wikberg and Ögren 2007). Also the processes involved in cold hardiness (hardening and dehardening) and the implications for breeding were addressed (Hjelm and Ögren 2004, Lennartsson and Ögren 2004 a, b). In addition, research has focused on long-term stand development in relation to management, plant material and site characteristics in Sweden (Nordh and Verwijst 2004, Nordh 2005). The work on *Salix* physiology and long-term dynamics has generated valuable information for modelling of biomass growth in willow plantations on a stand basis (e.g. Sannervik et al. 2006). The long-term development of biomass production in willow plantations is greatly affected by the dynamics of pests and diseases and much research has been allocated to pest and disease problems. For example, the induction of certain types of insect resistance is being studied (Höglund and Larsson 2005, Höglund et al. 2005), as well as the factors affecting palatability of willow leaves for herbivores (Albrectsen et al. 2004, 2007, Glynn et al. 2004, 2007). Also the factors affecting willow leaf beetles are under investigation with particular focus on the common management practice of willow plantations and the possibilities for biological control (Björkman et al. 2004, Dalin et al. 2004, Björkman and Ahrné 2005, Björkman and Eklund 2006, Fernandez et al. 2007). Another field of research addresses bacterial infections of willows and the possibility of a combined effect of frost and bacterial disease resulting in the severe dieback of trees observed in some commercial *Salix* plantations in Sweden (Nejad et al. 2004, 2006, Cambours et al. 2005).

*Phytoremediation and vegetation filter applications*

During recent years in Sweden, the use of nutrient-rich residues as an alternative, cost-efficient fertilization method was developed in parallel with the development of appropriate production systems for willow culture as a source of biomass for energy purpose (Dimitriou and Aronsson 2005, Mirck et al. 2005). The principal residues used in Sweden are municipal wastewater, landfill leachate, log-yard runoff, sewage sludge and wood-ash and the benefits are both environmental and economic (Rosenqvist and Ness 2004, Berndes et al. 2004, Berndes and Börjesson 2007). Around 30 large-scale phytoremediation systems irrigated with different wastewaters have been established in Sweden and about 10 000 ha of short-rotation willow coppice are fertilized with sewage sludge (Dimitriou and Aronsson 2005). A series of research activities has been connected to phytoremediation applications in Sweden using *Salix*. For example, biomass allocation and wood fuel quality were studied in willow stands fertilised with sludge, ash and sludge-ash mixtures (Adler 2007, Adler et al. 2008a, 2008b), irrigation with landfill leachate has been shown to increase willow growth and to not result in excessive nutrient drainage (Dimitriou and Aronsson 2008), and high retention ability for some critical substances (i.e. organic carbon, phenols and phosphorus) was demonstrated when log-yard runoff was applied in willow plantations (Jonsson et al. 2006). Monitoring of pests and diseases on leaves of willows fertilised with wastewater, urine and sewage sludge revealed variable results compared to untreated willows (Åhman and Wilson 2008). Other research addresses one of the main concerns for the sustainability of commonly applied sludge-ash treatments in commercial willow plantations, i.e., the amount of heavy metals (especially cadmium, Cd) remaining in the soil. Results show that the amount of Cd removed with the harvested shoots in a willow field is much higher than the amount of Cd supplied with sludge and ash application (Dimitriou 2005). Laboratory studies focused on the physiological effects of heavy metal treatment on willow and demonstrated great genetic differences in heavy metal sensitivity and accumulation among willow genotypes (Lux et al. 2004, Wang and Greger 2004, Greger et al. 2005). Possible environmental hazards associated with wastewater treatments on willow plantations, e.g. N leaching and $N_2O$ emissions into the atmosphere, are monitored and results so far indicate minimal risks, whilst biomass growth is higher than the average for commercial short rotation willow coppice in Sweden (Grelle et al. 2007).

*Genetics and breeding*

Today, all commercial breeding of *Salix* in Sweden is located at the company Lantmännen Agrobränsle AB, which has registered the following four willow cultivars during the period from 2004 to 2007: ‘Karin’ (((*Salix schwerinii* x *S. viminalis*) x *S. viminalis*) x *S. burjatica*), ‘Doris’ (*S. dasyclados*), ‘Nora’ (*S. burjatica* x *S. viminalis*), ‘Klara’ (((*S. burjatica* x *S. viminalis*) x *S. burjatica*) x (*S. viminalis* x (*S. schwerinii* x *S. viminalis*))). The major species used in the Swedish breeding program are *S. viminalis* and *S. dasyclados*, but *S. schwerinii*, *S. burjatica, S. triandra, S. caprea*, *S. daphnoides* and *S. ericocephala* are also used. The commercial breeding program is strongly linked to integrated research activities performed at the Swedish University of Agricultural Sciences (SLU) through a breeding project established in 2007 (Weih et al. 2008). During recent years, quantitative trait loci (QTL) analysis has been used to study the genetic control of complex growth traits in Salix grown

under various environmental conditions and the QTL have been identified and mapped with significant effects on *Salix* frost resistance and phenology (Tsarouhas et al. 2004), growth, water-use efficiency and drought tolerance (Rönnberg-Wästljung et al. 2005, Weih et al. 2006). A part of this analysis is to develop genetic linkage maps, which have been made for various *Salix* species and hybrids (see Rönnberg-Wästljung et al. 2005 and references therein). The broad knowledge base on QTL for yield and resistance traits in *Populus* and the sequencing and annotation of genes in the *Populus* genome (Tuskan et al. 2006) make new approaches available for the identification of genes behind QTL in *Populus*. The close taxonomic relationship between *Populus* and *Salix* renders the *Populus* genome sequence a valuable tool also in *Salix* breeding.

