

# Sustaining mahogany: research and silviculture in Mexico's community forests

Laura K. SNOOK<sup>1, 2</sup>

<sup>1</sup> Center for International Forestry  
Research (CIFOR)  
PO Box 6596 JKPWB, Jakarta, 10065  
Indonesia

<sup>2</sup> Current address:  
The Elms, The Walk, Islip OX5 2SD  
United Kingdom

## The most advanced

efforts to sustainably produce mahogany (*Swietenia macrophylla* King) are those of communities that harvest multiple products, including timber, from production forests on Mexico's Yucatan peninsula<sup>3</sup>. Over the past 20 years, their foresters have developed inventories and management plans and overseen enrichment planting efforts, while researchers have established experiments and studies to evaluate management alternatives.

<sup>3</sup> The view expressed in this publication are those of the author, and not necessarily those of CIFOR.



Mahogany saplings two years after they were planted as three month-old seedlings averaging 20 cm in height, in the center of a 5 000 m<sup>2</sup> clearing produced using the slash and burn treatments used by local farmers to create agricultural clearings (Figure 3b). Photo L. K. Snook.

## RÉSUMÉ

### PRODUCTION DURABLE DE BOIS D'ACAJOU: RECHERCHE ET SILVICULTURE DANS LES FORÊTS COMMUNAUTAIRES DU MEXIQUE

L'acajou (*Swietenia macrophylla*), principale essence forestière de la zone néo-tropicale, provient de forêt naturelle. Sa régénération difficile en forêt exploitée explique son inclusion, en 2003, dans l'Annexe II de la Cites, qui impose aux pays producteurs la mise en place de systèmes de production durable. Les avancées les plus intéressantes émanent de communautés du Yucatan, au Mexique, qui prélèvent divers produits, dont plus de 8 000 m<sup>3</sup>/an de bois d'acajou, sur près de 730 000 hectares de forêt. Depuis vingt ans, les forestiers mettent en œuvre des inventaires, plans de gestion et programmes d'enrichissement, alors que des chercheurs mènent des études pour évaluer des options de gestion. Sept ans de recherches sur la régénération de l'acajou montrent que les meilleurs semenciers sont les arbres d'un diamètre supérieur à 75 cm, mais ceux-ci sont rares en raison des coupes sélectives des arbres dépassant le minimum réglementaire de 55 cm. Des essais sylvicoles sur clairières de diverses superficies montrent que celles de 5 000 m<sup>2</sup> ouvertes mécaniquement ou par brûlis – procédés néfastes aux rejets d'autres essences – sont les plus favorables. Les arbres de semis transplantés sous couvert forestier n'ont pas repris. Chercheurs, forestiers, agences gouvernementales et communautés travaillent ensemble pour réviser les orientations de gestion en y intégrant ces constatations, et pour modifier en conséquence les politiques forestières. Ces résultats devraient pouvoir s'appliquer à la gestion de l'acajou en dehors de son aire naturelle, et aux acajous africains très voisins.

**Mots-clés :** foresterie communautaire, acajou, gestion des forêts naturelles, recherche.

## ABSTRACT

### SUSTAINING MAHOGANY: RESEARCH AND SILVICULTURE IN MEXICO'S COMMUNITY FORESTS

The most important timber species in the Neotropics, mahogany (*Swietenia macrophylla*) is still harvested from natural forests. The difficulty of ensuring its regeneration in logged-over forests was a primary reason for listing this species in CITES Appendix II in 2003, requiring producer countries to develop sustainable production systems. The most advanced efforts are those of communities that harvest multiple products, including more than 8 000 m<sup>3</sup>/year of mahogany timber, from over nearly 730 000 hectares of production forests on Mexico's Yucatan peninsula. Over the past twenty years, their foresters have developed inventories and management plans and overseen enrichment planting efforts, while researchers have established experiments and studies to evaluate management alternatives. Seven years of research on mahogany regeneration has revealed that mahogany trees with diameters superior to 75 cm are the most important seed producers, but selective harvesting of all trees over the minimum diameter limit of 55 cm is depleting them. Silvicultural experiments on different sizes of clearings have shown that 5 000 m<sup>2</sup> clearings produced by machinery or burning, treatments which impede resprouting by trees of other species, were most favourable, to establishment and growth of mahogany seedlings. Seedlings did not survive when planted under the forest canopy. Researchers, foresters, government agencies, and communities have been collaborating to integrate these new findings into revised management guidelines and to modify forestry policies accordingly. These findings are likely to be applicable to the management of this species elsewhere in its native range, and possibly also to the closely related African mahoganies.

