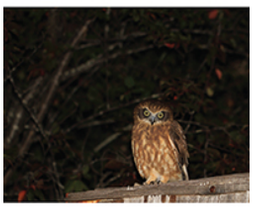
EMU AUSTRAL ORNITHOLOGY



Emu - Austral Ornithology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/temu20

Using anecdotal reports to clarify the distribution and status of a near mythical species: Australia's Night Parrot (*Pezoporus occidentalis*)

Nicholas P. Leseberg, Ian A. W. McAllan, Stephen A. Murphy, Allan H. Burbidge, Leo Joseph, Shane A. Parker, Nigel A. Jackett, Richard A. Fuller & James E. M. Watson

To cite this article: Nicholas P. Leseberg, Ian A. W. McAllan, Stephen A. Murphy, Allan H. Burbidge, Leo Joseph, Shane A. Parker, Nigel A. Jackett, Richard A. Fuller & James E. M. Watson (2021): Using anecdotal reports to clarify the distribution and status of a near mythical species: Australia's Night Parrot (*Pezoporus occidentalis*), Emu - Austral Ornithology, DOI: 10.1080/01584197.2021.1927760

To link to this article: https://doi.org/10.1080/01584197.2021.1927760

Published online: 22 Jun 2021.

EMU - AUSTRAL ORNITHOLOGY
https://doi.org/10.1080/01584197.2021.1927760

Taylor & Francis
Taylor & Francis Group

Using anecdotal reports to clarify the distribution and status of a near mythical species: Australia's Night Parrot (*Pezoporus occidentalis*)

Nicholas P. Leseberg[a,b], Ian A. W. McAllan[c], Stephen A. Murphy[a,b], Allan H. Burbidge[d], Leo Joseph[e], Shane A. Parker[f], Nigel A. Jackett[a,b], Richard A. Fuller[g] and James E. M. Watson[b,g]

[a]School of Earth and Environmental Sciences, The University of Queensland, Brisbane, Queensland, Australia; [b]Green Fire Science, The University of Queensland, Brisbane, Queensland, Australia; [c]Information Access and Advisory Services, Library, Macquarie University, New South Wales, Australia; [d]Department of Biodiversity, Conservation and Attractions, Woodvale Research Centre, Western Australia, Australia; [e]Australian National Wildlife Collection, National Research Collections Australia, CSIRO, Canberra, ACT, Australia; [f]South Australian Museum, Adelaide, South Australia, Australia; [g]Centre for Biodiversity and Conservation Science, School of Biological Sciences, The University of Queensland, Brisbane, Queensland, Australia

ABSTRACT

Shortfalls in our knowledge of the most basic parameters, such as overall range and population size, ensure evidence-based conservation of poorly known or 'missing' species is inherently difficult. Often, the only source of such knowledge is anecdotal reports, which are usually considered too unreliable to be of value. Methods that help conservation decision-makers use anecdotal records of poorly known or 'missing' species to decide where conservation action should occur, and how urgent that action might be, will support better conservation decisions for those species. Here, we use a Delphi-style process based on expert opinion to assess the largely anecdotal sightings record of the Night Parrot (*Pezoporus occidentalis*), an endangered species from arid central Australia that underwent a significant decline following the arrival of Europeans. Our results clarify the patterns and possible causes of this decline and subsequent range contraction. We conclude that the species persists in only two broad regions, and is probably extinct throughout much of its former range. Our method is applicable to other poorly known species with a similarly sporadic and largely anecdotal sightings record. This method could be used to clarify the historical and current distribution and status of such species, a critical first step in understanding their conservation requirements.

ARTICLE HISTORY
Received 19 November 2020
Accepted 6 May 2021

KEYWORDS
Anecdotal; conservation; uncertainty; sightings record; missing species; Night Parrot

Introduction

For poorly known or 'missing' species, anecdotal reports are often the only source of even the most basic information such as distribution or abundance. Notoriously unreliable (McKelvey *et al.* 2008), anecdotal reports may be the only data available on where a species can be found. Nonetheless, conservation planners must use these reports when estimating a species' risk of extinction (IUCN Standards and Petitions Committee 2019), or planning for a species' conservation (Rondinini *et al.* 2006). This makes effective evidence-based conservation difficult (Pullin and Knight 2001; Sutherland *et al.* 2004), particularly the accurate conservation assessment of data-deficient species (Bland *et al.* 2017). Methods that overcome the unreliability inherent in anecdotal occurrence data will improve the quality of decisions based on those data (Boakes *et al.* 2010).

Anecdotal reports of rare species are either a legitimate record, a case of mistaken identity, or very occasionally, a fabrication (Harrop *et al.* 2012). Wrongly accepting or rejecting contemporary reports may obscure the true status of a species (Roberts *et al.* 2010; Pillay *et al.* 2014), while mishandling historical reports can obscure trends in the status of a species over time (McKelvey *et al.* 2008; Roberts *et al.* 2010). Reliance on historical and contemporary false positive data has led to real and significant errors regarding the presence, population dynamics, and range of rare species (McKelvey *et al.* 2008). In such cases, field research is often the only way to reveal such errors. However, for poorly known, extremely rare, or cryptic species, meaningful field research may not be possible, so conservation assessments must rely almost entirely on review of anecdotal reports. Techniques have been developed to overcome the uncertainty associated with anecdotal reports, and are typically used to calculate the probability that a species is extinct (Thompson *et al.* 2013; Lee *et al.* 2015). Although useful when deciding whether to continue searching for a species or fund its conservation, these techniques do not necessarily provide detail

CONTACT Nicholas P. Leseberg n.leseberg@uq.edu.au

on a species' recent biogeographic history. Particularly for poorly known species, this is important information that may provide valuable insights into whether a species is threatened, what processes have driven changes in distribution, and where it remains extant.

Emblematic of this problem is the Night Parrot (*Pezoporus occidentalis*), a species for which there are little primary data, but numerous anecdotal reports. A nocturnal parrot endemic to arid central Australia, the Night Parrot was typically found in association with dense, low vegetation such as long unburnt *Triodia* grasslands or samphire flats (Andrews 1883; Wilson 1937). It was first seen by Europeans in 1845 (Davis 2002), and specimens were collected occasionally from inland Australia until the late-19th century (Higgins 1999). For most of the 20th century, the only evidence of the parrot's existence was a trickle of rumours and unconfirmed reports (see e.g. Wilson 1937; Parker 1980). Irrefutable proof of its continued survival only arrived in 1990 when a dead Night Parrot was found in western Queensland (Boles *et al.* 1994). Finally, in 2013 an extant population was discovered in Queensland (Koch 2013), and several further populations have since been found in Western Australia (Jackett *et al.* 2017).

Although it was accepted that the Night Parrot underwent a severe decline, this sporadic and primarily anecdotal history of its detection has not supported a clear narrative describing changes in its likely status and distribution. In the period where only anecdotal records were being made, some ornithologists wondered whether the species was actually extinct (Lendon 1968), while others thought it might not even be rare, simply very difficult to detect (Schodde and Mason 1980). Adding to the confusion, some historical reports are widely accepted (e.g. Wilson 1937; Parker 1980), while others meeting apparently similar evidentiary standards were less readily accepted (e.g. Menkhorst and Ryan 2015; Hamilton *et al.* 2017). This confusion has been perpetuated by sensationalism of recent media reports claiming the Night Parrot was thought extinct, a spate of new discoveries including several that remain unconfirmed (e.g. Beavan 2017), and findings that some claimed detections were fraudulent (Menkhorst *et al.* 2020).

For regulators assessing the potential impact of development on the Night Parrot, or agencies responsible for improving the species' population trajectory, knowing where it may occur, and its status, are fundamental requirements. In the absence of such data, we detail a method using the historical record of Night Parrot sightings to describe both changes in the species' distribution over time, and its likely current status and distribution. After compiling a database of all known and purported Night Parrot encounters, we use a method for reviewing anecdotal reports to assess the degree of certainty for each encounter. We use the results to map the distribution of the Night Parrot over time, including its likely current distribution. Lastly, we combine these results with a review of historical reports describing the Night Parrot's status to draw conclusions around historical changes in status. Beyond establishing these parameters for the Night Parrot, the method we propose is non-specific. It could be applied to other poorly-known or 'missing' species, improving the quality of formal conservation assessments such as extinction risk, and the resulting decisions by environmental regulators.

Materials and methods

Our basic process was to (1) compile reports of the Night Parrot, (2) assess the degree of certainty of each record, then (3) examine the resulting sight record and determine whether it revealed any patterns of occurrence that could provide insight into the species' historical distribution, and any changes in that distribution.

Compilation of Night Parrot record database

As a 'missing' species, the Night Parrot has always enjoyed a high public profile, and there is an extensive catalogue of alleged encounters. Commencing in the 1970s, SAP began compiling these encounters into a single database, a process continued by IAWM, with recent additions by AHB, SAM and NPL. The database contains all known reports the authors are aware of, from multiple sources, including but not limited to scientific journals, government reports, birding magazines, the general media, personal communications, and government-led campaigns that aimed to solicit information from the public. A 'report' included any reference to a possible encounter with a Night Parrot, such as sightings (first and second hand), specimen locations, photographs, and more recently, recorded calls. The database is comprehensive; searches for published reports have been exhaustive over several decades, and given the public profile of the Night Parrot, it is probable that most encounters have been either published, or reported directly or indirectly to the authors.

Details of the location, date, observer, and any relevant notes for each report were recorded in the database. The location information for some reports was vague, only permitting assignment to a general locality, often the centroid of a named property. As the aim of this study was to recognise trends at a continental scale,

these reports were retained. Only one report could not be assigned to a locality, so was removed for this analysis. The year of each sighting was noted. The median year was assigned to reports that included a possible date range. The latest year in a range of years was assigned to reports that included several encounters at a single site over time, as this reflected the last time the species was known to occur at the site.

Report assessment

We used expert opinion to assess the certainty that each of the 238 reports was of a Night Parrot. Expert opinion is commonly used in conservation science to resolve questions not easily answered empirically (Burgman *et al.* 2011a; Martin *et al.* 2012). However, because expert opinion varies, sometimes greatly due to inherent bias or differences in expertise, methods have been developed that account for this variation when deriving an accurate estimate of a specified parameter (Burgman *et al.* 2011b; McBride *et al.* 2012). These methods are extensions of the Delphi-style 'estimate-feedback-estimate' process, requiring experts to provide an initial independent opinion based on available information. Anonymised results of that initial elicitation are presented to the experts, and the opportunity provided to discuss them. Each expert may then revise his or her estimate, with the final result a combination of these final estimates.

For this assessment, AHB, SAM, NAJ and NPL were selected as experts. Each is an ornithologist with extensive field experience, and importantly, all four have direct field experience with the Night Parrot and are familiar with the Night Parrot literature. Although four seems a small number of experts, even small numbers of experts produce accurate estimates (Clemen and Winkler 1985) and extending the group to include additional experts with less experience of the species seemed unlikely to improve the result.

Before commencing their assessment, each expert was provided with the following list of factors to consider, where possible, when assessing each report: the physical description of the bird/s; observer experience (including previous experience with Night Parrots); observer pre-disposition to wanting to see a Night Parrot; light conditions; distance from observer to bird; duration of observation; habitat; range; behaviour; and, number of observers in the party (if more than a single observer). A scoring rubric was also provided, containing uncontentious examples of each of the six score categories (Appendix S1). Experts were then asked to consider each report, and estimate how *certain* they were each report was actually a Night Parrot by assigning a score of zero to five: zero for a report that was certainly not a Night Parrot, five for a report that certainly was a Night Parrot. Although research supports the separate assessment then pooling of some factors (Lee *et al.* 2015), it would have been difficult to assign an appropriate and consistent weighting across so many factors without artificially distorting the final score of some reports. Using an overall assessment allowed the experts to exercise their judgment in assessing the importance of each factor for any given sighting. Finally, it is important to note that the score expresses the *degree of certainty* that a particular report was of a Night Parrot. It is likely some low scoring records were in fact Night Parrots; however, the report did not include enough detail to be certain.

After each expert provided their initial independent assessment of each report, the results were collated, anonymised, and distributed to all experts for consideration. While there was consistency on many assessments, there were several where estimates varied. A discussion was held among the experts that focused on the assessment process, and particularly those records where there were clear differences in opinion. Following this discussion, each expert was invited to revise their estimates. These revised estimates were then averaged to determine a final score representing the certainty that each report was of a Night Parrot. The estimates of all experts were weighted evenly.

In addition to specific records, we collated any statements found in the literature that directly or indirectly referred to the status of the Night Parrot. Our aim was to determine whether any patterns of decline could be established from this commentary that might support patterns of decline established through the analysis of specific records.

Analysis of records

Inferring changes in status and distribution based on changes in the number of records meeting the certainty thresholds required variation in the number of records meeting the threshold to be spatially and temporally random. We confirmed that mean certainty scores for all records that involved some subjective assessment (i.e. those records not supported by definitive proof such as a skin or audio recording) were not correlated temporally ($r = -0.08$, $p = 0.25$), or spatially, using state as a proxy for spatial location (ANOVA, $F_{5,197} = 0.50$, $p = 0.77$). Because temporal changes in survey effort could influence interpretation of the results, we also examined changes in the rate of reporting over time (see Results).

We then extracted all reports of the Night Parrot that achieved an overall certainty score > 2.5. Reports that surpassed this threshold were termed 'probable' records. While this threshold is arbitrary, it achieves the requirement of applying a consistent standard to each report across the entire reporting period.

Research in Queensland (Murphy *et al.* 2017) and emerging evidence from Western Australia (Borrello 2018, N. Leseberg unpub. data) suggests that Night Parrots are largely sedentary, not nomadic as proposed by some authors (Andrews 1883; Higgins 1999). If this is true, the detection of Night Parrots in an area at a particular time could reasonably suggest a history of occupancy in that area up to that time. Therefore, we plotted all probable records of the Night Parrot since 1845 to represent a minimum estimate of the pre-European range of the Night Parrot. To detect changes in distribution over time we repeated this, plotting all probable records post 1920, post 1960, and post 2000. We reasoned that if birds were not recorded in a region since these particular years, it was likely they had ceased to occur in that region sometime before that year. The year 1920 was chosen as by this time the decline of the Night Parrot was being reported widely (White 1913; Whitlock 1924). The year 1960 was chosen because it represents the time by which all likely threats to the Night Parrot had reached their current extent within the species' range, and enough time had elapsed for their impact to be realised (Burbidge *et al.* 1988). The year 2000 was chosen to approximate the current distribution of the bird.

To determine whether raising the certainty threshold could lead to different conclusions, we repeated this analysis, using only reports scoring ≥3, and again using only reports scoring ≥4. These were classified respectively as 'likely' and 'very likely' records.

Finally, we reviewed all statements extracted from the literature that referred to the status of the Night Parrot. Statements were attributed a period, geographic location, and inferred status of the Night Parrot at the assigned location and time. The statements were placed in chronological order, and examined for trends at different spatial scales (Appendix S2).

Results

We collected 238 reports of Night Parrot, spanning the period 1845 to 2020. Seventy of these reports were classified as 'probable' records. Of these 'probable' records, 54 were classified as 'likely', and 34 as 'very likely'. There were probable records from all mainland states and territories except New South Wales and the Australian Capital Territory. Except for the 1870s, rates of reporting were consistent from 1845 until around 1960 (Figure 1). From 1960 onwards there was an increase in the rate of reporting, which continues to the present day. The 1870s spike in reports is associated with the work of F.W. Andrews, who collected most of the known Night Parrot specimens around this time (Black 2012). Increased reporting rates from the 1960s onwards probably reflects greater awareness of the species' plight, particularly following the widely publicised

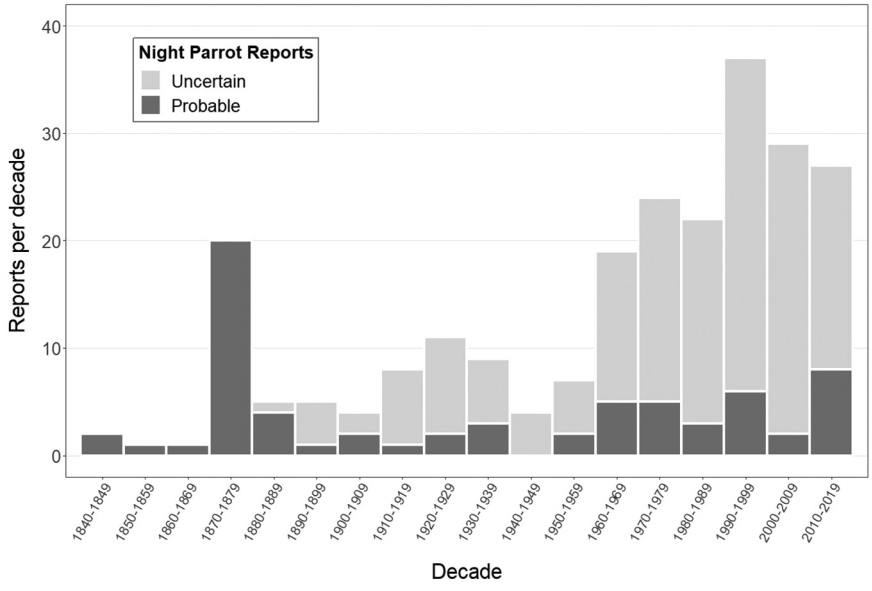


Figure 1. Plot of both uncertain and probable Night Parrot reports per decade since the first reported sighting in 1845, demonstrating a relatively consistent rate of confirmed sightings against an increasing rate of unconfirmed reports.

discovery of a dead Night Parrot in 1990. This discovery resulted in several campaigns for information relating to Night Parrot sightings, particularly by the Western Australian government. The increased number of probable reports in the decade 2010–2019 is associated with the 2013 discovery of birds in western Queensland, and subsequent development of effective detection methods which has led to the discovery of Night Parrots at several locations in central northern Western Australia.

Pre-European distribution

The plot of all probable Night Parrot records since 1845 is consistent with Night Parrots being found throughout central Australia prior to European settlement (Figure 2). Given the species can apparently persist in the driest parts of the continent, the absence of records from the Simpson, Gibson, Great Victoria and Tanami Deserts may reflect a lack of search effort rather than genuine absence. Several records obtained from these areas did not contain enough detail for acceptance, but it seems likely the bird occurred in suitable habitat throughout Australia's interior. Given the species' occurrence in north-western Victoria, it is also probable the species once occurred in far south-western, and possibly western New South Wales. With few exceptions, most reports that did not reach the threshold to be considered probable records were from areas where it was possible the Night Parrot did occur. Therefore, it is important to recognise that the absence of probable records does not necessarily indicate the historical absence of Night Parrots.

Using these results we constructed an approximate historical range using a smoothed convex polygon incorporating all probable records, and regions where, despite no probable records, the Night Parrot could have occurred. This was not meant to represent a definitive historical range, but a visual baseline against which potential changes in range could be compared.

Post-European changes in distribution

Since 1920 there have been probable records from throughout the Night Parrot's historical range. Although there were no apparent changes in distribution, there were few records from the southeast of the

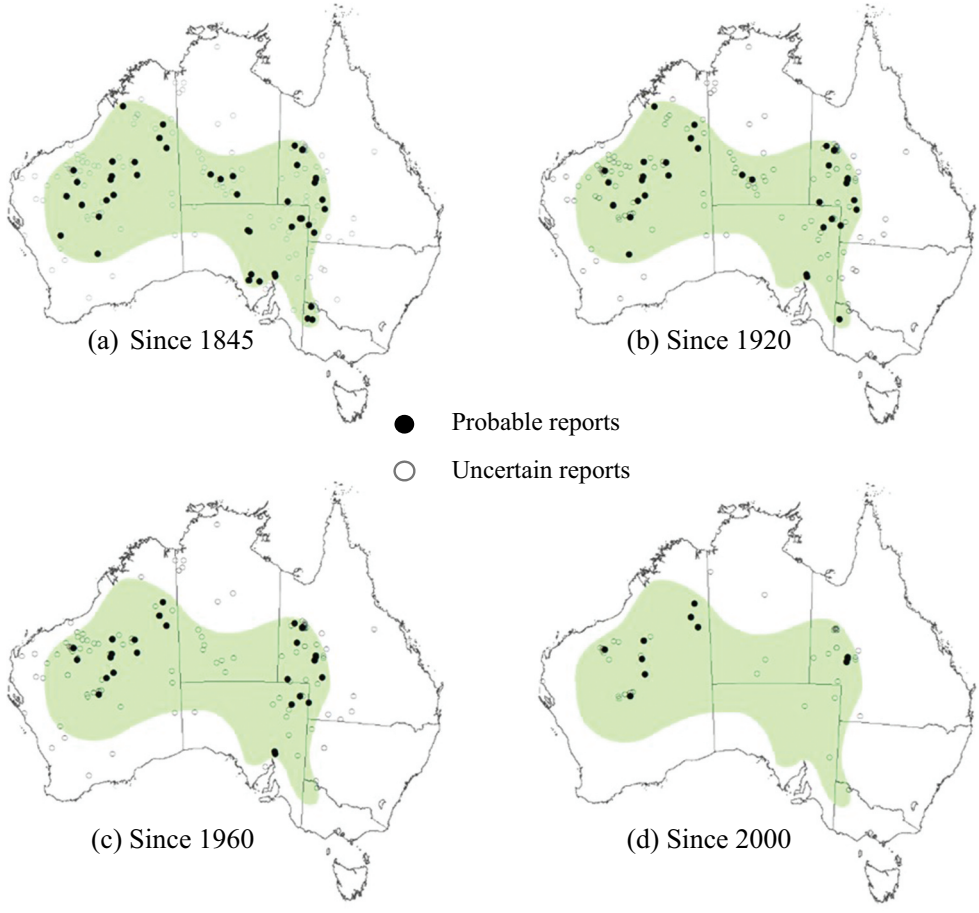


Figure 2. Probable and uncertain Night Parrot reports since (a) 1845, (b) 1920, (c) 1960 and (d) 2000. There is an apparent range retraction when compared against the approximate historical range (shaded green).

bird's range, and only two records from the southern Northern Territory, despite several records prior to 1920.

Since 1960, there have been continuing records from the northern part of the bird's historical range, but no records from northwest Victoria, and only two records from southern South Australia, suggesting a contraction from the southeast. There are also no probable records from the southern Northern Territory since 1960.

Since 2000, there have been probable records from only two regions of the Night Parrot's historical distribution: western Queensland, and central northern Western Australia. The lack of probable records from the southeast of the bird's historical range suggest the Night Parrot is locally extinct in southern South Australia and northwest Victoria. Likewise, the absence of probable records from the southern Northern Territory since before 1960 suggest local extinction. Importantly, increased rates of both unconfirmed reports and probable records from elsewhere as the range contraction progresses, point to the range contraction being genuine rather than an artefact of survey effort.

Effect of raising stringency for required certainty

Raising the stringency required for certainty of sightings did not change the estimated pre-European distribution substantially (Figure 3), although no records from northwest Victoria received a certainty score ≥ 4. Applying the higher certainty scores across the different periods produced similar results for each period, but suggests an acceleration in the decline, with Night Parrots not recorded in southern South Australia or the southern Northern Territory after 1920. The overall outcomes of this decline are similar, with the species retreating to western Queensland and central northern Western Australia.

Pre-European status and subsequent decline

Consideration of all statements relating to the Night Parrot's pre-European status suggest the species was at times relatively common, or at least regularly encountered, throughout most of its range. The species was reported sporadically from northwest Victoria and from central and northeast South Australia in the 1870s and early 1880s (Andrews 1883; Menkhorst and Ryan 2015). Its decline in Victoria had certainly been noted by the turn of the century, and likely earlier (Menkhorst and Ryan 2015), and by 1885, declines had been noted in the Gawler Ranges and the Lake Eyre Basin. It is probable no skins were received by the South Australian Museum after 1872, despite searches by the prolific collector of Night Parrots, F.W. Andrews (Black 2012; Olsen 2018). This abrupt disappearance within a decade indicates a rapid disappearance from the southeast of the species' range.

Declines in central Australia apparently commenced about 20 years after declines in the southeast, and were possibly more gradual. The Night Parrot was seen regularly in the southern Northern Territory until at least the early 1890s (North and Keartland 1896). In 1923, F. L. Whitlock spoke to several informants in the region who claimed first-hand knowledge of the species, including Indigenous Traditional Owners. They reported seeing the bird occasionally until around 1905, but rarely thereafter (Whitlock 1924).

Few reports indicate when the Night Parrot began to decline in Western Australia. It was encountered occasionally throughout central Western Australia until around 1900, with some observers reporting it as 'plentiful' at locations in the state's northwest (North and Keartland 1898; Wilson 1937). M. Bourgoin, who knew the bird well, claimed five encounters between 1912 and 1935 in central Western Australia (Wilson 1937), suggesting the species was persisting, perhaps at low densities. The bird's apparent disappearance from this part of its range was being reported by the mid-1920s (Olsen 2018). Although the evidence is not conclusive, this decline apparently came later, and was not as severe as the initial declines in southeast and central Australia.

Discussion

This analysis explored whether the record of largely anecdotal sightings of the Night Parrot could be used to infer spatial and temporal changes in its geographical range. Because there are only 28 specimens known (Black 2012), and few definitive sight records since the bird was first seen by Europeans in 1845, there is little evidence to sustain robust conclusions about the bird's distribution and status. Given how difficult the species is to detect, coupled with the vast and remote landscapes it inhabits, it will be some time before the Night Parrot's true status can be determined through field research. In these circumstances, methods that harness the anecdotal record fill a critical gap and support decisions around management priorities and required research.

Application to other species and associated risks

This method ultimately relies on anecdotal reports, which are notoriously unreliable (McKelvey *et al.* 2008). The risks of using anecdotal data to draw conclusions about a species' status and distribution are well

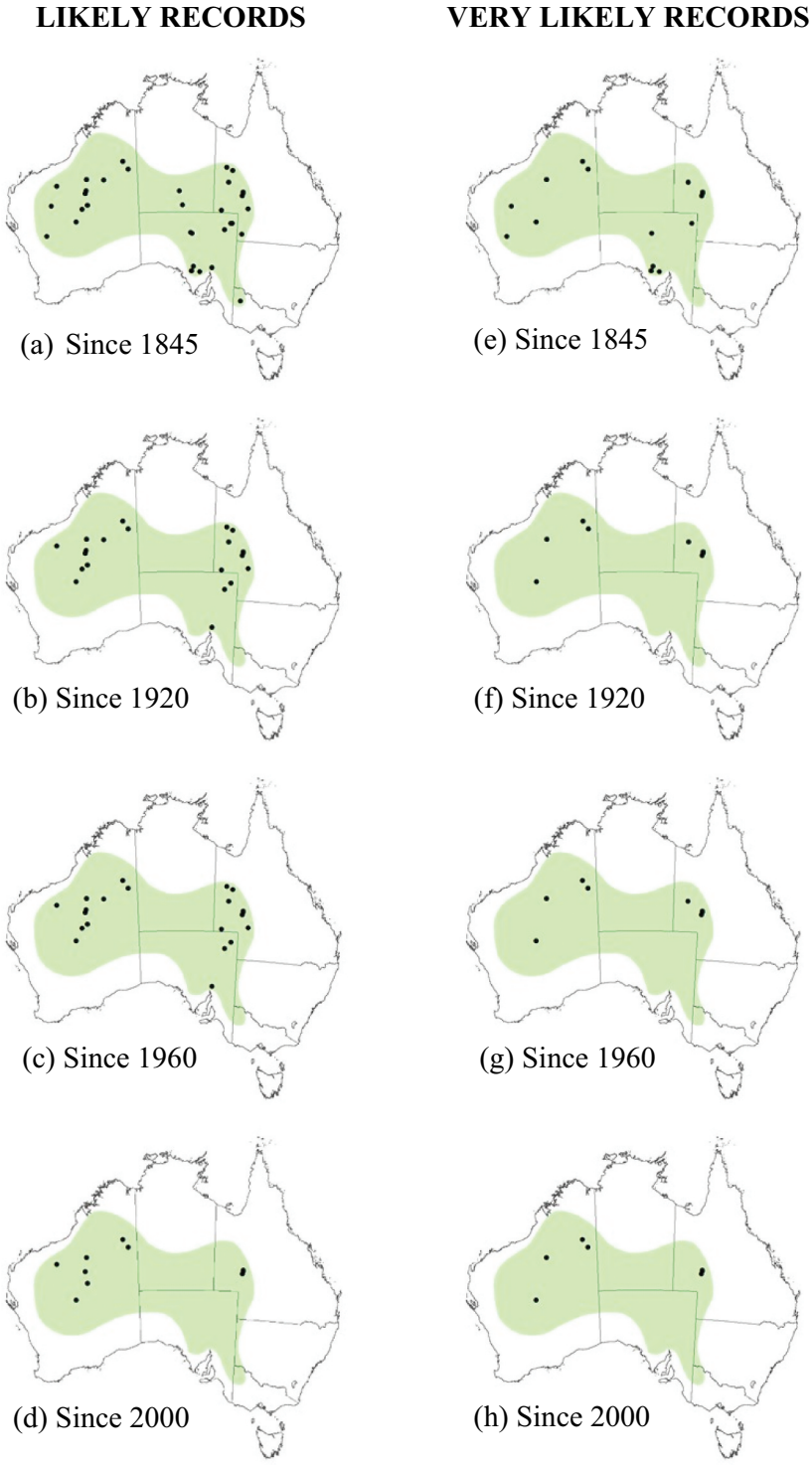


Figure 3. Plot of likely Night Parrot records since (a) 1845, (b) 1920, (c) 1960 and (d) 2000, and very likely records since (e) 1845, (f) 1920, (g) 1960 and (h) 2000. Despite the increasing threshold, each demonstrates a similar pattern of contraction as the analysis using probable sightings.

known (Leseberg *et al.* 2020). If a higher standard of proof is applied, valid sightings may be rejected, while a lower standard of proof may see false claims accepted. These errors could result in mistaken claims of presence or absence. The risks of either approach must be considered when setting certainty thresholds, and making

conclusions based on the results of this method. Importantly, results should not be treated as a definitive biogeographical history, but as a starting point to inform conservation assessment and further research priorities.

Because the Night Parrot is a high profile species, and was likely to be encountered, at least sometimes, in circumstances permitting a detailed and accurate description, it is particularly suited to this analysis. Furthermore, this assessment could incorporate significant recent advances in our knowledge of the species. These factors allowed collation of a substantial catalogue of probable sightings. However, if a species is not well-known, there is little knowledge of its ecology and behaviour, or if that species is easily misidentified, it will be more difficult to accurately assess sightings and generate a useful corpus of probable records. Consequently, patterns of distribution are likely to be more obscure. Here, applying the higher certainty scores to the Night Parrot data simulated performing the analysis when levels of knowledge are lower. Although some temporal and spatial detail was lost, the number of sightings reaching the higher thresholds supported the same broad conclusions. The threshold of valid sightings required to support robust conclusions will vary between species, and may be unachievable. Identifying this threshold requires a species-specific assessment of the risk associated with any conclusions based on this approach.

Support for conclusions around Night Parrot distribution and status

The pattern of the Night Parrot's decline revealed here is familiar, matching that of many ecologically similar small-to-medium sized mammals from Australia's arid zone. These mammal declines also began in southeast Australia in the mid to late 19th century, before continuing throughout central and western Australia during the early and mid-20th century (Woinarski *et al.* 2015). This supports the view that the Night Parrot declined due to many of the same factors. Research suggests several interacting factors triggered these mammal declines, including habitat degradation, competition associated with the spread of pastoralism and the accompanying large numbers of introduced and native herbivores (McKenzie *et al.* 2007; Morton *et al.* 2011). Concurrently, changed fire regimes homogenised the landscape, reducing the amount of cover available. The subsequent spread of cats (*Felis catus*) and foxes (*Vulpes vulpes*), sustained by high numbers of rabbits (*Oryctolagus cuniculus*), and possibly aided by the persecution of dingoes (*Canis dingo*), compounded these problems and forced the local extinction of many small-to-medium sized mammals. Local extinctions further fragmented populations in an already patchy landscape, subjecting remaining populations to increased extinction pressure to which most eventually succumbed.

Our conclusions also fit with predictions from theory about causes of species' declines. For example, extinction is a likely outcome if historical declines are sudden (Gotelli *et al.* 2012), especially if the decline is due to invasive species rather than habitat loss (Clavero *et al.* 2009). Our results suggest that declines in the south and southeast of the Night Parrot's range were sudden, and field research indicates these were probably linked to both introduced species and habitat loss (Murphy *et al.* 2018). This supports our conclusion that the absence of recent records from the south and southeast of the Night Parrot's range means the species is probably extinct there. Similarly, this analysis confirms a sporadic detection history from western Queensland and central northern Western Australia, there being probable records from almost every decade since 1845. This is also an expected pattern; threatened species are more likely to persist at the edge of their range (Channell and Lomolino 2000; Fisher and Blomberg 2011), particularly the edge most isolated from the origin and onward spread of threatening processes, while a pattern of regular but infrequent records suggests a species probably occurs in isolated pockets, and at extremely low densities (Fisher and Blomberg 2011). Accordingly, while the Night Parrot persists along the northern and western edge of its likely historical range, it probably does so very patchily, and at extremely low densities.

Comparison with other methods of quantifying decline

There is a growing body of research on methods to assess anecdotal reports and make conclusions about the status of a species (Solow 2005; Boakes *et al.* 2015; Butchart *et al.* 2018). Typically, these methods assess whether a potentially extinct species remains extant. Although it is popularly reported that the Night Parrot was once thought extinct, the steady stream of plausible, if not definitive reports, led most authors to believe the species remained extant but extremely rare. Therefore, techniques that predict likelihood of extinction were not useful for examining the Night Parrot's decline. The issue concerning the Night Parrot was, and still is, knowledge of where it may persist. The method outlined here adapts similar procedures developed for assessing anecdotal records of potentially extinct species (Lee *et al.* 2015), but permits simple comparison between

records at a larger scale, revealing patterns of decline more specific methods may not. It will be appropriate for making general assessments around a species' likely distribution and status, particularly when there is uncertainty. More focused methods, such as those aimed at estimating probability of extinction, will be appropriate for species when there is a clear trend towards potential extinction, even if only at a local scale.

Future conservation implications for the Night Parrot

The ongoing decline revealed by this analysis suggests the Night Parrot's current federal and IUCN classification of endangered is justified under population size reduction criteria, but supports a classification of critically endangered depending on estimated population size (Threatened Species Scientific Committee 2015; BirdLife International 2019). Furthermore, the results of this research and widespread searches for the species in western Queensland (N. Leseberg unpub. data), and emerging data from searches in central and northern Western Australia, point to the species occurring in very low numbers, at extremely low densities, and in isolated, resident populations. The probable extreme fragmentation of the population poses a significant extinction risk.

One probable record from near Innamincka in north-eastern South Australia in 1999, and another tantalising report from this region in 2019 that scored 2.5, and therefore did not reach the threshold to be considered probable, suggest the Night Parrot could still persist in far north-eastern South Australia. However, the apparent strongholds for the species, western Queensland and central northern Western Australia, should be the primary focus of conservation funding and intervention, given the evidence of continuous occurrence in these areas. Assessment by federal and state governments of development impacts on Night Parrots in these strongholds should consider their demonstrated importance for the species' persistence. Conversely, requirements for developers to consider the Night Parrot in regions such as southern South Australia where it is likely the bird no longer occurs, but which are currently mapped as potential Night Parrot habitat (Australian Government 2018), could be reviewed.

In summary, this analysis demonstrates the value of a centralised, systematic, and critical review of anecdotal records for poorly known species. This process has generated a clear, logical picture of the Night Parrot's distribution and status during the 175 years since its discovery by Europeans, whereas the *ad hoc* collection and analysis of records for much of the 20th century contributed to continuing misperceptions around the bird's status, and perhaps complicated efforts to find and conserve it. This method could clarify the status of other poorly known species with primarily anecdotal detection histories, leading to more accurate estimation of important metrics such as extent of occurrence and area of occupancy. In turn, this could influence assessment of their conservation status, and the more effective prioritisation and allocation of scarce conservation resources. Obvious Australian examples include the Buff-breasted Button-quail (*Turnix olivii*) and Coxen's Fig-Parrot (*Cyclopsitta diophthalma coxeni*). This analysis also shows the importance of reviewing sighting records as more sightings and more knowledge become available. The systematic review of both historical and future reports of a poorly known species using the most up-to-date knowledge will provide the best foundation for evidence-based management for such inherently difficult-to-conserve species.

Acknowledgements

The authors would like to acknowledge all those people who provided their first, second, and third hand reports of the Night Parrot to this project. The authors would like to particularly acknowledge the work of co-author Shane Parker, who passed away in 1992. Shane made a considerable contribution to Night Parrot research, and commenced compiling the database that is the foundation of this work. Bush Heritage Australia, the Australian Government's National Environmental Science Program through the Threatened Species Recovery Hub, and the Australian National Wildlife Collection Foundation provided support for this research. NPL received an Australian Government Research Training Program (RTP) Scholarship, and additional support through the Max Day Environmental Fellowship, University of Queensland strategic funding, and Birds Queensland. We thank Bill Venables for many fruitful discussions during the conduct of this research. We also thank the editors and reviewers who challenged us to improve our original manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Nicholas P. Leseberg http://orcid.org/0000-0001-6233-2236
Allan H. Burbidge http://orcid.org/0000-0002-2136-3973
Leo Joseph http://orcid.org/0000-0001-7564-1978
Richard A. Fuller http://orcid.org/0000-0001-9468-9678
James E. M. Watson http://orcid.org/0000-0003-4942-1984

References

Andrews, F. W. (1883).Notes on the Night Parrot. *Proceedings of the Royal Society of South Australia* **6**, 29–30.

Australian Government (2018). '*Pezoporus Occidentalis* Night Parrot *in* Species Profile and Threats Database.' (Department of Water and the Environment: Canberra.)

Beavan, K. (2017). 'Birdwatchers make 'probable' rediscovery of elusive Night Parrot in Central Australia.' (NT Country Hour, Australian Broadcasting Commission). 24 May 2017. Availale at http://www.abc.net.au/news/2017-05-24/night-parrot-possibly-found-in-central-australia/8553916 [Verified 22 July 2017].

BirdLife International (2019). 'Pezoporus occidentalis.' The IUCN Red List of Threatened Species 2019, e. T22685237A155460294. doi:10.2305/IUCN.UK.2019-3.RLTS.T22685237A155460294.en [Verified 29 October 2020].

Black, A. B. (2012). Collection localities of the Night Parrot *Pezoporus* (*Geopsittacus*) *occidentalis* (Gould, 1861). *Bulletin of the British Ornithologists' Club* **132**, 277–282.

Bland, L. M., Bielby, J., Kearney, S., Orme, C. D. L., Watson, J. E. M., and Collen, B. (2017). Toward reassessing data-deficient species. *Conservation Biology* **31**(3), 531–539. doi:10.1111/cobi.12850

Boakes, E. H., McGowan, P. J. K., Fuller, R. A., Chang-qing, D., Clark, N. E., O'Connor, K., and Mace, G. M. (2010). Distorted views of biodiversity: Spatial and temporal bias in species occurrence data. *PLoS Biology* **8**(6), e1000385. doi:10.1371/journal.pbio.1000385

Boakes, E. H., Rout, T. M., Collen, B., and Hodgson, D. (2015). Inferring species extinction: The use of sighting records. *Methods in Ecology and Evolution* **6**(6), 678–687. doi:10.1111/2041-210X.12365

Boles, W. E., Longmore, N. W., and Thompson, M. C. (1994). A recent specimen of the Night Parrot. *Geopsittacus Occidentalis*. *Emu* **94**, 37–40.

Borrello, E. 2018. 'Night parrot's Kimberley location under wraps after rare bird snapped for just the second time.' (Australian Broadcasting Commission). 24 November 2018. Available at https://www.abc.net.au/news/2018-11-24/night-parrot-photographed-in-kimberley-for-only-second-time/10550784?nw=0. [Verified 25 January 2019].

Burbidge, A. A., Johnson, K. A., Fuller, P. J., and Southgate, R. I. (1988). Aboriginal knowledge of the mammals of the Central Deserts of Australia. *Australian Wildlife Research* **15**(1), 9–39. doi:10.1071/WR9880009

Burgman, M., Carr, A., Godden, L., Gregory, R., McBride, M., Flander, L., and Maguire, L. (2011a). Redefining expertise and improving ecological judgment. *Conservation Letters* **4**(2), 81–87. doi:10.1111/j.1755-263X.2011.00165.x

Burgman, M. A., McBride, M., Ashton, R., Speirs-Bridge, A., Flander, L., Wintle, B., Fidler, F., *et al.* (2011b). Expert status and performance. *PLOS ONE* **6**(7), e22998. doi:10.1371/journal.pone.0022998

Butchart, S. H. M., Lowe, S., Martin, R. W., Symes, A., Westrip, J. R. S., and Wheatley, H. (2018). Which bird species have gone extinct? A novel quantitative classification approach. *Biological Conservation* **227**, 9–18. doi:10.1016/j.biocon.2018.08.014

Channell, R., and Lomolino, M. V. (2000). Dynamic biogeography and conservation of endangered species. *Nature* **403**(6765), 84–86. doi:10.1038/47487

Clavero, M., Brotons, L., Pons, P., and Sol, D. (2009). Prominent role of invasive species in avian biodiversity loss. *Biological Conservation* **142**(10), 2043–2049. doi:10.1016/j.biocon.2009.03.034

Clemen, R. T., and Winkler, R. L. (1985). Limits for the precision and value of information from dependent sources. *Operations Research* **33**(2), 427–442. doi:10.1287/opre.33.2.427

Davis, R. C. (2002). 'The Central Australian Expedition 1844-1846: The Journals of Charles Sturt.' (Hakluyt Society: London.)

Fisher, D. O., and Blomberg, S. P. (2011). Correlates of rediscovery and the detectability of extinction in mammals. *Proceedings of the Royal Society B* **278**(1708), 1090–1097. doi:10.1098/rspb.2010.1579

Gotelli, N. J., Chao, A., Colwell, R. K., Hwang, W., and Graves, G. R. (2012). Specimen-based modeling, stopping rules, and the extinction of the Ivory-Billed Woodpecker. *Conservation Biology* **26**(1), 47–56. doi:10.1111/j.1523-1739.2011.01715.x

Hamilton, N. A., Onus, M., Withnell, B., and Withnell, K. (2017). Recent sightings of the Night Parrot *Pezoporus occidentalis* from Matuwa (Lorna Glen) and Millrose Station in Western Australia. *Australian Field Ornithology* **34**, 71–75.

Harrop, A. H. J., Collinson, J. M., and Melling, T. (2012). What the eye doesn't see: The prevalence of fraud in ornithology. *British Birds* **105**, 236–257.

Higgins, P. J. (Ed.) (1999). 'Handbook of Australian, New Zealand and Antarctic Birds. Vol. 4. Parrots to Dollarbird.' (Oxford University Press: Melbourne.)

IUCN Standards and Petitions Committee. (2019). 'Guidelines for Using the IUCN Red List Categories and Criteria: Version 14.' (IUCN: Gland, Switzerland, and Cambridge, UK.)

Jackett, N. A., Greatwich, B. R., Swann, G., and Boyle, A. (2017). A nesting record and vocalisations of the Night Parrot *Pezoporus occidentalis* from the East Murchison, Western Australia. *Australian Field Ornithology* **34**, 144–150. doi:10.20938/afo34144150

Koch, T. (2013). 'Tweets in the night, a flash of green: Is this our most elusive bird?' *Weekend Australian*, 29-30 June 2013. Pp. 1,10.

Lee, T. E., Black, S. A., Fellous, A., Yamaguchi, N., Angelici, F. M., Al Hikmani, H., Reed, J. M., *et al.* (2015). Assessing uncertainty in sighting records: An example of the Barbary Lion. *PeerJ* **3**, e1224. doi:10.7717/peerj.1224

Lendon, A. (1968). The distribution of the Australian Psittacines (Order Psittaciformes: Parrots, Cockatoos, etc.). *South Australian Ornithologist* **25**, 3–17.

Leseberg, N. P., Murphy, S. A., Jackett, N. A., Webster, P. T. D., MacColl, C., Stoetzel, H. J., and Watson, J. E. M. (2020). Recognising the impact of sight record assessment on the scientific record and a species' conservation status. *Emu - Austral Ornithology* **120**(2), 181–183. doi:10.1080/01584197.2020.1774395

Martin, T. G., Burgman, M. A., Fidler, F., Kuhnert, P. M., Low-Choy, S., McBride, M., and Mengersen, K. (2012). Eliciting expert knowledge in conservation science. *Conservation Biology* **26**(1), 29–38. doi:10.1111/j.1523-1739.2011.01806.x

McBride, M. F., Garnett, S. T., Szabo, J. K., Burbidge, A. H., Butchart, S. H. M., Christidis, L., Dutson, G., *et al.* (2012). Structured elicitation of expert judgments for threatened species assessment: A case study on a continental scale using email. *Methods in Ecology and Evolution* **3**(5), 906–920. doi:10.1111/j.2041-210X.2012.00221.x

McKelvey, K. S., Aubry, K. B., and Schwartz, M. K. (2008). Using anecdotal occurrence data for rare or elusive species: The illusion of reality and a call for evidentiary standards. *BioScience* **58**(6), 549–555. doi:10.1641/B580611

McKenzie, N. L., Burbidge, A. A., Baynes, A., Brereton, R. N., Dickman, C. R., Gordon, G., Gibson, L. A., *et al.* (2007). Analysis of factors implicated in the recent decline of Australia's mammal fauna. *Journal of Biogeography* **34**(4), 597–611. doi:10.1111/j.1365-2699.2006.01639.x

Menkhorst, P., Fitzsimons, J., Loyn, R., and Woinarski, J. (2020). Assessing the strength of evidence for records of Night Parrots at Kalamurina Wildlife Sanctuary (South Australia) and Diamantina National Park (Queensland), 2016–2018. *Emu - Austral Ornithology* **120**(2), 173–177. doi:10.1080/01584197.2020.1774394

Menkhorst, P. W., and Ryan, E. (2015). CH McLennan ('Mallee Bird') and his Aboriginal informant Jowley: The source of early records of the Night Parrot *Pezoporus occidentalis* in Victoria? *Memoirs of the Museum Victoria* **73**, 107–115. doi:10.24199/j.mmv.2015.73.09

Morton, S. R., Stafford Smith, D. M., Dickman, C. R., Dunkerley, D. L., Friedel, M. H., McAllister, R. R. J., Reid, J. R. W., *et al.* (2011). A fresh framework for the ecology of arid Australia. *Journal of Arid Environments* **75** (4), 313–329. doi:10.1016/j.jaridenv.2010.11.001

Murphy, S. A., Paltridge, R., Silcock, J., Murphy, R. K., Kutt, A. S., and Read, J. (2018). Understanding and managing the threats to Night Parrots in south-western Queensland. *Emu - Austral Ornithology* **118**(1), 135–145. doi:10.1080/01584197.2017.1388744

Murphy, S. A., Silcock, J., Murphy, R. K., Reid, J. R. W., and Austin, J. J. (2017). Movements and habitat use of the night parrot *Pezoporus occidentalis* in south-western Queensland. *Austral Ecology* **42**(7), 858–868. doi:10.1111/aec.12508

North, A. J., and Keartland, G. A. (1896). Aves. In 'Report on the Work of the Horn Scientific Expedition to Central Australia. Part II – Zoology.' (Ed. B. Spencer.) pp. 53–111. (Dulau and Co.: London.)

North, A. J., and Keartland, G. A. (1898). List of birds collected by the Calvert exploring expedition in Western Australia. *Transactions of the Royal Society of South Australia* **22**, 125–192.

Olsen, P. (2018). 'Night Parrot.' (CSIRO: Clayton South, Victoria.)

Parker, S. A. (1980). Birds and Conservation Parks in the North-East of South Australia. *South Australian Parks and Conservation* **3**, 11–18.

Pillay, R., Miller, D. A. W., Hines, J. E., Joshi, A. A., and Madhusudan, M. D. (2014). Accounting for false positives improves estimates of occupancy from key informant interviews. *Diversity & Distributions* **20**(2), 223–235. doi:10.1111/ddi.12151

Pullin, A. S., and Knight, T. M. (2001). Effectiveness in conservation practice: Pointers from medicine and public health. *Conservation Biology* **15**(1), 50–54. doi:10.1111/j.1523-1739.2001.99499.x

Roberts, D. L., Elphick, C. S., and Reed, J. M. (2010). Identifying anomalous reports of putatively extinct species and why it matters. *Conservation Biology* **24**(1), 189–196. doi:10.1111/j.1523-1739.2009.01292.x

Rondinini, C., Wilson, K. A., Boitani, L., Grantham, H., and Possingham, H. P. (2006). Tradeoffs of different types of species occurrence data for use in systematic conservation planning. *Ecology Letters* **9**(10), 1136–1145. doi:10.1111/j.1461-0248.2006.00970.x

Schodde, R., and Mason, I. J. (1980). 'Nocturnal Birds of Australia.' (Lansdowne: Melbourne.)

Solow, A. R. (2005). Inferring extinction from a sighting record. *Mathematical Biosciences* **195**(1), 47–55. doi:10.1016/j.mbs.2005.02.001

Sutherland, W. J., Pullin, A. S., Dolman, P. M., and Knight, T. M. (2004). The need for evidence-based conservation. *Trends in Ecology & Evolution* **19**(6), 305–308. doi:10.1016/j.tree.2004.03.018

Thompson, C. J., Lee, T. E., Stone, L., McCarthy, M. A., and Burgman, M. A. (2013). Inferring extinction risks from sighting records. *Journal of Theoretical Biology* **338**, 16–22. doi:10.1016/j.jtbi.2013.08.023

Threatened Species Scientific Committee. (2015). 'Threatened Species Scientific Committee Guidelines.' (Department of the Environment: Canberra.)

White, S. A. (1913). Field ornithology in South Australia: The Gawler Ranges. *Emu - Austral Ornithology* **13**(1), 16–32. doi:10.1071/MU913016

Whitlock, F. L. (1924). Journey to Central Australia in search of the Night Parrot. *Emu* **23**(4), 248–281. doi:10.1071/MU923248

Wilson, H. (1937). Notes on the Night Parrot, with references to recent occurrences. *Emu - Austral Ornithology* **37**(2), 79–87. doi:10.1071/MU937079

Woinarski, J. C. Z., Burbidge, A. A., and Harrison, P. L. (2015). Ongoing unraveling of a continental fauna: Decline and extinction of Australian mammals since European settlement. *Proceedings of the National Academy of Sciences* **112**(15), 4531–4540. doi:10.1073/pnas.1417301112