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THE SEARCH FOR SUSTAINABLE TROPICAL SILVICULTURE:
Regeneration and growth of mahogany after disturbance in Mexico’s Yucatan forests

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INTRODUCTION TO MAHOGANY AND SILVICULTURE

To be sustainable, timber harvesting in natural forests must not exceed the replacement rate of the desired trees through growth and regeneration. By integrating knowledge of ecological processes into the design of harvesting practices and other treatments, silviculture not only ensures the sustainability of yields but can also maximize them by stimulating faster growth and encouraging more abundant regeneration. A major obstacle to the practice of silviculture in the tropics is the lack of basic ecological information on most tropical hardwood species, including Honduras mahogany (Swietenia macrophylla), the most important neotropical timber.

Honduras mahogany is native to the dry and moist tropical forests of eastern Mexico and Central America, the Atlantic slope of northern South America, and the Amazon Basin. A large buttressed tree which may reach 3.5 meters in diameter and 70 meters in height, mahogany grows as a canopy emergent at densities of one to two trees per hectare in both primary and secondary forests. In Mexico, mahogany is abundant in the semideciduous forests of Quintana Roo, a state in the southeastern quadrat of the Yucatan peninsula (see map). Up to 50% of the tree species in these forests, including mahogany, drop their leaves during a portion of the three- to six-month dry season.

Durable and easily worked, mahogany timber has been harvested for hundreds of years from the natural forests of Mexico and Central America. By the beginning of this century, European and American shipbuilders and furniture makers were concerned about the future supply of mahogany. In what was then British Honduras (now Belize), the Office of the Conservator of Forests was established in 1922 to encourage natural regeneration of mahogany in the forest. Elsewhere foresters took an agronomic approach to assuring future yields, planting mahogany in monospecific plantations throughout the tropics. Most of these plantations have failed due to disappointing growth and poor tree form resulting primarily from infestations of a nightflying moth, Hypsipyla grandella, whose larvae bore into the terminal shoot of young trees. Because the moth apparently flies at random searching for its host plant, it has trouble locating mahogany trees growing within a matrix of other tree species. Consequently, silvicultural management of natural forests may be the most efficient way to produce sustainable yields of mahogany.

Mahogany is a pillar of the economy in central and southern Quintana Roo, where the government recognizes forestry as a more sustainable land use and stimulus for rural development than clearing the shallow soils for agriculture or cattle ranching. In 1983, ten communities with 125,000 hectares of forest land were integrated into a model community forestry project called the ‘Plan Piloto Forestal’. The communities involved care about sustainable management of their forests because they have permanent rights to their land. They realize that the future of their forest industries depends on balancing the extraction of mahogany with natural replacement through growth and regeneration.
THE STUDY OF STAND DEVELOPMENT

In order to establish silvicultural guidelines which ensure and maximize mahogany harvests, two basic questions must be answered. First, how fast does mahogany grow in mixed natural stands? Second, under what circumstances and at what densities does mahogany regenerate in the forest? The interactions between mahogany and associated species are integral to both questions. It seemed that the answers could be found through the study of stand development, using a conceptual framework and methodology developed at the Yale School of Forestry and Environmental Studies by Professor David M. Smith and several of his students, notably Dr. Chadwick Oliver.

Studies of stand development focus on the role of disturbances in initiating or releasing regeneration, and subsequent changes in relative abundance, height and dominance among different individuals and species of trees growing in aggregations. Because forest stands take decades or centuries to develop from the seedling stage to maturity, only brief intervals in this process can be observed chronologically. Instead, most stand development studies reconstruct and analyze patterns of past growth or compare stands of different ages to elucidate how a stand has developed over time. Stand development studies have so far been carried out only in temperate forests, where the ages and past growth rates of trees can be determined by counting and measuring annual rings. The difficulty of aging tropical trees has proven an obstacle to this kind of research in the tropics.