**Keywords:** community forestry, mahogany, natural forest management, research.

## RESUMEN

### PRODUCCIÓN SOSTENIBLE DE MADERA DE CAOBA: INVESTIGACIÓN Y SILVICULTURA EN LOS BOSQUES COMUNITARIOS DE MÉXICO

La caoba (*Swietenia macrophylla*), principal especie forestal de la zona neotropical, se extrae de bosques naturales. Su difícil regeneración después de la extracción llevó a su inclusión, en 2003, en el Anexo II de la CITES, que impone a los países productores el establecimiento de sistemas de producción sostenible. Los adelantos más interesantes proceden de comunidades del Yucatán, en México, que extraen una variedad de productos, destacando los más de 8 000 m<sup>3</sup>/año de madera de caoba, de cerca de 730 000 ha de bosque. Desde hace veinte años, los silvicultores aplican inventarios, planes de manejo y programas de enriquecimiento, mientras que los investigadores realizan estudios para evaluar opciones de manejo. Siete años de investigaciones sobre la regeneración de la caoba ponen de manifiesto que los mejores árboles semilleros son aquellos cuyo diámetro supera los 75 cm, pero éstos escasean debido a las talas selectivas de los árboles que exceden el mínimo reglamentario de 55 cm. Algunos ensayos silvícolas en aperturas de distintas superficies muestran que los de 5 000 m<sup>2</sup>, abiertos mecánicamente o mediante quema, –métodos que impiden los rebrotes de otras especies– son los más favorables para la regeneración. Plántulas de caoba plantadas bajo la cubierta forestal no se desarrollaron. Los investigadores, silvicultores, agencias gubernamentales y comunidades trabajan juntos para integrar estos nuevos conocimientos al manejo las políticas forestales correspondientes. Estos resultados deberían poder aplicarse al manejo de la caoba en otras partes de su área de distribución natural y a las caobas africanas, que son similares.

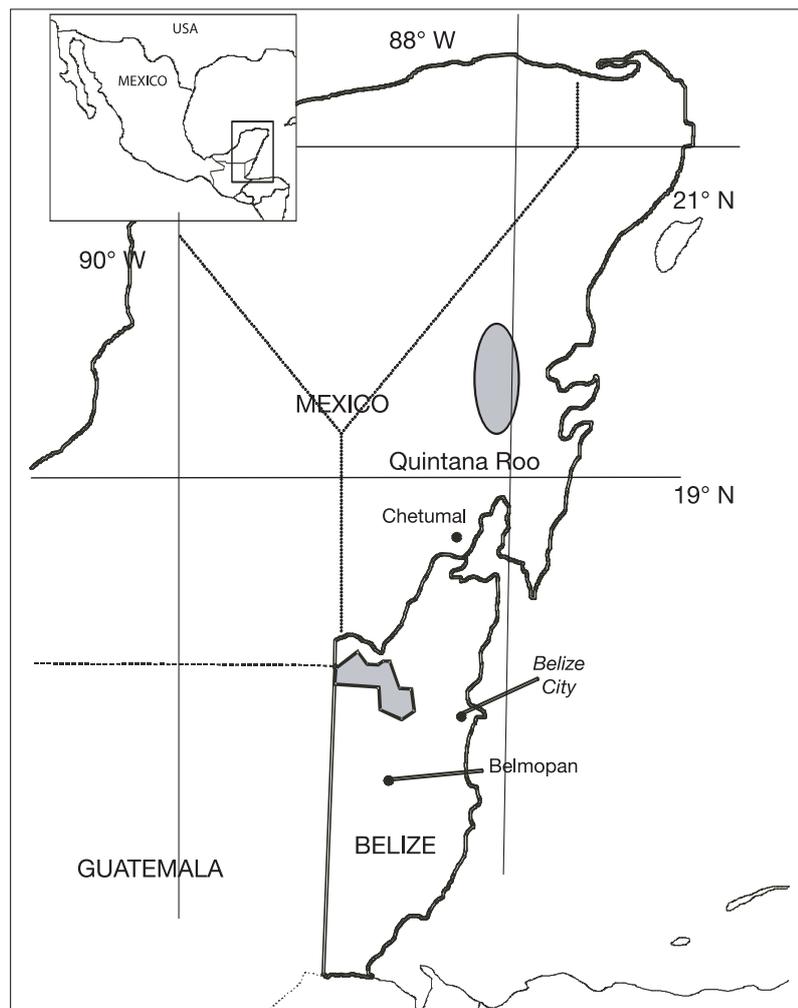
**Palabras clave:** silvicultura comunitaria, caoba, manejo de bosques naturales, investigación.

