Plantation Forests as Sustainable Sources of Products and Welfare to Society

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Abstract

Planted forests are one of the most appropriated mechanisms to provide wood and forest products to human society in the quantity and quality demanded by the different players on this world, and also performing important environmental and social missions. Intensively managed plantation forests are growing in importance and they are to become the dominant procedure to generate forest products, mainly due to the top technologies that enable them to result in fast-growth and very productive forests, with minimum impacts to the natural resources. Since they are renewable sources of forest products, they may become one of the ways to prevent further damage to the remaining natural forests in Earth, in some cases exploited by improper logging. However, sustainable and ecoefficient management procedures and certification of these plantations by reliable third party systems are vital. This chapter discusses the main advantages and missions of the planted and plantation forests to fulfill these important requirements. Several end-products demanded for citizens welfare may be enhanced and produced using the materials derived from these forests, such as pulp and paper, wood panels, furniture, saw-timber, construction wood, chemicals, charcoal and other energy-oriented products. The potential for quality and quantity improvements in these products originated from plantations are discussed in details.

Key-words: forestry, planted forests, plantation forests, wood quality, forest productivity, environmental benefits, social responsibility

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Since the early days of Mankind in Earth, the forests have provided innumerous benefits to people, offering sheltering, food supply, protection, fuel, raw materials for several products, etc. The utilization of forest products by human society has ever been an important feature from past to now-a-days' economy. There is a great variety of consumption products based on the utilization of trees, including paper, wood panels,

furniture, housing materials, fuels, chemicals, etc. There is no doubt that forests are powerful drivers in widening economic and social activities.

For centuries, the natural forests were the main supplier of raw materials to the manufacture of industrial products derived from the wood, bark, leaves and other components from trees. However, two major factors have influenced the need to obtain trees from other sources: human population growth (and consequent consumption) to dramatic levels and the impossibility to obtain all forest products by extraction from these natural sources, due to depletion of this kind of forests as a function of intense and in many cases, irresponsible harvesting, without subsequent reposition.

Planting forests have deserved increased attention for several reasons, but the most important are:

- They are the best available solution to provide forest raw materials to society in an environmentally friendly approach;
- They offer improved production yields and uniform quality in the products;
- They enable reduction on overall costs, even considering the high costs of implementing the new forest stands;
- They may be planned according to the consumption needs in terms of geographical locations, distances, timing, quality and quantity of commercially-oriented products, etc.
- They may use different species, clones or genetic materials adapted to the most varied conditions of climate, soils, locations, wood/timber quality requirements, etc.

In general, there are two main types of planted forests: those oriented to environmental conservation purposes and those destined to commercial utilization of wood or biomass.

In the first case, the planted forests have the aim to improve or to rehabilitate the quality of a fragile or degraded site, as function of intense land use. In other cases, the conservation or protective forests may be planted to improve some environmental conditions such as the quality or availability of water in a natural watershed, or the quality of a soil degraded by erosion, or as a barrier to strong winds, or as a measure to avoid extinction of an depleted forest species, etc. In some cases, the protective planted forests may also combine recreational utilizations in the format of natural parks.

In recent years, the increased area of planted forests for productive purposes has been associated to their ability to fulfill economic, social and also environmental benefits. The commercially-oriented plantation forests have as main purposes the production of industrial raw materials to be supplied to certain manufacturing industries; or to offer large quantities of biomass to be used as fuel or converted into derived fuels. As examples of the first option, there are thousands of industrial plants in the world using materials produced by the planted forests to manufacture: pulp and paper, wood panels, saw-timber, veneers, plywood, furniture, housing construction

materials, etc. Energy-oriented biomasses coming from planted forests generally go to production of charcoal, firewood, pellets, briquettes, fuel gases, alcohols, etc. The today's development of biorefineries associated to several traditional forest products is enabling widening opportunities to the forest-based sector, more specifically to the one supplied by the materials produced by plantations.

In accordance to FAO – Food and Agriculture Organization of the United Nations, the world planted forests occupy close to 291 million hectares on area (in 234 countries and territories), equivalent to about 2% of Earth's available land and close to 7% of all types of existing forests. 75% from these planted forests were established on the basis of producing wood or non-woody products (fruits, seeds, oils, etc.), and 25% with exclusive natural resources protective purposes. Planted forests may be referred both to the intensively managed plantation forests using homogeneous forest trees, or the forests of indigenous species with original low density in tree population and that have been enriched by direct seeding or planting of additional seedlings for population densification. Planted forest may also include multiple-use plantings for commercial and non-commercial use. The planted forests may be established based either in mixtures of species or monocultures with a broad range of management intensity and purposes. Based in the way these forests are planted and managed, they are able to supply wood (and biomass fuel), non-wood forest products and many of the environmental services provided by the conventional natural forests.