## IV. GENERAL INFORMATION

*Administration and Operation of the National Poplar Commission or equivalent Organization*

Annual meetings of the National Poplar Commission of Sweden were held in March 2005 and May 2008. The 2005 meeting was organized within the frame of a national poplar seminar held in Uppsala and the proceedings of the seminar are published by Christersson and Verwijst (2006). Apart from summaries of the various seminar contributions, this publication also includes the notes of the annual meeting, during which the board of the National Poplar Commission of Sweden was elected. Due to unclear financing and other problems, the board started its work not before the 2008 annual NPC meeting. Motivated by the increased interest in poplar and willow culture during recent years, the Swedish NPC intends to establish a webpage on current regulations and other relevant information with respect to poplar and willow culture under the Swedish conditions. In addition, a 2-day workshop on poplar and willow culture, including relevant research, is planned in autumn 2009.

## IVa. LITERATURE LIST ON *POPULUS* AND *SALIX* RESEARCH IN SWEDEN (2004 to early 2008)


Adler A, Verwijst T, Aronsson P (2005) Estimation and relevance of bark proportion in a willow stand. Biomass Bioenergy 29: 102-113.

Adler A (2007) Accumulation of elements in Salix and other species used in vegetation filters with focus on wood fuel quality. Doctoral Thesis No. 2007: 6. Uppsala: Swedish University of Agricultural Sciences.

Adler A, Karacic A, Weih, M (2008a) Biomass allocation and nutrient use in fast-growing woody and herbaceous perennials used for phytoremediation. Plant Soil 305: 189-206.

Adler A, Dimitriou I, Aronsson P, Verwijst T, Weih M (2008b) Wood fuel quality of two *Salix viminalis* stands fertilised with sludge, ash and sludge-ash mixtures. Biomass Bioenergy (in press).

Åhman I, Wilson F (2008) Symptoms of pests, rust and other disorders on leaves of willow fertilised with wastewater, urine or sewage sludge. Biomass Bioenergy (in press).

Albrectsen BR, Gardfjell H, Orians CM, Murray B, Fritz RS (2004) Slugs, willow seedlings and nutrient fertilization: intrinsic vigor inversely affects palatability. Oikos 105:268-278.

Albrectsen BR, Guiterrez L, Fritz RS, Fritz RD, Orians CM (2007) Does the differential seedling mortality caused by slugs alter the foliar traits and

subsequent susceptibility of hybrid willows to a generalist herbivore? Ecol. Entomol. 32: 211-220.
Andersson A, Keskitalo J, Sjodin A, Bhalerao R, Sterky F, Wissel K, Tandre K, Aspeborg H, Moyle R, Ohmiya Y, Bhalerao R, Brunner A, Gustafsson P, Karlsson J, Lundeberg J, Nilsson O, Sandberg G, Strauss S, Sundberg B, Uhlen M, Jansson S, Nilsson P (2004) A transcriptional timetable of autumn senescence. Genome Biology 5: R24.
Andersson-Gunneras S, Mellerowicz EJ, Love J, Segerman B, Ohmiya Y, Coutinho PM, Nilsson P, Henrissat B, Moritz T, Sundberg B (2006) Biosynthesis of cellulose-enriched tension wood in Populus: global analysis of transcripts and metabolites identifies biochemical and developmental regulators in secondary wall biosynthesis. Plant J. 45: 144-165.
Aronsson P, Weih M, Åhman I (2007) Salix cultivation yields added value – in addition to energy. Formas Fokuserar nr 11: Bioenergy – for what and how much?, Stockholm, p. 269-283.
Aspeborg H, Schrader J, Coutinho PM, Stam M, Kallas A, Djerbi S, Nilsson P, Denman S, Amini B, Sterky F, Master E, Sandberg G, Mellerowicz E, Sundberg B, Henrissat B, Teeri TT (2005) Carbohydrate-active enzymes involved in the secondary cell wall biogenesis in hybrid aspen. Plant Physiol. 137: 983-997.
Augustson ÅS, Lind A, Weih M (2006) Floristisk mångfald i odlingar av Salix [Floristic diversity in willow biomass plantations]. Svensk Botanisk Tidskrift 100: 52-58.
Berndes G, Fredrikson F, Borjesson P (2004) Cadmium accumulation and *Salix*-based phytoextraction on arable land in Sweden. Agricult. Ecosyst. Environ. 103: 207-223.
Berndes G, Börjesson P 2007. Multifunctional bioenergy systems. AGS Pathways report 2007:EU1.
Björklund S, Antti H, Uddestrand I, Moritz T, Sundberg B (2007) Cross-talk between gibberellin and auxin in development of *Populus* wood: gibberellin stimulates polar auxin transport and has a common transcriptome with auxin. Plant J. 52: 499-511.
Björkman C, Bommarco R, Eklund K, Höglund S (2004) Harvesting disrupts biological control of herbivores in a short-rotation coppice system. Ecol. Appl. 14: 1624-1633.
Björkman C, Eklund K (2006) Factors affecting willow leaf beetles (*Phratora vulgatissima*) when selecting overwintering sites. Agricult. For. Entomol. 8: 97-101.
Björkman C, Ahrné K (2005) Influence of leaf trichome density on the efficiency of two polyphagous insect predators. Entomol. Exp. Appl. 115: 179-186.
Börjesson P, Berndes G (2006) The prospects for willow plantations for wastewater treatment in Sweden. Biomass Bioenergy 30: 428-438.
Börjesson P (2007) Bioenergy systems – which are the most efficient? Formas Fokuserar nr 11: Bioenergy – for what and how much?, Stockholm, p. 133-148.
Cambours MA, Nejad P, Granhall U, Ramstedt M (2005) Frost-related dieback of willows. Comparison of epiphytically and endophytically isolated bacteria from different *Salix* clones, with emphasis on ice nucleation activity, pathogenic properties and seasonal variation. Biomass Bioenergy 28: 15-27.
Cooke JEK, Weih M (2005) Nitrogen storage and seasonal nitrogen cycling in *Populus* - genomics as a bridge between molecular physiology and ecophysiology. New Phytol. 167: 19-30.

