ForHeal Forestry Higher Education Advancement in Laos

Co-funded by the Erasmus+ Programme of the European Union

Forest Plantations in Tropics

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Plantation foresty in Tropics and Subtropics

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Content

- General situation
- Criticism
- General management principles
- Perspectives
- Some important species

Plantations - definition

- Forest stands established by planting and/or seeding in the process of afforestation (planting in areas where there have never been trees before, or more than 50 years before) or reforestation (replanting in areas previously supporting natural forest, or within 50 years after deforestation)
- FAO: forest plantations consisting of introduced or indigenous species which meet a minimum area requirement of 0.5 ha, tree crown cover of at least 10% of the land and total height of adult trees above 5 m (Syn.: human-made forest, artificial forest)

- Plantations amount to 3.8% of total forest area in 2005, 7.0% in 2010, 7.2 in 2015
- In 2000 plantations supplied about 35% of global roundwood (2020 – 44 %)
- In 1995 tropical and subtropical plantations comprised 45% of the global net plantations area (57% of TS plantations covered by hardwoods)

Including species as *Tectona grandis, Swietenia macrophylla, Dalbergia spp.* (valuable luxury hardwoods)

Table 3.2. Planted forests sub-group in the continuum of FRA 2005 categories.

		Planted forests subgroup		
			Plantation	
Primary	Modified natural	Semi-natural	Productive	Protective
Forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed	Forest of naturally regenerated native species where there are clearly visible indications of human activities	**Assisted natura regeneration** th ough silvicultural prac ces for intensive management • Weeding • Fertilizing • Thinning • Selective logg ng	**Planted component** Forest of native species, established through planting, seeding, coppice	Forest of introduced species and in some cases native species, established through planting or seeding, mainly for *production of wood or non-wood goods*	Forest of native or introduced species, established through planting or seeding, mainly for *provision of services*

(FAO, 2006c)

(Evans 2009)

FIGURE 7
Characteristics of the world's forests, 2010

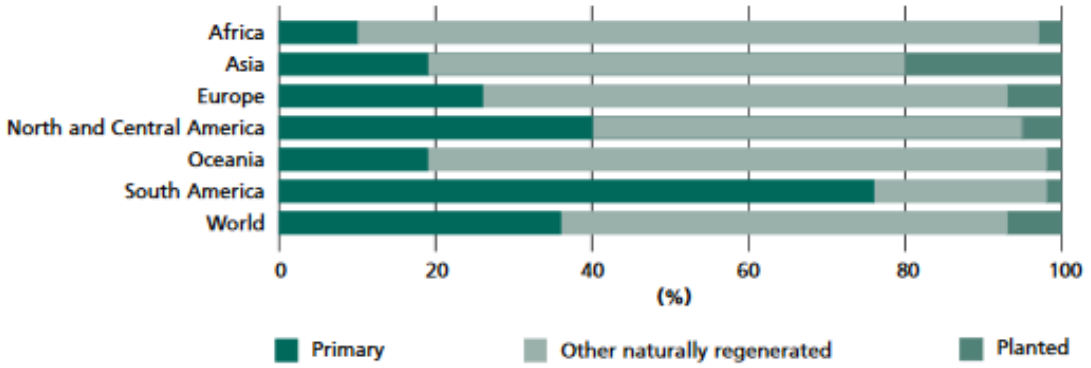
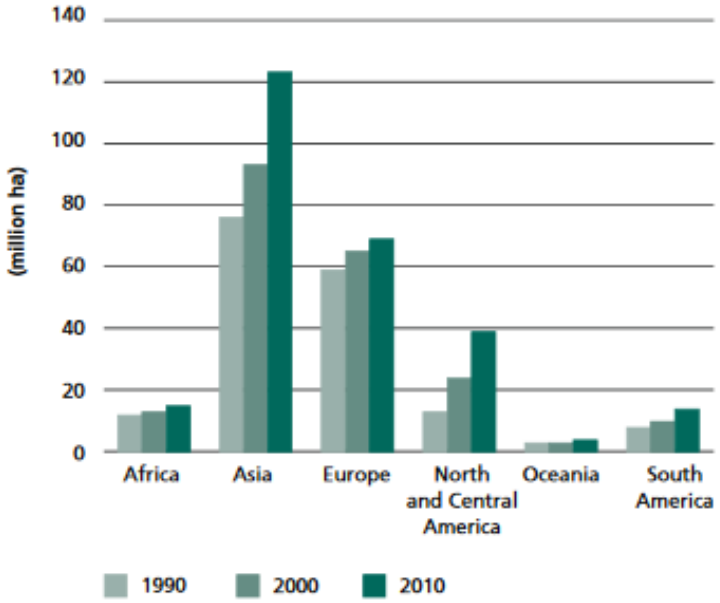


FIGURE 8
Trends in area of planted forests, 1990–2010



Forests and trees are planted for many purposes and make up an estimated 7 percent of the total forest area, or 264 million hectares.

Between 2000 and 2010, the area of planted forest increased by about 5 million hectares per year (FAO 2010).

