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Six years of fruit production by mahogany trees (*Swietenia macrophylla* King): patterns of variation and implications for sustainability

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Abstract

Although mahogany, the most commercially important timber tree in Neotropical forests, is widely acknowledged to be threatened by unsustainable logging which does not provide for its regeneration, its fruiting dynamics are poorly understood. During each of six successive years, we measured tree diameters and counted woody fruit capsule segments that fell below the crowns of 82 mahogany trees in natural forest in central Quintana Roo, Mexico. Sample trees ranged from <20 cm to more than 100 cm DBH. Fruit production increased with diameter, and trees $\geq$75 cm produced significantly more fruits each year than did trees of smaller diameters. Large trees could produce more than 700 fruits/year. Trees $\geq$75 cm DBH were also more consistent producers: while up to 27% of trees <75 cm DBH produced <1 fruit/year in any year, at least 93% of larger trees produced fruit every year. Over the 6 years, individual trees $\geq$75 cm produced a total of 367 $\pm$ 34 fruits, as compared to 91 $\pm$ 8 fruits among trees <75 cm (an average of 61 $\pm$ 7 and 15 $\pm$ 2 fruits/year, respectively). However, the number of fruit produced per unit crown volume was not significantly different between the two size categories. Fruit production varied among years, with the highest production in 1998 and the lowest in 1999 and 2000. The population of sampled mahogany trees produced approximately three times more fruit, and individual trees produced up to five times more fruit, in the year of highest production, as compared to the lowest. Mahogany does not exhibit the fruit production patterns found in mast fruiting species. Inter-annual variability in size of fruit crops at both the population and individual-tree levels are lower than in masting species, and the synchronocity among trees was low. Basal area growth averaged 76.5 $\pm$ 18.6 cm^2/year for trees $\geq$75 cm and 29.9 $\pm$ 1.7 cm^2/year for trees <75 cm DBH, and varied significantly among years. Years of high fruit production were also years of good growth, implying "resource matching" rather than the "resource switching" associated with masting. To ensure seed production for the regeneration of mahogany it is important to retain mahogany trees $\geq$75 cm DBH as seed sources. This presents a challenge, since currently mahogany trees in this region are harvested down to a minimum diameter as low as 55 cm.

Keywords: Fruiting cycles; Growth; Mast fruiting; Maya forest; Mexico; Regeneration; Seed production; Seeding; Tropical forest

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1. Introduction

1.1. The challenge of sustaining mahogany harvests

Big-leaf mahogany (*Swietenia macrophylla* King) is the most commercially important timber tree in Neotropical forests extending from southern Mexico to an arc along the southern Amazon basin of Bolivia, Brazil and Peru (Lamb, 1966; Brown et al., 2002). Its valuable timber has been exported from this region to Europe since the 1600s, and to the United States since the 1800s (Lamb, 1966). Mahogany timber 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, 2003), and new sources were tapped (e.g. Brazil, Bolivia, and Peru, successively, starting in the 1960s) (Snook, 1996; Blundell and 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; Kammesheidt et al., 2001; Blundell and Rodan, 2003; Navarro et al., 2003; Blundell and Gullison, 2003; Kometter et al., 2004). A major factor in the debate about the future of mahogany 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 (Martini et al., 1994; Snook, 1996; Jennings et al., 2000). 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 define sustainable levels of harvest for the species and provide export permits accordingly, and 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) (Snook, 1996; Rodan and Blundell, 2003). This, in turn, requires the implementation of silvicultural practices based on ecological knowledge of the regeneration ecology of this species (e.g. Guariguata and Pinard, 1998).

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., Stevenson, 1927; Lamb, 1966; Wolffsohn, 1961; Weaver and Sabido, 1997), followed by a second wave that began in the late 1980s, in Mesoamerica (e.g., Negreros-Castillo, 1991, 1996; Snook, 1993, 2003; Gerhardt, 1994; Dickinson and Whigham, 1999), and South America (e.g., Gullison et al., 1996; Grogan, 2001; Grogan et al., 2003). In the few mahogany forests where silvicultural management practices are applied, notably, the community forests of Quintana Roo, Mexico (Snook et al., 2003), efforts to regenerate mahogany have relied on enrichment planting of seedlings (e.g. Negreros-Castillo and Mize, 2002; Snook and Negreros-Castillo, 2004; Snook et al., 2003) or sowing seeds (Mayhew and Newton, 1998; Negreros-Castillo et al., 2003). Techniques to stimulate natural regeneration of mahogany were tested in British Honduras in the 1920s (Stevenson, 1927), and in a few more recent studies (Wolffsohn, 1961; Rodríguez et al., 1994; Toledo and Snook, in press). All three of these regeneration techniques require a supply of mahogany seed. Our study seeks to understand the dynamics over multiple years of mahogany seed production in natural forests in Quintana Roo, Mexico (Fig. 1), in order to determine how to sustain seed production, and thus the potential for mahogany regeneration, using any one of the possible silvicultural techniques. Previously published studies of mahogany seed production, carried out in South America, have extended only 1–2 years (i.e., Gullison et al., 1996; Grogan et al., 2003; but see Grogan, 2001).

1.2. Objectives

This study documents fruit production over 6 years of a set of mahogany trees of a broad range of size classes, from 25 to 105 cm in diameter at breast height (DBH). The primary goal is to develop knowledge about mahogany seed production in natural forests that can be incorporated into silvicultural planning for natural regeneration systems or to maintain productive seed collection stands. In this regard, the objectives are: