CONSIDERATION OF PROPOSALS FOR AMENDMENT OF APPENDICES I AND II

Other proposals

A. Proposal

Include in Appendix II, in accordance with Article II.2(a), the neotropical populations of *Swietenia macrophylla*, and its natural hybrids with *Swietenia humilis*, and for both taxa their logs, sawn wood, veneer sheets, and plywood sheets.

Excluded from this proposal are all other parts and derivatives of the species and its natural hybrids, *i.e*. mostly those in second to final stages of transformation, such as furniture and particle board. Also excluded are those parts and derivatives (such as the seeds) that are specified as the standard exclusions (*cf*. Resolutions Conf. 4.24 and Conf. 6.18).

B. Proponents: United States of America and Republic of Bolivia

C. Supporting Statement

1. Taxonomy

1.0. DivisionMagnoliophyta (angiosperms; flowering plants)
1.1. Class Magnoliopsida (dicotyledons)
1.2. OrderSapindales
1.3. Family Meliaceae
Genus*Swietenia* Jacquin (3 spp.; Styles 1981, Miller 1990)

1.4. Species*Swietenia macrophylla* King, 1886

1.4.1. Hybrids (see Whitmore and Hinojosa 1977, Styles 1981):

Natural hybrids occur between *Swietenia* species with proximity in their native ranges. Artificial hybrids can occur between native and non-native (introduced or naturalized) species, either: (1) spontaneously, from crosses unaided by people; or (2) artificially, from human-aided crosses (*e.g*., in research for forestry or horticulture).

1.4.1.1. Natural: Only *S. macrophylla* × *S. humilis*. Drier areas, NW **Costa Rica** (Whitmore 1983, Holdridge and Poveda 1975). Also potentially in **México** (Tehuantepec); and **Guatemala** (yet in the appropriate area, none were found — Styles 1981).

1.4.1.2. Artificial, yet spontaneous: *S. macrophylla* × *S. mahagoni* [probable syn. = *S*. × *aubrevilleana* Stehlé & Cusin]. Several Caribbean islands; also Asia (Whitmore and Hinojosa 1977, Styles 1981, Howard 1988, Schubert 1979). (See Resolution Conf. 2.13.)

1.5. Scientific Synonym: *Swietenia candollei* Pittier

1.6. Common Names (many others: *e.g*. Constantine 1959, Lamb 1966)

Spanish:	caoba, mara, aguano
Portuguese: mogno, mógno, aguano	
English:	bigleaf mahogany, American mahogany, New World mahogany, Honduras mahogany
French:	acajou amérique, swiéténie

The name "mahogany" in the trade has expanded to include other genera (Knees and Gardner 1983a), and "caoba" may also be used broadly. "True or genuine mahogany" is generally accepted to refer to the genus *Swietenia*, *i.e.* American mahoganies.

1.7. Code Numbers

2. Biological Parameters

Aspects of the biology of *Swietenia* spp. are provided by, *e.g*. MacLellan (1996), Gullison (1995), Snook (1993), Hartshorn (1992), Miller (1990), Betancourt (1987), Whitmore (1983), Styles (1981), and Record and Hess (1943). Considerable information on the ecology of *Swietenia*, as well as its history, trade and silviculture, is in Lamb (1966); see also Betancourt (1987), Snook (1993 — Middle American populations), and Gullison *et al.* (1996 — Bolivian populations). Overall conservation aspects and status are presented by Snook (1996), Figueroa (1994), Rodan *et al.* (1992), NRC (1991), Read (1990), Oldfield (1988), FAO (1984), Huxley (1984), Knees and Gardner (1983a, 1983b), Mabberley (1983), Whitmore (1981), Bramwell (1980) and Lamb (1966).

2.1. Distribution (maps in several Figures and Appendices below;
Edlin *et al.* 1973)

The natural distribution of *Swietenia macrophylla* is from southern **México** southward, ordinarily on the Atlantic slope, through **Costa Rica**, **Panamá**, northwestern South America and peripheral upper Amazonia to **Bolivia** and southern Amazonia into **Brazil**. Lamb (1966) maps the distribution of *S. macrophylla* (along with *S. mahagoni* and *S. humilis*) in México, Central America and South America (see Appendix A, Figs. 5 & 6). Using Lamb's (1966) maps, combined with more contemporary reports, Figueroa (1994) provides a similar overall estimate of the total range of the species.

The distribution of *Swietenia macrophylla* in **Bolivia**, as estimated by Viscarra and Lara (1992), is mapped in Appendix B below. The location of forest types and departments in **Bolivia** is included in Appendix C (Remsen and Traylor 1989). *Swietenia macrophylla* can be found in Pando, Beni, La Paz, Cochabamba and Santa Cruz departments, primarily following the occurrence of lowland tropical forest. López (1993) noted a similar, although not identical, distribution of forest types (Appendix D).

Barros *et al.* (1992) revised the estimated distribution of *Swietenia macrophylla* in **Brazil** using vegetation types, soils, climatological, and empirical data. The authors indicate a smaller but still extensive mahogany belt in **Brazil** (Figure 1b below) that is more equatorial than had been estimated by Lamb (1966), and totals ca. 800,000 km^2. Barros *et al.* (1992; their Table 19) derived this figure by estimating a gross range of 1,518,964 km^2, followed by reductions for the absence of *S. macrophylla* on higher lands (est. 211,486 km^2) and the encroachment of human exploration actions (est. 461,534 km^2). Within **Brazil**, *S. macrophylla* is most concentrated in an area of ca. 250,000 km^2 in southern Pará state (Veríssimo *et al.* 1992).

Swietenia macrophylla has been introduced extensively elsewhere for forestry, and also for horticulture (Styles 1981, Newman 1990, Schubert 1979, Prance and da Silva 1975); also, it has sometimes naturalized (*e.g*. Howard 1988).

2.1.1. Ecotypes

Swietenia macrophylla occurs in moist (or even wet) to dry, evergreen to deciduous tropical to subtropical forests, with typically (800-)1,000-2,500 mm of annual rainfall, and at altitudes from 0 m to 1,400 m (Lamb 1966, Whitmore 1983, Betancourt 1987, Rzedowski 1978, Toledo 1982, Pennington and Sarukhán 1968). It has been reported that the species "reaches optimum development under tropical dry forest life zone conditions (Holdridge 1947), namely a mean annual temperature of 24°C or higher, mean annual precipitation [m.a.p.] of 1,000-2,000 mm, and a potential evapotranspiration (pet) between 1.00 to 2.00. It also extends into the tropical moist forest life zone (24°C or above, m.a.p. 2,000-4,000 mm, and pet 0.50-1.00), as well as into the subtropical dry and subtropical moist forest life zones (about 18°-24°C for both, with 1.00-2.00 pet/500-1,000 mm precipitation and 0.50-1.00 pet/1,000-2,000 mm, respectively). Ideal precipitation conditions reportedly are 1,200-2,000 mm (Bascopé *et al.* 1957). Mahogany grows naturally on alluvial, volcanic, limestone, granitic, andesitic, and other sedimentary, igneous, and metamorphic-based soils" (Whitmore 1992).

Swietenia macrophylla is not distributed evenly within broadly defined ecotype regions, but tends to cluster, as a result of local regenerative preferences and events. Clustering in preferred locales can affect *S. macrophylla* population estimates, making extrapolations between areas of different topography and disturbance patterns unreliable. In **Bolivia** (and probably **Brazil**), *S. macrophylla* is principally located on land that has been subject to hydrological disturbance, such as the edges of erosion gullies and low-lying areas that have experienced episodic flooding due to downstream river obstruction. Research by Gullison (1995) in the Chimanes forest of Beni department, **Bolivia** (see Appendix L) revealed that:

> "In the Chirizi site ..., mahogany is associated with areas of previous erosion on high terraces. The three plots in this area showed a correlation between increasing density of mahogany with increasing area of erosion on the plots. ... The mahogany trees are generally located along the periphery of the erosion gullies (Gullison, pers. obs.). ... In contrast to the erosion at the Chirizi site, flooding and deposition of sediment by the river were responsible for the current regeneration of mahogany in the Cuberine plots."

Based on the ecotype region in which it occurs, four distinct races of *Swietenia macrophylla* are recognized by Bolivian woodsmen: (1) **Mara acedretada** grows "very rapidly," and the wood resembles Spanish cedar; (2) **Mara acuchisada** grows slowly in dry forests, producing a very dense wood; (3) **Mara peluda** grows in flooded areas and poorly drained soil, producing timber with a "woolly" grain that is worthless; (4) **Mara grano de oro** grows in well-drained soils with a superficial water table, and is considered to produce the best wood. Unfortunately, the land on which mara grano de oro occurs is highly suitable for slash-and-burn agriculture, and so is cleared for that purpose (Bascopé 1992).

2.2. Habitat Availability

Deforestation rates over Latin America provide partial information on the loss of habitat for *Swietenia macrophylla*. Following deforestation, regeneration of *S. macrophylla* in its functioning, natural habitat is contingent upon the extent of damage to the natural forest, future land-use patterns, and the availability of seed sources, plus additional biological requirements discussed in Section 2.4.

In **México**, Myers (1989) estimated that tropical moist forests originally covered 400,000 km^2. By 1989, this area had been reduced to 166,000 km^2, of which only 110,000 km^2 were considered to be primary forest. The deforestation rate in **México** was estimated to be 4.2% annually.

In **Central America**, at the time of Columbus' voyage, tropical moist forests covered an area of ca. 500,000 km^2. By the mid-1980s, remaining forest was estimated at 90,000 km^2, of which only 55,000 km^2 could be considered primary forest (Myers 1989). The deforestation rate was estimated at 3.7% (Myers 1989). Citing Leonard (1987), Beavers (1994) noted that Central America lost 15% of its forest cover in the 1970s alone.

In the Petén region of **Guatemala**, the principal habitat for *Swietenia macrophylla* in that country, tropical forest constituted 36,000 km^2 in 1960, but since that time at least one-third has been eliminated (Myers 1989). Beavers (1994), citing Schwartz (1990), gave a higher figure of 60% deforested or degraded by 1989. Human population in Petén department had been growing at 9.5% per year, leading to agricultural encroachment, fuelwood consumption, and consequent forest loss (Salazar 1992).

For **Brazil**, Skole and Tucker (1993) calculated "that 6% of closed-canopy forest had been cleared as of 1988 and ~15% of the forested Amazon was affected by deforestation-caused habitat destruction, habitat isolation, and edge effects." Analysis of LANDSAT data by the Brazilian Instituto Nacional de Pesquisas Espaciais [National Space Research Institute] (INPE) demonstrated that during 1991-1992 the rate of deforestation in the Amazon was 0.37% per year. For 1992-1994, the rate was 0.40% annually, which had declined from 0.54% annually during the 1980s, but increased from the 1990-1991 annual rate of 0.30%. The cumulative data demonstrated that roughly 90% of the vegetative cover in the Legal Amazon remained unaltered by deforestation (Brazilian Embassy 1996). However, a disproportionate amount of this deforestation has occurred in the mahogany belt. INPE data (FUNATURA 1993) indicated the following estimated deforestation levels in Brazilian states: Rondônia, 14.24%, Pará 11.86%, Mato Grosso 19.61%, Acre 7%, and Amazonas 1.5%. As illustrated in Figures 1a-1d (see below, preceding the Appendices), the primary remaining untouched regions of the mahogany belt are located in Amerindian reserves and biological reserves.

In **Bolivia**, data on the forested area vary depending on the source and the specific criteria used to define forest, or tropical forest. Programa ERTS of the Servicio Geológico de Bolivia (GEOBOL) in 1978 stated that 51% of Bolivia was then forested (Solomon 1989). The department of Santa Cruz accounted for about 48% of the forested area, with 19% in Beni, 11% in La Paz and 11% in Pando (López 1993). Myers (1989) estimated that the tropical forests originally covered 90,000 km^2 of **Bolivia**, of which primary forest cover had by then been halved to 45,000 km^2, with a continuing rate of decline of 2.1% annually. Deterioration or clearing of native forest has been estimated at ca. 2,000 km^2/year (López 1993, based on MACA/FAO/PNUD 1990).

2.2.1. Logging, Road Construction, and Habitat Loss

In regions where *Swietenia macrophylla* is native, there is a complex interrelationship between logging, road construction, human settlement, and deforestation/habitat loss. The adverse effects of this interrelationship directly impact mahogany populations, both in generating the impetus for logging and by altering the potential for mahogany regrowth (Rodan *et al.* 1992). Road construction, often to facilitate the extraction of commercially valuable timber such as mahogany, may open the forest to colonization and land clearing (Nations 1987, Veríssimo *et al.* 1992), especially in frontier areas that previously had limited forest disturbance (TFW 1989). In southern Pará, **Brazil**:

> "the immense area bounded by Pará Highway 150 on the east, the TransAmazon forest to the north, and the Cuiabá-Santarém Highway to the west is rapidly being opened up by logging roads [see Appendix E]. On official maps this region appears as a sea of green forest dotted with Indian reserves." (Veríssimo *et al.* 1992).

In the Xikrin do Cateté Amerindian reserve, 130 km of primary roads and 173 km of secondary roads were made to log 600 mahogany trees (Watson 1996). The principal logging road in the Morada do Sol region, north of the city of Tucumã, Pará, was begun by mahogany loggers in 1985. By 1992 the road was ca. 400 km long. Colonists were concentrated along the first 70 km, and 42% of the area occupied had been deforested in the years since road construction. Seven landowners (5 of whom operate sawmills) controlled the remaining 330 km of road, an area of perhaps 5,000 km^2 total, and after mahogany extraction from these holdings cattle pastures were being established (Veríssimo *et al.* 1992).

> "In 1985 the region cut by this road was almost completely covered by forest. ... But over the past seven years, loggers, colonists and ranchers have used this logging road to gain access to the land, converting

the logged forest into agricultural fields and pastures for cattle. ... The migration route of these agriculturists coincides with the movement of loggers in search of virgin mahogany forests." (Veríssimo *et al.* 1992).

Human settlement may also precipitate, and be dependent upon, logging of the commercially valuable timbers present on a property. In certain instances, it is the presence of valuable commercial species on subsistence plots that makes them economically viable in the short term. In reviewing the economics of a non-mahogany forestry operation in Brazil, Uhl *et al.* (1991) noted that the security provided by timber resources allowed colonists to persist for longer periods than otherwise, while continuing to clear the forest each year for farmland on which to produce food for home consumption and sale. When the land was exhausted, settlement moved elsewhere (Uhl *et a*l. 1991).

In **Bolivia**, deforestation accompanied the opening of a highway to Santa Cruz in 1952, resulting in waves of immigrants, urban growth and industrialization based on agriculture and logging. Development and forest encroachment jumped ahead of the government regional development program. According to Bascopé (1992), forest degradation was increasing because of: (1) lack of coordination among government forest management agencies (Forest Service, National Colonization Institute, and National Agrarian Reform Council); (2) destruction by colonists under plans drawn up by the National Colonization Institute and the Agrarian National Reform Council; (3) a weak forestry service; (4) the building of logging roads by logging companies and rural roads by public institutions (opening the forest to settlers); (5) agrarian development projects financed by the Inter-American Development Bank, World Bank, and USAID without any consideration for the natural resources; (6) selective logging of mahogany (*cf*. Cárdenas 1945); and (7) increasing numbers of illegal loggers using chainsaws. A 1988 study by MACA (Bolivia's Ministerio de Asuntos Campesinos y Agropecuarios) concluded that "massive deforestation resulting from colonization has created serious aeolian erosion in the Department of Santa Cruz" (Stewart *et al.* 1993). Bascopé (1992) noted that the highly prized "mara grana de oro" type of mahogany grows on soils highly suitable for agriculture, and thus often cleared.

The Food and Agriculture Organization of the United Nations (FAO 1988, Lanly 1982) estimated that "logging directly causes 10 percent of tropical deforestation — and facilitates tropical forest losses stemming primarily from other causes. In most humid tropical forest areas, logging practices today are typically `mining' operations that deplete or eventually eradicate tropical forests. While logging in tropical forests more generally tends to be selective, it can be very destructive if poorly planned and inadequately regulated" (Johnson and Cabarle 1993). Appropriate forest management practices, such as limiting public access through road design, closures and guard stations, can reduce human encroachment and settlement following selective logging (Gullison 1995).

2.3. <u>Population Status</u>

Swietenia macrophylla populations are undergoing exploitation nearly throughout the species' natural range, resulting in reports of substantial depletion of extant populations (WWF/IUCN 1996 in press, Rodan *et al.* 1992, Foster 1990, Lamb 1966, Smith 1965, Correa 1990, Betancourt 1987). Lamb (1966, p. ix) reported that:

"the inherent characteristics of the tree in relation to the highly competitive environment of the tropical forest have resulted, after 250 years of heavy cutting, in serious depletion of mahogany growing stock. The remaining, accessible, unmanaged reserves have been reduced until they are no longer capable of supporting continuous production sufficient to supply the potential demand for the wood. Mature and over-mature stands have been liquidated without maintenance of adequate reserve growing stock. Over the years only an insignificant part of the income derived from the liquidation of this forest capital has been reinvested to maintain the source of income."

Detailed inventory data on *Swietenia macrophylla* are, however, limited in extent of coverage and are of varying quality (Snook 1996). Most inventories are done for logging purposes, where the focus is on mature specimens, not smaller trees which are usually absent from the estimates. The mature mahoganies are subsequently logged, making the inventory moot for conservation purposes. Extrapolations based on commercial inventories must adjust for lower population densities outside current, commercially viable logging regions, in addition to the habitat preferences of *S. macrophylla* which lead to its predominantly clumped distribution (Snook 1996, Gullison 1995, Veríssimo *et al.* 1995). Static inventories of mature specimens are also inadequate to evaluate the potential for future yields or the biological status (demographics) of the species, because these factors are dependent on regeneration and regrowth rates.

The susceptibility of the wild-functioning species *Swietenia macrophylla* to logging pressure is a crucial issue for CITES. *Swietenia macrophylla* is considered by Martini *et al.* (1994) to be a species susceptible to population reductions in the face of intensive logging due to (1) its irregular fruit production; (2) poor regeneration in natural forest; (3) inability to sprout from cut stumps; and (4) the high insect predation on its seeds. Conversely, the authors also note the good regenerative capacity of *S. macrophylla* in well-lit areas, and its wide geographic range.

The conservation status of *Swietenia macrophylla* populations in selected Latin American nations, as reported in the U.S. CITES COP8 proposal (1991), varied from abundant to nearly extirpated depending upon the locale and the information source (Rodan *et al.* 1992). Additional information is provided in Hartshorn (1992).

Based on interviews, field visits, and literature search, Figueroa (1994) provided country-profile estimates on *S. macrophylla* for a number of Middle American and South American range States. Although specific conservation status designations were not routinely provided, the following qualitative profiles, varying from reasonably common to greatly depleted, are reported by Figueroa (1994): **México**, unable to summarize on a country-wide basis; **Guatemala**, low natural densities; **Belize**, common; **Honduras**, greatly reduced; **Costa Rica**, showing the effects of indiscriminate selective harvesting; **Panamá**, greatly depleted, main reserves in province of Darién; **Colombia**, no overall status assessment; **Venezuela**, no overall status assessment; **Ecuador**, status poorly known; **Perú**, threatened, high priority for conservation; **Bolivia**, large natural range, overall status impression not provided; and **Brazil**, large range but status not uniform and difficult to assess due to inadequate current biological data. The Brazilian assessment was based primarily on the Barros *et al*. (1992) report discussed below.

Some examples of extensive inclusion of *Swietenia macrophylla* in national parks and other types of protected areas were provided by Figueroa (1994), although the intended management and extent of illegal logging in such areas was not assessed in detail.

Both stock and volume replenishment extrapolations were also performed for *Swietenia macrophylla* by Figueroa (1994). The stock extrapolations were based on the *S. macrophylla* range estimate multiplied by one merchantable *S. macrophylla* specimen per 10 ha. The volume-replenishment extrapolations were based on the *S. macrophylla* range estimate multiplied by either 1 [-2] m^3/ha/yr (Figueroa 1994, abstract, Table 6, p. 14 for Brazil, and conclusions) or 0.1 m^3/ha/yr (Figueroa 1994, p. 13 for Brazil). Synnott, one of the reviewers commissioned by the ITTO to evaluate the Chimanes Project (see Section 2.3.2 below), considered the resulting stock and volume calculations by Figueroa (1994) to be "more serious over-estimates" than concerns about estimates of the total range of the species (pers. comm. 1994 to F.T. Campbell, NRDC). The volume errors stemmed from insufficient allowance being given for unrecorded harvests and for deforestation.

> "Even so, ... the large forest areas which have been logged still contain significant populations of younger and smaller mahoganies, ensuring the continued existence of the species (even if not of the timber trade)." (Synnott, pers. comm. 1994 to Campbell, NRDC).

Of particular concern were the regrowth-rate extrapolations. Synnott (pers. comm. 1994 to F.T. Campbell, NRDC) stated that Figueroa's (1994):

"estimates of <u>increments</u> (volume growth rates) are so far from reality ..." [emphasis in original].

2.3.1. México and Central America

The historical pattern and relationship between logging and *Swietenia macrophylla* populations in the Yucatán Peninsula of **México**, **Belize** and **Guatemala** are detailed in Snook (1993). Mahogany logging, which began in the 17th century, was originally severely constrained logistically by the size of the tree and the paucity and inadequacy of transportation mechanisms. Logging was initially only of specimens occurring near rivers (where the logs could be floated or shipped out), but with the successive introduction of oxen, railroads and then roads, these restrictions were negated. Purchaser requirements also acted in the past to protect selected *S. macrophylla* populations, and only sound, straight logs at least 14 feet long by 16 inches at the top (ca. 427 $\times$ 41 cm) were desired for export. More recent restrictions have limited the selective cutting of *S. macrophylla* to only those specimens of 55-60 cm diameter at breast height (dbh). Concession foresters are now proposing a reduction in the diameter limit from 60 cm to 40 cm, as communities switch from selling logs for veneer to feeding their own sawmills and as a result of over-estimates of the natural growth rate of mahogany (Snook 1993, 1992). Even the larger diameter (60 cm) falls below the size considered by Gullison and Hubbell (1992) to be necessary for providing a good seed supply. Most of the areas logged in the past have been converted to other uses, leading to an ~80% reduction in the extent of mahogany-containing forests in **México** (de la Garza 1991, in Snook 1992).

The status of *Swietenia macrophylla* populations and habitat availability in **Central America** have been presented by Navarro (1996). In the course of recent work collecting genetic samples over Central America, Navarro recorded a very much reduced range for *S. macrophylla* compared to maps suggested by Lamb (1966). His revised range estimate is incorporated as Figure 2 (see below) of this proposal. Navarro expressed disappointment due to the inability to locate sufficient trees for his study despite hours of driving and hiking. He concluded that "[a]pproximately 25% of the original distribution [in Central America] still remains with small fragmented populations, mostly exploited. The exploitation of the actual distribution can be over 80%."

In **Guatemala**, Salazar (1992) reported that:

> "The mahogany found in the biologically rich lowlands of northern Guatemala ... is naturally found only in hidden recesses protected by natural barriers such as flooded zones, steep slopes and rivers. In general, the species is undergoing extensive exploitation throughout nearly all of its natural range in northern Guatemala. Severe social and economic problems have contributed to species exploitation. Until recently (the last 8 to 10 years) there were no programs to conserve or to manage the species." ...

"Unless concrete actions are taken immediately, the future for mahogany in the Petén is bleak."

In the Petén, Beavers (1994) reported that loggers selectively harvest mahogany, tropical cedar (*Cedrela*) and some secondary woods. Little attention was paid to where and how wood was extracted, so there was little management, policing, or even collecting of revenue owed to the government. The result was increased profits for the loggers, more rapid timber extraction, and the opening of more areas to settlement. High-grading was practiced in a wasteful manner, and sometimes cut logs were left lying on the ground to waste. Since the mahogany and cedar do not regenerate well in logged areas, they were being replaced by trees of lesser value (Beavers 1994).

Swietenia macrophylla reserves in **Belize** are declining, with reports of reductions in minimum cutting diameters and difficulties in controlling illegal extraction (Weaver and Sabido 1996, Whitman *et al*. 1996). The Nature Conservancy (TNC, pers. comm. to NRDC 1994) reported that only 3 out of ca. 40 sawmills accounted for approximately two-thirds of production, and that timber production could be substantially increased on a sustained-yield basis if forest reserves were protected from agricultural encroachment, effective management plans implemented, and technology modernized. The Belize Forestry Department attempts to enforce a 63 cm dbh cutting limit for *S. macrophylla*, but some cut trees as small as 49 cm dbh. The size limits were established in order to protect some reproductive individuals as seed sources (TNC, pers. comm. to NRDC), but may be inadequate (see Gullison 1995, and Section 2.4.2 below).

Weaver and Sabido (1996) noted the following density results for *Swietenia macrophylla* in the 98,000 ha Belize Estates production region: > 20 cm dbh, 7.4 stems/ha; > 40 cm dbh, 0.6 stems/ha; > 60 cm dbh, 0.2 stems/ha.

Current data on *Swietenia macrophylla* densities were reported by Whitman *et al*. (1996) for the Rio Bravo Conservation and Management Area in **Belize**, and are lower than those given above. At this location, unlogged forest contained a mean *S. macrophylla* stem density of 2.25 stems > 10 cm dbh/ha and a mean density of legally harvestable stems (> 63 cm dbh) of 0.11 stems/ha.

In response to over-harvesting, **Honduras** banned the export of rough lumber of mahogany and cedar, along with their logging during fruiting (Ussach 1992; *cf*. Shank 1949). Coolidge (1945) was already concerned about the threatened extinction of *Swietenia macrophylla* in *Panamá*.

In **Perú**, scattered large individuals of *S. macrophylla* are found in the floodplain forest of Manu National Park. Gentry (1996, in press) records that *S. macrophylla* and *Cedrela odorata*:

"have been severely over-harvested and today are usually encountered only rarely elsewhere. ... For many vertebrate species, as well as over-exploited plant species as in *Cedrela* and *Swietenia*, Manu NP provides one of the last conservation strongholds."

2.3.2. Bolivia

In **Bolivia** and **Brazil**, currently the primary sources of the international trade in *Swietenia macrophylla*, regional commercial extinctions are increasing (Collins 1990, Gullison 1995, Veríssimo *et al.* 1992). In a report on Bolivian forestry commissioned by the International Tropical Timber Organization (ITTO), Synnott and Cassells (1991) stated that:

"[T]he rate of harvesting of Mara is recognized by all parties as being too high to ensure that commercial logging can continue uninterrupted. There are major uncertainties about the volumes of Mara and other timbers ... There are also uncertainties about the areas of forest effectively available for logging after taking into account considerations of inaccessibility and environmental protection requirements within timber production areas. ... [T]he 1989-91 logging areas are now scattered widely in separate blocks, presumably selecting the richest areas first."

"The managers of logging companies told the Review Team that they did not expect to maintain their present rates of logging for more than a few years, before exhausting the best areas. Indeed, they seemed to prefer to remove the large Mara quickly and perhaps return in the future when markets for other species improve. ... However, our recommendations must aim at encouraging slower use of Mara supplies, more rapid addition of other species, and secure conditions for investment in more wood-processing equipment ..."

Gullison (1995) updates the status of the Bosque Chimanes sustainable management project, reporting that:

"Current logging in the forest is highly selective and limited almost entirely to a single species, mahogany (*Swietenia macrophylla*). The volumes of mahogany harvested have clearly been unsustainable. Large-scale mahogany logging officially began in Chimanes in 1987. Since then, one concession has completely exhausted its mahogany supplies and the remaining concessions are apparently not far behind (Burniske 1994, Synnott and Cassells 1991). The original ITTO management goal of implementing a 30 yr cutting cycle has clearly not been met. Unsustainable mahogany logging has occurred despite large amounts of funding earmarked specifically for controlling harvests and preventing this outcome [ca. $US 400,000 annually, Burniske 1994]. Both ecological and economic factors have contributed to the failure in achieving sustainable management objectives."

Mara (*Swietenia macrophylla*) represented 71% of wood cut in Santa Cruz in 1971 but only 48% in 1980, 52% in 1987, and 45.9% in 1989. Mahogany loggers have recently turned to northern parts of Santa Cruz, La Paz (including provinces Franz Tamayo and Iturralde) and Beni departments. In the Trinidad region of Beni, production of mara fell from 85% of the total in 1980 to 65% in 1988 (López 1993). The selective logging of *Swietenia macrophylla* (high-grading) and other valuable species in the rather temperate forests of the semi-dry region of Santa Cruz has been so intensive that, at present, "they are considered commercially extinct" (Stewart *et al.* 1993, final draft). In the Bosque Chimanes (ca. 14°30'-16°00'S, 66°-67°W) of Beni, López (1993) cites representatives of indigenous groups as indicating that the forest will run out of mahogany in 2-3 years.

According to R. Rice, the director of economic policy at Conservation International (CI):

"All the commercially usable mahogany is going to be gone in Bolivia in five years. ... What we are looking at is timber mining. They are not driving mahogany to physical extinction, but to commercial extinction." (Nash 1993).

These sentiments are echoed in interviews conducted recently by Costa Rica's Centro Científico Tropical [CCT] (1996) in **Bolivia**, where:

"The interviewees, in great majority, declared their preoccupation with the imminent commercial extinction of mahogany in Santa Cruz. The situation is aggravated when one recognizes that, apparently, the persons in charge of control of compliance with the silvicultural standards and [prevention] of illegal commerce are not in the capacity to carry out their functions efficiently."

The CCT (1996) concluded "... it is reasonable to surmise that, if matters continue as up to now, mahogany will be exhausted commercially in a few years."

