Chapter 15
Challenging a Paradigm: Toward Integrating Indigenous Species into Tropical Plantation Forestry

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15.1 Introduction

The world's forests are disappearing at an alarming rate. Between 2000 and 2010 the net annual loss of the world's forests was 6.4 million ha (0.13%). While the rate of forest cover loss has slowed compared to the period of 1990–2000 (net annual loss of 8.3 million ha year^{-1}) (FAO 2011), it is still severe enough to warrant a concerted effort to slow or reverse this trend. This is especially true in the tropical regions, where net forest losses increased from 6.3 million ha year^{-1} in the 1990s to 8.0 million ha year^{-1} between 2000 and 2005 (FAO 2011)

Tropical forests, which represent 44% of the world's forested area (FAO 2011) and contain much of the world's biological diversity (USAID 1992), are cleared mainly for agricultural purposes (García-Montial and Scatena 1994; Brothers 1997; Leopold et al. 2001; Pearce et al. 2003; Gibbs et al. 2010). Timber harvest (Islam and Weil 2000) and collection of fuel wood (Wilcox 1995; Islam and Weil 2000) also contribute to the removal of forest cover. Natural disturbances, including fires and hurricanes, add to the loss of forest cover, but forest recovery from natural causes tends to be more rapid than from anthropogenic disturbances (Myster and Pickett 1990; Finegan 1992). Deforestation is defined as the removal of forest cover

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and withdrawal of land from forest cover, whether deliberately or circumstantially (NRC 1995). Given estimates that over half of tropical forest area has been lost (Myers 2003), it is not surprising that tropical deforestation is considered the leading factor in worldwide biodiversity loss (Sánchez-Azofeifa et al. 2003).

In this chapter, the current state of tropical forestry is described, as are global experiences with the use of exotic species and monocultures in plantation establishment, and experiences to date of afforestation and reforestation in tropical countries. The purpose of this chapter is to draw attention to potential afforestation (establishing trees where forests have been absent for an extended period) and reforestation (regeneration of forests after harvesting) strategies that would improve the state of tropical forest management by conserving biological diversity in tropical regions and increasing potential economic benefits to local communities. The global and local benefits from adopting these strategies are economic and environmental; they can be accomplished through the cooperation of researchers and forestry-related practitioners working toward establishment of compositionally diverse, economically viable plantations of native species.

15.2 Land Conversion and Plantation Establishment

Land converted from forest to agriculture and pasture is often abandoned soon after conversion (Aide et al. 1995; Finegan 1996; Wright and Muller-Landau 2006). Reasons for abandonment include shifts in the economy (Deitz 1986), invasion of grasses (Aide et al. 1995), and degradation of soil (Aide et al. 1995; Simmons 1997). Soil degradation, which may cause an immediate and lasting reduction in productivity (Milham 1994), results from a decrease in microbial biomass associated with burning (García-Oliva et al. 1999), nutrient runoff (Malmer 1996), erosion (Kaihura et al. 1999), and/or hydrologically mediated nutrient loss (Malmer 1996). In some cases cultivation further degrades soil quality (Islam and Weil 2000) such that it becomes necessary for farmers to clear new land to maintain agricultural productivity.

Farmlands are often characterized by low species richness (Fujisaka et al. 1998; Zapfack et al. 2002), and are often dominated by exotic species (Rivera and Aide 1998; Chinea 2002). Slashing and burning can greatly alter the seed bank composition in tropical deciduous forests (Miller 1999). Consequently, the biological communities regenerating on these farmlands after abandonment do not resemble those on similar sites with low anthropogenic disturbance (Zou et al. 1995; Oosterhoorn and Kapelle 2000; Chinea 2002; Marcano-Vega et al. 2002). Planting trees and shrubs, both exotic and native, to create microhabitats that facilitate the establishment of native tree species may be effective in increasing native forest cover. Several authors (Aide et al. 1995; Parrotta 1999; Feyera et al. 2002) argue that plantations established with exotic species can act as nurse trees to facilitate natural forest regeneration. However, plantations established to accelerate natural succession must be done with careful consideration of species selection, as Healey and Gara (2003) found that plantations of non-native teak (*Tectona grandis* Linn.f.) limited the development of native species compared to natural succession on abandoned fields in Costa Rica. Additionally, Haggar et al. (1997) found that woody regeneration beneath plantations, in terms of species richness and abundance, was related to the species planted. A study conducted by Cusack and Montagnini (2004) affirmed that timber species established in plantations accelerated understory recruitment when compared to abandoned pasture in Costa Rica, and that the effectiveness of species at recruiting understory plants varied by site. Even so, such transformations may be slow; Honnay et al. (2002) determined that it takes at least a century for the understory of European temperate forest plantations to attain a similar understory composition as that found under a natural forest.