Criticism

- Lack of environmental and social sustainability
- Deforestation of natural forests in order to establish plantations

X

- Governments – 50%; Multination companies 17%; small owners 33%
- Frequently certified (FSC, PEFC)
- Plantation conservation benefit

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Do timber plantations contribute to forest conservation?

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ABSTRACT

For some time there has been a proposition in forestry and nature conservation disciplines that timber plantations can potentially support natural forest conservation outcomes when wood logged in extensive natural forests is substituted by wood production from smaller areas of intensive timber plantations. Here, we have called this the *plantation conservation benefit*. We review evidence from the literature of this intuitively appealing proposition, both empirical and theoretical, and add emphasis on methods (theoretical modelling, econometrics and descriptive statistics) in order to explicitly address causative mechanisms and potential negative or positive feedback processes. This understanding is critical to developing effective policy. We find a convergence of conclusions of reduced degradation of natural forests associated with the expansion of timber plantations, but also potential increased deforestation due to either lower market value of natural forests in the absence of logging, or displacement effects. Yet, a main limitation of studies is the lack of consideration of the role of policies and institutions beyond market drivers, especially in econometric studies. We conclude on the need for integrated policy approaches applied simultaneously to both natural forests and plantations to maximize the potential benefit.

Management principles

- Function of species genetics, silvicultural practices, site factors (climate and site)
- *Eucalyptus* and *Pinus* species dominating industrial plantations in industrial countries similar MAI of 10 – 20 m^3/ha/a (in many cases more than 40 m^3/ha/a)
- Hardwoods rather less than 15 m^3/ha/a and frequently under 10 m^3/ha/a

Generally tropical plantation must be considered as a top leage with respect to wood productivity

Example:

Eucalyptus deglupta in Papua New Guinea 3 years, H=24 m, V= 288 m3 /ha.

At the end of rotation periodo: **MAI> 90 m³ /ha·año**

Eucalyptus grandis in South Africa 30 years V> 1.000 m³

Eucalyptus plantation stand in Mexico

Same species are very site sensitive. Example: *Gmelina arborea* worldwide yields 25 m^3/ha/a, while on good sites in Costa Rica 40 m^3/ha/a

Highest production “industrial species” (tree breeding) of *Pinus* and *Eucalyptus* (hybrids of *grandis* and *urophylla = urograndis*) can be harvested after 7 years for pulp or at 15 years for sawn wood

Genetic improvements advanced by private companies

Table 2.3 Growth rates of managed forest and plantations

	Yield ($m^3\ ha^{-1}\ year^{-1}$)	Rotation (years)
Canada average	1.0	—
Siberia (Russia)	1.0–1.4	—
Sweden average	3.3	60–100
US average	2.6	—
UK average (conifers)	12	40–65
New Zealand pines	18–30	20–40
South African pines	10–25	20–35
Subtropical eucalypts	5–30	8–25
Teak plantations	4–18	40–80
Tropical hardwood plantations	25–45	8–20
Tropical pines	15–45	8–30
Tropical eucalypts	up to 70	7–20
Tropical high forest (managed)	0.5–7	—
Southeast Asia dipterocarp forest (managed)	up to 17	—

Source: Modified from Wood (1975).

(Evans y Turnbull 2004)

Tendency in plant breeding is to select for individuals with few desirable characteristics (aimed at production):

- Rapid growth
- Good form

Often neglected characteristics are:

- Large roots (stability)
- Efficient association between roots and mycorrhizal fungi
- Production of root exudates
- Resistance to diseases
- Allelopathic repression of other plants

Rotation period

- Influencing end-use and economics
- Short rotations mainly for pulp wood or fuelwood

Example from Kenya: *Eucaliptus grandis*

- 6 years for domestic fuelwood
- 7 – 8 years for telephone poles
- 10 – 12 industrial fuelwood

- High value saw logs usually longer rotation period (in general 25 years minimum, often more than 50 years)
- Pines – medium length rotations 20 – 30 years

Note: Rapid growth can negatively influence the wood quality (density) – important for saw wood and valuable hard woods

Mean anual increment of selected plantation tree species in conditions of Colombia

Departamento donde se localiza la plantación	Especie arbórea	Incremento medio anual (m³/ha/año)	Turno (años)
Antioquia	*Cupresus lusitanica*	20-30	18-22
Caldas	*Pinus patula*	20-35	18-20
Cauca	*Pinus oocarpa*	12-35	15-25
Córdoba	*Tabebuia rosea*	18-20	20-25
Costa Atlántica y Magdalena medio	*Tectona grandis*	15-25	25-35
	Pachira quinata	10-16	25-30
Magdalena	*Eucalyptus tereticornis*	12-15	7
Nariño	*Alnus jorullensis*	18	16-20
Norte de Santander	*Gmelina arborea*	19	12
Santander	*Schizolobium parahybum*	17-24	15-18
Orinoquia	*Pinus caribaea*	15-30	18-20
Tolima	*Cordia alliodora*	20-25	18
Valle del Cauca	*Eucalyptus grandis*	25-35	7

Fuente: *CONIF. 2003.*

Source: Manual de plantaciones Forestales. CONIF, Serie de documentacion No. 46. 2002.

