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Short Rotation Forestry
An Overview of Sweden and Spain

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Short Rotation Forestry, an Overview of Sweden and Spain

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ABSTRACT

Short rotation forestry (SRF) has got a high relevance the last decades. Fast-growing tree plantations with low rotations and high yields are expanding worldwide to meet the increasing demand of forest products. Furthermore, management of fast-growing species with energy purposes is playing an important role to accomplish bioenergy goals in the way to reduce fossil fuels consumption.

This paper describes short rotation forestry aspects and its differences in Sweden and Spain, with main species and the practices used in both countries.

Eucalyptus sp, *Pinus radiata* and *Populus sp*, mostly managed for pulpwood, wood-based panels and sawn products are the main species in Spain. On the other hand, Sweden is one of the leaders in Europe in willow SRF for energy, with more than 16 000 ha of willow plantations and small areas of hybrid aspen and poplar.

Keywords: Bioenergy, forest management, short rotation forestry, Spain, Sweden

CONTENTS

I . INTRODUCTION

1.1 Plantations and Fast-growing plantations. Background

There are about 264 million hectares in forest plantations in the world and each year this area is expanded by five million hectares worldwide (FAO, 2010). Despite that this only constitutes 7% of global forest area, it provides about 40% of global roundwood. Within this annual increase, about two million hectares are the fast-growing tree plantations. Plantations of Eucalyptus, Acacias, Pines and Poplar species have been established for decades, being a controversial issue especially in the implementation in the Developing World. The increase in demand for paper and other wood products as well as the search for renewable energy led to the growth of these kind of plantations. (Cossalter & Pye-Smith, 2003).

1.2 History of plantations and statistics

In the first half of the 20^{th} century, plantations of trees began in Western Europe, United States, Australia, New Zealand, South Africa and developing countries like India, Chile, Indonesia and Brazil, followed in the 1950s by new reforestation areas in Korea, Japan and China (Evans, 1992) most of them motivated by the absence of natural forests.

In the decade of the 1960s large-scale plantations were initiated in many tropical and subtropical countries. Between 1965 and 1980 this area was multiplied by three. In these years the work of FAO was essential providing technical information. However, the lack of marketing and the failed attempt to connect the plantations with the industrial consumers of wood products meant that most of these plantations ended when external support ceased (Cossalter & Pye-Smith., 2003). Despite this, the total area continued to expand at high rates, from 17.8 million ha in 1980 to 178 million ha in 1990. Between 1991 and 2000 another significant increase was stated, in part due to private sector involvement in commercial plantations and the inclusion of the Asian market, achieving 187 million ha planted in late 2000 (FAO, 2000). In the table below the trends of plantations are between 1990 and 2010 are shown.

Table 1. ***Trends in forest planting (1990-2010)*** **FA0 2010**

	Total Area forest planted(x 1000 ha)			
	1990	2000	2005	2010
Africa	11 663	12 958	14 032	15 409
Asia	76 258	92 928	109 670	122 775
Europe	59 046	65 312	68 502	69 318
North and Central America	20 481	30 261	35 787	38 661
Oceania	2 583	3 323	3 851	4 101
South-America	8 276	10 058	11 123	13 821
World	**178 307**	**214 839**	**242 965**	**264 084**

According to FAO, two thirds of the current plantations are located in temperate and boreal areas and one third in the Tropics. The dominant countries by far are China, United States, Russia, India and Japan with 65% of the total. The annual growth of plantations between 2005 and 2010 is 4.2 million ha with China and the U.S. in the lead with 1.9 and 0.8 million hectares respectively.

1.3 Fast-growing plantations

- Terminology

The term of fast growth in Forestry is relative and depends on several factors like location, age and management purposes. According to Dwivedi (1993), fast growing species are those which yield at least 10 m^3 ha^{-1} $year^{-1}$ of wood. In younger plantations, a height increment of 60 cm per year is necessary.

"*Fast-wood plantations* are those plantations which are intensively managed for commercial plantation, set in blocks of a single species, which produce industrial round wood at high growth rates (mean annual increment of no less than 15 m^3 ha^{-1} $year^{-1}$) and which are harvested in less than 20-year rotation" (Cossalter and Pye-Smith, 2003).

According to the report "Fast-wood forestry, Myths and Realities" (2003), there are around ten million ha of fast-wood plantations worldwide out of 242 million ha of plantations in total. Due to the definition of fast-wood plantations, it is important to notice that large stands of fast-growing species were not considered fast-wood plantations since the mean annual increment reached was below the 15 m^3 required. The same as softwood plantations with rotation periods larger than 20 years. Thus, the real area of fast-growing species is expected to be much larger than the stated ten million ha. In Europe, the data for the total existing area is not available since these plantations are registered as forest area or are part of trees outside the forests with no registration (Leek, 2008)

In this report we will deal with the broader term “Short Rotation Forestry” and “short rotation species” that describe forest systems using fast-growing species at denser spacing and elevated maintenance than in traditional forestry (Hansen EA, 1991) harvesting between 2 and 25 years.

- History

Brazil was the first country in the establishment of large fast-growing tree plantations about 40 years ago with hybrid eucalyptus and seven year rotation periods, followed by Chile, Argentina and Uruguay. In the Iberian Peninsula one million hectares of eucalyptus were planted in the same period (Carrere & Lohmann, 1996).

The reason for the rapid initial expansion of plantations with fast-growing species was mainly economic. Such plantations can produce two times more wood per hectare and year and reach maturity in two to three times faster. Cost of raw material is lower due to the high performance. Less area is needed to produce the same amount of wood and the costs of purchase, production and transportation costs are lower.

Meanwhile, countries with a strong Poplar culture in Europe such as Italy, Spain, France, Belgium, Hungary or Serbia started to focus on hybrids and clones of poplar with higher yields.

In the U.S. and Canada the commercial establishment of hybrid poplars started in the 1980s, plantations of *Populus deltoides* and *Populus trichocarpa*, with a spacing of 2 x 2 m to 3 x 3 m and rotation periods between six and seven years. (Stanton et al., 2002).

On the other hand, after the oil crisis in the 1970s, countries like Sweden and Finland turned their efforts on alternative fuels, finding in fast-growing crops a possible alternative.

Currently there are many examples, for instance bamboo plantations in China, *Tectona grandis*, *Gmelina arborea*, and *Acacia auriformis* in India, or *Eucalyptus globulus* in countries like Australia and Ethiopia. This is only a portion of the large implementation and species used worldwide.

- Species

Mainly hardwoods are used for Short Rotation Forestry due to the growth capacity and easy regeneration. Just below, there are softwood plantations that produce sawlogs usually with rotations between 20 and 30 years. Cases such as *Pinus taeda* and *Pinus echinata* in the United States, *Pinus patula* and *P.elliottii* in Swaziland or *Pinus radiata* in Spain are some of the examples in this report we include also these longer-rotation softwood plantations.

In a global scale, the species more used for Short Rotation Forests are *Eucalyptus grandis* with 3 700 million ha, tropical eucalypts with 1 500 million ha temperate eucalypts with 1 990 million ha, tropical Acacias with 1 400 million ha, Poplars with 900 million, Caribbean pines with 300 million ha and other species of pines with 100 million ha as shown in figure 1.