2.3.3. Brazil

The Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis [Brazilian Institute of Environment and Renewable Natural Resources] (IBAMA) has included *Swietenia macrophylla* in an official list of 108 Brazilian species of flora considered to be in danger of extinction (15 January 1992; Proclamation No. 006/92 N), and the Brazilian Botanical Society has also included *Swietenia macrophylla* in a list of species at risk of extinction (Sociedade Brasileira de Botânica 1992). The natural populations of *Swietenia macrophylla* in **Brazil** are increasingly affected by illegal as well as legal logging, and by illegal as well as planned deforestation.

In an unpublished report supported by the Association of Timber Exporters of Pará and Amapá (AIMEX), Barros *et al.* (1992) estimated that, at the current rate of exploitation of 500,000 m^3 (ca. 137,773 trees) per year, from a conservative point of view present mahogany stocks would persist in legally obtainable areas for a minimum of 32 years. Beyond standing timber reserves, the authors expressed their "hopes that the forest has the capacity to replace its stocks, through natural regeneration ..." Barros *et al.* (1992) recommended "of urgent necessity a policy for the rationalization of the use of this species, in an exploitation perspective under regimes of sustained management that guarantee the maintenance of this natural resource."

The studies that form the basis for the conclusions by Barros *et al.* (1992) were performed by RADAMBRASIL in the 1970s, and thus pre-date much of the mahogany logging and agricultural expansion that has occurred in southern Amazonia. Of the 552 one-hectare sampling units of RADAMBRASIL that occur within the predicted mahogany belt, only 55 units (10%) revealed the presence of mahogany. Figure 4 of Barros *et al.* (1992) indicates that these 55 units were located in regions of Pará, Rondônia and Acre where mahogany is already known to occur, and has been logged (see Lamb 1966).

Veríssimo *et al.* (1992) expressed general reservations about the accuracy of *S. macrophylla* estimates in the Amazon, noting that:

"Mahogany trees tend to occur in small clumps in the forest. Several or even tens of kilometers may separate the mahogany clumps. Mahogany clumps tend to occur in low-lying areas. Because of this clumped distribution, it is extremely difficult to estimate the regional stock of mahogany and all such estimates should be regarded with skepticism at the present time." (Veríssimo *et al.* 1992).

With funding from the International Tropical Timber Organization (ITTO), FUNATURA (Fundação Pró-Natureza) also studied the occurrence and distribution of mahogany in the Brazilian Amazon (FUNATURA 1993). FUNATURA highlighted the large number of indigenous human reserves (140 officially recognized, ca. 30 autonomous territories, encompassing ca. 350,000 km^2), national parks, biological reserves, and ecological stations (totalling 34,929 km^2) within the mahogany zone of **Brazil**. The extent of illegal logging of *Swietenia macrophylla* from these areas had not been assessed or incorporated in the study by Barros *et a*l. (1992). FUNATURA (1993) concluded that:

"Without going into the merits of the methodology employed by Barros *et al.* (1992) in obtaining their results, and considering the acceptance of their estimate of 32 years as the minimum time of persistance of mahogany stocks, one is able to conclude that this species is quite threatened ... This form of empirical and predatorial forest exploitation, suggests that without any urgently adopted measures to ensure the conservation of the species and a more rational utilization, mahogany will have a future similar to the Paraná pine (*Araucaria angustifolia*), practically exhausted, hardly remaining in some areas without becoming reserves, or similar to species of the Amazon region like pau-rosa (*Aniba duckei*) and virola (*Virola surinamensis*)."

FUNATURA (1993) and Greenpeace Brasil (1992) also consider that Barros *et al.* (1992) gave inadequate consideration to the extent of human encroachment, agricultural conversion, and deforestation that has already occurred over much of this region. Barros *et al.* (1992) had estimated that human activity had occurred in 40%, 30% and 20% of the predicted low, regular and high-density mahogany regions, respectively.

The extent of human encroachment on the estimated mahogany-containing region in **Brazil** is evident from satellite images taken in 1988, which were analyzed and aggregated by Skole and Tucker (1993) (Figure 1a below). Comparison of this satellite analysis to the estimated mahogany region identified by Barros *et al.* (1992) (Figure 1b below) indicates the presence of human activity over much of this region, leading to varying degrees of deforestation and habitat fragmentation. The regions in the satellite composites where human activity is not evident generally correspond to indigenous peoples' (Amerindian) reserves and biological conservation regions (Veríssimo *et al.* 1992) (Figure 1c below). Figure 1d below consists of the satellite composite (Figure 1a) overlain by the distribution of mahogany (Figure 1b) and the location of indigenous reserves (Figure 1c). The expanse of untouched forest (8°S, 53°W) shown in southern Pará state, overlying a region of relatively dense mahogany-containing forest, indicates the site of the Kayapó Amerindian reserve.

To the extent that human activity in regions of the southern Amazon can be correlated with mahogany extraction, these satellite composites indicate the need for caution when extrapolating mahogany resources based upon the assumption of primary forest. The presence of unlogged forests in Amerindian reserves and conservation regions, with a relative abundance of mahogany and located close to existing timber-industry infrastructure, also highlights the incentives present to extract mahogany from this source, rather than to expend resources searching for the presumed mahogany reserves in more distant and isolated regions of southern Amazonia.

The satellite composites published by Skole and Tucker (1993) were based on satellite images taken in 1988. In the years since 1988, considerable road construction has been undertaken to facilitate the extraction of mahogany, often in what had been areas of primary forest in 1988. For instance, the 1988 satellite composites reveal an untouched area (6°S, 53°W) of presumed (Barros *et al.* 1992) high-yield mahogany forest located north of the main Kayapó Amerindian reserve. Since then, road construction by mahogany timber companies, as illustrated in Veríssimo *et al.* (1992, 1995) (see Appendix E), has continued to open this area. In Pará, "[t]he distance between the extraction areas and sawmills has grown from only a few kilometers in the early 1980s to 300-500 kilometers at present", and there are now more than 3,000 kms of logging roads in southern Pará that have been used by colonists, ranchers and loggers (Veríssimo *et al.* 1992).

2.3.4. Densities

Swietenia macrophylla is generally widely dispersed, although the concentration varies markedly with location and the rate and type of natural forest disturbance (Lamb 1966, Snook 1992, 1993). In **México** and **Central America**, *S. macrophylla* occurs more plentifully on sites that were disturbed hundreds of years ago, such as following hurricances, fires, or human agricultural practices, compared to undisturbed sites. The average density in unlogged mahogany-containing forest is approximately one commercial size *S. macrophylla* tree per hectare [2.47 acres] (Snook 1993, citing Pennington and Sarukhán 1968, and Medina *et al.* 1968).

Great variation in *Swietenia macrophylla* density has been recorded in Amazonia. In undisturbed forests containing mahogany in **Brazil** and **Bolivia**, harvestable specimens occur at an average density of less than 1 to 2 trees per hectare. Accurate data on stocks are difficult to collect as the mahoganies occur in scattered groups in inaccessible locations, with just a few mature trees per hectare or km^2 of undisturbed forest (Quevedo 1986, Veríssimo *et al.* 1992, Whitmore 1983, Betancourt 1987, Sanderson and Loth 1965, Barros *et al.* 1992).

In **Brazil**, Barros *et al.* (1992) collated data sources and calculated an average occurrence of 1.022 mahoganies (s = 0.947) per ha of mahogany-containing forest. The authors noted that their density estimates would constitute an upper bound, as most mahogany population studies had been performed in areas considered for logging, thus in the regions of highest concentration. Taking these factors into account, Barros *et al.* (1992) estimated an average density of mahogany of 0.2 m^3/ha (1 tree/18 ha), 0.4 m^3/ha (1 tree/9 ha), and 0.6 m^3/ha (1 tree/6 ha) respectively over the range of areas of estimated low, normal, and high density.

In **Bolivia**, Gullison and Hardner (1993) report an average density of 0.12 harvestable *Swietenia macrophylla* specimens per hectare in the Bosque Chimanes of Beni. Gullison (1995) reported that:

> "The density of mahogany trees > 80 cm dbh was 0.1-0.2 trees ha^{-1} on the five 100 ha plots. The density of trees < 80 cm dbh was similar among plots (0.1-0.2 trees ha^{-1}), with the exception of the high density of small trees in the Cuberene plot [which had active regeneration following flooding]."

Szwagrzak and López (1993) report densities of only 1 tree per 1,000 ha in the Alto Madidi section of La Paz department (*cf*. Killeen 1996). Stewart *et al.* (1993, final draft), citing Stolz and Quevedo (1992), found densities of 0.6, 0.283, and 0.1 utilizable *Swietenia macrophylla* specimen (> 80 cm dbh) per hectare in three primary mahogany-containing forests. Specimens with girths between 60-80 cm dbh occurred at densities of 0.621 and 0.4 trees/ha for the two sites where this information was reported. The inclusion of smaller *S. macrophylla* specimens (> 20 cm dbh) resulted in a total density of ~1.339-2.39 trees/ha in these forests.

In a consultant report to the World Wide Fund for Nature (WWF), the CCT (1996) obtained similar density results when studying standing *Swietenia macrophylla* specimens and stumps in El Choré Forest of **Bolivia** (Appendix L), in far western Santa Cruz department. Of 35 one-hectare plots on 4 concessions, CCT (1996) identified a total of 36 specimens between 60-80 cm dbh and 13 specimens > 80 cm dbh, the great majority of which had been logged (Appendix M). A marked lack of *S. macrophylla* in the 10-60 cm dbh classes was evident, with only 11 detected over the 35 hectare total area. Most of these trees were in the smaller size ranges (10-40 cm dbh), and 5 of the 11 small trees clustered in two of the plots. There were 95 additional seedlings and saplings (< 10 cm dbh) identified on the 35 hectares.

Estimates of timber volume per tree vary. Barros *et al*. (1992) found an average of 5.009 cubic meters of timber per tree (s = 1.709, s_x = .604, LL = 3.61 m^3/tree; for calculation purposes, they used a figure of 3.6302 m^3/tree, derived from Queiroz' 1984 volume equation). Stewart *et al.* (1993, final draft) found timber volumes per tree to be 3.4-4.16 m^3 for specimens > 80 cm dbh, but only 0.68-1.18 m^3 for trees with girths between 60-80 cm dbh. Utilizable volumes were 3.3, 1.916 and 1.02 m^3/ha in the regions studied. Considerably reduced volumes of mahogany were found in intervened forest (0.1-0.15 m^3/ha).

2.3.5. Genetic Conservation

2.3.5.1. Genetic Loss, and Dysgenic Selection: The *in situ* conservation of *Swietenia macrophylla* has been accorded highest priority by the FAO (1989). The U.S. National Research Council report on plant genetic resources (NRC 1991) identified *S. macrophylla* as Vulnerable. The ITTO (1991a) cited Brazilian mahogany as a species where long-term measures were becoming necessary to conserve the genetic variability of populations.

The extent to which *Swietenia macrophylla* is susceptible to genetic loss within and of populations is of critical importance in assessing its status for CITES, and in developing conservation plans (Newton *et al.* 1992, 1996, FAO 1984, Palmberg 1987, Mabberley 1983, Oldfield 1984). Genetic conservation is necessary to maintain natural populations as evolutionarily viable units that can adapt to changing conditions in the long term, and as well for sustainable economic viability via the genetic characteristics of wood quality, growth rate, and pest resistance (see Newton 1996 for a detailed review).

Wide variation in *Swietenia macrophylla* leaves, flowers, fruit, and wood structure was noted by Lamb (1966), raising the possibility that this species exhibits high genetic plasticity over its large geographic range and among many separate breeding populations. In particular, there are indications that tree form and resistance to shoot-borer attack are heritable characteristics, emphasizing the importance of genetic conservation, as logging tends to deplete the population of individuals with these desirable genetic characteristics (Newton *et al.* 1992). Concerns about potential dysgenic selection following logging of *S. macrophylla* are accentuated by field observations suggesting that *Swietenia mahagoni* (which was included in CITES Appendix II in 1992) has suffered that fate. Styles (1981) considered *S. mahagoni* to be a prime example of genetic erosion resulting from past exploitation of the best genotypes. Newton *et al.* (1996) elaborate on these concerns:

"No quantitative information is currently available to assess whether or not genetic erosion has in fact occurred in apparently depleted populations. From a theoretical standpoint, it is conceivable that the selective removal of trees of superior form (long, straight trunks) could deplete a population of particular genetic combinations, if variation in form has a significant heritable component (Zobel and Talbert 1984). In forest trees in general, mean heritabilities for traits such as stem straightness and branching are similar to values for height, diameter and volume growth, although rather lower than specific gravity (Cornelius 1994). The results presented here [Newton *et al.* 1996] confirm that both growth and form traits are under significant genetic control in mahogany. Loss of gene complexes associated with superior form is therefore likely to occur as a consequence of selective logging (Zobel and Talbert 1984), even if the process is difficult to quantify. It is also worth noting that if pest-resistant trees were present in a population, these genotypes would also tend to be removed by logging activities ..."

Only a limited number of quantitative investigations of the extent of genetic variation in *Swietenia* species have been undertaken, by either commercial forestry or scientific research institutes (NRC 1991, Newton *et al.* 1992). This is despite the apparent amenability of *Swietenia* species to breeding techniques (Styles and Khosla 1976). Three such investigations are:

1. During 1964-1965, the International Institute of Tropical Forestry in **Puerto Rico** performed provenance studies of both *S. macrophylla* and *S. humilis*. Seed from 14 locations in **México** and **Central America** was established in seven contrasting locations in **Puerto Rico**. Highly significant differences in wood density were identified between progenies, with mean values ranging from 0.48 to 0.57 g/cm^3 (Chudnoff and Geary 1973). These same trial plantings were subsequently assessed for form traits by Glogiewicz (1986), who also recorded differences between provenances, although these were not consistent across different sites.

2. More recent genetic studies have been performed in a collaborative project between the Institute of Terrestrial Ecology (ITE) and the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in Costa Rica. Detailed results are reported in Newton *et al.* (1996). Half-sib progeny seeds [one parent known, the other unknown] were obtained from trees in **Honduras** and **Costa Rica**, and in **Trinidad** (where non-native). In separate experiments in **Costa Rica** (of the **Costa Rica** and **Honduras** provenances) and in **Trinidad**, half-sib *S. macrophylla* families were compared for height growth and incidence of pest attack 30-33 months after establishment. Newton *et al.* (1996) report that:

"In the combined provenance/progeny test established at CATIE, mean height growth of different progenies ranged between 245 cm and 471 cm after 33 months. Similarly, in the progeny test in Trinidad, mean height growth of the different half-sib families varied between 357 cm and 470 cm after 30 months. In the formed trial, the maximum family mean was 192% of the minimum value, giving an indication of the extent of genetic variation recorded. The effect of genetic origin (either provenance or family) was statistically highly significant ($P < 0.001$: ANOVA, F test) in both of the trials. Individual-tree narrow-sense heritabilities of height growth in the Costa Rican and Trinidadian trials were 0.38 ± 0.12 and 0.11 ± 0.06, respectively. Although these results are preliminary in nature, based on tests with only a limited range of material and after fewer than four years' growth, they indicate clearly that significant genetic variation exists both within and between different mahogany populations in terms of height growth."

3. Loveless and Gullison (1996) presented results from isozyme studies of genetic variation, population differentiation, and mating systems in natural populations of *Swietenia macrophylla* in the Chimanes Forest of Beni, **Bolivia**. They concluded that:

— *Swietenia macrophylla* populations in Beni are not genetically diverging from each other over the scale studied in this forest, and there is considerable gene flow between trees.

— *Swietenia macrophylla* has a natural outcrossing rate of 100%, which is consistent with most tropical trees. This implies a self-fertilization restriction mechanism, a reasonably large genetic neighborhood for the species, and much pollen exchange.

— Reproductive patterns are altered in *S. macrophylla* populations that become isolated following the logging of surrounding forests. The logging of forest surrounding the Chirizi site in 1992, after fertilization of that year's seed crop, decreased outcrossing rates by 15% (they declined from 100% in 1991, 97.4% in 1992, to only 84.4% in 1993). This was considered to hold potential consequences for inbreeding and low survivorship, the occurrence and extent of which remain to be determined.

Loveless also noted that preliminary results of isozyme studies of Central American *Swietenia macrophylla* specimens from the U.S. Forest Service provenance study revealed much genetic diversity among these populations, to the extent that the initial gels appeared to be from different species.

2.3.5.2. <u>Genetics and Resistance to Shoot-borer Attack</u>:
Shoot-borers (*Hypsipyla* spp.) are the principal biological limitation to the silviculture of mahoganies. In areas where the tree is native, they are particularly affected by the mahogany shoot-borer (*Hypsipyla grandella*). Shoot-borers are moth larvae that tunnel into the apical shoot of young mahoganies. The predominant adverse effect is to cause stem branching or forks, thereby reducing the economic value of the tree (Newton *et al.* 1993). It has been established that some species of the genus *Swietenia* are less susceptible to attack by the mahogany shoot-borer than others. In cultivation in **Puerto Rico**, *Swietenia mahagoni* is attacked less than *S. macrophylla*, and the hybrid *S. mahagoni* × *S. macrophylla* is intermediate (Whitmore and Hinojosa 1977). Grijpma (1976) noted that there is a strong possibility that non-preferred mahoganies may exist, which could be exploited in a selection program to heighten shoot-borer resistance.

In the early 1970s, ITE/CATIE (in **Costa Rica**) employed 100 scientists in an attempt to solve the shoot-borer problem through various planting techniques and pesticides, but with no positive results. Small-scale tree improvement programs have recently been initiated in **Trinidad**, **Costa Rica** and **Honduras**, based on clonal selection and *ex situ* conservation (Newton 1990, Newton *et al.* 1992).

The genetic provenance/progeny trials in **Costa Rica** and **Trinidad** (Newton *et al.* 1996, discussed above) also assessed the response of *S. macrophylla* to shoot-borer attack by scoring trees for the number of damage sites (branching or forking points). Newton *et al.* (1996) reported that:

"In the progeny tests established in Costa Rica and Trinidad, family mean number of attack sites varied between 2.2-4.7 and 2.7-4.4, respectively. The most pronounced genetic variation was recorded in the Bajo Chino trial at CATIE, where the maximum family mean was 217% of the minimum value. The effect of genetic origin (either provenance or family) was statistically significant in both of the trials ($P < 0.001$ in the Costa Rica trial and $P < 0.023$ in the Trinidadian trial; ANOVA, F test). Individual-tree narrow-sense heritabilities of number of forking points in the Costa Rican and Trinidadian trials were 0.56 ± 0.15 and 0.42 ± 0.12, respectively. The results from these trials indicate that significant genetic variation exists within *S. macrophylla* in terms of susceptibility to pest attack. This suggests that there may be scope for the development of pest-tolerant planting stock for use in reforestation, through a program of genetic improvement ..."

Newton *et al.* (1992) conclude that:

"The potential loss of genotypes resistant to pest attack is perhaps one of the strongest arguments in favour of greater protection for remaining stands of mahogany. As described above, selection for pest resistance has great potential as a method of reducing the damage to commercial plantations caused by the mahogany shoot borer. The exploration and testing of *Swietenia* genotypes is therefore an urgent priority. If resistant genotypes and populations are identified, their *in situ* and *ex situ* conservation and utilization should become immediate objectives, on economic as well as biological grounds."

2.4. Population Trends

2.4.1. Natural Regeneration

In the combined presence of a major forest disturbance and residual mature seed trees, *Swietenia macrophylla* regenerates well and grows robustly (Lamb 1966, Snook 1992, Gullison 1995). Nevertheless, the canopy-emergent trees that form the natural mature *Swietenia macrophylla* populations are often one to several centuries old, having survived numerous natural forest disturbances (Lamb 1966, Terborgh 1990, Betancourt 1987, Mabberley 1983). There are few younger specimens because *Swietenia macrophylla* is shade intolerant, and cannot regenerate to maturity beneath a closed, or closing, forest canopy. As a result, *S. macrophylla* tends to occur in even-aged clumps of mature trees over 100 years old, lacking the age stratification necessary for continued harvest rotations.

On the Yucatán Peninsula of **México**, Snook (1993) found that:

A. *Swietenia macrophylla* survives both fire and hurricanes as an adult.

B. *Swietenia macrophylla* regenerates in essentially even-aged mixed-species stands, becoming established at the highest densities on areas formerly cleared or burned, and less abundantly after hurricanes. Particularly favorable conditions occur after the combination of hurricane damage followed by fire.

C. The highest density of *S. macrophylla* regeneration was found on loosened, disturbed, exposed soil.

D. Where conditions are favorable (*e.g*. suitable roadside) and seed trees are available, *S. macrophylla* can become established at higher densities than any other species.

E. Light fire stimulates sprouting by several species, suppressing *S. macrophylla* seedlings.

In contrast to the hurricane and fire regeneration pattern seen in Middle America, the predominant regeneration event for *Swietenia macrophylla* in the Bolivian Amazon is after major hydrological disturbances. This regeneration strategy is also based on canopy opening and the elimination of competing vegetation. In the Bosque Chimanes of the Bolivian Amazon, research by Gullison (1995) indicated that:

"mahogany appears to regenerate only after episodic hydrological disturbances of either erosion, or logjam-induced flooding and deposition of alluvial sediments. Since these disturbances are infrequent, most stands have not regenerated for many years, and entire stands can be larger than the diameter limit. With the current lack of management control in the Chimanes Forest, harvest is exceeding sustainable levels. There is little or no regeneraion in logged stands, presumably because the disturbances caused by logging are too small."

The sensitivity of *Swietenia macrophylla* regeneration to a variety of perturbations is evident from the data collected by Snook (1993) and Gullison (1995). Natural regeneration requires the presence of seed trees. The absence of seed trees, as occurs following unregulated logging, removes the potential for natural regeneration. Moreover, a single tree can seed only a limited area of forest. The funnel-shaped seed shadow of a mahogany 23 m tall in Quintana Roo was found to extend 200 m downwind (westward) of the tree, covering an area of approximately 3 ha (Rodríguez *et al.* 1992, in Snook 1993). In **Bolivia**, Gullison (1995) found the median dispersal distance of mahogany seeds to be < 36 meters. As a result, isolated seed trees can only repopulate an area of 3-4 hectares downwind (water and animal as well as wind conveyance of seeds is possible).

The natural growth rate of *Swietenia macrophylla* was demonstrated by Snook (1993) using measurements of trees on a chrono-sequence of post-fire stands 15-75 years old. Growth increments were found to follow a sigmoid curve (see Appendix F). Extrapolating from this curve, Snook (1993) calculated that *S. macrophylla* requires, on average, 120 years to attain the current 55 cm commercial diameter limit in Quintana Roo. A corollary of this is that the specimens of *S. macrophylla* currently being cut, with girths greater than 100 cm, are at least one to several centuries old, and current timber harvest rotations are based upon over-estimates of the growth rate of *S. macrophylla*.

Simulations by Gullison and Hubbell (1992) estimate that 105 years are required to reach the current Bolivian cutting diameter of 80 cm dbh (see Appendix G). Empirical estimates by Gullison (1995), based on annual rings found in 117 mahoganies in the Bosque Chimanes, indicated median growth rates of 2.6 to 9.0 mm/yr (Appendix H). These growth rates were similar to those reported by Lamb 1966 (3.6-9.1 mm yr^{-1}) and Snook 1993 (2.0-10.9 mm yr^{-1}). Gullison (1995) notes that:

"If a tree grows at the maximum growth rate throughout its life, it will take 52 yr to reach commercial size, while growing at the median growth rate throughout it will take 148 yr. The actual growth rates that the current trees have experienced will be somewhere in between."

2.4.2. Lack of Regeneration After Selective Logging

Swietenia macrophylla has been found to regenerate poorly, if at all, following logging operations in closed forests using current management practices (Gullison 1995, Quevedo 1986, Veríssimo *et a*l. 1992, Snook 1992, Stevenson 1927, Lamb 1966, Johnson and Chaffey 1973, Finol 1971). Snook (1992) noted that selective logging impedes *S. macrophylla* regeneration in the following ways: (1) selective logging removes mahoganies but leaves other species behind to take over their space; (2) the openings created by a single tree fall do not provide conditions suitable for *S. macrophylla* regeneration, such as the provision of adequate light and disturbed mineral soil; and (3) logging removes seed sources.

In **México**, Negreros-Castillo (1996) reported on seedling survival rates under a variety of natural and artificial propagation circumstances. Natural regeneration was found to be essentially absent in 10 m^2 gaps following selective logging:

Harvest Year	# Plots	Total Woody Plants	# *S. macrophylla*
1986	68	299	1
1990	35	102	0
1993	19	144	0

Natural regeneration was absent in 10 m^2 undisturbed areas near harvest gaps:

Harvest Year	# Plots	Total Woody Plants	# *S. macrophylla*
1986	42	91	0
1990	12	200	0
1993	6	106	0

Seedling survival was also low in artificial enrichment plantings along main roads, skids trails, landings, and under the forest canopy. Negreros-Castillo concluded that the trees that are being harvested are not being replaced, and that increased communication is needed between scientists and field workers so that more precious time and money are not wasted on futile *Swietenia macrophylla* enrichment methods.

In **Bolivia**, Quevedo (1986) reported that, while *S. macrophylla* regeneration was found in forest harvested 3 years previously, in forest harvested 9 years previously the mahogany seedlings had disappeared and the regrowth was dominated by other species. Betram and Reilingh (1993) found high densities of mahogany seedlings up to 1.8 m tall (326 per ha) in forest selectively logged in 1975, but very few trees with diameters greater than 5 cm dbh. They concluded that, while seedlings could survive for some time in shade, they needed considerable light to grow rapidly to the canopy and then slowly add girth. Gullison (1995) analyzed regeneration in plots established around old tree-fall gaps, concluding that "the disturbances caused by low intensity logging are very different from the disturbances that mahogany naturally recruits after, and there is little natural regeneration in logged forest."

Gullison (1995) expressed particular concern that limiting *Swietenia macrophylla* harvest to the trees over 80 cm in diameter disproportionately removes the most fecund individuals of the population:

"Mahogany regenerates after episodic disturbances, and its stands are made up of one or a few even-aged cohorts. The long time between disturbances favours late maturation. Mahogany trees allocate their photosynthates to growth until they reach 80 cm dbh, at which point they increase allocation of their photosynthates to reproduction. Unfortunately, this coincides with the minimum cutting diameter, and the postharvest seed input into logged forests is substantially reduced."

In southern Pará, **Brazil**, Veríssimo *et al.* (1992) reported *Swietenia macrophylla* to be "quite scarce" in regeneration plots. Searching plots of 5 m $\times$ 15 m at the base of old mahogany stumps, the authors found *S. macrophylla* seedlings/saplings in only 31% of the 70 gaps located, and at an average number of 0.59 per plot. The continuing presence of seed trees was noted as an important predictive variable in the finding of seedlings. At 89% of the clearings without *S. macrophylla* regeneration, not a single mature specimen was nearby, whereas in half of the 22 clearings with mahogany seedlings, at least one older mahogany was found nearby (Veríssimo *et al.* 1992).

Preliminary results on rates and fates of mahogany regeneration in closed and logged forests of southeastern Pará, **Brazil**, were presented by Grogan *et al*. (1996). The authors confirm low seedling survival 2-3 years post logging. They note seed dispersal to ca. 100 meters from the mother tree, the potential for water dispersal, and that seedling growth was keyed to light availability. Regarding mature populations, Grogan *et al*. (1996) reported the occurrence of a broad size-class distribution of *S. macrophylla* when assessed along tributaries of defined watersheds.

2.4.3. Minimal Prospects for a Second Cut

As a result of its mode of regeneration, *Swietenia macrophylla* tends to occur in even-aged groups in Amazonia, lacking age stratification within individual populations (CCT 1996, Gullison 1995, Quevedo 1986, Gullison and Hubbell 1992, Veríssimo *et al.* 1992). Logging to a diameter limit has the potential to remove all mature mahoganies within a region, particularly those with good seed production and dispersal potential, resulting in a loss of seed production and curtailing of regenerative options for the population (Veríssimo *et al*. 1992, Gullison and Hubbell 1992). The relative absence of intermediate-sized mahoganies, and the limited potential for regeneration after selective logging, combine to provide little option for a future second cut:

"The prospects of a second mahogany harvest in the near future are dim. The stock of mahogany trees between 10 and 45 cm dbh ... is only 0.3 trees/ha ... Considering natural mortality, it is unlikely that this stock could produce a second harvest." (Veríssimo *et al.* 1992).

Veríssimo *et al.* (1995) conclude that:

"... future cuts of Mahogany are in doubt: in extensive surveys in each of three Mahogany extraction areas we encountered only 0.25 Mahogany trees > 30 cm dbh/ha and no trees between 10 and 30 cm dbh. Mahogany seedlings were also exceedingly rare."

In **Bolivia**, the small number of residual *Swietenia macrophylla* specimens with diameters less than 80 cm presents "a potentially serious problem for sustainable management of this species" (Gullison and Hubbell 1992). Gullison and Hubbell tentatively "conclude that, with proper management, mahogany can continue to be produced in the Bosque Chimanes, although with a hiatus of 70-100 years while current seedling banks grow to merchantable size."

CCT scientists (CCT 1996) assessed the prospects for sustainable management of *Swietenia macrophylla* in El Choré Forest of **Bolivia** (Appendix L). They noted some natural regeneration of the species in 1995 on a reduced scale following shifting agriculture in the presence of seed trees:

"... but in El Choré, within the forest studied, this regeneration is not occurring in the abundance required."

CCT (1996) data (Appendix M) confirm the adverse effects of logging to a diameter limit (in this case 60 cm), with removal of the majority of mature trees in the study area following logging. Of 49 *Swietenia macrophylla* specimens > 60 cm dbh initially in the 35-ha total study area, just 6 remained after logging, 5 of which were in the smallest size class (60-70 cm dbh). CCT (1996) conclude that:

"The number of individuals is very small for securing two fundamental aspects: the future commercial cut of timber and the existence of seed sources. The data indicate that in actuality there is not even the sufficient quantity of seeds."

