

# National Poplar Commission of Sweden

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## Country Report 2008 – 2011

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### I. POLICY AND LEGAL FRAMEWORK

IPC aims to promote the cultivation, conservation and utilization of members of the family *Salicaceae*, which includes poplars and willows. In this context we see that the major interest for the species in Sweden lies in developing new cultivars, cultivation and utilization of them, and environmental effects of cultivation. That does not mean that conservation issues are lacking, but are of less size. The values of old sallow and aspen are well known and they constitute valuable ingredients in nature reserves and landscape planning.

Europe and Sweden are implementing strategies for 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 and in 2011 bioenergy became the single largest energy source in the country representing 32 % of the energy consumption. Do date this source is dominated by black liquors and biofuels from forest residues, but new sources like aspens, poplars and willows are increasing.

The success of bioenergy 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
- 2008 EU Commission – Targets for renewable energy to 2020, Sweden should increase from 40% to 49%
- 2009 Swedish government – raises the target for renewables to 2020 to 50% in total and 10% in the transport sector

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. *Populus* and *Salix* species, except European aspen, are only used in small quantities in Swedish forestry, which made it difficult to supply the relevant information.

## III. TECHNICAL INFORMATION

### 1. Identification, registration and varietal control

There are currently two *Populus* cultivars registered at the Swedish Forestry Agency ([www.skogsstyrelsen.se/Aga-och-bruka/Lagen/Handelsregler/Rikslangden-och-National-List/](http://www.skogsstyrelsen.se/Aga-och-bruka/Lagen/Handelsregler/Rikslangden-och-National-List/)). One consists of 15 clones of hybrid aspen (*P. tremula* x *P. tremuloides*; KB-002) which is delivered to practice as a clone mixture. The other cultivar is a mix of 12 poplar clones (KB-003). This mix of pure species and hybrids consists of species from the section *Tacamahara* (balsam poplars) of *Populus*. Both cultivars have been tested by the Forestry Research Institute of Sweden. New tests for improved material, suitable for larger areas of the country, are in progress.

Breeding of *Salix* has been done since the 1980s and over twenty varieties have been developed since that. All of them have gained Community Plant Variety Right and hence are protected throughout the European Union. . A list of the Swedish varieties is given in Table 1. In a recently published 'handbok för salixodlare' at [www.jordbruksverket.se](http://www.jordbruksverket.se), the following clones are recommended for areas exposed to frost in the northern part of the country Gudrun and Klara; for average sites Tora, Tordis, Inger, Stina, Lisa, Sven, Olof and Torhild; and for dry sites Inger and Tordis.

Table 1. *Salix* varieties produced by SW in Sweden with granted PBR (Plant Breeders' Rights) date and expire date.

Variety name	PBR grant date	PBR expire date
Ulv	1996	2022
Tora	1996	2026
Rapp	1996	2026
Orm	1996	2022
Jorunn	1996	2026
Jorr	1996	2026
Björn	1996	2026
Loden	1997	2027
Helga	1998	2028
Torhild	1999	2029
Sven	1999	2029
Olof	2000	2030
Tordis	2002	2032
Gudrun	2002	2032
SW Inger	2003	2033
Karin	2005	2030
Doris	2005	2030
Klara	2008	2033
Nora	2008	2038
Lisa	2010	2035
Stina	2010	2035
Dimitrios	2010	2035

### 2. Production Systems and Cultivation

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. During the last 4-year-period a new handbook for growers of *Salix* has been published by the National Board of Agriculture,

[www.jordbruksverket.se](http://www.jordbruksverket.se) (Hollsten *et al.*, 2012). Fertilization recommendations for *Salix* plantations with economical evaluations have also been published (Aronsson & Rosenqvist 2011).

The Forestry Institute of Sweden and the Swedish University of Agricultural Sciences were commissioned by the Swedish Energy Agency to investigate the possibilities for a large scale introduction of *Populus* plantations (Rytter *et al.* 2011a, 2011b). The investigation showed a large potential but also that the need of, for example, intensified breeding, development of cost-effective regeneration methods and cultivation systems, development of decision tools for maximizing environmental qualities, and investigations of public attitudes and social aspects. A review on short-rotation forestry with hybrid aspen in northern Europe has been published (Tullus *et al.* 2012), as well as a handbook on cultivation of *Populus* species for landowners and authority people (Rytter *et al.*, 2011b), which was complemented by a course tour in southern Sweden. Information on *Populus* was also included in the investigation (Jo 2008/1885) commissioned by the Swedish government aiming at evaluate the possibilities for intensive management of the forests (Rytter & Verwijst 2009). The new knowledge compilation of silviculture is published on line by the Swedish Forest Agency (<http://www.skogsstyrelsen.se/Aga-och-bruka/Skogsbruk/Skogsskotselserien/>) and includes a chapter about ordinary deciduous species (Rytter *et al.* 2008). Weih (2009b) described and compared growth and management of *Salix* and *Miscanthus* which also included environmental aspects.