Christersson L (2006) Biomass production of intensively grown poplars in the southernmost part of Sweden: Observations of characters, traits and growth potential. Biomass Bioenergy 30: 497-508.
Christersson L, Verwijst T (2006) Proceedings from a Poplar seminar at the Department of Short Rotation Forestry, SLU, Uppsala, Sweden. Reports of the Department of Crop Production Ecology, SLU, No. 3. 74 p.
Dalin P, Björkman C, Eklund K (2004) Leaf beetle grazing does not induce willow trichome defence in the coppicing willow *Salix viminalis*. Agricult. For. Entomol. 6: 1-5.
Dimitriou I (2005) Performance and sustainability of short-rotation energy crops treated with municipal and industrial residues. Doctoral Thesis No. 2005: 44. Uppsala: Swedish University of Agricultural Sciences.
Dimitriou I, Aronsson P (2005) Willows for energy and phytoremediation in Sweden. Unasylva 221 (56): 47-50.
Dimitriou I, Aronsson P, Weih M (2006) Stress tolerance of five willow clones after irrigation with different amounts of landfill leachate. Bioresource Technol. 97: 150–157.
Dimitriou I, Aronsson P (2008) Landfill leachate treatment on Short-Rotation Willow Coppice: Resource instead of waste? In: Landfill Research Focus. Nova Publishers, New York, USA, pp. 263-291.
Djerbi S, Aspeborg H, Nilsson P, Sundberg B, Mellerowicz E, Blomqvist K, Teeri TT (2004) Identification and expression analysis of genes encoding putative cellulose synthases (CesA) in the hybrid aspen, Populus tremula (L.) x P-tremuloides (Michx.). Cellulose 11: 301-312.
Eriksson E, Johansson T (2006) Effects of rotation period on biomass production and atmospheric $CO_2$ emissions from broadleaved stands growing on abandoned farmland. Silva Fennica 40: 603-613.
Fernandez PC, Meiners T, Bjorkman C, Hilker M (2007) Electrophysiological responses of the blue willow leaf beetle, Phratora vulgatissima, to volatiles of different *Salix viminalis* genotypes. Entomol. Exp. Appl. 125: 157-164.
Fritz RS, Hochwender CG, Albrectsen BR, Czesak ME (2006) Fitness and genetic architecture of parent and hybrid willows in common gardens. Evolution 60: 1215-1227.
Garcia MV, Ingvarsson PK (2007) An excess of nonsynonymous polymorphism and extensive haplotype structure at the PtABI1B locus in European aspen (*Populus tremula*): a case of balancing selection in an obligately outcrossing plant? Heredity 99: 381-388.
Geisler-Lee J, Geisler M, Coutinho PM, Segerman B, Nishikubo N, Takahashi J, Aspeborg H, Djerbi S, Master E, Andersson-Gunneras S, Sundberg B, Karpinski S, Teeri TT, Kleczkowski LA, Henrissat B, Mellerowicz EJ (2006) Poplar carbohydrate-active enzymes. Gene identification and expression analyses. Plant Physiol. 140: 946-962.
Glynn C, Ronnberg-Wastljung AC, Julkunen-Tiitto R, Weih M (2004) Willow genotype, but not drought treatment, affects foliar phenolic concentrations and leaf-beetle resistance. Entomol. Exp. Appl. 113: 1-14.
Glynn C, Herms DA, Orians CM, Hansen RC, Larsson S (2007) Testing the growth-differentiation balance hypothesis: dynamic responses of willows to nutrient availability. New Phytol. 176: 623-634.
Gray-Mitsumune M, Blomquist K, McQueen-Mason S, Teeri TT, Sundberg B, Mellerowicz EJ (2008) Ectopic expression of a wood-abundant expansin