The importance of the economic, social and environmental issues with regard to planted forests has been acknowledged in international forums organized by credible and renowned organizations, such as: FAO – Food and Agriculture Organization of the United Nations; ITTO – International Tropical Timber Organization, CIFOR – Center for International Forestry Research; IUFRO – International Union of Forestry Research Organizations; and many others. These issues were reinforced by commitments presented in the UNCED Declaration of Forest Principles in 1992. Proposals for actions on sustainable forest management were strengthen by the Intergovernmental Panel on Forests, the Intergovernmental Forum on Forests, the United Nations Forum on Forests and the UN Millennium Development Goals. These proposals had as vital consequences the creation of forest certification initiatives, mostly of them in mid-1990's, in schemes also dedicated to plantation forests.

Today, it is widely accepted that planted forests are able to fulfill several functions to benefit social, economic and environmental issues when considering the demands of world human society in the road to the future. The main functions expected to be fulfilled by planted forests are the following:

- Protection of world natural forests in two ways: significant production of forest goods that may partially replace the utilization of products extracted from natural forests under improper logging; and, rehabilitation of thin and sparse natural forests to guarantee a mosaic design in the establishment of plantation forests;
- Reduction on the utilization of land area to provide forest products to supply human society needs;

- Utilization of areas that have been previously exhausted by agriculture is by far the most recommended practice to grow forests and to protect the soil, prevent erosion and preserve water resources in such lands;
- Intense and organized production of high quality wood and/or forest biomass at low cost;
- Production of non-wood goods and services, such as: tannins, cork, essential oils, fruits, seeds, latex, gums, leisure, recreation, etc.;
- Maintenance of the long-term productive ability of the land;
- Protection and enhancement of biodiversity, when plantations are combined with other natural resources areas in a type of mosaic architecture or design;
- Recovery of degraded lands (the ones previously and exhaustively used for agricultural purposes) and those in process of desertification;
- Contribution to complement the beauty of the local landscaping, by showing a more diverse design than the monotony of the cultivation of large areas with a single type of forest species;
- Protection and improvement of water quality and regulation of hydrological water flows are some of the important environmental services that planted forests may offer. However, the ecological planning prior to establishment of the plantations is fundamental to avoid opposite effects.
- Mitigation of green-house effects due to absorption of carbon dioxide to be converted and stored as organic compounds by trees;
- Protection and contribution to local weather attenuation and stabilization;
- Offer of an efficient and renewable source of energy products;
- Production of oxygen through photosynthesis to maintain the equilibrium of the atmospheric gases composition;
- Important and significant social and economic contributions: energizing and diversification of regional economies; partnership with society through shared forest projects, generation of wealth, surplus production to exports, industrial growth, government taxes; generation of jobs; labor safety, reduction of poverty; social responsibility, etc.;
- Offer of new opportunities to small and medium sized rural farmers;
- Intense utilization of clean and minimum impact technologies and based on the fundamentals of ecoefficiency.

Taking all these points into consideration, it is clear that planted forests are not just efficient production units of low cost raw materials to forest products manufacturing or to fuel energy-oriented plants (power, steam and heat). They are living collections of elements in constant dynamic interaction with the biotic and abiotic resources. They are able to perform, as well, economic, environmental and social functions, without opposing the principles of sustainability. The context in which planted forests are inserted and their benefits in response to local conditions will be different and may vary case-by-case. It should not be expected that planted forests will be performing the same functions of old-growth natural forests, since they are

conceptually different. It is better to consider planted forests as sustainable and renewable supply of goods and services demanded by society on an increasing scale and at global level.

Intensively managed planted forests with productive purposes are usually referred as plantation forests. They are planted and managed similarly to agricultural crops, with intensive utilization of genetics (tree breeding), chemicals (herbicides, fertilizers, insecticides, etc.) and automation/mechanization for planting, managing, harvesting and logistics. Considering just the areas planted with forests in such model, a recent study contracted by FSC - Forest Stewardship Council (INDUFOR, 2012) estimated a world area of 54.3 million hectares of plantation forests in this specific year. The projections of the study indicate that this area will double till the year 2050. Close to 75% of the plantation forests are located in just ten countries: USA, China, Brazil, India, Indonesia, Chile, New Zealand, Australia, Japan and South Africa. Other important and with great potential plantation forests producers are: Uruguay, Argentina, Spain, Portugal, Angola, Mozambique, Canada, Colombia and Venezuela. No matter the country, the majority of the plantation forests are been established in the basis of similar and few *geni* of trees: *Eucalyptus*, *Pinus*, *Acacia*, *Pseudotsuga* and *Populus*. Another common feature of the commercially oriented plantation forests is the care with proper environmental conditions. Today, the great percentage of plantations are certified according to reliable third party principles and criteria defined by FSC – Forest Stewardship Council or another national system endorsed by the PEFC – Programme for the Endorsement of Forest Certification Schemes.

