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Land rehabilitation in the tropics with indigenous tree species: economic and ecological considerations and research needs

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Abstract

In order to restore degraded (grass-) land in the humid tropics, indigenous tree species become increasingly important in agroforestry and other land use systems. Most of these species have never been cultivated before and must be propagated from seeds and seedlings collected in forest remnants. The timber tree species still come from forest remnants and have mostly never been cultivated before. Knowledge on their ecology is fragmentary at best, and economic expectations are based on experiences from the exploitation of primary forests. In this contribution we present results and observations referring to (a) growth performance, (b) pest susceptibility and (c) reproduction of native Philippine tree species from a land rehabilitation trial on Leyte, Philippines .

· (a) Descriptions of tree habit, timber properties and quality are usually based on individuals from primary forests. Especially legumes are described as providing excellent timber. The planted specimens evaluated performed poorly. Besides rather small growth they tended to develop forked stems and shrubby habits. Such trees will not fulfil the economic expectations. The question arises if this is just a matter of management and site selection or the result of unsuited genetic material or even genetic erosion of the species due to overexploitation..

· (b) It is generally assumed that native species are less susceptible to pests than exotics. Although no direct comparison between exotic and native trees could be made our observations show that native species are also prone to insect damage. Again, legume trees performed worse compared to the other species. To ensure a successful and sustainable production, the responsible pests as well as underlying mechanisms (e.g. species-specific susceptibility, planting stress, wrong habitat selection) need to be analysed and understood.

· (c) Maturity and reproduction of tree species occur rather late in primary forests. In the Leyte State University´s "ecoparc" trees, including dipterocarps, could be observed fruiting at an age of 10–12 years. Early reproduction of valuable species provides the opportunity to sell seeds and seedlings and to be independent from forest sources which are often costly to monitore and harvest. An important and largely unsolved question is how these species are pollinated since the trees are outside their natural forest habitat and far away from the next mother tree. If the species participate in the species´ gene flow, this would mean an important contribution to retain the species´ genetic diversity.

Introduction

Native tree species become increasingly important in land rehabilitation (e.g. Butterfield & Fisher 1994, Butterfield 1995). Additionally, a trend can be observed to establish mixed species stands instead of monocultures. The most sophisticated approach currently observable is to imitate original forest structure and processes to create so-called 'successional analogs' or 'analogs' (Ashton & Ducey 2000, Ewel 1999). It is assumed that - due to their high ecological diversity - such forests are less susceptible to pests and much more stable and sustainable compared to monocultures. Additionally, they are much better suited to provide a wide variety of goods and benefits to rural people and thus to contribute to their livelihood.

Most indigenous tree species used for establishing 'analogs' have never been cultivated before, and the seeds or seedlings required are usually collected from forest remnants. Knowledge on the ecology of such species is fragmentary at best, and economically relevant data as tree dimensions, growth habit and timber quality are based on experience from the exploitation of primary forest (e.g. Whitford 1911a,b).

In 1990ies, a land rehabilitation model named 'rainforestation farming' (Milan & Margraf 1994) resembling the idea of 'successional analogs' has been developed on the island of Leyte, Philippines. Based on plantings established at that time we present observations and results considering growth performance, pest susceptibility, and reproduction of native tree species.

Material and Methods

In 1996, a c. 1 ha trial-plot in the lowland of the island of Leyte, Philippines, has been planted with 36 tree species by a farmer community. In 2004, we conducted a survey on the performance of these species. Besides measuring diameter and estimating height – we used median values to reduce impact of measuring and estimation bias, respectively, we classified each individual tree according to the amount of leaves showing signs of herbivory (insect damage) (class 0 = 0% leaves affected, 1 ≤ 25%, 2 ≤ 50%, 3 ≤ 75%, 4 ≤ 100%). Dead trees have been included as class 5. Additionally, we created the following categories do get an overview on damages negatively affecting future timber quality: none observable, forked stem, shoot damaged by insects, shoot dead. Since quality features as forked stems are relevant for timber trees only, fruit trees have not been included in this presentation except they are also potential timber species. We only considered species represented by at least 20 individuals.

The data on fruit setting of single trees are based on observations in the 'ecoparc' of the Leyte State University (LSU), which is located only few kilometres away from the above mentioned trial-plot. The exact age of plants in the 'ecoparc' cannot be given since it has been planted successively since 1992 which results in a maximum age of 12 years. As typical for a parc area the trees have been planted widely spaced. Some growth data from 'ecoparc' trees are given where adequat.

