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Conservation of tropical forest tree species in a native timber plantation landscape

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ABSTRACT

Tropical terrestrial environments are becoming dominated by anthropogenic land-uses, making retention of biodiversity in production landscapes of critical conservation importance. Native timber plantations may represent a land-use capable of balancing production and conservation by potentially supporting understorey plant and tree species otherwise restricted to old-growth forests, with little impact on yield. In this study we investigated the conservation value of native plantation forests in the lowlands of New Britain, Papua New Guinea. We compared the composition of tree species ($\geqslant$10 cm DBH) of unlogged forest to those of different aged native *Eucalyptus deglupta* plantations and intervening (historically logged) secondary forests. We found a high capacity for biodiversity conservation within plantations, with 70% of forest tree species persisting in mature plantations (13–15 years old). However, compositional analyses revealed lower numbers of large individuals ($\geqslant$10 cm DBH) in both late-successional and non-vertebrate-dispersed species in the plantations, indicating the difficulty of retaining mature old-growth forest trees in production land-uses. Secondary forest protected by conservation reserves was compositionally indistinct to unlogged forest. Our results demonstrate the potential for tropical native timber plantations to contribute to the retention of biodiversity. However, appropriate management is required to ensure the persistence of source populations of old-growth forest tree species. With careful planning a balance between production and conservation can be achieved in lowland tropical regions.

1. Introduction

Deforestation and degradation of tropical forests has precipitated a change in the global composition of rainforest cover, whereby around half of remaining forest cover consists of secondary regrowth and degraded old-growth forests (Chazdon et al., 2009b). Tropical lowland forests experience particularly high levels of deforestation because they occur on flat and fertile soil comparative to other tropical forests, making them valuable for agriculture, logging and agroforestry (Miettinen et al., 2011; Wright, 2010). The loss and degradation of these forests has broad ramifications as they contain over half of the world's terrestrial plant and animal species (Dirzo and Raven, 2003; Sodhi et al., 2010) and play a key role in maintaining global carbon and hydrological cycles (Bradshaw et al., 2007; Houghton, 2012). Consequently, sustainable management of lowland forests has been identified as a conservation priority (Bradshaw et al., 2009; Gibson et al., 2012).

The needs of local human populations and global demand for forest products means that the full protection of tropical lowland forests is unlikely (Coad et al., 2009). For example, despite being recognised as one of the world's most significant tropical wilderness areas (Myers et al., 2000), the Southeast Asia–Pacific region has one of the world's highest rates of deforestation and degradation (Shearman et al., 2012). As such, conservation priorities are shifting from using reserve-based systems to ones targeting sustainable management of multi-purpose landscapes, which attempt to balance biodiversity conservation with production land-uses (Melo et al., 2013). For such approaches to be successful, conservation managers need to understand the capacity of different land-uses to support native biodiversity and the processes which allow persistence of species in heterogeneous production landscapes (Perfecto and Vandermeer, 2010).

Native timber plantations may represent a land-use capable of balancing production and conservation in tropical forests. This is

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because they can potentially support understorey plant and tree species otherwise restricted to remnant forest (Bremer and Farley, 2010), which in-turn would provide for rainforest-dependent fauna (Brockerhoff et al., 2010). By contrast, most agroforests and tree crops are comparatively limited in this capacity (Wilcove et al., 2012). However, the extent to which native timber plantations can support plant communities similar to natural forests is poorly understood, particularly outside of the Neotropics (Chazdon et al., 2009a; Stephens and Wagner, 2007). Given the expansion of timber plantations in the tropics (Carnus et al., 2006) and the push for greater representation of native plantations globally (Davis et al., 2012) it is crucial to gain a better understanding of the contribution that such plantations can make to biodiversity conservation.

Little is known regarding the functional breadth of forest plant species that can be supported in native plantations. For instance, do plantations support species from multiple forest successional stages, or only early successional species? How is this affected by plantation age? The ecological mechanisms underpinning the ability of species to colonise native plantations are also poorly understood. Examining how species' traits affect their ability to become established in plantations may provide valuable understanding of the dynamics of understorey composition. For example, following clearing of tropical forests, recruitment of tree communities is largely dependent on *ex situ* colonisation (Chazdon et al., 2007; Holl, 1999) because most of the seed bank and "seedling bank" (pre-existing seeds stored in the soil and small seedlings) is destroyed during land clearing, particularly when fire is used (Mamede and de Araujo, 2008). Consequently, dispersal mode is likely to be a fundamental trait influencing assemblages post-clearing (Uhl et al., 1982).