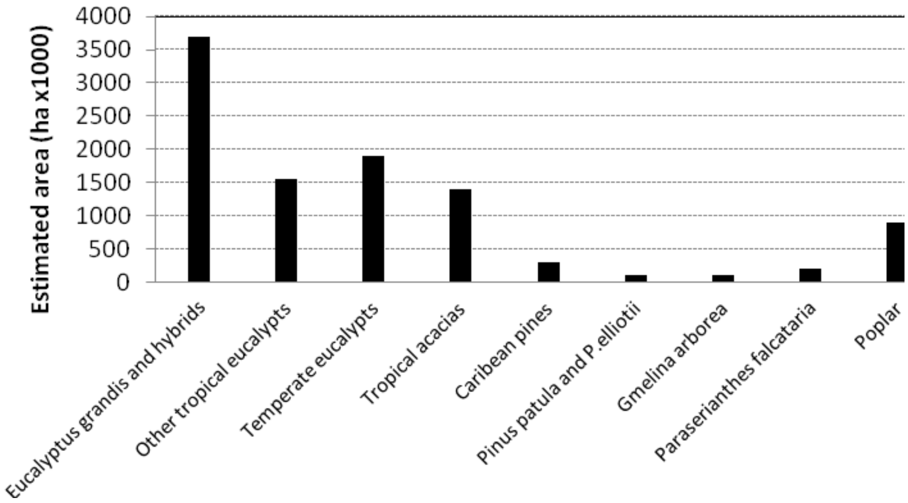

***Figure 1*. Fast-growing species plantations (Fast-Wood Forestry. Myths and realities, 2002)**

1.4 Typical products from fast growing plantations

Produce large volume of small-diameter logs in a short period of time and getting a competitive price for pulp and paper industries is the main purpose of these plantations. (Cossalter & Pye-Smith, 2003)**.** Pulpwood and charcoal are the main products, also it is important the commercial production of reconstituted products like hardboard, particleboard, medium density fibreboard (MDF), oriented strand board (OSB) and laminate strand lumber (LSL).

In this section we will define according to FAO terminology the main products in Fast-wood forestry. Next to each section the evolution of the production in the period from 1962 to 2010 in the World and Europe is stated into figures. Europe is a good indicator since with 158

Billion US$[1] of imports and 184 Billion US$ of exports, monopolize nearly half of the world trade in forest products (FA0, 2007).We do not include here the uses of fast growing species for energy purposes.

[1)] 1 US$ =0.79 Euro (€) = 7.2 SEK (2012)

- Wood Charcoal

According to FAO, "Wood carbonized by partial combustion or the application of heat from external sources. This includes charcoal used as a fuel or for other uses, e.g. as a reduction agent in metallurgy or as an absorption or filtration medium"

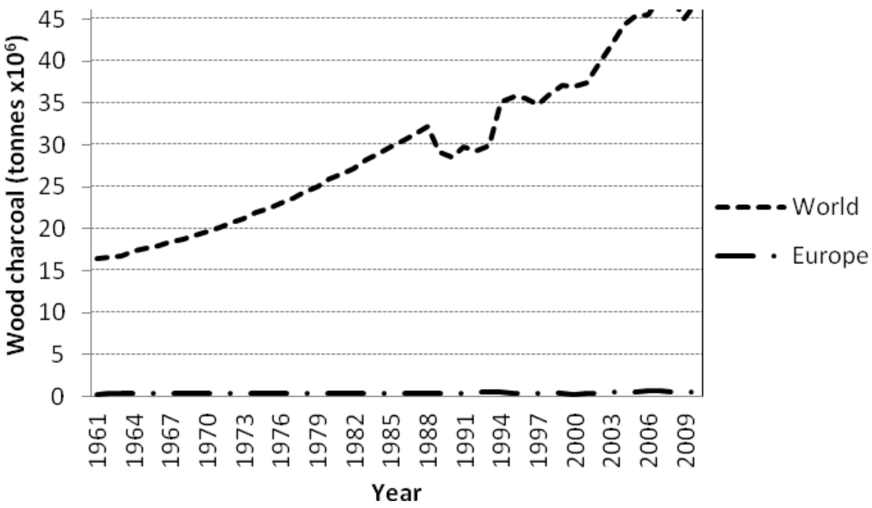

***Figure 2*. Trends in Wood charcoal production (1961-2010) FA0 2010**

As a product of fast-wood plantations, the steel industry demands large amounts of charcoal for the smelting of iron core. The world production of charcoal has experienced an exponential growth, from 16 million tonnes to 47 million tonnes in the last 50 years. This growth in the production is located almost in non-developed and developing countries. In this aspect, the contribution of Europe is fairly small. FAOstat figures (2010) show that Africa with around 30 million tonnes is the leader in wood charcoal, and Brazil (11%), Nigeria (8%) and Ethiopia (8%) the main countries.

- Pulpwood

According to FAO, Pulpwood is "the roundwood that will be used for the production of pulp, particleboard or fibreboard. It includes: roundwood (with or without bark) that will be used for these purposes in its round form or as splitwood or wood chips made directly (i.e. in the forest) from roundwood solid volume underbark (i.e. excluding bark)".

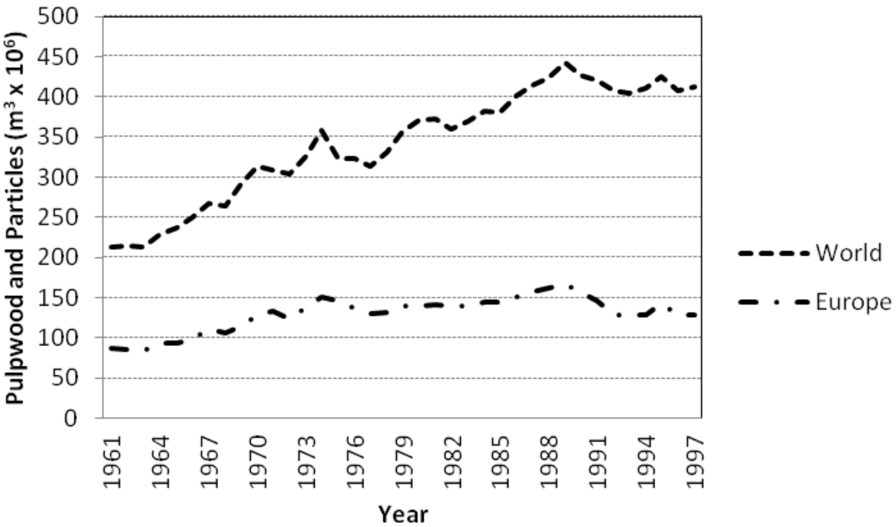

***Figure 3*. Trends in Pulpwood and Particles production (1961-2010) FA0 2010**

The main transformation of pulpwood is to make pulp, for paper as the final product. For species like Acacia, Aspen, Birch, Eucalyptus or Maple the main destination is the production of pulpwood (Biermann & Christopher, 1993) and these species are usually managed as fast-wood plantations.

The global pulpwood production has been almost doubled in the last 50 years, while in Europe this increasing rate is smaller (around 50%). The main producer of chemical pulpwood is Canada with eight million tonnes. (FAOstat, 2011)

- Wood-based panels

According to FAO terminology, this aggregate includes veneer sheets, plywood, particle board and fibreboard compressed or non-compressed.

-Veneer sheets.

Thin sheets of wood of uniform thickness, not exceeding 6 mm, rotary cut (i.e. peeled), sliced or sawn.

-Plywood

A panel consisting of an assembly of veneer sheets bonded together with the direction of the grain in alternate plies generally at right angles. The veneer sheets are usually placed symmetrically on both sides of a central ply or core that may itself be made from a veneer sheet or another material

-Particle Board

A panel manufactured from small pieces of wood or other ligno-cellulosic materials (e.g. chips, flakes, splinters, strands, shreds, shives, etc.) bonded together by the use of an organic binder together with one or more of the following agents: heat, pressure, humidity, a catalyst, etc

-Oriented strandboard (OSB)

A structural board in which layers of narrow wafers are layered alternately at right angles in order to give the board greater elastomechanical properties.

-Fibreboard

Includes hardboards, insulation boards and medium density fibreboards (MDF). It is a panel manufactured from fibres of wood or other ligno-cellulosic materials with the primary bond deriving from the felting of the fibres and their inherent adhesive properties. This felting can be wet, if pulp is washed first to remove the soluble carbohydrate fraction and then suspended in water or dry felting if wood fibre is blown directly into the dryer to evaporate moisture.