Research activities about *Salix* production systems and cultivation include testing effects of nutrient supply on wood quality (Adler *et al.* 2008b). A model linking juvenile traits, such as shoot biomass, leaf area and leaf nitrogen to the long-term biomass production has been developed (Weih and Bonosi 2009). Verwijst and Nordh (2010) studied the effect of first-year shoot cut back on willow biomass production and found production losses with the method, which thus could not be recommended. A study by Mola-Yudego (2011) showed that the productivity of *Salix* stands has increased by 2.06 tons DM ha<sup>-1</sup> decade<sup>-1</sup> during the period 1986–2000 due to use of more productive land areas, better willow varieties and more experienced farmers.

During the period several articles have been published concerning productivity of poplar and hybrid stands. Christersson investigated the growth in 9 poplar stands in southern Sweden and found mean annual increments of 3–10 tons DM ha<sup>-1</sup> yr<sup>-1</sup>. Johansson and Karačić (2011) recorded growth in 41 poplar stands and concluded that a production of 70–105 tons DM ha<sup>-1</sup> could be produced in 10–15 years for biofuel purposes. Studies of the root sucker regeneration of hybrid aspen is an on-going activity and has so far shown that initial sprouting can be expected to more than 50 000 shoots ha<sup>-1</sup> (Rytter & Stener 2010). The biomass production increases fast and is estimated to about 10 ton DM ha<sup>-1</sup> yr<sup>-1</sup> during the first 10 years. A new tree species trial aiming at comparing productivity of important Swedish tree species for biomass production on five agricultural soils on different latitudes in the country was set up (Rytter & Lundmark 2010). Another issue of this trial is to follow soil changes, i.e. changes in carbon stock and essential nutrients (Rytter & Högbom 2010). The trial will complement an earlier trial comparing tree species in conventional forestry, and hybrid aspen, poplar as well as *Salix* are included.

Tools for estimating tree volumes (Hjelm 2011) and site index (Johansson 2011) have been developed for poplar in Sweden. Models for estimating productivity of plantations in Sweden based on yield records and climatic data has been developed for willows by Mola-Yudego and Aronsson (2008) and Mola-Yudego (2011).

In Sweden *Populus* and *Salix* stands are most often grown to produce biomass for energy purposes. However, other assortments are highly appreciated globally. A study on pruning of hybrid aspen (Rytter & Jansson 2009) showed that pruning works well for the hybrid. Thus, *Populus* wood may be used to more valuable assortments in the country in the future if those markets arise.

Several publications with more physiological direction have also been published since 2008. Weih (2009c) studied phenology dynamics and found that timing of bud-burst and leaf abscission is more important for willow biomass production than growth cessation, which has implications for breeding activities. Weih *et al.* (2010, 2011a) evaluated the concept nutrient use efficiency (NUE) and suggested conceptual framework where *Salix* was used as an example. Weih *et al.* (2011b) studied the nitrogen economy under drought and found that N-uptake efficiency and leaf N efficiency are

important traits to improve growth under drought. Rytter and Rytter (2012) evaluated the use of minirhizotrons for fine root studies and concluded them to be of limited use for root density studies when not complemented with soil coring, but useful for studying root dynamics and morphology. Verwijst *et al.* (2012) evaluated the effects of cutting traits on later growth and found that longer and thicker cuttings developed more and taller shoots. Cuttings from apical positions grew better than equal-sized cuttings from basal parts. The recommendation was to use larger and more even-sized cuttings with short storage time. The physiological studies on cultivation also include water stress studies of *Salix* genotypes (Bonosi *et al.* 2010), where the different effects of temporarily and permanent water deficit were shown.

### **3. Genetics, Conservation and Improvement**

The investigation on *Populus* possibilities (Rytter *et al.* 2011) stressed the importance of continued and intensified breeding for the genus and this is also underway. Stener (2010) studied wood density and vitality in 280 and 120 clones of hybrid aspen and poplar, respectively, and found that most clones selected for practice based on volume production and vitality had satisfactory density although it will be possible to do improved selections for biomass production in the future.

