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Conservation cornerstones: Capitalising on the endeavours of long-term monitoring projects

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ABSTRACT

Ecological monitoring is widely used to measure change through time in ecosystems. The current extinction crisis has resulted in a wealth of monitoring programs focussed on tracking the status of threatened species, and the perceived importance of monitoring has seen it become the cornerstone of many biodiversity conservation programs. However, many monitoring programs fail to produce useful outcomes due to inherent flaws. Here we use a monitoring program from south-eastern Australia as a case study to illustrate the potential of such endeavours. The threatened carnivorous marsupial, the brush-tailed phascogale (*Phascogale tapoatafa*), has been monitored at various locations between 2000 and 2010. We present strong evidence for a decline in relative abundance during this period, and also describe relationships with environmental variables. These results provide insights likely to be valuable in guiding future management of the species. In the absence of the monitoring program, informed management would not be possible. While early detection of population declines is important, knowledge of the processes driving such declines is required for effective intervention. We argue that monitoring programs will be most effective as a tool for enhanced conservation management if they test specific hypotheses relating to changes in population trajectories. Greater emphasis should be placed on rigorous statistical analysis of monitoring datasets in order to capitalise on the resources devoted to monitoring activities. Many datasets are likely to exist for which careful analysis of results would have benefits for determining management directions.

1. Introduction

Long-term monitoring is commonly employed to improve understanding of ecological systems and is the cornerstone of many conservation endeavours (Lindenmayer and Likens, 2010; Lovett et al., 2007). The goal of all monitoring programs is to detect change through time in an entity of interest, often in response to environmental change, anthropogenic disturbance, or targeted management actions (Legg and Nagy, 2006; Lindenmayer and Likens, 2009). As the number of species threatened with extinction continues to grow worldwide, long-term monitoring and research is becoming increasingly important for tracking the status of species (e.g. Hawkins et al., 2006; Mac Nally et al., 2009), with the ultimate objective being to document population declines and guide management to facilitate population persistence.

Despite their prevalence, the usefulness of monitoring programs is often equivocal. Projects frequently suffer from deficiencies including vague goals and objectives, inadequate study design, and lack of rigorous data analyses and self-assessment (Field et al., 2007; Lovett et al., 2007). Consequently, monitoring programs may fail to report any findings, or worse still, management actions may be based on anecdotal observations that lack quantitative support. Monitoring activities can also be limited by a focus on pattern but not process: documenting a decline may be of limited value if the underlying cause of the decline is not also identified. This has led to greater scrutiny of monitoring projects and a more critical evaluation of how scarce conservation resources are utilised (McDonald-Madden et al., 2010). Various authors (e.g. Lindenmayer and Likens, 2009; Nichols and Williams, 2006) have advocated an 'adaptive monitoring' framework whereby objectives are clearly defined, data collection is governed by careful study design, and findings are fed back into the framework to guide future efforts. A key component of this framework is

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rigorous statistical analysis of collected data. Such analyses permit conclusions to be drawn with confidence and can be used to refine and improve monitoring protocols (Field et al., 2007; Lindenmayer and Likens, 2009). Despite the unquestionable value of this step, formal analysis is a much neglected aspect of monitoring programs (Field et al., 2007; Lovett et al., 2007).

We believe that long-term monitoring and research has an important role to play in conservation biology and that, when conducted appropriately, can be a valuable tool for informing management. In this paper we illustrate this point using a monitoring program for a threatened carnivorous marsupial, the brush-tailed phascogale (*Phascogale tapoatafa*), as a case study. Populations of *P. tapoatafa* have been monitored in south-eastern Australia since 2000, providing an opportunity to rigorously analyse the dataset and identify trends in relative abundance through time. Population trajectories are also analysed in relation to broad environmental variables. Through this case study we demonstrate the value of long-term monitoring and the importance of critical assessment of monitoring outcomes. We also argue that studies of mechanistic processes should be more routinely incorporated into monitoring programs to facilitate understanding of population trajectories and to allow informed management interventions.

2. Methods

2.1. Study species

P. tapoatafa is a small carnivorous marsupial that feeds mostly on arthropods. It is largely arboreal and requires tree hollows for nesting (van der Ree et al., 2006). Large area requirements typically result in low densities. All males die shortly after the annual breeding season, thereby obtaining a maximum age of 1 year. After weaning their first litter, most females do not survive to breed a second time (Rhind and Bradley, 2002; Soderquist, 1993).