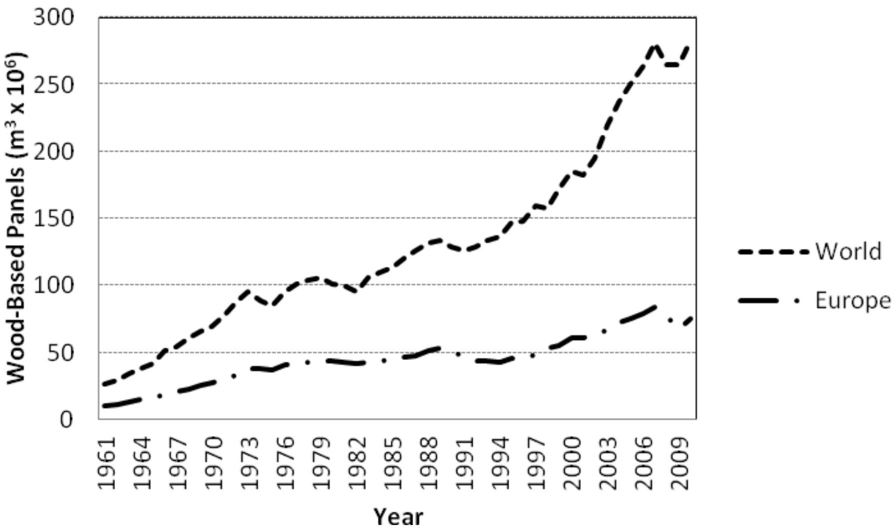

***Figure 4*. Trends in Wood-Based Panels (1961-2010) FA0 2010**

Europe is the largest producer in Wood-based panels with about 80 million m^3 followed by the U.S and China (FAO, 2008). Between 2003 and 2005 primary products like logs and sawnwood was overtaken by secondary processed wood products (SPWPs).Part o this achievement is motivated for the observed exponential increasing in the production of wood-based panels for instance, plywood production increased 200% between 1980 and 2005. (FA0, 2007)

- Paper and paper board

The paper industry demands large quantities of fresh wood fibre. And most of these demands are met by fast-wood plantations. In paper and paperboard trades it includes printing and writing paper, other paper and paper-board. (FAO terminology)

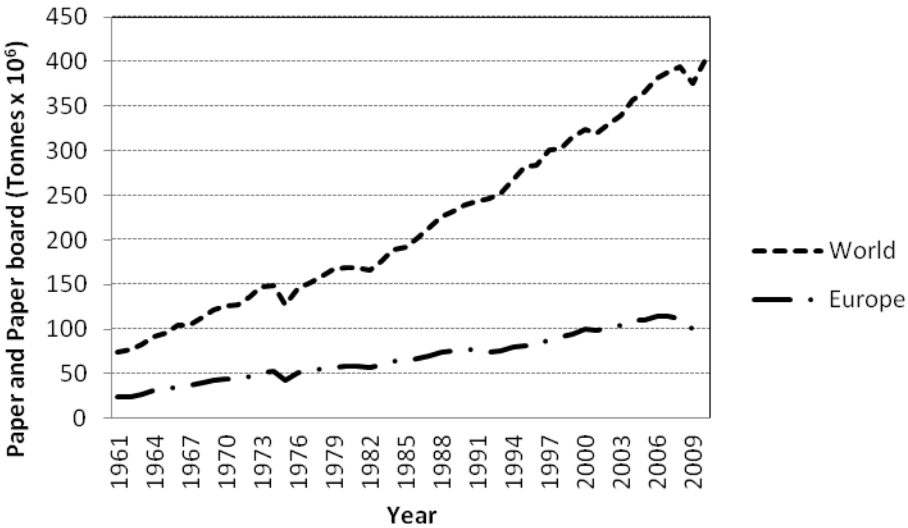

***Figure 5*. Trends in Paper and paper board (1961-2010) FA0 2010**

Europe is the largest producer of paper and paper board in the World with about 110 million tonnes, followed by the U.S. Almost half of the annual production of paper and paper boards is exported (FAO, 2008)

1.5 Harvest systems

Since most of the fast growing species as hardwoods can coppice and they are usually managed under coppice systems, it is necessary to make a description of the terms related coppice. In this section the fast growing softwoods are excluded. Also some fast growing hardwood stands after the felling, the stump is removed and a new plantation is carried out.

- Coppice and coppice silviculture

A forest crop raised from shoots produced from the cut stumps (stools) is called coppice. Coppicing can be repeated and is a useful mean of regenerating broadleaves at short intervals to produce small roundwood (Evans, 1984)

Only broadleaved species can coppice, although some broadleaved species don not coppice vigorously or only when the stump is small like beech birch, cheery and some poplar.

As a form of vegetative propagation, the coppice shots arise either from adventitious buds or from dormant shots on the side of the stool. Most of the Shots emerge from the above-ground part of the stool and also from below the surface, like hazel. Sprouting capacity of coppice generally declines with the tree age.

There are three different coppice types according to the Forestry Commission Bulletin terminology;

-Simple coppice; crop managed as coppice and it is worked in the same time (even age). With only one species it is called pure coppice and with several species, mixed coppice.

-Coppice with standards; Two storey forest, the coppice so-called underwood with scattering of the trees called standards being grown to timber size. Standards may be of seedling origin (maidens) or develop from a stump shoot left for the purpose (stored coppice).

-Stored coppice; tree or stand of coppice origin as a result of growing coppice on beyond its normal rotation.

1.6 New products of fast growing plantations.

1.6.1 Biomass as a renewable energy source

As we briefly stated in the first section of this draft, the last decades the interest in fast growing plantations with energy purposes has increased.

The need to find alternatives to fossil fuels and to meet environmental commitments set by Kyoto protocol made that many countries focused their interest and investment efforts on the research of renewable energy. Currently, biomass is being seen as one way to reach those goals. (EEA, 2006).

The European Union (EU) is one of the best of implementing this type of energy use were important goals have been set in different documents.

One of these documents is the “White Paper on Renewable Energy” (European Commission, 1998) which established the target of 12% of all EU primary energy production from renewable sources by 2010. Subsequently, a directive on the promotion and use of energy from renewable sources in 2008 stated that 20% of the energy consumption in the EU in 2020 must come from renewable sources.

In this scenario, biomass is a resource which is considered more relevant to meeting the renewable targets in the short to medium term, both at national and European level. (Sixto et al., 2011)

1.6.2 Short Rotation Coppice (SRC) for biomass production

Short Rotation Coppice is a variety of Short Rotation Forestry, defined as coppice worked on a cycle between 2 and 10 years to produce stick size material (Evans, 1984). Also called "energetic crops¨ include woody and non-woody plants, managed on high densities with the objective of attaining the highest biomass production for energy purposes. Poplar and willow are the most common species in SRC.

The harvest and the practices used (soil preparation, weed control, planting...etc) are more similar to the agricultural annual crops. However, deeper-rooted plants and higher water consumption than arable crops are some of the differences. Once established, no annual planting and also less agrochemical input is needed (IEA Bioenergy ,2011)

This kind of short rotation forestry has been used by the Human kind for thousands of years, mainly for rural craft, fuelwood and coal production but nowadays the interest is focus in the production of biomass for energy.

According to IEA report harvest usually occurs during the winter in northern Europe, when the soil is frozen in order to avoid soil compaction by machines and the need for fuel is the greatest.

1.6.3 Accomplishing bioenergy goals in Europe

In 2005 the biomass consumption from energy crops was 2 Mtoe[1](CEC, 2005). To meet the goals of bioenergy production, it is estimated that at least 27 Mtoe (93 TWh) are required from short rotation forestry (Kuiper et al, 1998). To reach this goal eight million ha in total of bioenergy plantations on agricultural lands are needed to be established within the next years (Mola-Yudego,B. & Pelkonen, P.,2008). The estimations of the EEA (2006) the EU biomass production potential from energy crops without put in risk the environment is 43-46 Mtoe in 2010.