PttEXPA1 promotes cell expansion in primary and secondary tissues in aspen. Plant Biotechnol. J. 6: 62-72.
Grelle A, Aronsson P, Weslien P, Klemedtsson L, Lindroth A (2007) Large carbon-sink potential by Kyoto forests in Sweden - A case study on willow plantations. Tellus Series B – Chem. Phys. Meteorol. 59: 910-918.
Greger M, Wang YD, Neuschutz C (2005) Absence of Hg transpiration by shoot after Hg uptake by roots of six terrestrial plant species. Environ. Pollut. 134: 201-208.
Hall D, Luquez V, Garcia VM, St Onge KR, Jansson S, Ingvarsson PK (2008) Adaptive population differentiation in phenology across a latitudinal gradient in European aspen (*Populus tremula*, L.): A comparison of neutral markers, candidate genes and phenotypic traits. Evolution 61: 2849-2860.
Helby P, Rosenqvist H, Roos A (2006) Retreat from Salix - Swedish experience with energy crops in the 1990s. Biomass Bioenergy 30: 422-427.
Hellgren JM, Olofsson K, Sundberg B (2004) Patterns of auxin distribution during gravitational induction of reaction wood in poplar and pine. Plant Physiol. 135: 212-220.
Hjelm U, Ogren E (2004) Photosynthetic responses to short-term and long-term light variation in *Pinus sylvestris* and *Salix dasyclados*. Trees 18: 622-629.
Hoffmann D, Weih M (2005) Limitations and improvement of the potential utilisation of woody biomass for energy derived from short rotation woody crops in Sweden and Germany. Biomass Bioenergy 28: 267-279.
Höglund S, Larsson S (2005) Abiotic induction of susceptibility in insect-resistant willow. Entomol. Exp. Appl. 115: 89-96.
Höglund S, Larsson S, Wingsle G (2005) Both hypersensitive and non-hypersensitive responses are associated with resistance in *Salix viminalis* against the gall midge *Dasineura marginemtorquens*. J. Exp. Bot. 56: 3215-3222.
Hyvönen R, Ågren GI, Linder S et al. (2007) The likely impact of elevated [$CO_2$], nitrogen deposition, increased temperature and management on carbon sequestration in temperate and boreal forest ecosystems: a literature review. New Phytol. 173: 463-480.
Ingvarsson PK (2005) Nucleotide polymorphism and linkage disequilbrium within and among natural populations of European Aspen (*Populus tremula* L., Salicaceae). Genetics 169: 945-953.
Ingvarsson PK (2005) Molecular population genetics of herbivore-induced protease inhibitor genes in European aspen (*Populus tremula* L., Salicaceae). Mol. Biol. Evol. 22: 1802-1812.
Ingvarsson PK, Garcia MV, Hall D, Luquez V, Jansson S (2006) Clinal variation in phyB2, a candidate gene for day-length-induced growth cessation and bud set, across a latitudinal gradient in European aspen (*Populus tremula*). Genetics 172: 1845-1853.
Ingvarsson PK (2007) Gene expression and protein length influence codon usage and rates of sequence evolution in *Populus tremula*. Mol. Biol. Evol. 24: 836-844.
Ingvarsson PK, Garcia MV, Luquez V, Hall D, Jansson S (2008) Nucleotide polymorphism and phenotypic associations within and around the phytochrome B2 locus in European aspen (*Populus tremula*, Salicaceae). Genetics 178: 2217-2226.
Israelsson M, Sundberg B, Moritz T (2005) Tissue-specific localization of gibberellins and expression of gibberellin-biosynthetic and signaling genes in wood-forming tissues in aspen. Plant J. 44: 494-504.

Johansson T (2006) Site index conversion equations for Picea abies and five broadleaved species in Sweden: *Alnus glutinosa, Alnus incana, Betula pendula, Betula pubescens* and *Populus tremula*. Scand. J. For. Res. 21: 14-19.

Jonsson M, Dimitriou I, Aronsson P, Elowson T (2006) Treatment of log yard run-off by irrigation of grass and willows. Environ. Poll. 139: 157-166.

Karacic A, Weih M (2006) Variation in growth and resource utilisation among eight poplar clones under different irrigation and fertilisation regimes in Sweden. Biomass Bioenergy 30: 115-124.

Kuzovkina Y, Weih M, Abalos Romero M, Charles J, Hurst S, McIvor I, Karp A, Trybush S, Labrecque M, Teodorescu T, Singh NB, Smart L, Volk TA (2008) *Salix*: Botany and Global Horticulture. Horticultural Reviews 34: 447-489.

Lennartsson M, Ogren E (2004a) Screening for efficient cold hardening in a breeding population of *Salix* using near infrared reflectance spectroscopy. Ann. For. Sci. 61: 449-454.

Lennartsson M, Ogren E (2004b) Clonal variation in temperature requirements for budburst and dehardening in *Salix* species used for biomass production. Scand. J. For. Res. 19: 295-302.

Linderson ML, Iritz Z, Lindroth A (2007) The effect of water availability on stand-level productivity, transpiration, water use efficiency and radiation use efficiency of field-grown willow clones. Biomass Bioenergy 31: 460-468.

Luquez V, Hall D, Albrectsen BR, Karlsson J, Ingvarsson P, Jansson S (2008) Natural phenological variation in aspen (*Populus tremula*): the SwAsp collection. Tree Genetics & Genomes 4: 279-292.

Lux, A, Sottnikova, A, Opatrna, J, Greger, M (2004) Differences in structure of adventitious roots in *Salix* clones with contrasting characteristics of cadmium accumulation and sensitivity. Physiol. Plant. 120: 537-545.

Mellerowicz EJ, Sundberg B (2008) Wood cell walls: biosynthesis, developmental dynamics and their implications for wood properties. Curr. Opin. Plant Biol. 11: 293-300.

Mirck J, Isebrands JG, Verwijst T, Ledin S (2005) Development of short-rotation willow coppice systems for environmental purposes in Sweden. Biomass Bioenergy 28: 219-228.

Neale DB, Ingvarsson PK (2008) Population, quantitative and comparative genomics of adaptation in forest trees. Curr. Opin. Plant Biol. 11: 149-155.

Nejad P, Ramstedt M, Granhall U (2004) Pathogenic ice-nucleation active bacteria in willows for short rotation forestry. For. Pathol. 34: 369-381.