Here, we investigate the role that native plantation forests can play in biodiversity conservation in the lowlands of New Britain Island, Papua New Guinea. We assess: (1) the relative ability of different aged *Eucalyptus deglupta* plantations and intervening secondary forest (historically logged) elements to support tree species of undisturbed forest; (2) the ability of plantations to support a diverse range of successional tree species (e.g. early-, mid-, and late- successional species); and (3) the effects of dispersal mode on establishment in plantations. We include the non-plantation landscape elements in our study in order to comprehensively assess the biodiversity value of this production landscape and to gain insight into processes influencing the persistence of species within plantations (Chazdon et al., 2009a; Gardner et al., 2009). Identifying the conservation value of native plantations will provide vital information for management and the design of production landscapes.

2. Methods

2.1. Study area

This study was conducted in the Open Bay Timber (OBT) operation area on the Gazelle Peninsula, East New Britain, Papua New Guinea (PNG) (Fig. 1). New Britain is an oceanic island, rich in endemism because of its evolutionary isolation (Mayr and Diamond, 2001). The main vegetation type is wet tropical rainforest. Mean annual rainfall is 2000–3500 mm, with a noticeably wetter period between December and March (McAlpine et al., 1983).

Open Bay Timber is one of only two plantation enterprises in PNG cultivating locally native tree species. The focal species, *E. deglupta* is an evergreen tree native to Indonesia, Timor-Leste, PNG and the Philippines (Ladiges et al., 2003). It is a fast-growing, light-demanding, wind- and water-dispersed species that forms dense, pure stands on river flats and after disturbances such as landslips and volcanic activity (Paijmans, 1973). We have classified it here as an early-successional species (Section 2.4). Before forestry activity at Open Bay (~1950) *E. deglupta* stands occurred naturally on river flats and disturbed patches of lowland forest and were eventually replaced by successional processes, culminating in mixed alluvium forest (Paijmans, 1976).

E. deglupta plantations were first established in the 1980's through conversion of selectively-logged secondary forest, between an elevation of 10–350 m. Plantation management includes clear-fell harvesting, after which remnant logs are left to decompose and fire used to clear weeds prior to seedling planting. Trees are planted on average at a density of ~313 trees/ha (spacing 4 m × 8 m). Manual weed tending occurs from six months-to-three years, and vine cutting from three-to-six years. There is no tree thinning. Plantations are harvested at 15–17 years and *Eucalyptus* timber products are exported predominantly to Vietnam for use in construction and furniture (veneer).

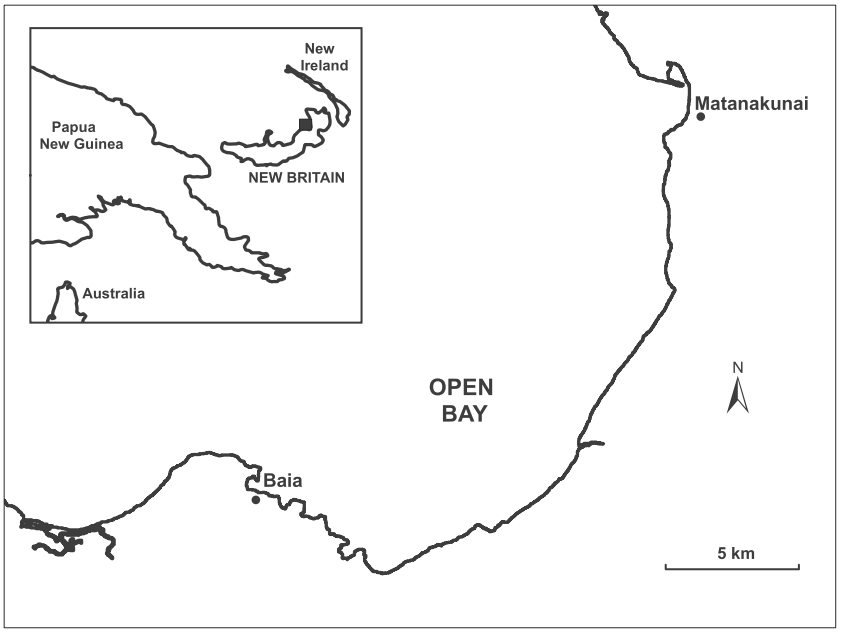

Fig. 1. The study site on New Britain Island, Papua New Guinea.