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Selective cutting of woody species in a Mexican tropical dry forest: Incompatibility between use and conservation

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ABSTRACT

A major challenge of forest management is to maintain the biodiversity and integrity of the forests while at the same time satisfying human needs through productive activities. While selective extraction of natural resources has less severe consequences on biodiversity and ecosystem function than complete removal of vegetation, such consequences need to be evaluated in detail. "Varas" or stems cut from small trees of tropical dry forests (TDF) in the Pacific Coast of Mexico have been used as plant support stakes in horticultural fields (mainly tomato crops) since the middle of the last century. In this study, we evaluated the effects of selective cutting of plant support stakes on the diversity of woody vegetation of a TDF in northwestern Mexico. Stakes were cut by local harvesters before our assessment of cutting effects. In each of three cutting treatments (T_0 = uncut, T_1 = one cut event, and T_2 = two cut events), we established three sampling plots each consisting of ten 50 m × 2 m parallel transects. All woody plants (stems ≥1.0 cm diameter at 1.3 m height, DBH) were identified and measured on each transect. Species richness (*S*) decreased as the number of cuts increased (T_0 = 65 species, T_1 = 50 species, and T_2 = 38 species). The Simpson (*C*) and the Shannon (*H*′) diversity indices, as well as the rarefaction curves and non-parametric estimates of diversity (Chao1 and ACE) confirmed this tendency of change. Comparison of dominance–diversity curves showed that the woody plant community loses equitability with every additional stake cutting event. The total number of stake providing species did not vary notably across treatments (T_0 = 8 species, T_1 = 9 species, and T_2 = 7 species), but four species reduced their dominance considerably in T_2, while *Croton septemnervius*, the most used species, increased its abundance and relative basal area with each additional stake harvest, reaching a representation of more than 59% of total number of stems in T_2. The reduction in species diversity, changes in patterns of dominance, and the proliferation of species associated to disturbed sites suggest that current practices of selective cutting require adjustments to make this forest management application more consistent with local conservation of woody plant species diversity and community structure.

1. Introduction

Traditionally, the use of forests has concentrated on the extraction of timber and non-timber forest products (NTFP) with the purpose of satisfying the demands of the growing human population (Fuhrer, 2000; Foley et al., 2005). However, the extraction of forest resources, coupled with other anthropogenic practices that result in a total transformation of the vegetation cover, such as intensive agriculture, cattle raising, or the establishment of human settlements, has resulted in a considerable loss of biodiversity and of carbon storage capacity of forests, thus diminishing their capacity to maintain their functions and provision of ecosystem services (Masera et al., 1997; Foley et al., 2005; Williams et al., 2008). In such context, one of the major challenges faced by forest managers today is to maintain the biodiversity and integrity of forests while at the same time satisfying human needs through productive activities (Pinard et al., 1999; Simberloff, 1999; Piussi and Farrel, 2000; Foley et al., 2005; Burke et al., 2008).

Selective extraction of timber is a widely practiced productive activity of tropical forests (Thiollay, 1992; Nwavu and Witkowski, 2008). It consists of periodically cutting trees that are valuable for their wood properties and allowing site recovery by natural regeneration (Johns, 1988; Pearce et al., 2003; Clarke et al., 2005). Selective cutting varies from mechanized tree extraction on large forest areas to manual extraction on a small scale, using vehicles drawn by animals (Bawa and Seidler, 1998; Asner et al., 2005). In

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general, selective extraction follows two contrasting schemes (Rice et al., 1997). Under the most conventional scheme, wood is extracted maximizing the short-term economic benefits, hence harvesting as many stems as possible at once without the implementation of any activities to promote natural regeneration, and often without technical regulation. The other scheme, which seeks sustained production in the longer term, timber harvesting is based on a technically sound management plan, and should incorporate actions directed at reducing the negative impacts associated with wood extraction (Putz et al., 2001; Pearce et al., 2003). Under both systems, it is assumed that these forests will return to their original condition through natural regeneration after a certain time (Bowles et al., 1998). However, selective cutting can have severe environmental impacts which might inhibit the functional integrity of the forests, in particular their regeneration capacity (Putz et al., 2001; Kozlowski, 2002; Pearce et al., 2003). Therefore, in the need to find more sustainable forest management practices, it becomes imperative to evaluate whether under current practices of extraction, the diversity, composition, and species dominance of forests is maintained, and to suggest alternative management plans in case any of these variables are found to change drastically as result of extraction (Noble and Dirzo, 1997; Pinard et al., 1999; Simberloff, 1999; Fox, 2000; Piussi and Farrel, 2000; Palik et al., 2002; Pearce et al., 2003).

