

Managing natural forests for sustainable harvests of mahogany (*Swietenia macrophylla*): experiences in Mexico's community forests

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In the state of Quintana Roo, Mexico, collaborative research and adaptive management are providing a foundation for sustainable management of mahogany.

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Big-leaf mahogany (*Swietenia macrophylla*), the most important timber tree in neotropical forests, has become the flagship species in debates about the feasibility of sustainable tropical forest management (e.g. Rice, Gullison and Reid, 1997). The natural range of mahogany extends from southern Mexico to an arc along the southern Amazon basin of Bolivia, Brazil and Peru (Lamb, 1966). In its native range, mahogany timber is still obtained from natural forests because decades of attempts to grow the species in monospecific plantations have been largely unsuccessful owing to attacks by a shootboring insect, *Hypsipyla grandella* (Patiño Valera, 1997; Mayhew and Newton, 1998). Continuing harvests have depended on progressive expansion into previously unlogged forests as skidding technologies changed and diameter limits dropped with changing markets, and as new sources were utilized (e.g. Brazil, Bolivia and Peru) (Grogan, Barreto and Veríssimo, 2002; Blundell and Rodan, 2003). In recent years, significant quantities of mahogany entering the international trade from the Amazon region have been obtained illegally, sometimes from the lands of indigenous tribes, without their consent (Watson, 1996). As a result, the United States and some European countries froze imports of big-leaf mahogany from Brazil in 2002, and the Brazilian Government suspended mahogany logging (Grogan, Barreto and Veríssimo, 2002; Blundell and Gullison, 2003). Today, most mahogany timber in international trade comes from Peru, and most is imported by the United States.

Both deforestation (forest conversion) and timber harvesting have severely decreased the abundance of mahogany across much of its range, leading to concern about the survival of many populations of the species, as well as

the sustainability of its commercial trade (Kammesheidt *et al.*, 2001; Blundell and Rodan, 2003). As a result, in 2002, after three previous and contentious debates among the signatories, big-leaf mahogany was listed on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which calls for the scientific and management authorities of each exporting country to define sustainable levels of harvest for the species and to provide export permits accordingly (Rodan and Blundell, 2003). Appendix II requirements enter into force in November 2003.

According to the mahogany working group of the CITES Secretariat, the community mahogany producers of southern Mexico represent the only example of serious, long-term efforts to produce mahogany timber sustainably from natural forests (J. Grogan, personal communication). In the Maya Forest, the most extensive contiguous tropical forest area north of the Amazon, considerable progress towards sustainable management has resulted from almost 20 years of inventories, silvicultural efforts, observations and studies which have augmented the knowledge base on mahogany silviculture. These experiences and studies can provide a foundation on which producers elsewhere might model sustainable and equitable mahogany production systems that provide not only timber but livelihoods for rural people, as well as favouring forest conservation.

THE CHALLENGE OF SUSTAINING MAHOGANY HARVESTS

The only way to sustain mahogany harvests into the future is to ensure that harvested trees are replaced by the growth of existing trees not yet of commercial size and to promote regeneration in each annual cutting area.

Mahogany regenerates abundantly after catastrophic disturbances which destroy most associated species and create relatively large open areas (ideally, greater than 5 000 m²). In Central America, favourable conditions have been produced by hurricanes followed by fire, clearing for log yards, and slash-and-burn practices used to open shifting agricultural fields (Lamb, 1966; Snook, 1996). Thus mahogany trees tend to occur in essentially even-aged stands which may include some older individuals that survived the stand-initiating disturbance. Post-disturbance clumps may include densities as high as 50 mahogany trees (>30 cm) per hectare among 450 trees per hectare of other species (Snook, 2003), although overall densities of commercial-sized mahogany trees in the region are closer to one tree per hectare. In the southern Yucatan peninsula, where disturbances have been frequent, forests are typically mosaics of even-aged stands of different ages.