In spite of all cares, it should be clear that any intensive activity will generate impacts, even when dealing with natural, planted and plantation forests. However, these impacts can be minimized, when adverse, and maximized when positive. Moreover, there is always the need to seek for a balance between the economic demands of society and the environmental, social, cultural and anthropological issues. Therefore, dialogue among stakeholders will grow in importance in the processes of decision making on all kind of forest production and utilization for commercial purposes.

Independent certification schemes of sustainable forest management and other voluntary mechanisms for proving or to provide evidence of corporate responsibility (ecolabels, certificates of environmental management, corporate social responsibility, health and safety at workplace, etc.) should grow in importance, as instruments of access to green markets and qualifying the planted forests in the attendance of their socio-economic and environmental requirements. In several countries, more than half of the forest plantations are voluntarily certified; in others, almost all are certified. It is estimated that soon, more than 80% of all industrial wood coming from plantation forests will be certified by reliable systems. Also, industrial products from certified forests in the chain-of-custody mechanism (paper, pulp, panels, etc.) will find new other volunteer systems to prove their environmental suitability along their life cycle, including those recognized as very effective environmental instruments, such the type I ecolabels.

Thanks to science and technology, a great number of innovations have been placed on this field, leading to improvements in productivity, product quality and environmental sustainability. New productive opportunities have been created to agriculture in combination to forestry (agroforestry models). Considering these planted forest models, technological development on plantation forestry with exotic and indigenous tree species will be strongly demanded either by companies that are currently accessing other sources of wood and biomass, or by small and medium-sized producers to whom it is important to have diversification of species in their agri-businesses. Due to all these economic, environmental, social and cultural dimensions, plantation forests will continually grow in importance. They are to have planning, planting, managing and harvesting systems tailored to balance all the requirements imposed by producers, consumers and interested parties of the society. Eco-physiological models and precision forestry - as today adopted by several forest-based companies - are available to integrate this novel way of doing things regarding the productive functions of plantation forests and to guarantee the minimum impacts to the environment.

As far as plantation forests are renewable resources, they are considered as key players in the low-carbon economy (green economy), the one based in the reduction of fossil fuel consumption and maximum utilization of renewable sources of goods to offer better level of sustainability to human society.

Plantation forests are a legitimate form of land use. In many countries and regions, they are vital options for production and/or to environmental protection. The expansion of plantation forests is projected to occur mainly in tropical countries, due to their comparative advantages. Probably, this expansion in area will be based on the most frequent species being planted and managed today to supply timber, fuelwood, biomass and other forest products for commercial and industrial utilization: pines, eucalyptus, acacia, poplar, Douglas-fir, teak, cypress, willow, rubber tree, araucaria, platanus, sweetgum, etc. Although not usually been referred as forest species, other plants that are also established in extensive areas, such bamboos and palms are also expected to grow in importance.

In a world scale, plantation forests are becoming the most attractive business selection to produce wood and biomass to supply several types of industries, such as: pulp and paper, wood panels, saw-timber, charcoal and firewood. For each of these final products, it is possible to combine high forest productivity either in volume of wood or weight of biomass, with high quality in the products derived from the plantations.

The quality requirements vary from one destination to another. The production of charcoal or other energy oriented wood or biomass utilization depends on the following quality requirements: high values for calorific power, lignin content, wood density and low moisture content. On the other hand, the production of saw-timber demands for timber with excellent dimensional stability, softness to be processed by machines and strength in the final products to resist utilization. Wood panels also have specific demands: wood density, moisture content, ash content and cleanliness.

The pulp and paper sector is probably the one with more studies and achievements in obtaining successes with regard to the desired quality requirements in wood and the high productivity in the forests. The quality also depends on the type of market pulp or paper being manufactured. There are several industrial processes to manufacture wood pulp and two major fiber products demanded by the markets: long (softwoods) and short fibered pulps (hardwoods). In all cases, the wood must have appropriate wood density, low lignin content, high conversion pulping yield from wood to pulp, and to offer fibers that provide desired final qualities in the paper being manufactured. Since papers are different in basis weight and final qualities according to their utilizations, the plantation forests are developed and managed to fully comply with these requirements. The first and the most desired is forest productivity, since it is the one that brings economic success to the business. Productivity is associated to tree breeding through appropriated genetic improvement of seedlings, genomes and to silvicultural practices and management interventions (fertilization, irrigation, pest control, site selection, etc.).