Nejad P, Ramstedt M, Granhall U, Roos S, McIvor I (2006) Biochemical characterization and identification of ice-nucleation-active (INA) willow pathogens by means of BIOLOG (R) MicroPlate, INA gene primers and PCR-based 16S rRNA-gene analyses. J. Plant Diseases Protection 113: 97-106.

Nishikubo N, Awano T, Banasiak A, Bourquin V, Ibatullin F, Funada R, Brumer H, Teeri TT, Hayashi T, Sundberg B, Mellerowicz EJ (2007) Xyloglucan Endo-transglycosylase (XET) functions in gelatinous layers of tension wood fibers in Poplar - A glimpse into the mechanism of the balancing act of trees. Plant Cell Physiol. 48: 843-855.

Nordh NE, Verwijst T (2004) Above-ground biomass assessments and first cutting cycle production in willow (*Salix* sp.) coppice - a comparison between destructive and non-destructive methods. Biomass Bioenergy 27: 1-8.

Nordh N-E (2005) Long term changes in stand structure and biomass production in short rotation willow coppice. Doctoral Thesis No. 2005: 120. Uppsala: Swedish University of Agricultural Sciences.
Richardson J, Verwijst T (2005) Sustainable bioenergy production systems: environmental, operational and social implications. Biomas Bioenergy 28: 95-96.
Richardson J, Verwijst T (2007) Multiple benefits from sustainable bioenergy systems: Proceedings of a joint workshop of IEA bioenergy task 30 and task 31, August 2005, Perth, Western Australia – Preface. Biomass Bioenergy 31: 599-600.
Rönnberg-Wästljung AC, Glynn C, Weih M (2005) QTL analyses of drought tolerance and growth for a *Salix dasyclados* x *Salix viminalis* hybrid in contrasting water regimes. Theor. Appl. Gen. 110: 537-549.
Rönnberg-Wästljung AC, Åhman I, Glynn C, Widenfalk O (2006) Quantitative trait loci for resistance to herbivores in willows: field experiment with varying soils and climates. Entomol. Exp. Appl. 118: 163–174.
Rosenqvist H, Ness B (2004) An economic analysis of leachate purification through willow-coppice vegetation filters. Bioresource Technol. 94: 321-329.
Rosenqvist H (2007) Energy crops on arable land – who will grow them? Formas Fokuserar nr 11: Bioenergy – for what and how much?, Stockholm, p. 285-296.
Rytter, L (2004) Production potentials of aspen, birch and alder – a review on possibilities and consequences of harvest of biomass and merchantable timber. Skogforsk, Redogörelse No. 4, Uppsala, 62 pp. In Swedish with English summary.
Rytter L (2006) A management regime for hybrid aspen stands combining conventional forestry techniques with early biomass harvests to exploit their rapid early growth. For. Ecol. Manage. 236: 422-426.
Rytter L, Stener LG (2005) Productivity and thinning effects in hybrid aspen (*Populus tremula* L. x *P.-tremuloides* Michx.) stands in southern Sweden. Forestry 78: 285-295.
Rytter L, Werner M (2007) Influence of early thinning in broadleaved stands on development of remaining stems. Scand. J. For. Res. 22: 198-210.
Sannervik AN, Eckersten H, Verwijst T, Kowalik P, Nordh NE (2006) Simulation of willow productivity based on radiation use efficiency, shoot mortality and shoot age. Eur. J. Agron. 24: 156-164.
Segerman B, Jansson S, Karlsson J (2007) Characterization of genes with tissue-specific differential expression patterns in *Populus*. Tree Genetics & Genomes 3: 351-362.
Siedlecka A, Wiklund S, Péronne M-A, Micheli F, Lesniewska J, Sethson I, Edlund U, Richard L, Sundberg B, Mellerowicz EJ (2008) Pectin methyl esterase inhibits intrusive and symplastic cell growth in developing wood cells of *Populus*. Plant Physiol. 146: 554-565.
Sjodin A, Bylesjo M, Skogstrom O, Eriksson D, Nilsson P, Ryden P, Jansson S, Karlsson J (2006) UPSC-BASE - *Populus* transcriptomics online. Plant J. 48: 806-817.
Smith CM, Rodriguez-Buey M, Karlsson J, Campbell MM (2004) The response of the poplar transcriptome to wounding and subsequent infection by a viral pathogen. New Phytol. 164: 123-136.
Stener,L-G (2004) Resultat från sydsvenska klontester med poppel. Skogforsk, Arbetsrapport No. 571, Uppsala, 27 pp.

Stener, L-G, Karlsson, B (2004) Improvement of *Populus tremula* x *P. tremuloides* by phenotypic selection and clonal testing. Forest Genetics 11: 13-27.

Sterky F, Bhalerao RR, Unneberg P, Segerman B, Nilsson P, Brunner AM, Campaa LC, Lindvall JJ, Tandre K, Strauss SH, Sundberg B, Gustafsson P, UhlEn M, Bhalerao RP, Nilsson O, Sandberg G, Karlsson J, Lundeberg J, Jansson S (2004) A Populus EST resource for plant functional genomics. Proc. Natl. Acad. Sci. USA 101: 13951-13956.

Talyzina NM, Ingvarsson PK (2006) Molecular evolution of a small gene family of wound inducible Kunitz trypsin inhibitors in *Populus*. Journal of Molecular Evolution 63: 108-119.

Tuskan GA, DiFazio S, Jansson S, et al. (2006) The genome of Black Cottonwood, *Populus trichocarpa* (Torr.&Gray). Science 313: 1596-1604.