Approximately 5% of the world's forests are plantations, comprising a total area of 187 million ha (FAO 2001). While most plantations are located in industrialized, non-tropical nations, a growing number are found in developing tropical countries (Pandey and Ball 1998; Evans 1999). Plantations account for as much as 90% of the wood supply in countries including New Zealand and Chile (Park and Wilson 2007). In the future, an increased proportion of the world's wood supply will come from tree plantations (Pandey and Ball 1998; Hartley 2002). Based on high productivity and successful experiences with plantation management to date (Wright et al. 2000; Montagnini 2001), it is probable that tropical regions will host many of these plantations. While potential benefits of tropical plantation establishment, such as erosion control (Lugo 1997; McDonald et al. 2002), carbon sequestration (Wright et al. 2000) and efficient timber production (Montagnini 2001; Healey and Gara 2003) are well known, the continued high rate of loss of forest cover implies that additional economic incentives are required for many tropical landowners to maintain forests on their land. Further, if financial benefits are realized from the development of a carbon sequestration and credit system, then demand for, and motivation to establish, tropical forest plantations would increase (Wright et al. 2000). Evidence suggests that increased short-term financial incentives could be effective in increasing the number of plantations established, as well as ensuring their continued management, as Piotto et al. (2004) found with Costa Rican and Nicaraguan farmers. These landowners, with continued subsidization from their governments, were willing to reforest their properties.

Globally, plantation forestry is a controversial subject, with concerns about establishment of monocultures being a primary objection. Commonly stated risks include high susceptibility to damage by pests and pathogens (Jactel and Brockerhoff 2007), changes to hydrological processes, and the perceived inability of plantation forests, with their inherent compositional and structural characteristics, to facilitate ecological processes associated with naturally-regenerating forests. However, Gadgil and Bain (1999) argue there is no substantial evidence showing plantation forests are more susceptible to pathogen and pests than managed natural forests. In addition, research in the USA found that hydrological processes in young poplar plantations were similar to those of young natural forests (Perry et al. 2001) and, in China, that plantations on degraded sites decreased annual runoff and its coarse sediment content, which contributes to the restoration of natural hydrologic processes (Zhou et al. 2002).

Although horizontal and vertical structure (Cannell 1999) and species composition of flora (Thomas et al. 1999; Ross-Davis and Frego 2002) and fauna (Lambert and Hannon 2000; Lomolino and Perault 2000; Erdle and Pollard 2002) are significantly different in plantations and natural forests, establishment of plantations can ultimately lead to succession of natural understory communities (Haggar et al. 1997; Powers et al. 1997; Parrotta 1999; Otsamo 2000; Senbeta et al. 2002). Management for specific objectives in plantations can provide habitat for many plant and animal species (Cannell 1999; Cawsey and Freudenberger 2008), and incorporating indigenous tree species in plantation establishment helps maintain species and genetic diversity and allows for continued interactions between indigenous animal and plant species (Montagnini 2001). In fact, O'Neill et al. (2001) recommended plantation establishment to maintain genetic diversity in the Peruvian Amazon; plantations reduce high-grading in natural forests and well-planned plantations can decrease harvesting pressure placed on natural forests, which will continue to be exploited if needs for forest products are not met on lands managed for production of forest products (Buckman 1999).

15.3 Global Experiences with Exotic Species and Monocultures

Establishing plantations to help mitigate effects of deforestation is logical. Lamb (1998) and Paquette and Messier (2010) highlight the variable degree to which plantations can be successful at achieving restoration objectives; a sliding scale dependant on myriad factors ranging from ownership issues to environmental conditions. Afforestation and reforestation are important contributors to natural resource management through their provisions to local and global economies, and by alleviating pressures placed on natural forests (FAO 2011). To date, most afforestation and reforestation projects in tropical regions of the world have used exotic species with inherent fast growth rates (Leopold et al. 2001; Montagnini 2001) to establish monoculture plantations (Hartley 2002). Globally, *Pinus* and *Eucalyptus* are the most commonly-planted genera, comprising 20 and 10% of the total area in plantations, respectively (FAO 2001). In tropical regions, approximately 85% of forest plantations consist of the genera *Pinus*, *Eucalyptus*, and *Tectona* (Montagnini 2001).