Unfortunately, selective timber harvesting alone does not produce favourable regeneration conditions for mahogany. Selective harvesting impedes mahogany regeneration in two ways: by maintaining shady conditions inimical to the survival of mahogany seedlings (Dickinson and Whigham, 1999; Snook and Negreros-Castillo, 2003) and by depleting mahogany seed sources. Markets for species other than mahogany are limited, and even harvests of as many as 15 species were found to open less than 3 percent of the canopy, largely in gaps of less than 300 m² (Whitman, Brokaw and Hagan, 1997; Robinson, 1998). Mahogany seeds do not remain viable longer than a few months (Morris, Negreros-Castillo and Mize, 2000), so there is no mahogany seed bank in the soil. The lack of seed sources can be overcome by sowing mahogany seeds or

The average density of commercial-sized mahogany trees in Central America is about one tree per hectare, but densities can be higher when mahogany regenerates in post-disturbance clearings



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Creating favourable conditions for survival of light-demanding mahogany seedlings is a challenge; ejidos in Quintana Roo plant them on log yards, in felling gaps and on skid trails

planting mahogany seedlings. Creating favourable conditions for their survival is more challenging, and requires investment in silvicultural treatments.

PROGRESS IN MANAGEMENT OF MAHOGANY IN QUINTANA ROO, MEXICO

The state of Quintana Roo, Mexico, in the eastern part of the Yucatan Peninsula, is 49 percent forested and produces 32 percent of Mexico's precious tropical timbers (mostly mahogany as well as some cedar, *Cedrela odorata*) (INEGI, 1990). Forty-three percent of Quintana Roo's land is controlled through communal land ownerships called *ejidos* (INEGI, 1990). Most *ejidatarios* are

farmers, who fell and burn fields each year for the production of subsistence crops of corn, beans and squash. The state has 125 *ejidos* that are currently involved in commercial forestry, controlling from less than 1 000 ha to more than 55 000 ha of land each. Since control of timber harvesting was granted to these *ejidos* in 1984, each of them has delineated areas ranging from less than 1 000 to 40 000 ha as permanent forest reserves which are managed for the production of timber and other forest products. Agriculture is excluded from these areas. As of 2003, these forest reserves totalled nearly 800 000 ha, but additional *ejidos* are still being integrated. Thirty-six *ejidos* are currently author-

ized to harvest approximately 7 000 m³ of mahogany timber per year. A number of the *ejidos* are certified under the guidelines of the Forest Stewardship Council. Annual harvests may be modified and additional *ejidos* will begin producing mahogany as forest inventories and management plans are completed and the necessary permits are granted.

Most of the mahogany-producing *ejidos* of Quintana Roo belong to one of five associations, each of which has a technical directorate, a team of foresters and technicians that oversees forest inventories and develops a management plan for each *ejido*'s forest. The technical directorate also supports the *ejidos* in developing the organizational capacity to manage their forestry operations and provides support for the sale of forest products. Some of the technical directorates have received funding from the federal or state government and/or international donors.

In addition to harvesting mahogany, communities produce and sell other tropical timbers, both hardwoods and softwoods. They also produce and sell railroad ties, small understorey trees for construction poles and a variety of non-wood forest products, as well as environmental services. Timber is harvested by the *ejido* and sold as a community resource, with profits reinvested in the *ejido* or shared equally among its members. Seven *ejidos* and one of the associations have functioning sawmills, where members also earn wages by converting mahogany or other timbers to boards. Logs and boards are sold primarily on the domestic market.

Total combined volumes of softwood and hardwood species other than mahogany are much higher than mahogany volumes, but mahogany yields profits many times those obtained from the same volume of other species: in 2002, 1 517 pesos (US\$137) per cubic metre as



Logs are harvested and sold by the ejido, with profits reinvested in the ejido or shared equally among its members

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Several of the ejidos in Quintana Roo have functioning sawmills, where members earn wages by converting mahogany or other timbers to boards for sale, mainly on the domestic market



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compared to 264 pesos (US\$24) per cubic metre for softwoods and \$241 pesos (US\$22) per cubic metre for hardwoods. This difference is even higher when logs are sawn into boards.