Salicaceae represents in Europe the species with more potential in these issues as a biomass and energy purposes (Sixto et al., 2011) .Currently, there are around 16 000 ha willow SRC cultivations in Sweden, mostly on productive agricultural land, and smaller areas of SRC in

Italy (c. 6 000 ha, mostly poplar), Poland (c. 3 000 ha mostly willow), the UK (c. 3 000 ha, mostly willow), Germany (c. 1 500 ha, mostly poplar) (IEA Bioenergy, 2011).

Other species can also fulfill the requirements for being used as a short rotation crops, pioneer species, with easy capacity for establishment and high initial growth.

In Europe species of *Eucalyptus sp*, *Robinia* spp in Italy (Candilo et al., 2004), or experimental Ulmus in Siberia (*Ulmus pumila*) and different hybrids of Paulownia (Mezzalira & Brocchi, 2002) can be of interest. Also some other species would be considered with a high potential like Alder *(Alnus* spp.), Sycamore *(Platanus* spp.), Ash *(Fraxinus* spp.), Birch *(Betula spp*.), Beech *(Fagus* spp.), Sweetgum *(Liquidambar* spp.), Chestnut *(Castanea* spp.), or Ailanthus *(Ailanthus* spp.)

[1)] Mtoe; Megatonne of oil equivalent equal to 4.1868 x 10^{16} J

1.7 Objectives

The aim of this paper is to make a comparative study between Spain and Sweden focus on the short rotation forest plantations.
The objective of this study is to describe Short Rotation Forestry aspects and its differences in Sweden and Spain such as:

- General structure of Forest sector in both countries
- Main short rotation species in both countries
- Establishment and management
- Harvesting and techniques used.
- Production and industrial use
- Market and economics.

2. MATERIALS AND METHODS

In this project we will compare two European countries: Sweden and Spain. The data on which this paper is based on are scientific literature provided by SLU library and "Escuela Técnica Superior de Ingenierías Agrarias" in Palencia. Data has also been collected from different Internet sources such as SLU Library e-ref, Dictionaries, Reference databases like

Scopus, web of Science, electronic archives like Epsilon and websites of FAO, FAOSTAT, UNECE, Eurostat and The National Board of Forestry (Skogsstyrelsen).

3. RESULTS AND DISCUSSION

3.1 Background. Forests in Spain and Sweden

A brief introduction is necessary to know the state of forestry in each country and have a better perspective of the results.

- Sweden

Two-thirds of Sweden's area is covered by forests being the first country in Europe in forest cover with 28.2 Million ha (FA0, 2010) and half of its national income comes from the export of forest products.

The relevant species are Norway spruce and Scotch pine, which represent 80% of the national forests following by 12% of birches. (Swedish Forest Federation, 2009)

The growing stock is over 3 000 million m^3 (3 358 in 2010 according to FAO). 75% of the Swedish forests are privately owned (21.5 million ha, FAO 2010) with approximately 260 000 smallholders.

Only 2.6 million ha are primary forest and 3 million have the status of biodiversity protection. Around 0.9 million ha. are managed for production purposes.

In Biodiversity Sweden currently only records 32 native tree species.

Sweden is among the leading country in certifying the forest, with approximately 60% of the country forest area under some kind of protection, 10.1 million ha by Forest Stewardship Council (FSC) and 2 million hectares by the Pan European Forest Certification (PEFC).
The first reforestation laws date from the 16th century. The major forest law was set in 1979 and subsequently revised in 1994. The Swedish Forestry Administration is responsible for the regulation of the Swedish forest policy.

- Spain

Spain is the third country in Europe in forest cover with 18.3 million ha (SECF, 2011) but also 9.5 million ha of other wooded land almost pastures and Mediterranean-typescrub. Spain is one of the most important countries in tree biodiversity in Europe with 123 native species recorded.

Deforestation has strong importance in Spanish history starting with the Roman occupation and ever since deforestation has continued to the meet the populations need of more land. Strong forest plantations have being carried out for more than 50 years with soil protection and erosion prevention as its main aims. Currently Spain is the 9th country in the world and the first in Europe in reforestation with a rate of 296 000 ha per year between 1990 and 2005 (MAGRAMA[1], 2009)

The total growing stock is around 900 million m^3 (M m^3) of which 140 million corresponds to *Pinus pinaster*, 139 M m^3 to *Pinus sylvestris*, 69 M m^3 to *Fagus sylvatica* ,68 M m^3 *Pinus halepensis*, and 67 M m^3 to *Pinus nigra*.(MAGRAMA, IFN III[2], 2009) Conifers represents 57% of the total growing stock and the remainder 43% are broadleaved species.
According FAO data sources from 2010, around 24.5 million ha are used for conservation purpose, including protection of soil and water 8.3 million ha for multiple use, and only 3.7 million ha which is the 12% of the total area production purposes.

1) MAGRAMA; Ministerio de Agricultura, alimentación y Medio Ambiente (Ministry of Agriculture, Food and Environment)

2) IFN III; Tercer Inventario Forestal Nacional (Third National Forest Inventory)

3.2 Characterization of the Spanish and Swedish Forest Sector

Although the annual growth of forests in Sweden is over 100 million m^3 annually, the annual cut is about 70 million m^3 (Figure 7), due to the government policy efforts in sustainability.

The annual forest growth in Spain is 46 million m^3 per year, and the extraction in 2009 was recorded in 19 M m^3 (MAGRAMA, 2010). Of these 19 million in 2009, 4.2 M m^3 of *Eucalyptus sp*, 3.9 M m^3 of *Pinus pinaster*, 1.5 Mm^3 of *Pinus radiata* and 0.9 M m^3 of *Pinus sylvestris*.

The Swedish and Spain production of roundwood over the last decade is stated in the figure below.

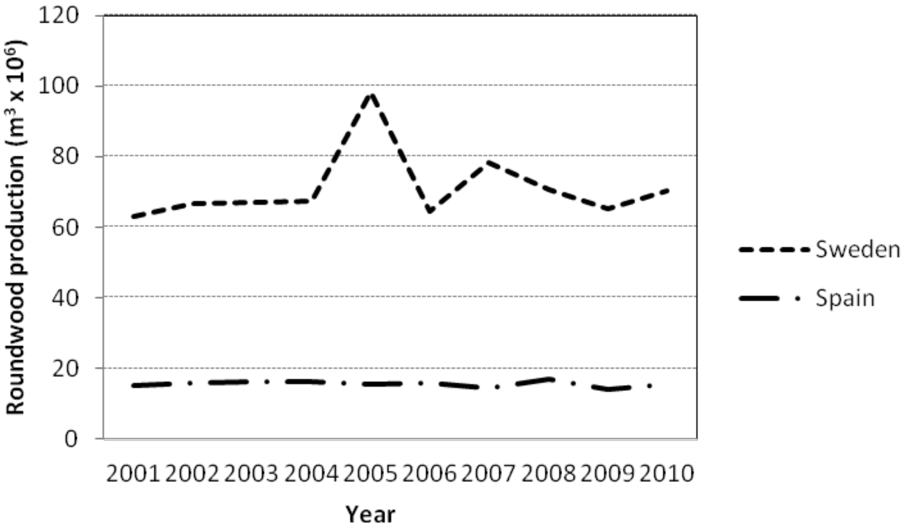

***Figure 7*. Roundwood production in Sweden and Spain (FAO, 2010)**

Currently Sweden is the leading country in Europe in roundwood production per year. The major products are sawlogs and pulpwood, the export of sawnwood is the most important with eleven M m^3, which means more than two thirds of the annual production. Exports of paper and paperboard with ten millions of metric tonnes and wood pulp with three million metric tonnes are the most important (Skogsstyrelsen,2010)

The three main forest products in Spain by volume are: sawnwood (36%), Wood chips and particles (27%) and wood-based panels (25%) (MAGRAMA, 2008).

Although Swedish domestic output of roundwood is sufficient to meet the national demand, the import of roundwood for its developed industry is stated between two and four M m^3 per year. On the other hand, Spain does not meet the national demand and high quantities of roundwood are imported each year, as we can see in the next figure.