Monocultures of exotic species in the tropics are often, at the time of establishment, viewed as a ready solution to the apparent need to cover the land. The selected exotic species frequently have exceptional growth rates and standardized management plans that can be easily implemented (Montagnini 2001). With the existing high rate of deforestation in tropical regions, many observers welcome plantation establishment as a means of returning stability to the land. The act of increasing forest cover worldwide to compensate for loss through agriculture, settlement, and other anthropogenic disturbances is an important and noble goal.

The benefits and costs associated with exotic species and monoculture plantation management have been experienced globally. Given an objective of maximizing timber and fiber production, forest plantations established as monocultures of exotic species appear to be most productive. It is important to recognize that most of the plantations now being established will differ from naturally-regenerated forests in both composition and structure. This means they will be sustained by different ecological processes and will generate different functional outcomes. Moreover, as conservation values change and new forest policies and management objectives are developed and refined, monocultural plantations of exotic species may no longer meet the needs of society. There are increasing numbers of examples where managers have sought to modify silvicultural practices to take account of these changing social goals. For example, forest management practices that associate harvest schedules with natural disturbances regimes are considered to be ecologically sustainable (Mönkkönen 1999), and mimicking natural systems in the humid tropical lowlands can lead to the design of sustainable land-use systems (Ewel 1999). In Israel, a country without extensive natural forests, forest management practices have shifted from the establishment of large, even-aged monoculture blocks to the use of small, uneven-aged multi-species blocks in an effort to increase ecological stability and biological diversity (Ginsberg 2002). Koch and Skovsgaard (1999) posited that the European approach to forestry has shifted from a single-use management objective (wood production) to management for multiple values, and that greater focus has been placed on protection of natural forests and minimizing stand conversion. Furthermore, plantations should be established in a manner that minimizes the time necessary to develop into a semi-natural forest.

These objectives aim to thwart the loss of biological diversity and authenticity that occurs with establishment of monocultures of exotic species, as has been noted in Britain (Peterken 2001). In Australia, the spread of Monterey pine (*P. radiata* D. Don) from plantations to natural forests has resulted in a decrease in native plant and animal diversity (Gill and Williams 1996). Increased understanding of the consequences of species introduction has resulted in many industrialized countries with well-developed forest management strategies now preferring forest compositions closer to those that preceded large-scale human intervention; forest restoration is often used to facilitate return of natural ecosystem components and/or processes (Harrington 1999). For example, forest restoration projects in the United States aim to reintroduce stand-driving events (i.e., fire) as a means of maintaining natural species compositions and facilitating natural processes (Blake and Schuette 2000; Bailey and Covington 2002), while in Central Europe projects are underway to re-convert non-native conifer forests to more characteristic deciduous forests (Zerbe 2002).

Lodgepole pine (*P. contorta* Dougl. ex. Loud.), extensively planted as an exotic species in Scandinavian countries, is being thoroughly studied given concerns over its potential to escape plantations and invade native forests (Sykes 2001), and subsequent strict management plans have been suggested to reduce the potential impact of this exotic species (Engelmark et al. 2001). In Sweden, for example, Engelmark et al. (2001) suggest management plans should include maintaining strict control over the locations and total area of lodgepole pine plantations established to reduce the incidence of this species spreading beyond plantations, and to define zones where lodgepole pine should not be planted as a means of promoting growth of native species. It has been argued that exotic species are free from natural pests and pathogens when first introduced, and that there is little evidence of native pests and pathogens adopting them as hosts (Gadgil and Bain 1999). However, one concern associated with the introduction of lodgepole pine in Sweden is the transfer of exotic pathogens along with the species, and the potential for these pathogens to spread from the exotic lodgepole pine to the native Scots pine (*P. sylvestris* L.) (Ennos 2001). The effect of such disease transmission can be devastating.