In the south-eastern Australian state of Victoria, *P. tapoatafa* is currently distributed across north-eastern, central and western regions (Fig. 1) where it occurs in Dry Forests containing box, ironbark and stringybark eucalypt species with an open understorey and little ground cover (Menkhorst, 1995). Much of the original forest in this region has been cleared for agricultural development: remaining forest typically occurs on areas less suitable for agricultural production, is highly fragmented, and is often disturbed by grazing, mining and firewood collection (Environment Conservation Council, 2001). As a result of this habitat loss and degradation, *P. tapoatafa* has declined in both distribution and abundance (Menkhorst, 1995) and is classified as threatened in Victoria.

An Action Statement for *P. tapoatafa* prepared under the Victorian *Flora and Fauna Guarantee Act 1988* identifies long-term monitoring at key habitat sites as an important management action to identify changes in population size and vulnerability (Department of Sustainability and Environment, 2003). In response, the Brush-tailed Phascogale Coordinating Group has been conducting population surveys at various sites across Victoria since 2000.

2.2. Study area

P. tapoatafa populations have been monitored at 17 sites (Fig. 1), located in large forest blocks ($\geqslant$2200 ha) within the known distribution of the species. All sites contain Dry Forests and woodlands characterised by stringybark, box and ironbark eucalypts. Midstorey vegetation generally consists of a moderate to sparse shrub layer, over a moderate to sparse ground layer of grasses and herbs. Long-term mean annual rainfall across the monitoring sites ranges from 464 mm at Dalyenong to 788 mm at Kinglake (mean = 594 mm).

2.3. Monitoring protocol

Surveys for *P. tapoatafa* were always performed between February and May. Sites were surveyed a maximum of once per year, but only a subset of sites was surveyed in any given year (Fig. 2). Six sites (Bolangum, Paddys Ranges, Rushworth, Wellsford, Ararat and Pyrenees) were surveyed on just one occasion between 2000 and 2010, while Reef Hills and Mt. Pilot were surveyed on ten and nine occasions, respectively (Fig. 2).

A single trapping transect was employed at each monitoring site. Forty trap stations (39 at Hepburn, Ararat, Pyrenees and Mt. Cole) were established per transect with a spacing of 300 m between each trap station (total transect length = 11.7 km). Two large Elliott aluminium traps (48 cm $\times$ 15 cm $\times$ 16 cm) were deployed at each trap station. Traps were fixed to T-shaped wooden brackets, nailed to the bole of trees at a height of approximately 2 m. Large, rough-barked eucalypts were chosen for trap deployment. A bait mixture of peanut butter, rolled oats and honey was squeezed into

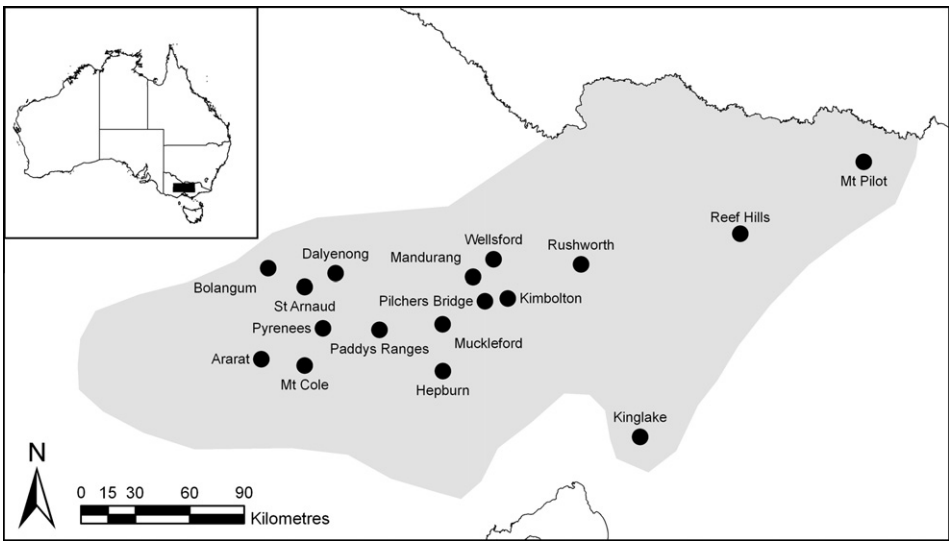

Fig. 1. Location of 17 monitoring sites for the brush-tailed phascogale (*Phascogale tapoatafa*) in Victoria, south-eastern Australia. Grey shading indicates the approximate current distribution of *P. tapoatafa* in Victoria.