Mostly frequently, there are two usual forest management systems: full-harvesting (clear-cutting) of the forest at a given age, depending on the proper combination of productivity and wood quality; and thinning of trees from forest to manufacture pulp or wood panels (as most common examples), and a final harvesting in a forest age that may offer higher volume in the individual and remaining trees, being the wood oriented to high-value products obtained by mechanical processing of the logs.

The wood harvested from these genetically improved and well managed plantation forests combines all the specifications aimed by marked and forest producers: low unit production costs ($/m³), high productivity, easy harvesting, excellent wood quality and amazing homogeneity. In most of the cases, they are single species planted forests, in a different model in relation to the natural forests, which are multi-species forests, with a much wider variation in quality among trees and woods. In the case of eucalyptus and poplars, the model is even more specific, with the implementation of clonal plantations. Very often, these plantations are established based on a single clonal material, what confers amazing uniformity and highly specific quality to the harvested trees. Although the advantages being achieved now-a-days, there are indications that they are still far away from the real benefits accruing from the fast-growing forests. These forests were developed thanks to enormous investments and dedication in scientific and technological studies and researches. However, there are new technological roads being paved, thanks to the increment in the utilization of new biotechnological tools: genomics, genetic engineering, development of dedicated and specific clones with more tolerance to pests/diseases and to stress conditions (weather and soil); and many other opportunities.

Thanks to the today achieved scientific developments, plantation forests are being able to grow in rates approaching 35 to 55 cubic meters per hectare per year in the leading producing countries, offering marvelous growth and productive figures at early

ages (from 5 to 12 years, depending on management conditions and oriented products). There are golden and marvelous plantation forests providing excellent raw materials in quantity and quality to the industry. The economic advantages are combined to the fact that the required area to obtain a given volume of wood is significantly smaller in a plantation forest than in a natural forest managed to supply industrial wood. A single hectare of eucalyptus plantation forest harvested at age 6 or 7 years in Brazil can offer to a kraft pulp mill the equivalent production of 10 to 15 tons of pulp per year of growth, enabling the possibility of construction of industrial pulp plants with annual capacity of 2 million tons in the same geographical site. As far this type of industry is very dependent on production scale, this fact may be considered the reason that pulp industry is moving from the traditional North Hemisphere countries to South, in the tropical areas where plantations may be successfully installed as sources of wood. For these reasons, powerful world corporations of the forest business are being born or moving to South Hemisphere, building new greenfield units in different countries for manufacturing different products, as market pulps, wood panels, biomass pellets, etc. Some of them are also oriented to produce wood or biomass to export in the format of chips or logs. It is a new and turbulent world, which is growing thanks to plantation forests.

The high performance plantation forests have received a great support from science in the past 50- years to find the required technologies and to reach this present position. New gains are expected to happen on the following years to come, thanks to genetics, biotechnologies, improved silviculture and harvesting operations and the new opportunities in management and automation/mechanization.

The most expected gains are to be situated in:

- Improved engineering of growing trees (more concentration of wood formation in tree stem, with reduction on the proportion of bark, branches, roots, leaves, etc.);
- Enhanced distributions of trees in the land area to improve the role of the ecological mosaic, in combination to forest harvesting age and final products qualities.
- Engineering of individual trees with higher volume and weight at the harvesting age. This is a vital development to reduce the number of planted trees per unit area, and to reduce all associated costs on planting and harvesting.
- More efficient genetic materials (in general, clones obtained by hybridization or single species selection), for the proper utilization of the natural resources such as water, nutrients, light, etc. In some extent, these new developments demand for better understanding of forest tree physiology, anatomy and chemical composition (photosynthesis, nutrients utilization, cell-wall formation and engineering, wood/water relationships, etc.).
- More adapted genetic materials to stressing conditions (droughts, hydrological deficits, frosts, pests, diseases, etc.);