Tsarouhas V, Gullberg U, Lagercrantz U (2004) Mapping of quantitative trait loci (QTLs) affecting autumn freezing resistance and phenology in *Salix.* Theor. Appl. Gen. 108: 1335-1342.

Volk TA, Verwijst T, Tharakan PJ, Abrahamson LP, White EH (2004) Growing fuel: a sustainability assessment of willow biomass crops. Frontiers Ecol. Environ. 2: 411-418.

Wang YD, Greger M (2004) Clonal differences in mercury tolerance, accumulation, and distribution in willow. J. Environ. Qual. 33: 1779-1785.

Weih M (2004) Intensive short rotation forestry in boreal climates: present and future perspectives. Can. J. For. Res. 34: 1369-1378.

Weih M, Nordh N-E (2005) Determinants of biomass production in hybrid willows and the prediction of field performance from pot studies. Tree Physiol. 25: 1197-1206.

Weih M (2006) Willow short rotation coppice grown on agricultural land – possibilities for improvement of biodiversity and landscape design. Report to the Swedish Environmental Protection Agency (Dnr 802-114-04). Uppsala, Sweden: Swedish University of Agricultural Sciences (SLU). 36 p. (in Swedish, with English Summary) (http://pub-epsilon.slu.se/75/)

Weih M, Rönnberg-Wästljung AC, Glynn C (2006) Growth analysis and QTL patterns coincide in hybrid willow (*Salix dasyclados x S. viminalis*) grown under two water regimes. New Phytol. 170: 467-477.

Weih M, Rönnberg-Wästljung AC (2007) Shoot biomass is related to vertical leaf nitrogen gradient in *Salix* canopies. Tree Physiol. 27: 1551-1559.

Weih M, Nordh N-E (2007) Biomass production with fast-growing trees on agricultural land in cool-temperate regions: possibilities, limitations, challenges. In: Environmental Research Advances. New York, Nova Science Publishers, pp. 155-170.

Weih M, Didon UME, Rönnberg-Wästljung A-C, Björkman C (2008) Integrated agricultural research and crop breeding: Allelopathic weed control in cereals and long-term productivity in perennial biomass crops. Agricult. Syst. 97: 99-107.

Wikberg J, Ögren E (2004) Interrelationships between water use and growth traits in biomass-producing willows. Trees 18: 70-76.

Wikberg J (2006) Water relations in *Salix* with focus on drought responses. Doctoral Thesis No. 2006: 48. Uppsala: Swedish University of Agricultural Sciences.

Wikberg J, Ögren E (2007) Variation in drought resistance, drought acclimation and water conservation in four willow cultivars used for biomass production. Tree Physiol. 27: 1339-1346.

# V. ANNEX 1

# *QUESTIONNAIRE ON POPLARS AND WILLOWS*

## INTRODUCTION

The Questionnaire on Poplars and Willows is designed to complement the Country National Report.

Response to the questionnaire is crucial for FAO to allow country, regional and global analyses of status and trends in Planted Forest development and to assist in improving formulation of policies, preparing outlook studies and undertaking planning, management, monitoring and reporting.

We understand the difficulties that experts can find in providing such information however in lack of detailed statistical data, aggregated data and/or best professional estimates are also very much appreciated.

## TABLE OF CONTENTS



## CONTACTS


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Alberto Del Lungo, Alberto.DelLungo@fao.org

**COUNTRY NAME: Sweden**

***Table 1: Total Area of Poplars and Willows by Main Forest Categories, Degree of Mixing with Other Species and Purpose (area change over the last 4 years)***

Table 1, is the starting point of the questionnaire. We request here to provide area of poplars and willows by the main FAO forest categories.

According to FAO forest categories Poplar and willows can be classified[2] as:

- **Indigenous forest**: forest of native species, where there are no clearly visible indications of human activities [...]
- **Planted forests**: forest of native species, [...] or of introduced species, established through planting or seeding mainly for *production of wood or nonwood goods* and/or *provision of services*
- **Agroforestry/Trees Outside Forests (TOF)**: Stands smaller than 0.5 ha; trees in agricultural land (agroforestry systems, homegardens, orchards); trees in urban environments; and scattered along roads and in landscapes

In the following table please indicate area (ha) and purpose (%) of poplars and willows for years 2004 and 2007, and an estimate of the degree of mixture with other species (100% = pure stand). List the poplar and willow species and other relevant tree genera present (if any); e.g. *Quercus, Alnus, Betula*
Please note that the total of the three Purpose classes (wood production, environment and other) can not be more than 100%

| Poplars and Willows Forest categories | | 2004 | | | | | 2007 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Area (000 ha) | % of presence versus other Sp.(*) | Purpose | | | Area (000 ha) | % of presence versus other Sp.(*) | Purpose | | |
| | | | | Production (%) | Protection (%) | Other (%) | | | Production (%) | Protection (%) | Other (%) |
| **Indigenous** | Poplars | 0 | | | | | 0 | | | | |
| | Willows | 0 | | | | | 0 | | | | |
| | Mix P & W | 0 | | | | | 0 | | | | |
| | **Total** | **0** | ---------- | ---------- | ---------- | ---------- | **0** | ---------- | ---------- | ---------- | ---------- |
| **Planted** | Poplars | 0.2 | | 99 | | 1 | 0.25 | | 99 | | 1 |
| | Willows | 15 | | 99 | | 1 | 15 | | 99 | | 1 |
| | Mix P & W | 0 | | | | | 0 | | | | |
| | **Total** | **15.2** | ---------- | **--99--------** | ---------- | ---------- | **15.25** | ---------- | **---------99--** | ---------- | ---------- |
| **Agroforestry TOF** | Poplars | 0 | | | | | 0 | | | | |
| | Willows | 0 | | | | | 0 | | | | |
| | Mix P & W | 0 | | | | | 0 | | | | |
| | **Total** | **0** | ---------- | ---------- | ---------- | ---------- | **0** | ---------- | ---------- | ---------- | ---------- |
| **Overall total** | | | ---------- | ---------- | ---------- | ---------- | | ---------- | ---------- | ---------- | ---------- |

[2] Source: ftp://ftp.fao.org/docrep/fao/009/j9256e/j9256e00.pdf - FAO Working Paper 37/E,F,S, Responsible management of Planted Forests: voluntary guidelines.

