The effect of changing land use on the availability of potential nest trees for the endangered Muir's Corella *Cacatua pastinator pastinator*. A case study of the establishment of commercial Tasmanian Blue Gum plantations in Western Australia.

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ABSTRACT

In the mid-1990s commercial Tasmanian Blue Gum *Eucalyptus globulus* plantations were established in south-west Western Australia. . We examined the extent of loss of potential nesting trees for an endangered obligate hollow-nesting cockatoo, Muir's Corella *Cacatua pastinator pastinator*, resulting from establishment of these plantations during 1995-2004. Clearing of native vegetation was extensive in both Tonebridge (51%) and Frankland (76%) study sites. The proportion of land used for timber plantation increased significantly from 2.4% to 12.1% (Tonebridge) and 0.5% to 9% (Frankland) in the period 1995-2004. Plantations were predominantly established on already cleared farmland, but during the rapid development of plantations, large numbers of remnant paddock trees (avg. 56%) in cleared farmland were removed. Despite the loss of more than 50% of potential nesting habitat over an area of 376 km^2 within its current distribution, Muir's Corella continued to increase in numbers. However, there are concerns about delayed impacts of the clearing of potential nest trees we have observed, and consequences of further tree loss during future plantation harvesting. Evidence-based demonstration of biodiversity protection is increasingly needed to fulfil forest and plantation stewardship requirements, so greater care needs to be directed towards the management of extant remnant vegetation in paddocks..

Key words: Muir's Corella, nest tree, paddock trees, Tasmanian Blue Gum plantations, vegetation clearing

INTRODUCTION

Muir's Corella *Cacatua pastinator pastinator* is a large white cockatoo endemic to the south-west of Western Australia (WA; Johnstone and Storr 1998; Higgins 1999). It was formerly distributed from the lower Pallinup River, Albany and Broome Hill west to Augusta and north through coastal plains to the Swan and Avon Rivers (Johnstone and Storr 1998; Higgins 1999; Figure 1; the avian taxonomy used here is consistent with the Checklist of Terrestrial Vertebrate Fauna of Western Australia and what is also used in the threatened species listing at the state and national level). The species was shot and poisoned by early settlers in an effort to protect grain and horticultural crops (Carter 1912) to the extent that by the 1940s its distribution was restricted to the Lake Muir area east of Manjimup. With the benefit of full protection since 1990 it recovered in numbers to just over 13,000 by 2009 (Department of Environment and Conservation *unpublished data*). The subspecies was removed from the WA state threatened fauna list in 2012, although it remains on the national threatened fauna list (http://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=fauna Accessed 30/9/2014). Its range now extends from Boyup Brook in the north, south to Rocky Gully and east to Frankland.

The preferred habitat of Muir's Corella is *Eucalyptus* woodland dominated by Wandoo *E. wandoo* and Marri *Corymbia calophylla* (Massam and Long 1992; Mawson and Long 1994). These woodlands were usually located along drainage lines (Smith and Moore 1992) and typically had deeper, more fertile soils suitable for agriculture; as a result they were preferentially cleared (Jarvis 1979). Conversion of native vegetation to sparsely treed parkland did not negatively impact on food availability for Muir's Corella, as it was able to adapt quickly to a range of introduced foods derived from cultivated grains (Wheat *Triticum aestivum* and Oats *Avena sativa*) and introduced pasture weeds such as Onion Grass *Romulea rosea* and Wild Geranium *Erodium* spp. (Smith and Moore 1992). Therefore, with protection from direct culling, the species appears to be capable of recovering provided there are sufficient nest sites to sustain a viable breeding population.

