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Regrowth woodlands are valuable habitat for reptile communities

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ABSTRACT

Protection of passive regrowth, or secondary vegetation, offers the potential to cost-effectively alleviate biodiversity declines caused by deforestation. This potential often goes unrealised because the habitat value of regrowth is generally considered marginal. However, the habitat value of regrowth varies among taxa. Disturbed subtropical woodland landscapes provide large-scale passive restoration opportunities. Subtropical woodlands are also rich in reptile diversity. We addressed the question: 'What is the habitat value of subtropical regrowth woodlands for reptile communities?' We identified five commonly-observed models of regrowth habitat value and then surveyed reptile communities in 43 cleared, regrowth and remnant *Acacia*- and *Eucalyptus*-dominated woodland sites in subtropical Queensland, Australia. Reptile species richness, diversity, dominance and community composition followed the "regrowth = remnant" model of high regrowth value, where the habitat values of regrowth and remnant woodlands were similar, and higher than that of cleared land. Unexpectedly, the proportion of juveniles was highest in cleared sites and lower in both regrowth and remnant sites. Our findings challenge the view that the habitat value of regrowth is limited. Consistency in findings between contrasting woodland types suggest that our results may apply in other similarly disturbed woodlands. We conclude that although remnant woodlands are irreplaceable, regrowth woodlands provide valuable habitat for reptile communities and the protection of such regrowth should be a high priority in disturbed subtropical woodland systems.

1. Introduction

Globally, the loss of habitat is the primary cause of biodiversity declines (Dirzo and Raven, 2003; IUCN, 2008). Habitat restoration attempts to redress this loss, although there is little evidence that any restoration method can ultimately restore full biodiversity or ecosystem function (Allen, 1995; Munro et al., 2007; Rey Benayas et al., 2009). Despite this, forests and woodlands in the regrowth phase of restoration can contribute to biodiversity recovery (Plieninger and Gaertner, 2011) and have inherent conservation value (Bowen et al., 2009; Chazdon et al., 2009; Lindenmayer et al., 2012). However, the habitat value of regrowth is difficult to quantify and varies among taxa (Barlow et al., 2007). This has led to the biodiversity conservation value of regrowth being overlooked in vegetation management plans (e.g. Government of South Africa, 2010; Queensland Government, 1999). To maximise restoration and biodiversity benefits in disturbed landscapes, it is vital to understand how regrowth contributes to habitat availability for different biota.

Whilst the spatial extent of active restoration is limited by costs and logistics, passive regrowth can provide important restoration and biodiversity benefits for large areas at minimal cost (Geddes et al., 2011; Guerrero, 2010; Prach and Hobbs, 2008). Passive regrowth is prominent in subtropical woodlands that have been cleared for agriculture, particularly in the most extensively deforested woodland areas of the world such as the Chaco in South America (Dinerstein et al., 1995; Grau et al., 2005) and the Brigalow Belt and Mulga Lands in Australia (Australian State of the Environment Committee, 2001). Woodlands in these regions are high in biodiversity, particularly of reptiles (Covacevich et al., 1998; Leynaud and Bucher, 2005; Uetz, 2010); however many species are declining due to historical and contemporary habitat loss (IUCN, 2010).

Regrowth is generally considered to have intermediate habitat value between cleared or cultivated, and intact vegetation, based on studies focusing on bird and invertebrate communities (Bowen et al., 2007; Gardner et al., 2007a; Gibson et al., 2011). However, the responses of different taxonomic groups to the same disturbance can vary considerably, with regrowth vegetation ranging in habitat value from minimal to high (Barlow et al., 2007). Such findings highlight the limited capacity to generalise the responses of one or two taxa, and the need to understand the impact of

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disturbance and recovery on all components of biodiversity (Barlow et al., 2007; Wolters et al., 2006). To date, the impact of disturbance and recovery on reptile communities has received minimal attention (Gardner et al., 2007a).

Studies assessing the value of regrowth as habitat for reptile communities are geographically biased towards tropical regions and rainforests (Shvidenko et al., 2005), with few studies in subtropical or temperate woodlands (Bowen et al., 2007). Those studies located in cooler and drier regions tend to suffer from insufficient sample size and statistical power (e.g. Green and Catterall, 1998), or compare reptile communities in regrowth and remnant vegetation, but not disturbed areas (e.g. Cunningham et al., 2007; Michael et al., 2011). Given the lack of research in the subtropics, and little consensus on the value of regrowth for reptiles in tropical and rainforest areas (e.g. Gardner et al., 2007b; Kanowski et al., 2006; Luja et al., 2008), it is difficult to infer the value of subtropical and temperate regrowth woodlands for reptile communities.