The possibilities and constraints pertinent to human assistance of natural *Swietenia macrophylla* regeneration following logging or deforestation are covered by Snook (1993), Veríssimo *et al.* (1992) and Gullison (1995). In addition to modifying the current practice of cutting to a diameter limit, these recommendations include instituting silvicultural policies that encourage: (1) the early removal and use of other species; (2) the appropriate spacing and location of *S. macrophylla* seed trees; (3) the opening of sites near seed trees to allow for regeneration;

(4) awaiting seed dispersal before harvesting; and (5) the intermittent removal of seedlings and other vegetation that is competing with *S. macrophylla* regrowth.

2.5. Geographic Trends

Principal geographic trends are encompassed within the preceding sections on Habitat Availability (Section 2.2), Population Status (Section 2.3) and Population Trends (Section 2.4). Deforestation and relative *Swietenia macrophylla* population depletion are generally greater in **México** and **Central America**. This reflects the duration of extraction since European colonization times, the increased accessibility of *S. macrophylla* for extraction purposes, and higher human population pressures in the species' range. The extraction of *S. macrophylla* from the Amazonian regions generally requires the construction of roads and primary human encroachment (excluding Amerindian inhabitation). Absolute extraction rates and forest impacts are higher in **Brazil** due to the much greater range and extent of the mahogany resource. Bolivian mahogany resources appear to have been depleted at a relative rapid rate (see CCT 1996, Gullison 1995, Synnott and Cassells 1991).

Geographical scale impacts of climatic fluctuations (*e.g*. El Niño events) on mahogany regeneration have been postulated (Snook 1996), but not confirmed. Ancient agricultural practices of the Maya (Snook 1993, Lamb 1966) and Bolivian Amerindians (Gullison 1995, Gullison *et al*. 1996) may have led to local increases in *S. macrophylla* density, following temporary forest clearing in the presence of seed trees.

2.6. Role of the Species in Its Ecosystems

The ecological role of *S. macrophylla* is as a canopy-emergent tree (Lamb 1966, Lugo 1992). *Swietenia macrophylla* is "a very large and magnificent, deciduous timber tree with an umbrella-shaped crown, reaching 35-40 m tall, but specimens up to 55 m or 60 m tall and 2 m diameter have sometimes been recorded in Brazil. The bole is straight and cylindrical, unbranched for up to 25 m, with very broad, plank-like buttresses up to 5 m at the base" (Styles 1981). Mature, canopy-emergent mahoganies predominate over small or mid-size specimens, except in isolated areas of active regeneration. The substantial population declines that result from logging to a diameter limit (see Section 2.3, and Gullison 1995), plus breaches of size and seed-tree requirements, are concurrent with elimination of *S. macrophylla* from its role as a canopy-emergent species. Limited instances of regeneration or replanting require ca. 50 + years (ca. 22 m height, 30 cm dbh; Gullison 1995) to again reach the canopy, assuming that the natural forest survives for the requisite decades.

Lamb (1966) details the floristic associations of *S. macrophylla* on the Yucatán Peninsula of Middle America (see also Snook 1993). The species occurs in tropical dry-forest and tropical moist-forest formations, particularly in zapotal, caobal (named after mahogany) and corozal associations in Mesoamerica (Lamb 1966, Snook 1993). In the general three-storied structure of zapotal and caobal associations, *S. macrophylla* in the canopy is often accompanied by palms in the middle and lower stories, especially the escoba palm (*Cryosophila argentea*). In the corozal association of valleys and riverbanks, *S. macrophylla* overtops a canopy of coroza palms (*Orbignya cohune*). The absence of young mahogany trees in these vegetational associations was considered to be the result of dense shade (Lamb 1966). *Swietenia macrophylla* reaches its highest local stocking per hectare in wooded swamps, although in this association it is considered to be of no commercial value because of its poor form and stunted size (Lamb 1966).

Bees and moths have been recorded as pollinators of *Swietenia macrophylla* flowers (Styles and Khosla 1976, Loveless and Gullison 1996). It is not known what species pollinate *Swietenia macrophylla* flowers in Quintana Roo, and what species these animals may require to survive (Snook 1993). Numerous epiphytes colonize *S. macrophylla*, including orchids and bromeliads. Mahogany seeds are a nutrient source for forest rodents (*e.g*. agouti, *Dasyprocta punctata* and paca, *Cunicula paca*), parrots (*Amazonas* spp. and macaws), and insects. Toucans (*Ramphastos*) selectively nest in the large old mahogany trees in some areas of Middle America. No research has been conducted to determine if there are any obligate species of fauna (or flora) whose survival is dependent on mature mahoganies; no such dependencies have been reported.

2.7. Threats

The principal threat to *Swietenia macrophylla* as a functioning wild species is logging of mature specimens. The adverse effects of logging are compounded by biological and economic constraints to sustainable management, details of which are elaborated upon throughout this proposal. In brief, current logging practices (*e.g*. cutting based on diameter limits) remove the majority of *S. macrophylla* specimens from the logged area. Replacement of mature, canopy-emergent specimens in natural forest systems is foreclosed by: (1) the paucity of mid-level or young specimens to replace the predominantly old age-stratified population distribution; (2) insufficient seed trees due to the extensive extraction of mature specimens in the logged region (~95% first-pass extraction efficiency — see Snook 1992, Gullison and Hubbell 1992, Veríssimo *et al.* 1995); (3) routine breaches of forestry codes of practice which require that seed trees be identified and preserved; (4) reduced fecundity of remaining seed trees due to the size sensitivity for strong seed production; (5) limited dispersal range of seeds and seed survival time; (6) poor regeneration in shaded conditions; (7) prolonged time required for canopy emergence and maturity; and (8) loss of the natural forest to clearing and general deforestation accompanying human expansion.

Extensive logging of *Swietenia macrophylla* may also reduce its genetic variability, adversely impacting the species' capacity to adapt to changing environmental circumstances, and also limiting future silvicultural options for selective breeding. In particular, logging of the best genotypes for form and pest resistance may result in dysgenic selection (Newton *et al.* 1996).

The economic value of mahogany in international markets is the driving force behind the extraction of *Swietenia macrophylla*. The high value of individual trees provides the incentive for illegal logging and trade, threatening specimens in national parks, other variously designated and protected areas (*e.g*. biosphere reserves), and on Amerindian lands. Economic factors also militate against sustainable management of *S. macrophylla* in native forests, where opportunity costs make it more advantageous to log all specimens and reinvest the profits elsewhere, rather than stagger the harvest and accrue additional volume growth for harvesting at some time in the future. Silvicultural ventures are also governed by economic concerns, where the rate of return on investment must be balanced against other options and where the timber produced must compete with mahogany obtained from logging wild specimens (often illegally). A clear separation between legal and illegal mahogany, and natural versus silviculturally derived timber, will act to both protect native populations and to facilitate sustainable management ventures (Gullison 1995, Rodan and Campbell 1996).

3. Utilization and Trade

National and international utilization and trade in *Swietenia macrophylla* chiefly involve its timber. Properties of mahogany wood include easy workability, stability, durability, and above all beauty (grain, color and finish), making it perhaps the most valuable timber of the neotropics (*e.g*. see Bramwell 1976, Walker 1989, Constantine 1959, Lewington 1990, Whitmore 1981, Fosberg 1945, Lamb 1966, Styles 1981, FPRL 1956, Chudnoff 1984). Mahogany is particularly desired for high-class cabinets, chairs, joinery, panelling and pianos, and is used as solid wood or veneer (Walker 1989, Bramwell 1976, Samba Murty and Subrahmanyam 1989). Increasing costs, with supplies diminishing, have resulted in greater usage in commerce of the veneer only.

3.0. Yield Conversions

The following approximate yield conversions are provided by Stewart *et al.* (1993, final draft):

One m^3 of stumpage yields 0.80-0.85 m^3 of log;
One m^3 of log yields 0.43-0.60 m^3 of green lumber;
One m^3 of log yields 0.20-0.33 m^3 of dry sliced veneer;
One m^3 of log yields 0.41-0.45 m^3 of finished hardwood plywood;
One m^3 of lumber yields 0.60 m^3 of plank parquet;
One m^3 of green lumber yields 6.5 finished solid raised-panel doors.

3.1. National Utilization

Bolivia: The Cámara Nacional Forestal (CNF) reported average annual domestic use of mahogany in **Bolivia** during the 1985-1990 period to be 14,598 m^3. Allowing for waste during processing, this accounts for ~30,000 m^3 felled. Additional wood is used to make boats and homes for colonists and sawmill operators. López (1993) calculated that the annual domestic use constituted ca. 42% of Bolivia's total mahogany production.

Brazil: Domestic use of mahogany in **Brazil** was estimated by Barros *et al.* (1992) and Veríssimo *et al.* (1995) to account for roughly one-third of the lumber extracted.

3.2. Legal International Trade

The severe depletion of *Swietenia mahagoni* (Caribbean mahogany) populations by about the 1850s caused a commercial shift to *S. macrophylla* (Samba Murty and Subrahmanyam 1989), despite the wood of bigleaf mahogany being coarser grained and thus considered inferior (Styles 1981, Bramwell 1976); *S. mahagoni* was included in CITES Appendix II in 1992 (at COP8). *Swietenia macrophylla* is now the main source for the mahogany market (when it is not supplied by similar woods from Southeast Asia or Africa; Knees and Gardner 1982, 1983a). Readily accessible populations in Central America have been diminished considerably (*e.g*. Boucher *et al*. 1983, Walker 1989). *Swietenia macrophylla* was discovered in the Amazon ca. 1923 (Little and Wadsworth 1964); intensive extraction in inland South America began more recently, with the opening and development of that region (*e.g.* White 1978 for **Perú**). Representative is the 1977-1987 sixfold increase in mahogany extraction with **Bolivia**'s northeastern road construction (Dept. Beni) (Collins 1990).

For volumes of "mahogany" traded internationally, see Appendix J of this proposal, and Jimerson (1993) and Bishop (1993) (and for additional data, see also Lamb 1966, and Knees and Gardner 1982, 1983a). Note that, although some of the "mahogany" wood included under these harmonized tariff schedule (customs) designations is probably not from *Swietenia macrophylla* (*e.g.* wood originating in Africa), certainly most of the mahogany wood in trade is from this species; also note that the country listed on customs data is not necessarily the initial source (the originating country) for the timber shipped.

3.2.1. Exports

Guatemala: Most of the demand for mahogany and cedar (*Cedrela*) is to supply the export market. The export industry has increased in importance in the Petén over the past two decades. In 1992, there were 21 mills licensed to operate in the Petén, with 10 mills dominating (Beavers 1994, citing Conservation International 1992). For example, of the three firms studied in detail by Beavers (1994), firm 1 sold ca. 60% of wood for export (plus 25% more No. 3 Common grade in a special deal to **México**); firm 2 exported 80% of output; and firm 3 exported ca. 78%.

Mahogany Export Data, Guatemala (DIGEBOS):

Year	1988	1989	1990	1991	1992 (½ yr)
Vol.(m^3)	10,309	20,922	8,970	14,608	9,163

Brazil: In 1989 the Brazilian government adopted a quota policy for mahogany exports. The allowable quotas and export volumes have declined since then and are as follows (comm. Eduardo de Souza Martins, President of IBAMA, **Brazil**, to U.S. Fish and Wildlife Service, 12 Nov. 1996):

Year	1990	1991	1992	1993	1994	1995	1996

Quota(m^3)	150,000	150,000	130,000	100,000	106,000	100,000	70,000
Exported	110,488	116,527	113,144	112,025	96,587	97,699	62,452*

* by October 1996

Mahogany exports from Pará state, **Brazil**, in 1995 were destined for the following countries or regions: **United States** 29,800 m^3, **United Kingdom** 18,900 m^3, **Ireland** 3,800 m^3, **Caribbean** 3,400 m^3, **Spain** 1,600 m^3, **Europe** (other) 2,900 m^3, **Gulf** 1,600 m^3, and others 1,000 m^3. Exports from Pará totalled 63,000 m^3 (IBAMA, State of Pará exports; pers. comm. FOE-UK).

Bolivia: In 1985, approximately 73% of Bolivian mahogany production was exported, representing 88% of total timber exports. Between 1986 and 1990, 74% of Bolivian sawnwood mahogany production was exported. The exported mahogany generally consists of the higher grades, with domestic usage being concentrated in lower grades of timber (López 1993). More than 95% of the total Bolivian exports to the **United States** is made up of mahogany sawnwood at least 7 feet long (ca. 213 cm), classified No. 1 Common and Better. Bolivian exports are primarily through the ports of Corumbá, **Brazil** and Arica, **Chile** (Stewart *et* al. 1993, final draft).

Bolivian CITES certificate of origin data from March through December 1996 (DAF 1997) indicate that 26,403 m^3 of mahogany were exported (11,187,658 board feet [pt]; conversion 1 bd ft = 0.00236 m^3). The majority of that mahogany was destined for the **United States** (25,354 m^3); other destinations were the **Dominican Republic** (389 m^3), **Argentina** (250 m^3), **Spain** (247 m^3), **England** (102 m^3), **Italy** (32 m^3), and **Chile** (28 m^3).

3.2.2. Imports

The **United States** is the largest importer of mahogany worldwide (see Appendix J, below). Subcontract reports for ITTO by FUNATURA (1993) provide detail on volumes of trade and the prices paid for various forms of mahogany, whether sawnwood, veneer or plywood, for imports to the **United States** (Jimerson 1993) and **United Kingdom** (Bishop 1993). Jimerson (1993) calculated that imports of mahogany into the **United States** had, between 1980-1991, averaged 108,000 m^3 for rough lumber, 15,000 m^3 for dressed lumber, 2,250-7,500 m^3 for veneer, and 1,125 m^3 for plywood, totalling ca. 131,625 m^3 annually. Logs are now rarely exported due to originating-government restrictions.

United States imports of rough and dressed mahogany lumber since 1991 were (U.S. Bureau of the Census 1992-1996):

Year	1991	1992	1993	1994	1995
Volume (m^3) Rough	97,187	86,486	86,739	103,115	116,387
Volume NESOI	15,516	11,714	11,554	16,630	22,503

Imports from **Brazil** to the **United States** remained steady during the 1990s, averaging 47,693 m^3 rough and 6,343 m^3 dressed mahogany during the years 1991-1995. Total mahogany lumber imports from **Bolivia** substantially increased in 1994 (44,668 m^3) and 1995 (51,414 m^3) compared to levels in 1992 (20,984 m^3) and 1993 (23,244 m^3) (especially when the imports from **Chile** are presumed to have originated in **Bolivia**). A similar qualitative rise is evident for Peruvian mahogany exports to the **United States** (see Appendix J).

Mahogany imports to the **United Kingdom** have declined considerably in recent years, and are now far less than those to the **United States**. The **United Kingdom** imported 94,000 m^3 of mahogany lumber in 1989, 70,000 m^3 in 1990, and 55,000 m^3 in 1991 (Bishop 1993). Export data from **Brazil** indicate that this decline has continued. In 1992, 31,323 m^3 of mahogany were shipped from Belém, **Brazil**, to the **United Kingdom** (Amazon Wood Data; pers. comm. FOE-UK). This figure had fallen to 19,189 m^3 in 1994 (Amazon Wood Data) and 18,900 m^3 in 1995 (IBAMA, State of Pará exports; pers. comm. FOE-UK). Belém is the principal port for mahogany exports from Pará and **Brazil**, and provides an indication of most, but not all, of **Brazil**'s mahogany exports to the **United Kingdom**.

Prices for rough mahogany off the dock in the **United States** varied around $700 per m^3 in 1993, depending on the grade of timber. Veneer prices were noted by Jimerson (1993) to have doubled since 1984 to $2,200 per m^3 for A-grade imported veneer and $5,000 per m^3 for domestic veneer. Rodan *et al.* (1992) calculated the value of an average mahogany tree in Pará, **Brazil**, to be US$ 324 in log form (5.4 m^3 per tree, $60 per m^3), and US$ 1,500 on import to the **United States** (5.4 m^3 per tree, 50% processing loss, US$ 545 average declared customs value at that time). Noting the price structures outlined by Jimerson (1993), the use of $545 per m^3 should be considered conservative in estimating the value of individual *S. macrophylla* trees.

The implementation details from the inclusion of *Swietenia macrophylla* in CITES Appendix III in November 1995 were under review by the CITES Timber Working Group, which found no significant effects (negative or positive) at its second meeting in October 1996 in Panamá. Amendment of the CITES appendices to include *S. macrophylla* in Appendix II would not substantially alter logistical factors in the international trade and permit-monitoring requirements already operative following the listing in Appendix III. The additional Appendix II requirement of scientific non-detriment findings from range States may impact international supplies through the heightened scrutiny given to sustainability requirements, and the prevention of illegal extraction and trade.

3.3. <u>Illegal Trade</u>

Illegal logging of natural populations of *Swietenia macrophylla* has been widely reported from national parks, forest reserves, and Amerindian lands in many Middle American and South American nations. The extent of this illegal trade is difficult to estimate, as illegal timber may be admixed with legally extracted timber. The continuing high demand for this valuable wood, combined with impediments to law enforcement from fiscal constraints, corruption and/or logistical problems, have resulted in inadequate control over the logging of *S. macrophylla* in many regions (ITTO 1988, Plowden and Kusuda 1989, Lutzenberger 1992, Rodan *et al.* 1992). Despite the presence of considerable domestic legislation, much of the mahogany trade from Middle America and Amazonia is considered to be from illegal sources (Watson 1996, IEWPN 1990, Paz Juárez 1990, Monbiot 1991, Terborgh 1990, Correa 1990, Greenpeace Brasil 1992).

Guatemala: UNEPET estimated that over 1,500 illegal chainsaws are in use in northern **Guatemala** (Salazar 1992). Paz Juárez (1990), Snook (1993) and Beavers (1994) reported illicit trafficking in logs of cedar and mahogany from the Petén National Reserves of **Guatemala** into **México**. According to Salazar (1992), lack of international control and law enforcement cooperation between **Guatemala**, **Belize** and **México** are considered to be contributing to this problem. For example, mahogany trees over 200 years old surrounding the Maya ruins at Tikal are threatened by this illegal trade.

In **Brazil**, lands reserved for indigenous human populations comprise ca. 22.5% of the mahogany-containing region (Barros *et al.* 1992), and the logging of *Swietenia macrophylla* is increasing in these areas (Veríssimo *et al*. 1992, Greenpeace Brasil 1992). In 1987, 69% of the mahogany exported from **Brazil** came from the Kayapó reserve in the eastern Amazon (CEDI 1992). Concern about the adverse effects of illegal mahogany logging was expressed by Sydney Possuelo during his presidency of Brazil's Fundação Nacional do Índio [National Amerindian Agency] (FUNAI), and by José Lutzenberger, a previous Brazilian Minister for the Environment. In an open letter to British mahogany consumers, Lutzenberger (1992) stated that:

> "The trade in Brazilian mahogany and other tropical timbers is out of control. In 1992, most of the timber leaving this country for Britain will come, illegally, from Indian and biological reserves. … The cutters are not only ransacking the forests in these protected areas to supply you with kitchens and lavatory seats: in many places they are also killing the Indians."

Illegal logging of *Swietenia macrophylla* on Amerindian lands in **Brazil** continues (*cf*. Watson 1996). The Rainforest Action Network, World Rainforest Report (Jan./March 1994, Vol. XI, No. 1), stated that a logging company was charged by the Brazilian environmental agency IBAMA with illegally extracting over 5,400 mahogany logs from an Amerindian reserve in the region of São Félix do Xingu, in the state of Pará. As a result, IBAMA is reported to have temporarily revoked the company's export license. Friends of the Earth UK (FOE-UK 1995) report on continuing illegal trade and supply of mahogany lumber to Britain.

In the Brazilian state of Rondônia, FUNATURA (1993), in a study commissioned by ITTO, noted the manipulation of forest inventories by timber cutters in order to obtain mahogany logging permits, a "fachada legal", which are then used to legalize timber extracted illegally. Matricardi and Abdala (1993) estimate that ca. 90% of production in Rondônia in 1991 and 1992 originated from indigenous reserves or conservation areas.

In **Bolivia**, forestry officials have been unable to control the numbers of trees cut even in the intensively managed Chimanes Project area. Synnott and Cassells (1991) note that:

> "… In other cases, the felling contractors exceeded their approved volume [for 1990] and cut unmarked trees, which could not be extracted in 1990 but are to be extracted in 1991. In other cases, logging was apparently intentionally concentrated in areas proposed for allocation to indigenous people …, before the deadline …"

Gullison (1995) confirmed the extent of illegal felling in the Bosque Chimanes:

> "There were 75 alive or recently felled mahogany trees > 60 cm dbh in the three harvested 100 ha plots. Seven of the 10 trees < 80 cm dbh had been illegally felled. Of the 65 trees > 80 cm dbh, only one had been designated as a seed tree (1.5%). Five of the trees were left standing after trial chainsaw cuts in the trunk revealed rot. The companies did not obey the minimum cutting diameter of 80 cm dbh, nor the regulation requiring that 10% of commercial trees be left as seed trees."

Szwagrzak and López (1993) studied forest exploitation in Iturralde province of the department of La Paz, **Bolivia**. In 1990, the opening of a road to Ixiamas led to an influx of colonists, both legal and illegal, and to logging firms, whose activities primarily focussed on *Swietenia macrophylla*. Logging concessions in Iturralde were also used to compensate loggers for the reversion of some concessions in Chimanes that resulted from the mandates of the government's 1990 Historic Ecologic Pause (see Section 4.1.1 below). A major portion of the subsequent logging in Iturralde was performed by "chainsaw loggers", operating illegally outside government controls and in national parks and other protected areas. Although large logging firms criticize the activities of the chainsaw loggers, Szwagrzak and López (1993) report that logging firms actually collaborate with chainsaw loggers, buying high-value wood and financing equipment. Chainsaw loggers were particularly useful in the extraction of *S. macrophylla*, as the species is sparsely distributed. Szwagrzak and López (1993) estimated that 10 such chainsaw teams were active in Ixiamas and ca. 300 in that region of **Bolivia**. Each team can process ca. 1,000 trees per year. In March 1992, indigenous forest guards seized 2,805 mahogany trunks that had been illegally taken from the Chimanes Forest of Beni, **Bolivia** (IIB 1992, in López 1993). Suárez Morales (1986) had reported that in the Reserva Forestal "El Choré" (which was declared in 1966), more than 90% was exploited and depredated because of uncontrolled forest exploitation.

Stewart *et al.* (1993, final draft) concluded that the Bolivian Centro de Desarrollo Forestal [Forest Development Center] (CDF) had been unable to comply with its mandate to manage **Bolivia**'s forest resources. The authors stated that:

> "Because of shortages in personnel and financial resources, there has been only negligible supervision of cutting areas at the field level. The logging firms themselves mark and cut the trees and keep harvesting statistics. In addition, less than 30% of potential stumpage fees are collected, making it essentially a voluntary payment."

In their previously logged study area in Guarayos province, **Bolivia**, Betram and Reilingh (1993) found few mahogany trees greater than 40 cm dbh. Although trees of this size are far smaller than the legal limit for cutting, Betram and Reilingh (1993) reported that they are extracted nevertheless.

In **Perú**, considerable illegal extraction of *S. macrophylla* is reported from parks and reserves, to the extent that the only populations believed to be still protected sufficiently are those in the still remote Manu National Park (Chávez 1990, Terborgh 1990, Gentry 1996).

The issue of whether logging taking place in indigenous (Amerindian) reserves is legal or not is complex and contentious, and subject to the constitution and legislation of the relevant range State. Boas (1993) noted that in **Brazil**:

> "... approval of logging was linked to the interests of groups of employees acting as go-betweens with the companies. As a result, the leadership of FUNAI ... authorized, regulated and centralized the negotiation of logging indigenous areas. In 1987 countless contracts were signed between FUNAI's headquarters and the logging companies, ... even in areas where the Indians did not agree with this way of exploiting their natural resources."

Further clarification of the extent of *S. macrophylla* logging on Amerindian lands in **Brazil** is provided by Veríssimo *et al.* (1995; *cf*. Watson 1996):

> "The first incidence of commercial Mahogany extraction on Indian lands dates to 1975, but it was in the 1980s that this extraction increased significantly (CEDI 1993). The Kayapó Indians, with the help of FUNAI (Federal Agency for Indian Affairs), were the first to sell logging rights to their lands. FUNAI acted as an intermediary in Mahogany wood sale negotiations until 1988 when a Federal judge nullified all Mahogany extraction contracts on Indian lands (CEDI 1993). Although FUNAI's role as an intermediary was curtailed, many Indian tribes had learned to negotiate by themselves by that time. Of 257 documented cases of Mahogany extraction on Indian lands in the Brazilian Amazon between 1975 and 1992 reported by CEDI, 26 were arranged through the mediation of FUNAI and 99 were the result of direct negotiations between Indians and loggers. In the remaining 132 cases, Mahogany was apparently extracted without Indian consent.

We found that 45% of the Mahogany extractors that we interviewed in south of Pará (n = 24) in 1991 admitted extracting Mahogany from Indian lands. And by the end of 1992, Mahogany extraction had occurred in all fifteen reserves in the south of Pará (CEDI 1993, Heringer 1993). The volume of Mahogany extracted from these reserves was at least 574,000 m^3 ..."

In the Chimanes region of **Bolivia**, Synnott and Cassells (1991) stated a few years ago that:

"[t]here is some uncertainty about the long-term future ownership and management of the forest. The Decree No. 22611 of September 1991 states that the Commercial Harvesting Zones form part of the Chimanes Indigenous Area, and that these areas will ultimately revert to the indigenous people (unspecified) at the end of their long-term contracts (unspecified). It is not clear whether the proposed long-term logging contracts will, in fact, be renewable or whether the whole logging area will be handed over for direct management by indigenous groups."

The CCT (1996) reports some of the progress made since that time.

3.4. Actual or Potential Trade Impacts

International demand for mahogany is the driving force behind threats to the status of *Swietenia macrophylla*, as summarized in Section 2.7, and detailed throughout this proposal. Appendix II of CITES has a suitable mandate and infrastructure to facilitate international cooperation in overseeing the international trade in *S. macrophylla*, obliging importing nations to help ensure that the timber was obtained in accordance with the laws of the exporting country, and giving the trade-monitoring organizations access to information that may reveal violations. For range States, CITES Appendix II listing would enhance efforts to scientifically monitor and manage the species, thereby protecting representative functioning populations and genetic resources in national parks and other variously designated protected areas throughout the range of the species. The legitimacy accorded the CITES regulatory and monitoring process would also add to consumer confidence that the mahogany they purchase will have been obtained legally and in accordance with scientific non-detriment findings of the originating country.

A useful outcome of CITES Appendix II listing could be improved separation of mahogany traded legally from mahogany traded illegally. This separation is a necessary prerequisite to sustainable management of the species, because the higher prices that are conducive to silviculture ventures also heighten the incentives to instead illegally extract wild *Swietenia macrophylla* trees that have been growing and accruing value for several centuries. International cooperation through the CITES process could restrain illegal trade and help break this paradox.

3.5. Artificial Propagation for Commercial Purposes

Between 1991-1995, ca. 97% of mahogany lumber imported into the **United States** came from countries with native mahogany populations (U.S. Bureau of the Census 1992-1996). Virtually all mahogany sawnwood currently traded on international markets comes from *Swietenia macrophylla* specimens extracted from primary forests. Volumes of plantation mahogany lumber (not including finished products) from countries outside the range of the species constitute only a very small fraction of the international trade. The principal exporter of plantation mahogany, **Indonesia**, supplied ca. 1.97% of mahogany sawnwood imported to the **United States** between 1991-1995 (11,177 m^3 out of a total 567,831 m^3; see Appendix J). Both quality and quantity constraints indicate that now, and for years to come, plantation-grown timber will not significantly substitute for wild-derived mahogany in international markets.

3.5.1. Artificial Propagation Considerations — Cultivation
(Outside Country of Origin, and Within Country)
(See Resolution Conf. 9.18.)

Most large-scale planting efforts of *Swietenia macrophylla* for commercial timber production have failed (Whitmore 1983, 1992). There are few examples of *S. macrophylla* being managed within its native range on a sustained-yield basis, either in natural forest or in plantations of various types (Lamb 1966, Whitmore 1992, 1983, Newton 1992, Ussach 1992). Current silvicultural techniques have not proven effective in overcoming the many biological, technical, sociopolitical, and economic barriers sufficiently to supply the international demand for mahogany.

Countries (within native range and elsewhere) in which mahogany (*Swietenia*) plantations have been reported include, *e.g*. **México** (also reforestation), **Belize**, **Honduras**, **Cuba**, **Puerto Rico**, **Martinique** (also reforestation), **Trinidad and Tobago**, **Venezuela**, **Brazil**, **USA** (Hawaii), **Fiji** (42,000 ha), **Indonesia** (104,000 ha), **Philippines** (25,000 ha), **Malaysia**, **Myanmar**, **Bangladesh**, **Sri Lanka**, **India** and **Nigeria**. Figueroa (1994, Table 10) collates *S. macrophylla* plantation area estimates based on secondary sources. The plantation estimate for **Sri Lanka** of 20,000 ha may however be an over-estimate, as Sri Lanka reports only 3,015 ha planted with mahogany (between 1925-1968), at 330 trees/ha (comm. W.R.M.S. Wickramasinghe, Deputy Conservator of Forests, to Sri Lankan Embassy, Washington, D.C., 9/12/94).

The mahogany shoot-borer is the main limitation to the artificial establishment of mahogany throughout Middle America and South America (see Martorell 1943, Strong 1940, Newton *et al.* 1993). Damage is caused by larvae of shoot-boring moths [principally *Hypsipyla grandella* (Zeller), Lep. Pyralidae], which burrow inside the terminal part of the stem, destroying the shoot apex and causing branching, forking or deformation of the bole. Virtually all terminal shoots can be attacked within a year, and the resulting multiply branched stems "seriously reduce the stand value and utility at maturity" (Liegel and Venator 1987). Despite research over the last 100 years, no practical control methods have been developed (Whitmore 1992, 1976a, 1976b, Grijpma 1976, Betancourt 1987, Lamb 1966, Newton *et al.* 1992).