Big-leaf mahogany (*Swietenia macrophylla* King) is the most commercially important timber tree in tropical forests extending from southern Mexico to the southern Amazon basin of Bolivia, Brazil, and Peru. Its valuable timber has been exported from this region to Europe since the 1600s, and to the United States since the 1800s (LAMB, 1966), and is still obtained almost entirely from natural forests in its native range. In the past, timber supplies have been sustained through progressive expansion into previously unlogged forests as technology permitted increased penetration into the forests of Central America (SNOOK, 1998), and new sources were tapped (e.g. Brazil, Bolivia, and Peru, successively, starting in the 1960s) (SNOOK, 1996; BLUNDELL, RODAN, 2003). Both forest conversion and 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 (VERISSIMO *et al.*, 1995; SNOOK, 1996; BLUNDELL, RODAN, 2003; NAVARRO *et al.*, 2003; BLUNDELL, GULLISON, 2003). At the crux of the controversy is the difficulty of ensuring regeneration of this light-demanding species, which occurs at low densities and is selectively harvested from a matrix of largely non-commercial species (SNOOK, 1996). 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 of Endangered Species (CITES), which calls for the “scientific and management authorities” of each exporting country to manage their harvesting in such a way as to “maintain [mahogany] throughout its range at a level consistent with its role in the ecosystems in which it occurs” (Art. IV.3). This, in turn, requires the implementation of ecologically based silvicultural practices to ensure its regeneration in forests from which it is logged.

Research on the ecology of mahogany regeneration in natural forests was initiated in the 1920s in what was then British Honduras (now Belize) (e.g. LAMB, 1966; WEAVER, SABIDO, 1997), followed by a second wave that began in the late 1980s in Mesoamerica (e.g. NEGREROS-CASTILLO, 1996; DICKINSON, WHIGHAM, 1999; SNOOK, 2003) and South America (e.g., GULLISON *et al.*, 1996; GROGAN *et al.*, 2003). This article synthesizes additional insights obtained from research carried out over the past seven years in the forests of south-eastern Mexico and north-western Belize (Figure 1), and discusses the corresponding evolution since the mid-1980s of silvicultural management practices in the community-owned natural forests of Quintana Roo, Mexico.

## Community forest management in Quintana Roo

The state of Quintana Roo, on Mexico’s Yucatan peninsula, is a relatively flat limestone platform of karst topography with fairly fertile soils, a mean temperature of 25 °C and average annual rainfall of 1 100 to 1 500 mm/year that falls mostly between May and October (CNA, 2002). Quintana Roo is affected nearly every year by tropical cyclones or hurricanes (JAUREGUI *et al.*, 1980), which are occasionally followed by wildfires (LÓPEZ-PORTILLO *et al.*, 1990; SNOOK, 2003). The state is 74% covered with forest (JHONES *et al.*, 2000 in BRAY *et al.*, 2004), part of the Maya Forest



**Figure 1.** Studies of mahogany ecology and silviculture were carried out in the areas shaded grey, in Quintana Roo, Mexico and Belize.

which extends into Belize and Guatemala. This tropical seasonal forest is made up of over 100 canopy tree species, of which the currently most abundant are *Manilkara zapota*, which occurs at densities of 15 to 60 individuals per ha, and *Brosimum alicastrum*. Canopy height averages 20-25 m, and mahogany trees are emergents that may grow to more than 30 m in height (SNOOK, 2003). Mahogany is more common in this forest type than any other in Mexico (PENNINGTON, SARUKHÁN, 1968). While mahogany trees are typically found in clumps in which their densities may be equivalent to almost 50 trees/ha among about 450 trees/ha of other species, average densities of about one commercial-sized tree/ha have been estimated from forest inventories (SNOOK, 2003).

Quintana Roo produces 32% of Mexico's precious tropical timbers (INEGI, 1990), notably about 8 000 m<sup>3</sup>/yr of mahogany (NOLASCO *et al.*, in press; Table I). Forty-six percent of Quintana Roo is controlled through communal land ownerships called *ejidos* (INEGI, 1991). Since the conclusion of a 25-year concession to a government-owned veneer mill in

the early 1980's, these *ejidos* have had the legal right to carry out industrial timber harvesting in their forests (SNOOK, 1998). As of 2003, 127 *ejidos*, with a population of approximately 14 000 people, have done so, defining and managing production forest reserves ranging in size from 1 000 ha to more than 40 000 ha per *ejido*, and totalling approximately 730 000 ha of natural tropical forest (SNOOK, NAVARRO, in press; Table I; Figure 2). Of the 54 *ejidos* which have been organized the longest, 21 currently produce mahogany timber (SNOOK, NAVARRO, in press). Some *ejidos* have sawmills and sell boards, while others sell logs. The permitted annual harvest volume of mahogany is always cut and sold. If buyers are interested in other types of wood, some proportion of the available volume of as many as 20 other species may also be harvested and sold as industrial timber. In addition, some *ejidos* cut and sell railroad ties from species with durable "hard" woods. Harvest intensities are quite low, removing, at most, only a few trees/ha. Most *ejidos* also obtain income from the harvest and sale of non-timber forest products (chicle

latex from *Manilkara zapota*, palm thatch, building poles, and honey). State-wide, mahogany sales yield the largest portion of earnings among all these categories of forest products, accounting for approximately 25% of the total of US\$ 11.7 million in 2003, even though total volumes of "hard" and "soft" woods are much higher (Table I). This not only reflects the higher value per meter of mahogany, but the lack of market demand for other species (SNOOK *et al.*, 2004; NOLASCO *et al.*, in press).

