REGENERATION AND GROWTH OF MAHOGANY (*SWIETENIA MACROPHYLLA* KING) IN BEL,IZE: IMPLICATIONS FOR SUSTAINABLE MANAGEMENT

by

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ABSTRACT

Big-leaf mahogany (*Swietenia macrophylla* King) has been lost from much of its natural range in Central and South America due to unsustainable harvesting practices that do not provide adequate conditions for the regeneration of mahogany's shade-intolerant seedlings. A set of experiments designed to determine what silvicultural treatments would ensure the successful regeneration of mahogany in logged forests was established in the Rio Bravo Conservation and Management Area of Belize.

In this study, survival and growth of mahogany seedlings planted in patchcuts (openings in the forest canopy) were evaluated to determine what size patchcut and how much of the area within that patchcut best promote mahogany development. Clearing method (bulldozed vs. hand felled), cleaning treatment (cleaned vs. uncleaned), location within the patchcut, patchcut size (500 to 5000 m^2), and incoming light levels were analyzed to determine how each factor affected annual height growth, 1999 height growth, and survivorship. Survival and growth were similar across plots with different clearing methods and throughout patchcuts of a given size. Cleaning (removal of understory woody vegetation) treatment negatively affect survival due to increased number of attacks by mahogany shoot borers (*Hypsipyla grandella* Zeller) in cleaned patchcuts.

Patchcut size and corresponding light levels were the most significant factors affecting both survival and growth of mahogany seedlings to age three from 1996 to 1999. Survival varied from 54 to 63 percent and annual height growth from 39 to 61 cm yr between the $500m^2$ and $5000m^2$ patchcuts. The increases in survival (17%) and annual height growth (56%), however, were not proportional to increases in incoming light levels, which increased 40% from 40 to 56 mol m^{-2} d^{-1} between then $500m^2$ and $5000m^2$ patchcuts. The greatest average annual height growth (61 cm yr^{-1} and highest survivorship (63% survival) occurred in the $5000m^2$ patchcuts. Mahogany seedlings neither survived nor grew under the forest canopy.

The results of these studies indicate that $5000m^2$ openings in the forest canopy provide the best conditions for mahogany survival and growth; therefore, canopy openings of this size should be incorporated into sustainable timber harvesting systems.

CONCLUSIONS AND RECOMMENDATIONS

Summary of Results

The development of a sustainable timber production system for valuable hardwood species presents many scientific challenges, which are illustrated by the experiments in the Rio Bravo Conservation and Management Area (RBCMA) of Belize. One such challenge is understanding the ecological characteristics and regeneration requirements of mahogany (*Swietenia macrophylla* King). The studies presented here address this challenge and demonstrate that available light, which is related to forest canopy opening size, is more important to mahogany survival and growth than clearing method, cleaning treatment, or edge effects. This high light dependency agrees with known ecological characteristics of mahogany as described by Lamb (1966), Mayhew and Newton (1998), and Snook (1993, 1996, 1 998a). Both survival and growth increased with patchcut size and corresponding light levels. Mahogany seedlings neither survived nor grew under the forest canopy, and survival and growth were highest on the largest patchcut size ($5000m^2$ (Figure 22).

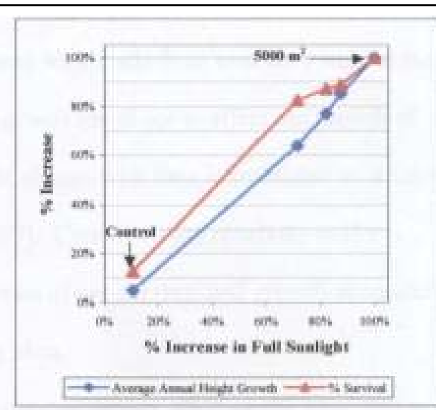

Figure 22: Relationship between average annual height growth, percent survival and percent full sunlight. Percent increase is the amount average annual height growth and percent survival increased relative to the maximum value measured in the $5000m^2$ patchcuts. Percent increase in full sunlight is the amount incoming light increased relative to 100% full sunlight in the $5000m^2$ patchcut, using the photosynthetically active radiation (PAR) measurements taken in June 1998.