The incidence of shoot-borer attack on naturally regenerating *S. macrophylla* populations in **México** was found to be between 17% and 40% on stands between 8 and 15 years of age. Some specimens appeared to be attacked preferentially (Snook 1993). A similar attack rate of 11-58% was noted in line plantings of mahogany by the U.S. Forest Service in **Puerto Rico** (Weaver and Bauer 1986). Adult mahoganies with borer-deformed stems resembling those common in plantations were never seen in the forests of Quintana Roo, **México**. This is presumably due to the death of individuals damaged as a result of shoot-borer attack and unable to compete for scarce light resources (Snook 1993).

Swietenia macrophylla seedlings can also be attacked by the sugarcane stalk-borer (*Diaprepes abbreviatus*), and heavy infestations can kill entire seedling beds (Liegel and Venator 1987). In **Fiji**, mahogany planting was suspended after the discovery of Ambrosia beetle (Platypodidae) attack on semimature plantations (Whitmore 1992, Bramwell 1980), but has since been resumed following re-evaluation of the extent of damage (Cown *et al.* 1989).

Examples of relative biological successes in the silviculture of mahogany have been reported from **Puerto Rico** where *S. macrophylla* is not native (Weaver 1987, Weaver and Bauer 1986, Whitmore 1992), and from **Brazil** (Yared and Carpenezzi 1981). Details of these experimental plantings are provided in the CITES proposal of the species for COP9 (Netherlands 1994). Additional detail on plantation management was presented at a USDA Forest Service International Conference on Big-leaf Mahogany, 22-24 October 1996 in Puerto Rico. Notable were prospects for taungya silviculture (Ennion 1996, Matos *et al*. 1996) and the large reduction in shoot-borer attack in abundant natural regrowth under established plantations (Wadsworth *et al*. 1996, Mayhew *et al*. 1996). The majority of these experimental plantings have not incorporated an economic assessment of returns from initial capital and labor investments, and their commercial applicability remains problematic.

An economic assessment of plantations in **Martinique** (Chabod 1996) illustrates the extent of start-up costs and the impact that these expenses have when capitalized over the prolonged duration until plantation maturity. Of the 1,500 ha of *Swietenia macrophylla* plantations in **Martinique**, 65% of stems were well formed with an estimated rotation duration of 50-55 years at 55-65 cm dbh, making this a successful silvicultural venture, albeit outside the native range of the species. The start-up costs for selective clearing, planting, cleaning, correcting shoot-borer damage through pruning (100% attack rate), and removal of damaged trees were estimated at US$ 4,700 per hectare. This figure does not include subsequent extraction costs. **Martinique** is currently selling ca. 2,500 m^3/yr, but must import mahogany from **Brazil** to support its furniture industry. Chabod (1996) concluded that **Martinique** would maintain current *Swietenia macrophylla* plantation practices, relying also on natural *S. macrophylla* regrowth, but emphasized the high costs of these practices. Similar plantations in **Guadeloupe** are not performing well, where the best quality is less than the worst found in **Martinique**.

A principal economic factor constraining plantation viability is the time to maturity. The U.S. Forest Service projects rotations of 40-60 years for *Swietenia macrophylla* in the Luquillo Experimental Forest in **Puerto Rico** (Whitmore 1992). Other research has estimated a minimum of 40 years for *S. macrophylla* plantation maturity (Vega 1976, Bascopé *et al.* 1957). Individual specimens may reach the designated cutting diameter more rapidly in accord with the Gaussian or bell-shaped distribution curve of tree diameters in a single-age population (Snook 1993; see Appendix K). Indonesian mahogany plantations require 50 years to reach maturity (Perum Perhutani 1991). Silvicultural ventures in natural forest will require ca. 80-120 years to reach designated commercial maturity.

4. **Conservation and Management**

4.1. Legal Status

4.1.1. National

Included are general and/or specific logging regulations, and the establishment of timber reserves, variously designated nature reserves, and Amerindian lands. Many range States have more or less economic regulation of the trade in *Swietenia macrophylla*, particularly restricting the export of unprocessed logs. In some instances, regulations also ban export of the wood if not processed beyond the first stage of transformation (*e.g*. more than simply cut slabs or blocks).

Central America: Between 1974-1990, ca. 350 protected forest areas were set up in Central America, although none is guaranteed free from unauthorized exploitation (Beavers 1994, citing Green 1990). In **Costa Rica**, *e.g*. officials have been bribed to allow logging in national parks, and all parks and reserves have suffered some level of damage by loggers (Beavers 1994, citing Omang 1987).

Guatemala: Logging anywhere north of parallel 17°10_N, including the Sierra Lacandón National Park, is prohibited. However two loggers were operating in the Sierra Lacandón National Park in 1992. Illegal logging was also occurring in the Maya Biosphere Reserve (created 1989) and its periphery (Beavers 1994).

As noted above, **Brazil** instituted an export quota system for mahogany in 1989. Decrees have also been enacted to enhance the "value added" from mahogany extraction, such as banning the export of mahogany logs and by restricting the export of timber greater than 3 inches (ca. 7.6 cm) in diameter. At least 50% of all forest areas opened to new agriculture in **Brazil** were to be kept in natural forest (Forestry Code Decree Law 4771); recently, this has been increased to 80% (Brazilian Embassy 1996). The extent of problems generated by *S. macrophylla* extraction in **Brazil** has resulted in a recent:

"suspension of all authorizations and concessions for the commercial exploitation of Mahogany (*Swietenia macrophylla* King) and Virola (*Virola surinamensis* Warb.). Those authorizations already granted will be respected during this period, however they well be put under a special supervision arrangement. ...

The protection of forest resources in the Amazon constitutes one of the central elements of Brazilian environmental policy. The domestic efforts toward that end will be increasingly effective to the extent to which they are reinforced by measures, outside Brazil, that value the sustainable exploitation of forest resources. Therefore, non-discriminatory access to markets is an indispensable condition for the promotion of sustainable use of forest resources ..." (Brazilian Embassy 1996).

In **Bolivia**, the severity of declines in mahogany forests stimulated the issuance of a Presidential Decree (11 January 1990) declaring a "Historic Ecologic Pause". Under this decree, a 5-year freeze was placed on approving new logging concessions, minimum cutting sizes were set, and companies were required to begin executing sustainable management plans within 1 year (Bascopé 1992). Such a plan was developed for the Bosque Chimanes, but it did not take into consideration the indigenous people (Bascopé 1992), and it failed to manage *S. macrophylla* on a sustainable basis (Gullison 1995).

At the instigation of the International Tropical Timber Organization (ITTO), Synnott and Cassells (1991) reviewed the then-prevailing standards of forest management and protection in **Bolivia** as these pertained to the Bosque Chimanes (*cf*. Suárez Morales 1986). Their conclusions provide a contrast between regulatory intent and field implementation, the applicability of which extends beyond **Bolivia**:

"... [I]n reality, no Bolivian forests are at present subject to professional management for sustained yield of commercial timber. In all forests, essential elements of management are either incomplete or absent. In particular, neither the legally permitted activities such as timber harvesting, nor unauthorized activities, such as forest clearance and settlement and log-stealing, are adequately controlled. ...

It is widely acknowledged that government staff are unable to evaluate the accuracy of timber inventories presented to them by the timber companies or to supervise the implementation of Management Plans or the actual volumes of logs harvested. ...

The principal weaknesses, which make existing operations unsustainable, are the lack of adequate controls over rates and intensities of timber harvesting (by both licensed and unlicensed loggers), and the lack of adequate controls over forest settlement and clearance by colonists, farmers, and other land owners. ...

Tree marking and log-measurements activities are important elements of forest management, and, to our knowledge, are unique to Chimanes and being carried out nowhere else in Bolivia" (Synnott and Cassells 1991).

Even in the Bosque Chimanes, where intensive management had been introduced with at least US$ 400,000 of assistance from the ITTO:

"[t]he operational control of logging is also poorly developed. ... [W]hen logging licenses were first issued by CDF, the permitted annual volumes of Mara far exceeded what was allowed in these [Management] Plans. Since then, the annual permitted volumes have been reduced steadily each year, ... in spite of protests from the logging companies. This reduction ... has occurred only on paper, and the reality in the forest is different. ...

Every year, the annual permitted harvest of Mara (and the volumes actually cut in 1990) greatly exceeded the volumes prescribed in the Management Plans, and the volumes which could be sustained for a full 20-30 year cutting cycle. Furthermore, the report presented in Quito (Goitea 1991a), showed a recommended permitted volume for 1991 that was even higher than the volumes actually harvested in 1990 in five of the six active areas. ...

The 1988 Management Plans, the consultancy report by Dance and many other reports including Goitea (1991a) all describe the necessity of defining blocks and compartments for regulating harvesting. However, such simple management categories have not even been drawn on maps, nor decided in principle by Project staff, in spite of two years of operation and over $400,000 of funding" (Synnott and Cassells 1991).

Findings by the CCT (1996) in El Choré Forest in **Bolivia** concur with the assessment that mahogany logging is unsustainable:

“From the analysis done in the present study we can determine that there is not sufficient mahogany to guarantee the sustained production of the species for the second and third cutting cycles.”

On 12 July 1996, **Bolivia** established a new Forest Law (No. 1700) for its forest resources, which was designed in part to help rectify such findings as those presented above (*Gaceta Oficial de Bolivia* Año 36, No. 1944, 28 pp.; see CCT 1996).

4.1.2. International

At the request of **Costa Rica**, *Swietenia macrophylla* was included in CITES Appendix III in November 1995.

Four countries have been sufficiently concerned to include their *Swietenia macrophylla* populations in the Annex to the Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere (OEA/OAS 1967, USDS 1942; see Coolidge 1945, 1949, Orejas-Miranda 1976; Ashton 1945):

Brazil 22/10/65: *S. macrophylla*
Venezuela 3/02/42: *S. macrophylla* [as *S. candollei*]
Costa Rica 22/10/65: *S. macrophylla*
Nicaragua 23/04/41: *S. macrophylla* [as "caoba *S. mahagoni*" [*sic*], which is not native; that name was misused in past (Standley and Steyermark 1946); and listed with comparable spp.]

4.2. Species Management

4.2.1. Population Monitoring

Biological and economic evaluations of current *S. macrophylla* logging operations indicate that they are clearly unsustainable in most locations, throughout the range of the species (see *e.g*. Gullison 1995, Snook 1993). Current information is unavailable from range States on programs to monitor the status of wild-functioning *Swietenia macrophylla* populations.

4.2.2. Habitat Conservation

The extensive distribution of *Swietenia macrophylla* has fostered its inclusion in some national parks, variously designated nature reserves, and forestry reserves (*cf*. WWF/IUCN 1996). Yet, they are not considered sufficient for assuring conservation of adequate biological populations of the species and its genetic variability, in part because of illegal logging (*e.g*. Monbiot 1991, Correa 1990).

For example, the species is in the Montes Azules Biosphere Reserve in Chiapas (~331,000 ha) and Calakmul Biosphere Reserve in Campeche (~700,000 ha) in southern **México** (Hernández 1964, Snook 1992), and Río Platano Biosphere Reserve in northeastern **Honduras**, but illegally exploited (IUCN 1982, NYZS 1990, CI 1991). Twelve new protected areas were under study for the southern Petén in **Guatemala**, and in the northern Petén *Swietenia macrophylla* is established in the 1.5 million hectare Maya Biosphere Reserve, where, however, illegal logging has been widely practiced (Salazar 1992).

It occurs in four forestry reserves in **Venezuela**. In **Perú**, while found in a variety of parks and reserves, logging is such that the only populations considered to be protected sufficiently securely are in the yet remote Manu National Park (Chávez 1990, Terborgh 1990, Gentry 1996). The locations of national parks and reserves for indigenous peoples in **Bolivia** were mapped by López (1993; *cf*. Suárez Morales 1986, regarding severe management and enforcement problems). The López map and its explanatory table are included as Appendix L of this proposal. Many national parks, biological reserves and ecological parks are present within the mahogany zone of **Brazil**, and total 3,492,886 ha. But again, illegal extraction of *Swietenia macrophylla* is a major problem (FUNATURA 1993).

4.2.3. Management Measures

Guatemala: Although reforestation has been required since 1965, it was not implemented until 1975 when INAFOR (Instituto Nacional Forestal) was created, and 1977 when fiscal incentives were incorporated. Reforestation of one hectare of land is compulsory for every 150 m^3 of wood extracted, although enforcement is not strong. Between 1975-1987, the government was involved in the reforestation of 49,914 ha — 29.4% on government plantations, 61.9% from government funding, and 8.7% due to fiscal incentives (Beavers 1994, citing URL 1987). Species other than mahogany and cedar are also being planted. The level of private forest plantations has not been measured. Very little of this reforestation has taken place in the Petén. Reforestation efforts by large logging firms in the Petén are hampered by inadequate protection from poachers, clearing of the degraded forest for farming, and the poor regeneration of mahogany and cedar under forest canopies (Beavers 1994).

Plantations of *S. macrophylla* have commenced in **Brazil** and **Bolivia**, as a result of encouragement by national legislation mandating compulsory reforestation operations, and in response to national and international efforts toward timber sustainability. Barros *et al.* (1992) tabulate a list of companies associated with AIMEX (Association of Timber Exporting Industries of Pará and Amapá) that have forest replacement projects, including the number of mahogany seedlings planted and the area covered in these projects. Veríssimo *et al.* (1992) reported reasonable growth but frequent problems with the shoot-borer on mahogany plantings by the five biggest sawmills in southern Pará.

In Rondônia, **Brazil**, a study of *S. macrophylla* silviculture and reforestation revealed that only 13 of 25 sites reviewed were planting mahogany (not all sites were registered with IBAMA/RO), and even then were planting only to a limited extent (Matricardi and Abdala 1993). Preliminary results from this study indicated varying results from different mahogany silvicultural strategies. Planting in grass used as pasture resulted in excessive shoot-borer attack (unless chemical pesticides were used), with additional adverse effects from soil compaction and competition for nutrients. Where *S. macrophylla* was planted with cultivated perennial crops, the site was abandoned with the demise of the cacao and coffee trees. The enrichment of logged forests with *S. macrophylla*, in combination with the elimination of competing vegetation, was noted to result in a diminished growth in diameter and height, considered to be a result of deficient levels of light. The enrichment of secondary forests or "capoeira", combined with the elimination of secondary vegetation, produced the best results, with an average annual height increment of 1.186 m and diameter increment of 1.2 cm (Matricardi and Abdala 1993). Numerous farmers in Rondônia have been encouraged to plant timber species on their properties, of which ~400 ha were planted with *S. macrophylla*, mostly in combination with other agricultural crops. Practically all the *Swietenia macrophylla* plantings by small property owners were done with the support of IEF/Rondônia (the State's Institute for Forestry Studies, 1988-1991) and SEDAM (1992 and later). This support included the provision of free technical assistance, seeds and seedlings (Matricardi and Abdala 1993).

Veríssimo *et al.* (1995) report three approaches that might facilitate *S. macrophylla* management; these are measures to increase: natural regeneration, *S. macrophylla* plantings in forests, and plantations in open areas. The authors express concern about the potential for success of all three options.

Measures to increase natural regeneration, such as girdling nearby non-commercial species and leaving seed trees, suffer from the apparent absence of *S. macrophylla* specimens between 10-50 cm dbh. As a result, a second harvest may not be possible for 100 years. Planting *S. macrophylla* seedlings in logged forests, as conducted by four large mahogany companies in Pará, suffered from lethargic growth (height growth less than 50 cm/yr), possibly due to inadequate light levels. The third option, plantation silviculture/agroforestry, resulted in good growth rates (2.5-3 m tall after 1 year) but suffered from frequent attacks by the shoot-borer.

In **Bolivia**, all forestry replanting totaled ca. 11,000 ha in 1990, ca. 500 ha/yr (López 1993, citing PAFT 1991). Most replantings at higher elevations are of eucalyptus species (López 1993). Instead of reforesting cut areas themselves, most companies pay a fee to the Cámara Forestal (Forest Industry Chamber) of each department, which is supposed to pay for reforestation. In the Chimanes Project, the fees have been "used for staff salaries, pending the arrival of full expected Government of **Bolivia** (GOB) funding" (Synnott and Cassells 1991). Stewart *et al.* (1993, final draft) note that the reforestation fee paid to the Cámara Nacional Forestal (CNF) by logging firms is voluntary and that, in practice, "reforestation has been negligible, in part, because only a few firms seem to make this voluntary contribution."

Some *Swietenia macrophylla* plantations have been established in **Bolivia**, such as under the auspices of the Universidad Autónoma Gabriel René Moreno, Santa Cruz, which initiated a project to develop a model sustainable management plan using the Meneses Experimental Forest in El Choré Forest Reserve (Bascopé 1992); see also Bascopé *et al*. 1995. In Bolivia's Bosque Chimanes, Gullison and Hubbell (1992) note that "despite planting a considerable number of seedlings each year, seedling growth and survival have been poor." In the study period 1989-1990, *S. macrophylla* plantings had been done on skidding trails, where they lacked sufficient light.

4.3. Control Measures

4.3.1. International Trade

In addition to the inclusion of *Swietenia macrophylla* CITES Appendix III, a major contemporary initiative in international trade is the use of voluntary certification procedures to distinguish sustainably harvested mahogany from unsustainably logged timber originating from primary forests. Detail on a variety of these proposed timber certification programs was provided by Johnson and Cabarle (1993). Emphasis was placed on the Smart Wood Program of the Rainforest Alliance and the then-proposed certification program by the Forest Stewardship Council (FSC). The Smart Wood Program had certified five sources of tropical timber, four of which are in Latin America. Although four of these five sources use mahogany, only two sources had been certified for mahogany. These were New River Enterprises, Ltd., in **Belize**, and the Indonesian State Forestry Corporation, Perum Perhutani, on Java (Ussach 1992). Ussach (1992), reporting on the Smart Wood Program, concluded that listing mahogany in CITES Appendix II would be compatible with certification:

"such listing would probably lead to a much clearer elaboration of whatever forest management activities were actually being conducted, as well as act as a spur for the development of such management activities."

4.3.2. Domestic Measures

Domestic measures to encourage *S. macrophylla* replanting in range States are discussed above. Included are national legislation, research endeavors, local reforestation projects, and seed banks for settlers. Efforts are of recent onset, and will not substitute for wild, mature populations in the foreseeable future, as time to maturity in natural forest varies from ca.
80-120 years.

5. Information on Similar Species

Mahogany wood from *Swietenia* spp. is well known and generally readily recognizable (Bramwell 1976, Edlin 1969, Bond 1950, Koehler 1922, Miller 1990). International *Swietenia* trade data may be recorded just as mahogany. Trade in the other two species of *Swietenia*, *S. mahagoni* and *S. humilis*, is already regulated under Appendix II of the Convention.

Within the Meliaceae, *Khaya* and *Entandrophragma* species sometimes are referred to as African mahoganies. They and *Swietenia* produce similar timbers, but are considered distinct in commerce (Bramwell 1976, Walker 1989, Knees and Gardner 1982, 1983a). The neotropical *Carapa guianensis* Aublet (andiroba, carapa, crabwood or royal mahogany) sometimes is mixed with *S. macrophylla* in trade, but its wood is known to be inferior (Record and Hess 1943, Knees and Gardner 1982).

6. Other Comments

6.1. For COP10: Communications have been made by both proponents with the range States, and the United States provided a draft potential proposal to the 13 range States on 23 September 1996. That U.S. circulation of a draft proposal was reported to the CITES Plants Committee meeting of 11-15 November 1996 in San José, Costa Rica. **Ecuador** recently communicated its support for inclusion in Appendix II, and **Brazil** and **Perú** had earlier communicated their opposition to such a proposal.

Comments also were sought via a notice (28 August 1996) in the U.S. *Federal Register* 61(168): 44324-44332, with a closing date for the public of receipt at the U.S. Fish and Wildlife Service/OSA, Washington, D.C., by 11 October 1996. There were comments by the deadline and continuing afterwards from the public (organizations and individuals) in favor of and against submitting a proposal, and as usual with the U.S. process comments will be summarized in a forthcoming *Federal Register*.

6.2. COP9: At COP9, Ft. Lauderdale, in November 1994, the proposal by **The Netherlands** (1994) to include *S. macrophylla* in CITES Appendix II achieved a substantial majority of the vote (50 votes for, 33 against), but fell 6 votes short of the required two-thirds majority needed for inclusion. Most range States had expressed support for the listing, including *e.g*. **México**, **Guatemala**, **Honduras**, **Costa Rica**, **Colombia** and **Venezuela**. **Brazil**, **Bolivia**, **Perú** and **Belize** opposed the proposal. The **United States** and the **European Union** countries, which are the main importers of mahogany, supported the proposal.

6.3. COP8: Prior to its withdrawal before voting at COP8, Kyoto, in March 1992, the Costa Rican and/or U.S. CITES proposals were preliminarily supported by all but three of the range States, including **Brazil** and **Belize**, and were opposed by **Bolivia**, **Perú** and **Honduras**. The proposals were also supported by the CITES Secretariat, the World Conservation Union (IUCN 1992), and TRAFFIC (Turner 1992). Particulars regarding the separate COP8 proposals by the **United States** and **Costa Rica**, and the other tropical timber issues dealt with at COP8, are provided in Campbell (1992).

7. Additional Remarks

There is considerable variation and local adaptation in *Swietenia macrophylla*, suggesting that conserving the genetic variability of the species must include populations from throughout its range. Additional species have been infrequently recognized (Styles 1981). There has been limited speculation whether to taxonomically reduce the three species usually recognized in the genus *Swietenia* to one species for the genus (Styles 1981, Whitmore and Hinojosa 1977), although recent genetic studies confirm the existence of the three distinct species (Abrams *et al*. 1996).

Emphasis must be placed on developing sufficient long-term silviculture ventures to supply the world demand for mahogany, both to reduce the pressure on wild *Swietenia macrophylla* populations and to maintain the industry. However, even if the biological, economic, and wood-quality problems with *S. macrophylla* silviculture are overcome, it will take a half century for current seedlings to reach the earliest levels of maturity. In the interval, pressures to extract valuable *Swietenia macrophylla* specimens from reserves and parks will continue. This indicates strong discrepancies between the potential of plantation mahogany, the need for improved forestry management of the species, and the reality of continued illegal logging, even in ostensibly protected areas.

CITES Appendix II listing is compatible with the sustainable timber objectives — Target 2000 — of the International Tropical Timber Organization (ITTO 1991b, 1992; and CITES Resolution Conf. 8.3). As noted by a Director of the U.S. Fish and Wildlife Service (Turner 1992), Appendix II listing of the genus *Swietenia* is "an option of considerably greater merit than a blanket boycott of trade."

The species that is herein proposed for inclusion in Appendix II under the provisions of Article II.2(a), as shown above, qualifies under the criteria in Annex 2a of Resolution Conf. 9.24.

8. References

ABRAMS, J., NELSON, D., SOLIMAN, K. and REAVES, J. 1996. Classification of *Swietenia* spp. using Random Amplified Polymorphic DNA (RAPDs) and taxonomic traits. Abstract for International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

ASHTON, J. 1945. On the plant resources and flora of Nicaragua. Pp. 60-63 in Verdoorn, F., ed., *Plants and Plant Science in Latin America*. Chron. Bot. Co., Waltham, Mass.

BARROS, P.L. C. DE, QUEIROZ, W.T., SILVA, J.N.M., OLIVEIRA, F. DE A., FILHO, P.P.C., TEREZO, E.F. DE M., FARIAS, M.M. and BARROS, A.V. 1992. *Natural and Artificial Reserves of Swietenia macrophylla King in the Brazilian Amazon - A Perspective for Conservation*. FCAP, Belém, Pará, Brazil. 56 pp. + appendices, illustr.

BASCOPE, F. 1992. Mahogany (*Swietenia macrophylla* King) in Bolivia: Its sites, industrial development and actual situation. In Hartshorn, G., ed., *Mahogany Workshop: Review and Implications of CITES, February 3-4, 1992*. Tropical Forest Foundation, Washington, D.C.

BASCOPE, F., BERNADI, A.L. and LAMPRECHT, H. 1957. *Descripciones de Arboles Forestales No. 1: Swietenia macrophylla King*. Instituto Forestal Latino-Americano, Mérida, Venezuela. 18 pp.

BASCOPE, F., SARAVIA, P., ITURRALDE, J., CENZANO, J.C. and RODRIGUEZ, P. 1995. *Natural Regeneration of Mara (Swietenia macrophylla King) and Some Experiences in Plantations in the Departments of Santa Cruz and Cochabamba, Bolivia: A Brief Case Evaluation Report*. Santa Cruz, Bolivia. 12 pp. + appendices, illustr.

BEAVERS, J.P. 1994. *Resource Rent, the Wood Industry, and Survival of the Rainforest in Guatemala*. Masters thesis, University of Massachusetts, Amherst, Mass., USA.

BETANCOURT, B.A. 1987. *Silvicultura Especial de Arboles Maderables Tropicales*. *Swietenia macrophylla* and *Swietenia mahagoni*, pp. 309-322, 323-341. Edit. Ci.-Técn., La Habana.

BETRAM, I. and REILINGH, H. 1993. *La Regeneración Natural de la Mara en el Bosque Explotado de la Tala Selectiva en la Provincia Guarayos, Bolivia*. 12 pp. [unpublished]

BISHOP, P.W. 1993. *Mahogany in the UK: A study for FUNATURA*. FUNATURA (Fundação Pró-Natureza), Brazil/International Tropical Timber Organization (ITTO).

BOAS, A.V. 1993. *"Green Gold" on Indian Land: Logging Company Activities on Indigenous Land in the Brazilian Amazon*, 2nd edition, revised, corrected, and updated. Centro Ecumênico de Documentação e Informação, São Paulo, Brazil.

BOND, C.W. 1950. *Colonial Timbers*. *Swietenia macrophylla*, pp. 80, 159. Sir I. Pitman & Sons, London.

BOUCHER, D.H., HANSEN, M., RISCH, S. and VANDERMEER, J.H. 1983. Agriculture: Introduction. Pp. 66-73 in Janzen, D.H., ed., *Costa Rican Natural History*. University of Chicago Press, Chicago and London.

BRAMWELL, M., ed. 1976. *The International Book of Wood*. M. Beazley, London & Simon and Schuster, New York.

BRAMWELL, M. 1980. Products of the jungle. Pp. 176-195 in Ayensu, E.S., ed., *Jungles*. Marshall Edit., London & Crown Publish., New York. (*Swietenia*, pp. 177, 181).

BRAZILIAN EMBASSY, Washington, D.C. 1996. Deforestation. 25 July 1996. Internet posting at http://Brasil.emb.nw.dc.us/evar03df.htm

BROWDER, J.O. 1986. *Logging the Rainforest*. Doctoral dissertation, University of Pennsylvania, Philadelphia, USA. xli + 393 pp., illustr.

BROWDER, J.O. 1987. Brazil's export promotion policy (1980-1984): Impacts on the Amazon's industrial wood sector. *J. Developing Areas* 21: 285-304.

BROWDER, J.O. 1989. Lumber production and economic development in the Brazilian Amazon: Regional trends and a case study. *J. World Forest Resource Management* 4: 1-19.

BURNISKE, G.R. 1994. *Final Evaluation - Phase I. Conservation, Management, Utilization, Integral and Sustained Use of the Forests of the Chimanes Region of the Department of El Beni, Bolivia*. ITTO Report PD 34/88 Rev. 1 (F,I).

CAMPBELL, F.T. 1992. Tropical timber issues at CITES. *Species* 18 (June): 28-30.

CARDENAS, M. 1945. Recursos naturales del reino vegetal en Bolivia. Pp. 313-315 in Verdoorn, F., ed., *Plants and Plant Science in Latin America*. Chron. Bot. Co., Waltham, Mass., USA.

CCT. 1996. *Estudio Sobre el Estado de Regeneración Natural de* Swietenia macrophylla *King, "Mara", en Santa Cruz, Bolivia. Informe Final de Consultoría*, Jiménez Saa, H., Alpízar, E., Ledezma, J., Tosi, J., Bolaños, R., Solórzano, R., Echeverría, J., Oñoro, P., Castillo, M. and Mancilla, R. Centro Científico Tropical [CCT], San José, Costa Rica. 113 pp.

CEDI. 1992. *Povos Indígenas no Brasil 1987/88/89/90*. Aconteceu Especial 18. Centro Ecumênico de Documentação e Informação [CEDI], São Paulo, Brazil.

CHABOD, D. 1996. Big-leaf mahogany and its silviculture in Martinique. Presentation to International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

CHAVEZ, J.S. 1990. Comm. to NRDC (F.T. Campbell). Centro de Datos para la Conservación [CDC]. Universidad Nacional Agraria La Molina, Lima, Peru.

CHUDNOFF, M. 1984. *Tropical Timbers of the World*. *Swietenia macrophylla*, p. 157. U.S. Dept. Agric. [USDA] Forest Serv., Agric. Handb. 607. Washington, D.C.

CHUDNOFF, M. and GEARY, T.F. 1973. On the heritability of wood density in *Swietenia macrophylla*. *Turrialba* 23: 359-362.

CI (Conservation International). 1991. Mexico swaps debt for nature conservation. *Orion Nat. Quart*. 10(1): 62.

COLLINS, M., ed. 1990. *The Last Rain Forests: A World Conservation Atlas*. Oxford University Press, Oxford and New York. 200 pp., illustr.

CONSTANTINE JR., A. 1959. *Know Your Woods*. New World mahogany, pp. 262-266. Home Craftsman Publish. Corp., New York.