ForHeal

Sustainability of forest plantations

- Relative tree tissue nutrient concentrations are : foliage > branches > stems
- Branches and foliage summed together represent only 25 – 35% of total tree biomass, but they represent 50% of total aboveground tree nutrient content

= Leaving branches and leaves on the site reduce the nutrient loss by one half

- Avoid site preparations reducing the soil fertility
- Avoid removal of whole trees
- Avoid burning since N - nitrogen can be lost by volatilization before being incorporated into the soil
- Use of native trees helps preserve genetic diversity and serves as habitat for local fauna, nevertheless many limitations

Plantations of Native Tree Species

Advantages

- Better adaptation to local environmental conditions
- Seeds are locally available (at least theoretically)
- Local people are familiar with them and their uses

Disadvantages

- Uncertainty of growth rates and adaptability to soil conditions other than those where naturally found
- Lack of guidelines for management
- Lack of genetic improvement and large variability in performance
- Seeds not commercially available
- Pests and diseases
- Lack of established markets

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Can native tree species plantations in Panama compete with Teak plantations? An economic estimation

Verena C. Griess · Thomas Knoke

Received: 7 January 2010 / Accepted: 2 June 2010 / Published online: 12 June 2010

Abstract Panama has the highest rate of change in the area of primary forests within Central America. However, to meet growing timber demands, it became popular over the last decades to establish plantations made up of foreign species such as *Tectona grandis* or *Pinus* spp. In the majority of the cases the species used are well known; their characteristics such as growth performance have been reviewed intensively and can be accessed in numerous publications. Characteristics of Panama's native tree species of commercial relevance such as *Hieronyma alchorneoides*, *Swietenia macrophylla* and *Terminalia amazonia* are largely unknown and have been investigated within the study at hand. Using valuation methods of financial mathematics, the competitive position of these three indigenous species was assessed, the results compared to those of *T. grandis* stands in the same area. Land costs and taxes were not considered, as they would be the same for all species. Financial estimates for indigenous species will enlarge their acceptance for use in reforestation and plantation projects. Using the NPV method and applying the standard scenario, the profitability of *T. grandis* is lower than that of *T. amazonia* and *S. macrophylla* and lies only slightly above the profitability calculated for *H. alchorneoides*. This result clearly indicates that the investigated native tree species are comparable with *T. grandis* regarding their economic profitability. Besides its ecological impact, growing native tree species is now also economically legitimate. By calculating land expectation values for all tree species, ideal rotation lengths could be determined. For these species, considerable flexibility exists regarding the optimal rotation length.

Mixed Species Plantations

- Species diversity can contribute to protection against pests and diseases in plantations such as those of cedar and mahagony
- In monocultures main interaction is competition for main growth factors
- Differences in utilization of resources may lead to higher production in mixed plantations

Arguments for mixed plantations establishment are both of ecological and economical nature

Table 1: Basic descriptive characteristics for heights for groups of clones

Group	Clones N	Valid N	Mean	Minimum	Maximum	SD	CV
A	6	139	3.10	1.5	8.1	1.1422	36.8283
P	14	320	3.11	1.4	8.2	1.1643	37.3890
R	35	984	3.44	1.4	8.5	1.4747	42.8241
S	24	538	3.26	1.4	7.6	1.2902	39.5363

Boraginaceae

Cordia alliodora

Natural distribution from northern Mexico to Northern Argentina

In lowland tropical regions trees may reach over 40 m in height and over 1 m d.b.h. at overmaturity

Variety of ecological conditions (600–6000 mm precipitation)

Does not support water logged soils and shadow

Cordia alliodora

Wood used for:

- Construction
- Furniture
- Flooring
- Veneer
- Turnery
- Carving

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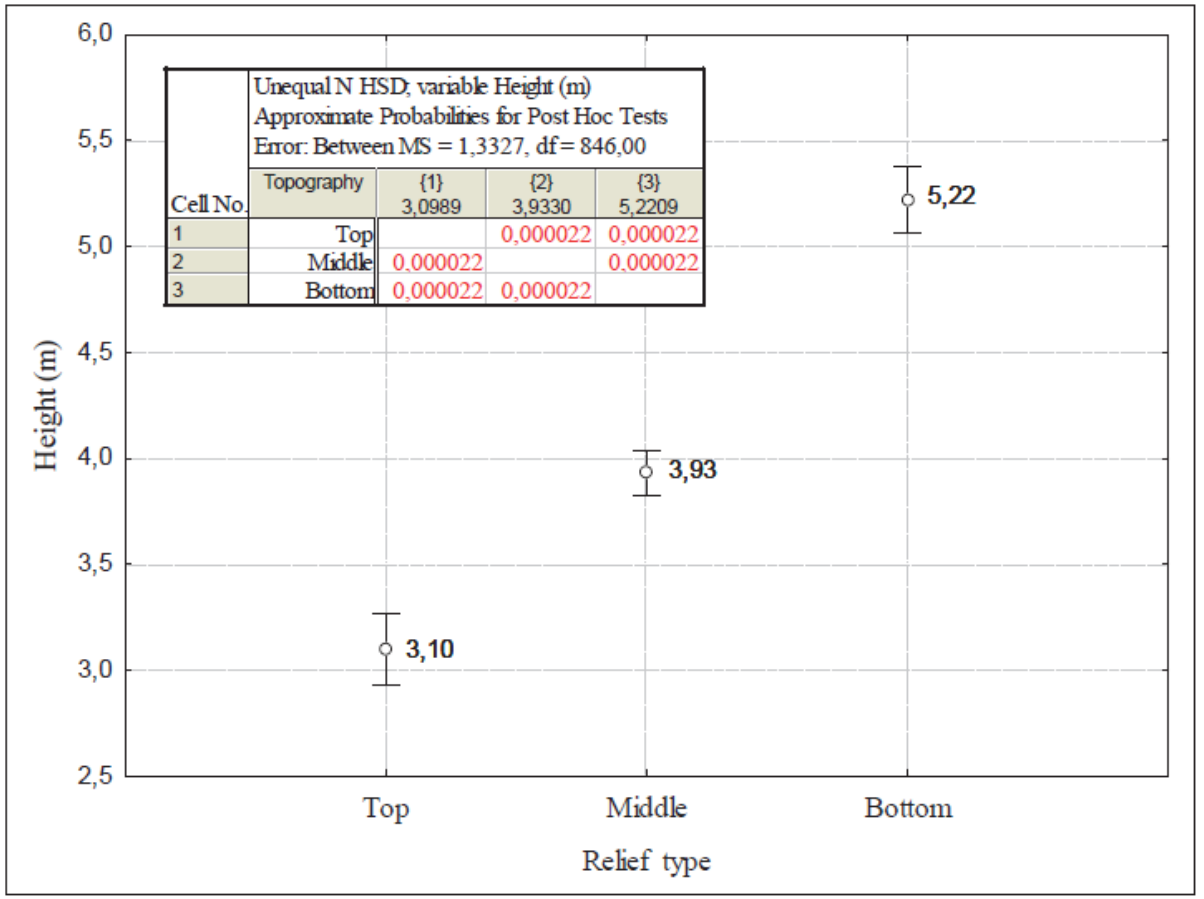
Figure 4: ANOVA and Tukey HSD test: analyses of variance of tree heights on different relief types



Diversity as a defense against plant disease

- Mahagony shoot borer (*Hypsipyla grandella*) – American tropics, *Meliaceas* (cedar and mahagony)
- Larvae bore into the stems and terminal shoots of young plants
- Pure plantations suffer severe attacks
- Approaches of control: biological control, genetic engineering, systemic chemicals
- Wide spacing with native species and agroforestry may be effective way (combining previous approaches)

Figure 5. Tallo de caoba antillana partida para revelar larva de taladrador de las meliáceas, *Hypsipyla grandella* (Zeller). Credits: Jim DeFilippis, University of Florida

Figure 1. Taladrador de las meliáceas, *Hypsipyla grandella* (Zeller), polilla preservada en alfiler. Credits: L.J. Buss, University of Florida

Figure 3. Taladrador de las meliáceas, *Hypsipyla grandella* (Zeller), larva. Credits: FW Howard, University of Florida

Economical effects and safety of production

- Diversification of investments and safegurad against pests and diseases
- Greater variety of wildlife, higher landscape diversity
- Technical difficulties of establishing and managing (more complicated design and management)
- Mixed plantations used in forest restoration projects

Usefull links:

- https://videoportal.uni-freiburg.de/category/video/Michael-Scherer-Lorenzen-Tree-growth-in-mono-and-mixed-cultures/215108baabc69ef0288852a83d60a360/61
- https://www.youtube.com/watch?v=FvkUYSDTcME

- Plantations support fewer native wildlife than native forest but they often support more diversity than other land uses
- Plantations also support a greater diversity of native plants in the understorey
- Variety of management systems can be used to increase the diversity of plantations (shade tolerant species in understorey, light demanding in overstorey, forest remnants, biocorridors etc.)

Potential negative effects on soils should be concerned

- Soil acidity (under pines)
- Decrease in water yield downstream (plantations of Eucalyptus on riverside)
- Danger of fire (fuel accumulation under eucalyptus)

- In other cases eucalyptus plantations can improve soil conditions by humus accumulation (degraded savanna) – return of natural vegetation and wildlife
- Carbon sequestration
- Economic growth
- Social functions (income, employment) – case of China, Japan and South Korea supporting investments in medium and long-rotation plantations

General management principles in plantations

- Selection of site and of appropriate tree species
- Site preparation, fertilisation, meliorations and forest establishment
- Weed control
- Pruning
- Thinning

- Selection of nursery stock (clones, seeds, mixed origin …)

- Density:

  3 x 3 m = 1111 ind./ha

  4 x 4 m = 600 ind./ha max.

  2 x 2 m = 2500 ind./ha min.