While it seemed likely that a marked dry season would lead to the formation of annual rings in at least some species, two additional features of the Quintana Roo forest made it possible to determine tree ages. Periodic drastic disturbances have destroyed patches of forest, defining starting points for the development of new forest stands. In addition, because local people have hunted and harvested subsistence and commercial products in the forest for generations, they know when and where different kinds of disturbances have occurred.

DISTURBANCES IN THE FORESTS OF QUINTANA ROO

The forests of Quintana Roo grew up on former agricultural lands and urban centers abandoned by the Mayans when their culture collapsed beginning about 1000 years ago. These forests have been affected by an array of disturbances, both natural and anthropogenic. An average of two hurricanes a year slam into Quintana Roo. Since 1955, three of these storms have caused massive destruction, affecting hundreds of square kilometers of forest. Hurricanes are 'top down' disturbances which blow down individuals and groups of trees. Defoliation and crown damage kill others gradually, but the understory is left relatively intact.

Agriculture in Quintana Roo, based on a shifting system of clearing, burning, cultivation, and subsequent abandonment of small fields in the forest, dates back thousands of years. In addition to creating clearings, agricultural practices have also caused fires which periodically burn thousands of hectares of forest. Both agricultural clearing and fires affect forests 'from the bottom up', killing trees from the base and destroying seedlings and other understory plants.

Another cause of disturbance in the forests of Quintana Roo is timber harvesting. Selective felling of individual trees opens holes in the canopy, while extraction of logs creates skid trails through the forest and clearings scraped clean by bulldozer blades to serve as loading areas.

FIELD METHODS

The forests of Quintana Roo represent a mosaic of 'natural experiments', patches which grew up after different kinds of 'treatments' at particular times in the past. With the assistance of the community of Noh Bec (Mayan for 'great tree') in whose forests this research is being conducted, sample plots were established on sites with known histories: burns dating to 1945 and 1974, a 1955 hurricane blowdown, and log-yards opened up over the past 40 years during selective harvesting operations. Evidence used to confirm site histories included burn scars on residual trees, sprouting, crown breakage, uprooted trees, stumps, and rotting logs.

On each plot, trees were identified and mapped, and their diameters, heights, and crown radii were measured. These data on numbers and sizes of different species of trees and their horizontal and vertical distribution on each type of site will be analyzed and compared for insights into the regeneration potential and growth rates of mahogany and its associated species. Sites will be compared according to types of disturbance to reveal how the density and species of survivors and initial environmental conditions favor or impede regeneration. Harvesting systems or silvicultural treatments could then be designed to imitate the post-disturbance conditions which are found to give rise to the highest densities of mahogany.

Where the date of an initiating disturbance is known, tree ages can be determined. Average growth rates are derived from age and diameter measurements. This provides a point of reference for defining cutting cycles and rotation lengths. Comparing the sizes and numbers of different tree species among stands of different ages provides
additional information about growth and reveals changes in density and dominance among species over time. This provides an estimate of the number of young trees which are likely to survive to commercial size, and indicates how they are affected by interspecific competition.

To determine whether trees produce annual growth rings, an increment borer was used to extract cores from mahoganies and several other species which were 1) soft enough to core, and 2) revealed visible rings. Checking the number of tree rings against the hypothesized stand age serves to confirm the stand history and indicates whether or not tree rings in a given species are annual.

INITIAL OBSERVATIONS

While the data have yet to be analyzed, certain useful observations have been made already:
1) Mahogany became established naturally in clumps at densities equivalent to 60/ha on sites affected by drastic disturbance, as compared to the average density of 1-2/ha. This implies that silvicultural practices which imitate natural disturbances can probably increase the density of mahogany trees in the forest.
2) Some mahoganies have reached commercial size at 40 years of age.
3) Several species of trees have been found to produce annual rings in Quintana Roo. This permits determination of ages and growth rates, which in turn can be inferred for associate trees if stands are even-aged.
4) The complex, multi-strata tropical forests of Quintana Roo include many even-aged or two-aged stands (which include even-aged regeneration of residual trees surviving the initiating disturbance) like those commonly found in the forests of the United States. Although tropical forests are inherently complex due to their high species diversity, their patterns of development appear to correspond to familiar models.

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