COOLIDGE JR., H.J. 1945. Notes on conservation in the Americas. Pp. 328-335 in Verdoorn, F., ed., *Plants and Plant Science in Latin America*. Chron. Bot. Co., Waltham, Mass., USA.

COOLIDGE JR., H.J. 1949. A world approach to nature protection. Pp. 714-724 in USDS, *Proceedings of the Inter-American Conference on Conservation of Renewable Natural Resources, Denver, Colorado, September 7-20, 1948*. U.S. Dept. State [USDS] Publ. 3382. Washington, D.C. 782 pp.

CORREA, G. 1990. [Most of Lacandon Forest Said Destroyed]. *Proceso* (México, D.F.) 706 (14/05): 26-29.

COWN, D.J., MCCONCHIE, D.L. and KIMBERLEY, M.O. 1989. A sawing study of Fijian plantation grown large-leaf mahogany. *Commonw. For. Rev*. 68: 245-261.

DAF. 1997. *Administración del Certificado de Origen "CITES" para la Exportación de la Mara (Swietenia macrophylla) en el Departamento de La Paz, Gestión 1996 [Período Marzo - Diciembre 1996]*. Ministerio de Desarrollo Sostenible y Medio Ambiente, Secretaría Nacional de Recursos Naturales y Medio Ambiente, Subsecretaría de Recursos Naturales, Dirección de Aprovechamiento Forestal [DAF], La Paz, Bolivia. 9 pp.

EDLIN, H.L. 1969. *What Wood is That*? *Swietenia macrophylla*, pp. 129-131. Viking Press, New York.

EDLIN, H.L., [Nockels, D. and Barnett, H.]. 1973. *Atlas of Plant Life*.
W. Heinemann, London. (Mahogany, pp. 84-88, 90, 94-95.)

ENNION, R. 1996. Evaluation of low taungya mahogany increment plots, age 36-38 years in Belize. Presentation to International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

FAO. 1984. *A Guide to* In-Situ *Conservation of Genetic Resources for Tropical Woody Species*. FORGEN/MISC/84/2, Food and Agriculture Organization [FAO], Rome. 196 pp., illustr.

FAO. 1988. *An Interim Report on the State of the Forest Resources in the Developing Countries*. Food and Agriculture Organization, Rome.

FAO. 1989. *Report of the FAO Panel of Experts on Forest Gene Resources*. Food and Agriculture Organization, Rome.

FIGUEROA COLON, J.C. 1994 (Feb.). *An Assessment of the Distribution and Status of Big-leaf Mahogany (Swietenia macrophylla King)*. Puerto Rico Conservation Foundation and USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico. 28 pp. + appendix.

FINOL, H. 1971. Nuevos parametros a considerarse en el análisis estructural de las selvas virgenes tropicales. *Revista Forestal Venezolana* 21: 29-39.

FOE-UK. 1995 (Dec.). Pará Inglês Ver — 1995 Update Report on Illegal Mahogany Logging and Trade in the Brazilian Amazon. Friends of the Earth England, Wales, and Northern Ireland [FOE-UK], London.

FOSBERG, F.R. 1945. Principal economic plants of tropical America: Timbers [p. 32]. Pp. 18-35 in Verdoorn, F., ed., *Plants and Plant Science in Latin America*. Chron. Bot. Co., Waltham, Mass., USA.

FOSTER, R.B. 1990. The floristic composition of the Río Manu floodplain forest. Pp. 99-111 in Gentry, A.H. [and Guzmán-Teare, M.], eds., *Four Neotropical Rainforests*. Yale University Press, New Haven and London.

FPRL. 1956. *A Handbook of Hardwoods*, [3rd edn.]. *Swietenia*, pp. 141-142.
DSIR Forest Prod. Res. Lab. [FPRL], HMSO, London.

FUNATURA. 1993. *Projeto Mogno. Sumario: Ocorrência e Distribuição do Mogno na Amazônia Brasileira*. Versão Preliminar. FUNATURA (Fundação Pró-Natureza), Brazil.

GENTRY, A.H. 1996. Lowlands of Manu National Park: Cocha Cashu Biological Station, Peru. Pp. 360-363 in WWF/IUCN, *Centres of Plant Diversity: A Guide and Strategy for Their Conservation*, Volume 3. *The Americas*. IUCN Publications Unit, Cambridge, UK. In press.

GLOGIEWICZ, J.S. 1986. *Performance of Mexican, Central American and West Indian Provenances of Swietenia Grown in Puerto Rico*. Master of Science thesis, State University of New York, Syracuse.

GREENPEACE BRASIL. 1992 (Nov.). *O Corte Predatorio do Mogno: Ameaca ao Futuro da Amazônia*. Versão Preliminar. Greenpeace Campanha de Florestas Tropicais, Brazil.

GRIJPMA, P. 1974. *Contributions to an Integrated Control Programme of Hypsipyla grandella (Zeller) in Costa Rica*. Doctoral thesis, Landbouwhogeschool te Wageningen, Wageningen, The Netherlands. 147 pp., illustr.

GRIJPMA, P. 1976. Resistance of Meliaceae against the shoot borer *Hypsipyla* with particular reference to *Toona ciliata* M.J. Roem. var. *australis* (F. v. Muell.) C. DC. Pp. 69-78 in *Tropical Trees: Variation, Breeding and Conservation* (eds. Burley, J. and Styles, B.T.). Linnean Society, London, UK. xv + 243 pp.

GROGAN, J., SIMÕES, L., GALVÃO, J. and VERÍSSIMO, A. 1996. Rates and fates of mahogany regeneration in closed and logged forests of southeastern Pará, Brazil: Explaining pattern and process through life history studies. Presentation to International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

GULLISON, R.E. 1995. *Conservation of Tropical Forests Through the Sustainable Production of Forest Products: The Case of Mahogany (Swietenia macrophylla King) in the Chimanes Forest, Beni, Bolivia*. Doctoral dissertation, November 1995, Princeton University, Princeton, N.J., USA.

GULLISON, R.E. and HARDNER, J.J. 1993. The effects of road design and harvest intensity on forest damage caused by selective logging: Empirical results and a simulation model from the Bosque Chimanes, Bolivia. *Forest Ecology and Management* 59: 1-14.

GULLISON, R.E. and HUBBELL, S.P. 1992. Natural regeneration of *Swietenia macrophylla* in the Bosque Chimanes, Bolivia. In Hartshorn, G., ed., *Mahogany Workshop: Review and Implications of CITES, February 3-4, 1992*. Tropical Forest Foundation, Washington, D.C.

GULLISON, R.E., PANFIL, S.N., STROUSE, J.J. and HUBBELL, S.P. 1996. Ecology and management of mahogany (*Swietenia macrophylla* King) in the Chimanes Forest, Beni, Bolivia. *Botanical Journal of the Linnean Society* 122(1): 9-34.

HARTSHORN, G., ed. 1992. *Mahogany Workshop: Review and Implications of CITES, February 3-4, 1992*. Tropical Forest Foundation, Washington, D.C. (Unpaged.)

HERNANDEZ-X., E. 1964. Plantas comunes en la vegetación de la región cálida húmeda tropical del Golfo de México. *Swietenia macrophylla*, pp. 175, 184. In INIF, *Contribuciones al Estudio Ecológico de las Zonas Cálido-Húmedas de México* (eds. Hernández-X., E. and Sarukhán-K., J.). SAG Inst. Nac. Invest. Forest. [INIF], Publ. Espec. 3: 173-207. Mexico, D.F.

HOLDRIDGE, L.R. 1947. Determination of world plant formations from simple climatic data. *Science* 105: 367-368.

HOLDRIDGE, L.R. and POVEDA, L.J. 1975. *Arboles de Costa Rica*, Vol. 1. *Swietenia macrophylla* and *Swietenia mahagoni*, pp. 285, 286. Centro Ci. Trop. [CCT], San José.

HOWARD, R.A. 1988. *Flora of the Lesser Antilles*, Vol. 4. *Swietenia*, pp. 591-593. Arnold Arboretum of Harvard University, Jamaica Plain, Mass., USA.

HUXLEY, A. 1984. *Green Inheritance*. Collins/Harvill, London.

IEWPN. 1990. Business Trends (Abroad): Brazil. *Import/Export Wood Purchasing News* [IEWPN], Aug./Sept. 1990, Memphis, Tenn., USA.

ITTO. 1988. *Conservation, Management, Utilization, Integral and Sustained Use of the Forest of the Chimanes Region Department of El Beni, Bolivia*. Project PD 34/88 Rev. 1 (F,I), International Tropical Timber Organization [ITTO], Yokohama, Japan. 30 pp., illustr.

ITTO. 1991a. *The Conservation Status of Tropical Timbers in Trade*. Pre-Project Report, PPR-23/91 (M), International Tropical Timber Organization, Yokohama, Japan. 6 pp.

ITTO. 1991b. *Report of Working Group on ITTO Guidelines for the Establishment and Sustainable Management of Planted Tropical Forests*. ITTC (X) 9, Quito, Ecuador. iii + 50 pp.

ITTO. 1992. *Criteria for the Measurement of Sustainable Tropical Forest Management*. Policy Development Series No. 3, International Tropical Timber Organization, Yokohama, Japan. 5 pp.

IUCN. 1982. *IUCN Directory of Neotropical Protected Areas*. IUCN Commiss. Natl. Parks and Protected Areas [CNPPA], Tycooly Int. Publish., Dublin. 436 pp.

IUCN. 1992. *CITES and the Tropical Timber Trade*. International Union for the Conservation of Nature, Position Paper, presented to the Eighth Meeting of the Conference of the Parties to CITES, Kyoto, Japan. 2 pp.

JIMERSON, L.J. 1993. *Mahogany in the USA: A study for FUNATURA*. FUNATURA (Fundação Pró-Natureza), Brazil/International Tropical Timber Organization (ITTO).

JOHNSON, M.S. and CHAFFEY, D.F. 1973. *An Inventory of the Chiquibul Forest Reserve, Belize*. Land Resource Study No. 14, Foreign and Commonwealth Office, Overseas Development Administration, Land Resources Division, Surrey, UK. 87 pp.

JOHNSON, N. and CABARLE, B. 1993. *Surviving the Cut: Natural Forest Management in the Humid Tropics*. World Resources Institute, Washington, D.C.

KILLEEN, T.J. 1996. Madidi-Apolo region, Bolivia. Pp. 486-489 in WWF/IUCN, *Centres of Plant Diversity: A Guide and Strategy for Their Conservation*, Volume 3. *The Americas*. IUCN Publications Unit, Cambridge, UK. In press.

KNEES, S.G. and GARDNER. M.F. 1982. *An Assessment of World Trade in Mahoganies*. Fauna and Flora Preservation Society, London, UK. 28 pp. [unpublished]

KNEES, S.G. and GARDNER, M.F. 1983a. Mahoganies: Candidates for the Red Data Book. *Oryx* 17(2): 88-92, illustr.

KNEES, S.G. and GARDNER, M.F. 1983b. Mahogany — An endangered resource. *Threatened Plants Newsl*. 12: 12-13.

KOEHLER, A. 1922. *The Identification of True Mahogany, Certain So-called Mahoganies, and Some Common Substitutes*. USDA Agric. Bull. 1050. 18 pp.

LAMB, F.B. 1966. *Mahogany of Tropical America: Its Ecology and Management*. University of Michigan Press, Ann Arbor, Mich., USA. x + 219 pp., illustr.

LANLY, J.P. 1982. *Tropical Forest Resources*. FAO Forestry Paper 30, Food and Agriculture Organization of the United Nations, Rome.

LEWINGTON, A. 1990. *Plants for People*. [British] Natural History Museum Publ., London.

LIEGEL, L.H. and VENATOR, C.R. 1987. *A Technical Guide for Forest Nursery Management in the Caribbean and Latin America*. U.S. Department of Agriculture, Forest Service, General Technical Report SO-67. vii + 156 pp., illustr.

LITTLE JR., E.L. and WADSWORTH, F.H. 1964. *Common Trees of Puerto Rico and the Virgin Islands*. *Swietenia macrophylla* and *Swietenia mahagoni*, pp. 248-252. USDA Forest Serv., Agric. Handb. 249. Washington, D.C.

LOPEZ SORIA, J. 1993. *Recursos Forestrales de Bolivia y su Aprovechamiento*. La Paz, Bolivia.

LOVELESS, M.D. and GULLISON, R.E. 1996. Genetic variation, population differentiation, and mating systems in natural populations of mahogany *Swietenia macrophylla* in the Beni, Bolivia. Presentation to International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

LUGO, A.E. 1992. Comparison of tropical tree plantations with secondary forests of similar age. *Ecological Monographs* 62(1): 1-41.

LUTZENBERGER, J.A. 1992. *Open letter to British Consumers, April 30, 1992*. Pôrto Alegre, RGS, Brazil. 1 p.

MABBERLEY, D.J. 1983. *Tropical Rain Forest Ecology*. Blackie & Son, Glasgow and London; Chapman & Hall, New York.

MACLELLAN, A., ed. 1996. *Is There a Future for Mahogany? Papers Presented at a Meeting on "The Future for the Genus Swietenia in its Native Forests"*, Linnean Society of London, 8 September 1994. *Botanical Journal of the Linnean Society*, Vol. 122, No. 1. 87 pp.

MARTINI, A.M.Z., ROSA, N. DE A. and UHL, C. 1994. An attempt to predict which Amazonian tree species may be threatened by logging activities. *Environmental Conservation* 21: 152-162.

MARTORELL, L.F. 1943. Forests and forest entomology. *Caribbean Forester* 4: 132-134.

MATOS, J.C.S., SOUSA, S.G.A. DE, WANDELLI, E., PERIN, R., ARCOVERDE, M. and FERNANDES, E.C.M. 1996. Performance of mahogany (*Swietenia macrophylla* King) in agroforestry systems in the western Amazon region of Brazil. Presentation to International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

MATRICARDI, E.A.T. and ABDALA, W.S. 1993 (Draft). *Mogno em Rondônia*. USFWS grant #14-48-0009-92-1341. [unpublished]

MAYHEW, J., ANDREW, M., SANDOM, J., THAYAPARAN, S. and NEWTON, A. 1996. Silvicultural systems for pure and mixed mahogany plantations. Presentation to International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

MEDINA, R., CUEVAS A., L. and DE LOS SANTOS M., V. 1968. *Ajuste al Proyecto de Ordenación Forestal, UIEF, MIQRO*. Chetumal, QR, Mexico. 200 pp.

MILLER, N.G. 1990. The genera of Meliaceae in the southeastern United States. *Swietenia*, pp. 476-486. *J. Arnold Arbor*. 71: 453-486.

MONBIOT, G. 1991. Against the grain. *The Guardian*, 3 May 1991, London, UK. 2 pp., illustr.

MYERS, N. 1989. *Deforestation Rates in Tropical Forests and Their Climatic Implications*. Friends of the Earth, London, UK. 116 pp., illustr.

NASH, N.C. 1993. Bolivia's rain forest falls to relentless exploiters.
New York Times, 21 June 1993.

NATIONS, J.D. 1987. Mesoamerica's tropical rainforests: Conflicts and conservation. *Tulane Studies in Zoology and Botany* 26(1): 59-75.

NAVARRO, C. 1996. Phenotypical variation and preliminary results of the collection of Central America *Swietenia macrophylla*. Presentation to International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

NEGREROS-CASTILLO, P. 1996. Enrichment planting and the sustainable harvest of mahogany (*Swietenia macrophylla* King) in Quintana Roo, Mexico. Presentation to International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

NETHERLANDS CITES PROPOSAL. 1994. *[Proposal for COP9 to list Swietenia macrophylla in Appendix II of the Convention on International Trade in
Endangered Species of Wild Fauna and Flora (CITES).]* Directie Natuurbeheer,
The Hague. 42 pp. + appendices.

NEWMAN, A. 1990. *Tropical Rainforest*. Facts On File, New York.
NEWTON, A.C. 1990. Selección por resistencia al perforador de las Meliáceas. Pp. 4-7 in *Noticiero (5), Mejoramiento Genético y Semillas Forestales para América Central*. CATIE, Turrialba, Costa Rica. 22 pp., illustr.

NEWTON, A.C. 1992. *Prospects for growing mahogany in plantations*. Presentation to The Second Pan American Furniture Manufacturers' Symposium on Tropical Hardwoods, November 3-5, 1992. Center for Environmental Study, Grand Rapids, Michigan, USA.

NEWTON, A.C., BAKER, P., RAMNARINE, F.W., MESEN, J.F. and LEAKEY, R.B.B. 1993. The mahogany shoot borer: prospects for control. *Forest Ecology and Management* 57: 301-328.

NEWTON, A.C., CORNELIUS, J.P., BAKER, P., GILLIES, A.C.M., HERNANDEZ, M., RAMNARINE, S., MESEN, J.F. and WATT, A.D. 1996. Mahogany as a genetic resource. *Botanical Journal of the Linnean Society* 122(1): 61-73.

NEWTON, A.C., LEAKEY, R.R.B. and MESEN, J.F. 1992. Genetic variation in mahoganies: Its importance, utilization and conservation. In Hartshorn, G., ed., *Mahogany Workshop: Review and Implications of CITES, February 3-4, 1992*. Tropical Forest Foundation, Washington, D.C.

NRC. 1991. *Managing Global Genetic Resources: Forest Trees*. National Research Council [NRC], Board on Agriculture. National Academy Press, Washington, D.C.
x + 228 pp., illustr.

NYZS. 1990. Mexico: Vast rainforest falling to ax, chainsaw, and match. *Wildl. Conserv*. 93(6): 16.

OEA/OAS. 1967. *La Convención para la Protección de la Flora, de la Fauna,
y de las Bellezas Escénicas Naturales de los [Países de América]: Listas
de Especies de Fauna y Flora en Vías de Extinción en los Estados Miembros*.
[Conf. Especializada Interamer. Tratar Probl. Relacionados Conserv. Recursos Nat. Renovables del Continente, Mar del Plata, Argentina, 18-22 oct. 1965]. Organización de los Estados Americanos [OEA] / Organization of American States [OAS], Washington, D.C. 48 pp.

OLDFIELD, M.L. 1984. *The Value of Conserving Genetic Resources*. U.S. Dept. Interior, National Park Service, Washington, D.C. 360 pp.

OLDFIELD, S. 1988. *Rare Tropical Timbers*. IUCN, Gland, Switzerland. 37 pp.

OREJAS-MIRANDA, B. 1976. The OAS and renewable natural resources. *Parks* 1(3): 8-10.

PALMBERG, C. [1987]. *Conservation of genetic resources of woody species*. Simposio Sobre Silvicultura y Mejoramiento Genético, Centro Invest. y Estud. Forest. [CIEF], Buenos Aires, 6-10 abril 1987. [FAO, Rome. 16 pp., annexes; unpublished].

PAZ JUAREZ, H.R. 1990. *Prensa Libre*, 16 August 1990, Petén, Guatemala.

PENNINGTON, T.D. and SARUKHAN, J.K. 1968. *Arboles Tropicales de México*. *Swietenia macrophylla*, pp. 244-245. FAO and SAG INIF, Mexico, D.F.

PERUM PERHUTANI. 1991. *Mahagony (Swietenia spp.) Plantation in Java*. Perum Perhutani (State-owned Forest Enterprise), Jakarta, Indonesia. 4 pp., illustr.

PLOWDEN, C. and KUSUDA, Y. 1989. *Logging in the Brazilian Rainforest*. Rainforest Alliance Workshop, April 13-14, 1989, New York, USA. 25 pp., illustr.

PRANCE, G.T. and DA SILVA, M.F. 1975. *Árvores de Manaus*. *Swietenia macrophylla*, pp. 189-191. CNPq, INPA, Manaus, Brazil.

QUEIROZ, W.T. 1984. *Analise de Fatores ("Factor Analysis") pelo Metodo de Maxima Verossimilhanca: Aplicação ao Estudo da Estrutura de Florestas Tropicais*. Tese de Boutorado, ESALQ, Piracicaba, SP, Brazil. 112 pp.

QUEVEDO, L. 1986. *Evaluación del Efecto de la Tala Selectiva sobre la Renovación de un Bosque Húmedo Subtropical en Santa Cruz, Bolivia*. Masters thesis, Universidad de Costa Rica and Centro Agronómico Tropical de Investigación y Enseñanza [CATIE], Turrialba, Costa Rica. xix + 221 pp., illustr.

READ, M. 1990. *Mahogany — Forests or Furniture?* Fauna and Flora Preservation Society, Brighton, England, UK. 16 pp., illustr.

RECORD, S.J. 1924. *Timbers of Tropical America*. *Swietenia*, pp. 348-356. Yale University Press, New Haven.

RECORD, S.J. and HESS, R.W. 1943. *Timbers of the New World*. Yale University Press, New Haven.

REMSEN JR., J.V. and TRAYLOR JR., M.A. 1989. *An Annotated List of the Birds of Bolivia*. Buteo Books, Vermillion, South Dakota, USA.

RODAN, B.D. and CAMPBELL, F.T. 1996. CITES and the sustainable management of *Swietenia macrophylla*. *Botanical Journal of the Linnean Society* 122(1): 83-87.

RODAN, B.D., NEWTON, A.C. and VERÍSSIMO, A. 1992. Mahogany conservation: Status and policy initiatives. *Environmental Conservation* 19: 331-338, 342.

RODRIGUEZ, S., CHAVELAS-P., B.J. and ESCOTO-P., J.C. 1992. Dispersión de semillas y establecimiento de caoba (*Swietenia macrophylla* King) despues de un tratamiento mecánico del sitio. Presented at the Workshop: "Madera, Chicle, Caza y Milpa: Fundamentos para el Manejo Integral de las Selvas de Quintana Roo", Chetumal, Quintana Roo, 9 de julio 1992.

RZEDOWSKI, J. 1978. *Vegetación de México*. Edit. Limusa, Mexico, D.F.

SALAZAR, M. 1992. A brief analysis of the current status of *Swietenia* spp.
in Guatemala. In Hartshorn, G., ed., *Mahogany Workshop: Review and Implications of CITES, February 3-4, 1992*. Tropical Forest Foundation, Washington, D.C.

SAMBA MURTY, A.V.S.S. and SUBRAHMANYAM, N.S. 1989. *A Textbook of Economic Botany*. Mahogany, pp. 321-323. Wiley Eastern Ltd., New Delhi, India.

SANDERSON, I.T. and LOTH, D. 1965. *Ivan Sanderson's Book of Great Jungles*.
J. Messner/Pocket Books, New York. (*S. macrophylla*, p. 129).

SCHUBERT, T.H. 1979. *Trees for Urban Use in Puerto Rico and the Virgin Islands*. *Swietenia macrophylla*, *S. mahagoni* [and their hybrid], pp. 73-74. USDA Forest Serv., Gen. Tech. Rep. SO-27.

SHANK, P.J. 1949. Forest resources of Honduras. In *Proceedings of the Inter-American Conference on Conservation of Renewable Natural Resources, Denver, Colorado, Sept. 7-20, 1948*. USDS Publ. 3382: 559-563. Washington, D.C.

SKOLE, D. and TUCKER, C. 1993. Tropical deforestation and habitat fragmentation in the Amazon: Satellite data from 1978 to 1988. *Science* 260: 1905-1910.

SMITH JR., C.E. 1965. Meliaceae. *Swietenia*, pp. 60-62. In *Flora of Panama*. *Ann. Missouri Bot. Gard*. 52: 55-79.

SNOOK, L.K. 1992. Logging and mahogany in the forests of Quintana Roo, Mexico: Why silvicultural management is necessary to sustain *Swietenia macrophylla*. In Hartshorn, G., ed., *Mahogany Workshop: Review and Implications of CITES, February 3-4, 1992*. Tropical Forest Foundation, Washington, D.C.

SNOOK, L.K. 1993. *Stand Dynamics of Mahogany (<u>Swietenia macrophylla</u> King)
and Associated Species After Fire and Hurricane in the Tropical Forests of
the Yucatan Peninsula, Mexico*. Doctoral dissertation, May 1993, Yale University, New Haven, Conn., USA.

SNOOK, L.K. 1996. Catastophic disturbance, logging and the ecology of mahogany (*Swietenia macrophylla* King): Grounds for listing a major tropical timber species on CITES. *Botanical Journal of the Linnean Society* 122(1): 35-46.

SOCIEDADE BRASILEIRA DE BOTÂNICA. 1992. *Centuria Plantarum Brasiliensium Exstintionis Minitata*. Rio de Janeiro, Brazil. xii + 167 pp., illustr.

SOLOMON, J.C. 1989. Bolivia. Pp. 455-463 in Campbell, D.G. and Hammond, H.D., eds., *Floristic Inventory of Tropical Countries: The Status of Plant Systematics, Collections, and Vegetation, plus Recommendations for the Future*. New York Botanical Garden, Bronx.

STANDLEY, P.C. and STEYERMARK, J.A. 1946. *Flora of Guatemala*: Meliaceae. *Swietenia humilis* and *Swietenia macrophylla*, pp. 456-459. *Fieldiana, Bot*. 24(5): 444-468.

STEVENSON, N.S. 1927. Silvicultural treatment of mahogany forests in British Honduras. *Empire Forestry Journal* 6: 219-227.

STEWART, R., CLAURE, H. and GIBSON, D. 1993. *Final Draft. The Effects of Trade and Concession Policies in Bolivia's Forest Sector: A Methodological Framework for Analysis*. Funding by USAID, Bureau for Latin America and the Caribbean (LAC/DR/RD).

STRONG, L.A. 1940. *Report of the Chief of the Bureau of Entomology and Plant Quarantine*. U.S. Department of Agriculture, Washington, D.C. 128 pp.

STYLES, B.T. 1981. Swietenioideae. Pp. 359-418, illustr., in Pennington, T.D., Styles, B.T. and Taylor, D.A.H., Meliaceae. Flora Neotropica Monograph No. 28, New York Botanical Garden, New York. 470 pp., illustr.

STYLES, B.T. and KHOSLA, P.K. 1976. Cytology of and reproductive biology of Meliaceae. Pp. 61-67 in *Tropical Trees: Variation, Breeding and Conservation* (eds. Burley, J. and Styles, B.T.). Linnean Society, London, UK. xv + 243 pp.

SUAREZ MORALES, O. 1986. *Parques Nacionales y Afines de Bolivia*. La Paz, Bolivia. 135 pp.

SYNNOTT, T.J. and CASSELLS, D.S. 1991. *Evaluation Report on Project PD 34/88 Rev.1 (F): Conservation, Management, Utilization and Integrated and Sustained Use of the Chimanes Region, Department of Beni, Bolivia*. International Tropical Timber Organization PCF(IX)1 1991.

SZWAGRZAK, A. and LOPEZ-S., J. 1993. *Explotación de las Maderas, Caso: Prov. Iturralde — Bolivia*. PRODENA, La Paz, Bolivia.

TERBORGH, J. 1990. An overview of research at Cocha Cashu Biological Station [Manu National Park, Peru]. Pp. 48-59 in Gentry, A.H. [and Guzmán-Teare, M.], eds., *Four Neotropical Rainforests*. Yale University Press, New Haven and London.

TFW (TROPICAL FORESTRY WORKSHOP). 1989. *Consensus Statement on Commercial Forestry, Sustained Yield Management and Tropical Forests*. Smithsonian Institution / International Hardwood Products Association, Washington, D.C., October 1989. 10 pp.

TOLEDO, V.M. 1982. Pleistocene changes of vegetation in tropical Mexico. Pp. 93-111 in Prance, G.T., ed., *Biological Diversification in the Tropics*. Columbia University Press, New York.

TURNER, J. 1992. [Letter to Natural Resources Defense Council (NRDC's J.H. Adams)]. Director, U.S. Fish and Wildlife Service, U.S. Department of the Interior, April 9, 1992, Washington, D.C. 4 pp.

UHL, C., VERÍSSIMO, A., MATTOS, M.M., BRANDINO, Z. and VIEIRA, I.C.G. 1991. Social, economic, and ecological consequences of selective logging in an Amazon frontier: The case of Tailândia. *Forest Ecology and Management* 46: 243-273.

U.S. BUREAU OF THE CENSUS. 1987-1989. *U.S. Imports for Consumption and General Imports. TSUSA Commodity by Country of Origin*. FT246/Annual 1986-1988. U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C.

U.S. BUREAU OF THE CENSUS. 1990-1996. *U.S. Imports for Consumption. TSUSA Commodity by Country of Origin*. FT247/Annual 1989-1995. U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C.

U.S. CITES PROPOSAL. 1991. *[Proposal for COP8 to list two Swietenia spp. in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).]* U.S. Department of the Interior, U.S. Fish and Wildlife Service, Washington, D.C. 21 pp., illustr.

USDS (U.S. Dept. of State). 1942. Annex. Lists [1940-1942] of species referred to in Article VIII of the Convention [on Nature Protection and Wildlife Preservation in the Western Hemisphere] [CNWH]; and Explanatory notes and translations. [U.S.] Treaty Ser. 981: 27-66, 67-77.

USSACH, I. 1992. Mahogany, certification and CITES. In Hartshorn, G., ed., *Mahogany Workshop: Review and Implications of CITES, February 3-4, 1992*. Tropical Forest Foundation, Washington, D.C.

VEGA, L. 1976. Influencia de la silvicultura en el comportamiento de *Cedrela* in Surinam. Pp. 26-49 in Whitmore, J.L., ed., *Studies on the Shoot Borer Hypsipyla grandella* (Zeller) Lep. Pyralidae, Vol. III. IICA Misc. Publications No. 101, CATIE, Turrialba, Costa Rica. 116 pp., illustr.

VERÍSSIMO, A., BARRETO, P., TARIFA, R. and UHL, C. 1992. Mahogany extraction in the Eastern Amazon: A case study. In Hartshorn, G., ed., *Mahogany Workshop: Review and Implications of CITES, February 3-4, 1992*. Tropical Forest Foundation, Washington, D.C.

