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Understory Colonization of *Eucalyptus* Plantations in Hawaii in Relation to Light and Nutrient Levels

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Abstract

Exotic tree plantations may serve as catalysts for native forest regeneration in agriculturally degraded landscapes. In 2001, we evaluated plant species regeneration in the understory of a 7-year-old experimental *Eucalyptus saligna* forest in Hawaii approximately 1 year after the cessation of 5 years of herbicide. These forests were organized in a 2 × 2–factorial design of planting density (1 × 1– or 3 × 3–m spacing) and fertilization (unfertilized control and regular fertilization), which resulted in varying resource availabilities. We found that understory biomass was highest under high light conditions, regardless of fertilization treatment, whereas species richness was lowest under fertilized 1 × 1–m plots. The understory was dominated by species exotic to Hawaii. The most common tree species, the noxious weed *Citharexylum caudatum*, was particularly successful because high light–saturated photosynthesis rates and a low light compensation point allowed for high growth and survival under both light conditions. To assess longer-term recruitment patterns, we resurveyed a portion of this site in 2006 and also surveyed five *Eucalyptus* plantations in this region of Hawaii that differed in age (5–23 years), species (*E. saligna, E. grandis, E. cloeziana, E. microcorys*), and management (experimental, industrial, nonindustrial stewardship); all were established on previous agricultural sites within approximately 3 km of native-dominated forest. Again, very few native species were present in any of the stands, indicating that within certain landscapes and for native species with certain life history traits, exotic plantations may be ineffective nursery ecosystems for the regeneration of native species.

Key words: biodiversity, Hawaii, regeneration, secondary succession, tropical forest.

Introduction

An increasingly important question in tropical conservation biology is how to restore native biodiversity, ecosystem function, and ecosystem services to large areas at low costs. Extensive areas of tropical forest have been degraded through harvesting and conversion to non-forest land uses (Houghton 1991; Nepstad et al. 1999), with often devastating impacts on native plant and animal biodiversity (Uhl et al. 1990; Nepstad et al. 1991; Whitmore & Sayer 1992; Lugo et al. 1993; Cabin et al. 2002). The duration, extent, and disturbance frequency of a land use practice will determine recuperation rates for an impacted site (Uhl et al. 1990; Nepstad et al. 1991), and for sites that have been heavily impacted, active restoration in the form of weed control and planting may be required to assure the return of native forest cover. However, replanting native forest species to degraded landscapes for conservation purposes is often prohibitively expensive. Further, seed of native species may be difficult to obtain, expertise to propagate native material may be scarce, and replanted forests may be subject to same land use pressures as the original forest (Lamb et al. 2005).

Forest plantations represent one of the fastest growing forest types in the tropics (Brown et al. 1997), and these forests may serve as potential catalysts for native forest restoration on degraded tropical lands because they also can harbor significant biodiversity in the understory (Lugo 1997; see also accompanying articles in the *Forest Ecology and Management* special issue on the topic). Further, they may represent a low-cost approach to native forest restoration by providing an economic return through harvest of the plantation overstory while ameliorating site conditions for colonizing native species through improved microclimate, the buildup of litter, enhanced nutrient cycling, and the creation of roosting sites (Parrotta et al. 1997). However, the use of forest plantations for restoration of native biodiversity is also associated with uncertainty. Understory composition may vary as a function of overstory species (Guariguata et al. 1995; Powers et al. 1997), land use (Haggar et al. 1997), and age (Keenan et al. 1997). In addition, colonization by exotic species can limit recruitment of native biodiversity.

Light levels are an important factor driving understory species composition and growth in forests, as demonstrated by both canopy manipulations (e.g., thinning; Thomas et al. 1999) and tree fall gap dynamics (Denslow 1987). Light manipulations in plantations may favor high light–demanding species, which may include exotic species with higher photosynthetic rates or more efficient light use

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