In Australia, controls on clearing that were recently introduced have resulted in large areas of subtropical woodland regrowth (Geddes et al., 2011; McAlpine et al., 2009) that have the potential to increase the amount of habitat available to reptiles and aid in arresting declines (Driscoll, 2004). Yet the value of such regrowth as habitat for reptiles is not known (Munro et al., 2007). Therefore, empirical assessments of the capacity for regrowth woodlands to help conserve and restore reptile diversity are vital in these highly disturbed regions.

We addressed the question: Do regrowth woodlands have equivalent, lower, or higher habitat value for reptile communities than remnant woodlands and cleared areas? To answer this question, we developed five models of regrowth habitat value for taxonomic communities in disturbed and intact vegetation. We then surveyed reptile communities in cleared, regrowth and remnant woodlands in sub-tropical Queensland, Australia, and compared our field data against these models. This process enabled us to determine the relative habitat value of passive regrowth in comparison to cleared and remnant woodlands for reptile communities.

2. Methods

2.1. Habitat value models

To assess the value of regrowth vegetation as habitat for reptile communities, we first defined three levels of regrowth habitat value – limited, moderate and high – based on published taxonomic community trends in disturbed, regrowth and remnant vegetation (Fig. 1, Appendix A). Disturbed sites were defined as those experiencing ongoing disturbance that prevents ecosystem regeneration (e.g. regular clearing, cultivation etc.). Regrowth sites were those that had experienced historical clearing but no recent structural disturbance, and are naturally regenerating ecosystems. Remnant sites were those with no record of historical clearing or recent structural disturbance. The most commonly observed trends in fauna diversity, abundance and community composition in these three vegetation states were used to develop five competing models of regrowth habitat value (Fig. 1b), which form the conceptual framework for our analyses. A detailed description of the studies we reviewed in formulating the models can be found in Appendix A. The models are:

(1) "Null" model: No difference in community measures (diversity, abundance, biomass etc.) between cleared/cultivated, regrowth and remnant vegetation; and community compositions in cleared/cultivated, cleared and remnant vegetation do not differ. Regrowth is of limited habitat value for biodiversity restoration.

(2) "Cleared = regrowth" model: Community measures do not differ significantly between cleared/cultivated areas and regrowth vegetation, but are significantly lower than in remnant vegetation (Fig. 1b); and community compositions in cleared/cultivated and regrowth vegetation are similar to each other but divergent from that of remnant areas. Regrowth is of limited habitat value for biodiversity restoration.

(3) "Increasing" model: Community measures increase from cleared/cultivated to regrowth to remnant vegetation (Fig. 1b); and community composition is nested, with cleared/cultivated communities containing a subset of species found in regrowth, and regrowth containing a subset of species found in remnant vegetation. Regrowth is of moderate (intermediate) habitat value for biodiversity restoration.

(4) "Regrowth = remnant" model: Community measures do not differ significantly between regrowth and remnant vegetation, but are significantly higher than in cleared/cultivated areas (Fig. 1b); and community compositions in regrowth and remnant vegetation are similar but divergent from that of cleared/cultivated areas. Regrowth is of high habitat value for biodiversity restoration.

(5) "Complementary" model: Community compositions differ significantly between cleared/cultivated, regrowth and remnant vegetation, and are not nested (Fig. 1b). This model applies to community composition only. Regrowth is of high habitat value for biodiversity restoration because it contains a unique community composition.

2.2. Predicting reptile community trends

In our literature search, we found only five studies that had assessed reptile communities in cleared/cultivated, regrowth and remnant woodlands (Appendix A): four in tropical rainforest, one in tropical and subtropical rainforest, and one in tropical woodlands. Reptile species richness and abundance trends varied in these studies; however, the "cleared = regrowth" model, indicating limited regrowth habitat value, was the most commonly observed model for both richness and abundance (Appendix A). Community composition was assessed in only two studies ($n = 4$ groups), with the "complementary" model dominating (Appendix A). Only one study assessed species diversity (Bowman et al., 1990) and another study assessed evenness (Gardner et al., 2007b), with both identifying "increasing" model trends (Appendix A). These findings were used to establish *a priori* predictions of the trends expected in our study (Table 1).

2.3. Study area and habitat classification

We assessed reptile community trends in a regenerating woodland landscape in semi-arid subtropical Queensland, Australia (Sattler and Williams, 1999, Fig. 2). Rainfall at the closest meteorological station averages 530 mm per year, with temperatures averaging from 21 to 34 °C in summer, and 6 to 20 °C during winter (Bureau of Meteorology, 2013).

Forty-three survey sites were located at least 1 km apart in three woodland states: (i) "Remnant": woodlands that had never been cleared (Queensland Government, 2010), (ii) "Regrowth": areas that were first cleared 10–23 years prior to this study and had regrown to approximately half the canopy height of remnant areas, and (iii) "Cleared": treeless paddocks containing a mixture of native and introduced pasture grasses. The specific land use history for the study area is uncertain prior to 2001 due to changes in ownership and tenure; however, historical aerial photographs show that regrowth areas were initially cleared between 1988