VERÍSSIMO, A., BARRETO, P., TARIFA, R. and UHL, C. 1995. Extraction of a high-value natural resource in Amazonia: The case of mahogany. *Forest Ecology and Management* 72: 39-60.

VISCARRA ALTAMIRANO, S. and LARA RICO, R. 1992. *Maderas de Bolivia (Características y Usos de 55 Maderas Tropicales)*. CUMAT/CNF, Santa Cruz, Bolivia.

WADSWORTH, F.H., GONZALEZ GONZALEZ, E., FIGUEROA COLON, J. and LUGO PEREZ, J. The performance of big-leaf mahogany on a favorable site in Puerto Rico. Presentation to International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

WALKER, A., ed. 1989. *The Encyclopedia of Wood*. Facts On File, Oxford and New York.

WATSON, F. 1996. A view from the forest floor — The impact of logging on indigenous peoples in Brazil. *Botanical Journal of the Linnean Society* 122(1): 75-82.

WEAVER, P.L. 1987. Enrichment plantings in tropical America. Pp. 259-278 in Figueroa-C., J.C., Wadsworth, F. and Branham, S., eds., *Management of the Forests of America: Prospects and Technologies*. USDA Forest Service, Institute of Tropical Forestry, Río Piedras, Puerto Rico.

WEAVER, P.L. and BAUER, G.P. 1986. Growth, survival and shoot borer damage in mahogany plantings in the Luquillo Forest in Puerto Rico. *Turrialba* 36: 509-522.

WEAVER, P.L. and SABIDO, O.A. 1996. Mahogany in Belize: An historical perspective. Presentation to International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

WHITE, S. 1978. Cedar and mahogany logging in eastern Peru. *Geogr. Rev*. 68: 394-416.

WHITMAN, A.A., BROKAW, N.V.L. and HAGAN III, J.M. 1996. Population biology of mahogany (*Swietenia macrophylla*) in northern Belize. Presentation to International Conference on Big-leaf Mahogany, San Juan, P.R., October 22-24, 1996. USDA Forest Service, International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

WHITMORE, J.L., ed. 1976a. *Studies on the Shoot Borer Hypsipyla grandella* (Zeller) Lep. Pyralidae, Vol. II. IICA Misc. Publications No. 101, CATIE, Turrialba, Costa Rica. 139 pp., illustr.

WHITMORE, J.L., ed. 1976b. *Studies on the Shoot Borer Hypsipyla grandella* (Zeller) Lep. Pyralidae, Vol. III. IICA Miscellaneous Publications No. 101, CATIE, Turrialba, Costa Rica. 116 pp., illustr.

WHITMORE, J.L. 1983. *Swietenia macrophylla* and *S. humilis* (caoba, mahogany). Pp. 331-333 in Janzen, D.H., ed., *Costa Rican Natural History*. University of Chicago Press, Chicago.

WHITMORE, J.L. 1992. An introduction to *Swietenia*, with emphasis on silvics and silviculture. In Hartshorn, G., ed., *Mahogany Workshop: Review and Implications of CITES, February 3-4, 1992*. Tropical Forest Foundation, Washington, D.C.

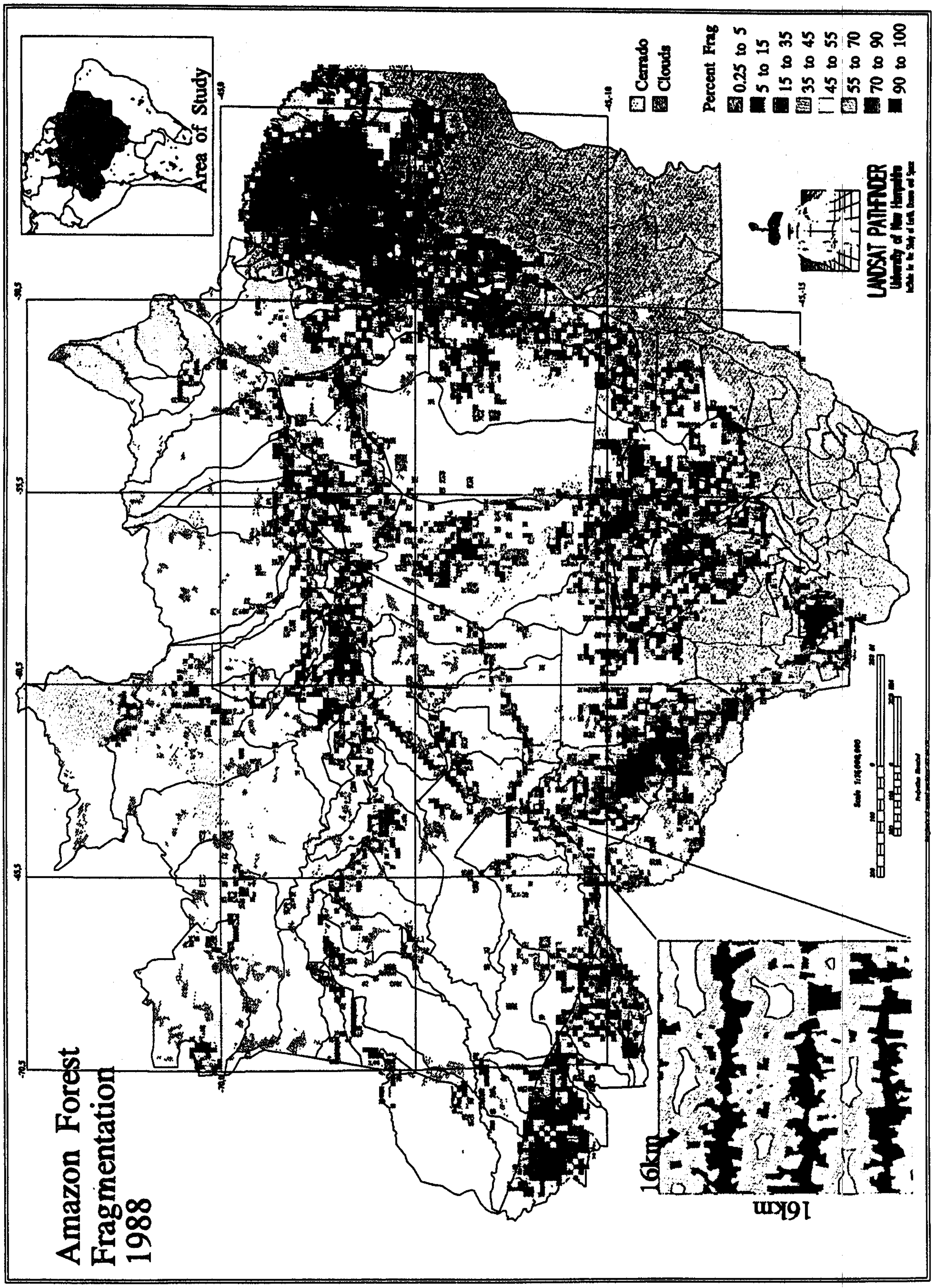
WHITMORE, J.L. and HINOJOSA, G. 1977. *Mahogany (Swietenia) Hybrids*. U.S. Dept. Agric. Forest Serv., Res. Paper ITF-23. 8 pp.

WHITMORE, T.C. 1981. Trees of tropical America. Pp. 267-269 in *The Oxford Encyclopedia of Trees of the World* (ed. Hora, F.B.). Oxford University Press, Oxford and New York. 228 pp., illustr.

WWF/IUCN. 1996. *Centres of Plant Diversity: A Guide and Strategy for Their Conservation*, Volume 3. *The Americas*. IUCN Publications Unit, Cambridge, UK. 560 pp. In press.

YARED, J.A.G. and CARPANEZZI, A.A. 1981. *Conversão de Capoeira Alta da Amazônia em Povoamento de Produção Madeireira: O Metoda "Recru" e Especies Promissoras*. EMBRAPA, CPATU, Boletim de Pesquisa 25. 27 pp.

FIGURE 1a


Amazon Forest Fragmentation 1988
Area of Study
Cerrado
Clouds
Percent Frag
0.25 to 5
5 to 15
15 to 35
35 to 45
45 to 55
55 to 70
70 to 90
90 to 100
LANDSAT PATHFINDER
University of New Hampshire
16km
16km

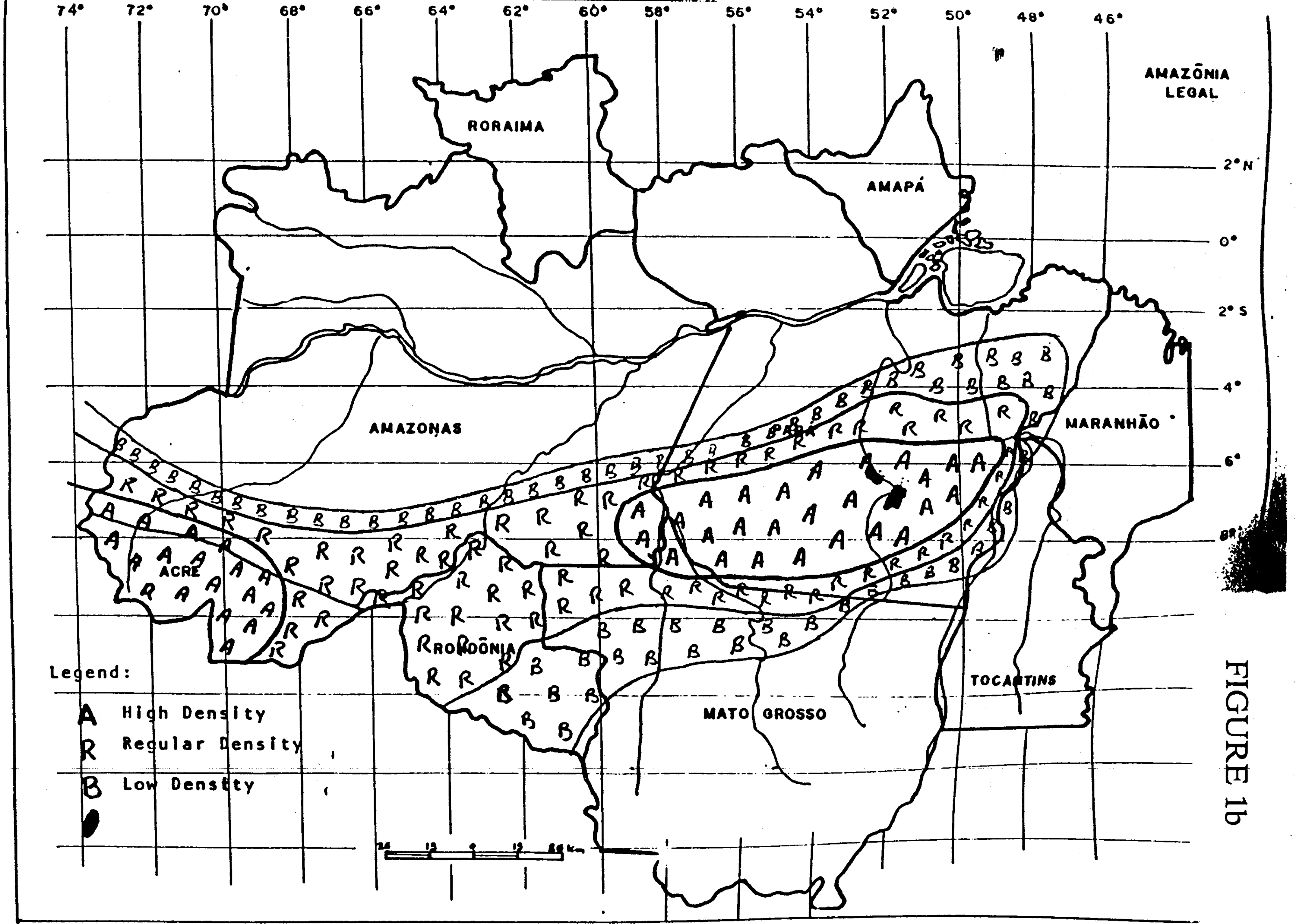


FIGURE 1b

Figure 7 Zoning, according to density, of the natural area of Mahogany - S.macrophylla, King occurrence in Brazilian Amazon

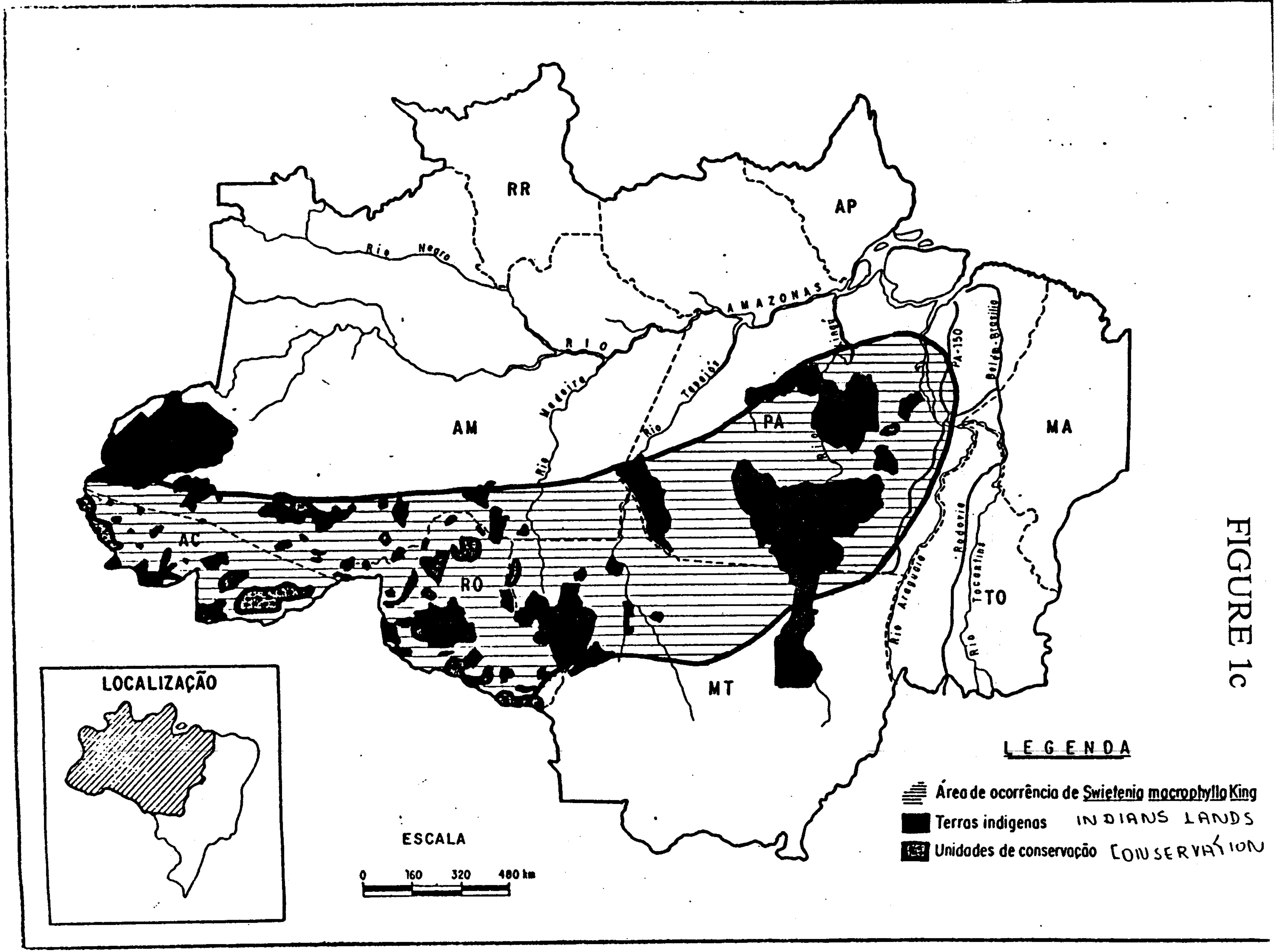

RR
AP
AM
PA
MA
AC
RO
TO
MT
Rio Negro
AMAZONAS
RIO
Rio Madeira
Rio Tapajós
PA-150
Belém-Brasília
Rodovia
Rio Araguaia
Rio Tocantins
LOCALIZAÇÃO
ESCALA
0 160 320 480 km
LEGENDA
Área de ocorrência de Swietenia macrophylla King
Terras indigenas INDIANS LANDS
Unidades de conservação CONSERVATION

FIGURE 1c

OVERLAY - Forest Fragmentation in Brazil's Mahogany Belt

Amazon forest fragmentation 1988 (Skole and Tucker, Science 1993) +
Estimated range of S. macrophylla (Barros et al. 1992, unpublished) +
Indigenous lands and conservation areas (Verissimo et al., Forest Ecol. Manag. in 1995)

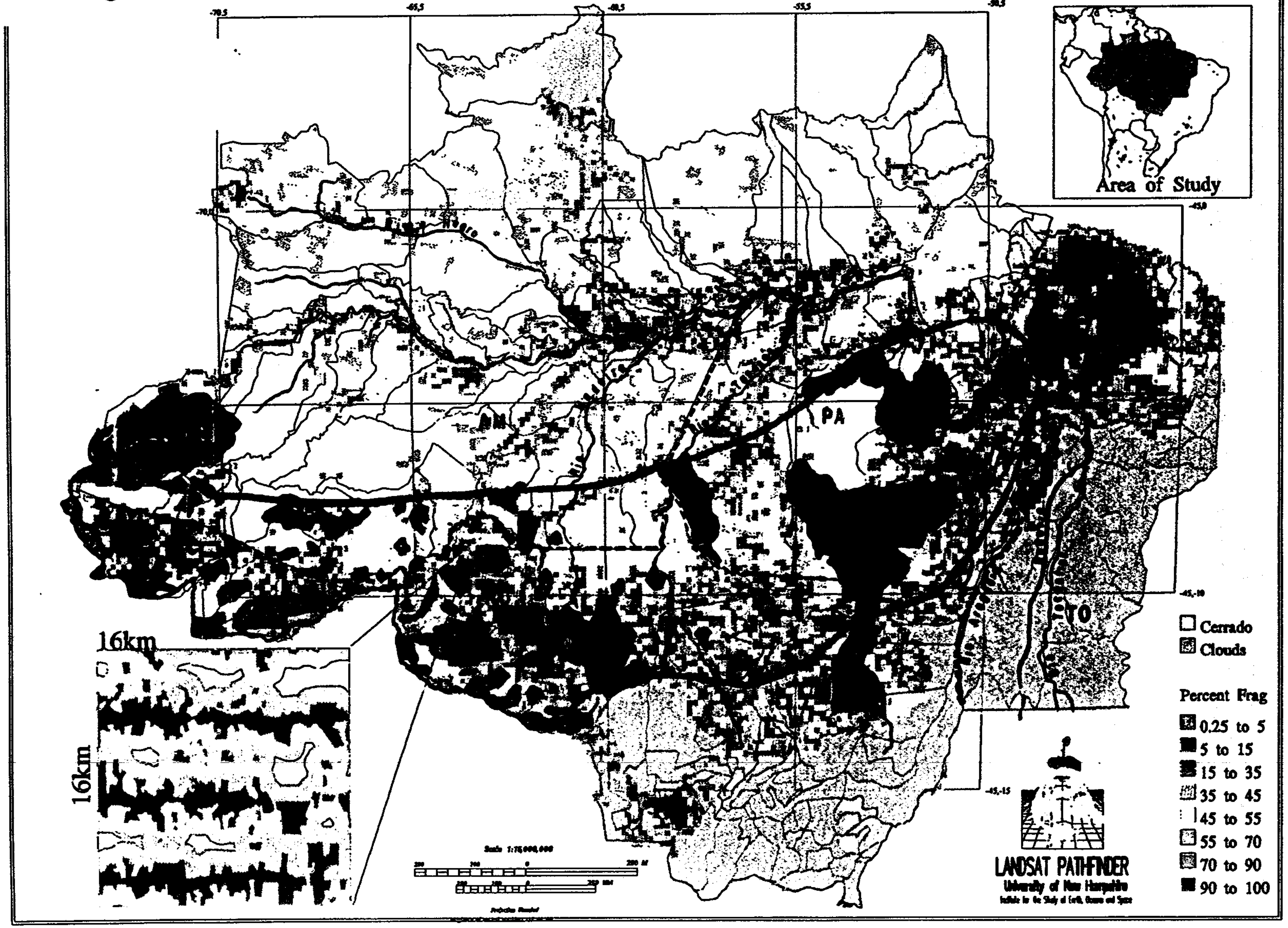


FIGURE 1d

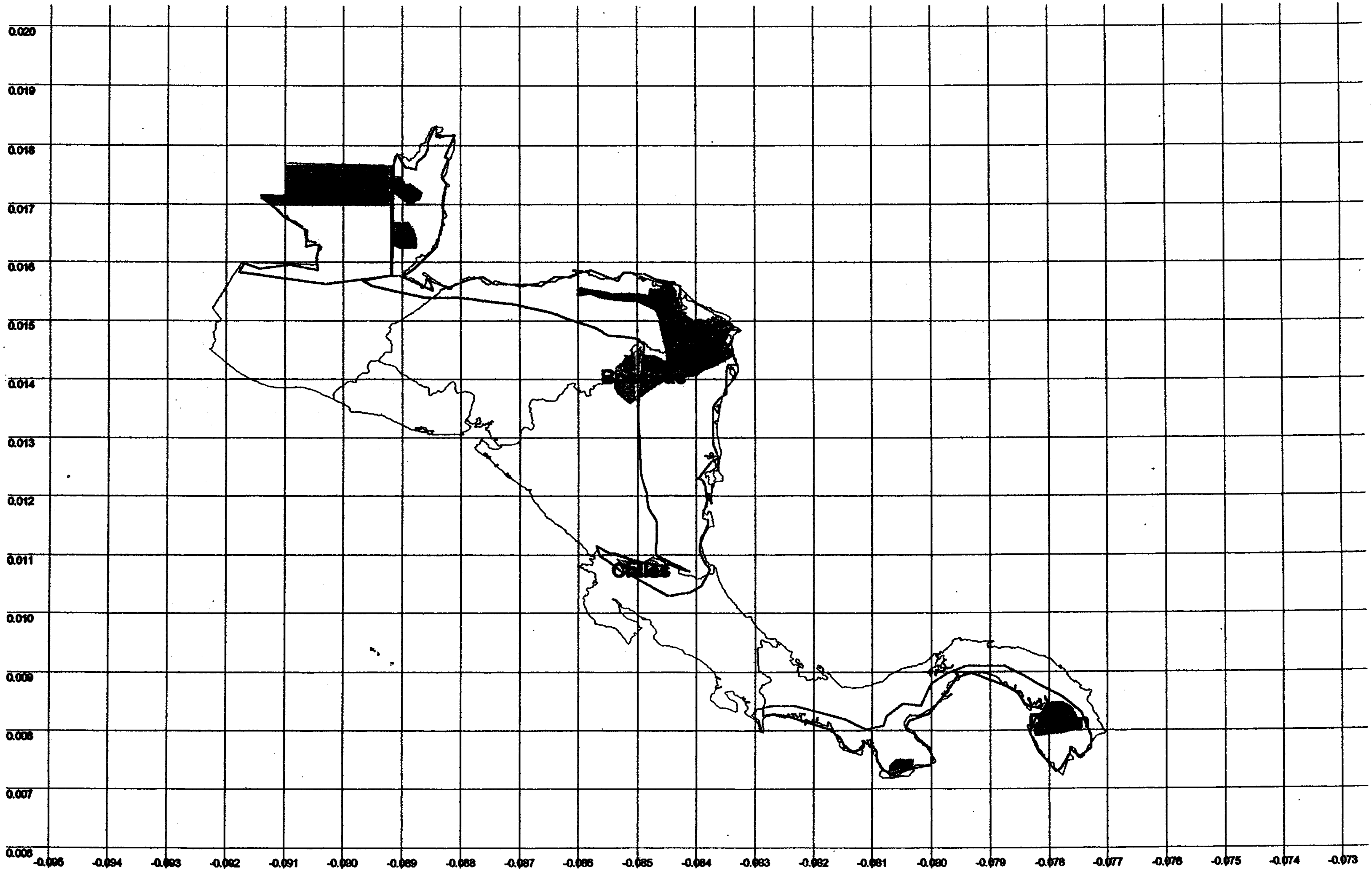


Fig.7. Lamb 1966. (yellow) and Navarro 1996 distribution (red) of S. macrophylla.

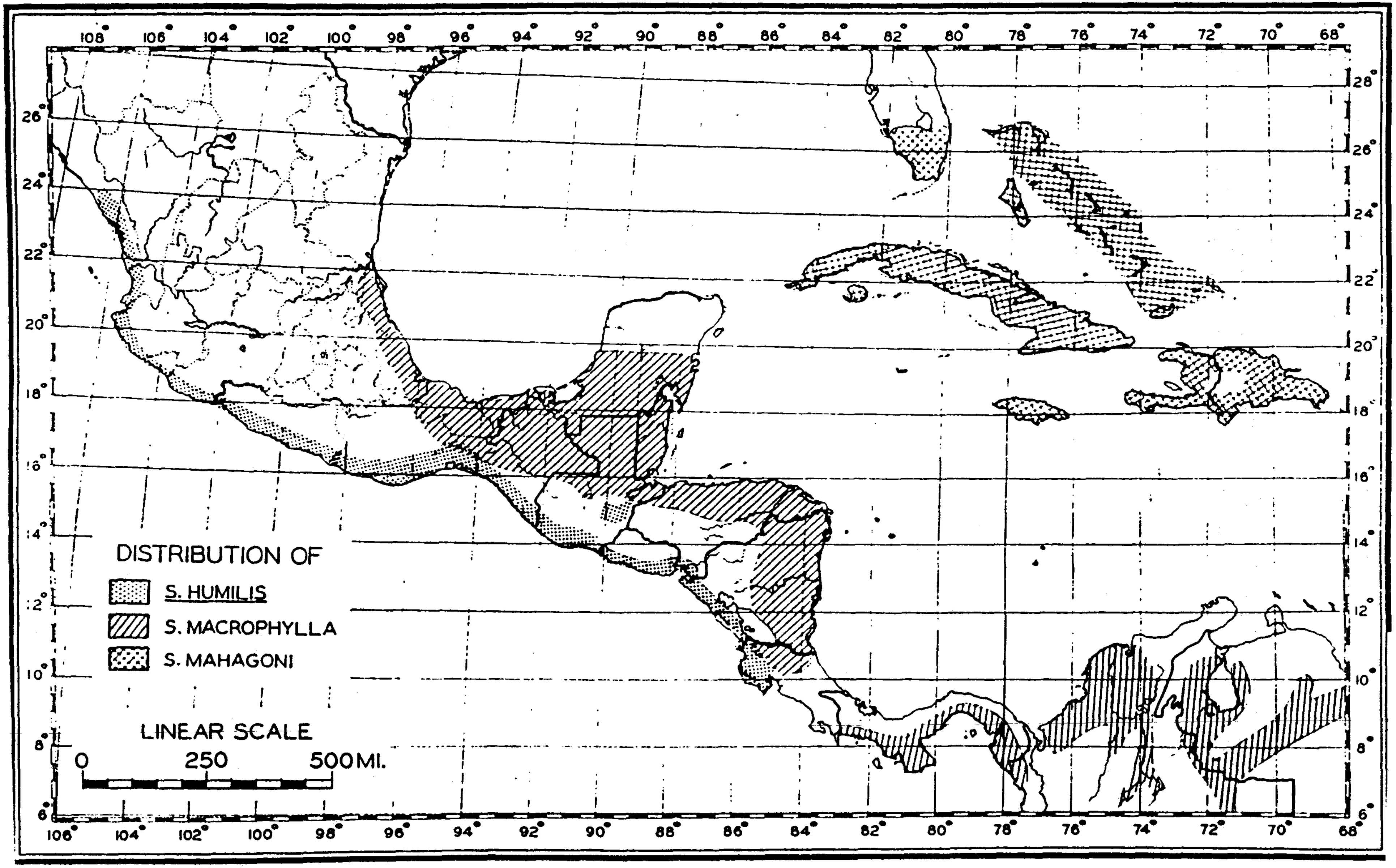


Figure 5. Distribution map of mahogany in Central America and Caribbean area.