Under Mexican law, although communities/*ejidos* have the right to make decisions and obtain the benefits from managing their timber resources, licensed professional foresters must develop and oversee management plans that comply with federal forestry regulations. These plans are built around a polycyclic system integrating three principal components:

- A 25-year cutting cycle.
- Annual harvest volumes by species group, determined from forest inventories.
- Minimum diameter limits which vary among species and according to end use.

**Table I.**

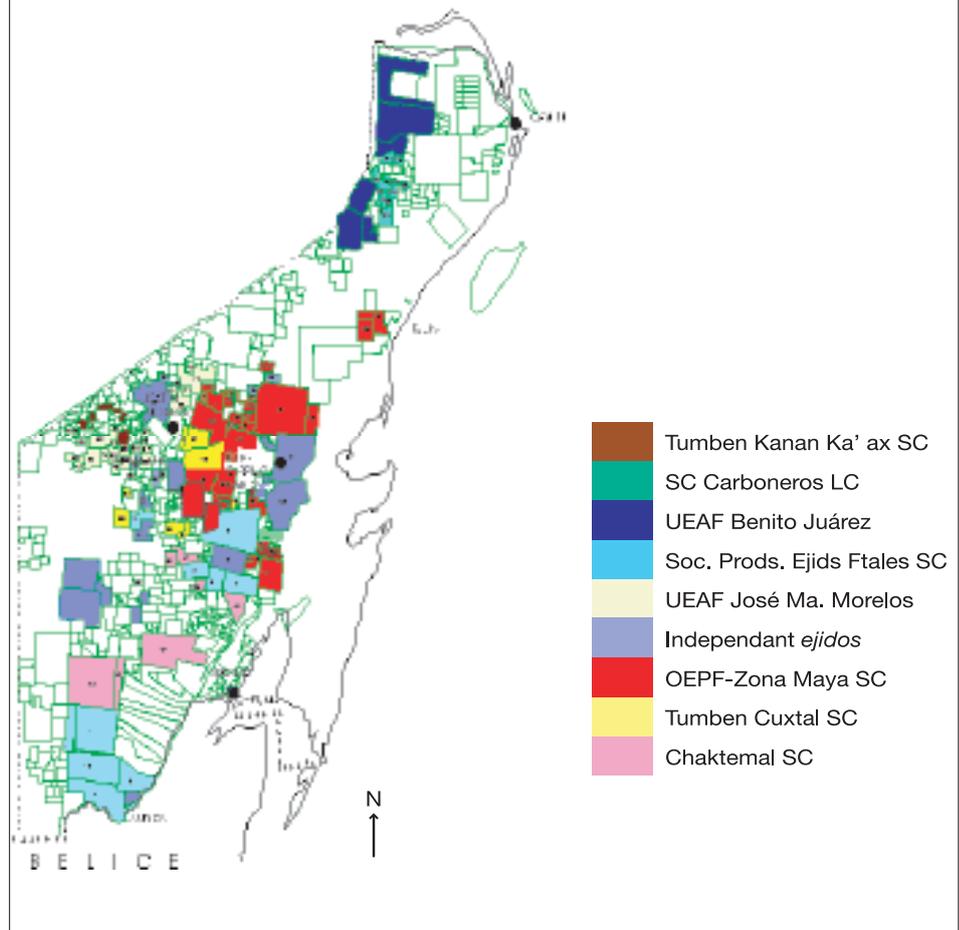
Associations of *ejidos* organized to carry out timber harvesting in Quintana Roo, Mexico, with their total areas and areas of permanent production forest, number of constituent *ejidos* and *ejidatarios*, annual harvest areas, and authorized annual harvests in 2003 of precious woods (> 90% of which is mahogany), "soft" woods, "hard" woods, and poles. Independent *ejidos* are not part of any association. Zeros do not indicate a lack of standing volume, but reveal that inventories and permits had not yet been completed at the time the table was integrated.