A review on the topic integration of agricultural research with crop breeding was published by Weih *et al.* (2008) and a major conclusion was that breeding programs for future biomass crops would greatly benefit from integration of ecological information affecting long-term productivity.

Research groups at Umeå Plant Science Centre have continued working with *Populus* species on physiological and molecular biological topics resulting in a substantial amount of publications (eg. Abreu *et al.* 2011, Albrechtsen *et al.* 2010a, Babst *et al.* 2009, Bernhardsson & Ingvarsson 2011, Bjurhager *et al.* 2010, Fracheboud *et al.* 2009, Ingvarsson *et al.* 2008, Luquez *et al.* 2008, Mellerowicz & Sundberg 2008; see also the literature list below).

The molecular work at SLU has been directed to developing dense linkage maps for mapping traits related to yield and resistance in willow (Rönnerberg-Wästljung *et al.* 2008, Berlin *et al.* 2010, 2011, Samils *et al.* 2011). Hjältén *et al.* (2012) and Axelsson *et al.* (2012) tested the effect of leaf beetle damage on genetically and not genetically modified aspens and concluded that although damage was lower for modified plants this was not necessarily expressed in increased biomass production. A new research project, coordinated by SLU and including both academia and private companies has started in December 1 2011 with the aim to develop molecular markers for the use in practical breeding.

Hryniewicz *et al.* (2012) compared the mycorrhiza colonisation and species composition in *Salix* plantations and nearby natural/naturalized willow stands. The interactions between mycorrhiza and host plant genotypes were studied in *Salix* varieties, showing significant effects on foliar chemistry, which may affect leaf herbivores (Baum *et al.* 2009b). Hryniewicz *et al.* (2010) studied the effect of rotation periods on mycorrhiza frequency but found no differences depending on the cutting cycle length. The role of mycorrhiza in biomass forestry has also been penetrated by Rooney *et al.* (2009) and mid-alpine ectomycorrhizal communities on *Salix* has been explored (Ryberg *et al.* 2011).

### **4. Forest Protection**

The works dealing with forest protection have often been of physiological character and are thus also presented under heading 3 above. Toome *et al.* (2009) found that wastewater treatment of willows resulted in increased leaf rust occurrence while no effect of mineral fertilization was seen three years after treatment. By using the leaf beetle *Phratora vulgatissima* Dalin *et al.* (2009) demonstrated that insect pest outbreak risk is higher in monocultures than more diverse habitats. The interaction between the serious damaging blue willow beetle and its natural enemy *Perilitus brevicollis* was studied by Stenberg (2012) who suggested that *Perilitus* parasitoids and omnivorous beetle predators may provide complementary protection to *Salix*.

### **5. Harvesting and Utilization**

A major concern with Salicaceae cultivation is the limited and stagnated areas occupied by these species. This issue has been addressed in some studies and reports. It was discussed in the *Populus* investigation mentioned above (Rytter *et al.* 2011), where the areas for *Populus* are increasing but are

still limited. The stagnation of *Salix* areas since the 90s was examined by Dimitriou et al. (2011). Low biomass was a main reason and in turn a result of low management activities, choice of land and the level of personal involvement.

In a dissertation (Mola-Yudego 2009) and other papers (Mola-Yudego & Pelkonen 2008, 2011, Mola-Yudego & González-Olabarria 2010) it was found that a successful development of wood biomass production on agricultural land in northern Europe depends among others on the spread of research results, skilled growers, existence of an infrastructure and market, and favourable policies.

On the technical side Henriksson and Rosenqvist (2011) demonstrated and evaluated the possibilities for billet harvesting of *Salix* in Sweden and concluded a significant potential for the future. Billets are a fuel material that are longer than chips but still short enough for easy handling. Bergström *et al.* (2011) tested the usefulness of conventional forest technology in large diameter willow stands but found that *Salix* harvest systems were superior, although forest machines will always function regardless of stem thickness.

The wood of Salicaceae species has also been studied. The wood of hybrid aspen and aspen has been compared showing different values for important wood characters (Young's modulus, tensile strength and wood density) in hybrid aspen (Bjurhager *et al.* 2008). Jansson *et al.* (2010) tested aspen wood for future ethanol production and concluded that the technology is well known and the technical risk should be low. Sassner *et al.* (2008) used steam pretreatment prior to enzymatic hydrolysis of *Salix* wood for sugar and ethanol extraction and calculated a theoretical ethanol yield of 79 %. Johansson and Kifetew (2010) studied and tested a model on capillary water uptake of three tree species including aspen, while Sandquist *et al.* (2010) reported occurrence of xyloglucan in tension wood of poplar..