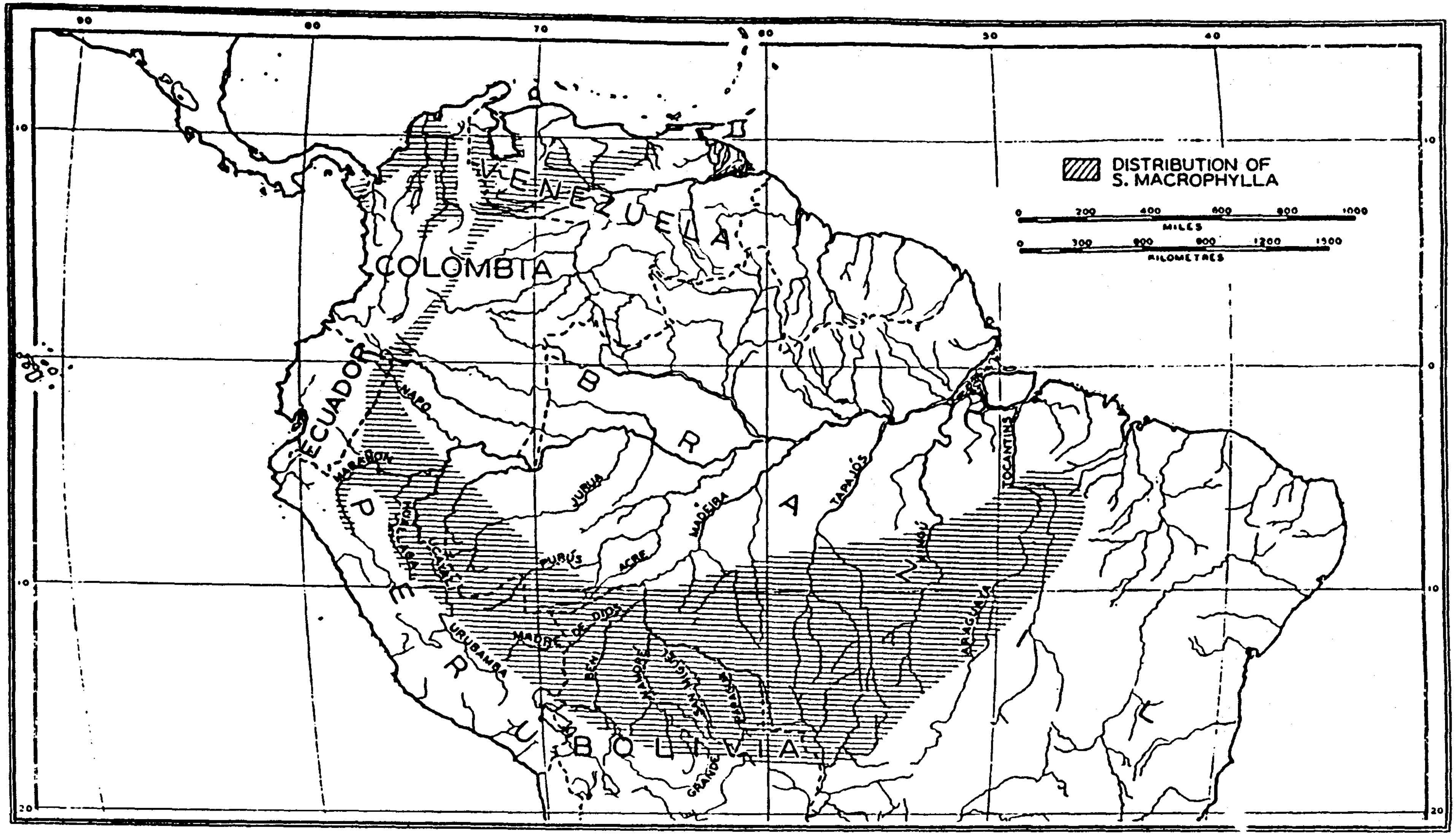


Figure 6. Distribution map of mahogany in South America.

mente 28%

A DUREZA LATERAL

371 kg
396 kg

puestas por el Pacto

/cm2
/cm2
/cm2
/cm2
/cm2
zas seleccionadas o

lores propuestos por

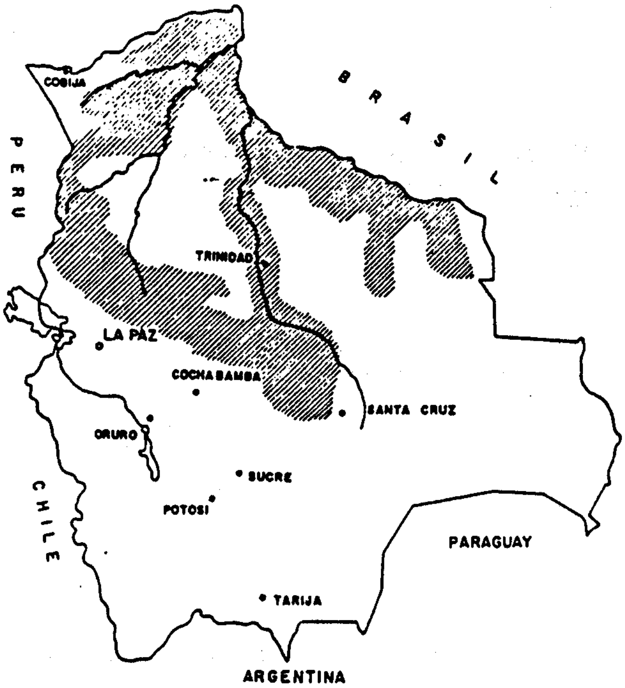
lavo
4"

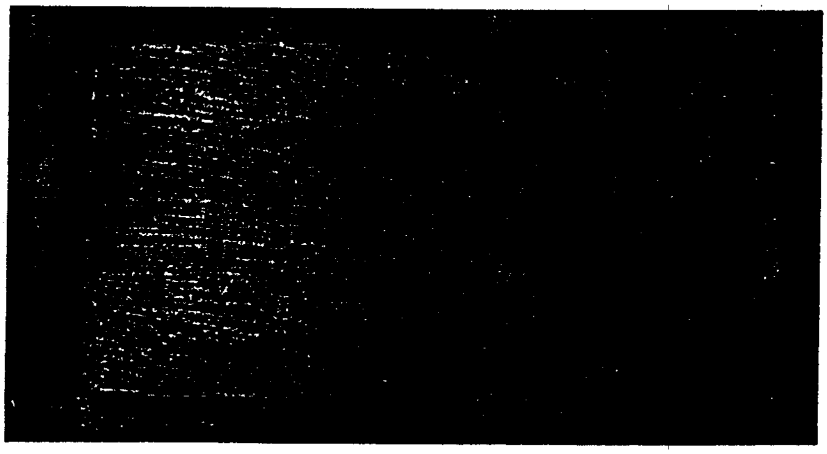
Se logra un buen

: Madera permeable
nte-frío al 5 % de
elevada absorción en
on resultados de 503
ervador.
panistería en general,
gueteria, canoas y
enis y ping pong; la
:" se emplean en la
seguridad y artículos
so que sea útil para

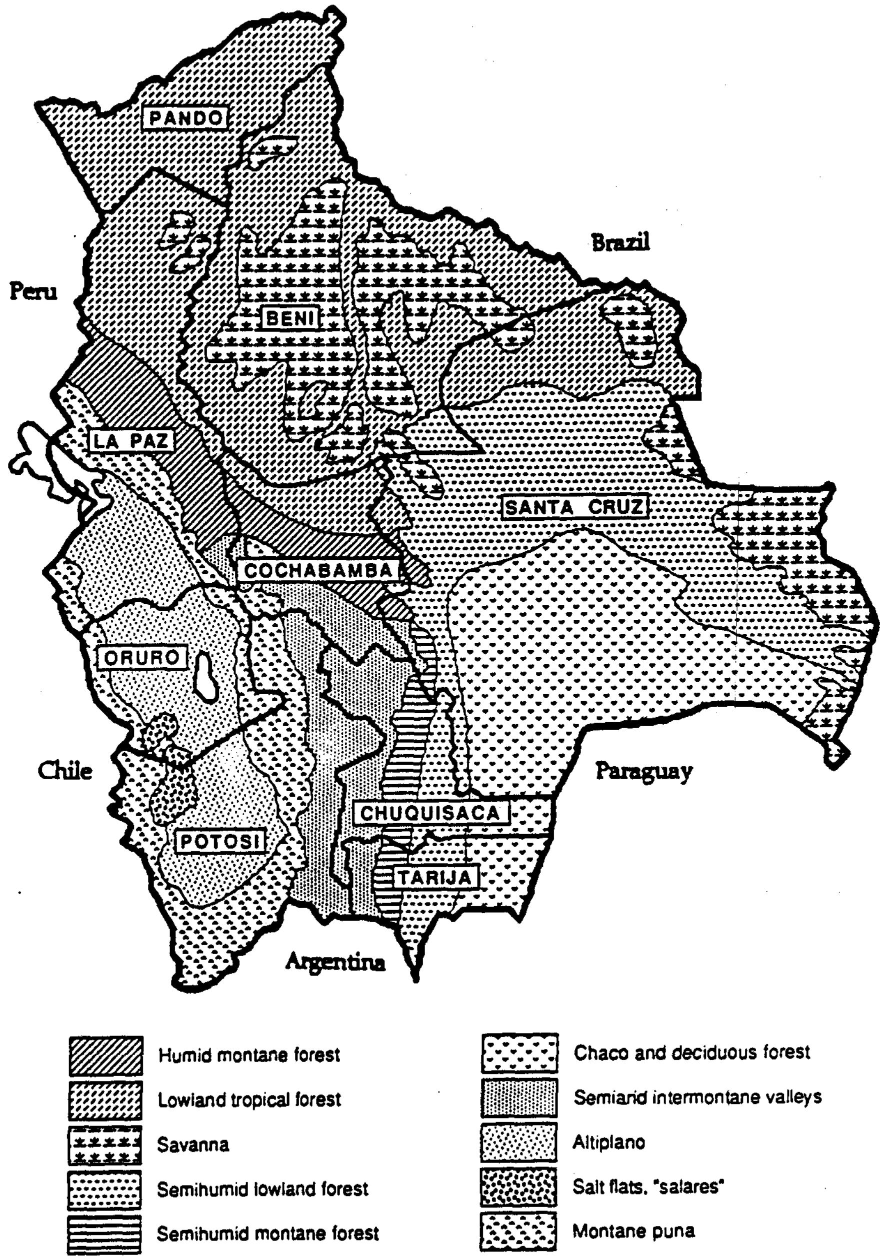
APPENDIX B

MARA
DISTRIBUCION APROXIMADA





APPENDIX C

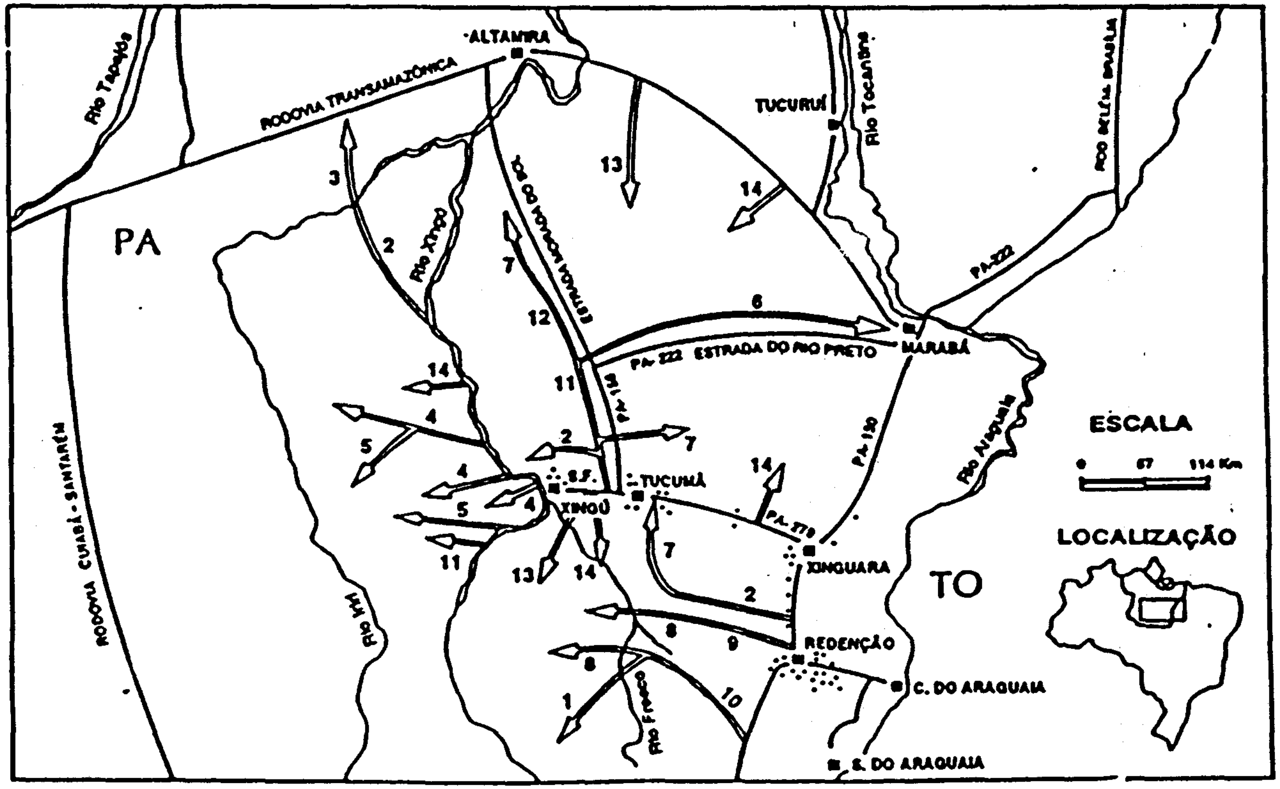


Departamentos and Habitats of Bolivia

BUTEO BOOKS, P.O. BOX 481, Vermillion, S.D., 57069
ISBN 0-931130-16-6

Figura 2 - Areas boscosas de Bolivia

ESTRADAS MADEIREIRAS DO ESTADO DO PARÁ



RODOVIAS •.• INDÚSTRIAS MADEIREIRAS ═══ ESTRADAS MADEIREIRAS

1 Campos Altos, 2 Bannach, 3 Seba, 4 Karapanã, 5 Pau D' Arco, 6 Jacafé, 7 Perachi, 8 Juari, 9 Minuano, 10 Madeplan, 11 Maginco, 12 Impar, 13 Angelim, 14 Não Identificadas

figura 4: Sobreposição dos mapas do DER-PA (1987) e Veríssimo et al. 1992.

APPENDIX E

APPENDIX F

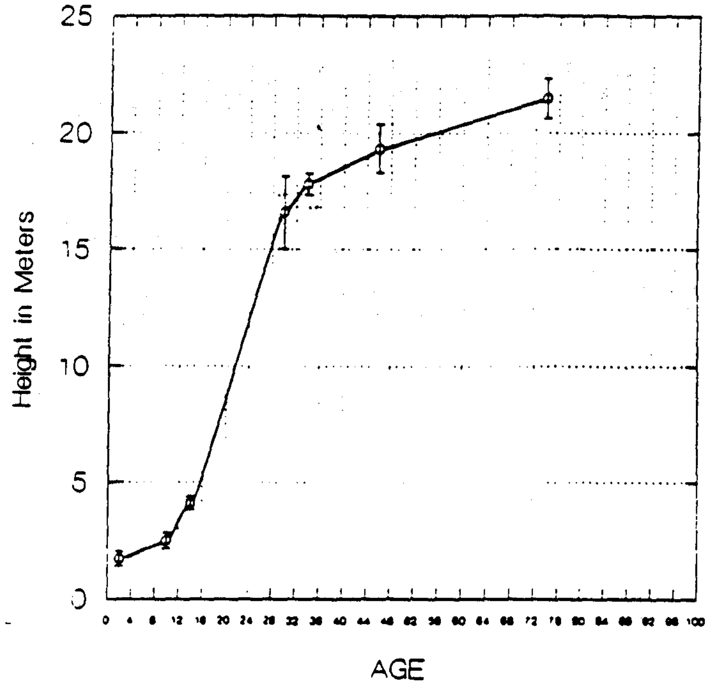


Figure 7-G. Heights of mahogany trees in mixed-species stands of known age. N = 161.

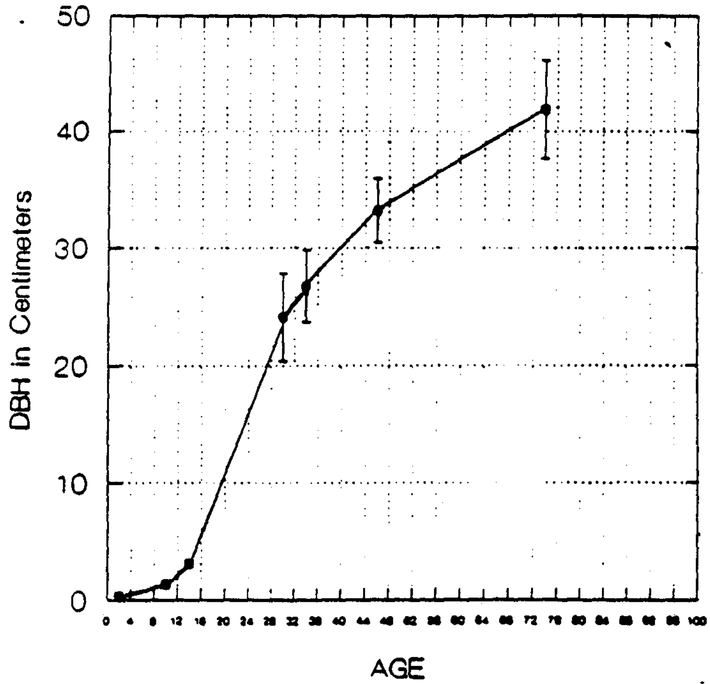


Figure 7-H. Diameters of mahogany trees in mixed-species stands of known age. N = 161

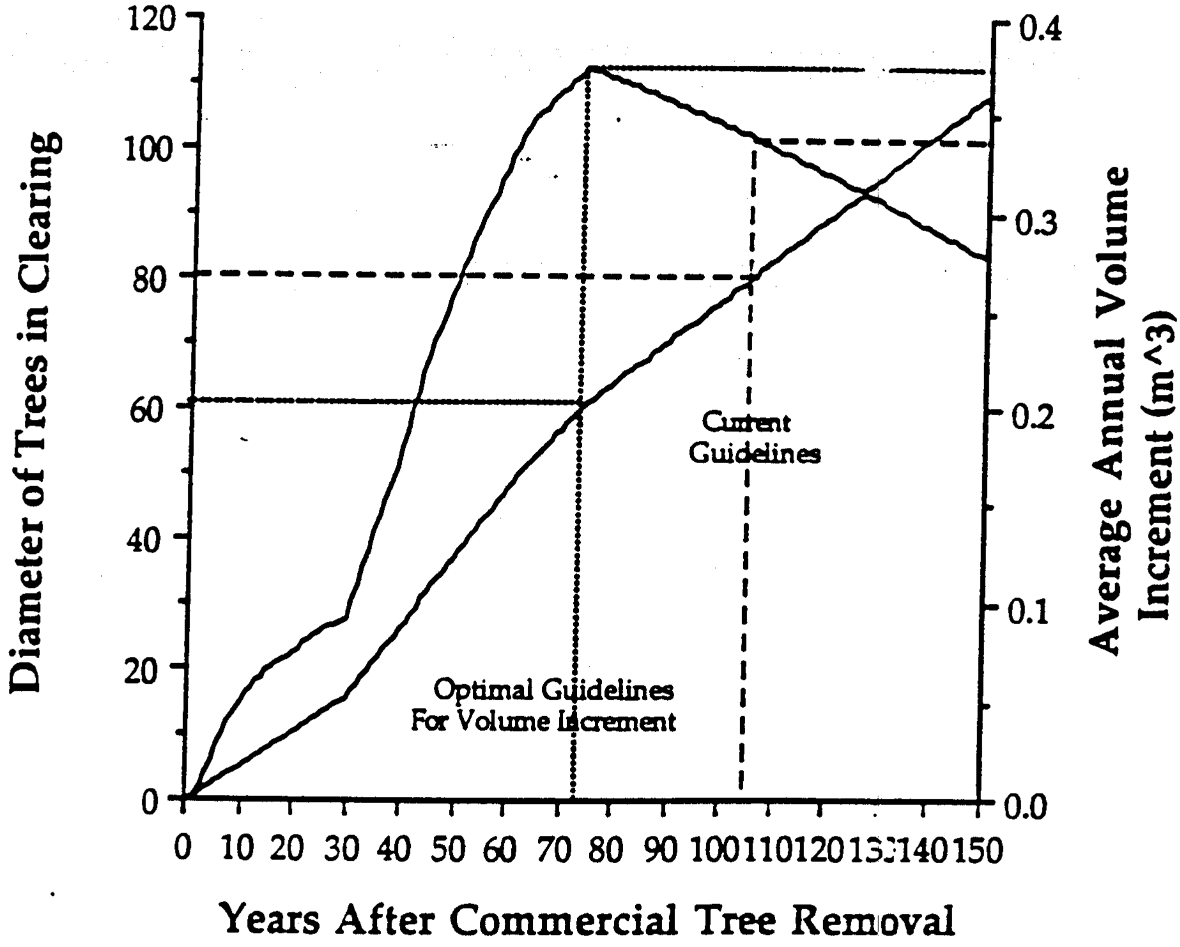
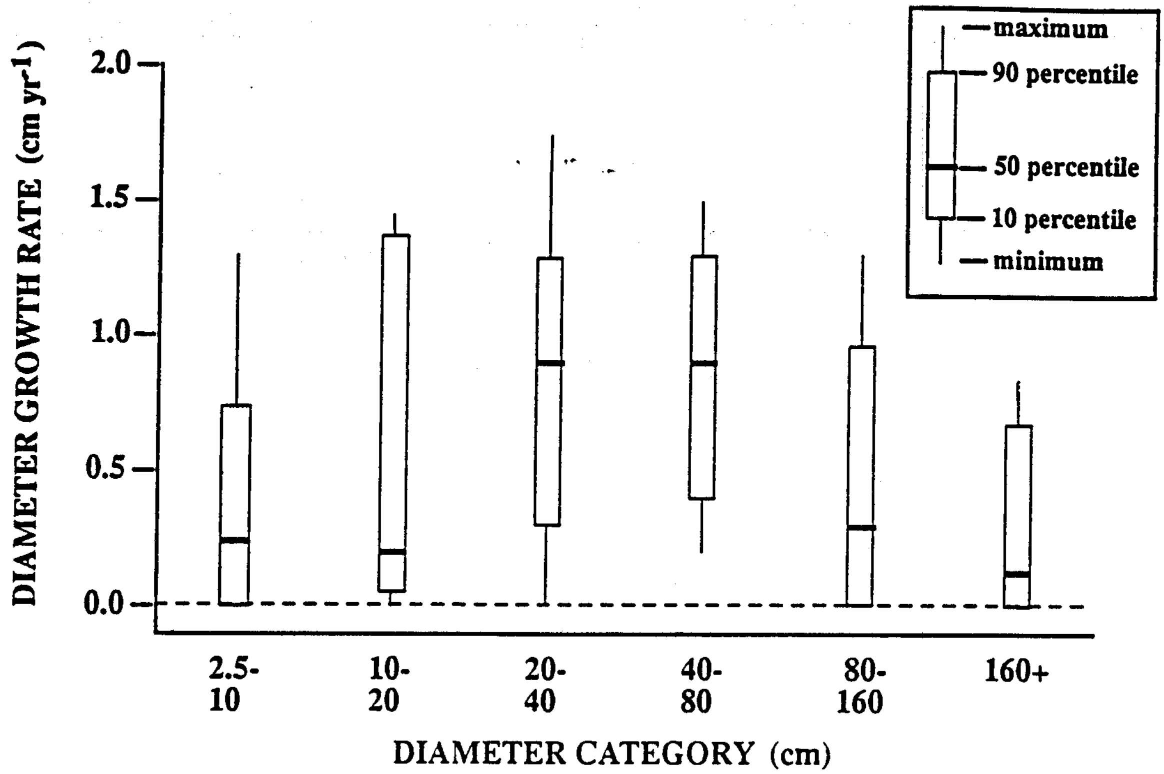


Figure 5: Predicted mean diameter of new trees surviving in a gap created by removing a single adult, and the average annual volume increment per tree of trees surviving in the gap. Growth rates are taken from growth ring data from the Bosque Chimanes, which agree closely with estimates provided by Lamb (1966). Average annual volume increment is calculated assuming a survivorship curve starting with annual values of 0.90 for seedlings (a value obtained from our plots) increasing to 0.99 (unpubl. data from Hubbell and Foster, BCI). The volume increment is calculated by assuming a commercial bole of 10 meters. Our simulation shows that 105 years are required to reach the current cutting diameter limit of 0.80 m dbh. Average annual volume increment is maximized by harvesting the trees at 73 years of age, or at a diameter of 62 cm.

APPENDIX H

Figure 2.12: Annual growth rates for 117 mahogany trees in the Chimanes Forest over the period of 1992-1994. (samples sizes are: 2.5-10 n=33; 10-20 n=15; 20-40 n=18; 40-80 n=17; 80-160 n=27; 160^{+} n=7)



The flooding is caused by a logjam 6 km downstream that began forming 8 yr ago. The logjam is caused by the accumulation of organic debris that falls into the river when river bends migrate. In the wet season, the logjam causes flooding and slows the flow of water. The reduction in velocity reduces the load that the river can carry (Carling, 1992), resulting in the deposition of sediment on the forest floor. Trees in the area can survive flooding, but not the deposition of sediments that bury their roots (Gullison, pers. obs.). The relative height of a site is more important than distance from the river in determining how much deposition occurs. High areas near the river, like the Pichi plot (Figure 2.8) can escape deposition, while low areas some distance from the river can experience high levels of deposition (Esperanza plot).

APPENDIX J

(4 pp.)

UNITED STATES IMPORTS - MAHOGANY ROUGH

Table 1.8 Mahogany Imports to the US 1978 to 1991: Rough Lumber, Cubic Meters (Thousands) *

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Total	Percent
Algeria							57								57	0.00
Argentina	592	708	35					42	7			24			1,409	0.00
Australia						47	24		57	14					142	0.00
Bahamas										66					66	0.00
Belgium and Luxem								87		64					151	0.00
Belize	540	42	76	9	276	392	139	208	135	4,175	267	400	169	164	6,992	0.00
Benin											191				191	0.00
Bolivia	24,440	14,115	21,301	15,538	979	1,385	2,211	52	349	7,266	24,870	22,561	38,705	46,438	220,212	0.16
Brazil	23,376	33,068	54,660	65,157	35,256	75,397	96,099	105,806	82,204	267,364	78,923	50,788	33,476	40,116	1,041,691	0.74
Burma						5									5	0.00
Cameroon		50	59				47	26		80		56	46		364	0.00
Canada	243	2	267	92	309	54	135	132	111	864	120	119	8	5	2,461	0.00
Cayman Islands											1,473			101	1,574	0.00
Chile		99	909	363	28		260	1,525	458	319	165	12,693	370	1,646	18,834	0.01
Colombia										5					5	0.00
Costa Rica			78	144	144								19		385	0.00
Ecuador										90					90	0.00
Fiji						5	21								26	0.00
Finland								5							5	0.00
France					24	24	722	302	17	158					1,246	0.00
Gambia									38						38	0.00
Germany, West			76		5		295	19	92	111				8	605	0.00
Ghana	1,598	694					80	231	1,116	5,013	2,582	2,018	2,457	1,062	16,851	0.01
Greenland											238				238	0.00
Guatemala	1,371	411	680	1,097	557	1,326	1,067	1,784	3,330	11,177	12,845	8,630	4,106	4,814	53,195	0.04
Honduras	569	85		80	57	71	14	24	59	54	2		34		1,049	0.00
Hong Kong						90									90	0.00
Indonesia			149						106	1,055	892			19	2,221	0.00
Israel								295	101						396	0.00
Italy							19								19	0.00
Ivory Coast	1,876	368	562	87	871	281	951	923	668	4,151	333	50		162	11,283	0.01
Jamaica									2						2	0.00
Kenya		42													42	0.00
Kiribati (Gilbert Isl)								149							149	0.00
Liberia				76	94										170	0.00
Libya				19											19	0.00
Malaysia					368	194	61		694	24	26	33		19	1,418	0.00
Mali								54	57						111	0.00
Mauritius										40					40	0.00
Mexico						87		19		465	54			81	706	0.00
Netherlands			156				101	635							892	0.00
New Zealand							47								47	0.00
Nicaragua	68	354				146							12	78	659	0.00
Nigeria								35			286				321	0.00
Pakistan							26								26	0.00
Panama			24					38							61	0.00
Paraguay	142									118					260	0.00
Peru	1,149	727	1,617	290	156	533	460	1,517	186	1,555	47	356	778	1,709	11,082	0.01
Philippines	165	52	101				73			78	19				489	0.00
Pitcairn Island										80					80	0.00
Portugal								3,549			31				3,580	0.00
Republic of South A	28	394	241	45		54	47		31	78					918	0.00
Singapore								538					95	35	668	0.00
Switzerland									189	170					359	0.00
Taiwan	71	19	26		28		28	94							267	0.00
Thailand						19							30		49	0.00
Trinidad and Tobag		47													47	0.00
United Kingdom			2				132	215	432						781	0.00
Venezuela								158				265			423	0.00
Western Samoa						12									12	0.00
Yugoslavia (former)							123								123	0.00
Zaire	2,844	3,509	720	1,069	219		73	142		172	35				8,784	0.01
Zambia									625						625	0.00
World	59,073	54,787	81,736	84,068	39,372	80,122	103,314	118,604	91,063	304,806	123,400	98,745	80,399	97,187	1,416,676	1.00

***NB: Correction – Data are in cubic meters, not thousands of cubic meters as stated in title.**

USDA Forest Service; US Department of Commerce

UNITED STATES IMPORTS - MAHOGANY DRESSED

Table 2.B Mahogany Imports to the US 1978 to 1991: Dressed Lumber, Cubic Meters (Thousands) *

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	Total	Percent
Australia				12				64	40	524					640	0.00
Bahamas										5					5	0.00
Barbados									5						5	0.00
Belize					111	347	17	229	31	97	111		1,469	117	2,528	0.01
Bolivia	437	142	168	1,100	73	146	427	387		42		4,163	7,211	1,208	15,504	0.06
Brazil	5,268	14,254	14,252	14,413	22,521	13,945	8,189	22,550	33,644	9,801	10,648	8,947	4,188	8,530	191,191	0.76
Cameroon		2	24												26	0.00
Canada	354	564	484	392	92	465	229	432	738	76	526	65	6	9	4,429	0.02
Cayman Islands								2							2	0.00
Chile			236		83	217		135	358	9	1,893	679	622	1,311	5,543	0.02
Colombia	170	45		127	328										670	0.00
Congo										33					33	0.00
Costa Rica						31					189			42	261	0.00
Ecuador	165									52					217	0.00
France						21		153			28				203	0.00
French West Indies						7									7	0.00
Germany, West			236			24	2	54		255	260				831	0.00
Ghana	24	26	118					33	1,864	1,359	76		51	780	4,329	0.02
Guatemala	78		26		66		35	1,154	798	1,692	198	1,341	300	57	5,706	0.02
Honduras	90	19	1,293	17	94	209		5	120	396	425	230	27	141	3,062	0.01
Hong Kong								111							111	0.00
India			165				5		57		73				300	0.00
Indonesia								194	52	66	1,477	466	771	1,599	4,627	0.02
Israel									732						732	0.00
Italy								19		163		2			184	0.00
Ivory Coast			28			33	210	97	118	257	38				781	0.00
Jamaica			19		42										61	0.00
Kenya		2				66									68	0.00
Liberia								26							26	0.00
Malaysia		158	26	33	42	7	7	363	215	262	484	190	140	80	2,008	0.01
Mexico							2	28		19					50	0.00
Netherlands						64									64	0.00
New Zealand						33									33	0.00
Nicaragua	5		118											334	457	0.00
Panama							144			120					264	0.00
Paraguay		2													2	0.00
Peru		19	33	703	498	455	196	927	12	104		220		199	3,367	0.01
Philippines			26		35		196			21	99		33		411	0.00
Poland									198						198	0.00
Republic of South A					2	2	9								14	0.00
Singapore	28		7			189								574	783	0.00
Spain		38													38	0.00
Suriname	26														26	0.00
Switzerland										28			70		98	0.00
Taiwan	210					120		5	76	186	231	78			908	0.00
United Arab Emirate							113								113	0.00
United Kingdom						2			2	14	9	93			121	0.00
Uruguay			47												47	0.00
Venezuela							9	38					161	103	311	0.00
Zaire	2	31	31			68			135	127					394	0.00
World	6,856	15,397	17,381	16,796	23,989	16,449	9,792	27,005	39,233	15,673	16,765	16,612	15,357	15,516	252,822	1.00

*NB: Correction -- Data are in cubic meters, not thousands of cubic meters as stated in title.