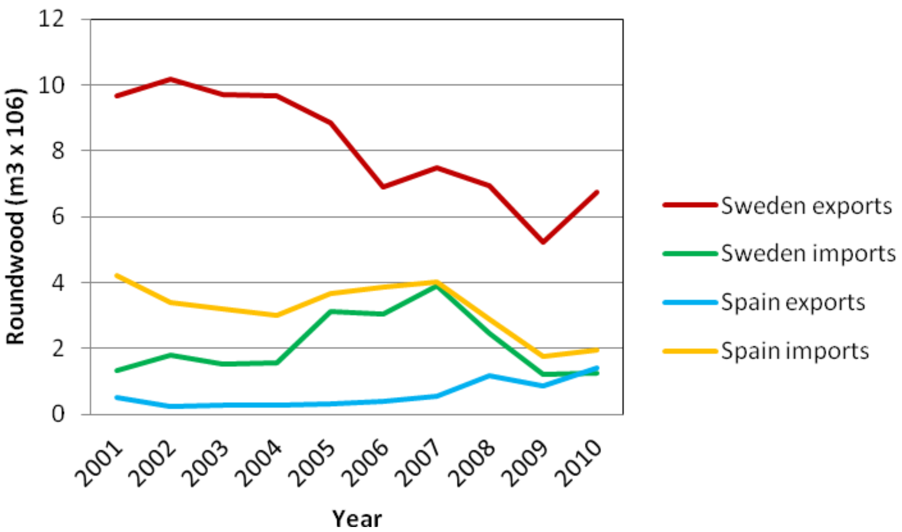

***Figure 8*. Roundwood imports and exports in Sweden and Spain (FAO)**

To understand the low productivity of Spanish forests it is important to notice four limiting factors;

1. 75% of the forests in Spain are located in poorly developed and shallow soils (Cambisols, Regosols and leptosols). Most forest stands are under erosive areas, and erosion caused by human activity is another important factor. Furthermore, a common feature of forest soils is the low content of organic matter in surface horizons. (Servicio de Protección de Agentes Nocivos, DGB, 2005)
2. Between 10 and 15% of the most representative species have significant degrees defoliation (> 25%), mainly caused by drought and insects. Pests and diseases in Spain due to climatic factors have greater impact. *Thaumetopoea pityocampa* is a major defoliator of conifers , *Rhynchaenus fagy* in beech and *Gonipterus scutellatus* in eucalyptus (SECF, 2011)
3. Forest fires affects between 60 000 to 150 000 ha of forest per year, which corresponds to around 1 to 2% of the total forest area (Área de lucha contra lncendios Forestales. DGB, 2005) Spain is the second country in Europe after Portugal in area burned in the period between 1990 and 2008 (European Commission, 2008).
4. Irregular rainfall between years with strong periods of drought damage the forest growth and vitality affecting the final production and timber quality.

3.3 Species

3.3.1 Spain

The main fast growing plantations in Spain are *Eucalyptus sp, Populus sp,* and *Pinus radiata.*

Eucalyptus sp.

- History and main species

These plant species come from Australia, Tasmania and New Guinea. There are about 500-600 species of eucalyptus in the world and can grow to over 100 meters height. Due to its high production and multiple use; sawnwood, pulp, firewood, poles, essential oils; protective or aesthetic qualities, this species have been introduced in many countries in southern and western Europe, California, South America, North Africa and South Africa. (De la Lama, 1976).

Eucalyptus came to Europe from Australia in 1774 after a voyage of Captain Cook. In Spain, it was introduced in 1846, currently its extension is about 760 000 hectares (1.5% of the country, IFN III, 2005) and occur both in mixed and pure stands, concentrated on the regions of Andalucia (242 000 ha) Galicia (149 000 ha) Extremadura (78 000 ha) and Asturias and Cantabria (30 000 ha both).

The main species of the genus *Eucalyptus* in Spain are;

-*Eucalyptus globulus* Labill. (Blue gum eucalyptus)

From Tasmania and South Australia, there are currently 325 000 ha in Spain and together with Portugal, constitutes the two-thirds of its artificial area in the World. It can reach a height of 50 meters and 1.5 meters in diameter at breast height in Spain. Its leaves contain many essential oils that are distilled for use in chemical and pharmaceutical industry. It is shade-intolerant specie, unable to withstand competition with other species in the early stages of life. It prefers wet climates without frost and minimum annual rainfall of 600 millimeters. The Adequate average temperature per year is between 10 and 15.5 ° C. Preference to soils with pH greater than 5 somewhat clayey and fertile. (Ceballos & Ruiz de la Torre, 1971)

- *Eucalyptus camaldulensis* subsp. *camaldulensis* Dehnh. (River Red Gum)

From Australia, it is widely distributed in Spain with 175 000 ha. It reaches less height than *Eucalyptus globulus* rarely exceeding 30-35 meters in height. The content of essential oils in the leaves is low, without distillation after cutting. The abundant and prolonged flowering in mild climates makes it a highly appreciated specie by apicultures. The root system can occupy 2.5 times larger area than the canopy diameter, being aggressive with water consumption and buildings. This large consumption of water has been used for the draining of swamps. It is also shade-intolerant specie. It prefers wet climates without frost and average annual rainfall exceeding 500 mm. It is more resistant to heat, drought and cold that *Eucalyptus globulus,* and also less demanding in the quality of soils. (Ceballos & Ruiz de la Torre, 1971)

Other species such as *Eucalyptus dalrimpleana*, *Eucalyptus gigantean*, *Eucalyptus grandis* and *E.Gamphocephala* have been introduced but occur today only in small areas.

- Establishment and management

The site preparation does not exceed 40 cm depth. Flat areas needs ploughing followed by a moldboard. The plantation is always made in the line ploughed. In areas with slopes greater than 20% a deeper ploughing up to 60-70 cm is made. In small plots, the planting can be done simply by holes (40 x 40 x 40 cm) or direct seeding between April and May with densities of 2 500 plants ha^{-1}.

A one-year-old plant material is used (ideally no more than 50 to 60 cm high).The planting is done in autumn in southern Spain, providing better resistance to drought the following year, while in the north in spring and summer. Generally, planting is done manually in the North because of the small plantation areas, if mechanized a 80 Cv tractor is needed.

Spacings of 4 x 4 m and 3 x 3 m in the South or 2 x 2 m in the North. Wider spacing is used with less favorable conditions. These spacing regimes may vary depending on specific conditions.

- Harvesting

The rotation periods vary depending on the site index and the spacing regimes for *Eucalyptus camaldulensis*. The most common period is between 6 and 12 years and for *Eucalyptus globulus* it varies between 7 to 14 years in the South and 10 to 18 in the North. These rotations with typical spacing of 3 x 3 m and 4 x 4 m. The higher of quality of the site and larger spacing, the longer rotation periods in order to attain higher valuable forest products.

After the first coppice, usually the rotation period is reduced due to the dense and numerous shoots. The eucalyptus plantations should coppice with the purpose of attaining shoots from the stump. Normally, the regrowth is vigorous, with several shoots per stool. Declining yields due to site exhaustion and stool mortality is stated after 3 – 6 cycles. Thereafter it needs a new plantation. Pruning is not necessary because the final destination is mostly pulpwood.

- Production and industrial use

The current production is 4.58 million m^3 per year (MAGRAMA,2008) of which 90% is *Eucalyptus globulus*. Figure 9 shows the concentration of *Eucalyptus* ssp extractions where 40% corresponds to the autonomous community of Galicia. Followed by Andalucia, Asturias and Cantabria with approximately 25% of the volume each one.

83% of the wood is used for pulpwood, mining posts and wood-based panels 6% respectively in the usage. (MINETUR[1], 2008)

[1]MINETUR; Ministerio de Industria, Energía y Turismo (Ministry of Industry, Energy and Tourism)

Figure 9. **Annual extractions of *Eucalyptus sp* in Spain by province. (MAGRAMA, 2008)**

- Market and economics

The Spanish paper sector records 95 industrial plants, being the sixth largest producer of cellulose in the European Union (EU). In the last decade the growth of eucalyptus plantations and the decrease in the capacity of Spanish factories has contributed to the declining price of eucalyptus wood by 20% between 1995 and 2009. More supply than demand and the financial crisis motivate this fall.