Most of the mahogany-producing *ejidos* have carried out inventories of mahogany and other commercial species on their forests, down to 10 cm diameter. Timber harvesting is carried out according to a 25-year cutting cycle. The forest is divided into 25 annual cutting areas, and each year all mahogany trees greater than the minimum cutting diameter (55 cm) are harvested from that year's cutting area. If buyers are found for other timber species, these, too, are harvested, down to a minimum diameter that varies by species. Many of the forest *ejidos* in Quintana Roo are now in the eighteenth or twentieth year of their first cutting cycle, although others became involved in forestry more recently.

Most *ejidos* collect seed (from felled or standing mahogany trees) and produce mahogany seedlings. After harvesting, they plant the seedlings on log yards, in felling gaps and on skid trails in that year's felling area. Seedlings and/or labour for these efforts have been paid for through either government-funded programmes or reinvestment of earnings from forestry.

RESEARCH AND ADAPTIVE MANAGEMENT

The community forestry organizations in Quintana Roo are dedicated to the principle of adaptive management, based on learning by doing, initiating forestry activities using the best available knowledge and modifying initial practices in light of new knowledge obtained from observations or research (Flachsenberg and Galletti, 1998). The first modification to initial management plans was a reduction in annual cutting volumes,

as initial stock surveys on areas rich in mahogany were replaced by full forest inventories that provided more realistic estimates of standing stocks. In one *ejido*, initial annual harvest estimates of 1 000 m³ per year were reduced to 310 m³ per year.

Monitoring of enrichment planting has been limited, but after one study indicated that only 22 percent of mahogany seedlings planted in skid trails and felling gaps survived one to three years after planting (Negreros-Castillo and Mize, 2003), *ejidos* began to focus their efforts on planting seedlings in areas with better solar exposure. Since most felling gaps have been found to be too small for the survival and growth of mahogany seedlings, efforts are now being focused on the largest gaps, averaging about 1 800 m². Experiments have also been initiated on enlarging and cleaning felling gaps prior to planting (at a density of 3 m x 3 m). This practice has become more feasible in recent years with the increasing market for construction poles, but it typically requires felling of trees smaller than the minimum cutting diameter. On log yards, where enrichment plantings have been successful, at least one *ejido* is now experimenting with cleaning, thinning and pruning (Argüelles *et al.*, 2003). Additional observations will be necessary to determine how much area needs to be regenerated each year to ensure future harvest volumes.

Collaborative arrangements between the forestry organizations of Mexico and researchers, typically funded in large part from international sources, have also contributed to learning about how best to achieve sustainability. Over the past seven years, studies on ways of sustaining mahogany have been carried out in these production forests with support from the Center for International Forestry Research (CIFOR).

The results of this research were presented to and discussed by foresters, forest owners and representatives of government agencies and research and educational institutions from Mexico and Belize in November 2003 at a workshop organized by CIFOR in Chetumal, Quintana Roo, with the goal of translating this new knowledge into management guidelines for sustaining mahogany regeneration. Both the research results and the conclusions of the workshop will be published in Spanish by the Tropical Agriculture Research and Higher Education Center (CATIE) in a special edition of the journal *Recursos Naturales y Ambiente*. The results include the following.

Regeneration on clearings. Three studies were carried out with support from CIFOR to evaluate ways of producing favourable conditions for mahogany regeneration, whether planted or natural. One experiment evaluated the survival and growth of mahogany seedlings on clearings of different sizes (500 to 5 000 m²) and found that growth was highest on the largest clearings. All seedlings planted on control plots under the forest canopy had died by the fifth year, confirming the futility of enrichment planting under shady conditions (Snook, Negreros-Castillo and O'Connor, 2003).