- Increased speed to develop new genetically improved trees and to discover new potential genes, thanks to genomics, genetic engineering, biotechnological tools, etc.;
- Increased understanding on new agroforestry systems to improve the production of wood and forest products by rural farmers;
- Improved coppicing techniques with regard some species that have this significant plant advantage (*Eucalyptus*, *Acacia*, *Populus*, etc.);
- Improved potential of the plantation forest to supply multiple products, widening the scope of this type of forestry;
- Significant improvements in technological, management and forest operations: seedling production, irrigation and fertilization, biological control of pests and diseases, nutrient cycling and nutritional balances, mechanical harvesting, forest wastes reduction and recycling, soil conservation, soil microbiology and interactions with trees (mycorrhiza and rhizobium), etc.
- Production of more uniform and specific wood to improved performance in industrial converting processes (single manufacturing process or multiple, as in the case of biorefineries). As consequence, these developments will lead to the reduction on specific wood consumptions and better integration in the forestry clusters. Other projected benefits are: reduction in the need of planted area to supply raw materials to the converting industrial plants; the reduction on forest wastes due to better utilization of forest biomasses by the forest clusters.
- Production of better wood quality according to end product needs (tailoring raw materials to the final products based on customers' viewpoints); etc.

Economically speaking, tailor-made trees plus forests and the proper utilization of the derived raw materials in the most appropriated industrial plants continue to be one of the main issues in the search for future gains. The specifications for the wood, bark or other products from the forest will depend both on the end use and on the available converting systems. For these reasons, there will not be a universal wood or forest product quality, being the quality and the specifications dependent on the end-use and in the limitations and bottlenecks of the industrial converting units.

Continuous efforts are also being placed on the development of wood and biomass quality parameters, and these improvements are focused in each group of forest end-products, as the following example, to illustrate how things are going on:

- *Pulp and paper quality parameters in continuous development*: wood lignin content, syringyl/guaiacyl ratio in lignin composition, wood basic density, hemicellulose and cellulose contents, pulp yield, pulp bleachability, wood specific consumption/ton of manufactured pulp or paper, fiber population in screened pulp, fiber coarseness, pulp sheet and individual fiber strengths, paper bulk, paper opacity, paper softness, paper porosity, water absorption value, etc.;
- *Wood panels quality parameters in continuous development*: wood basic density, bark content in wood, wood strengths, wood moisture, etc.;

- *Saw-timber quality requirements in continuous development*: dimensional stability, wood basic density, wood strengths, wood defects, wood color, resistance to pests attacks, etc.;
- *Energy-oriented forest biomasses requirements being developed*: lignin content, wood basic density, ash content, moisture content, calorific value, yield in conversion to gas, charcoal, etc.;

Today, competitiveness in forestry is not only an issue of economic growth, product specifications and production costs, but a wide and wise combination of social, environmental and economic and productive features.

Substantial growth in the needs coming from society will necessarily be expected and projected; and these products are to be provided by new and better forestry models, including planted and intensively managed plantation forests. This is a new and magnificent forestry world, no doubts about. It is just a question of making it happen.

Bibliography:

1. Foelkel, C. (2006). *Eucalyptus* tutorial TAPPI 2006. TAPPI – Technical Association of the Pulp and Paper Industry Tutorial. 75 slides. Atlanta. Available in: http://www.celso-foelkel.com.br/artigos/Palestras/Technical%20Development%20%20-%20Plantation%20Forestry%20_LATINA%202010_Celso%20Foelkel.pdf
2. Foelkel, C. (2010). Technological development in plantation forestry: will continuous improvements in forest productivity be sustained and/or expected? A view under the *Eucalyptus* pulp industry perspective. LATINA Conference 2010. 40 slides. Sao Paulo. Available in: http://www.celso-foelkel.com.br/artigos/Palestras/Technical%20Development%20%20-%20Plantation%20Forestry%20_LATINA%202010_Celso%20Foelkel.pdf
3. Garlipp, R.C.D., and Foelkel, C. (2011). The role of planted forests for meeting the future demands from world society. Eucalyptus Newsletter Edition Number 32. Available in: http://www.eucalyptus.com.br/newseng_jan11.html#quatorze
4. INDUFOR…Forest Intelligence. (2012). Strategic review on the future of forest plantations. Forest Stewardship Council (FSC). 121 pp. Helsinki.
5. FAO – Food and Agriculture Organization of the United Nations. (2015). Global forest resources assessment. Desk reference. 253 pp. Rome.
6. Keenan, R.J., Reams, G.A., Achard, F., Freitas, J.V., Grainger, A., and Lindquist, E. (2015). Dynamics of global forest area: Results from the FAO Global Forest Resources Assessment 2015. Forest Ecology and Management 352 (September: 09 – 20.
7. Lungo, A.D., Ball, J., and Carle, J. (2006). Global planted forest thematic study. FAO – Food and Agriculture Organization of the United Nations. Planted Forests and Trees Working Paper 38. 178 pp. Rome.
8. MacDicken, K.G. (2015). Global forest resources assessment 2015: What, why and how? Forest Ecology and Management 352 (September): 3 - 8.