(*) Please specify mixes with other relevant tree genera (if any); e.g. *Quercus*, *Alnus*, *Betula* for year 2004

Poplars _____

Willows _____

Mix P & W _____

(*) Please specify mixes with other relevant tree genera (if any); e.g. *Quercus*, *Alnus*, *Betula* for year 2007

Poplars _____

Willows _____

Mix P & W _____

***Table 2(a) Poplars: Mean Annual Increment (MAI), Rotation Lengths, Annual Removals by Species or Clones, Forestry Categories and Purpose***

Depending on the level of aggregation available, list for year 2007, by species, group of cultivar, cultivar or clone the total area covered by poplars, their forest category, purpose, average MAI, average Rotation Length and the Annual Removals.
Please note that:
Area must be expressed as % of the area 2007 reported in table 1, column highlighted in green so that the vertical overall total for area must tally to 100%.
Horizontal total for the three forest categories (indigenous, planted and agroforestry-TOF) must tally to 100%
Horizontal total for three purpose classes (wood production, environment and other) must tally to 100%

| Year 2007 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Group of cultivar/Cultivar/Clone** | **Area (%)** | **Forest categories** | | | **Purpose** | | | **Average MAI $m^3$/ha/yr** | **Average Rotation Length (years)** | **Annual Removals $m^3$** |
| | | **Indig.** | **Planted** | **Agrofor. TOF** | **Prod.** | **Prot.** | **Other** | | | |
| | | **Total of three categories by must tally to 100** | | | **(%)** | | | | | |
| **OP42** | **95** | | **100** | | | **100** | | **20** | | **10 tons?** |
| **Hybrid aspen Ekebo** | | | **100** | | **100** | | | **20-25** | | **8-10** |
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| **Total** | **100** | ---------- | ---------- | ---------- | ---------- | -------- | ---------- | ---------- | ---------- | |

***Table 2(b) Willows: Mean Annual Increment (MAI), Rotation Lengths, Annual Removals by Species or Clones, forestry categories and Purpose***

Depending on the level of aggregation available, list for year 2007, by species, group of cultivar, cultivar or clone the total area covered by poplars, their forest category, purpose, average MAI, average Rotation Length and the Annual Removals.
Please note that:
Area must be expressed as % of the area 2007 reported in table 1, column highlighted in green so that the vertical overall total for area must tally to 100%.
Horizontal total for the three forest categories (indigenous, planted and agroforestry-TOF) must tally to 100%
Horizontal total for three purpose classes (wood production, environment and other) must tally to 100%

| Year 2007 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Group of cultivar/Cultivar/Clone** | **Area (%)** | **Forest categories** | | | **Purpose** | | | **Average MAI $m^3$/ha/yr** | **Average Rotation Length (years)** | **Annual Removals $m^3$** |
| | | **Indig.** | **Planted** | **Agrofor. TOF** | **Prod.** | **Prot.** | **Other** | | | |
| | | **(%)** | | | **(%)** | | | | | |
| **Various clones (no statistics available)** | | | | | | | | **10 tons** | | |
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| **Total** | **100** | ---------- | ---------- | ---------- | ---------- | -------- | ---------- | ---------- | ---------- | |

***Table 2C) Mixture Poplars and Willows: Mean Annual Increment (MAI), Rotation Lengths, Annual Removals by Species or Clones, forestry categories and Purpose***

Depending on the level of aggregation available, list for year 2007, by species, group of cultivar, cultivar or clone the total area covered by poplars, their forest category, purpose, average MAI, average Rotation Length and the Annual Removals.
Please note that:
Area must be expressed as % of the area 2007 reported in table 1, column highlighted in green so that the vertical overall total for area must tally to 100%.
Horizontal total for the three forest categories (indigenous, planted and agroforestry-TOF) must tally to 100%
Horizontal total for three purpose classes (wood production, environment and other) must tally to 100%

| Year 2007 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species/Group of cultivar/Cultivar/Clone** | **Area (%)** | **Forest categories** | | | **Purpose** | | | **Average MAI $m^3$/ha/yr** | **Average Rotation Length (years)** | **Annual Removals $m^3$** |
| | | **Indig.** | **Planted** | **Agrofor. TOF** | **Prod.** | **Prot.** | **Other** | | | |
| | | **(%)** | | | **(%)** | | | | | |
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| **Total** | **100** | ---------- | ---------- | ---------- | ---------- | -------- | ---------- | ---------- | ---------- | |

### *Table 3 Main cultivars in use*

Please list, starting with the most common in use:

Poplars: OP42

Hybrid aspen: Ekebo

Willows: Most common is probably 'Tora', but other varieties are also planted (e.g. 'Gudrun', 'Tordis', 'Jorr', 'Loden'). No detailed statistics are available.

