ELSEVIER

Forest Ecology and Management 92 (1997) 87—96

Forest damage caused by selection logging of mahogany (Swietenia macrophylla) in northern Belize

Andrew A. Whitman, Nicholas V.L. Brokaw, John M. Hagan

Manomet Observatory for Conservation Science. Division of Conservation Forestry P Box 1770, Manomet, MA 02345, USA

Accepted 10 September 1996

Abstract

We assessed the damage caused by selection jogging of mahogany in a tropical forest in northern Belize and compared it with damage reported in other Neotropical logging and disturbance studies. We mapped skid roads and tree felling sites, and assessed soil compaction, loss of canopy cover, damage to saplings and trees, seedling survival and seedling height growth. Logging had been conducted using hand crews with chain saws and cable skidders, Logging directly affected 11.9 ha (12.9%) of the 92.3 ha logging area. Canopy cover decreased the most at logging gaps. and soils were most compacted on skid roads. Soil compaction was much greater on roads where more than one tree had been skidded. Fir the whole logged area, canopy cover declined 2% and compacted soils covered 3.8% of the area. Seedling height growth was unaffected by soil compaction, but seedling survival was less on compacted sites, About 50% of the trees and about 15% of the saplings were damaged in gaps and along skid roads. However, only 4.8% of the trees and 1.9% of the saplings were damaged for the logged area as a whole. The most common kinds of damage included scraped hark, snapped tops, and run-over stems. Although this logging operation had relatively low impacts compared with other logging operation in the Neotropics, it may not be silviculturally sustainable because its disturbance may be insufficient to promote adequate mahogany regeneration.

Keywords: Canopy openness; Soil compaction; Tree damage; Seedling growth Disturbance; Neotropical forest

4. Discussion

To forest conservationists, low-intensity selection logging operations such as the one studied here are attractive. Only a small portion (12.9%) of the total logged area was affected directly by the logging. Although gaps were of moderate size and contained many trees damaged by logging, they accounted for a small proportion of the area and left much of the advance regeneration (saplings) undamaged. Because soil compaction was most severe on skid roads sites where multiple passes occurred, efforts should be made in the planning stages to minimize the length of these types of skid roads (e.g. Gullison and Hardner, 1993). Skid roads were areas vith much soil compaction and reduced seedling survival but were nan-ow and occupied a small proportion (3.8%) of the total area. As a result, only a small part of the residual stand, trees, and regeneration were damaged by this operation. Because the similar numbers of commercial and non-commercial species were damaged, loggers did not appear to make an effort to avoid damaging species of commercial value. In contrast to the positive correlations between sizes of naturally fallen trees and gap sizes found elsewhere (Brokaw, 1982; ter Steege et al., l994), the felling of large trees did not produce larger disturbance zones and gaps than the felling of small trees. Perhaps, loggers fell trees to reduce the chance of the target stem getting caught in or damaged by the surrounding trees when it is felled, and in doing so reduced variation in the logging gap area. Thus, compared with other Neotropical operations, total damage at our site was low because few trees were harvested per unit area.

Given the interest in natural forest management, it is useful to compare the logging disturbance found in this study to natural disturbance. Although proportion of area damaged (12.9%) was higher than that produced by natural treefalls at four (mean 3 range: 0.3—6%) of five Middle American sites (fifth site, gap area = 25%), the proportion of canopy loss due to logging, 2.0% was less than natural disturbance (Brokaw, 1985) excepting for a nearby dry forest site (03%, Noh Bec, Mexico, D. Whigham personal communication. 1995). And while logging gaps in this study were larger on average, 583 m^2 than natural gaps (mean = 130 m^2 range: 86—200), density of logging gaps in this study was less, 0.5 ha^{-1} than the density of natural treefall gaps in Middle America (mean = 7.1, range 3.2-12.8). Given that loggers revisit logged sites about once every five years (C. Polk, personal communication, 1993), the stand turnover rate would be about 100 years, similar to natural turnover rates in other Middle American forests (mean = 100, n = 3, range = 62-135). Thus, selection logging at the rate observed in this study might double the kinds of disturbance resulting from treefall gaps. Given that this forest is severely disturbed by hurricanes at regular intervals, it is more likely that centuries of large-scale disturbance by hurricanes has had a greater impact on the forest than low-intensity selection logging (e.g. Lynch and Whigham. 1995). Therefore, the impacts of selection logging in Belize at this intensity may be trivial compared to natural disturbance.

However, there are tradeoffs associated with low logging densities (Gullison and Hardner, 1993). Compared with other Neotropical studies, the area disturbed per tree was nearly twice as great as was found in other studies. We attribute this difference(*s*) to the harvest density. At low harvest densities found in this study, much of the logging disturbance results from skid roads. As the harvest density increases, damage area per tree due to skid roads declines as each additional harvested tree requires less and less new skid road, while damage area per tree due to logging gaps remains constant (Gullison and Hardner, 1993). Thus, logging damage per tree declines as harvest density increases.

Although this logging operation had relatively low impact compared to other logging operations in the Neotropics and had little impact on the bird community (Whitman c al., 1994), it was not silviculturally sustainable. The complete harvest of the largest and probably most fecund trees may have greatly reduced the seed production potential of the residual stand. Ironically, adequate recruitment and regeneration of mahogany requires disturbances much larger than those created by this logging operation (Snook, 1992). Moreover, elsewhere we determined that the mahogany harvest rate far exceeded the mahogany regeneration and recruitment capacity of the forest (Whitman et al., 1994). Thus, further research is necessary to determine forest practices that will assure the silvicultural sustainability of mahogany. These practices will almost assuredly require disturbing the forest much more than the current logging operations and will also require studies to determine how to maintain ecological integrity and biodiversity of tropical forests at these greater disturbance levels.

Appendix A. The relative economic value of tree species found on plots

Economic value	**Species**
High	*Swietenia macrophylla*
	Cedrela mexicana

Medium	*Aspidosperma cruenta*
	Calophyllum brasiliense
	Spondias mombin
	Terminalia amazonia
Low	*Alseis yucatanensis*
	Ampelocera hottlei
	Bucida buceras
	Bursera simaruba
	Drypetes brownii
	Ficus spp.
	Guettarda combsii
	Manilkara chicle
	Metopium brownei
	Cojoba arborea
	Simarouba amara
	Vitex gaumerii
	Zanthoxylum juniperum

High value species were species desirable for international markets. Medium value species were species currently sought after for domestic and international markets. Low value species were species occasionally harvested or listed in Lamb (1946) and Joseph Loskott (personal communication. 1993) as species of value.