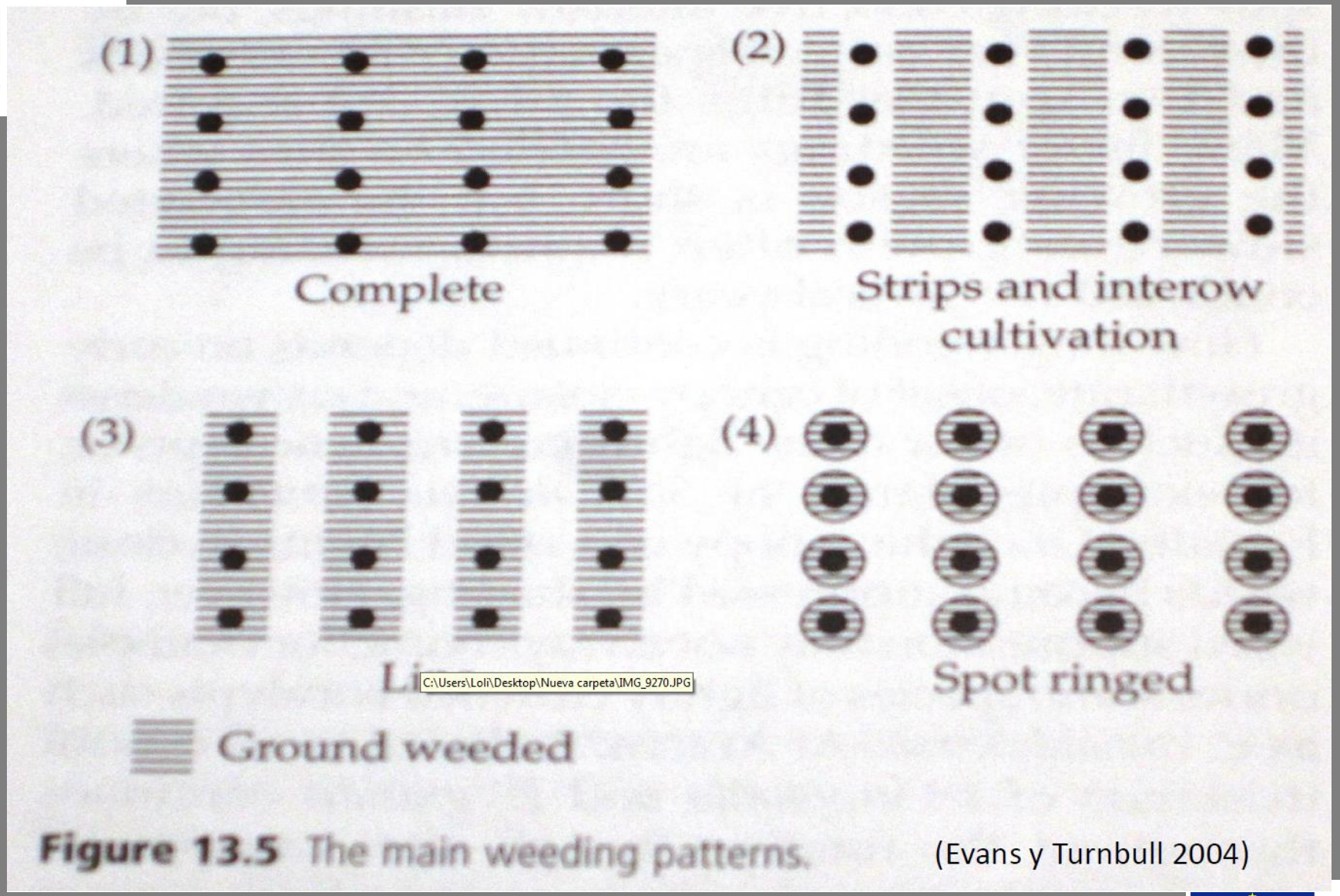


Figure 13.5 The main weeding patterns.

(Evans y Turnbull 2004)

Pruning in Teak plantation

***Gmelina arborea* plantation – 3 years old**

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Useful links to dendrology:

- http://database.prota.org/
- http://www.hear.org/
- http://www.worldagroforestry.org/
- http://www.worldagroforestry.org/sea/Products/AFDbases/af/asp/Search.asp (direct link to the database)
- http://www.rngr.net/publications/ttsm

Araucariaceae (around 18-21 species)

Primarily the southern hemisphere range. Almost all found in rainforest, the principal exceptions being the montane *Araucaria araucana* of South America and the Araucaria species found in sclerophyllous maquis vegetation in New Caledonia

- SE Asia and Australia 16-19 sp.,

  2 sp. South America

Araucaria araucana

- endemitic sp. from Chile and Argentina
- In Chile harvesting prohibited
- also planted in Europe

Araucaria angustifolia

- Southern Brazil, 500-1800 meters
- Critically endangered

Wollemia nobilis - the world's rarest plant

with less than 100 adult trees, discovered 1994 in Australia – Wollemi national Park (SE Australia)

All individuals are clones

The cover. *Araucaria angustifolia*, a naturally-occurring conifer in the south of Brazil, being known popularly as pinheiro-do-Paraná, araucaria, or pine tree, nowadays is in a critical conservation stage. Photograph by Alexandre Mariot.