Populus sp (Engler, 1964)

- History and main species

Populus genera belongs to the family of *Salicaceae*. The family contains two genera, *Populus* and *Salix* The genus *Populus* is composed of about 40 species.

Poplar cultivation extends in about 70 countries, occupying 80 million ha. 91% of the poplars are found in natural forests, plantations 6% and 3% in agroforestry (International Poplar Commission, 2008).

Russia, Canada and the U.S are the countries with higher natural extension while China, India and Pakistan the countries with higher extension planted. China with 4 million productive hectares accounts the 81% of the global area of poplar plantations (FA0, 2005)

In Spain there are three native species (Soriano, 1993) *P.Alba*, *P.tremula* and *P.nigra*. Remarkable is *Populus* x *canescens* (Ait.) Sm the only known hybrid with spontaneity in Europe and Spain, crossing of *P.Alba and P.tremula* (Padro, 2001)

Poplar clones in Spain are traded on the “Primer Catálogo Nacional” (BOE 07/27/1992) and its extension, where the legislation of poplar is collected. *Populus* x *euramericana* is the most important hybrid in Spain.

-*Populus* x *euramericana* (Dode) Guinier

This is a basic hybrid in the European and Spanish poplar culture. The mother derives from *Populus deltoides* and the father from *Populus nigra*. The I-214 clone is a Italian hybrid and is used in 70% of the Spanish plantations. (IFN III, 2005)

Poplar has a preference for wet climates. Most species grow well in flood plains and river banks. Shade-intolerant specie, in general can reach 30 meters tall and it grows very fast, about one meter per year in the early years. Flowering begins in February and the seed appears from May to June. Optimum between 500 and 1 000 meters altitude with light soils (fine sand, loam, or clay loam). (Ceballos & Ruiz de la Torre, 1971)

The area of poplar in Spain is about 135 710 ha (National Poplar Commission, 2008). The autonomous community of Castilla y Leon possess 65% of the plantations (87 600 ha), followed distantly by Castilla la Mancha (9 371 ha) and Andalucia (8 434 ha) Private property is estimated around 46.5% in 2008.

- Establishment and management

Site preparation includes stump removal and leveling the ground.

Planting can be made with deep root, if the water table is less than 4 meters depth, with a backhoe making the holes. If not, the surface planting is needed with pits to depths of between 0.8 and 1 meter.

In surface planting it is recommended to use one or two-year-old plant material and height at least of 35 dm while deep root plantations need two-years-old cutting with heights of 50 dm at least.

Common densities of plantations varies between 278 and 350 stems ha $^{-1}$. The spacing regimens vary between 4 x 4 m and 6 x 6 m when rich and deep soils.

Get rid of the weeds in the early years and pruning for the first three meters to get a free knot stem is essential.

- Harvesting

Time of harvesting generally seeks to obtain the maximum volume of wood so applying economic criteria with the objective of 35 cm at breast height. Therefore the rotation periods vary between 12 and 17 years. The cut can be made with a chain saw or any other appropriate machinery. It is necessary to remove the stump after the felling and next plantation is carried out. Coppice regeneration is not likely to be used in Spain.

- Production and industrial use

About 600 000 m^3 of poplar wood is extracted annually (572 701 in 2008, MAGRAMA) representing 5% of annual production of roundwood.
The evolution of the annual cutting weight in the period 2000-2008 is as follows

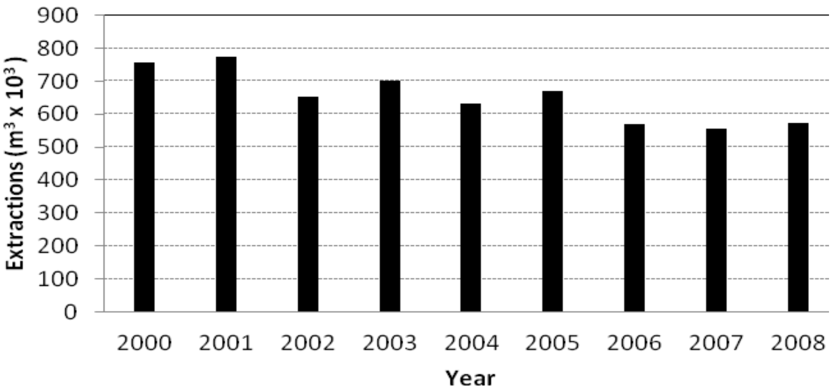

***Figure 10*. Annual extractions of *Populus sp* in Spain. (MAGRAMA, 2009)**

With an average stem volume of 0.66 m^3 and average production of 13 m^3 ha^{-1} year^{-1}, the productivity of poplar plantations with 15 years as a rotation period is close to 180 m^3 ha^{-1}. (MINETUR, 2010). The distribution of annual felling by provinces is showed in figure 11;

***Figure 11*. Annual extractions of *Populus sp* in Spain by province. (MAGRAMA,2009)**

More than 50% are used to the plywood industry, with carpentry and furniture applications. The transformation of poplar also generates significant sawlogs and industrial roundwood. Some researches of Poplar with high densities (10 000 to 25 000 trees ha^{-1}) for bioenergy production and rotation periods between 2 and 5 years are carried out (Sab Miguel et al., 1992; Ciria, 1998; Marcos et al., 2005)

- Market and Economics

With an average site index, densities of 278 stems ha^{-1} and 15 years as rotation periods, the annual income is up to 612 € ha^{-1} $year^{-1}$ (Comisión Nacional del Chopo,2008)

Pinus radiata D.Don

- History and species

The radiata pine is a conifer of the family *Pinaceae*. It is a native species from the region of Monterrey, California. Its original area is up to 5 400 ha in California and 200 in Guadalupe Island and Cendrós (Mexico).

It was introduced in the Basque Country in the mid-nineteenth century for use in reforestation. Currently, it is mainly located in the Cantabrian coast, not more widespread due to difficulties in finding suitable land. The stands exceed 150 000 ha distributed as follows; 60 000 ha in Galicia, Asturias 26 000 ha, Cantabria 15 000 ha, Navarra 6 000 ha and the Canary islands 3 000 ha.

It reaches 20 to 30 meters height. It has needles in sheath 3 in 3 with 10 to 15 cm length. It is limited by the low resistance to cold, and the need for regular rainfall is 400-500 mm (up to 900 mm). Too hot and wet conditions encourage the appearance of diseases. The specie has preference for acid and deep sand/loamy soils (Ceballos & Ruiz de la Torre, 1971)

- Establishment and management

Initially, the plantation were manual, in large holes of 40 x 40 cm and spacing of 2 x 2 m or 2.25 x 2.25 m, creating densities of 2 000 to 2 500 stems ha^{-1}.

The foreseeable destiny of *Pinus radiata* wood is sawnwood so it seems reasonable to make plantations with densities between 1 300 and 1 700 stems ha^{-1} (spacing between 2 x 3 to 2.5 x 3 m) allowing the use machinery of subsequent treatments.

The weed control and two to three cleanings before 10 years are needed, along with a low pruning of all stems. Three thinnings, at 15, 20 and 25 years, are appropriate should be mediate or or strong, with a removal around 30 to 40% of the stand in each intervention.

- Harvesting

The maximum volume of timber is obtained at 15 or 20 years, but elongating up to 32-35 years is proposed in Spain (Ruiz Urrestarazu, 1992) based on assortment specifications and requirements, sawmills is the major consumers of pine wood. In Galicia, small companies in capacity and productivity, and market conditions are characterized by a strong demand for wood chips and particles, so the rotation period applied can be smaller.

From a financial point of view, recent studies indicate rotations from 30 to 35 years if social uses are included, and 25 to 35 years for economic criteria, depending on the site index (Díaz & Romero, 1995)

- Production and industrial use

Currently 1 367 000 m^3 are extracted per year (MAGRAMA, 2008) with slight fluctuations in the last decade without a tendency. The most productive provinces are highlighted in the figure 12.