In the United States, the once-dominant American chestnut (*Castanea dentata* (Marsh.) Borkh.) was decimated by the introduction of an aggressive diffuse canker disease, *Cryphonectria parasitica* (Murrill) Barr (Anagnostakis 1987), which was likely introduced through the importation of chestnut seedlings from Europe (Marchant 2002). Since 1920, Dutch elm disease (*Ophiostoma ulmi* (Buisman) Nannf. and *O. novo-ulmi* (Brasier)), a wilt disease originally identified in Holland, has spread across Europe, North America, and Central Asia, and resulted in the death of most mature elms (*Ulmus* spp.) in the northern hemisphere (Brasier and Buck 2001). Introduction of Dutch elm disease into Britain and North America was likely by importation of infested timber (Brasier and Buck 2001). Lack of pests and pathogens adapted to exotic species as natural population controls is not always the case; in lowland humid tropics, pests and pathogens have limited the productivity of *Eucalyptus*, a genus comprising approximately ten million ha of tropical plantations (Turnbull 1999).

With these problems associated with monoculture plantations of exotic species, stricter controls are being placed on the new use of exotic species. For example, in the Forest Stewardship Council's (FSC 2012) Principles and Criteria, Principle 6.9 mandates that exotic species be 'carefully controlled and actively monitored to avoid adverse ecological impacts.' For this reason, it is paramount that recommendations for afforestation and reforestation strategies come from researchers and practitioners in countries with experience in plantation and exotic species management; their experiences can help land managers in developing countries avoid making similar mistakes. The best approach, however, may be to change the plantation paradigm and place more emphasis on plantations comprised of native tree species.

15.4 Establishing Tropical Plantations Using Native Species

Evidence shows that since 1995, the diversity of species planted globally has increased (FAO 2001); this is due in part to more research (e.g. Butterfield 1995, 1996; Haggar et al. 1998; Leopold et al. 2001; Montagnini 2001; McDonald et al. 2003; Pedraza and Williams-Linera 2003) investigating the suitability of indigenous tropical species for afforestation and reforestation. In many of these studies, native species have been identified as being at least as productive as exotic species. Montagnini (2001) reported a number of native Latin American species that achieved greater biomass than plantations of exotic species, and Leopold et al. (2001) found that growth rates achieved by mixed-species plantations of native hardwoods in Costa Rica compared favorably with those reported for exotic species. In Australia, mixed-species plantations including native species were found to be more productive than monocultures (Erskine et al. 2006). Haggar et al. (1998) determined that selected native species in the lowland humid tropics of Costa Rica could produce similar growth rates to exotic species grown in plantations, and that the native species showed higher survival and required less intensive site preparation for establishment. In the Jamaican Blue Mountains, McDonald et al. (2003) identified native species that, based on growth rate, would be preferable for reforestation. In Costa Rica, plantations established with native species are able to produce value-added products such as furniture and construction wood (Wightman et al. 2001). A comparison of monetary gains between native Indian rosewood (*Dalbergia sisso*o Roxb. ex DC.) and exotic eucalyptus (*E. tereticornis* Sm.) in India found that Indian rosewood had net annual gains of almost twice that of eucalyptus (Jalota and Sangha 2000). While in many cases exotics have shown to be better able to establish, under heavy competition, than indigenous counterparts (e.g. Otsamo et al. 1997), it is possible that further research into appropriate plant materials, or alternative nursery cultural practices (e.g. Dumroese et al. 2009), may lead to more acceptable indigenous species for plantation establishment in many regions for which exotic species are currently the primary component.

For the use of native species in afforestation and reforestation efforts to become accepted by landowners and government agencies, suitable species and their management requirements must be correctly identified and described. Both the management protocols and plant material must be made readily available for public consumption (McDonald et al. 2002). In Panama, the provision of materials and technology has led to increased tree planting by small producers (Simmons et al. 2002). Continued extensive research and dissemination of knowledge at the local level will help to accomplish these requirements. Species performance in plantations cannot always be predicted by that in natural forests, as evidenced by work in the Jamaican Blue Mountains by McDonald et al. (2003) where no relationship between the growth rates of native species in a plantation trial and their mean growth rates in natural forests was detected. As is the case in all plantations, site selection is important, as it is difficult to infer performance across a variety of sites (Turner et al. 1999). Further variation between development in natural stands and in plantations may be explained by interspecific interactions that are lacking in monocultures.

In tropical northern Thailand, where many native tree species have not been grown in nurseries, successful nursery production of native species is limited by lack of knowledge of propagation requirements (Elliott et al. 2002); minor changes in nursery cultural practices can have major implications for seedling quality and suitability for establishment (Dumroese et al. 2009). For production of seedlings, or other plant material where appropriate, of native species to become more common, it must be simple enough to be completed by community members with little or no training in this field. Research to identify suitable nursery practices to cultivate seedlings of native tropical species is needed before quality seedlings will become available (Blakesley et al. 2002). Increased availability of seedlings will advance afforestation and reforestation efforts. Traditional use and familiarity with the species, a benefit provided by working with native species as opposed to exotic species (Montagnini 2001), may help with the development of practical and effective propagation techniques.