Muir's Corella is an obligate hollow nesting species, nesting in mature eucalypts such as Wandoo, Marri, Jarrah *E. marginata* and Flooded Gum *E. rudis* and even very large paperbark trees *Melaleuca priesii* ; Mawson and Long 1994). The majority of nest trees are located in otherwise cleared paddocks, on roadside verges or in remnant woodland adjacent to farms or eucalypt plantations. Few nests have been located in surrounding state forest. It is not clear whether this is a pre-existing preference for nest trees located in the valley floors or a result of the removal of the larger trees in the state forest located on upslope areas due to commercial logging activities. Given the differences in soil type and fertility it is likely that nest trees were always more common on the valley floors (Strelein 1988; Biggs *et al.* 2011). What is clear is that persistence of large, hollow-bearing nest trees in otherwise cleared paddocks and in remnant vegetation on agricultural land is necessary for the continued survival of this species.

Diversification of farming activities in the higher rainfall areas of the southwest of WA by including plantation forestry of Tasmanian Blue Gum *E. globulus* (Barbour and

Butcher 1994; Butcher 1996) became popular in the mid to late 1990s. At the time there was little consideration of the biotic implications of establishing these timber plantations (Hobbs *et al.* 2003; Lindenmayer and Hobbs 2004; Kanowski *et al.* 2005). Although recent studies have demonstrated benefits for some woodland birds from planting of native vegetation and hardwood plantations (Kavanagh *et al.* 2007; Lyon *et al.* 2009; Archibald *et al.* 2010), generally the benefits to native wildlife from the establishment of native hardwood plantations have been few. All of the studies that have been conducted to date have focused on which native species can forage or live in tree plantations, but few have examined the potential impact on native fauna associated with the establishment of plantations (Tyndale-Biscoe and Calaby 1975).

Initially, there were no specific policies to guide plantation establishment in WA. When plantations were established on already cleared farm land there was no requirement to obtain government approval to clear remnant vegetation, as the isolated stands of trees or solitary trees in cleared paddocks were not protected by the clearing legislation in place at the time. Early Tasmanian Blue Gum plantation establishment generally involved the felling or pushing over of all native trees remaining in paddocks, although plantations established after 2005 more often involved the retention of some or most large paddock trees. Plantation hardwoods are harvested 10-25 years after establishment, well before they are old enough to form nest hollows that could be used by corellas, and so plantation trees cannot overcome the loss of native hollow-bearing trees removed during the establishment of plantations.

Observations by those involved in recovery efforts for Muir’s Corella suggested that the removal of large mature trees was likely to have a long-term impact on the species due to the loss of critical nesting habitat (Garnett and Crowley 2000; Department of Environment and Conservation 2008). This study quantifies the potential extent of loss of critical nesting habitat for Muir’s Corella due to establishment of Tasmanian Blue Gum plantations on previously cleared farmland by comparing potential nest tree density from aerial photographs taken at the beginning of the establishment phase of commercial plantations with those taken 10 years later, when most of the plantations had been established. We provide comment on current forest stewardship policy and provide recommendations for changes to government policy affecting retention of mature trees in agricultural landscapes to enhance conservation of biodiversity.

METHODS

Aerial photographs for Tonebridge (2229; 1:100000) and Frankland (2329; 1:100000) from 1995 and 2004 were used to examine changes in land use and presence of potential corella nest trees for the areas incorporating Lake Muir, Tonebridge, Unicup (Lake Unicup) and Frankland in the southwest of WA (Figure 1). We use the term potential nest trees here because it is important to note that not all large paddock trees contain hollows, or contain hollows that are suitable for use by obligate hollow nesting species such as Muir’s Corella. Photographs were obtained from the WA Department of Land Administration (now Department of Planning); hard copy photographs were available for 1995, and digital photographs for 2004.

Three broad land-use categories were identified: farmland, characterised by low tree density and a generally geometric outline, remnant vegetation, characterised by high tree density and random tree distribution, and eucalypt plantations, characterised by high tree density, ordered rows of trees and dark green colouration. Areas of land use for 1995 were identified by generating a transparent overlay bearing a 1:25000 grid. The software Earth Resources Mapping (v7.1) was used to measure areas of each land use type for the 2004 digital photographs.