Cleaning treatment did not increase average height of mahogany seedlings nor did cleaning promote mahogany survival and growth. In fact, cleaning may negatively affect mahogany development, since average seedling growth and survivorship are greater in uncleaned patchcuts. This contradicts previous studies that found beneficial (Lamb 1966; Gerhardt 1996a, 1996b; Negreros-Castillo & Mize 1993) or neutral effects (Marquis et *al*. 1986) on survival and growth; however, none of these experiments were conducted on clearcuts.

The changing environmental gradient associated with shade from overstory trees at the forest edge to the open center of the forest openings was found not to affect the growth of mahogany seedlings up to age three, but this might change with time as predicted by d'Oliveira (2000), Gerhardt (1996b), and Poorter (1999). Conditions are relatively uniform throughout patchcuts of a given size, so at three years of age survival and growth along the four axes are comparable to that in the central seedling plots.

These results parallel Minnemeyer's (1999) study on factors affecting the germination and establishment of mahogany from seed, conducted in the same experimental patchcuts in 1998. Minnemeyer (1999) found available light levels to be the most important factor controlling mahogany survival and growth to one year of age. Similarly, Minnemeyer (1999) found that seedling establishment was greatest in the 5000m^2 patchcuts, where the light levels are highest. Collectively, these studies indicate that the 5000m^2 patchcuts provide the best conditions for mahogany establishment, survival and growth, since it has the greatest available light levels.

Management Recommendations

Based on these studies investigating the factors affecting the survival and growth of mahogany, the 5000m^2 patchcuts appear to be best suited for promoting mahogany regeneration and development since it provides the greatest amount of incoming light. Three years after planting, the 5000m^2 patchcuts have the highest average seedling height (2 m), highest average annual height growth rate (61 cm y^{-1}), highest 1999 growth rate (61 cm y^{-1}), and highest survivorship (63% survival). Rates of growth and survival in the 5000m^2 patchcuts were significantly greater than those in the 500m patchcuts. Comparing the 500m^2 and 5000m^2 patchcuts, height increased by 38 percent and average annual height growth by 56 percent, while the number of surviving seedlings increased by 192 percent in cleaned patchcuts and 127 percent in uncleaned patchcuts. Mahogany regeneration can also be encouraged in small openings greater than 500m^2 but survival and growth will not be as high.

Implications for Sustainable Management

All the experimental patchcuts are larger than the single and multiple felling gaps created by harvesting operations in the RBCMA. The average size of single and multiple felling gaps in 1998 were 235m^2 and 469m^2 respectively (Cohen 1999). Cohen (1999) found that mahogany gaps, which are closest by definition to the extracted seed source, were smaller in area than gaps created by other species. The mean size of mahogany gaps was 158m^2 while gaps created by secondary commercial species averaged 249m^2 in I 998 (Cohen 1999). The effects of harvesting operations in RBCMA confirm results from a similar studies conducted by Verissimo, Barreto, Tarifa, and Uhl (1995), which found that logging practices are insufficient to create conditions necessary to promote mahogany growth and development in the Brazilian Amazon. In addition, Quevedo (1986) in Bolivia observed that post-harvest felling gaps were too small for optimal mahogany survival nine years after harvest. The mahogany gaps in RBCMA, therefore, at best will have intermediate survival and growth rates between the controls and 500m^2 and will probably be insufficient to provide conditions that mimic the effects of natural disturbances that are required for successful mahogany development.

The results of these gap studies in conjunction with the results of the patchcut studies presented here clearly reveal that the current harvesting practices in the RBCMA are insufficient to promote mahogany growth and regeneration, despite attempts to provide sufficient seed sources. Currently, PfB leaves at least twenty mahogany seed trees per 100 hectares of forest, including the largest mahogany tree, and all mahogany seedlings and saplings less than 50 centimeters diameter (dbh) are retained (Mayhew & Newton 1998; PfB 1996). The results of research on experimental patchcuts indicate that 5000m^2 openings in the forest canopy could achieve this objective, if integrated into the harvesting and management system at the RBCMA.