***Figure 12*. Annual extractions of *Pinus radiate* in Spain by province. (MAGRAMA, 2009)**

The production in an average site is 14 m^3 ha^{-1} $year^{-1}$. With rotation periods of 35 years and with average silviculture practices it is obtained an average profit of 650 € ha^{-1} $year^{-1}$, while for a rotations of 18 years in the absence of treatments benefits down to 222 € ha^{-1} $year^{-1}$ (Díaz et al., 2005)

3.3.2 SRF with energy purposes in Spain

In Spain, the 2005-2010 Renewable Energy Plan (PER) stated that the biomass should have constituted about 47% of all renewable energy in 2010. They must have assumed 1.9 Mtoe $year^{-1}$ for thermal and electrical applications in 2010 and 2.2 $year^{-1}$ biofuels. However, this objective has not been achieved today, so a new targets have been set in the National Action Plan for Renewable Energies 2011-2020.

In Spain it was expected to produce 3.87 Mtoe in 2010 from crops (PER 2005-2010), in fact only 37% of the expected increased use of renewable energy was fulfilled from the figures of 2005.

According to estimates by the European Environment Agency in 2006 http:www.eea.europa.eu), the potential contribution of land suitable for a sustainable energy crops in Spain could be around 2.5 million ha in 2030.The biomass that then would be obtained with an energy equivalent of 0.69 EJ $year^{-1}$ (1 EJ = 10^{18} J) . In the EU (25 states), the cited study evaluated 5.85 EJ $year^{-1}$ potential energy crops in 2030.

Some research is developing about SRF for biomass production in Spain.;

-Some trials with Poplar species are under way. To be evaluated in Spain, rotations varies between 4 and 5 years and the densities vary between 6 000 and 1 000 stems ha^{-1} (San Miguel & Montoya, 1984; Ciria, 1990).

-In 2006 the installation of trial plots of different species and hybrid clones of Poplar was established, in various potential regions. The evaluation of the trials will be made by the Centro de Investigación Forestal (CIFOR) of INIA.

-*Eucalyptus maidenii* and *E.dunni* with rotations of 3 years, densities between 2 300 and 3300 stems ha^{-1} and typical spacing of 3 x 1 m in Andalucia. (Cardenete et al.,2010)

-*Ulmus pumila* experiences in extreme continental climate (Teruel), planting densities of 3 333 plants ha^{-1} after the 3 years of crop the productivities obtained ranged between 3.40 and 13.98 dry 29ones $year^{-1}$ (Iriarte, 2008)

-*Paulownia sp* as a energy crop with 235 ha planted in 2009 with more than 390 000 Paulownia plants. Spacing of 2 x 3 m in order to produce biomass in cycles of 3 years and the plantation life time is estimated in 21 years (seven cycles). Expected average yield of 33 ton dry mass ha^{-1} $year^{-1}$ by RWE Innogy Iberia.

Furthermore, the Spanish project "On Crops" (2005-2012) supported by the Ministerio de Educación y Ciencia with 15 000 ha of land available, are conducting studies with species of *Populus sp*, *Salix sp Robinia pseudoacacia*, *Jatropha curcas* and other agricultural crops to study their viability as energy crops.

3.3.3 Sweden

It is estimated that between 300 000 and 500 000 hectares of arable land in Sweden can be cultivated with energy crops and fast growing tree species in the future (Larsson et al., 2009). Today Willow and hybrid aspen constitute the short rotation species most developed in Sweden, but also hybrid poplar have experienced high yields in south and central Sweden.

Salix sp. (Willow)

- History and Species

Early studies of Short Rotation *salix* spp coppice started in the late 1960s, showing the potential raw material for the pulp industry and paper. The Oil crisis that arose in the 1970s motivated new research. In 1986 the first commercial plantations were established. The increment of the subsidies next years along with the rates of carbon and sulfur encouraged the expansion of these plantations.

There are currently some 16 000 ha of SRC willow crops in Sweden with an increasing rate of 500 ha per year before 2000, now the land area is stable (Swedish Board of Agriculture's statistics, 2009). Most plantations are below the latitude of 60 ° in the south and central Sweden as is shown in the figure 13. The ownership of most of these crops belongs to private farms (1 250 willow growers) administered by the Federation of Swedish Farmers (Lantbrukarnas Riksförbund) and crops are managed by Lantmännen Agroenergi AB.

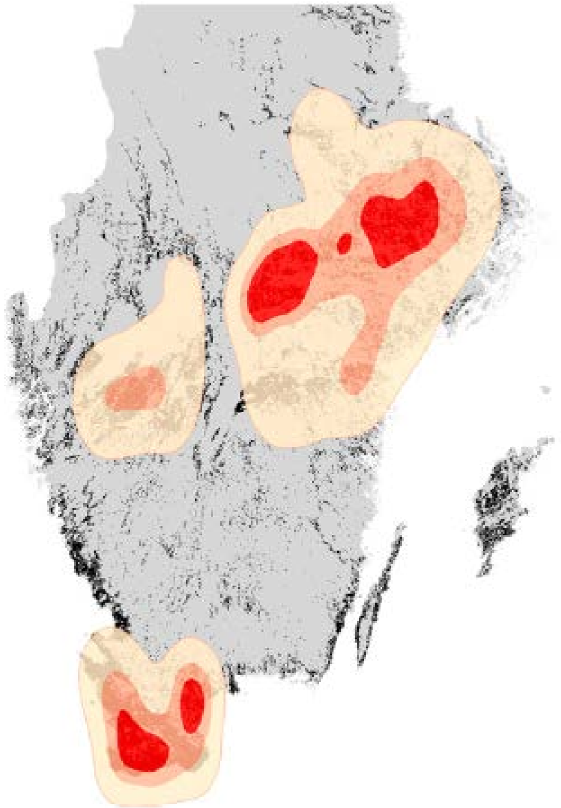

***Figure 13*. Areas with high, middle and low concentrations of willow growers (Blas Mola-Yudego & José Ramón Gonzalez-Olabarria,2010)**

The main species used is *Salix viminalis* (90-95%) (Pertuu, 1998) although new varieties of *Salix dasyclados* and hybrids of *Salix viminalis* and *Salix schwerinii* are being used in the market. (Danfors et al., 2000).

Preference of soils with pH between 5.5 and 7.5. Light, medium clays or heavy clays are suitable for SRWC[1]. They also grow well on organic soils although these are prone to weeds.

- Establishment and management

According to the Manual for SRC Willow Growers, site preparation the year before planting is very important to get rid of weeds, where gliphosato applications are common in summer and phoughing the ground during the fall.
Planting starts from March to June and the harvest is from late autumn until the spring following year (November-April). Harrowing is needed before planting at depths of 6 to 10 cm.

The planting process is done with one-year-old rods, which are prepared and stored during the winter at -4 ° C. The rods of 1.8 to 2.4 meters are cut into cuttings approximately 18 cm long, are introduced into the ground so that only protrude 2 cm. Planted a total of 13 000 cuttings per ha, with a spacing of 0.75 m between rows and 1.5 meters between twin rows

The weeds control is needed right after planting, usually applying herbicide to the soil in the following week and later on with tools or machinery during the first year. Fertilization may be required, usually with nitrogen or sludge in Sweden.
The following winter after planting, the annual shoots are cut back in order to achieve greater density with new shoots per cutting.
[1)] Short Rotation Willow Coppice (SRWC)

- Harvesting

The rotations vary between three and four years when the woody biomass reaches 25 oven dry tonnes or shoots exceed 6 cm at the base and always in winter. Mechanization includes the cutting and processing wood chips simultaneously.

The crop can last for about 25 years before the stools lose the ability to resprout, which means that about five to six cycles are completely covered.

- Production and industrial use

The production of wood chips can reach between 6 and 10 tonnes of DM per ha (Larsson & Lindegaard, 2003), corresponding to an energy value of 4-5 m^3 of oil.