Hard copy photographs from 1995 were digitised using a high-resolution flatbed scanner, and the resulting images rectified and geo-referenced (i.e., resized, adjusted and geographically matched to the 2004 digital photographs) using the software ArcGIS. Areas of farmland in 1995 which were converted to eucalyptus plantation in 2004, in regions consisting of >10% plantation in 2004, were examined for the presence of potential nest trees in both 1995 and 2004. Potential nest trees were identified as single paddock trees, or small clumps of five or fewer trees (which were recorded as a single tree). The location of the trees in 1995 was marked using ArcGIS, the same locations were then examined on the 2004 photograph, and previously marked trees were recorded as present or absent.

Changes in land use were examined using chi-square analysis, with the 1995 data as the expected values and 2004 data as the observed values. Contingency tables were used to determine if the number of potential nest trees had declined significantly between

1995 and 2004, and if the availability and decline of nest trees was similar between Tonebridge and Frankland. Statistical analyses were carried out using StatistiXL v1.8.

RESULTS

In 1995 Tonebridge consisted of approximately 1,016 km^2 of farmland (48% of the region), 1,040 km^2 of remnant vegetation (49.4%) and 51 km^2 of plantation (2.4%). Remnant vegetation was concentrated in the western part of the region, and farmland in the east. There were few areas with > 10 % plantation (Figure 2). In 2004, land use had changed significantly ($\chi^2_2 = 848$, $p < 0.001$). The area of remnant vegetation remained the same (48.8%), farmland was reduced to 814 km^2 (39.1%) and the area of plantation had increased to 254 km^2 (12.1%).

Farmland covered 1,027 km^2 (75.8%), remnant vegetation 321 km^2 (23.7%) and plantation 7 km^2 (0.5%) in Frankland in 1995 (Figure 2). In 2004, land use had also changed significantly, ($\chi^2_2 = 1902$, $p < 0.001$). Although the area of remnant vegetation remained the same, farmland decreased to 912 km^2 (67.3%) and the area of plantation increased to 122 km^2 (9.0%): 1,600% increase in area. Again, new plantations were planted on existing farmland, and did not replace remnant vegetation, although plantations tended to replace farmland in the south of the region in areas where there was mixed farmland/remnant vegetation (Figure 2).

In areas which were subsequently converted to plantation, a total of 7,207 potential nest trees were identified within the Tonebridge region in 1995. Of these, 3,104

(57%) remained within areas converted to plantation in 2004. In Frankland, 5,535 potential nest trees were identified in areas where farmland was subsequently converted to plantation. Of these, 2,475 trees (55%) remained in 2004. There were significantly fewer potential nest trees present in 2004 than 1995 ($\chi^2_1 = 26.3$, $p < 0.001$), but the proportion removed was similar for Tonebridge and Frankland ($\chi^2_1 = 1.35$, $p = 0.246$).

DISCUSSION

Our study indicates that 51% of the Tonebridge region and 76% of the Frankland region had been cleared of native vegetation by 1995 and these proportions were similar in 2004. Graetz *et al.* (1995) used satellite imagery to determine that almost 52% of the intensive land-use zone (about 20% of the Australian continent) had been cleared or thinned and Saunders et al. (1985) that showed that 54% of the south-west of WA was cleared between 1945 and 1982. Our data suggest a similar extent of clearing of native vegetation in Tonebridge, but much more extensive clearing in Frankland than is typical for Australian intensive land-use zones. However, establishment of Tasmanian Blue Gum plantations did not affect the overall area of remnant vegetation retained, as plantations were restricted to already cleared agricultural land. Rather than impacting on areas of natural remnant vegetation, Tasmanian Blue Gum plantations have had a significant effect on agricultural areas, which are of importance as nesting habitats for Muir's Corella (Smith and Moore 1992; Mawson and Long 1994).