http://jhered.oxfordjournals.org/content/97/5.cover-expansion

Betulaceae

Alnus jorullensis

- Evergreen or semievergreesn alder
- Native: central to Souther Mexico, Guatemala, Andes
- Tolerates poor soils, short periods of sub-zero temperatures
- Light demanding species, 1000 – 3000 mm preciptitation, 2–5 month dry season
- Important plantation species, rotation ca. 16 - 20 years, spacing 3 x 3 m, MAI 12 – 18 m^3/ha/a

Bignoniaceae (Trumpet Creeper Family)

- ***Jacaranda copaia***
- ***Jacaranda mimosifolia*** (ornamental)
- ***Spathodea nilotica*** (mainly ornamental)
- ***Tabebuya guayacan***
- ***T. chrysantha***
- ***T. rosea***
- ***T. donell***
- *Crescentia sp.*

Jacaranda copaia

(= Jacaranda)

- pioneer and colonizing species
- fast-growing tree 30 m in height and 20 cm d.b.h.
- grows in formations of the wet and very wet Tropical forest (adapts to areas with a marked dry season – precip. 600 – 3000 mm)
- leaves grow in terminal bundles, erect on top of the crown

Foto: M. Böhm

Jacaranda copaia (= Jacaranda)

Foto: M. Böhm

Tabebuia donell (Guyacán Venezolano)

Native : Bolivia, Colombia, Ecuador, El Salvador, Guatemala, Honduras, Mexico

Exotic : Costa Rica, Puerto Rico

wide spacing (9 x 4.5 m); rapid growth; saw log rotation of 30 years

Erasmus+

Flowering Jacarandas (*J. mimosifolia*) in Harare - Zimbabwe

Bombacaceae

http://herbaria.plants.ox.ac.uk/adc/downloads/capitulos_especies_y_anexos/bombacopsis_quinata.pdf

Bombacopsis quinata

***Common names**: English: red ceiba, French: mahot coton, Spanish: cedro espino*

- 40 m height, d = 1 m, bole inclined to be buttressed and completely clothed with heavy prickles
- Distribution from very dry to wet tropical forests
- Altitude: 0-900 m, Mean annual temperature: 21-27 deg C, Mean annual rainfall: 800-3000 mm
- furniture, doors, window and ceiling frames, roof construction, interior panelling, particleboard, plywood and veneer

Ceiba pentandra

Ochroma sp.

Adansonia sp.

http://www.camcore.org/gene-conservation/species.php

Ceiba pentandra

http://database.prota.org

Kapok fibre: The fibre from the inner wall of the fruit is unique in that it combines elasticity and resilience and is resistant to pests, to make it ideal for stuffing pillows and mattresses. It is light, water repellent and buoyant, making it ideal for life jackets, lifeboats and other naval safety apparatus

Wood: plywood manufacturing, but also for making boxes and crates, and for lightweight joinery, dugout canoes, musical instruments, etc.

Food, medicinal uses,

http://database.prota.org

Ochroma piramidale

- Fast growing pioneer tree reaching 15-25m of height; dbh 60-80cm
- Native: SA, introduced to Africa and Asia
- Balsa wood 50-150 $kg.m^{-3}$
- Evergreen or dry-season deciduous

Boraginaceae

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In lowland tropical regions trees may reach over 40 m in height and over 1 m d.b.h. at overmaturity

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Wood used for:

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- Carving

Three-way mutualism

- **plant** (1 species – *Cordia alliodora*), **ants** (1 species in Chamela, Mexico – *Azteca pittieri*; up to 5 species in Santa Rosa, Costa Rica, including *Azteca pittieri* and another *C. alliodora* specialist, *Cephalotes cetulifer*), **coccoids** (*e.g.* insects in the families Coccidae (scale insects) and Pseudococcidae (mealybugs), several species)
- *Azteca* ants protect plants from damage caused to leaves by some types of herbivores
- New plants form domatia (hollow cavities that house the ant colony) automatically (antplants, also known as myrmecophytes, are usually defined as those plants that are genetically programmed to have these cavities).
- **Coccoids** are insects of the order Hemiptera that suck plant phloem. They represent a direct cost to the plant. They produce carbohydrate-rich honeydew as a waste product.
- **All *Cordia* ants tend coccoids inside plant domatia**, and benefit from the sugar resources provided by the honeydew.

Cordia alliodora

Burseraceae

Trees and shrubs characterized by resins – often aromatic bark (smelling like almonds or incence)

- *Dacryodes peruviana*
- ***D. copularis*** (Copal)
- ***Bursera simaruba***
- *Protium sp. (**P. columbianum** –* Animé*)*

Bursera simaruba

- **Native:** Belize, Colombia, Cuba, Dominican Republic, Guatemala, Honduras, Jamaica, Mexico, Nicaragua, Panama, Puerto Rico, United States of America
- Plantations outside this range not known, excpet expermental pl. in Costa Rica, landscaping U.S.A, Mexico
- **Medium-sized, deciduous tree, 18-30 m tall**
- Easily recognized by the smooth, reddish-brown or copper-coloured bark, peels off in papery flakes
- Generally found in **dry forests**
- **Timber:** Used for veneer, as plywood for interior use, in rustic furniture, for rough boxes and crates, as handles for tools, as soles for sandals, to build cabinets, to make decorative articles
- **Gum or resin:** yields a balsam resin known as American elemi, cachibok or gomart. The resin is concentrated, dried and used in South America as incense in churches

http://www.redorbit.com/education/reference_library/plants/gumbolimbo/4225/index.html