Results

Especially the pioneer tree *Casuarina rumphiana* (Mt. Agoho) showed a dominant growth performance, while late successional species as *Hope* spp. (Yakal, Dalingdingan) clearly stood behind (Tab. 1). *Terminalia microcarpa* (Kalumpit) and *Vitex parviflora* (Molave) also showed a comparatively good growth performance. By far the greatest dimension has been achieved by *Melia dubia* (Bagalunga), a species planted on the LSU campus and in the 'ecoparc', respectively. One tree in the 'ecoparc' had reached a dbh (diameter at breast height = 1.3m) of 62cm and a measured height of 21,5m (Tab. 2). The branchless stem reached up to 6.4m.

Insect damage of leafes was a common feature of most of the trees (Fig. 1). Least affected were *Casuarina rumphiana* (Mt. Agoho) (see discussion) and *Artocarpus odoratissima* (Marang). Especially the legumes (*Intsia bijuga, Ormosia calavensis, Pterocarpus indicus*) and the dipterocarps (*Parashorea malaanonan,* Bagtikan, and *Shorea contorta,* White lauan) showed comparatively high rates of insect damage. More than 20% of the individuals of each legume species had to be classified in category IV (75% ≤ 100% affected leaves). *Ormosia calavensis* (Bahai) even reached a figure of 64%. The two dipterocarps had values of 29% (*Parashorea malaanonan*) and 36% (*Shorea contorta*), respectively. Besides high degrees of leaves damaged by insects the two legumes *Intsia bijuga* (Ipil) and *Pterocarpus indicus* (Narra) as well as the Anacardiaceae *Dracontomelon dao* (Dao) had rates of dead individuals between 13% and 15%.

Table 1: Growth performance of native Philippine tree species in a mixed-species planting-trial (c. 1 ha) on the island of Leyte, Philippines

Local name[1]	Scientific name	Family	height median / m	diameter median / cm
Apitong	Dipterocarpus grandiflorus	Dipterocarpaceae	4,5	3,5
Bagtikan	Parashorea malaanonan	Dipterocarpaceae	4,5	3
Bahay	Ormosia calavensis	Leguminosae	2,5	2
Bitanghol	Calophyllum blancoi	Clusiaceae	5,5	5
Dalingdingan	Hopea sp.	Dipterocarpaceae	3,5	2
Dao	Dracontomelon dao	Anacardiaceae	3,5	2,5
Ipil	Intsia bijuga	Leguminosae	5,5	5
Kalumpit	Terminalia microcarpa	Combretaceae	6,5	6,5
Malakauayan	Podocarpus rumphii	Podocarpaceae	4	4
Marang	Artocarpus odoratissima	Moraceae	5,5	5
Molave	Vitex parviflora	Verbenaceae	(7,5)[2]	(7,5)[2]
Mt. Agoho	Casuarina rumphiana[3]	Casuarinaceae	(14)[4]	15
Narra	Pterocarpus indicus	Leguminosae	4	4
Tamayuan	Strombosia philippinensis	Olacaceaea	4	3
White Lauan	Shorea contorta	Dipterocarpaceae	4,5	3,5
Yakal	Hopea sp.	Dipterocarpaceae	4,5	3

1 Comon official name after Salvosa (1963).

2 See discussion.

3 The genus *Casuarina* has been taxonomically split. According to the new classification *C. rumphiana* has been renamed into *Gymnostoma rumphianum*. Since this name is locally neither known nor practiced the traditional name has been used.

4 The height is definitely too high and the result of overestimation. A realistic figure is c. 10 m.

Most of the species and individuals evaluated didn´t show features having impact on future wood quality (Fig. 2). To a lesser extend the diperocarps *Shorea contorta* (White Lauan), *Parashorea malaanonan* (Bagtikan), and *Hopea* spp. (Yakal, Dalingdingan) showed forked stems or dead or damaged shoots possibly leading to forked stems in the future. High rates of forked stems and damaged or dead shoots could be documented for the three legume species *Intsia bijuga* (Ipil), *Pterocarpus indicus* (Narra), and *Ormosia calavensis* (Bahay). Another legume species which has been present in LSU´s ‘ecoparc’ only, *Kingiodendron alternifolium* (Batete), also showed the tendency towards a shrubby growth.