Between 1995 and 2004, 254 km^2 (Tonebridge) and 122 km^2 (Frankland) of parkland within the study sites had been converted to plantation. This conversion was associated with a greater than 50% decrease in the abundance of potential nest trees for Muir’s Corella. It might have been expected that removal of such a large quantity of mature potential nest trees would have had an adverse impact on an obligate hollow-nesting species such as Muir’s Corella. However, population survey data (Department of Environment and Conservation 2012) clearly indicate that the population continued to increase for nearly twenty years after establishment of Tasmanian Blue Gum plantations in the region commenced. This suggests that factors other than nest site availability are currently influencing population size of Muir’s Corella.

The rapid establishment and large extent of the Tasmanian Blue Gum plantations suggest that corellas maintained their breeding effort within the farm landscape. We consider this a likely response given that Muir’s Corella is known to nest in loose aggregations within groups of mature eucalypts. As many as three nests have been recorded in a single tree (P. Mawson *pers. obs*.), and there is some fidelity to nests between years (Carter 1912, 1923). There were no reports of major shifts in the distribution of Muir’s Corella within its known range and no new populations were reported establishing outside of its acknowledged range (Department of Environment and Conservation 2008). In the absence of any baseline data on the number of nest hollows available to Muir’s Corella before and after the establishment of the plantations, it is unclear whether the corellas have increased their nesting density within remaining suitable nesting habitat to compensate for the loss of nest hollows, or whether nest hollows are not yet a limiting resource.

The fact that the removal of around 50 percent of the potential nesting trees to facilitate establishment of hardwood plantations has not yet had an obvious negative impact on the population of Muir's Corella to date does not mean that this reduction in a key resource may not have some impact in the future. If the corella population continues to grow, nest site availability could become the factor limiting further population growth, as has been recorded for other psittacids (Wirminghaus *et al.* 2001; Heinsohn *et al.* 2003; Manning *et al.* 2004). Development of Tasmanian Blue Gum plantations has potentially halved the number of available nest hollows. The remaining potential nest trees are also subject to a suite of impacts associated with grazing by stock, fertilizer application, herbicide spray drift (Landsberg and Wylie 1983; Reid and Landsberg 2000) and general decline in tree health associated with aging (Saunders *et al*. 2003; Gibbons *et al.* 2008; Saunders et al. 2014). Added to these issues are emerging fungal diseases such as Marri canker (Paap 2006; Paap *et al.* 2008); the incidence of which is nearly three times higher in paddock and roadside trees than in forest trees. The other likely major impact on nest tree availability is the possible removal of remaining potential nest trees during the plantation harvesting process.

To gain, or retain access to, international export markets for hardwood fibre and timber products, plantation managers are increasingly subject to biological audits. They are required to demonstrate a secure chain of custody of all marketed wood products (Anon. 2013). A similar situation exists for producers seeking Australian Forest Stewardship Certification (Forest Stewardship Council of Australia 2013) for timber products marketed on the domestic market. The general focus of current policy documents is directed at mitigating the impact on conservation values in extant forest (where 'forest' is a term not defined in Forest Stewardship Council of Australia policy). The policies are silent concerning potential impacts on biodiversity through the establishment of plantations on production lands that have already been 'cleared'. Plantation owners may have difficulty in addressing issues such as the loss of critical nesting habitat for a listed species such as Muir's Corella or any of the three sympatric, listed black cockatoo *Calyptorhynchus* species, even when the loss of the original habitat occurred nearly 30 years ago and may have been carried out by a third party.

Governments need to reconsider the value of remaining native vegetation on lands that have already been largely cleared, and accept that remnant vegetation retained within those cleared landscapes has both intrinsic and economic value. While the replacement value of this habitat has been estimated with respect to carbon and salinity mitigation costs (Lindenmayer and Burgman 2005), no estimate has been made of the value of this habitat to native wildlife, including threatened species. If some value could be assigned to the remnant vegetation in 'cleared' paddocks then it is likely that more informed and balanced decisions could be made regarding proposed clearing, even if the default value was the predicted costs (or part thereof) of implementing the recovery actions set out in recovery plans for state and national threatened species affected by agricultural and forestry activities.