Casuarinaceae

- *Casuarina cunninghamiana*
- *Casuarina equisetifolia*

http://en.wikipedia.org/wiki/Casuarina_equisetifolia

Casuarinaceae

Casuarina cunninghamiana

- native to northeastern Australia, from Queensland to New South Wales, forming part of **hot and wet subtropical forests**
- introduced as part of **reforestation efforts in the tropical and subtropical countries of Africa, Asia, and America** (mainly to mountains – it is cold resistent)
- prospers in a variety of soils **(from rich to poor and sandy, endures salinity, and seasonal flooding**), fast-growing
- annual temperature of 13 to 27 °C, and an average annual precipitation of 500 to 1500 mm, tolerates shade, N - fixing
- **Services:** it is used in reforestation programs to control erosion, preserve the soil, stabilize riverbeds, and stop the advance of dunes
- **Wood:** firewood, and charcoal, construction, poles, pulp

Casuarinaceae

Casuarina equisetifolia

- Native to the tropical and subtropical coastlines of Australia, Southeast Asia, Malesia, Melanesia, and Polynesia and New Caledonia
- coastal species and has the rare property of growing upright and symmetrical on windswept coasts.

Wood: very dense, difficult to saw, and splits and warps when dried. Used as roundwood for fencing, pilings, beams, poles, and rafters and as split wood for fencing, pilings, and roofing shingles.

However,

- very susceptible to attack by drywood termites
- Not durable in the ground.
- high-quality fuelwood that burns, it has been called the best firewood in the world

Cecropiaceae

- *Cecroipia sp.*
- *Coussapoa sp.*
- *Pouruma sp.*
- *61 species in the Neotropics, pioneers, myrmecophytic*

Cecropia obtusifolia (= Guarumo)

Combretaceae

- ***Terminalia oblonga***
- ***T. amazonica***
- ***T. superba***
- ***T. ivorensis***
- ***T. catappa***
- *Laguncularia racemosa*

Terminalia ivorensis (Framiré)

Black bark
Lower branches "self-clean", leaving a clear bole even in open conditions. The base of older trees has high, but **small buttresses**, Wood density is 0.53 g/cm3.

Evergreen forest, moist semideciduous forest, secondary forest

Terminalia superba (Limba)

Steep buttresses (up to 3.5 m) when fully grown. Wood density is 0.48 g/cm3.

Moist evergreen forest, moist semideciduous forest, dry semi-deciduous forest, secondary forest

Terminalia sp.

Terminalia catappa

- Grown as ornamental tree throughout tropics
- Part of littoral woodland community, seeds dispersed by water
- Fast growing, medium-sized, heavy wood, good quality (constructions, furniture, railroad ties, parquets…)
- Stems utilized in Polynesia for canoes,

various degrees of degradation of drift seed – called „Tropical Almond"

http://www.seabean.com/guide/Terminalia_catappa/index.asp

Dipterocarpacea

- *Dipterocarpus sp.*
- *Hopea sp. (104 species)*
- *Shorea robusta (196 species)*
- *Dipterocarpus (70 species)*

One of the moct important trees in India (use: hardwood for building purposes, constructions of all kinds)

Dipterocarpacea

- 500 species of mainly tropical lowland rainforest trees
- *Dipterocarpus*, is derived from Greek (*di* = two, *pteron* = wing and *karpos* = fruit) and refers to the two-winged fruit
- Their distribution is pantropical (S. Am., Africa, Asia)

Euphorbiaceae

- ***Hyeronima alchorneoides***
- ***H. oblonga***
- ***H. choceonsis***
- ***Hevea brasilensis***
- ***Croton sp.***
- *Hura crepitans*

- *Hyeronyma alchornoides*
  (Mascarey)

Hyeronima alchorneoides

- Canopy tree from humid tropics
- Reaches up to 50 m in height and 100 to 120 cm d.b.h.
- The elevational range of this species is 20 to 900 m
- Annual rainfall is 3500 to 5000 mm and temperatures are 24 to 30 °C
- Grows in in plantations (spacing 3 x 3 m), pruning necessary
- 80% of ind. straight bole
- Hard high quality wood

Hevea brasilensis (para rubber tree)

- **Native**: Bolivia, Brazil, Colombia, Peru, Venezuela
- **Exotic**: Brunei, Cambodia, China, Ethiopia, India, Indonesia, **Laos**, Liberia, Malaysia, Myanmar, Philippines, Singapore, Sri Lanka, Thailand, Uganda, Vietnam
- **Fast growing tree** (25 m in plantations, 40 m in natural forest); local word in the Amazon, **'heve' meaning rubber**
- practically all of the world's supply of natural rubber comes from plantations of *H. brasiliensis (30% n. rubber, 70% synth. r.)*
- The Firestone Company began plantings in Liberia in 1924.
- In last decades the value of **wood** from old plantations recognized