One of the most worrying aspects associated with selective extraction of forest products is the local loss of plant species (Bawa and Seidler, 1998). Such loss can occur gradually, although the effect of extraction on any particular species may become evident in the short-term through two mechanisms. One mechanism is by the direct reduction in abundance as a consequence of harvesting, or by modifications in the size- or age-distribution of the species being harvested (Uhl et al., 1997; Chapin et al., 2000; Putz et al., 2001). The other mechanism is by indirect damage to harvested and non-harvested species as a consequence of biophysical changes associated with extraction operations, such as biomass removal (Uhl and Vieira, 1989; Johns et al., 1996) and soil compaction (Johns, 1997), which may in turn have negative effects on the recruitment of species. Therefore, a first step in evaluating the potential loss of diversity as a consequence of extraction practices, would be to separate the effects on those species directly harvested, versus the effects on non-harvested species.

In tropical dry forests (TDFs), the patterns of natural regeneration after timber extraction might be affected by adaptations of woody species to scarce precipitation and unpredictable pattern of water availability (Deiller et al., 2003), and by geomorphological components of the landscape (Burgos and Maass, 2004). In particular, under natural or anthropogenic disturbances which lead to the felling of trees or to partial loss of aerial biomass, many TDF species have the capacity of developing resprouts which grow faster than seedlings (Nyerges, 1989; Miller and Kauffman, 1998a; Shackleton, 2000; Van Bloem et al., 2007). This response of TDF species to disturbance, which results in multi-stemmed trees, should be considered in the management of this ecosystem, since it allows for the periodical harvesting of stems without causing the direct death of the individuals (Sennerby-Forsse et al., 1992). However, by promoting this regeneration mechanism through selective cutting, the richness patterns of the plant community might be affected, given that the capacity to resprout and sprout survival may vary across species (Kruger et al., 1997; Van Bloem et al., 2007).

On the coast of Jalisco, western Mexico, vegetation is dominated by a TDF where tree dimensions and forest biomass are much smaller than in their humid counterparts (Murphy and Lugo, 1986). In some areas, the cutting and marketing of local forest resources provide an additional income for the rural population. In the case of woody raw materials, thin stems of selected tree species (which would fit into the broad category of NTFP) are harvested to be used as plant support stakes for vegetable crops in Sinaloa, the most important horticultural state in Mexico. Harvested stems, of specific commercial size (3–9 cm DBH and 2.0–2.5 m long) are generally cut from the base and from trees of at least nine tree species (Rendón-Carmona, 2002). Most individuals are reproductive by the time they reach the size in which they are harvested, and usually resprout vigorously after harvesting. On average, 1910 stakes ha^{-1} are cut per harvest event. From these, *Croton septemnervius* McVaguh (Euphorbiaceae), locally known as "canelilla" or "vara blanca", is the most harvested species (89% of total number of cut stems) because of its superior woody quality. Other commonly used species include *Bauhinia* sp., *Lonchocarpus* sp., and *Randia* sp. (Rendón-Carmona, 2002).

The selective cutting of "varas" from selected TDF species, began in the middle of the last century in the Mexican states of Sonora and Sinaloa (López-Urquídez, 1997; Lindquist, 2000; Yetman et al., 2000). In Jalisco state, this practice arose until the 1980s, it has been regulated by federal and state laws since the mid nineties, but management plans, when available, are technically deficient, suggesting incompatibility between selective cutting and conservation of the harvested species (Rendón-Carmona, 2002). Extraction levels are difficult to determine and the effect of prolonged, intensified harvesting on the species and at the community level are still unknown (Lindquist, 2000).

Considering the scarcity of information about the management of TDF woody species in general, the objective of this study was to evaluate, at the community level, the changes in relative abundance and diversity of harvested and non-harvested tree species as a consequence of selective cutting. Particularly, the questions posed were: (1) is the diversity of woody species reduced as a consequence of increasing number of cutting events?, (2) how do the patterns of woody plant species dominance (i.e., density, basal area, and number of stems) change with increasing number of cutting events?, and (3) what is the availability of stems (resource) of the used species (i.e., commercially desirable species) in sites differing in their history of selective cutting?. Answers to these questions should provide a clear indication as to whether current practices of support stake harvesting should be modified to make them compatible with dry forest woody species conservation.

2. Materials and methods

2.1. Study area

The study was conducted in Ejido Campo Acosta, municipality of Tomatlán, Jalisco (19°46′13″ N and 105°14′60″ W, Fig. 1), located at about 50 km northeast of the Chamela-Cuixmala Biosphere Reserve, on the Pacific Coast of Mexico. There are no previous studies on flora, fauna, or of the environmental variables at this particular site. Nevertheless, the dominant vegetation type within the ejido is an extension of the tropical dry forest (*sensu* Rzedowski, 1978) in the Reserve, for which 1120 vascular plant species have been identified that belong to 544 genera, and 124 families, with about 10% of this flora endemic to Jalisco and Colima states (Lott, 1993). Mean forest canopy height is 7 m, with some emergent trees up to 15 m in height (Martínez-Yrízar et al., 1992). The climate is hot and strongly seasonal, with a 6–8 mo dry period during which most species remain leafless. Mean annual temperature is 24.6 °C and mean annual precipitation is 788 mm, with 80% of the rain falling between June and November (García-Oliva et al., 2002).