## 6. Environmental Applications

The work with water effects and phytoremediation by fast-growing Salicaceae stands has continued (Dimitriou 2009). The Salicaceae species have been compared with other species (Adler *et al.* 2008a) and with different loads of nutrients (Aronsson *et al.* 2010, Dimitriou & Aronsson 2010, 2011). The economy of such systems has also been evaluated (Dimitriou & Rosenqvist 2011). It was shown that poplar and willows are suitable for phytoremediation and have soil ecological advantages compared to former arable soils (Baum *et al.* 2009a). The increased use of wastewater, sludge etc. may harm the crop but the study of Åhman and Wilson (2008) could not detect any difference when wastewater, sewage sludge or urine were used compared with clean water on *Salix*. Among the conclusions were preferences for smaller stands with varying varieties and with buffer zones. A review on the impact of SRC on water issues have also been published (Dimitriou *et al.* 2009b) and stressed mainly positive effects with SRC.

The potential of *Salix* for growing in heavy metal polluted areas as well as taking up metals has previously been demonstrated. During this period Ohlsson *et al.* (2008) showed that nicotinamide and nicotinic acid availability increase the defence against heavy metals of *Salix viminalis*. In another study the effect of potassium on cesium uptake was investigated where no overall effect of potassium supply was seen (Rosén *et al.* 2011). However, since the  $^{137}\text{Cs}$  activity increased in roots and leaves the  $^{137}\text{Cs}$  activity in ash was lower from K-fertilized plots.

Hultgren *et al.* (2009) studied degradation of polyaromatic hydrocarbons (PAH) and found that the presence of *Salix viminalis* enhanced degradation, which was mainly explained by increased microbial activity in the presence of willows.

The effect of short rotation forestry on biodiversity has also been studied during the last four-year period. A review on possibilities with willows to improve biodiversity and landscape design has been published within the frame of IEA (Weih 2009b). Baum *et al.* (2009c, 2012a-c) studied vascular plant diversity in Swedish and German willow and poplar plantations from stand to landscape level and found that these plantations can contribute to increase habitat and species diversity in rural landscape, but do not add new species to the landscape. An evaluation of aspen abundance showed that changes in land use practices are the main cause of changes in abundance in Sweden during the last 50 years (Edenius *et al.* 2011). Fire and retaining aspen in pre-commercial thinnings are the most important

management recommendations to secure regeneration of aspen. A study on cyanolichens on aspen concluded that the biological value cannot be assessed on the basis of habitat quality alone but has to include a landscape perspective for sustainable management of specialist species (Hedenås & Ericson 2008). A positive relation between habitat patch size and richness of aspen-associated species has been demonstrated (Sahlin & Schroeder 2010). Schroeder *et al.* (2011) also showed the value of leaving aspen dead wood after final cuttings for saproxylic beetles inhabiting dead aspen wood.

Rytter (2012) evaluated the potential of short rotation forests as carbon sinks and concluded that almost one tenth of the annual anthropogenic emissions of C in Sweden could be sequestered if 400 000 ha of arable land were planted with willow and poplar.

An important topic when introducing new fast-growing species is the attitude to the plantations from growers, authorities and the public. Wróbel *et al.* (2009) found that an important aspect was the suspiciousness from the farmers towards new crops. In the popular science book *Bioenergy – for what and how much?*, published by the Swedish Research Council Formas, complimentary values to biomass production for *Salix* cultivation were discussed (Aronsson *et al.* 2008).

## IV. GENERAL INFORMATION

### 1. Administration and Operation of the National Poplar Commission

The National Poplar Commission has been active during the period 2008 – 2011, with several annual meetings of the board as well as one annual meeting for the general public with elections of the board and accompanied by excursions to different hosts of interest for *Salicaceae* issues. Efforts have been made to get a more official status from the government. This work was successful as the government declared the Swedish University of Agricultural Science as the official body for the National Commission by January 20 2012. The University now has the responsibility for the international work of the commission.

### 2. Literature involving the family Salicaceae

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### 3. Relations with other countries

The new clone tests, established during 2010 and 2011, for hybrid aspen and poplar include material from other countries, i.e. Belgium, Finland, Italy, Latvia and Germany. This means we have an organized exchange of plant material with those countries. With economic support from Nordic Energy Research Sweden will also start collaborating about bioenergy supply systems, which includes management systems with hybrid aspen and poplar, with the other Nordic countries, i.e. Denmark, Finland and Norway. A series of demonstration stands will be set up during the forthcoming years as well as a series of joint publications.