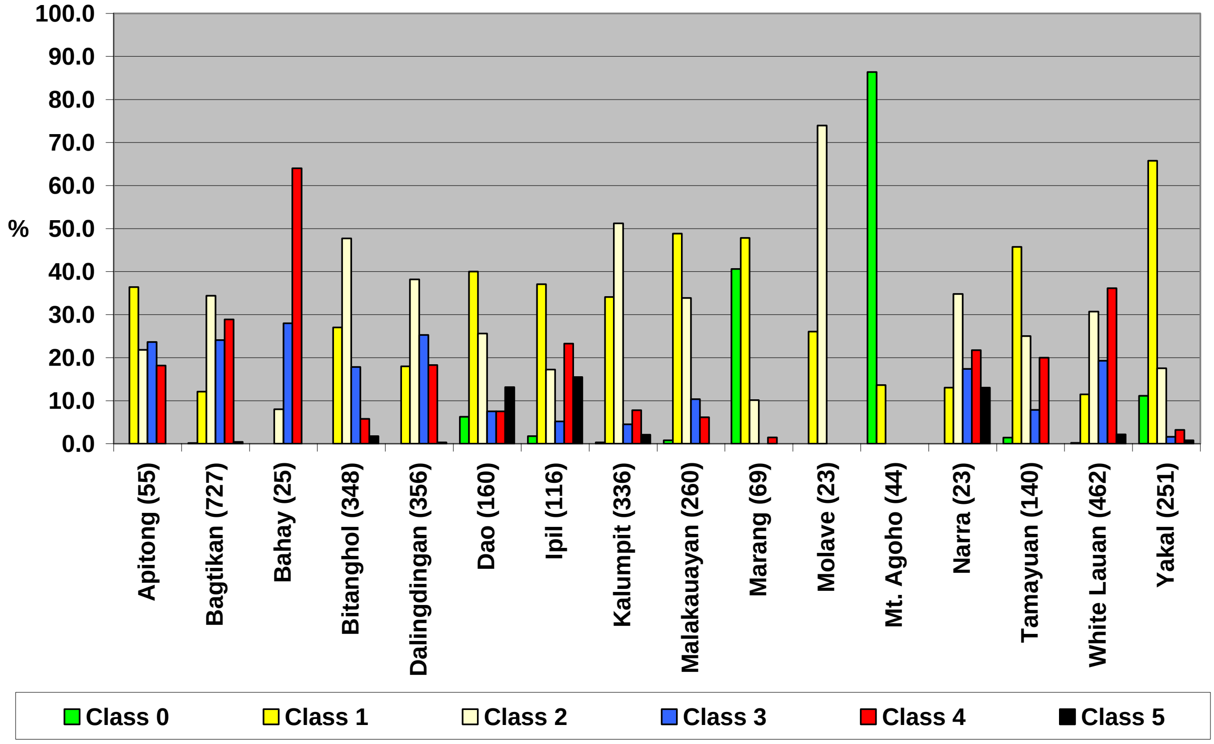

Fig. 1: Degree of leaf damage in different native tree species in a planting trial (c. 1 ha) on the island of Leyte, Philippines

The figures in brackets give the number of trees evaluated.

Class 0: percentage of trees without sign of leaf damages

Class 1: percentage of trees which show insect damage on up to 25% of their leafes

Class 2: percentage of trees which show insect damage on more than 25% up to 50% of their leafes

Class 3: percentage of trees which show insect damage on more than 50% up to 75% of their leafes

Class 4: percentage of trees which show insect damage on more than 75% of their leafes

Class 5: percentage of dead individuals

Fruiting or flowering has not yet been documented for trees of the planting-trial, while several species could be observed fruiting in LSUs 'ecoparc' (Tab. 2) or along roadsides on the campus. None of the trees was older than 12 years. *Dipterocarpus validus* and *Planchonia spectabilis* developed only few fruits so far, while the other species produced at least small numbers. An exception was *Hopea plagata*, a typical late successional species, which showed already a mast fruiting, although the trees were still small (6-8m high, 8-10cm diameter at 1.3m height). A detailled description of the dipterocarp fruiting has been given by Langenberger (2005). Except for *Hopea plagata*, where germination of seeds has been observed, no proof of viability can be given for the other species.