The advisory documents and codes of practice (Anon. 2006) that have variously been developed to facilitate the establishment of plantation forestry should be revised to consider specifically the impact on wildlife associated with the establishment of plantations, rather than limit themselves to the potential benefits (lowered water tables, improved water quality, reduced soil erosion) that could arise from integration of plantations into farm economies, and the limited, but often cited, benefits of plantations to wildlife (Archibald *et al.* 2010). Future native hardwood plantings on private property are likely to be a consequence of some form of carbon market as much as the current paper pulp fibre market. If such a system does evolve then it will be critical that whatever eucalypt species are planted are locally native, and are planted in so wildlife has a genuine prospect of benefiting. Even if no new industry based on hardwood plantings is established, the need to remove existing plantations at the end of the current rotation to restore the land under plantations to an arable condition may lead to the loss of the < 50% remaining remnant vegetation in cleared paddocks unless clear policy and legislation pertaining to paddock trees are developed and implimented.

Manning and Lindemayer (2009) examined the issues of paddock trees and parrots in agricultural production landscapes in south-eastern Australia, and provided a vision for future landscapes that could be equally applicable in areas of south-western WA such as those inhabited by Muir's Corella. An appreciation of wildlife issues when considering funding models for any future carbon industry is needed to ensure that any money provided to establish an alternative farm forestry program to sequester carbon is not limited solely to farm economics, but genuinely delivers biodiversity gains, and does not result in further loss of critical wildlife habitat, as has been demonstrated in this study.

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Figures

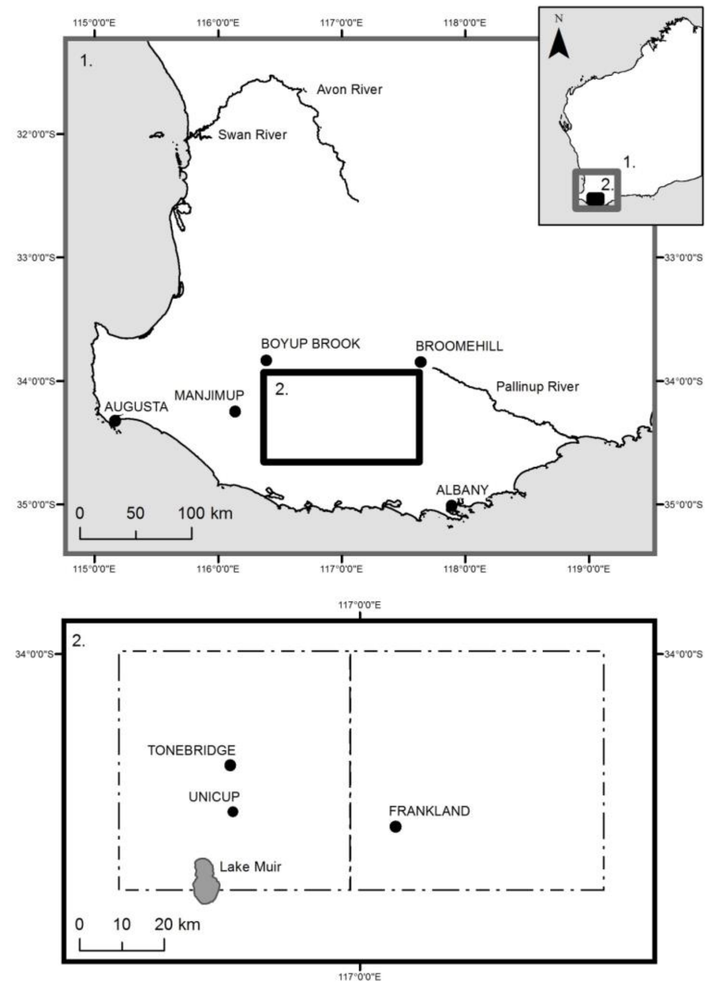

Figure 1 Location of the study sites at Tonebridge and Frankland, within in the greater southwest of Western Australia.

