Some simple management guidelines could help the sustainable management of bigleaf mahogany in the neotropics

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BIGLEAF mahogany (*Swietenia macrophylla* King), known as *caoba* in Spanish-speaking Central and South America and as *mogno* in Brazil, is the most valuable timber species in the neotropics. In recent years an international debate has arisen about the sustainability or otherwise of highly selective, largely unplanned mahogany extraction across the species' vast natural range, which stretches from Mexico to Bolivia (Gullison et al. 1996, Snook 1996, Lugo 1999; see also page 25). This is because the pace and efficiency of mahogany's exploitation have increased rapidly over recent decades as the extension of overland road networks into Amazonia has brought previously inaccessible natural populations within reach of a highly mechanised modern logging industry. As well, mahogany's exploitation is often linked to increased deforestation rates, as ranchers and smallholder agriculturalists follow logging roads into previously inaccessible frontier regions (Veríssimo et al. 1995).

Marvellous mahogany: the author perches against the bole of a giant mahogany in southeast Pará, Brazil.

An alternative to current logging practices is sustained-yield production of mahogany from natural forests. However, this requires a detailed understanding of the species' survival, growth and reproductive strategies under natural conditions. With this it should be possible to use harvesting techniques and silvicultural treatments to create conditions favourable to the growth of surviving sub-merchantable trees and the recruitment of future harvestable generations of trees. This knowledge should ideally be region- and even site-specific, considering the wide variety of climatic, topographic and edaphic conditions across which mahogany occurs.

I travelled to southeast Pará, Brazil, the heart of the Brazilian mahogany resource, in search of life-history information that could provide a biological basis for sustained-yield management systems for mahogany. Here I review some of the findings presented in my doctoral dissertation (Grogan 2001) and recently synthesised in an IMAZON publication (Grogan et al. 2002) that was partly funded by ITTO.

Research objectives and methods

An ITTO Fellowship helped support fieldwork in 1999 in a region where I have been studying natural populations of mahogany since 1995. My research objectives were to: 1) describe mahogany's landscape-scale distribution, density, growth and mortality patterns in selectively logged and unlogged forests; 2) identify the principal abiotic and biotic factors governing germination, survival and growth of seeds and seedlings; 3) describe patterns in reproductive phenology and seed production; and 4) synthesise research results into recommendations for forest management systems that would ensure future supplies of mahogany from natural and logged forests in the study region and, more generally, in the Brazilian Amazon.

Research was conducted at four sites. Three of these were timber industry-owned areas which had been selectively logged at varying intensities during the early 1990s. One site was unlogged primary forest. At each site, mahogany trees larger than 10 cm diameter at breast height (dbh) were located and mapped to describe original population structures. Surviving trees (nearly 600 in about 2750 hectares) have been re-censused annually since 1996 for survivorship, diameter increment, fruit production and reproductive phenology. Experimental studies examined seed germination behaviour and seedling survival and growth under various light (gap size) and soil fertility (topographic position) regimes. Because mahogany's distribution pattern demonstrates a strong positive correlation with seasonal streambeds in this landscape, these studies were supplemented by descriptive work documenting changing forest composition and structure across topographic and edaphic gradients.

Results

Density and population structure: from a randomly stratified survey I estimated that the 1035 hectares of forest at Marajoarca, our principal research site, contained nearly 700 mahogany trees larger than 20 cm dbh (about 0.6 trees per hectare) before logging. Density increased to nearly three trees per hectare on low ground adjacent to seasonal streams. The size class frequency distribution of these trees showed roughly equal representation of stems in each 10-cm size class between 20 cm and 80 cm dbh, with stem frequencies declining above this diameter.

Fruit production: in southeast Pará, fecundity rose with stem diameter but fruit production rates were highly idiosyncratic. Not all large trees produced large fruit crops, some small trees were among the most fecund, and year-to-year production rates varied widely by individual tree and by local population. Because rates of seed availability for dispersal are unpredictable for a given tree in any given year, regeneration failure after logging—widely reported for mahogany in the literature—may be due to inadequate seed supply as well as to tree-felling before seed dispersal and a failure to open adequate growing space for newly germinated seedlings and advance regeneration.

Seeds, seedlings and saplings: seed germination rates were higher in the shaded understorey where moisture conditions were more favourable than in gaps, but vigorous seedling and sapling growth required higher light levels than those available under closed forest canopies. Saplings taller than 50 cm and pole-sized stems up to 10 cm dbh were rare in unlogged forest, occurring only in small or large gaps within dispersal distance of adult trees. Early growth rates were also influenced by soil nutrient status, with mean height increments in low-ground hydromorphic soils exceeding those in dystrophic soils on higher ground where adult trees were rare.

Growth by juvenile and adult trees: diameter increment data from four study sites for trees larger than 10 cm dbh indicated mean population-level growth rates of 0.49–0.79 cm/year. Optimal growth rates represented by mean values for the fastest-growing quartile by size class exceeded 1 cm per year for nearly all size classes smaller than 70 cm dbh. This suggests that under some management scenarios juvenile trees may require 50–60 years to attain a merchantable size of 55–60 cm dbh.

Management recommendations

Some of the management recommendations derived from this research are described below.

The minimum diameter cutting limit should be determined with two issues in mind: the retention of sufficient sub-merchantable trees to provide a second harvest on a rotation cycle of approximately 30 years; and the retention of sufficient reproductive capacity for the establishment of future rotation cycles and for the maintenance of population-level genetic structures. In southeast Pará, where forest structure is highly irregular and stature is low, a minimum-diameter cutting limit of 55–60 cm dbh could satisfy these requirements. In the taller forests of western Amazonia such as in Acre, where mahogany occurs at lower densities, appropriate minimum-diameter cutting limits may be 70–80 cm dbh.

Seed trees should be retained as sources for seed collection and re-distribution across management areas. Some proportion of large, highly fecund adult trees should be retained for this purpose. Large, hollow (and therefore unmerchantable) trees may be otherwise healthy and capable of producing high-quality seeds. Where landscape-scale population densities are extremely low, seed trees should be retained in groups to preserve reproductive capacity. That is, if distances between surviving trees increase dramatically due to logging, insect pollinators may not be able to transport pollen between flowering trees, depressing seed production rates.

Enrichment planting and tending: seeds or seedlings should be planted directly into logging gaps at the beginning of the rainy season following the dry-season harvest. Site preparation may include the enlargement of smaller gaps, the clearing of residual vegetation, and, depending on local conditions, burning to reduce above- and below-ground competition. Planting densities should be low to reduce the incidence of mahogany shootborer (*Hypsipyla grandella*, Lepidoptera) infestation. Periodic tending (clearing around growing saplings and poles, occasional gap enlargement) will be required during the first ten years following establishment; the precise schedule should be determined experimentally.

The future of mahogany in Brazil

Regions of the Brazilian Amazon with the highest natural population densities of mahogany (south Pará, Rondônia) have already been heavily exploited by the logging industry. Because many of these forests have been degraded by logger re-entry and/or fire, or converted to other uses such as pasture and agriculture, the management of intact populations may occur principally in western Amazonia. The Instituto do Homem e Meio Ambiente da Amazônia (IMAZON) is currently testing management recommendations derived from this research within an industry-owned management area near Sena Madureira in Acre. Results from this project should be available in the near future.

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