Meliaceae

- ***Cedrela odorata***
- ***C. montana***
- ***Swietenia macrophylla***
- ***Toona ciliata*** (Asia, Australia)
- ***Khaya ivorensis*** (Africa - Angola, Cameroon, Côte d'Ivoire, Gabon, Ghana, Liberia, and Nigeria - lowland tropical rainforests)
- ***Azadirachta sp.*** (Asia)
- ***Carapa sp.*** (America, Africa)

Swietenia macrophylla

- Timber called **mahagony** (like in the case of *Swietenia mahagoni*).
- ***threatened by habitat loss*** – native areas restricted in use of timber
- Introduced to tropical Asia – plantation forestry
- In some cases can become an invasive species

Cedrela odorata

- **Spanish cedar**, **Mexican cedar**, **Cigar-box cedar**,
- New World tropics, moist and seasonal subtropical or tropical life zone from latitude 26°N. on the Pacific coast of Mexico, throughout Central America and the Caribbean, to the lowlands and foothills of most of South America up to 1200 m (about 4,000 ft) altitude, finding its southern limit at about latitude 28°S. in Argentina.
- Wood naturally termite- and rot-resistant
- Suitable for plantations, but regulary attacked by *shootborer* (*Hypsipyla grandella*).

Swietenia macrophylla

Cedrela odorata

Toona ciliata

http://upload.wikimedia.org/wikipedia/commons/a/a0/Starr_020803-0078_Toona_ciliata.jpg

Guarea kuthiana
(= Colorado manzano)

- *Guarea macrophylla*
  (= Colorado manzano)

Leguminosae

- Legumes are plants of the pea or bean family, the Leguminosae (Fabaceae in the USA)
- The Leguminosae is one of the largest families of flowering plants with 18,000 species
- The species within the family range from dwarf herbs of arctic and alpine vegetation to massive trees of tropical forest
- The principal unifying feature of the family is the fruit, a pod, technically known as a Legume. The Legume is modified in many ways to facilitate dispersal by animals, wind and water

Leguminosae

- The family is usually divided into three sub-families:

A. Caesalpinioideae,

B. Papilionoideae,

C. Mimosoideae.

- Many Legumes are able to convert atmospheric nitrogen into nitrogenous compounds useful to plants.
- This is achieved by the presence of **root nodules** (which are visible to the naked eye) containing bacteria of the **genus *Rhizobium***. These bacteria have a symbiotic relationship with Legumes, fixing free nitrogen for the plants. In return legumes supply the bacteria with a source of fixed carbon produced by photosynthesis.
- Root nodules are general in the *Mimosoideae* and *Papilionoideae*, but rarely formed in the *Caesalpinioideae*.

Caesalpinacea (Leguminosae)

The majority of the Caesalpinioideae are tropical or subtropical trees and shrubs

- ***Schyzolobium parahybum***
- *Casia sp.*

Schizolobium parahybum

Schizolobium parahybum

Papilionacea (Leguminosae)

- *The Papilionoideae is the largest of the three subfamilies with about two-thirds of all the genera and species of the family. It is also the most widespread, extending further into temperate regions than the other two subfamilies*

- butterfly-like flowers

- *Centrolobium sp.*
- *Erythrina sp.*
- *Platymiscium sp.*
- ***Myroxylon balsamum*** *(balsam and wood production, S Am.,* ***invasive species in many tropical countries****)*

Platymiscium pinnatum

(= Caoba verdadera)

Mimosaceae (Leguminosae)

Like the Caesalpinioideae, the majority of the Mimosoideae are tropical or subtropical trees and shrubs

- *Inga cordata*
- *Cedrelinga catenaeformis*
- *Parkia brasiliensis*
- *Parkia multijuga*
- *Acacia sp.*
- *Albizia sp.*

Cedrelinga catenaeformis

Parkia multijuga

Moraceae

- ***Chlorophora sp.*** *(African teak - IROKO)*
- *Artocarpus sp.*
- *Ficus sp.*

A. altilis (= Frutepan)

Myrtaceae

- *Eugenia sp.*
- ***Eucalyptus globulus***
- ***Eucalyptus grandis***
- ***Eucalyptus sp.***
- *Psidium guayba*
- *Syzigium aromaticum*

Pinaceae

Pinus radiata – monterey pine

- Extremely limited natural range – California and Baja California
- But extensive stand in Chile, Argenitina, Australia, New Zeland, South Africa, Spain…

Pinus patula

- Mexican weeping pine
- Plante in high altitudes – Ecuador, Boivia …, New Zeland, UK – ornamental tree

Verbenaceae

- ***Gmelina arborea***
- ***Tectona grandis***
- ***Vitex cymosa***
- *Aegiphila alba* (margarito)

Gmelina arborea

Fast growing deciduous tree, Origin: India, Myanmar, Thailand, Laos Cambodia, Vietnam…, requires fertile soils and sufficient rainfall 750mm – 4500mm, many uses: pulp, furniture, constructions, sport instruments…

Tectona grandis

SE Asia: India, Myanmar, Malaysia, Indonesia,

average occurence: 1,250-1,650 mm with a 3-5 month dry season

traditional use in constructions, door and window frames, furniture…

Thank you for your attention