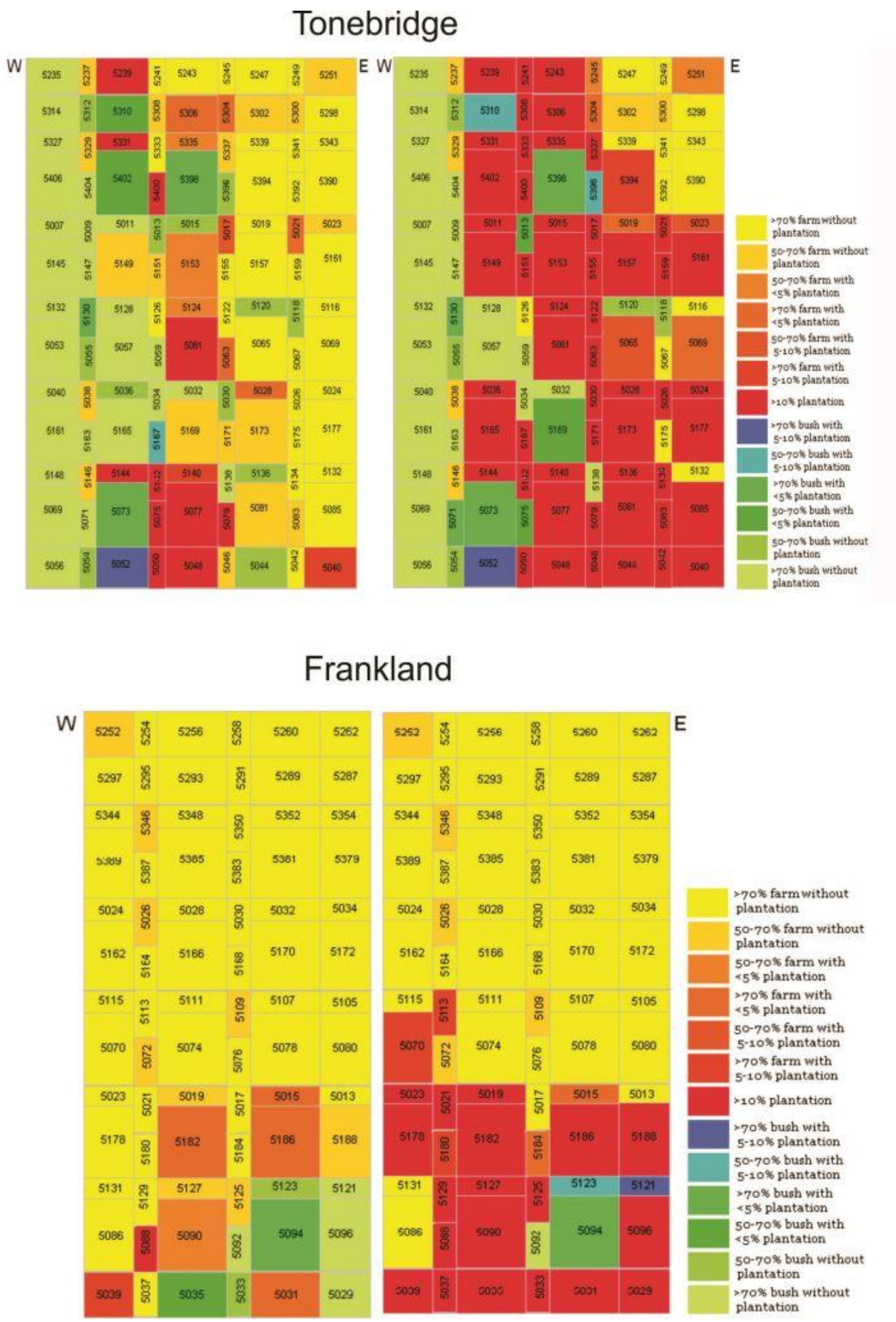

Figure 2 Distribution of land use changes in Tonebridge and Frankland, Western Australia in 1995 and 2004, identified from aerial photographs.