15.5 Future Directions and Potential Benefits

Dependence on forest products for livelihood is common in tropical forest communities (Byron and Arnold 1999). Diversification of assets is a necessary practice in economic spheres to reduce risk. Application of this same concept to species diversity in tropical plantations would serve land managers well. In addition to decreasing the likelihood of catastrophic pest outbreaks, the effect of fluctuation in the market value of tree species would be minimized. As timber values can deviate temporally (Trømborg et al. 2000), it is important not to invest solely in one particular species. Plantations established with mixed species reduce economic risk by increasing the potential end-products (Butterfield 1995) and decreasing dependence on any one species. Plantations established in parts of Costa Rica with native species are used for value-added products of greater economic benefit than pulpwood production (Wightman et al. 2001).

Production of non-timber forest products (NTFPs) for use as food, medicinal treatments, and household items can be a major contributor to community income (Narendran et al. 2001). A stand managed for revenue beyond that provided by timber production will be of greater economic value (Tewari 2000). Added to revenue generated through timber production, NTFPs could increase interest in maintaining forest cover, as well as provide short-term revenue. Effective marketing to ensure fair prices and commercial accessibility could increase the economic benefits of NTFPs. Many factors, including the distance to market and product value, must be considered and can have a major influence on the value of the product to the local community (Shanley et al. 2002). Establishment of plantations with native species will enable production and collection of many of these NTFPs, many of which are culturally significant, which may be precluded through the use of exotic species.

As forests are cleared for agriculture or pasture, carbon is released into the atmosphere, an additional problem associated with deforestation (Deacon 1995). A strategy that may help to diminish the rise in atmospheric carbon is to increase global forest cover, which would use trees as 'biological scrubbers' (Richards and Andersson 2001). The issue of how a system of credits for carbon sequestration could affect the practice of forestry is important. Fearnside (1999, 2000) stated that stemming the rate of deforestation yields greater potential for arresting global warming, but acknowledged that increasing the area in plantations is more feasible. A meta-analysis conducted by Silver et al. (2000) identified that afforestation of abandoned fields in the tropics can serve effectively as a carbon sink for at least 40 years, not surprising given that forest ecosystems contain up to 100 times the carbon found in agricultural systems. Species selection for carbon sequestration is important as biomass accumulation and carbon uptake is known to vary by species (Schroth et al. 2002). Forests have the potential to store carbon beyond current levels (Harmon 2001), and capitalizing on this will help ameliorate climate change. Schroth et al. (2002) found that multi-strata plantations (i.e., agroforestry) had greater potential to store carbon than even-aged monocultures. Cannell (1999) reported that trees in plantations managed for maximum timber volume contain considerably less carbon than the same area of unmanaged forests, based on the strategy of harvesting plantations at the maximum mean annual increment.

Genetic modification of common tropical plantation species such as Monterey pine has led to an increase in carbon sequestration by as much as 22% (Jayawickrama 2001). Should future efforts to increase the sequestration ability be concentrated only on those species that are already commonly used for reforestation in tropical areas, a decrease in the diversity of species being planted is likely. Furthermore, should there be a financial benefit to having species that are more adept at sequestering carbon, this would likely lead to an increase in the percentage of forests containing those particular species. While this could be beneficial to conservation efforts if those species were native, it could hinder attempts to foster diversity in reforestation programs if they were exotic.

The potential economic benefits of the aforementioned practices could create great opportunities for tropical regions of the world through plantation establishment. Revenue from a carbon-credit system could provide tropical landowners with financial justification to maintain forest cover on their land. Ramirez et al. (2002) determined that forest conservation to sequester carbon in Costa Rica would be economically sensible. With adoption of the REDD+ program, or reducing emissions from deforestation and forest degradation, carbon sequestration has become a significant international policy objective (FAO 2011).