Association	Number of <i>ejidos</i>	Number of <i>ejidatarios</i>	Total area (ha)	Permanent production forest (ha)	Annual cutting area (ha)	Authorized annual harvest in 2003 (m <sup>3</sup> )			
						Precious woods	"Soft" woods	"Hard" woods	Poles
SPEF QR SC	9	1 914	262 708	135 580	5 543	3 670	9 948	19 568	8 659
OEPF ZM SC	25	3 567	336 505	214 150	8 566	1 051	4 563	25 399	2 845
SPIF QR "Tumben Cuxtal"	8	676	81 446	30 311	1 212	65	2 015	4 867	820
OEF "Chaktamal" SC	6	1 041	174 225	83 250	3 330	495	580	1 215	719
SCFPCZN QR SC	25	501	74 516	15 000	600	0	99	536	45 435
OEPAF "Tumben Kanan Ka'ax"	15	1 108	94 112	41 100	1 604	0	1 489	2 959	916
UEFA "Jose Ma. Morelos"	12	1 361	64 003	29 500	1 180	0	0	0	0
UEFA "Benito Juarez"	4	1 094	124 880	55 800	2 232	488	3 562	11 508	10 174
OEF "Yum Ka'ax" SC	4	137	10 848	3 200	128	0	0	0	0
Independent <i>ejidos</i>	19	2 491	315 115	121 700	4 868	2 510	9 200	30 116	6 498
Total	127	13 890	1 538 358	729 591	29 263	8 279	31 456	96 168	76 066

Source: Secretaría de Desarrollo Agrícola y Ganadero Rural e Indígena (SEDARI), State Government of Quintana Roo, Chetumal, 2003.

Silviculture focuses principally on mahogany, both because it is the most valuable timber resource and because its regeneration represents a challenge (SNOOK, 1996). Mahogany is a light-demanding species with wind-dispersed seeds, which has been found to regenerate abundantly after disturbances that produce clearings. In this region, these have typically resulted from hurricanes followed by fire, or from shifting cultivation (SNOOK, 2003). The selective harvesting practiced in the region, by contrast, typically creates small gaps which open only about 2% of the canopy, even if more than 10 species are harvested (DICKINSON *et al.*, 2000).

Forestry regulations call for enrichment planting to replace harvested trees, efforts which have focused principally on mahogany. About February, *ejidos* collect mahogany seed from felled or standing mahogany trees. A number of *ejidos*, and one association of *ejidos*, have nurseries (SANTOS *et al.*, in press; CHAN, in press; ARGUELLES *et al.*, in press) where seeds are sown in plastic bags filled with soil. Once harvesting is completed and the rains have begun (about June), seedlings are transplanted, usually into felling gaps, skid trails, and the log loading yards cleared by bulldozers. Planting is done by *ejido* members. Sometimes, and in some *ejidos*, they have been paid for their labor, either through government programs or from earnings from timber sales; sometimes they plant seedlings as part of the community's unpaid labor requirement, referred to as *fajinas* (SANTOS *et al.*, in press). *Ejidatarios* have been willing to invest their communal labor in regeneration efforts because they consider such investments a way of benefiting their grandchildren.



**Figure 2.**

Map of *ejidos* in the state of Quintana Roo. Those involved in timber production are color-coded according to the association which provides its forestry technical services (Table I). Source: SEDARI, 2003.

## Advances towards sustainable management

Over the past twenty years, the application of silvicultural techniques to sustain mahogany in the community-owned natural production forests of the Quintana Roo *ejidos* has been favored by a number of factors, notably the community land tenure regime, the dynamics of community forestry development in Mexico, and the Mexican forestry laws and regulations (SNOOK, 1998). In addition, support by interna-

tional donors has played an important role. During the first ten years of the process of organizing community forestry in Quintana Roo, foresters funded by the German GTZ supported community organization, provided training in inventory techniques and proposed an initial paradigm for silvicultural management (FLACHSENBERG, GALLETI, 1998). Additional support was provided by several American foundations and by Britain's DFID (SANTOS *et al.*, in press).



**Figure 3.**

Three treatments used to create experimental 5 000 m<sup>2</sup> clearings where mahogany seedlings were planted, to compare their survival and growth: (a) complete felling; (b) slash and burn practices; (c) machine-clearing, which uprooted trees. The latter two treatments successfully impeded sprouting.  
Photos L. K. Snook.

Modification and refinement of silvicultural techniques over time has responded to three principal factors:

- Research that has increased the knowledge base about mahogany silviculture.
- Observations by foresters and community members of the results of their silvicultural efforts.
- Financial support and incentives provided through government programs and international donors.

The dedication of foresters who work with the *ejidos*, a number of whom have been involved since the initiation of community forestry in the

region, has also been crucial to continuing advances, as have the attitudes of the ejidatarios who own the forests, and appreciate the value of sustaining their productivity over the long term.