USDA Forest Service; US Department of Commerce

UNITED STATES MAHOGANY IMPORTS 1991 - 1995

Year / Country	4407230025 Mahogany Wood Sawn, Rough					4407230030 Mahogany Wood Sawn, NESOI				
	Cubic Meters									
	1991	1992	1993	1994	1995	1991	1992	1993	1994	1995
Brazil	40116	58531	53634	42819	43363	8530	7885	5076	5921	4302
Bolivia	46438	20075	23766	41003	47700	1208	909	478	3665	3714
Peru	1709	2103	2603	6091	6355	199	120	962	1174	2299
Chile	1646	28	442	4281	2315	1311	315		193	7175
Guatemala	4814	4611	3169	3866	5019	57	62	431	195	5
Mexico	81			30	4362					484
Belize	164	180	161	760	2504	117				130
Honduras		412	9	288	46	141	79	766	1380	905
Nicaragua	78		239	452	3193	334	164	674	236	460
Costa Rica		61			7	42				
Venezuela						103			40	
Ecuador							89			50
Dominican Rep.						3				
Cayman	101									
Indonesia	19	6	518	884		1599	1372	2167	2601	2011
Fiji			22							
New Guinea				9						
Malaysia	19		1438		29	80	37	228		95
Singapore	35		24			574	216	225	847	
Thailand			30							
Canada	5	9	38	109	1	9	37	24	18	9
Germany	8						121			
Australia					5			211	59	40
United Kingdom				1644	413			7	20	36
France									5	
Italy									12	
Spain				5						
Belgium					22					
W. Samoa			19							
Nauru	715					402				
Ivory Coast	162		61	11	82					24
Ghana	1062	401	551	863	918	780	266	138	210	629
Mozambique									9	
Nigeria		24	15		53	27	42		45	90
Sth. Africa										45
Tanzania	15									
Liberia		14								
Bangladesh								167		
Syria		31								
Total	97187	86486	86739	103115	116387	15516	11714	11554	16630	22503

UNITED KINGDOM IMPORTS

Figure 1. Total Latin American sawn lumber imports 1980 – 1991, m3.

	m3
1980	64300
1981	92500
1982	73300
1983	102600
1984	94000
1985	91000
1986	91800
1987	112000
1988	101500
1989	100000
1990	75400
1991	60000

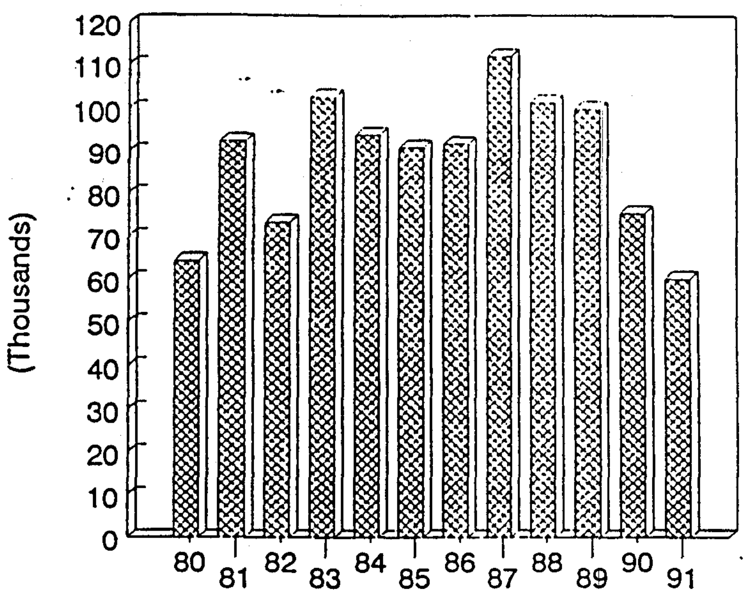
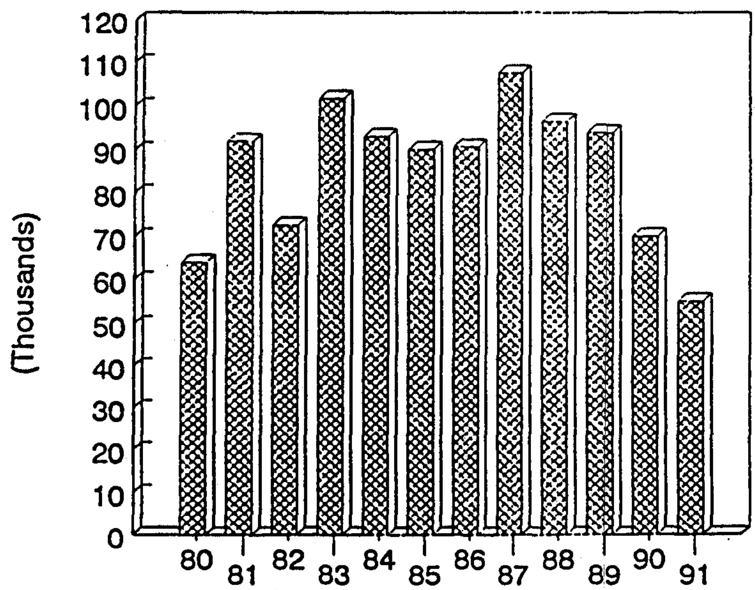
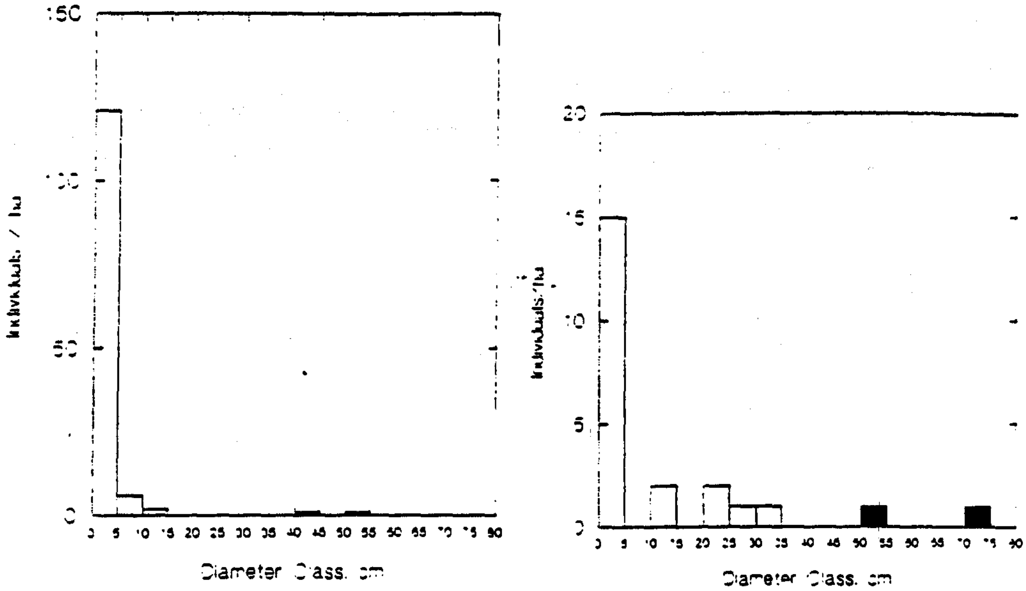


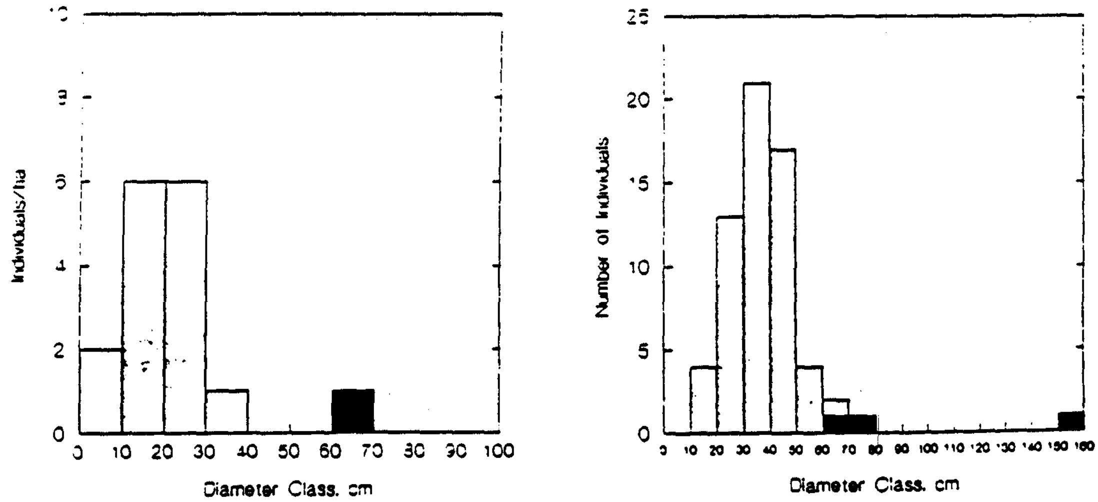
Figure 2. Total L.A. Mahogany lumber imports 1980 – 1991, m3.

	m3
1980	64000
1981	92000
1982	72500
1983	101700
1984	93100
1985	90100
1986	90800
1987	107500
1988	96500
1989	94000
1990	70000
1991	55000



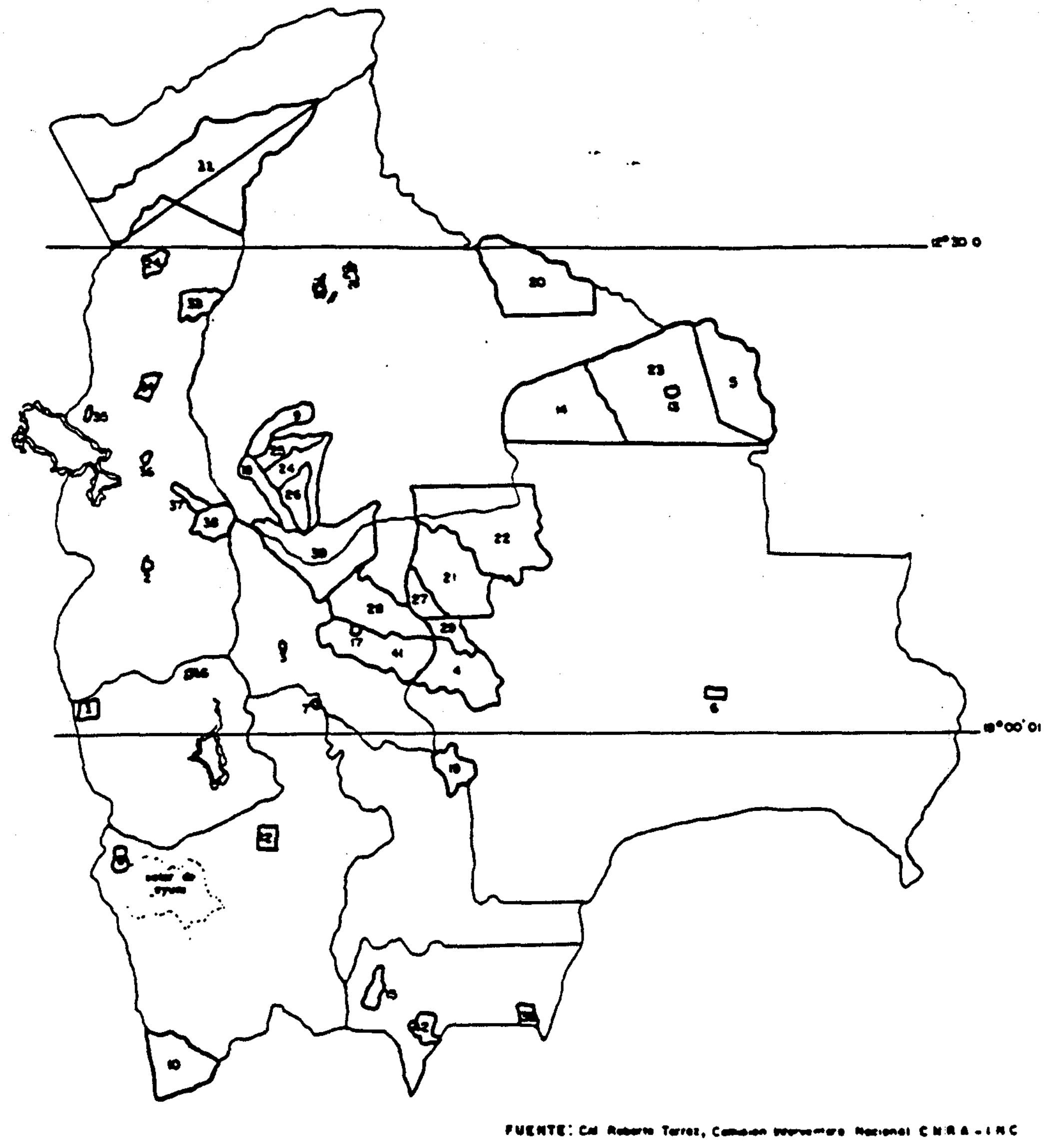


Figures 6-C (left) and 6-D (right). Diameter distributions of mahoganies on one hectare transects on a 15 year old post-fire stand (left) and a 30 year old post-fire stand (right). Residual trees that survived the fire are indicated in black. Gaps in the diameter distribution on the 30 year-old stand probably reveal past mortality due to a second fire 15 years previously.



Figures 6-E (left) and 6-F (right). Diameter distributions of mahogany on a one hectare transect in a 45 year old post-fire stand (left) and a 3 hectare transect in a 75 year old post-fire stand (right). Residual trees are indicated in black. Two of the residual trees were old stumps that would have grown to larger diameter classes if they had not been cut.

Figura 3 - Mapa de Parques Nacionales, Reservas y Territorios Indígenas



Parques Nacionales, Reservas y Territorios Indigenas

AREA	NOMBRE	DECRETO RESOLUCION MINISTERIAL	DEPARTAMENTO PROVINCIA	OBSERVACIONES
1	PARQUE NACIONAL SAJAMA	Ley s/n del 05/11/45	Sajama - Oruro	Tiene Coordenadas
2	PARQUE NACIONAL TUNI-CONDORIRI	D.S. s/n del 04/07/42	Murillo - La Paz	No cuenta con limites definidos
3	PARQUE NACIONAL TUNARI	Ley 6045 del 30/03/62	Cercado - Cochabamba	Bajo responsabilidad de CORDECO - COTESU
4	PARQUE NACIONAL AMBORO	D.S. 22939 del 11/10/91	Andres Ibanez, Ichilo, Florida, Caballero - Santa Cruz	Proteccion de Etnias y Recursos Naturales SE.N.M.A. - B.I.D
5	PARQUE NAL. NOEL KEMPF MERCADO	D.S. 21997 del 31/08/88	Santa Cruz	Ploteado
6	PARQUE NACIONAL HISTORICO SANTA CRUZ LA VIEJA	D.S. 22140 del 22/02/89		Ploteado En base a coordenadas existe un mapa con limites mas precisos en informe del U.T.D. - C.D.F. - S.C.R. Elaborado para su creacion en 1988
7	PARQUE NACIONAL TORO TORO	D.S. 22269 del 26/07/89	Charcas - Potosi	Ploteado El D.S. indica solo coordenadas extremas, pero existe poligonal elaborada por la comunidad conjuntamente de Toro Toro.
8	PARQUE NACIONAL DE LLICA	R.M. 228/90 del 29/11/90	Daniel Campos - Potosi	Ploteado
9	ESTACION BIOLOGICA DEL BENI	D.S. 19191 del 05/10/82	Ballivian, Yacuma - Beni	Ploteado Gran parte se encuentra dentro del area de Chimanes - respaldado por el D.S. 22611 El limite oeste no coincide con el decreto
10	RESERVA NAL. DE FAUNA EDUARDO AVAROA	D.S. 18431 del 26/06/81	Sud Lipez - Potosi	Ploteado
11	RESERVA NAL. MANURIPI-HEATH	D.S. 11252 del 20/12/73	Madre de Dios, Manuripi - Pando Iturralde - La Paz	Ploteado
12	RESERVA NAL. DE FAUNA YURA	D.S. 11397 del 20/01/74	Quijarro - Potosi	Ploteado El D.S. solo establece coordenadas extremas.
13	RESERVA BIOLOGICA NOEL KEMPF MERCADO	D.S. 22030 del 19/09/88	Velasco - Santa Cruz	Ploteado
14	RESERVA DE VIDA SILVESTRE RIO BLANCO Y NEGRO	R.M. 139/90 del 10/08/90	Nuflo de Chavez - Santa Cruz	Ploteado
15	RESERVA BIOLOGICA DE LA CORDILLERA DE SAMA	D.S. 22721 del 30/07/91	Mendez - Tarija	Ploteado Existe mapa en detalle por SE.N.M.A.
16	REFUGIO DE VIDA SILVESTRE HUANCAROMA	D.S. 12721 del 23/07/75	Tomas Barron - Oruro	Ploteado Solo en base a coordenadas no se dispone de mapa en detalle.
17	SANTUARIO CAVERNAS DE REPECHON	R.M. 157/86 del 22/05/86	Chapare - Cochabamba	Ploteado Solo en coordenadas geograficas.
18	AREA DE PROTECCION DE CUENCAS HIDROGRAFICAS EVA EVA MOSETENES	R.R. CDF-RN/02/87 del 23/02/87	Ballivian - Beni	Ploteado Area incluida en el area de Chimanes D.S. 22611 del 24/09/90

Parques Nacionales, Reservas y Territorios Indigenas

AREA	NOMBRE	DECRETO RESOLUCION MINISTERIAL	DEPARTAMENTO PROVINCIA	OBSERVACIONES
19	RESERVA FORESTAL DE INMOVILIZACION RIO GRANDE MASICURI	D.S. 17[illegible] del [illegible]	Valle Grande - Santa Cruz	Ploteado [illegible] por no figurar en la carta ([illegible])
20	RESERVA FORESTAL DE INMOVILIZACION ITENEZ	D.S. 21446 del [illegible]	[illegible] - Beni	Ploteado
21	RESERVA FORESTAL EL CHORE	D.S. 7779 del [illegible]	Ñuflo de Chavez - Santa Cruz	Ploteado
22	RESERVA FORESTAL GUARAYOS	D.S. [illegible] del [illegible] D.S. 11615 del 02/07/74	Ñuflo de Chavez, [illegible] - Santa Cruz Marban - Beni	Ploteado [illegible] zona "P" San Julian ([illegible])
23	RESERVA FORESTAL DE PRODUCCION BAJO PARAGUA	D.S. [illegible] del [illegible]	Velasco, Ñuflo de Chavez - Santa Cruz	Ploteado
24	AREA INDIGENA CHIMANES	D.S. 15585 del 27/06/78	Yacuma, Ballivian - Beni	Ploteado El D.S. 22611 [illegible] [illegible] del D.S. 15585 [illegible] R.F.I. Chimanes.
25	EXTENSION Y SUBDIVISION DE AREA INDIGENA CHIMANES [illegible] de Territorio para Chimanes, Mojenos, Yuracares y Movimas	D.S. 22611 del 24/09/90		Ploteado [illegible] del area indigena [illegible] de Chimanes, [illegible] ZP-1: Reserva de la Biosfera Estacion Biologica del Beni [illegible] ZP-2: Parque regional Yacuma [illegible] del C.D.F. regional norte. ZP-3: Zona de [illegible] Eva Eva Mosetenes, [illegible] 02/87 del C.D.F.
26	TERRITORIO INDIGENA CHIMAN	D.S. 22610 del 24/09/90	Ballivian - Beni	Ploteado Incluido en el area 40
27	TERRITORIO INDIGENA YUQUIS	D.S. 23111 del 09/04/92		Ploteado
28	TERRITORIO INDIGENA ARAONA	D.S. 23108 del 09/04/92	Iturralde - La Paz	Ploteado
29	AMPLIACION EL CHORE	D.S. 22899 del 16/09/91	Santa Cruz	Ploteado
30	ZONA "P" COLONIZACION SAN JULIAN	D.S. 11615 del 02/07/74	Santa Cruz	Ploteado
31	ZONA DE COLONIZACION CHAPARE - CHIMORE		Cochabamba Santa Cruz	Ploteado
32	TERRITORIO INDIGENA WEENHAYEK - MATACO	Proy. de D.S.	Gran Chaco - Tarija	Ploteado
33	EL DORADO	R.M. 340/88 del 26/10/88	Iturralde - La Paz	
34	PILON LAJAS	D.S. 23110 del 29/04/92	Sud Yungas, Larecaja, Franz Tamayo - La Paz Ballivian - Beni	
35	RESERVA NAL. DE FAUNA ULLA ULLA	D.S. 10070 del 07/01/72	Franz Tamayo - La Paz	Ploteado

Parques Nacionales, Reservas y Territorios Indigenas

AREA	NOMBRE	DECRETO RESOLUCION MINISTERIAL	DEPARTAMENTO PROVINCIA	OBSERVACIONES
36	QUINERA DEL ATEN	D.S. 14686 del 23/06/77	Prov. Tamayo - La Paz	
37	RIO BOPI	D.S. 17885 del 02/08/79	Nor Yungas, Sud Yungas - La Paz	
38	COVENDO	D.S. 21040 del 01/08/85	Sud Yungas, Inquisivi - La Paz Ayopaya - Cochabamba Ballivian - Beni	
39	ISIBORO SECURE	D.S. 7401 del 22/11/65 D.S. 22610 del 24/09/90	Moxos - Beni Chapare, Ayopaya - Cochabamba	
40	VILLA TUNARI YAPACANI		Cochabamba Santa Cruz	
41	CARRASCO	R.M. 281/88 del 09/12/88 D.S. 22940 del 11/10/91	Carrasco, Tiraque, Chapare - Cochabamba	
42	TARIQUIA	D.S. 22277 del 01/08/89	Arce, O'Connor, Gran Chaco - Tarija	

FUENTE: Cnl. Roberto Torres, Comision Interventora Nacional C.N.R.A. - D.C.C.

Cuadro 2c. Número de individuos de mara en pie y tocones en las unidades de muestreo de 100 m de diámetro, en las diferentes concesiones visitadas, por categoría diámetrica.

CON	UM	AN	BRI	LAT	'10-20	'20-30	'30-40	'40-50	'50-60	'60-70	'70-80	'80-90	'90-100	100 -+	Total
1	1	4A	0	0	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	1
1	2	2M	11	0	'----	'----	'----	'----	'----	'----	1	'----	'----	'----	12
1	3	8A	1	0	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	2
1	4	12A	0	0	'----	'----	'----	'----	'----	'----	'----	1	'----	'----	1
1	5	12A	0	0	'----	'----	'----	'----	'----	'----	1	'----	'----	'----	1
1	6	8A	0	0	'----	'----	'----	'----	'----	1	'----	1	'----	'----	2
2	7	12A	0	0	'----	'----	'----	'----	'----	'----	1	'----	'----	'----	1
2	8	5A	0	0	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	1
2	9	1M	0	0	'----	'----	'----	'----	1	'----	'----	'----	'----	'----	1
2	10	1M	1	1	'----	'----	'----	'----	'----	2	'----	'----	'----	'----	4
2	11	1M	3	0	'----	'----	'----	'----	1	'----	'----	'----	'----	'----	4
2	12	1M	21	1	'----	'----	'----	'----	'----	'----	'----	'----	'----	1	23
3	13	P	0	1	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	2
3	14	4A	0	0	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	1
3	15	2A	2	0	'----	'----	'----	'----	'----	1	2	1	'----	'----	6
3	16	2A	0	0	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	1
3	17	2A	1	0	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	2
3	18	P	2	1	'----	'----	'----	'----	1	'----	'----	'----	'----	'----	4
3	19	P	1	1	'----	1	'----	'----	'----	1	'----	'----	'----	'----	4
3	20	7A	5	0	'----	'----	'----	'----	'----	'----	1	'----	'----	'----	6
3	21	8A	6	0	'----	'----	'----	'----	'----	1	1	'----	'----	'----	8
3	22	8A	1	1	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	3
3	23	8A	5	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	5
2	24	11A	0	0	'----	'----	'----	'----	'----	'----	'----	1	'----	'----	1
2	25	12A	0	0	'----	'----	'----	'----	'----	'----	1	'----	'----	'----	1
4	26	10A	0	0	'----	'----	'----	'----	'----	'----	1	'----	'----	'----	1
4	27	2M	0	1	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	2
4	28	12A	1	3	1	'----	'----	'----	'----	'----	'----	1	'----	'----	6
4	29	12A	1	2	'----	1	1	'----	'----	'----	'----	2	'----	'----	7
4	30	2M	0	0	'----	2	1	'----	'----	1	'----	1	'----	'----	5
4	31	9A	0	2	'----	'----	'----	'----	'----	'----	1	'----	'----	'----	3
4	32	2A	1	0	'----	'----	'----	'----	'----	2	1	2	'----	'----	6
4	33	11A	14	0	'----	'----	'----	'----	'----	'----	2	2	'----	'----	18
4	34	13A	1	0	'----	'----	'----	'----	'----	'----	2	'----	'----	'----	3
3	35	9A	0	3	1	'----	'----	'----	'----	2	1	'----	'----	'----	7
Gran total			78	17	2	4	2	0	3	20	16	12	0	1	155
Total en pie			78	17	2	4	2	0	1	4	0	0	0	1	109
Total tocones			0	0	0	0	0	0	2	16	16	12	0	0	46

CON = Concesión (1: Don Enrique; 2: Marabol; 3: San Francisco; 4: Grigotá).
UM= Unidad de muestreo
AN = Edad de aprovechamiento (4A: 4 años; 2M: 2 meses; P: parcelas no aprovechadas).
Se formaron 5 categorías de aprovechamiento (ver aparte 3.3.3.A165) .
BRI = Brinzales ; LAT = Latizales
Desde 10-20 hasta 100 - + = categorías diámetricas en cm.

Cuadro 2d. Número de individuos de mara en pie, encontrados en las unidades de muestreo de 100 m de diámetro, en las diferentes concesiones visitadas, por categoría diámetrica.

CON	UM	AN	BRI	LAT	'10-20	'20-30	'30-40	'40-50	'50-60	'60-70	'70-80	'80-90	'90-100	100 -+	Total
1	1	4A	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
1	2	2M	11	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	11
1	3	8A	1	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	1
1	4	12A	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
1	5	12A	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
1	6	8A	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
2	7	12A	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
2	8	5A	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
2	9	1M	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
2	10	1M	1	1	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	3
2	11	1M	3	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	3
2	12	1M	21	1	'----	'----	'----	'----	'----	'----	'----	'----	'----	1	23
3	13	P	0	1	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	2
3	14	4A	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
3	15	2A	2	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	2
3	16	2A	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
3	17	2A	1	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	1
3	18	P	2	1	'----	'----	'----	'----	1	'----	'----	'----	'----	'----	4
3	19	P	1	1	'----	1	'----	'----	'----	1	'----	'----	'----	'----	4
3	20	7A	5	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	5
3	21	8A	6	0	'----	'----	'----	'----	'----	1	'----	'----	'----	'----	7
3	22	8A	1	1	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	2
3	23	8A	5	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	5
2	24	11A	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
2	25	12A	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
4	26	10A	0	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	0
4	27	2M	0	1	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	1
4	28	12A	1	3	1	'----	'----	'----	'----	'----	'----	'----	'----	'----	5
4	29	12A	1	2	'----	1	1	'----	'----	'----	'----	'----	'----	'----	5
4	30	2M	0	0	'----	2	1	'----	'----	'----	'----	'----	'----	'----	3
4	31	9A	0	2	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	2
4	32	2A	1	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	1
4	33	11A	14	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	14
4	34	13A	1	0	'----	'----	'----	'----	'----	'----	'----	'----	'----	'----	1
3	35	9A	0	3	1	'----	'----	'----	'----	1	'----	'----	'----	'----	5
Gran total			78	17	2	4	2	0	1	5	0	0	0	1	110

CON = Concesión (1: Don Enrique; 2: Marabol; 3: San Francisco; 4: Grigotá).
UM= Unidad de muestreo
AN = Edad de aprovechamiento (4A: 4 años; 2M: 2 meses; P: parcelas no aprovechadas).
Se formaron 5 categorías de aprovechamiento (ver aparte 3.3.3.A165) .
BRI = Brinzales
LAT = Latizales
Desde 10-20 hasta 100 - + = categorías diámetricas en cm.