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Declining woodland birds – is our science making a difference?

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Recent data from the Red List of the International Union for the Conservation of Nature show that 1240 of the world's estimated 10 027 species of birds (12.4%) are listed as threatened (Hoffmann *et al*. 2010). Globally, many more are 'declining' in conservation status. In Europe, much attention has been given to the marked decline in the abundance and distributional extent of farmland birds associated with the intensification of agricultural production (Fuller *et al*. 1995; Donald *et al*. 2001). Recent analyses suggest woodland species also may now be experiencing significant declines (e.g. Hewson *et al*. 2007). In the Americas, the declining status of neotropical migrants has motivated considerable research over the last 30 years (e.g. Terborgh 1989; Robinson and Wilcove 1994). In the tropics, narrowly endemic land birds have been identified as those species most at risk of decline globally in coming decades owing to projected changes in land-use (Jetz *et al*. 2007). Particular taxonomic groups also are experiencing marked declines. Migratory shorebirds, for example, which depend on key stop-over sites for refuelling during intercontinental migration, are particularly vulnerable to the degradation and destruction of these sites (Barter 2002; Rogers *et al*. 2010). Such widespread change among the world's avifauna has profound implications for global biodiversity, ecosystem function and the provision of ecosystem services (Sekercioglu 2006).

In Australia, the declining conservation status of 'woodland' birds has raised much concern over the last two decades (e.g. Robinson and Traill 1996; Ford *et al*. 2001). Typically, these are species associated with forests (~30–70% canopy cover) and woodlands (~10–30% canopy cover) of temperate southern Australia: from south-eastern Queensland through parts of New South Wales (NSW), Victoria, Tasmania, South Australia (SA) and Western Australia (WA). Vast tracts of forest and woodland have been transformed into the 'wheat–sheep' belt of Australia, the backbone of Australia's agricultural production and agricultural export industries. Although the nation's economy has benefited from production agriculture, it has come at a substantial ecological cost, including the clearing of native vegetation, typically 80–90% or more in many districts (Hobbs and Yates 2000) and profound changes to the biota of these systems (Lindenmayer *et al*. 2010). The 'cost' to woodland birds is manifested in terms of population declines (Barrett *et al*. 2003; Olsen *et al*. 2005), reductions in geographical ranges (e.g. Franklin *et al*. 1989) and cumulative losses of species from districts and regions (e.g. Saunders 1989; Ford *et al*. 2009), ultimately leading to the listing of woodland bird species among Australia's threatened fauna.

Woodland birds are the theme of this special issue of *Emu – Austral Ornithology*, which arose from a symposium of the Fifth Australasian Ornithological Conference held in December 2009 at Armidale, NSW, itself a noted centre for research on woodland birds. In addition to Watson's essay that expands on his keynote address, five of the papers in this issue (Doerr *et al*. 2011; Ford 2011; Maron *et al*. 2011; Sunnucks 2011; Szabo *et al*. 2011) arise directly from that symposium. The remaining three (Bilney *et al*. 2011; Jenner *et al*. 2011; Weaving *et al*. 2011) are additional contributions that complement this theme. Collectively, these papers represent the current state of knowledge about woodland birds, including overviews of recent work, reviews of methodological approaches, and stimulating new insights and perspectives. But what does research contribute to the conservation dilemma of population decline in woodland birds? How effective is our science in finding solutions to this problem? Are we making a difference?

We suggest that scientific research contributes in at least five ways to knowledge-based solutions to arresting the decline of woodland birds in Australia. These are: (1) documenting declines in woodland birds, including the taxonomic scope, geographical extent, magnitude and rate of declines; (2) identifying ecological patterns and correlates of decline; (3) proposing and testing mechanisms potentially associated with population decline; (4) evaluating solutions to arrest declines and promote recovery; and (5) developing conceptual models and analytical tools to enhance conservation management. We use this framework to place the papers in this volume in the context of wider work, to highlight the contributions that research is making to the issue of declining woodland birds, and to identify areas for further attention.

Documenting declines in woodland birds

A critical first step in addressing any environmental issue is to understand the parameters of concern. What is the problem? Where does it occur? How severe is it? In reviewing advances in knowledge over the last 10 years, Ford (2011) notes in this issue

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that there is now stronger evidence of the scope and extent of decline in woodland birds. Descriptive reports and summaries of historical changes (e.g. Ford and Howe 1980; Saunders 1989; Robinson 1993; Reid 1999) are now complemented by quantitative comparisons of change based on data from successive time intervals or (rarely) long-term repeated surveys (Ford *et al*. 2009; Mac Nally *et al*. 2009; Szabo *et al*. 2011; Lindenmayer and Cunningham 2011). Comparisons of records from the two national atlassing periods (1977–81 and 1998–2002; Birds Australia, Melbourne), the most comprehensive datasets in Australia, are particularly valuable in documenting species that have experienced national declines (Barrett *et al*. 2003).

There are still important gaps in our knowledge. Little is known about the relative rate and magnitude of decline among species, and how this may vary geographically. Not all woodland species are declining, and of those that are, it is not necessarily consistent among populations or regions (Barrett *et al*. 2003). Although not a woodland species, the population decline of the White-fronted Chat (*Epthianura albifrons*) documented in this issue by Jenner *et al*. (2011) illustrates this point well and demonstrates the value of quantitative data. For NSW as a whole, the reporting rate of this species declined by 65% between 1981 and 2005, but the decline was more pronounced in some bioregions than others. In the Sydney region, the species now is known from only two of 56 historical locations, and at both of these sites population sizes have continued to decline since 1996 (Jenner *et al*. 2011).

A critical insight from studies of woodland birds is recognition of the phenomenon of 'extinction debt' – the time-lag in the loss of species following habitat change. There is increasing evidence that we are now paying the extinction debt (Traill *et al*. 1996; MacHunter *et al*. 2006; Ford *et al*. 2009), with ongoing losses of species accumulating from local to district to regional levels. Quantitative analyses, such as that presented here by Szabo *et al*. (2011), are valuable in identifying those species most vulnerable to loss. However, it is far from clear how many species might be lost from particular regions, or as a consequence of particular forms of land transformation, and the time-scale over which such losses are likely to extend. A fundamental lesson is that we cannot assume that if we do nothing, present avifaunal assemblages will persist as they are: changes *will* occur.

Identifying ecological patterns and correlates of decline

Contributions in this issue by Bilney *et al*. (2011), Weaving *et al*. (2011) and Maron *et al*. (2011) add to a growing body of research that documents ecological patterns associated with the distribution of woodland birds and changes in their conservation status. Maron *et al*. (2011), for example, note the profound influence on the woodland avifauna of the extensive loss and fragmentation of temperate forests and woodlands. They review published studies of woodland birds in fragmented landscapes in south-eastern Australia to compare the relative influence on bird assemblages of the area of remnant woodland patches, isolation of patches, habitat structure, grazing by stock, and interspecific interaction with meliphagid miners (*Manorina* spp.) (Maron *et al*. 2011). In such fragmented landscapes, increasing evidence also points to the value to birds of modified elements, such as roadsides, scattered trees in paddocks, tree plantations and exotic vegetation (Cale 1990; Fischer and Lindenmayer 2002; Haslem and Bennett 2008*a*). Such modified habitats are critical for the conservation of some species of concern; for example, scattered trees in farmland for the Superb Parrot (*Polytelis swainsonii*) (Manning *et al*. 2004) and roadside networks for the Grey-crowned Babbler (*Pomatostomus temporalis*) (Robinson 2006).

Insights into the occurrence of species in different vegetation types, topographical positions and land-uses provide essential knowledge for conservation management. Bilney *et al*. (2011) describe in this issue how they used radio-telemetry to locate roosting and foraging sites of the Sooty Owl (*Tyto tenebricosa*), which then allowed comparison of the use of different vegetation types and different logging histories by this rare forest owl. They found that the scale of home-ranges occupied by these owls was greater than previously assumed. Watson (2011), in this issue, notes that declines of woodland birds have not occurred equally in all vegetation types; 'declining' species such as the Red-capped Robin (*Petroica goodenovii*), Diamond Firetail (*Stagonopleura guttata*) and Southern Whiteface (*Aphelocephala leucopsis*) may be scarce in eucalypt woodlands but persist in non-eucalypt woodlands dominated by species of *Allocasuarina*, *Callitris* or *Acacia* (Watson *et al*. 2000). Creeklines and riparian vegetation comprise a minor component of most landscapes but typically support rich assemblages of woodland birds (Bentley and Catterall 1997; Mac Nally *et al*. 2000) and have a conservation value disproportionately greater than their area. Knowledge of the values of regrowth vegetation (e.g. Bowen *et al*. 2009) and replanted areas (Munro *et al*. 2007) for woodland birds are invaluable for ecological restoration in modified systems.

The kinds of issues that conservation managers must address often relate to larger scales – to landscapes, catchments and regions. How much native vegetation is needed to retain the woodland avifauna? What configuration of habitats will enhance connectivity for declining populations? Where in the landscape will habitat restoration have the greatest benefit? Studies at individual sites or patches have only limited capacity to answer these questions. However, as noted by Ford (2011), recent research at the landscape scale is starting to address these questions and identify the properties of 'whole landscapes' that most benefit species and assemblages of woodland birds (Radford *et al*. 2005; Haslem and Bennett 2008*b*). In this issue, Weaving *et al*. (2011) illustrate the value of a multi-scale approach: they identify the properties of whole landscapes and of sites within landscapes that are associated with the occurrence of three nocturnal bird species across an urban to forest gradient. In doing so, they also provide new insights into the way in which urbanisation affects bird species, including species-specific differences in response to such landscape change.

Proposing and testing mechanisms associated with decline

In a seminal contribution, Ford *et al*. (2001) reviewed the potential causes for the decline of woodland birds in Australia. While recognising the overarching impacts of loss, fragmentation and degradation of habitats on bird species, they highlighted the importance of understanding mechanisms that lead to decline. Here, Ford (2011) reports an increased emphasis on 'process' in ecological research as one of the primary advances over the last decade. For example, recent studies have examined processes such as reproductive success and nest-predation (Debus 2006), movement and dispersal within fragmented landscapes (Cooper and Walters 2002; Cale 2003), foraging modes and degree of specialisation (Antos *et al*. 2008), and interspecific interactions with competitors (Maron 2007).

An important new dimension in understanding processes associated with the conservation of woodland birds is outlined in this issue by Sunnucks (2011). This significant review examines how genetic approaches provide both complementary and unique insights into the persistence of bird populations in the highly modified landscapes with which they must contend. Genetic approaches, for example, can be used to identify population boundaries and the differentiation of populations in space and time; and they provide important insights into the effective size of populations and the potential effects of inbreeding and genetic drift on population decline. They also offer valuable techniques for investigating dispersal rates, dispersal distances and the effectiveness of dispersal events (Sunnucks 2011), metrics that have proven far more difficult to estimate via traditional ecological methods. The emerging field of landscape genetics (Manel *et al*. 2003; Sunnucks 2011) offers great potential for integrating genetic approaches with data on demography, environmental gradients (e.g. vegetation, climate) and landscape structure to evaluate present impacts and future consequences of human land-use.

Movement of individuals and their genes among different habitat patches is of fundamental importance for species persisting in highly modified and fragmented landscapes. This has stimulated considerable research on the role of connectivity in conservation (Crooks and Sanjayan 2006). Initially considered in terms of continuous corridors of habitat, current studies of connectivity take a more functional approach, as discussed by Doerr *et al*. (2011), who compare movements of the Brown Treecreeper (*Climacteris picumnus*) with those of several other species. As one of the better-studied woodland birds in Australia, this cooperatively-breeding cavity-nester has yielded rare insight into the population-level consequences of individual gap-crossing decisions. Importantly, Doerr *et al*. (2011) found that other species (both nomadic and sedentary) also use scattered trees as ‘stepping stones’ and share similar gap-crossing thresholds, hinting at a more generalised response to the quality and spatial arrangement of wooded habitat. They speculate that species that have occupied the same kinds of environments over evolutionary time may share similar movement behaviour.

There is increasing evidence of the importance of interspecific aggression, particularly by the Noisy Miner (*Manorina melanocephala*), in determining the structure of woodland bird communities, as highlighted in this issue by Maron *et al*. (2011). By comparing studies in numerous localities, they show that the presence of the Noisy Miner is consistently associated with reduced abundance and richness of small insectivorous woodland birds. Such correlative observations have been confirmed by experimental work (Grey *et al*. 1998). The woodland bird assemblages most vulnerable to the Noisy Miner are those in small remnants, along roadsides, or at edges and peninsulas of large blocks (Loyn 1987; Taylor *et al*. 2008), and the problem is particularly associated with woodlands dominated by eucalypts (Maron 2007), including those on more-fertile soils (Oldland *et al*. 2009). Such knowledge provides a foundation for restorative action, whether by manipulating vegetation to reduce its suitability for Noisy Miners or by direct culling of the species at selected sites (Maron *et al*. 2011).

A further mechanism underlying declines of woodland birds, advanced in this issue by Watson (2011), relates to the effects of agricultural land-use on soil and water resources in south-eastern Australia, and hence the productivity of woodlands. He argues that selective loss of woodlands on the most fertile soils, coupled with the effects of grazing by domestic stock and a shift in the storage of water from within the soil to surface reservoirs (e.g. farm dams), has profoundly altered woodland food webs. The resulting decrease in primary productivity means there are reduced resources (e.g. invertebrates, nectar, vegetation structure) for woodland birds. This resource-based approach emphasises the causal influence of proximal factors – such as shrub cover, ground litter and availability of tree hollows – that provide shelter, foraging sites or nesting resources for bird species, compared with spatial attributes of woodland habitats such as patch size or isolation (Watson 2011).

Evaluating solutions to arrest decline and promote recovery

A hallmark of conservation science is the imperative to move beyond description, analysis and explanation, to direct involvement in developing and evaluating solutions to environmental problems. If ongoing declines in woodland birds are to be halted, and recovery initiated, then substantial changes in land management and an increased commitment to restoration are essential (Ford 2011). There is a critical role for science in proposing and monitoring different kinds of conservation actions, and evaluating their effectiveness in enhancing the status of woodland birds and their habitats.

Several authors in this issue point to the kinds of measures likely to be beneficial, including large-scale restoration and rehabilitation of woodlands (Ford 2011; Szabo *et al*. 2011), manipulating woodlands to make them less suitable for Noisy Miners (Maron *et al*. 2011), and directing management efforts to more fertile parts of the landscape (Watson 2011), but this compilation does not include specific examples of studies or reviews of the effectiveness of such conservation measures. However, other recent work illustrates the potential for research to inform and evaluate conservation actions: for example, the use of ‘natural experiments’ to examine the effect of stock grazing and tree clearing on woodland birds (Martin and McIntyre 2007) and to compare the relative values of remnant vegetation and planted vegetation on farms (Cunningham *et al*. 2008). Paton and O’Connor (2010) document other valuable examples where the benefits of woodland restoration for birds are being evaluated.

Developing conceptual models and analytical tools to enhance conservation management

An important way in which science contributes to conservation is by proposing and refining conceptual models of how a system ‘works’, and by developing analytical tools to measure, interpret and make predictions.

Central to understanding the status of woodland birds is an appreciation of how they have been affected by anthropogenic landscape change. A transition from a conceptual model of woodland fragments as 'islands' of habitat in a 'sea' of unsuitable terrain, to one in which landscapes are viewed as mosaics (or variegated habitats) of different land-uses of differing quality for woodland birds (e.g. McIntyre and Hobbs 1999) opens up different possibilities. One of these is new insights about connectivity, illustrated by Doerr *et al*. (2011) in this issue, in which different kinds of natural and semi-natural elements in the landscape (e.g. scattered trees) can enhance gap-crossing abilities and hence structural connectivity for birds. A second is the key message offered by Watson (2011), that woodlands differ profoundly in the resources they offer birds owing to differing levels of productivity. Where such new thinking generates testable predictions (e.g. Watson 2011) it creates the opportunity to further advance conceptual understanding.

New analytic tools and techniques can enhance research outcomes and also the application of scientific knowledge in setting priorities for conservation. Sunnucks (2011) highlights many opportunities that recent advances in molecular ecology offer to evaluating changes in bird populations, including ways in which population genetics may complement demographic analyses and work in concert with traditional ecological approaches to estimate connectivity between disjunct populations directly. Similarly, Szabo *et al*. (2011) illustrate a new flexible approach, list-length analysis, for analysing data from monitoring programs for woodland birds. This carefully designed monitoring program for woodland birds, sustained for 10 years, illustrates the potential for systematic monitoring not only to document past trends, but to identify likely trajectories of species (increasers, decliners) in the future.

Is our science making a difference?

The contributions in this special issue on woodland birds, together with recent research (Ford 2011), provide a wealth of new knowledge and insights for the conservation of woodland birds in Australia. Our science *is* making a difference in terms of improved understanding of the decline of woodland birds: there is now more quantitative data on trends in distribution and abundance; increased knowledge of factors that influence the status of species at both site and landscape scales; new insights into mechanisms and processes that underlie population trends; and more sophisticated analytical tools and techniques to analyse, interpret and predict change.

Scientific understanding on its own, however, cannot enhance the status of woodland birds. Whether or not woodland birds continue to decline, or recover, ultimately will be determined by how forest and woodland environments in Australia are managed. This depends, in turn, on the policies of state and federal governments and the land-management practices of thousands of private landholders and public land managers who collectively manage this national asset. Consequently, the extent to which science actually is 'making a difference' to woodland birds depends on the extent to which scientific understanding is incorporated in conservation and management practice. It has recently been demonstrated that vertebrate conservation efforts can make a difference (Hoffmann *et al*. 2010), highlighting two critical issues: effective communication of science and effective engagement of science in the implementation and evaluation of conservation measures.

On a pragmatic note, measuring the extent to which science-based solutions have resulted in improvements to woodland bird populations and their habitats over the last 30 years is difficult owing to a paucity of long-term monitoring. Aside from Birds Australia's Atlas of Australian Birds (see http://www.birdata.com.au/about_atlas.vm, accessed 20 January 2011), there is no continent-wide monitoring of bird populations and little way of knowing whether many local or regional strategies have effected meaningful change (but see Paton and O'Connor 2010). Likewise, there have been remarkably few longitudinal studies of woodland birds through time. The recently declared network of Important Bird Areas throughout Australia (Dutson *et al*. 2009) offers an unprecedented opportunity to establish ongoing fixed-site monitoring at a national scale, allowing comparison between southern areas experiencing declines with northern and inland areas that currently support relatively intact bird assemblages.

The greatest asset we have, however, in ensuring the long-term conservation of Australian woodland birds are the birds themselves. Whether the haunting cry of a Bush Stone-curlew (*Burhinus grallarius*) or a bright red Flame Robin (*Petroica phoenicea*) sitting atop a fence-post, most farmers and land managers have fond memories of native birds on their properties, and often are well aware of the local extinctions and changes in abundance associated with overall declines. By building on this personal connection and highlighting the value of woodland birds as indicators of habitat integrity and ecosystem function, we remain optimistic that broad-based changes in land-use practice can be achieved. The papers contained in this special issue help to take a further step in this direction.

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