Ecological research applicable to silvicultural management of mahogany in natural forests was initiated in the late 1980s by several international researchers, most of them PhD students at the time (SNOOK, BARRERA DE JORGENSEN, 1994; DICKINSON, WHIGHAM, 1999), and has continued to the present. These studies, supported largely by

international donors, have provided scientifically sound and statistically valid evaluations of silvicultural management initiatives and independent studies which have complemented the actions and observations of foresters. For example, although significant investments were being made each year in enrichment planting, these efforts were not evaluated until more than a decade had passed. Researchers working in collaboration with one of the *ejido* associations found that only about 22% of mahogany seedlings planted within the forest 1-3 years earlier had sur-

vived (NEGREROS-CASTILLO, MIZE, 2003). These findings were subsequently confirmed and complemented by the observations of foresters who visited early planting sites 10-15 years later and found that the canopy had closed over former felling gaps and skid trails, and that mahogany seedlings planted there had either stagnated or died. However, they found that plantings in log yards 0.25-1 ha in size, previously cleared by bulldozers, had developed well, yielding densities of approximately 50 good quality mahogany trees/ha that had grown an average of 0.83 cm/yr in diameter (ARGUELLES *et al.*, in press). These observations, in turn, were confirmed and expanded by experiments carried out by researchers to evaluate different silvicultural techniques for favoring regeneration. These revealed 50% survival and growth of up to 6 m in height over five years by mahogany seedlings planted on 5 000 m<sup>2</sup> clearings produced using bulldozers or the slash and burn techniques applied by local farmers each year to open agricultural fields; and 95% mortality and negligible growth, over the same period, of seedlings planted under the forest canopy. Competition by sprouts of other species impeded survival and growth of mahogany seedlings on clearings produced through felling alone (SNOOK, NEGREROS-CASTILLO, 2004; Figure 3). A companion study in neighboring Belize (Figure 1), evaluating survival and growth of mahogany seedlings on clearings between 500 m<sup>2</sup> and 5 000 m<sup>2</sup> in size, revealed that survival was adequate on all of them, but that growth was highest on the largest clearings (SNOOK *et al.*, in press; Figure 4). Both of these studies also evaluated the effect of cleaning around mahogany seedlings to reduce competition from re-growing vegetation and vines, and found that cleaning did not significantly increase growth on clearings produced using bulldozers or burning, but did significantly increase over 5 years the level of attack of seedlings by the shootborer *Hypsipyla gran-*

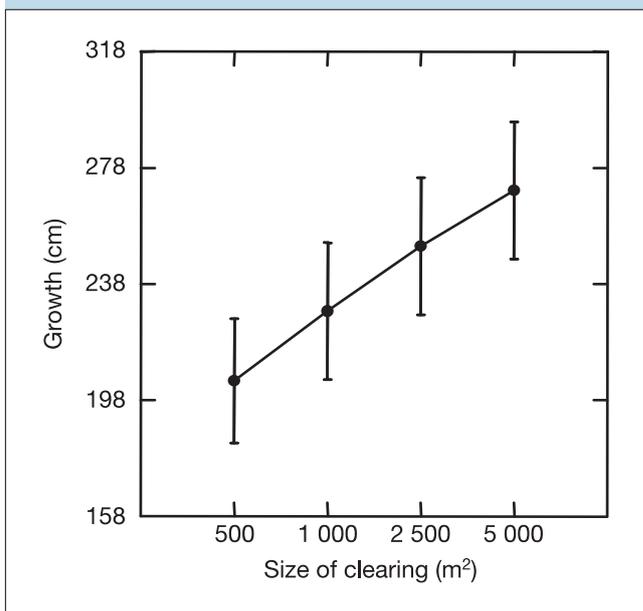
*della*, from a non-problematic 12 to 44% (SNOOK, NEGREROS-CASTILLO, 2004).

These insights led foresters to decide to concentrate enrichment plantings on log yards (although these represent only 1-3% of each annual harvest area) and shifting agricultural fields (although the latter are located outside the permanent forest reserves), and also stimulated efforts to find economically viable ways to increase the area favorable to mahogany regeneration within the production forest. The forest management team of one *ejido* recently initiated trials of a silvicultural approach intermediate between planting in post-harvest felling gaps and creating 0.50 ha clearings using bulldozers or burning. Using GPS to locate commercial trees on the annual harvest area, and mapping these using GIS, they seek to harvest groups of at least five trees, and then to completely open the relatively large gaps produced in this way, by felling and removing all residual trees and their crowns. This required obtaining authorization from the Ministry to fell trees below the minimum felling diameter, as part of the silvicultural system. Initial efforts have produced gaps averaging 1 800 m<sup>2</sup>. This technique, involving the felling of both canopy and understory trees, has become more cost-effective in recent years as the result of an increasing demand for small-diameter building poles for rustic beach constructions in the tourism zone of the nearby "Riviera Maya" (ARGUELLES *et al.*, in press). Survival and growth of seedlings planted in these areas has yet to be evaluated.

