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Trends in bird diversity over 12 years in response to large-scale eucalypt plantation establishment: Implications for extensive carbon plantings

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ABSTRACT

Large-scale plantations established for timber production or for carbon sequestration can dramatically transform landscapes, however little is known about the response of biodiversity. We report on trends in bird diversity during a 12 year longitudinal study on three large-scale plantations of locally indigenous eucalypts in northern New South Wales, Australia. The study began in a farmland mosaic and has continued to follow bird occupancy rates after the establishment of eucalypt plantations within the paddock areas. Bird surveys were undertaken at focal trees located in different classes of remnant vegetation, which became embedded within the plantations as well as in the plantation matrix itself. Reference sites were also located in adjacent blocks of forest. We found that species richness increased over time in the plantation matrix, as well as remnant vegetation embedded within the plantation (isolated trees, tree patches and remnants, but not riparian locations). When birds were classified as forest-dependent, forest-associated or mosaic generalist, the species richness of forest-associated birds increased and mosaic generalists decreased over time at selected remnant categories. Richness of forest-dependent birds did not change over time. After plantation establishment, bird composition at remnant locations gradually shifted towards that of forest, although all locations remained distinct from forest even after 11 years of plantation growth. The response of 36 individual species was assessed with 47% percent of species increasing over the 11 years and 31% of species declining. Notably the noisy miner, a hyper-aggressive species, decreased over time. We suggest a reduction in the occurrence of this species could be an important contributor to the increase in the diversity of smaller bird species. These include species of regional concern, such as the eastern yellow robin and the rufous whistler, which increased over the study period. Our results suggest that large-scale plantations of locally indigenous species contribute to ecological restoration of cleared landscapes. However, the plantation matrix after 11 years provided less suitable habitat than nearby forest as it supported fewer species, especially for birds that are characteristic of forest. Retention of remnant vegetation at the time of plantation establishment, including large isolated paddock trees, contributed considerably to the biodiversity present in the plantations and is likely to provide key refuge areas during any subsequent harvesting. Continued collection of longitudinal data are needed to describe changes through the full plantation rotation and harvest, while the extent to which other taxa respond to eucalypt plantation establishment also requires documentation.

1. Introduction

Converting farmland to commercial plantations alters the habitat available for biodiversity. Large-scale *Pinus* and *Eucalyptus* plantations tend to provide little habitat for biodiversity in countries where they are established as exotics (Lindenmayer and Hobbs, 2004; Calvino-Cancela et al., 2012). However, evidence for the value of native plantations to biodiversity is more limited (Stephens and Wagner, 2007; Brockerhoff et al., 2008; Mackay et al., 2014). Until recently there were very few published studies describing biodiversity in eucalypt plantations in Australia, where eucalypts are native (but see Woinarski, 1979; Kavanagh and Turner, 1994). There is now a growing body of evidence demonstrating that plantings of eucalypts established on cleared land contributes to ecological restoration in Australia, in that the plantings support higher diversity of some taxa than the surrounding cleared farmland (Kavanagh et al., 2007; Loyn et al., 2007; Munroe et al., 2007; Selwood et al., 2009). However, most of these studies

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are restricted to small plantings on farms, typically <50 ha in size (Bennett et al., 2000; Kinross, 2004). While faunal use of planted patches indicates that additional habitat is being provided for many species, the scale of such plantings may be too small to have a significant impact on biodiversity recovery at the landscape scale.

Proposals for large scale eucalypt plantations to either sequester carbon or for commercial timber production often cover areas >1000 ha in size and could have very different outcomes for biodiversity. Such plantations in their simplest form are monocultures of trees or mosaics of single species stands selected to maximize growth rates under different site conditions, especially topography. Often such plantations comprise species that are locally non-indigenous, such as southern blue gum *Eucalyptus globulus* in Western Australia (Hobbs et al., 2003; Cunningham et al., 2005), though this is not always the case. Little is known about the biodiversity supported by such large scale eucalypt plantations, how this changes with time or what effect plantations might have on biodiversity occurring in remnant native vegetation previously surrounded by a matrix of farmland, but subsequently embedded within the plantation. Indeed, the term 'bio-perversity' has been used to describe the potential for unexpected detrimental effects on biodiversity from establishing large scale carbon plantations (Lindenmayer et al., 2012a).

One example where the scale of plantations could have significant positive implications for bird diversity in south-eastern Australia is the potential effect on the occurrence of noisy miners *Manorina melanocephala*. The noisy miner is a large, communally breeding, endemic honeyeater renowned for aggressively excluding small birds from the area they occupy (Loyn, 1987; Grey et al., 1998; Major et al., 2001; Clarke and Oldland, 2007). Their ability to penetrate into large woodland remnants up to distances of 150–300 m has implications for restoration goals and the size of remnants if any core is to remain 'noisy-miner-free' (Piper and Catterall, 2003; Clarke and Oldland, 2007). Indeed, warnings have been raised that restoration efforts at small-scales may be creating additional habitat for noisy miners (Major et al., 2001; Clarke and Oldland, 2007). In contrast, altering the matrix over a large area from cleared paddocks to eucalypt plantation and in effect softening the edges of embedded remnants has the potential to reduce noisy miner abundance, with consequent increases in the diversity of small birds. The extent to which this might happen in remnant vegetation of different patch sizes remains unknown.