Table 2: Native tree species fruiting on the campus and the 'ecoparc' of the Leyte State University (LSU) (age of the trees up to 12 years)

Local name[1]	Scientific name	Family	Observations on fruiting[2]
-	*Cryptocarya* sp.	Lauraceae	fruiting 2004, dbh 20.1 cm, tree height 11.8m
Hagaghak	*Dipterocarpus validus*	Dipterocarpaceae	fruiting 2003 & 2004, dbh 18 cm, tree height 13.5m
Yakal Saplungan	*Hopea plagata*	Dipterocarpaceae	fruiting 2004, dbh 8-10cm, tree height 6-8m
Batete	*Kingiodendron alternifolium*	Leguminosae	fruiting before 2003, already
Bagalunga	*Melia dubia*	Meliaceae	fruiting before 2003, already; dbh 62cm, height 21,5m
-	*Planchonia spectabilis*	Lecythidaceae	fruiting 2004, dbh 22.3cm, height 11m
-	*Spondias pinnata*	Anacardiaceae	fruiting before 2003, already
Kalumpit	*Terminalia microcarpa*	Combretaceae	mast fruiting in 2004, probably even in earlier years
Mangkono	*Xanthostemon verdugonianus*	Myrtaceae	fruiting before 2003, already

[1] Comon official name after Salvosa (1963).
[2] dbh = diameter at breast height (1.3m).

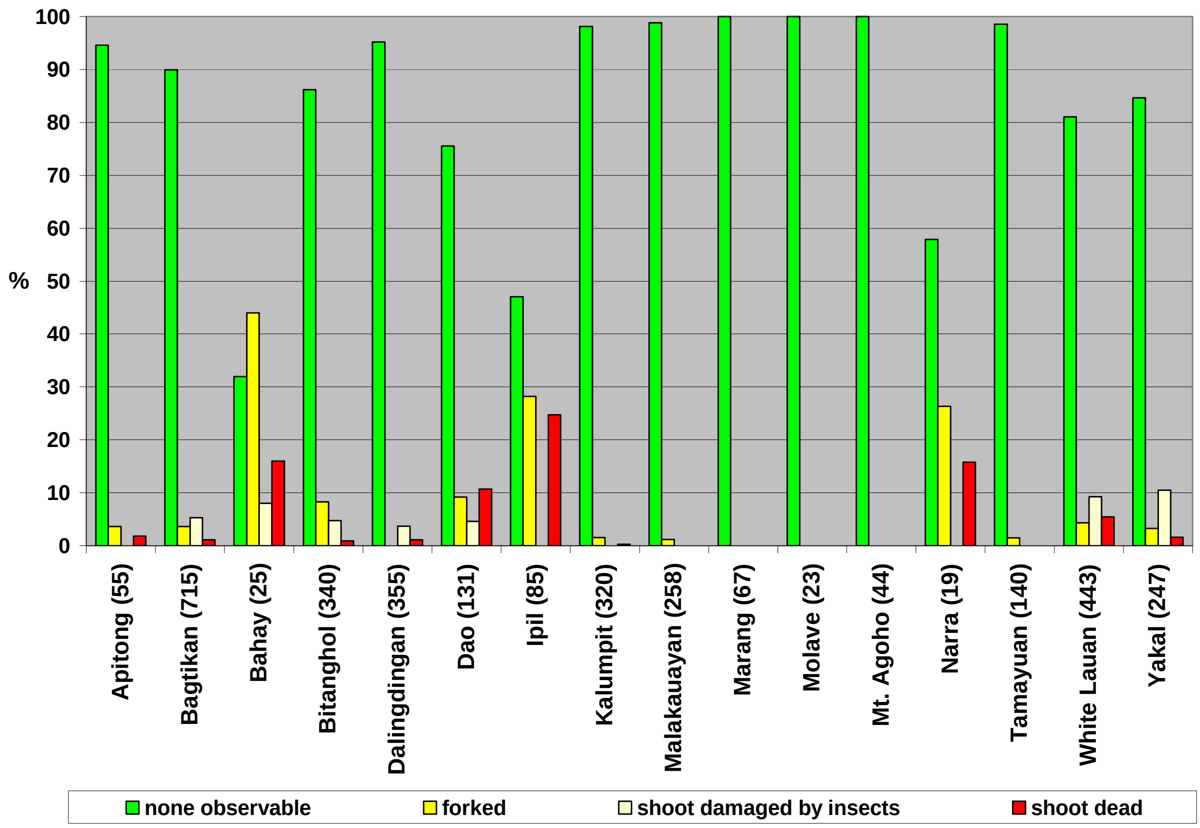

Fig. 2: Damages observed in a mixed tree species planting trial (c. 1 ha) on the island of Leyte, Philippines, affecting future wood quality
Figures in brackets refer to the number of trees evaluated for the respective species