Because potential carbon sequestration is another example of why the rate of establishment of tropical forest plantations may increase, it is important that before added pressure to establish plantations is applied to tropical countries, a better understanding of species selection be developed. NTFPs in India's forests are largely unaccounted for in terms of the economic value they provide (Chopra 1993). In Indonesia, farm-households that participated in tree-growing projects benefited from diversified revenues and added cash incomes (Nibbering 1999). The incorporation of NTFPs with traditional farming and forestry practices appear to be leading to financial and environmental benefits that may provide a basis for sustainable land use (Leakey and Tchoundjeu 2001). A combination of management for NTFPs and carbon sequestration could provide long-term benefits to local communities as well as the environment. Furthermore, these practices would be more likely to gain certification, which could otherwise lead to a loss of market access if, for example, European producers chose to purchase certified temperate forest products over uncertified tropical forest products (Ruddell et al. 1998). In 2007, Norway banned tropical timber from public procurement programs (FAO 2011). Actions like these increase pressure on tropical forest plantation managers to consider the economic and environmental consequences of plantation practices.

15.6 Summary and Recommendations for Future Progress

To conserve biological diversity and increase potential economic benefits to tropical communities, a global focus on establishment of tropical forest plantations should consider the impacts of species selection and stand composition. Such a careful *a priori* consideration of species selection could increase the long-term ecological contribution of resulting plantations. Mixed stand management using native species is recommended to conserve biological diversity and increase local economic opportunities. The ability of native species to sustain natural ecological processes and provide proper habitat for native animal and plant species far exceeds that of exotic species. Furthermore, mixed stand management provides diversity to offset damage associated with pest outbreaks. Therefore, a plantation comprised of a mix of native species is far more likely to: (1) facilitate processes associated with natural ecosystems, (2) meet local cultural needs, (3) maintain traditional forest values, and (4) produce traditional forest products, while minimizing biological, economic, and environmental risks (i.e., pests and pathogens, and dependence on a single forest product). Increased species richness in plantations ensures the potential for future development and diversification of forest products that will benefit local communities.

An increase in global consumption of wood products, potential financial gains from carbon sequestration, and acceptance of the need for erosion control to maintain clean water and ground structure will lead to enlargement of tropical forest plantation area. Addressing concerns over future stand composition prior to plantation establishment facilitates the potential to maintain key components of natural ecosystems. Over time, ecological restoration by humans will become increasingly important toward the conservation of biodiversity (Dobson et al. 1997). Currently, practices are being developed to rehabilitate and restore habitat for a multitude of species. These practices, however, are expensive and experimental. By limiting the establishment of sites which, in the future, may need to be restored, future costs can be avoided through present actions.

We propose four key points of consideration for future tropical plantation establishment:

1. Plantations are a necessary part of resource management, both for wood supply and for ameliorating pressures placed on natural forests
2. Plantation composition and structure can greatly impact both monetary and ecological values
3. Diversification of species (i.e., multi-species management) may reduce risks associated with disease and market fluctuations, while increasing contributions to ecosystem diversity
4. Use of native species does not preclude obtaining the same remuneration as exotic species, increases provision of ecosystem services, and maintains cultural traditions associated with indigenous forest trees

As a method of conserving biological diversity, maintaining natural ecosystem processes, and increasing local and global benefits, we recommend the following guidelines for tropical forest plantation establishment:

1. Use native species, within their native range (with attention to matching species to suitable site conditions)
2. Use multiple species to allow for access to traditional (including timber and non-timber and non-timber products) and emerging (such as biofuels and carbon) markets
3. Select species that facilitate, or at minimum do not restrict, native understory development

Recent research in tropical regions toward identification of native species suitable for plantation establishment is encouraging and necessary. Dedication of researchers from around the world to assist with development of strategies to conserve tropical forests will decrease the chance of repeating mistakes made in boreal and temperate ecosystems. Partnerships like the Model Forest Network, which involves cooperation between government, indigenous people, practitioners, researchers, non-government organizations, and other stakeholders, appear to be more effective than traditional means in creating sustainable resource management practices (LaPierre 2002). Individuals and organizations with experience in developing new market products could prove to be an invaluable resource for the economic production of NTFPs. Implementing the aforementioned recommendations will likely lead to a more desirable future forest plantation composition, but it is paramount that landowners understand the reasons for the actions they are taking. Whitmore (1987) recommended that a global network of plantation researchers and practitioners would ‘overcome barriers to plantation success.’ This still holds true, and we would all benefit from striving to attain this goal. Through proper management, tropical afforestation and reforestation can benefit society locally and globally while maintaining key ecosystem components and providing important services currently threatened or degraded by anthropogenic use.

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