Enrichment planting and other regeneration techniques require seed, and ensuring supplies of mahogany seed is crucial to sustaining this species. Government funding programs initiated in the late 1990s to support natural forest management (PRODEFOR) and reforestation (PRONARE), have supported the definition and protection of seed reserves in *ejido* forests. This has encouraged at least nine *ejidos* to establish such reserves, focused

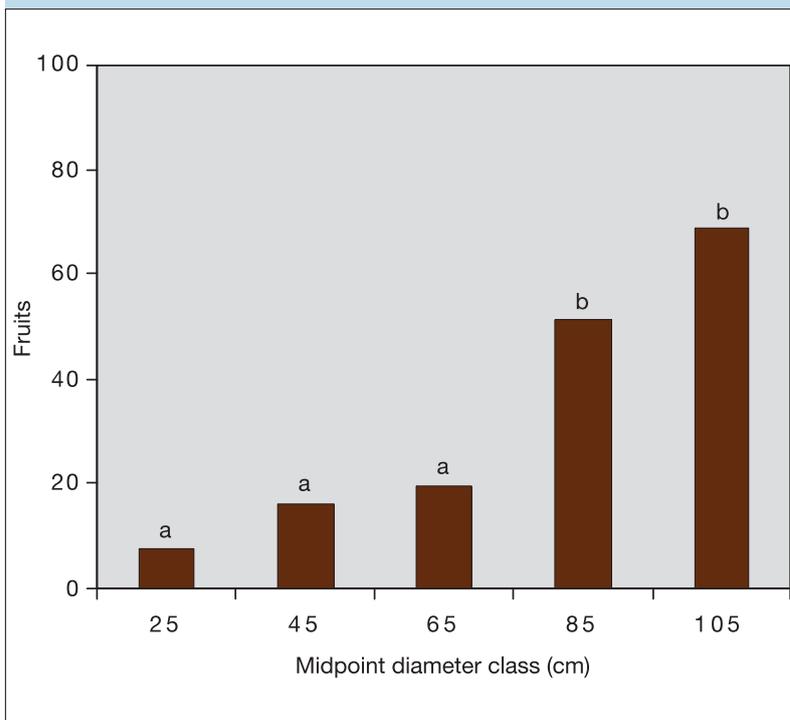
principally on mahogany (SANTOS *et al.*, in press; CHAN, in press; Francisco May Ek, pers. com.). Six years of research on fruit production by mahogany trees has revealed that mahogany trees larger than 75 cm dbh produce more seed, and produce seed more consistently, than do smaller diameter trees (Figure 5). These results suggest that existing guidelines for selecting seed trees and seed production areas should be modified, and call for the re-evaluation of the uniform application of minimum diameter limits in the light of the importance of large mahogany trees for seed production (SNOOK *et al.*, 2005).

To ensure that research results are known and understood by the foresters who write the management plans and the ejidatarios who make the decisions about investments in silviculture, it has been crucial that scientists disseminate these results in Spanish, orally and through field visits, as they did in workshops in 1992 and 2003, complemented by written proceedings that were distributed free to forest stakeholders in the region (SNOOK, BARRERA DE JORGENSON, 1994; SNOOK, NAVARRO, in press). In response to presentations of the results of five internationally funded studies on mahogany regeneration in November, 2003, the official forestry stakeholder group (Consejo Consultivo Técnico Forestal de Quintana Roo) made up of representatives of federal, state and municipal government agencies, foresters, ejidatarios, and NGOs, decided in January, 2004 to adopt management guidelines derived from recommendations emerging from the research, and to develop a technical commission for forestry research for the state (SNOOK, LÓPEZ, 2004). Several foresters consider additional applied research to be a major need and priority (SANTOS *et al.*, in press; Francisco May Ek, pers. comm.). Their consciousness may reflect, in part, the fact that a number of *ejidos* are certified under the guidelines of the Forest Stewardship Council, and certifiers have encouraged constant improvement of forest management.



**Figure 4.**

Height growth over five years of 20 mahogany seedlings planted on each of 32 100 m<sup>2</sup> plots in the centers of eight replicates of experimental clearings of four different sizes in Belize, each produced by complete felling and skidding. Bars correspond to standard errors.



**Figure 5.**

Average fruit production over six years by 83 mahogany trees in natural forest in Quintana Roo. As indicated by the different letters above the bars, mahogany trees larger than 75 cm dbh (diameter classes with midpoints of 85 cm and 105 cm) produced significantly more fruits each year than smaller trees ( $p < 0.001$ ).