Discussion

As could be expected at this early age pioneer tree species grew much faster compared to the other species. Especially Mt. Agoho (*Casuarina rumphiana*) was clearly ahead. Even though the height estimation is strongly biased and a realistic figure of the average height at the time of evaluation is c. 10m, the measured diameter is double that of the other species. Kalumpit (*Terminalia microcarpa*) also performed well. Since the species has also been planted along roadsides on the campus of the Leyte State University (LSU) and performed evenly well there – even producing large quantitites of seeds - it can be concluded that the species is well suited for local conditions. The evaluation of Molave (*Vitex parviflora*), which also shows comparatively big dimensions, is a bit more tricky. Molave can be found locally in secondary growth and degraded vegetation. Therefore, the figures for Molave might include trees which have not been planted but were already established when planting of the trial-plot was conducted. The most impressive figures are those from single trees in the 'ecoparc' of LSU, especially that of Bagalunga (*Melia dubia*) (62cm dbh). But since those trees grew up more or less as solitairs without intra- or interspecific competition with other trees a generalization of growth performance must be done with care. Nevertheless, the species can reach large dimensions within a very short time. Since - according to local communications - the timber also achieves good prices this species can act as umbrella tree for late successional species and at the same time contribute to early income in alternative land rehabilitation schemes like 'rainforestation'.

A tree group which seems to be very problematic when planted are the legumes. They performed unexpectedly poor while the species evaluated here are described in literature as providing excellent timber and big dimensions. While big tree dimensions might be achieved with time the quality usually required for sawn timber – single stem, few small branches or even branchless, etc. – can not be expected based on the current observations. But, considering the small amounts of timber which might be produced in such mixed stands the production has very likely to be sold on local markets where quality requirements might not be so strict. The question arises if the poor quality performance of the legumes, especially the shrubby growth, is already the result of genetic erosion, that is kind of a negative selection of mother trees due to the extraction of the valuable individuals long ago, or if it is just a matter of management (e.g. spacing of trees, pruning) and site selection. Due to the high timber value of these species mature trees have practically disappeared from local forests, and seeds have to be collected from the remaining sources, that is poorly shaped trees. But it might also be that legume trees are very flexible considering their growth form. Thus, *Kingiodendron alternifolium* (Batete), the only legume species which could still be found scattered in local forest fragments, developed good stem shapes within the closed forest but grew up as shrub in LSU's 'ecoparc', which would stress the latter assumption and the importance of proper management to achieve satisfactory results.

It is generally assumed that native species are less susceptible to pests than exotics. The results show that native species are also affected to different degrees by insect damage. But it should be clear that a/ this is how ecosystems work (trophic levels) and b/ this doesn´t proof that the affected trees realy suffer. Only the damage to shoots resulting in several leader shoots and thus forking of stems clearly affect economic perspectives.

Maturity and reproduction of late successional species, that is the typical species of old-growth forest, can usually be observed at a rather old age. In the Leyte State University´s "ecoparc" trees, including dipterocarps, could be observed fruiting at an age of 10-12 years or even earlier. Early reproduction of valuable species provides the opportunity to sell seeds and seedlings and to be independent from forest sources which are often costly to monitore and harvest. An important and largely unsolved question is how these species are pollinated since the trees are outside their natural forest habitat and far away from the next mother tree. If the species participate in the species´ gene flow, this would mean an important contribution to retain the species´ genetic diversity.

Mixed species plantings pose special difficulties on the evaluation of the performance of single trees or species. Due to the heterogeneity of such stands the identification of patterns and key factors responsible for the performance is difficult. None the less, identification of species´ habitat preferences and site-species interactions, growth dynamics and plant-pest interactions are a prerequisite to a successful management of such species and will be an important task for future tropical forest research. Additionally, the impact of mother tree quality on the performance of offsprings must be clarified for the different species. If legume species - which potentially provide high value timber – shall be part of management schemes, they need special focus.

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