Another experiment evaluated different ways to open 5 000 m² clearings. Two of the methods—clearing by machine, which uprooted all standing trees, and slashing, felling and burning—yielded good results: 50 percent survival of mahogany seedlings at five years and annual height growth averaging 65 cm. Where natural regeneration of other species was allowed around the mahogany seedlings, only 12 percent were attacked by the mahogany shootborer, as compared with 44 percent where vegetation was cut back. Planting

mahogany trees on clearings totalling 3 to 6 percent of each annual cutting area could provide for the replacement of the mahogany trees harvested (Snook and Negreros-Castillo, 2003).

A third experiment evaluated the establishment of natural regeneration on 2 700 m² areas, downwind of mahogany seed trees, which had been subjected to four different silvicultural treatments. Natural regeneration became established where the canopy had been completely removed, either by uprooting all standing trees or through clearfelling, but not in areas where residual trees had been girdled or the understorey had been felled (Toledo and Snook, 2003). These experiments confirm the value of planting or leaving seed trees on log yards and suggest the potential to integrate the use of slash-and-burn clearing as a forest management technique.

Seed production. A study of the dynamics over six years of seed production by mahogany trees of different sizes revealed considerable variability from year to year and from tree to tree; but trees with diameters of 75 cm or greater consistently produced many more seeds, and produced seed more consistently, than trees of smaller diameter. While as many as 27 percent of trees with diameter of less than 75 cm produced no seed in a given year, 93 percent of larger trees produced seed every year (Snook, Camara Cabrales and Kelty, 2003). These results have important implications for sustaining mahogany regeneration, whether natural or planted: unless some large mahogany trees are protected, harvesting mahogany to a minimum diameter limit will severely deplete the seed production potential in these forests. With support from Mexican government agencies, some *ejidos* have been delimiting seed production areas. The results of this study

provide a foundation for selecting these seed trees.

CONCLUSIONS

Sustaining mahogany in production forests is not simple, because trees of this species typically occur at low densities and are selectively harvested from a matrix of more abundant trees of largely non-commercial species, leaving a nearly intact canopy and few opportunities for the light-demanding establishment of mahogany regeneration. However, in Mexico's community forests, where government funds have supported the establishment of nurseries and other silvicultural activities, and *ejidos* can count on the labour of their members, enrichment planting is being carried out annually on each cutting area. Silvicultural practices continue to be refined in light of observations and measurements by managing foresters and complementary studies carried out by collaborating researchers. These efforts are also providing a model for the management of community concessions across the border in Guatemala (Gretzinger, 1998).

Challenges to sustainable mahogany silviculture remain. Some of these reflect the need for additional research, for example, to determine how much area should be subjected to regeneration treatments each year. Others are economic or institutional: limited markets for the high standing volumes of hardwood and softwood species reduce the economic potential of the forest and make it costly to create large openings for regeneration. Under current regulations, only trees larger than a minimum diameter can be felled and clearings cannot be created in permanent production forests. These guidelines limit the potential to apply more intensive silvicultural treatments to foster mahogany regeneration.

Other factors have the potential to

undermine natural forest management as a land use. Despite the extent and importance of natural forests in Quintana Roo, less government financial support is available for natural forest management than for plantation establishment or reforestation of degraded lands; while overall support to forestry is a fraction of government subsidies to agriculture, particularly cattle ranching, which requires forest clearing. Despite the sale of multiple products and services from the forest, earnings from forestry are insufficient, in many *ejidos*, to provide an adequate income to *ejido* members and to cover the costs of the forest management services provided by the technical directorates. In response to this situation, efforts are being made to improve the internal capacity of *ejidos* in forestry, so that they can provide more of their own forestry support services (Argüelles *et al.*, 2003)

Despite the challenges, the Maya Forest provides livelihoods for thousands of local families, from mahogany and a spectrum of associated forest resources and services, while sustaining a broad array of environmental services and conserving biological diversity. As CITES Appendix II protection comes into force, the management experience and research among the Maya Forest *ejidos* can provide useful lessons for mahogany-producing countries seeking ways of producing mahogany sustainably. ♦



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