## Challenges and opportunities ahead

The forest *ejidos* of Quintana Roo have provided the setting for the development of silvicultural management to sustain mahogany harvests from natural forests, and are the world leaders in its application. However, they still face challenges in achieving sustainable and viable forest-based economies. Although co-funded support from the Federal and State governments to support natural forest management has been appreciated, foresters consider that it is insufficient to provide for optimal forest management, and is disproportionate to the importance of forestry activities in the state, accounting for less than 1% of the government support provided to agriculture and animal husbandry (NOLASCO *et al.*, in press; SANTOS *et al.*, in press; CHAN, in press). In 2003, PRODEFOR invested the equivalent of US\$ 568 414 in natural forest management in Quintana Roo (NOLASCO *et al.*, in press).

*Ejidors* with small forests, or forests lacking commercial mahogany volumes, face particular challenges. Although government programs have, at various times, paid for the establishment of nurseries and replanting efforts, expenses associated with management, for example inventories and silvicultural treatments, have always been paid by the *ejidos* from forestry earnings, and can absorb significant quantities of total earnings in *ejidos* with low-value forests (SANTOS *et al.*, in press; CHAN, in press; ARGUELLES *et al.*, in press). Since 1992, when the government reduced its involvement in forestry, foresters who oversee forest management are no longer employed and paid by the federal government (NOLASCO *et al.*, in press; SANTOS *et al.*, in press). This has represented another hardship for both communities and foresters, particularly in smaller *ejidos*, where earnings from forestry are relatively low (SANTOS *et*

al., 1998; ARGUELLES *et al.*, in press; NOLASCO *et al.*, in press). It is worthy of note that the *ejido* which has advanced the most in silviculture (Noh Bec), also earns the most from forestry activities: US\$ 1 million a year, 50% of it from an annual harvest of 1 545 m<sup>3</sup> of mahogany. Over 150 *ejido* members earn wages from forestry activities, and each *ejido* member receives approximately US\$ 1 800/year in profit sharing (ARGUELLES *et al.*, in press). Most *ejidos*, with much lower – or no – annual harvests of mahogany, earn only a fraction of this amount (Table I).

A challenge facing even the *ejidos* with the best forests is the imminent conclusion of the first 25-year cutting cycle, which some *ejidos* will reach in 2008. During this first cutting cycle, many of the mahogany trees harvested have been considerably larger than the 55 cm minimum diameter limit. During the second cutting cycle there will be no such large-diameter trees, and both volumes and timber quality may be considerably lower. This transition may represent an important opportunity for exploring ways of increasing the value of the volumes harvested. For example, even the *ejidos* that are FSC-certified have not been able to translate their status into financial benefits because they sell their mahogany timber as boards on the domestic market, and have not, as yet, developed the capacity to supply the international market, or to produce higher-value products. This reflects, in part, the organization of production at the *ejido* level, none of which have an annual harvest of mahogany sufficient to supply the demands of the international buyers, or even to feed their own saw mills year-round. During the earlier concession period, the government mill that purchased the mahogany from these forests converted it into high-value veneers, but the company folded when the communities took control of their own mahogany production. To be able to increase the value of the

mahogany volumes they harvest, the Quintana Roo *ejidos* might have to pool their timber resources to feed an appropriate mill, which would also require additional capital investment. These options may represent opportunities for continuing development of the forestry sector in the region.

## Conclusions

The continuous expansion in the number of *ejidos* organized to carry out forestry, and the number of ha defined as permanent production forest in Quintana Roo, as well as the advances in the range and quality of forest management activities, provide a gratifying contrast to the situation in the countries of South America, where mahogany logging is commonly a mining operation unaccompanied by long-term management plans or silviculture, and is often uncontrolled, or even illegal (BLUNDELL, GULLISON, 2003). The listing of mahogany on CITES Appendix II may provide an incentive for other mahogany producers to implement sustainable management practices on their mahogany forests. The increase in community tenure over forest lands (WHITE, MARTIN, 2002) may further favor this transition, as community owners may be more interested in long-term sustainability than are industries with concessions. In Bolivia, where communities are being granted land and timber harvesting rights, some have already indicated an interest in planting mahogany (Peter Cronkleton, pers. comm.). Similarly, certification, which provided an additional incentive for developing and implementing silvicultural management practices among the Quintana Roo *ejidos*, is becoming more sought after by South American timber companies, notably in Bolivia and Brazil, and may encourage their interest in implementing silvicultural management to ensure future harvests.

Finally, the investments made by international donors to support forestry and forest research in Quintana Roo have yielded important environmental benefits, including a reduced deforestation rate (BRAY *et al.*, 2004), as well as socioeconomic benefits to local communities and a significant increase in the knowledge base for managing natural tropical forests. These multiple positive outcomes demonstrate the success of these investments, and should encourage funding agencies to replicate them elsewhere. The combination of CITES listing of mahogany and the increase in community forests make this a very favorable moment to do so.

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