### *Table 4: Area Trend*

**Area trend**: annual harvesting/regenerating or planting theoretically involves an area equivalent to the total production forest area divided by rotation length. Please indicate if trends are negative (more harvested than regenerated/planted), positive (more regenerated/planted than harvested) or stable: mark the appropriate boxes

Mark the selected box with "**X**"

| **Genus** | **Area Trends** | | | | | |
|---|---|---|---|---|---|---|
| | **Natural Forest** | | **Planted Forest** | | **Agroforestry/TOFs** | |
| **Poplars** | | Positive | X | Positive | | Positive |
| | | Negative | | Negative | | Negative |
| | X | Stable | | Stable | X | Stable |
| **Willows** | | Positive | X | Positive | | Positive |
| | | Negative | | Negative | | Negative |
| | X | Stable | | Stable | X | Stable |

### *Crop Ownership*

**Public ownership: crop** owned by the State (national, state and regional governments) or government-owned institutions or corporations or other public bodies including cities, municipalities and villages.
**Private ownership Corporate:** crop owned by private companies, co-operatives, corporations, industries, private religious and educational institutions, pension or investment funds (generally large scale)
**Private ownership Smallholders**: crop owned by individuals or families (generally small scale)
**Other ownership**: Crop not classified as public or private ownership that includes land where crop ownership is not defined or unknown (e.g. community, traditional).

### *Table 5a: Ownership at year 2004*

According to the above classification provided list, for year 2004, the area of poplars and willows, as percentage of the total area reported in table 1, by crop ownership categories and purpose. Please note that totals by ownership categories should tally to 100%

| **Poplars and Willows Forest categories** | | **2004** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Public (%)** | | | **Private Corporate (%)** | | | **Private Smallholder (%)** | | | **Other (%)** | | |
| | | **Wood Prod.** | **Prot.** | **Other** | **Wood Prod.** | **Prot.** | **Other** | **Wood Prod.** | **Prot.** | **Other** | **Wood Prod.** | **Prot.** | **Other** |
| **Indigenous** | Poplar | | | | | | | | | | | | |
| | Willows | | | | | | | | | | | | |
| **Planted** | Poplar | | | | | | | 100 | | | | | |
| | Willows | | | | | | | 99 | 1 | | | | |
| **Agroforestry TOF** | Poplar | | | | | | | | | | | | |
| | Willows | | | | | | | | | | | | |

### *Table 5b: Ownership at year 2007*

According to the above classification provided list, for year 2007, the area of poplars and willows, as percentage of the total area reported in table 1, by crop ownership categories and purpose. Please note that totals by ownership categories should tally to 100%

| **Poplars and Willows Forest categories** | | **2007** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Public (%)** | | | **Private Corporate (%)** | | | **Private Smallholder (%)** | | | **Other (%)** | | |
| | | **Wood Prod.** | **Prot.** | **Other** | **Wood Prod.** | **Prot.** | **Other** | **Wood Prod.** | **Prot.** | **Other** | **Wood Prod.** | **Prot.** | **Other** |
| **Indigenous** | Poplar | | | | | | | | | | | | |
| | Willows | | | | | | | | | | | | |
| **Planted** | Poplar | | | | | | | 100 | | | | | |
| | Willows | | | | | | | 99 | 1 | | | | |
| **Agroforestry TOF** | Poplar | | | | | | | | | | | | |
| | Willows | | | | | | | | | | | | |

### *Table 6: Poplar and Willow Forest Products Production*

List by forest categories the roundwood equivalent for each of the stated forest products

| **Poplars and Willows Forest categories** | | **Pulp, Paper, cardboard** | **Reconstituted wood panels** | **Plywood and Veneer** | **Sawnwood** | **Fuelwood & Biomass for Bioenergy** | **Other (specify*)** | **Total** |
|---|---|---|---|---|---|---|---|---|
| | | **000 m3** | | | | | | |
| **Indigenous** | Poplars | | | | | | | |
| | Willows | | | | | | | |
| **Planted** | Poplars | | | | | | | |
| | Willows | | | | | | | |
| **Agroforestry TOF** | Poplars | | | | | | | |
| | Willows | | | | | | | |

*** Other Forest Products (Specify Below):**

_____

### *Table 7: Average <u>Imports</u> of Poplar/Willow Roundwood or Wood Chips (not pulp, paper, wood panels, sawnwood or manufactured products)*

Average **Imports** of poplar/willow **roundwood** or **wood chips** (**<u>not</u>** pulp, paper, wood panels, sawnwood or manufactured products)

| | Use **either** $m^3$ **or** tonnes (**not** both) | | **Countries of origin (in order of importance)** |
|---|---|---|---|
| **Imports** | **$m^3$** | **tonnes** | |
| Roundwood | | | |
| Wood chips | | | |
| Other (specify below) | | | |

Other: _____

### *Table 8: Average <u>Exports</u> of Poplar/Willow Roundwood or Wood chips (not pulp, paper, wood panels, sawnwood or manufactured products)*

Average **Exports** of poplar/willow **roundwood** or **wood chips** (**<u>not</u>** pulp, paper, wood panels, sawnwood or manufactured products)

| | Use **either** $m^3$ **or** metric tonnes (**not** both) | | **Countries of destination (in order of importance)** |
|---|---|---|---|
| **Exports** | **$m^3$** | **tonnes** | |
| Roundwood | | | |
| Wood chips | | | |
| Other (specify below) | | | |

Other _____

**For transparency in referencing please list below all documents appropriate to completion of information and data for this questionnaire**

***Bibliography*** (Your new references inputs)