SRC willow combustion can be accomplished by different methods depending on the final destination. This may be for electricity generation dedicated biomass power stations or through co-firing in coal fired power plants. SRC wood chip is also used as fuel in heating plants as well as Combined Heat and Power plants (CHP).

The wood-fueled CHP plants have been very important for the rapid expansion of bioenergy in Sweden.

Swedish industry transforms annually about 2500 ha in about 25 annual heating / power plants.

- Market and economics

The price of biomass is determined by market energy prices, in particular those fossil fuels. The price of willow wood chip was about 13 € per MWh in 2003(Stig Larsson et al.). The subsidies have had a strong influence in willow profitability and expansion in Sweden (Mola-Yudego, 2008). Nowadays the subsidy is around 560 € per ha (5000 SEK) (Ericsson et al., 2009), much less than the 19 000 SEK per ha given in the period 1991-1996 (with the specific willow subsidy and unfenced)

Hybrid aspen *Populus tremula* L.x *P. tremuloides* Michx

- History

Poplars, aspens, and alders are considered the most suitable species for SRF in Sweden (excluding willow) (Karacic *et al*, 2003; Rytter, 2004; Rytter &Verwijst, 2009; Weih, 2004). Nowadays, hybrid aspen is the one with significant development.

First trials with Poplars and Aspen in Sweden had the aim of satisfying the needs of the Swedish Match Company, where plant material from Oregon and Washington was introduced in the late 1930s (Christersson, 1996) with different clones of hybrid aspen (*Populus tremula* x *P. tremuloides*). Main Annual Increments (MAI) of 12 m^3 per ha were achieved with a maximum of 17 m^3 per ha after 25-30 years. (Persson,1973; Eriksson 1984), giving better results than the parental species.

In the 1980´s new arable land were planted with new species where hybrid aspen focus strong interest (Stener & Karlsson, 2004). In the period between 1986 and 1991 a project was carried out by the Forestry Research Institute of Sweden, where 280 phenotypically selected trees were planted in 14 different plots with rotation periods between 12 and 18 years, reaching MAI of 20 m^3 ha^{-1} $year^{-1}$ (Rytter & Stener, 2005).

15 of the 280 trees were chosen for commercial use in southern Sweden with estimated MAI of 25 stemwood ha^{-1} $year^{-1}$ (Stener & Karlsson, 2004)

Currently the extension of Hybrid Aspen plantations in Sweden is estimated in 2 000 ha, with a growth rate of 300 ha $year^{-1}$ (*Rytter* et al., 2011).

The parental species of Hybrid Aspen are *Populus tremula* and *P.tremuloides.*

P.Tremula is widely distributed in Europe and Asia while *P.tremuloides* is a native species from North America. Both species can reach 35-40 meter height and 1 meter diameter at breast height. The crossing between both of them was first described in the 1920s in Germany. (Wettstein, 1933).

Hybrid Aspen is a shade-intolerant specie, preferably well-drained fertile soils of medium texture and airy. Within the boreal climate, has a certain thermophilic character.

- Establishment and management

Soil preparation is carried out in conjunction with chemical and mechanical treatments to weeds during the first year in agricultural land.

Generally densities vary between 1 100 and 1 600 stems per ha, while densities above 4 000 stems per ha and rotations of 5 to 10 years if the crop has a main energy purpose, although this case has not been sufficiently developed in Nordic countries.

Pruning as well as one to three thinning is needed depending on the initial density and growth rate. It has been suggested also to apply the mixed silvicultural concept with a corridor cleaning and biomass attained for energy purposes, and after subsequent traditional management (Rytter, 2006).

Usually the rotations oscillate between 15 and 30 years depending on the wood destination, and can extend over 20 years for merchandable timber (Hynynen *et al*, 2004; Rytter & Stener, 2005). In those cases, 300-450 m^3 ha of pulpwood and aspen logs are obtained.

- Production and Industrial use

Usually the rotations oscillate between 15 and 30 years depending on the wood destination, and can extend over 20 years for merchandable timber (Hynynen et al., 2004; Rytter & Stener, 2005). In these cases, 300-450 m^3 ha of pulpwood and aspen logs are obtained.

The average productions of 15m^3 stemwood ha^{-1} $year^{-1}$ corresponds to 7-8 tons of DM ha a year (including twigs and branches).

- Market and economics

Economically it has been proved that hybrid aspen in Sweden can be competitive with the typical Spruce stands, with an Internal Rate of Return of 8-10% (Rytter et al, 2011). The best economic results occurred when the density is kept below 2 000 stems per ha, (1 100 ha the best). This responds to to the high plant costs and also the performance of the root suckers stands decrease due to the expensive thinning operations.

Poplar

The area of planted poplar is still low (under 1000 ha) but trials of hybrid poplars in Sweden has shown promising production figures and it has recently been one of the most interesting choice of species in Short Rotation Forestry plantations on abandoned farmland. (Hjelm, 2011)

First fast-growing poplars were established in southern and central Sweden during between 1980 and 1990 along with mixtures of hybrid aspen clones.

The plant material chosen was hybrid poplar OP 42 (*Populus maximowiczii* Henry x *Populus deltoides*, Marshall.), clones SRF 24 (of the specie *P.trichocarpa* Torry & Gray) and pure species of *P.trichocarpa* and *P.balsamifera* L. or hybrids between them and *P. deltoides.*

Planting with bare-root or 20 cm cuttings and spacing of 3 x 3 m (a few 2 x 2 m) were carried out with different thinning regimens.

MAI for these plantations varied between 10 to 31 m^3 or 3 to 10 ton DM per ha. For high biomass production, higher densities are recommended since figures showed a total production of 500 m^3 per ha in a 16-year-old stand (Christenson, 2010). Lower densities can be managed to attain better valuable forest products.

Both for pulp and bioenergy management can be achieved by dense spacing and strong thinning afterwards. In one of the stands managed with this purpose, the net economic gain was around 10 000 SEK[1] per ha in the first nine years.

Other research projects has been carried out the last years (Johansson, 2010; Hjelm &Johansson, 2012) indicating the high potential for poplar plantations on abandoned farmland in Sweden.

[1)] US$ = 7.20 SEK, 2010

4. CONCLUSIONS

The conclusions of this paper are;

Related to fast-growing plantations;

- Fast-growing plantations are widely distributed worldwide, and the rates of its expansion are becoming higher each year. Most hardwoods with rotations lower than 20 years and high yields motivate this expansion to meet demands of forest products. The main products of these plantations are pulpwood, charcoal, wood-based panels, paper and paper board for different industries, showed the increasing tendency of these forest products. In the other hand, fast-growing species for energy purposes are taking strong importance in the International agenda.

Related to the countries studied;

- In the Forestry sector, Sweden is one of the largest producers of roundwood in the world and the first in Europe (Russia excluded), with a well developed forest industry. Spain, even though is third country in forest cover in Europe, the productivity of its forests are too low due to limiting factors like erosion, poor soils, pest and diseases, irregular rainfall and forest fires. As a result, Spain has focused his efforts in promoting biodiversity, reforestation programmes and combating soil erosion.

Related to fast-growing plantations in both countries;

- The main species in Spain in this matter are *Eucalyptus sp, Populus sp* and *Pinus radiata*. *Eucalyptus sp* with more than 4 Million m^3 per year is the highest roundwood producer in Spain. Fast-growing species are manly used for pulpwood, wood-based panels or sawnwood. SRF for bioenergy purposes has a little development in the country, and some research is under way.
- Sweden is one of leaders in Short Rotation Forestry as energy crops for more than 40 years, being aware of the global need of renewable energies and mitigation of climate change. More than 16 000 ha of Willow and 2 000 ha of Hybrid Aspen are distributed along the country.

  Still small areas (under 1 000 ha) but promising production results from trials in middle and south of Sweden has made poplar to an interesting group of species in establishment of Short Rotation Forestry plantations on abandoned farmland. The studies with other fast-growing species and managed for different purposes are still limited.

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