One limitation of most studies of biodiversity in plantations is that they represent chrono-sequences or snap-shots of comparisons between different land-use types. The assumption is therefore made that the matching of treatments is equal and evenly distributed across the same environmental niche and landscape context. Most importantly, a one-year snapshot may not be representative of temporal variation and dynamism over a longer period (Recher et al.,1983; Maron et al., 2005) and as such conservation plans developed from snap-shots may have limitations. In comparison, longitudinal studies are a powerful means of reporting temporal change, especially as a result of an intervention, because temporal and between site effects are separated (Kavanagh and Stanton, 2003; Lindenmayer et al., 2011). The power of longitudinal data is exemplified by Lindenmayer and Cunningham (2011) in an agricultural landscape in south-eastern Australia, where unexpectedly, it was revealed that few bird species had negative trends in reporting rates between 1998 and 2009, a finding that contrasted with a number of other studies. Where such longitudinal data are coupled with an intervention, accurate predictions of various management actions are likely to be possible. Such long-term studies are given high priority by ecologists (Stohlgren et al., 1995; Downes et al., 2008) for discerning land-use change and ecological impacts.

We report on trends in bird diversity during a 12 year longitudinal study of large-scale eucalypt plantation establishment in northern New South Wales, Australia. Most remnants and large paddock trees were retained during plantation establishment on farmland, presenting us with the opportunity to compare temporal trends in diversity in remnants of different sizes with reference sites located within the plantations remote from remnant vegetation and in native forest adjacent to the plantation. The study began in a farmland mosaic of cleared paddocks, scattered trees and remnants in paddocks and continued over time after the establishment of eucalypt plantations within the paddock areas. Initial surveys found that a wide range of fauna were present in the farmland mosaic, and among birds, open country species dominated the farmland and remnants in comparison to sites within adjacent forest (Law et al., 2000). In particular, noisy miners were one of the most frequently recorded birds in the farmland at this stage. Riparian sites supported bird species composition most similar to adjacent forests (Law et al., 2000). We predicted that an increase in the diversity of birds would occur within remnant vegetation embedded within plantations and that this would correspond with a decline in the occurrence of noisy miners over time. Noisy miner decline was predicted to correlate with replacing structurally simple habitat in the open farmland matrix (Loyn, 1987; Major et al., 2001) with less suitable, structurally more complex habitat comprising densely stocked plantation trees. We also predicted the matrix replacement/noisy miner decline would have the strongest effect on bird species associated with forest rather than farmland and that diversity would increase least in larger remnants because modification of the matrix would have less influence on the remnant interior.

2. Methods

2.1. Study areas

Study areas were selected in three different geographical regions of northern NSW to maximize the applicability of results throughout the broad area and to reduce the effect of localized weather patterns on bird movements into and out of the study areas. Each area previously supported cattle grazing, but were subsequently purchased by State Forests of NSW (now Forestry Corporation of NSW) to establish plantations of *Eucalyptus*. Prior to plantation establishment, grazed grasslands dominated all study areas, with scattered isolated mature trees growing in paddocks. Remnant vegetation, often containing many mature hollow-bearing trees, occurred along creek-lines and in fragments within the paddock matrix. Landscape context, such as the extent of native forest in the area, can have an important influence on nearby plantations (MacKay et al., 2014). We controlled for this by selecting only plantations that bordered onto large tracts of adjacent forest (see Law et al., 2000 for more details).

The first study area was a single 2562 ha property ("Kungurrabar") (152°37′E, 29°07′S) located adjacent to the Clarence River, north-west of Grafton. The property was bounded to the east by Sugarloaf and Keybarbin State Forests. Dry sclerophyll forests of *Corymbia variegata* and *E. siderophloia* occurred as isolated remnants on lower slopes and rises, while *Angophora subvelutina*, *E. tereticornis, E. seeana* and *Lophostemon suaveolens* grew along riparian areas or low-lying flats. Remnants were dominated by regrowth vegetation and generally lacked an understorey layer. Blady Grass *Imperata cylindrica* occurred extensively throughout the remnant vegetation.

The second area was located at Rollands Plains ("Sandys" and "Fletchers" – 460 ha), north-west of Wauchope (152°42′E, 31°19′S). Forest continuous with Cairncross State Forest bordered both properties to the south. Scattered across open grassland were a mix of dead stags from ring-barking in the previous 10 years,